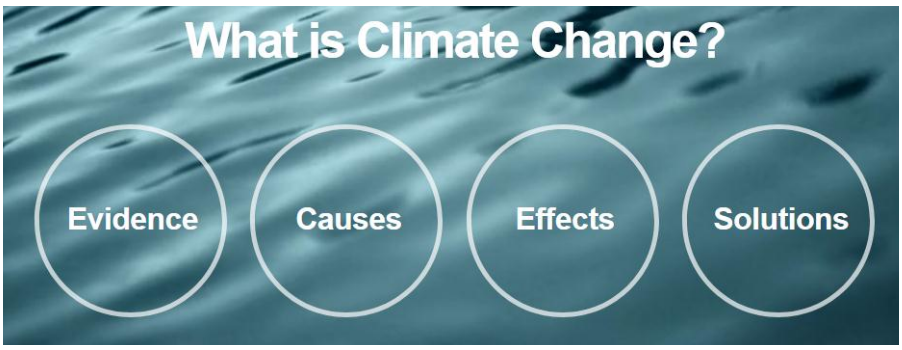
An environmentally competent generation of young people will need both to understand the science of the environment and to have the interest and willingness to address the problems that it raises. There is huge scope for education systems to help develop such competence.

"Environmental Change Is the Prospect of Global Climatic Changes, Accompanied By Associated Disruption of Weather Patterns"

Climate Change Could Drastically Change Ecosystems Around the World



PROCEEDINGS BOOK

OF THE

9th ICEEE – 2018

International Conference deals with

„Climatic Changes and Environmental (Bio) Engineering"

(22nd - 24th of November 2018)

at

Óbuda University

Rejtő Sándor Faculty of Light Industry and Environmental Engineering

III. District, H-1034 Doberdó Str. 6

Budapest, Hungary

Content

Under the auspices of:

Prof. Dr. Mihály RÉGER
Rector of Óbuda University

Presidency of the Conference:

Dr. László KOLTAI
Dean of Rejtő Sándor Faculty of Light Industry and Environmental Engineering

Dr. Ágnes BÁLINT
Director of the Institute of Environmental Engineering

Prof. Dr. Hosam BAYOUMI HAMUDA
President of International Council of Environmental Engineering Education
Conference Chair

Background

Dear Guests and Colleagues

In response, 195 nations as part of the United Nations Framework Convention on Climate Change adopted the Paris Agreement, which aims to limit the global temperature increase below 2°C above pre-industrial levels. On another level, for most decision makers there is little guidance on how to best address the linkages between air quality and climate change within the policy process to understand how the emissions of air pollutants and greenhouse gases will impact climate, human health, ecosystems, agriculture, etc.

As a part of the framework of the Hungarian Scientific Season in Budapest, Hungary and after a great successful of the last International Conferences of ICEEE which brought together the world's professions and practitioners from different fields of applied sciences and environmental engineering, the Óbuda University, Rejtő Sándor Faculty of Light Industry and Environmental Engineering (RKK), Institute of Environmental Engineering with the cooperation with the International Council of Environmental Engineering Education (ICEEE) have the great pleasure to welcome you as a speaker and contributor for our conference **the *9th ICEEE - 2018*** International Conference on „***Climatic Change and Environmental (Bio) Engineering***" which is now here in Budapest today November 22nd to 24th 2018 in Hungary.

The main goals of the conference are: to promote research and developmental activities in Environmental (Bio) Engineering and different fields of Natural Science; and to promote scientific information interchange between researchers, developers, engineers, students, and practitioners working in and around the world. This conference will provides opportunities for the delegates to exchange new ideas and application experiences face to face, to establish business or research relations and to find global partners for future collaboration.

Here we have to thanks our sponsor Dr. Patricia VARJU from Image-Science Ltd, (Nagykovacsi, Hungary) for supporting the Conference.

Wish you all the best.

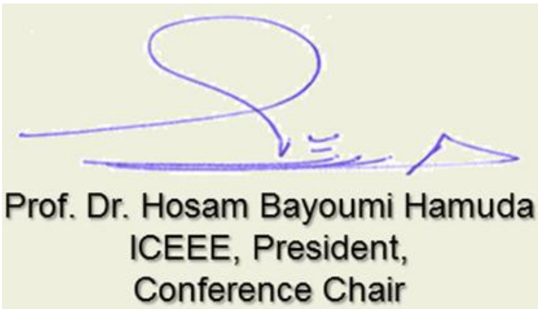
The organizing Committee of the Conference

Impressum

For the Programme Book, Abstracts and the Proceedings of the papers of the 9^{th} ICEEE-2018 International Conference titled: „*Climatic Change and Environmental (Bio) Engineering*”

– The official language is English.
– The Programme and Abstracts of the Conference is provided to all registered participants in printed form.
– All the received papers were reviewed by two of the members of the International Committee of the Conference.
All reviewed papers for the 9^{th} ICEEE-2018 International Conference will be published in the Conference Proceedings Book with the ISBN 978-963-449-105-7.
–the Proceedings form with **ISBN** 978-963-449-105-7 in CD-ROM format and online in the website of ICEEE: **www.iceee.hu**
– The selected high quality manuscripts will be also published in the online journal**.**
– The scientific information and quality of the manuscript is due to the corresponding author of the paper.
– The Publisher of the Programme, Abstracts and the Proceedings of the International Conference is the ICEEE, Sándor Rejtő Faculty of Light Industry and Environmental Engineering, Óbuda University, Budapest, Hungary.
– Publication year of the Proceedings is 2018.
– Important Websites:
o **www.iceee.hu**
– The Conference is organised in the framework of the Hungarian Scientific Season (Hungarian Scientific Festival).

November, 2018.



Introduction

Why Environmental Engineering Is Vital for Our Future and Why Climatic Changes!

Our planet has a natural environment, known as 'Ecosystem' which includes all humans, plant life, mountains, glaciers, atmosphere, rocks, galaxy, massive oceans and seas. It also includes natural resources such as water, electric charge, fire, magnetism, air and climate.

Engineering developments are resulting in resource depletion and environmental destruction. Modern technologies used in the engineering and manufacturing industry have a major impact on our life in past few years. Due to the rapid changes in the engineering and manufacturing industry have been drastic changes in the environment.

Humanity has always engineered the environment around us. From the earliest days of wetland drainage and the need to acquire fresh water, to keep it flowing and keep it clean enough to drink, building cesspits to take away our waste and to stop pollution of vital waterways, we have always strived to maximize our sanitation and living conditions in order to expand and survive.

Sanitation is a large part of our civil evolution; without it, we would yield more often to water-borne disease and illness - raising our mortality rates and lowering our quality of life. Therefore, we've always needed to find bigger and better ways of taking away our sewage, cleaning our water and harnessing natural or artificial water supplies for our health and environment.

Since the industrial revolution in the 19th century we have needed to prevent businesses and individuals from polluting the environment with harmful substances. The modern environmental engineer is dedicated to keeping our air, soil and water clean of pollutants and promoting good health for human, animal and plant and these days, protection against radioactive and toxic materials too; they also study the potential effects of climate change and other environmental factors on the infrastructure.

Couple this with environmental awareness in the general population and the (then) growing understanding of the effects of climate change meant that environmental engineering was born in this era. Since then, environmental legislation has sought to define environmental standards on clean water, air quality, solid waste disposal and pollution management (toxic and radioactive) - at state and national level, and to define international standards. We are using an ever-increasing number of chemicals with toxic waste and the remit of the environmental engineer is to keep the environment safe for humans and for other forms of life.

The terms climate change and global warming are often used interchangeably, but climate change refers to both the rise in global temperatures because of human activities and the many impacts this rise has on the Earth—such as more intense and frequent droughts and storms, melting glaciers and ice sheets, rising sea levels, warming seas (which can cause coral reef bleaching and disrupt the marine food chain), and ocean acidification. Climate change can also refer to natural fluctuations in the Earth's average temperature between cold periods (ice ages) and warm periods.

Since 2005, several global processes have called for an integrated approach to climate change adaptation (CCA) and disaster risk reduction (DRR). Calls to pursue this integration were intensified, with the adoption of three main and interrelated agendas, namely the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction (2015-2030) and the Paris Agreement on Climate Change. While the CCA and DRR communities follow separate paths, bridging the gap between them entails both opportunities and challenges. Similarities between the two communities need to be exploited and differences investigated in order to achieve synergies in dealing with all aspects of weather-related hazards and disasters, assessment tools, institutional arrangements and means of implementation to achieve synergy between the two agendas.

Conference Chair

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SCOPE AND OPPORTUNITIES

ICEEE is a non-profit organization that promotes the Engineering and Technology, related latest developments and issues to be discussed and experimented through interactions amongst the researchers and academician across the World at a common platform.
ICEEE is leading event in the Environmental Engineering Education sector, sharing the latest research results, developments & innovative environmental protection & applications from industry & the policy context. It is clear that, for the mitigation of climate change, urbanization & with rapid industrialization all over the world, pollution is on the increase, we need a transformation of the education, health, economy and environment, not a marginal change.

9th ICEEE - 2018 is a forum where researchers, environmentalists, scientists, scholars and students, share their ideas, experiences, advancements, and research results. There will be plenty of opportunities for organisations, projects and consortia to hold side events (meetings, seminars and workshops) on the Conference site to draw insights and encourage collaboration from many topics, disciplines, and backgrounds, promoting research and education to build a fair global community and more sustainable societies.

The purpose of the 9th ICEEE - 2018 Conference deals with „Environmental Change and Environmental Health due to the Climatic Change". Climate change is projected to harm human health through adverse changes in security of the life-style.

The 9th ICEEE - 2018 Conference will bring together keynote, invited speakers and international researchers from academia, authorities and industry, to communicate and share a wide range of highlighting potential issues and paths towards the environmental health and the sustainable due to climate change at present and future. The following core conference themes reflect an integrated approach to identifying solutions to the complex global challenge of climatic change.

Main Topics of Conference:

- Climate Change and:
- Adaptation & Migration
- Agriculture, Food & Forest Security
- Applied Sciences
- (Bio) Engineering
- Biodiversity Conservation & Bioindicators
- Carbon Reduction in the Built Environment
- Desertification
- Eco-design, Green Marketing & Textile Development
- Economics: Industry & Business
- Education, Innovation and Sustainable Development
- Energy
- Environmental Friendly Materials
- Environmental legislation & Regulations
- Environmental Pollution & Protection
- Health & Infectious Disease
- Impacts on Water & Sanitation
- Mathematical Modelling & Computation
- Technology & Climate Monitoring

The Relevant Topics Include too:

- Atmospheric Sciences & (Bio)monitoring
- Biodegradation of Hazardous Substances
- Bioengineering: Biochemical & Bioprocess Engineering
- Bio-Waste Recycling in Agricultural/Horticultural/Aquaculture Industries.
- Biosensors & Nanobiotechnology
- Biotechnology & Bioengineering
- CO_2 Capture & Sequestration
- Climatology & Meteorology
- Communications & Environmental Engineering
- Composite Material, Polymer Science & Engineering
- Designers & Engineers Can Start Designing for Climate Change
- Designing the Future: A New Society & A New Economy?
- Engineering Solutions Response to Climate Change
- Environmental Biology, Chemistry & Microbiology
- Environmental Engineering & Monitoring
- Environmental Footprint of Tourism
- Environmental Risk Assessment & Health Science
- Global, Regional & local analyses of Environmental security
- Green Technology & Greenhouse Gas Emissions
- Methods for Monitoring Climate Change & Its Effects
- Microbial Communities as Indicators of Climatic Changes
- Monitoring global health within Sustainable Development Goals
- Pollution Analysis & Environmental Sustainability
- Soil Science & Decontamination
- Solid Waste Minimization, Remanufacturing, Reuse and Recycling
- Sustainable bioenergy & biomass
- Water, Waste & Energy Management

Research and Solutions are needed to give promise for future application and contribution to the sustainable development and protect the impacts of climatic changes on the environment

CONFERENCE PROGRAMME

22nd of November 2018 (Thursday)

– 13:30 p.m. – 17:00 p.m.	Welcome and Registration	Aula of Faculty
– 13:30 p.m. – 18:00 p.m.	Suspension of Poster	Aula of Faculty
– 14:00 p.m. – 14:20 p.m.	Opening Ceremony	Schmalz Auditorium
– 14:20 p.m. – 14:30 p.m.	Group Photo	Aula of Faculty

14:30 p.m. – 16:00 p.m. Plenary Lectures
Schmalz Auditorium

Chairpersons: László KOLTAI – Lyudmyla SYMOCHKO

14:30 p.m. – 15:00 p.m.
Marina FRONTASYEVA *(Joint Institute for Nuclear Research, Dubna, Russia)*
COSMIC DUST STUDIED BY MOSS ANALYSIS

15:00 p.m. – 15:30 p.m.
Ruslan MARIYCHUK *(University of Prešov, Prešov, Slovakia)*
GREEN SYNTHESIS OF NANOPARTICLES: STATE OF ART AND FURTHER PERSPECTIVES

15:30 p.m. – 16:00 p.m.
Hosam E.A.F. BAYOUMI HAMUDA *(Óbuda University, Budapest, Hungary)*
SOIL BIOLOGICAL ACTIVITY AND THEIR SEASONAL VARIATIONS IN RESPONSE TO CLIMATIC CHANGES

16:00 p.m. – 16:15 p.m. Coffee Break

16:15 p.m. – 17:15 p.m. Technical Session-1
Schmalz Auditorium

Chairpersons: Ruslan MARIYCHUK – Márta KISFALUDY

16:15 p.m. – 16:30 p.m.

Ágnes BÁLINT[1], Csaba MÉSZÁROS[2] *([1]Óbuda University, Budapest, Hungary, [2]Szent István University, Gödöllő, Hungary)*

MODELLING OF THE COUPLED TRANSPORT PROCESSES THROUGH POROUS MEDIA AT PRESENCE OF ANOMALOUS DIFFUSION

16:30 p.m. – 16:45 p.m.

Lyudmyla SYMOCHKO[1], Hosam E.A.F. BAYOUMI HAMUDA[2], Olena DEMYANYUK[3], Vitaliy SYMOCHKO[1], Volodymyr PATYKA[4] *([1]Uzhhorod National University, Uzhhorod, Ukraine, [2]Obuda University, Budapest, Hungary, [3]Institute of Agroecology and Environmental Management, Kyiv, Ukraine, [4]D.K. Zabolotny Institute of Microbiology and Virology of NAS of Ukraine, Kyiv, Ukraine)*

CLIMATE CHANGE AND SOIL MICROBIOME

16:45 p.m. – 17:00 p.m.

Endre KISS, Miklós HORVÁTH, Tivadar PROHÁSZKA *(University of Dunaújváros, Dunaújváros, Hungary)*

INVESTIGATION OF EMISSION OF NOx, SO_2 AND CHLORINE BY BIOMASS-BURNING

17:00 p.m. – 17:15 p.m.

Paweł ŚWISŁOWSKI, Małgorzata RAJFUR *(University of Opole, Opole, Poland)*

INFLUENCE OF MOSSES SAMPLE PREPARATION METHODOLOGY ON THE COEFFICIENT OF VARIATION (*CV*)

17:15 p.m. – 17:30 p.m. Coffee Break

17:30 p.m. – 18:30 p.m. Technical Session-2
Schmalz Auditorium

Chairpersons: Miroslav BADIDA – Ágnes BÁLINT

17:30 p.m. – 17:45 p.m.

Emőke IMRE[1], Tibor FIRGI[2], Zsolt HORTOBÁGYI[3] *([1]Óbuda University, Budapest, Hungary, [2]Szent István University, Gödöllő, Hungary, [3]Budapest University of Technology and Economics, Budapest, Hungary)*
SETTLEMENT OF WIND TURBINE FOUNDED ON A LANDFILL HILL

17:45 p.m. – 18:00 p.m.

Myroslava DEMCHYNSKA[1], L. SYMOCHKO[1], O. DEMCHYNSKYY[2]
([1]Uzhhorod National University, Ukraine, [2]Main Administration of SSUFSCP in Zakarpatska region, Ukraine)
SPREAD OF INVASIVE SPECIES AND CLIMATE CHANGE

18:00 p.m. – 18:15 p.m.

Zakiyeh S. NAMROTEE[1], Hosam E.A.F. BAYOUMI HAMUDA[2] *([1]Eötvös Loránd University, Budapest, Hungary, [2]Óbuda University, Budapest, Hungary)*
Evaluation of Growth and yield of Various Barley Cultivars Irrigated with Artificial Wastewater

18:15 p.m. – 18:30 p.m.

Amina A.M. DAROUGI[1], Ali ALAMMARI[2], Hosam E.A.F. BAYOUMI HAMUDA[3] *([1]Eötvös Loránd University, Budapest, Hungary, Szent István University, Gödöllő, Hungary, [3]Óbuda University, Budapest, Hungary)*
A COMPARATIVE STUDY ON SOME STATISTICAL INVESTIGATIONS ON POPULATION AND ECONOMIC SECTORS IN LIBYA: PAST AND FUTURE

19:00 p.m. – 21:00 p.m. Welcome Dinner

23rd of November 2018 (Friday)

– 08:30 a.m. – 13:00 p.m. Registration at desk Aula of Faculty

09:00 a.m. – 10:00 p.m. Technical Session-3
Schmalz Auditorium

Chairpersons: Endre KISS – Lýdia SOBOTOVA

09:00 p.m. – 09:15 p.m.

Borbala BIRO[1], Dayakar GOVINDU[1,2], Sandor Attila PABAR[1], Tamás KOCSIS[1], Anita DUDAS[1], Levente KARDOS[1], Zsolt KOTROCZO[1] *([1]Szent István University, Budapest, Hungary, [2]Kakatiya University, Warangal, India)*
BIOEFFECTIVE SOIL-PLANT-INOCULATION TECHNIQUES FOR IMPROVED SOIL QUALITY AND FUNCTIONING

09:15 p.m. – 09:30 p.m.

Hosam E.A.F. BAYOUMI HAMUDA[1], Lyudmyla SYMOCHKO[2], Andrea PAUKÓ[1] *([1]Óbuda University, Budapest, Hungary, [2]Uzhhorod National University, Uzhhorod, Ukraine)*
IMPACTS OF COMPOST AND WASTWATER SLUDGE ON SOIL BIOLOGIC ACTIVITIES

09:30 p.m. – 09:45 p.m.

Éva KOVÁCS-BOKOR[1], Endre DOMOKOS[2], Endre KISS[1] *([1]University of Dunaújváros, Dunaújváros, Hungary, [2]University of Pannonia, Veszprém, Hungary)*
DETERMINATION OF THE ACCUMULATION OF HEAVY METALS OF RIVER SEDIMENT BY PLANTS

09:45 p.m. – 10:00 p.m.

Bushra ATFEH[1], Péter ANDRÁS[2], Róbert MÉSZÁROS[1], Hosam E.A.F. BAYOUMI HAMUDA[3] *([1]Eötvös Loránd University, Budapest, Hungary, [2]Mott Macdonald Company, Budapest, Hungary, [3]Óbuda University, Budapest, Hungary)*
ENVIRONMENTAL IMPACT ASSESSMENT OF NO_2 EMISSION AND THEIR RELATION TO METEOROLOGICAL CONDITIONS IN KOMÁROM, HUNGARY

10:00 p.m. – 10:15 p.m. Coffee Break

10:15 p.m. – 12:00 p.m. Technical Session-4
Schmalz Auditorium

Chairpersons: Hosam BAYOUMI HAMUDA – Bogdana VUJIĆ

10:15 p.m. – 10:45 p.m. Plenary Lecture

Tatjana JUZSAKOVA[1], József NÉMETH[1], Viktor SEBESTYÉN[1], László DIÓSSY[2], Le Phuoc CUONG[3], Igor CRETESCU[4], Endre DOMOKOS[1], Ákos RÉDEY[1] *([1]University of Pannonia, Veszprém, Hungary, [2]Chianti 3D Kft., Veszprém, Hungary, [3]University of Danang-University of Science and Technology, Danang, Vietnam, [4]"Gheorghe Asachi" Technical University of Iasi, Iasi, Romania)*
WATER MONITORING AND QUALITY ASSESSMENT

10:45 p.m. – 12:00 p.m. Technical Lectures

10:45 p.m. – 11:00 p.m.
Edmond HOXHA (*Department of Mineral Resources; Faculty of Geology and Mining, Polytechnic University of Tirana, Albania)*
CLIMATE CHANGE ACTUAL SITUATION, AND RISKS IN ALBANIA

11:00 p.m. – 11:15 p.m.
Tatjana JUZSAKOVA[1], Igor CRETESCU[2], Endre DOMOKOS[1], Ákos RÉDEY[1] *([1]University of Pannonia, Veszprém, Hungary, [2]"Gheorghe Asachi" Technical University of Iasi, Iasi, Romania)*
NEW ADSORBENTS IN POLLUTION CONTROL

11:30 p.m. – 11:45 p.m.
Zoltán JUVANCZ, Réka HALÁSZ, Rita BODÁNÉKENDROVICS, Krisztina DEMÉNY, Albert SZANISZLÓ *(Óbuda University, Budapest, Hungary)*
FIELD PRACTICE OF ENVIRONMENTAL ENGINEERS IN ALSÓ-HEGY (DIDACTICAL VISUAL GUIDE, ARRANGED IN THEMATIC ORDER)

11:45 p.m. – 12:00 p.m.
Abdussalam Ashour KHALIF[1], Ferenc LIGETVÁRI[2] *([1]Szent István University, Gödöllő, Hungary, Debrecen University, Debrecen, Hungary)*
GAS EMISSION AND PARTICULAR MATERIAL OF DIFFERENT ECONOMIC SECTORS IN HUNGARY BETWEEN 2000-2015

12:00 p.m. – 12:15 p.m. **Coffee Break**

12:15 p.m. – 13:15 p.m. Technical Session-5
Schmalz Auditorium

Chairpersons: Edmond HOXHA – Višnja MIHAJLOVIĆ

12:15 p.m. – 12:30 p.m.

Barnabás TÓTH[1], László KOLTAI[1], Péter BÖRÖCZ[2] *([1]Óbuda University, Budapest, Hungary, [2]Széchenyi István University, Győr, Hungary)*
METHODS FOR TESTING QUALITY OF VARIOUS PAPER COMPONENTS BY THERMAL ANALYSIS

12:30 p.m. – 12:45 p.m.

Katalin TAKÁCS-GYÖRGY, István TAKÁCS *(Óbudai Egyetem, Budapest, Hungary)*
AGRICULTURAL ANSWER TO CLIMATE CHANGE - OPTIMIZING RESOURCES

12:45 p.m. – 13:00 p.m.

Bingshen LIU *(Óbuda University, Budapest, Hungary)*
CLEANED WASTEWATER IRRIGATION IN AGRICULTURE

13:00 p.m. – 14:30 p.m. Lunch Break

14:30 a.m. – 16:00 p.m. Poster Presentations
Aula of Faculty

Chairpersons: Ákos RÉDEY – Marina FRONTASYEVA

1. **Abdussalam Ashour KHALIF[1], Ferenc LIGETVÁRI[2]** *([1]Szent István University, Faculty of Economic and Social Sciences, Gödöllő, Hungary, Debrecen University, Debrecen, Hungary)*
SOME ASPECTS OF CLIMATE CHANGE WITH EMPHASISING ON REDUCING GREENHOUSE GAS EMISSIONS

2. **Abdussalam Ashour KHALIF[1], Ferenc LIGETVÁRI[2]** *([1]Szent István University, Faculty of Economic and Social Sciences, Gödöllő, Hungary, Debrecen University, Debrecen, Hungary)*
SOME ISSUES IN THE EUROPEAN UNION EMISSIONS TRADING SYSTEM

3. **Ali D. SALMAN[1], Tatjána JUZSAKOVA[1], Zoltán BAKONYI[2], Tamás PAP[1], Endre DOMOKOS[1]** *([1]University of Pannonia, Veszprém, Hungary, [2]MAL Hungarian Aluminum Producing and Trading Closed Share Company, Ajka, Hungary)*
EXPERIMENTAL INVESTIGATION TO RECOVERY OF RARE EARTH ELEMENTS (REES) FROM HUNGARIAN RED MUD USING OPTIMIZATION TECHNIQUE

4. **Anna BADIDOVÁ, Marek MORAVEC, Miroslav BADIDA, Lýdia SOBOTOVÁ, Tibor DZURO** *(Technical university of Košice, Košice, Slovakia)*
UTILISATION OF PSYCHOACOUSTICS IN TECHNICAL PRACTICE

5. **Bernadett KÓSA, Lóránt SZABÓ** *(Óbuda University, Budapest, Hungary)*
BIOGAS POTENTIAL FROM FISH WASTE AND CATTLE MENURE

6. **Boglárka JOÓ[1], Judit PLUTZER[2], Hosam E.A.F. BAYOUMI HAMUDA[1]** *([1]Óbuda University, Budapest, Hungary, [2]National Public Health and Medical Office Service, Budapest, Hungary)*
ESTROGENIC ACTIVITY IN AQUATIC ENVIRONMENTAL SAMPLES ASSESSED BY IN VITRO ASSAYS

7. **Daniela GRUĽOVÁ, Štefan KOCO, Ruslan MARIYCHUK** *(University of Prešov, Prešov, Slovakia)*
MONITORING OF INVASIVE SOLIDAGO SPP. WITH LOW DISTRIBUTION IN PRESOV AREA (EAST SLOVAKIA)

8. **Dayakar GOVINDU[1,2], Sheak Rehana BEGUM[1], Srinivas PODETI[1], Borbala BIRO[2]** *([1]Kakatiya University, Warangal, India; [2]Szent István University, Budapest, Hungary)*
ROLE OF PLANT-MYCORRHIZA SYMBIOSIS IN REVEGETATION OF DISTURBED MINING SITES IN INDIA (NORTH TELANGANA)

9. **Dávid MÓNOK, Levente KARDOS** *(Szent István University, Budapest, Hungary)*
TOXIC EFFECTS OF HEAVY METALS (Cu, Zn, Pb, Cd) ON EARLY GROWTH OF THREE *Tagetes* SPECIES

10. **Endre KISS, Miklós HORVÁTH, Tivadar PROHÁSZKA, Miklós SOVÁK, Imre KOVÁCS, Éva KOVÁCS-BOKOR** *(University of Dunaújváros, Dunaújváros, Hungary)*
INVESTIGATION OF RED MUD IN ORDER TO UTILIZE IT

11. **Ferenc NOVOTHNY[1], Emőke IMRE[1], Benjámin SZEKERES[1], Tamás PÁLVÖLGYI[1], Péter KÁDÁR[1], Ágnes BÁLINT[1], László TÓTH[2], Tamás SCHNEIDER[3], István ELEK[4], Endre TŐRÖS[5], Tibor FILEP[6], Zsolt HORTOBÁGYI[7], János ŐSZ[7], Kálmán RAJKAI[8], Gábor MILE[9], Kornél KOVÁCS[10]** (*[1]Óbuda University, Budapest, [2]Szent István University, Gödöllő, Hungary, [3]Lakics Kft. Budapest, Hungary, [4]Eötvös Loránd University, Budapest, Hungary, [5]MFGI, Budapest, Hungary,[6]CSFK MTA, Budapest, Hungary, [7]Budapest University of Technology and Economics, Budapest, Hungary, [8]MTA-ATK TAKI, Budapest, Hungary, [9]FKF Zrt, Budapest, Hungary, [10]Szeged University, Szeged, Hungary)*
ENERGY HILL - MSW LANDFILL HILL

12. **Hosam E.A.F. BAYOUMI HAMUDA[1], Ibrahim ISSA[2]** *([1]Óbuda University, Budapest, Hungary, [2]Sirte University, Sirte, Libya)*
CHEMICAL PROPERTIES AND TOXICITY OF SOILS CONTAMINATED BY APPLICATION OF WASTEWATER STUDGE OF HIGH HEAVY METALS CONTENT

13. **Imre L. BICZÓ[1], Claudiu Iulian BARBU[2]** *([1]Óbuda University, Budapest, Hungary, Aurel Vlaicu University, Arad, Romania)*
APPLICATION OF MICROBIAL ELECTROCHEMICAL TECHNOLOGIES IN THE WASTE WATER TREATMENT AND BIOSENSOR DEVELOPMENT

14. **Konrád LÁJER** *(Óbuda University, Budapest, Hungary)*
THE EFFECTIVENESS OF PLANT COVER IN REDUCING EROSION OF STEEP SLOPES AND ITS USE FOR RECULTIVATION OF MINING WASTE DUMPS

15. **Levente KARDOS[1], Dávid MÓNOK[1], Borbála BIRÓ[1], Barbara BÓDI[2], Gyula KASZA[2]** *([1]Department of Soil Science and Water Management, Szent István University, Budapest, Hungary, [2]Department of Food Economics, Szent István University, Budapest, Hungary)*
    UPSCALING OF COMMUNAL SEWAGE SLUDGE VERMICOMPOSTING TECHNOLOGY

16. **Nadezda LJUBOJEV, Snezana FILIP, Dragica IVIN, Mila ZAKIN, Jasmina PEKEZ** *(University of Novi Sad, Zrenjanin, Serbia)*
    LEGISLATIVE FRAMEWORK OF CLIMATE CHANGE IN THE REPUBLIC OF SERBIA

17. **Márta KISFALUDY, Éva HOTTÓ** *(Óbuda University, Budapest, Hungary)*
    SOLUTIONS FOR NON-WASTE TAILORING METHODS

18. **Miloš BOŽIĆ[1], Vojislav VUJIČIĆ[1], Srećko ĆURČIĆ[1], Milan PAVLOVIĆ[2]** (*[1]University of Kragujevcu, Čačak, Serbia, [2]University Business Academy, Novi Sad, Serbia)*
    TYPES OF SERVO AXES SINCHRONIZATION FOR USE IN AUTOMOTIVE RECYCLING INDUSTRY

19. **Miloš BOŽIĆ[1], Vojislav VUJIČIĆ[1], Srećko ĆURČIĆ[1], Milan PAVLOVIĆ[2]** *([1]University of Kragujevac, Čačak, Serbia, [2]FIMEK Novi Sad, Serbia)*
    ELECTRONIC ACCELERATION SERVO OSA MOVEMENT ON THE SIEMENS S1500T PLC SET FOR THE REQUIREMENTS FOR RECYCLING THE CAR

20. **Miroslav BADIDA, Tibor DZURO, Anna BADIDOVÁ, Marek MORAVEC, Lýdia SOBOTOVÁ** *(Technical university of Košice, Košice, Slovakia)*
    MEASURING ACOUSTIC PROPERTIES OF MATERIALS WITH A MICROFLOWN SENSOR

21. **Orsolya NAGY SZABÓ** *(Óbuda University, Budapest, Hungary)*
    BODY POSTURE CORRECTION CLOTHES FOR CHILDREN

22. **Rita BODÁNÉ-KENDROVICS** *(Óbuda University, Budapest, Hungary)*
    PURIFIED SEWAGE AS AN ALTERNATIVE SOURCE OF WATER

23. **Ruzena KRALIKOVA, Laura DZUNOVA; Lydia SOBOTOVA** *(Technical University of Košice, Košice, Slovakia)*
WORKING FACTORS ANALYSIS IN THE SYSTEM „Man – Machine – Environment"

24. **Thamer ABDULLAH, Tatjana JUZSAKOVA, Endre DOMOKOS** *(University of Pannonia, Veszprém, Hungary)*
REMOVAL HYDROCARBONS FROM WASTEWATER OF PETROLEUM INDUSTRIES BY USING MWCNTS AFTER MODIFICATION WITH LOADING CERIUM OXIDE

25. **Veronika GUMANOVA, Lydia SOBOTOVA, Miriama PINOSOVA** *(Technical University of Kosice, Faculty of Process and Environmental Engineering, Košice, Slovakia)*
ANALYSIS OF THE PRESENT STATE OF TRAFFIC NOISE IMPACT ON HUMAN

26. **Višnja MIHAJLOVIĆ[1], Una MARČETA, Bogdana VUJIĆ, Jelena MIĆIĆ** *(University of Novi Sad, Zrenjanin, Serbia)*
PESTICIDE CONTAINER MANAGEMENT STATUS AND PERSPECTIVES IN SERBIA

16:15 p.m. – 17:15 p.m. Technical Session-6
Schmalz Auditorium

Chairpersons: Borbala BIRO – Tatjana JUZSAKOVA

16:15 p.m. – 16:30 p.m.

Ildiko DOBI *(Hungarian Meteorological Service, Budapest, Hungary)*
CLIMATE CHANGE: MONITORING, DATA, METHODS AND SERVICES

16:30 p.m. – 16:45 p.m.

Abdussalam Ashour KHALIF[1], Ferenc LIGETVÁRI[2] *([1]Szent István University, Gödöllő, Hungary, Debrecen University, Debrecen, Hungary)*
SOME MAIN GAS EMISSIONS OF DIFFERENT ECONOMIC SECTORS IN HUNGARY BETWEEN 2005-2015

16:45 p.m. – 17:00 p.m.

Ali ALAMMARI[1], Amina A.M. DAROUGI[2], Hosam E.A.F. BAYOUMI HAMUDA[3] *([1]Szent István University, Gödöllő, Hungary, [2]Eötvös Loránd University, Budapest, Hungary, [3]Óbuda University, Budapest, Hungary)*
POTENTIAL IMPACTS OF CLIMATIC CHANGES ON THE TOURISTIC ACTIVITY SECTOR IN LIBYA: A REVIEW AND FUTURE RESEARCH

17:00 p.m. – 17:45 p.m. **Free Discussion**

17:45 p.m. – 18:00 p.m. **Coffee Break**

– 18:00 p.m. – 18:45 p.m. Certificate & Award Distribution & Closing Ceremony Schmalz Auditorium

19:00 p.m. – 22:30 p.m. Conference's Banquet

Abstracts of the accepted papers

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SOME MAIN GAS EMISSIONS OF DIFFERENT ECONOMIC SECTORS IN HUNGARY BETWEEN 2005 AND 2015

Abdussalam Ashour Khalif[1], Ferenc Ligetvári[2]

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The study analyses the emissions of different kinds of gases, namely carbon dioxide (CO_2), dinitrogen oxide or nitrous oxide (N_2O), methane (CH_4), acidifying gas [nitrogen oxides (NO_x), sulphur dioxide (SO_2) and ammonia (NH_3)], non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) resulted by different economic sectors or industries/economic branches including the household for period of 2005–2015 in Hungary in tons (2005= 100%). The data base was selected from the Hungarian Central Statistical Office; Tables (STADAT). The trends in EU greenhouse gas (GHG) emissions relative to economic development – measured as GDP – in the EU, indicate an overall decoupling of emissions from economic development over time. Between 1990 and 2007, emissions per unit of GDP decreased in the EU-27 by more than a third. The study focuses on the analysing the correlations among economic sectors creating gas emissions, therefore the central object of the study is the environmental conservation, within which the air pollutions is. In this study analyse measure of the gas emissions as features of the different economic sectors in Hungary and correlations among economic sectors by their main feature, as measure of the gas emissions. Some kinds of the gasses responsible for the GHG emissions, for example CO_2, N_2O, CH_4, Acidifying, NMVOC, CO, as central subjects of gas emission. Within Special Program for Social Sciences (SPSS) statistical analyse variances are selected into two main Components as it is follows: Component-1: CO220151 (CO_2), CH420153 (CH_4), CO20156 (CO). The Component-2 includes N2O20152 (N_2O), AC20154 (Acidifying), NMVOC20155 (NMVOC). The decreasing trend of the total emission was moderately decreasing with considerable share of households. But this decreasing trend cannot solve the considerable decrease of the gas emission, because the new advanced technology should be introduced even in Hungary in order to avoid of danger gas emission causing global warming.

Keywords: *CO_2, Household, SPSS, Correlations, Environment conservation, Global warming*

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GAS EMISSION AND PARTICULAR MATERIAL OF DIFFERENT ECONOMIC SECTORS IN HUNGARY BETWEEN 2000 AND 2015

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The study analyses the correlations among the different economic variances namely different kind of gases and particular materials polluting the air surrounding environment of our economy. The economic sectors have been characterised by different measured gas emission and particular materials for several decades or even centuries. The study aims at analysing the role of the economic sectors from point of view of their realising pollutions [Nitrogen oxides (NO_x), Sulphur dioxide (SO_2), Ammonia (NH_3), Particulate matter (PM_{10}) and Particulate matter ($PM_{2.5}$)]. The Household as a main economic sector indicator has caused a large amount of pollutions for natural environment, because share of the Household has considerably increased in different gas and particular material emissions for the period of 2000 and 2015, mostly in fields of PM_{10}, $PM_{2.5}$ and NH_3. The SPSS (Special Program for Social Sciences) according to Sajtos –Mitev as the methodology, which can ensure better way of the research to discover the main and deep correlations among the economic variances as gas and pollution particular materials belonging to the different economic sectors. Analyses focus on demonstrating different gas emission and particular material conditions of economic sectors or industries/economic branches in Hungary and strengthen of correlations among economic sectors' gas emissions and particular materials. Middle correlation is between NOX1 and PM104, also middle strong correlation between SO22 and NH33, and very strong correlation between PM104 and PM255 variances. Because of the Household as family unit has remained one of the biggest responsible for the increasing gas and particular material emissions in Hungary in spite that the SO_2 gas emission has decreased at the national level for the same period, therefore the new strategy should be followed. This new environmental conservation strategy demands from all sectors to decrease their gas emission in order to follow the sustainable economic growth accompanying with sustainable environment.

Keywords: *SPSS, SO_2, Pollution, Household, Global warming, Natural environment*

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SOME ASPECTS OF CLIMATE CHANGE WITH EMPHASISING ON REDUCING GREENHOUSE GAS EMISSIONS

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In recent decades, changes in climate have caused impacts on human and natural systems, such as human diseases and environmental problems. The aim of the present paper is to give an overview, over the past decades and up-to-date in the climate change and its impacts as well as global warming in general, it serves as an introduction assessing atmospheric concentrations of greenhouse gases (GHGs) and gives general background reviews on the environmental policies of reducing GHG emissions at international levels for the climatic and environmental changes. Influences of human on the climate and environmental systems are clearly and recently man-made (GHG) emissions globally are the largest in history. So, the earth's average temperature has been increasing since the industrial revolution. Therefore, meeting the Paris Agreement's climate objectives will require and needed drastic reductions in global GHG emissions and global transition towards decarbonisation of human activities, as well as moving towards a low-carbon economy of the future. At the same time, evidence of climate change impacts is clear and the problem will become more and more urgent as the GHG accumulation continues and the costs of damages and adaptation to climate change arise. So, an effective response to the climate change problem at global level requires both a concerted international response and national efforts to reduce GHG emissions as well as much more robust and effective action than it was before. Nevertheless, the EU and its Member States have decreased their emissions by 21% between 1990 and 2013, while GDP has increased by 45% over the same period and thus contributed to the overall positive EU performance as well as the EU has a range of policies to reduce emissions, promote clean energy and energy efficiency, and stimulate Europe's transition to a low-carbon economy.

Keywords: *Climate Change, GHG Emissions, Environmental Policy, Global Warming,* CO_2

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SOME ISSUES IN THE EUROPEAN UNION EMISSIONS TRADING SYSTEM

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The present paper provides an introduction and updated background of the published information reported and discussed issued by European Union (EU) Member States as a synthesis of the most contentious issues surrounding climate policy and/or climate mitigation. Climate policy is an important tool to combat the impacts of climate change caused by mankind in general. This study aims at analysing and describing of the emissions trading and the emissions taxation in the context of climate policy instruments. On one hand, it gives a good introduction to the main features of a tradable emissions system in general and of the EU Emissions Trading Scheme or Emissions Trading System (ETS) in particular. On the other hand, it summarizes carbon taxes in general and of the carbon dioxide (CO_2) taxation in particular. It contributes to the existing literature in several ways, e.g., it focuses to the literature by both scientific and policy research. And also, it contributes to the literature by investigating the current policy tools and strategies regarding climate change in specific ways; on the reducing greenhouse gas (GHG) emissions especially in the EU Member States. In addition, it gives general background reviews on the climate change policies, and gives matter-of-facts presentation and references for whom wishing to investigate further about climate change policy and its EU ETS. Finally, the EU ETS is a 'cap-and-trade' scheme for GHG emissions regarded as the cornerstone of the climate policy, it is a major tool aims to meet reduction targets of GHG emissions at least-cost (cost-effectively), since January, 2005. Nowadays, it operates in 31 countries (EU-28 plus Iceland, Liechtenstein and Norway), and covers about 45% of the EU's GHG emissions, and also, by 2020, it has aimed directly to cutting emissions in EU-28 by 21% compared to 2005 levels.

Keywords: *Taxation, Climate Change Policy, CO_2, GHG Reduction, Cost-effectively, 31 Countries*

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MODELLING OF THE COUPLED TRANSPORT PROCESSES THROUGH POROUS MEDIA AT PRESENCE OF ANOMALOUS DIFFUSION

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The mathematical modelling of various types of coupled transfer processes plays nowadays a role of continuously increasing importance for understanding problems related to global energetic supply and dynamics of energetic systems in order to make them sustainable. Such methods are based on principles of the contemporary non-equilibrium thermodynamics, and are continuously re-examined and improved. In the present study, we will demonstrate a novel-type solution of the problem of coupled heat-, and mass transfer processes taking place through porous media, since this basic-type transport problem has countless number of applications ranging from e.g. modelling and simulation of drying processes till fundamental research calculations in the extended irreversible thermodynamics. The crucial novelty in our modelling method is the following one: it will be assumed, that the heat transfer may be described - as earlier – by a simple extension of the initial Fourier-type partial differential equation, while in the case of the diffusion, instead of the earlier usually applied Fick-type equations, the generalized version of its, able to describe anomalous diffusion processes must be incorporated into the initial coupled system of the relevant partial differential equations. Finally, following an earlier our own modelling method, we have solved this coupled system of partial differential equations by the usually applied operational calculation methods and have incorporated the effect of the anomalous diffusion effects, too. It was assumed, that the manifestations of the concentration changes due to anomalous diffusion are of second-order magnitude, but even under this assumption they influenced the final solution form of the problem very significantly.

Keywords: *thermodynamics, anomalous diffusion, environmental transport processes*

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POTENTIAL IMPACTS OF CLIMATIC CHANGES ON THE TOURISTIC ACTIVITY SECTOR IN LIBYA: A REVIEW AND FUTURE RESEARCH

Ali ALAMMARI[1], Amina A.M. DAROUGI[2], Hosam E.A.F. BAYOUMI HAMUDA[3]

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For tourism, climate change is not a remote event, but a phenomenon that already affects the sector and certain destinations in particular, mountain regions and coastal destinations among others. At the same time, the tourism sector is contributing to greenhouse gas emissions, especially through the transport of tourists. Climate is an essential resource for tourism, and especially for the beach, nature and winter sport tourism segments. Changing climate and weather patterns at tourist destinations and tourist generating countries can significantly affect the tourist's comfort and their travel decisions. Changing demand patterns and tourist flows will have impacts on tourism businesses and on host communities, as well as knock off effects on related sectors, such as agriculture, handicrafts or construction. Tourism is found to be a contributing factor to climate changes because the movement of people and their activities while on vacation increase the level of carbon emissions. There is a need for local and international cooperation so that the businesses and individuals in the sector will be able to adapt to these changes. The tourism industry has to adopt measures so that natural resources are protected. These measures should also contribute to the protection of the global environment. The vast lands of Libya have been settled by many civilisations across its history, including the Phoenicians, Greeks, Romans and Arabs amongst others. They have left some amazing ruins of their ancient cities, most notably the Roman ruins at Leptis Magna, one of the most impressive such sites in the world. Away from the lush Mediterranean coast lie the harsh but dramatic landscapes of the Libyan Desert, with the picturesque Acacus Mountains and Ubari Sand Sea as well as ancient desert towns and fascinating rock art paintings. Libya is well off the main tourist trails of North Africa and receives only a fraction of the visitors of its neighbours which, combined with its many attractions, makes it an ideal travel destination. These factors make Libya a centre of tourism in Middle East.

Keywords: Impacts of climatic changes, touristic activity, Libya, historic time, economic sector

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EXPERIMENTAL INVESTIGATION TO RECOVERY OF RARE EARTH ELEMENTS (REES) FROM HUNGARIAN RED MUD USING OPTIMIZATION TECHNIQUE

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The objectives of this work was to develop new ways and methods for the recovery of the rare earth elements (REEs) such as (Sc, La, Y) from the Hungarian red mud, Ajka, MAL company, which is presently considered as a waste material and to achieve optimum REEs recovery combined with low iron dissolution by using (WinQSB) and (Statistica) software's to predict the optimum conditions. Red mud or bauxite residue derives from Bayer process to produce alumina. The residue of the bauxite processing stems from digestion of the bauxite with sodium hydroxide at elevated temperature and pressure. Depending on the origin of the bauxite, the red mud may contain significant amounts of REEs. In Hungary karstic bauxite had been processed. The REEs recovery procedure includes using a combination of technological steps acid leaching, solvent extraction and ion exchange adsorption. The extraction of REEs from red mud by selective acid leaching was investigated in our study. Hydrochloric (HCl), sulphuric (H_2SO_4) and nitric (HNO_3) acids were applied for leaching. The chemical composition of leaching solutions was investigated by ICP-OES techniques. The effect of parameters including different acid concentrations, acid compositions, leaching time were studied.

Keywords: *Rare Earth Element, Red Mud, Acid leaching, Optimization, Scandium recovery*

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A COMPARATIVE STUDY ON SOME STATISTICAL INVESTIGATIONS ON POPULATION AND ECONOMIC SECTORS IN LIBYA: PAST AND FUTURE

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The growing international awareness about the fast pace of climate change taking place on our planet, together with the impacts that such changes are having on the natural environment, on humans and their economic activities have become evident. This study on data collection and statistics on population and economic sectors in Libya provides a preliminary inventory of the national institutions and procedures involved in the management and collection of data on population and economic status (1960-2018) in Libya and the currently available proposals for improving the systems. The largest city in Libya (area of approximately 1.76 million km^2) is Tripoli (pop around 1.2 million), which is the nation’s capital. Libya's second and third largest cities are Benghazi and Misrata. This statistic shows the population change in Libya from 2007 to 2017. In 2017, Libya's population increased by approximately 1.28% compared to the previous year. The CIA World estimates that the Libya Population in 2012 was 6,733,620. Based on the CIA's estimate, Libya was therefore the 101st largest country in the world. The UN's estimate in 2018 is that there are 6.47 million people in Libya, dropping it down to the 109th most populous country. It is important to evaluate how climate has varied and changed in the past (1901-2015). The monthly mean historical rainfall and temperature data can be mapped to show the baseline climate and seasonality by month, for specific years, and for rainfall and temperature. Libya is the country with the largest oil reserves in Africa, thus making the oil sector among the most successful ones in the continent, accounting for 80% of the country`s GDP and 97% of its exports. The statistic shows gross domestic product (GDP) in Libya from 2012 to 2016, with projections up until 2022. Gross domestic product (GDP) denotes the aggregate value of all services and goods produced within a country in any given year. GDP is an important indicator of a country's economic power. In 2016, Libya's gross domestic product amounted to around 18.54 billion U.S. dollars.

Keywords: Libya, population sector, economic sector, statistical data collection.

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UTILISATION OF PSYCHOACOUSTICS IN TECHNICAL PRACTICE

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Psychoacoustics is currently a powerful tool for optimizing the acoustic properties of sounds of machines, equipment and products in industry and in the home by thorough analysis and subsequent correction of psychoacoustic parameters (such as roughness, sharpness, volume, sound colour, etc.) in order to achieve acceptability for man. It should be noted that the perception of sound (noise) by man is of a subjective nature and heavily depends on a particular person and his current disposition. The psychoacoustic parameters (roughness, sharpness, volume, colour, tone, fluctuation force, subjective duration, and sound height) provide the foundation for solving many technical problems in practice. With respect to the application of psychoacoustics in practice, a relatively new scientific department has created a so-called acoustic product design that aims to optimize the acoustic effects of products (products) on its potential users and their surroundings. Its important role is to objectively assess the sound quality of the product, which is a certain acoustic product card; even it can be seen as the product's image. Acoustic quality can be understood as the adequacy (soundness) of the product's sound, in terms of its useful value and function. Adequacy of the sound of a product is important from the point of view of its users, required as low noise level as refrigerator, washing machine and others. Also as a product sound feature that allows the user to identify the presence of the product, its kind, brand, operating status, or malfunction or malfunction. As well as the sound of the product (so-called "loudness") to the user and his surroundings, for different user groups (in terms of age, gender, social status and other criteria), it is often a completely different sound. Psychoacoustics are currently most used to solve noise-related problems in areas such as the automotive industry, the design and manufacture of telecommunication products, the design and manufacture of home appliances and other areas.
The project is supported by project APVV – 0327 - 15 Development and research of the methodology for optimizing acoustic properties and acoustic quality of noise emitting devices.

Keywords: *acoustic, noise, psychoacoustics, psychoacoustic parameters, properties of sounds*

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METHODS FOR TESTING QUALITY OF VARIOUS PAPER COMPONENTS BY THERMAL ANALYSIS

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Knowing a suitable paper quality of packaging structures is an element process in the packaging industry involving the paper manufacturers, mainly on producing corrugated paperboards. The base-papers, produced from wood components are the most significant constituent of Corrugated Cardboards; contain mainly organic substances (e.g. cellulose, hemicellulose and lignin etc.) which are appropriate for thermo-analytical studies. The quality of the base-papers mainly defined by the primer cellulose, recycled paper and other incrust materials content. At the same time, it is difficult for users to precisely separate base papers that exhibit differences in mechanical and quality properties, as their ulterior identification is virtually impossible. The testing methods such as CCT, RCT, FCT, COBB, bursting etc. are supported by statistical technique, but do not provide perfectly accurate results. The reason is the deviation of testing results. In this paper, we publish the primary results of the thermoanalytical research for determination of different components of wood and paper types. Applying a Differential Scanning Calorimetries (DSC) method, it is possible to study endotherm and exotherm spectrums of paper's raw materials. During a heating process each component react in different ways, both of their physical and chemical characteristic. Due to their various organic substances content, these values are different referring for similar results of the finished products, which determines their mechanical and quality properties during their use. The results show that this method on the one hand can be helpful to testing the paper during packaging producing process on the other hand after using as a packaging. Using a DSC apparatus helps showing the differences between the various organic substances, which allow to measure obvious and exact results for each base-paper. This test method can help classify base paper types in a simple and transparent manner and be of use in tracing quality problems of papers.

Key words: Corrugated Cardboard, Base-paper, Cellulose, Thermo-analytical technique, Heatflow, DSC

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BIOGAS POTENTIAL FROM FISH WASTE AND CATTLE MENURE

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Today, to satiate our growing energy demand, we have to turn our face to the renewable energy sources instead of fossils. This change will be done in every type of consumption, such as industries, agriculture, smaller companies, households, even fisheries. The aim of this project is to optimize biogas production from fish waste and cattle manure. The project is carried out at a fishery centre, Aranyponty Zrt in Sáregres, where the recycling fish waste and produce valuable energy to heat its building of the project place. The project is managed in a specialized biogas laboratory by using Automatic Methane Potential Test System (AMPTS II) with the equipment and the help of NaWaRo Kft. This automated system incudes performing, biochemical potential tests, specific methanogenic activity assay activity and conducting residual gas potential analyses. There are three experiments based on the proportion of fish waste and cattle manure, id est. 1:0, 1:1 and 1:2. During this project a feasible biogas plant will be designed based on the results and analysis.

Keywords*: Biogas, fish waste and cattle manure, anaerobic digestion*

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ESTROGENIC ACTIVITY IN AQUATIC ENVIRONMENTAL SAMPLES ASSESSED BY IN VITRO ASSAYS

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The aquatic environment is particularly sensitive to the impacts of pollutants. Effluents from municipal and industrial wastewater treatment plants, and agricultural run-off and drainage add numerous exogenous compounds to the aquatic ecosystem. (Xeno)estrogens are believed to reach the aquatic environment mainly by means of municipal and industrial sewage outfalls. However, agricultural drainage may also be a route for (xeno)estrogens to enter the aquatic system. Numerous natural and anthropogenic substances are known to exhibit estrogenic activity. Estrogenic activity in the aquatic environment has primarily been ascribed to the natural steroids, 17β-estradiol (E2), estrone (E1) and estriol (E3), and the synthetic estrogen, 17α-ethinylestradiol (EE2), used in contraceptives and all being excreted by women and ending up in domestic sewage. To a lesser extent xenoestrogenic chemicals, such as alkylphenols and bisphenol A, may also contribute to the estrogenic activity in the aquatic environment. This has led to efforts of finding simple, sensitive and specific *in vitro* tests for rapid screening of samples from wastewater and surface waters for their estrogenic activity. Already existing in vitro assays (e.g., Yeast-based reporter gene assay: *Yeast estrogen screen* (YES)) for screening of the estrogenic activity of single compounds have therefore been applied to environmental samples. However, yeast has a number of advantages over other systems including the absence of endogenous steroid hormone receptors and consequent lack of complex interactions between the estrogen receptor (ER) and other receptors. This study gives an evaluation of the existing *in vitro* techniques for determination of estrogenic activity in various environmental samples. The existing knowledge on the potentials and limitations of these techniques will be presented with the aim of finding the optimal methods for monitoring the estrogens in the environment of wastewater and surface water.

Keywords: *Estrogenic activity, aquatic environment, in vitro assays, estrogen receptor, Yeast estrogen screen*

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CLEANED WASTEWATER IRRIGATION IN AGRICULTURE

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The municipal wastewater is the main type of wastewater which will be treated and irrigated in agriculture. There are two parts on this thesis. The first part is literature part and second part is research and experiment part. The literature part describes the method of wastewater treatment and main components of municipal wastewater, such as chemical and physical parameters, wastewater process, activated sludge biological treatment and methods of reclaimed water reuse in agriculture. The purpose of experiment is to research the difference of surfactant degradation in different solvent. In this case, the samples which contain LAS, LAS + Penconazole and Topas had been added in two different solvent, one is distilled water and another one is Danube river water. The aim is to find the interaction between active ingredients and Danube river water. So, the distilled water group is a parallel series. It will help us to find the distinction of two groups. Theoretically, the speed of degradation in Danube river water group should be faster than distilled water group. Because of the organic substances which have been produced by living organism can accelerate the nature degradation processes. All of the samples were measured by GC and HPLC-MS. The solubility of penconazole in water is 73 mg/L. In Dichloromethane (DCM), the solubility is 500 g/L. In this case, it has to be extracted and concentrated into DCM. The oven temperature is 300 °C in GC and carrier gas is hydrogen. All of the samples had been filtered before sampling. Related to the nice solubility of LAS in water, the LAS and LAS+ Penconazole samples will be analyzed by HPLC. Each of parameter was measured 3 times by HPLC. The GC measurement processes only did one time due to the long tension time. The results what had got showed that the speed of degradation in Danube river water group was faster than distilled water group whatever the components are LAS or Penconazole. But penconazole has longer degradation time. Cleaned wastewater can be used for irrigation in agriculture and natural environment can accelerate the degradation processes.

Keywords: Wastewater treatment, Surfactant, Adjuvants, Active ingredient, Degradation, Irrigation, Agriculture.

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BIOEFFECTIVE SOIL-PLANT-INOCULATION TECHNIQUES FOR IMPROVED SOIL QUALITY AND FUNCTIONING

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Biofertilizers are generally used for improving soil quality and functioning. Regarding of the foreseen effect of soil-inoculation, several microbes can be used in agri, horti- and the viti-cultural practices. Bioeffector (BE) strains, as *Trichoderma* sp., *Pseudomonas* sp., *Bacillus* sp. and/or of their combinations were tested for improving plant growth and reduction of soil-born plant pathogens. Beside soil inoculation, abiotic treatments of using natural minerals and/or industrial products (alginite, biochar) were used to improve soil quality and microbial survival. Pot and field experiments were designed with tomato (*Lycopersicum aesculentum*), potato (*Solanum tuberosum*) and maize (*Zea mays*) for 3 consecutive years. Growth parameters of plants: yield and soil physical-chemical-biological parameters (humus quantity/quality, pH, N-P-K nutrients, total number of bacteria/fungi and enzymatic activities of fluorescent diacetate/dehydrogenase) were estimated. Functioning of microbes was key-issue at all tested soil-plant-microbe systems. Plant growth and yield can be improved, in strong dependency with the BE-treatments. A more tasty fruit quality was found with the inoculation of P-solubilizing *Bacillus* strains. *Trichoderma* fungi on the other hand could reduce the severity of the soil-borne plant pathogen fungal diseases. Abiotic additives, especially with the combination of beneficial microbial inoculums, can improve the soil-physical-chemical- and the biological parameters. The bioeffectors, tested are useful elements in soil/environmental protection. Role and functioning of such microbial inoculums are improved by abiotic/inorganic bioeffective treatments.

Keywords: *biofertilizers, soil quality, soil-functioning, minerals, inoculation*

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ENVIRONMENTAL IMPACT ASSESSMENT OF NO_2 EMISSION AND THEIR RELATION TO METEOROLOGICAL CONDITIONS IN KOMÁROM, HUNGARY

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World's population live in a poisonous environment with a lot of toxic pollutants. Atmospheric pollution has direct, indirect or cumulative effects on human health, and a total load of contaminants may exceed the ability of the body to adapt. One of the best way to face environmental problems is an application of Environmental Impact Assessment (EIA) which is an essential process of sustainable development. This study was highlighted in air quality assessment of air pollution of bypass road No. 131 in Komárom, Hungary. The differences of air quality between the two years 2010 and 2015 before and after operating the bypass road were investigated during the application of EIA. For this purpose, the IMMI software was used which is a widespread noise and air pollution modelling software provided by the German Wölfel GmbH. For simulations, traffic network graphic elements, traffic data (numbers of cars and heavy trucks), emission factors for different pollutants and meteorological data (wind speed, wind direction, and stability categories) were used. Using a Gaussian dispersion model in IMMI software, the average concentration fields of NO_2 were simulated for the whole area and for specific receptor points in case of different wind speed intervals, wind direction, and different stability categories. According to the low traffic motion in the bypass road No. 131, the results of the dispersion model showed only small differences in air quality between 2010 and 2015, but indicate the impacts of the changes in traffic and environmental developments on air quality.

Keywords: *environmental impact assessment, air pollution, Gaussian dispersion model IMMI software, Komárom*

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MONITORING OF INVASIVE SOLIDAGO SPP. WITH LOW DISTRIBUTION IN PRESOV AREA (EAST SLOVAKIA)

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Increasing of human transportation all over the world in last century, has led to species exchange between biogeographically separated areas. Non-indigenous species are resistant against natural enemies and their fast spreading could suppress the natural biodiversity and in natural habitats provides an environmental problem in most regions of the world. One of the dangerous species is goldenrod (*Solidago* spp.) which spread fast in east Slovakia. Its huge morphological characteristic have predisposition to treat out the vulnerable indigenous species.
Aim of the scientific investigation is pilot monitoring of selected areas where Solidago spp. occurs in low density. Four localities were selected in Presov region - Lachôrka, Šidlovec, Malý Šariš and Chminianská Nová Ves. Geographical and environmental characteristics were described. Number of plants in bunches and number of bunches were counted and their exact positions with GPS were noted. The species monitoring was done using geographical information methods (GIS) to detect the occurrence of goldenrod spots with a high precision. Selected localities present floral diversity with different level of goldenrod dispersal. The results will be used as a starting data for monitoring in next years. The spread and range-expansion will be observed. However, the mechanisms underlying a successful plant invasion are poorly understood, precise scientific investigation could be a step to allows predictions about future spread in selected area.

Keywords: *biodiversity, GIS, goldenrod, invasion dynamics, non-indigenous species*

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TOXIC EFFECTS OF HEAVY METALS (Cu, Zn, Pb, Cd) ON EARLY GROWTH OF THREE *Tagetes* SPECIES

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Heavy metals in soil pose potential threats to the environment; therefore remediation of heavy metal contaminated sites is an important issue. *Tagetes* species have been proposed as potential plants for phytoremediation of heavy metal contaminated soil. Although much research has been carried out previously to investigate the bioaccumulation ability of *Tagete*s species, little information is available on the toxicity of metals on these plants. In our study a seed germination test was conducted to measure the toxic effects of four heavy metals (Cu, Zn, Pb and Cd) on early growth of three different *Tagetes* species (*Tagetes erecta, Tagetes patula* and *Tagetes tenuifolia*). Our results showed that all tested heavy metals had significant ($p<0.05$) toxic effects on seed germination and root/shoot elongation of the three plants. On the basis of IC_{50} values (concentration of a heavy metal which causes 50% inhibition) the following series of phytotoxicity was observed: Cd>Cu>Zn>Pb. *Tagetes tenuifolia* was the most sensitive plant to heavy metals, while *Tagetes erecta* and *Tagetes patula* were able to tolerate low concentration of metals (below 400 mg l^{-1} Cu, Zn, Pb, and below 16 mg l^{-1} Cd) without considerable decline in the measured growth parameters. However, our experiment was carried out under laboratory conditions, and the seeds were germinated in hydroponic solution, which means that these values could be much higher in natural soils. Our results indicate that *Tagetes erecta* and *Tagetes patula* could be suitable for remediating moderately heavy metal (Cu, Zn, Pb and Cd) contaminated soils. With the advantage that these plants can also beautify the environment, using them for phytoremediation has an important and practical significance.

Keywords: *heavy metals, phytotoxicity, Tagetes species, phytoremediation*

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ROLE OF PLANT-MYCORRHIZA SYMBIOSIS IN REVEGETATION OF DISTURBED MINING SITES IN INDIA (NORTH TELANGANA)

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Extensive mining activities develop with energy requirements of globalizing World. Both underground- and open cast mining are resulting disturbed soil surfaces, which need to revegetate for environmental safety. Coal mining sites at North Telangana region of India was investigated. Soils are poor habitats for any plant establishment; the growth and survival of revegetated plants are possible only with arbuscular mycorrhiza (AM) fungal inoculation. Two leguminous agroforestry tree species were selected (*Acacia nilotica, A.n.* and *Albizia lebbeck, A.l.).* AM fungal spores were isolated and based on their morphological structures, 5 different types of AM species, the *Glomus-, Gigaspora-, Acaulospora-, Scutellospora-* and *Sclerocystis* sp. were identified. We have investigated the AM colonization rates, efficiency of selected strains in green houses and also at coal mine dumps by inoculation experiments on two test plants. AM fungal strains were found to be effective for the selected leguminous tree species both in their natural forests and at disturbed soils. *Glomus* sp. was the most dominant among the five different AM fungal species, more particularly *G. aggregatum, G. fasciculatum, G. intraradices* showed the best colonization and biomass production with the test plants. The AMF isolates from natural forests are supporting the revegetation of the disturbed mining sites. Preselection is needed for considering the environmental protection and the best soil functioning.

Keywords: *mining sites, revegetation, AM fungi, isolation, inoculation*

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CLIMATE CHANGE ACTUAL SITUATION AND RISKS IN ALBANIA

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As it is known Albania is a small country where the main economy is services, some industry and agriculture and there are many challenges in addressing the climate changes risks. Main problems are heavy floods and landslides. Also the weather is changing in Albania bringing increase of temperature, extreme weather, floods, drought, waves, rainfall, etc. This papers gives an overview of climate change actual situation and risks in Albania. It brings information on how climate change impact main resources as agriculture, water resources, human health, coastal zones, ecosystems energy and infrastructure in Albania. It gives also a general overview on sector impacts and vulnerabilities to climate change, the policy context and information regarding ongoing climate change recently development in Albania. The paper ends with conclusion and recommendations for future development.

Keywords: *Climate change, actual situation, risks, Albania*

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SETTLEMENT OF WIND TURBINE FOUNDED ON A LANDFILL HILL

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In the frame of a research on the complex energy utilisation of the MSW landfill hills (landfill gas, solar and wind units on the hill), the preliminary geotechnical design of a wind turbine and its service road (Pusztazámor MSW landfill hill, Hungary) was made on the basis of the in situ and large-scale laboratory tests. In Geotechnical viewpoint, the basic properties of the waste were recapitulated. The three large-scale compression tests made on samples taken from a borehole in increasing depths showed stiffening with increasing depth (and degradation) possibly due to the increasing density. By evaluating with the extended Bjerrum model the large-scale compression test made on the deepest sample, the following ratio 0.36 : 0.48 : 0.16 was resulted for the immediate: creep: primary consolidation settlement, respectively. The compression test moduli E_i related to these settlement components and the small strain shear moduli G_0 determined by in situ seismic test were used for subgrade modulus computations. The settlement of the wind turbine under static load was estimated in two parts in the starting research. The final settlement value was estimated with a subgrade method, with a parametric analysis, the result was calibrated using earlier data measured earlier in Karlsruhe and the present subgrade modulus range computed on the basis of the measurements. The time history of the settlement was estimated with a new method based on the evaluation of the oedometric test data. The possibility of the use of the more sophisticated Hydro-Bio-Mechanical model is discussed.

Keywords: *MSW landfill, subgrade method, settlement modelling*

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INVESTIGATION OF EMISSION OF NOx, SO_2 AND CHLORINE BY BIOMASS-BURNING

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It is well known that burning biomass is somewhat CO_2 neutral, but it is not widely known that that process is still a serious environment polluting one. For the investigation of the emission of some biomass material such as energy willow, bamboo, energy crane were burnt and the emission of NOx, CO, CO_2, SO_2, and Chlorine were measured and analysed. The results show that the generation and emission of SO_2 observed at the beginning of the burning process, while the chlorine is leaving the fire at the end of the process. The emission of NOx is rather at the middle of the process. The sum of the SO^4, and the overall chlorine ion are more than those material in the biomass, indicating that these elements are present in the material in different form.

Keywords: *biomass burning, SO_2, NOx, chlorine*

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INVESTIGATION OF RED MUD IN ORDER TO UTILIZE IT

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As a byproduct of the alumina production about 50 Mt red mud is accumulated in Hungary, and the disposing and storing of this material can case and has caused environmental burden and damage for the environment. On the other hand, red mud contains a considerably high amount of iron in the form of Fe_2O_3 in the concentration of 30-40%. Utilization of this form of iron oxide can supply iron ore substituting material for the Hungarian metallurgical industry enough for 12-16 years. With this action the burden on environment could be eased, and the emerging technology could result jobs for many workers. In this paper we report the present status of an investigation during which the paramagnetic iron oxide content of the red mud was reduced by using different particles with carbon content by heating them in inert atmosphere. The resulted ferromagnetic products were separated by both magnetic and electrostatic separation. The usage of those particles was analysed, too. The magnetic properties of the product was analysed by measurement of relative magnetic permeability. The consistency of the product was investigated with scanning electron microscopy. The research showed that the magnetic properties of the iron oxide can be modified in a reproduceable way.

Keywords: red mud, red mud reprocessing, reduction, magnetic separation

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DETERMINATION OF THE ACCUMULATION OF HEAVY METALS OF RIVER SEDIMENT BY PLANTS

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Danube is one of the main rivers in Hungary. The river, its floodplains and oxbow lakes are often operating as ecological corridors, or they have important roles in turism as well as in logistics and industry. It is well known, that there are many industrial towns and cities along the river Danube, and their heavy industrial pollution has affected the water quality for a long time. Among these pollutants heavy metals are the most dangerous components in the water and in the sediment, because they can accumulate in the food-chain and cause serious health problems. The main aim of this research is to investigate the accumulation of the heavy metal content of the river sediment with different kinds of plants. The main sampling place was a sediment dump created by excavation from the Open Beach of Dunaújváros in 2009. The test plants were parella *(Rumex patientia)*, perennial rye-grass *(Lolium perenne),* sedge *(Carex riparia)* and persicaria *(Persicaria maculosa).* The heavy metals were extracted from the sediment and plant samples with nitric acid and hidrogen peroxide according to the MSZ (Hungarian) standard. Among the heavy metals lead, cadmium, nickel, chromium, copper and zinc were measured with AAS. The results were compared to the standard levels of the Hungarian regulations. According to the given data the distribution of the heavy metals within test plants were determined and compared. The results revealed that persicaria accumulated Cd, Ni, Cr and Zn mainly in the roots as long as parella accumulated all of the measured elements in the upper stem. Our further tasks are to find adequate plant species for accumulation of the heavy metals from the river sediment or industrial sludges.

Keywords: *heavy metals, sediment, bioaccumulation, phytoextraction*

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ENERGY HILL - MSW LANDFILL HILL

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Landfill gas is available at "no" cost and clustering wind and solar-based power generation with LFG will improve the economics and reliability. Its development can be controlled by leachate recirculation and by bio-technological tools. The power-generation efficiency can be characterized as follows. Typical steam power stations operate with an efficiency of 20-30%, an internal combustion engine has 25-37%, a combined gas-steam power station has 35-50%, an F-T Diesel has 35-45%, and the direct renewable and landfill gas utilisation has 50-68%. The most effective solution is the simple cleaning and selling or feeding natural gas networks. The combined utilisation may have a higher efficiency and a new aspect of the energy storage could be the methanol production. This paper presents a first example for the design on the combined utilization of landfill gas, with solar energy and wind energy on the example of Pusztazámor landfill site. The significance of the research is as follows. In the recent past, about fifty modern municipal landfill sites have been established in Hungary and, there are 2500 older landfills. According to the results of the first GIS analyses, within 5, 10 or 15 km of about fifty modern municipal landfills in Hungary, may be found respectively 24%, 44% and 60% of the total population and cities and, 3-13% of the yearly electrical energy used in Hungary can theoretically be based on the co-utilisation of landfill gas, solar and wind energy depending on the assumptions (e.g., concerning the exploitation time). The first results and some open questions are presented to help the elaboration of design principles for the future.

Keywords: *Landfill gas, solar energy, wind energy*

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ANALYSIS OF NOISE ON THE INHABITANTS OF SMALL CITIES

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At present, a noise is among the most widespread harmful factors in the living and working environment. A major problem has been occurred especially in recent years, particularly in the context of the advanced development of transport and industry. The aim of the contribution is not only to map and to evaluate the current situation in automotive transport, but also to point out the necessity of solving this issue, which is gaining importance every year along with the increasing density of road transport. Municipal residents, especially in the vicinity of large cities, are exposed to enormous noise, environmental pollution and other hazards on a daily basis and therefore they have complained over the past few years. The contribution was developed in cooperation with the municipality of Nova Polhora, Slovakia and Technical University of Kosice, Faculty of Mechanical Engineering, Department of Process and Environmental Engineering, where the intention was to evaluate the noise pollution situation and to evaluate its impact on the village population. The paper is supported by project KEGA 041TUKE-4/2018.

Keywords: *Environment, noise, transport, small city*

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SOIL BIOLOGICAL ACTIVITY AND THEIR SEASONAL VARIATIONS IN RESPONSE TO CLIMATIC CHANGES

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Climate change is a serious global problem that biosphere encounter in the present. Due to technological advancement and continuous innovation, they directly affect the atmosphere which causes climate change. Human activities are solely responsible for the actions. Climate change has consequences for global food sources (Lithosphere), health (human, animal, and plant), weather (atmosphere) and oceans (hydrosphere). The effect of climate change is the occurrence of longer and more frequent drought and flood that put challenges in growing crops, the animals shift to another places to live and the water supply diminish. It also affects physical health especially in urban areas where the air is polluted. In these scenarios, the application of engineering principles are important in solving problems especially in soil and water management, soil and water conservation engineering. Agricultural engineer has a great role in solving engineering problems that involve in soil and water conservation programmes such as erosion control, drainage, irrigation, flood control, moisture conservation and water resource development. It also includes the restoration of unused land, rural water supply and land use control and conservation of our natural resources. Brown forest soils characterized by three distinct microbial communities (winter and summer community, and summer community from wheat cultures, alfalfa culture) were investigated with or without inorganic CNP supply and analysed for substrate use and various microbial processes. Our results clearly demonstrate that the investigated microbial communities differed in their functional response to addition of various substrates as well as the changing in the ecological factors. The winter communities revealed a higher capacity for degradation of complex C substrates than the summer communities, indicated by enhanced cellulase activities and reduced mineralization of soil organic matter. Also, it was found that the microbial communities, soil respiration and enzyme activities were sensitive to the seasonal changes and in this case the climatic change can work as main factor in soil fertility.

Keywords: *C and N availability, enzyme activities, microbial community composition, microbial processes, soil respiration rate*

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CHEMICAL PROPERTIES AND TOXICITY OF SOILS CONTAMINATED BY APPLICATION OF WASTEWATER SLUDGE OF HIGH HEAVY METALS CONTENT

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Heavy metal (HM) contamination of agricultural soils and vegetation is a worldwide ecological problem. During the last decades, there has been a significant increase of industrial technologies and human activities that utilize HM ions or compounds. This remarkable industrialization has led to the continuous accumulation of HM ions in eco-environment and caused deterioration of many ecosystems and social health. Anthropogenic inputs such as agricultural activities, energy conversion and production, metallurgy and mining, microelectronics, solid and liquid waste disposal have been the major sources of HM ions accumulated in our environment. This research is aimed at assessing the total content and soluble forms of metals (zinc (Zn), lead (Pb) and cadmium (Cd)) and toxicity of soil subjected to strong human pressure associated with pollution. The study obtained total Zn between 141.93 and 4516 mg, Pb between 18.6 and 1337 and Cd concentration was between 0.34 and 41.34 mg kg^{-1} of soil. These variations in the HM concentrations were due to the application ratio of wastewater sludge to the soil. HM concentrations varied in the soil samples as Zn > Pb > Cd after the application of wastewater sludge. The lower solubility of the HMs in 1 mol NH_4NO_3 than 1 mol HCl is connected with that, the ammonium nitrate has low extraction power, and it is used in determining the bioavailable form of HMs. Toxicity assessment of the soil samples was performed using two test seeds, what and alfalfa. Germination index values were varied between 35 and 72% for what, and between 37 and 91% for alfalfa. The general trend observed was an increase in metal toxicity measured by the biotest with increasing available metal contents in soils. Biotest is a good complement to chemical analyses in the assessment of quality of soils as well as in properly managing them.

Keywords: *Soil, Heavy metals, Toxicity, alfalfa, wheat, wastewater sludge, biotest*

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IMPACTS OF COMPOST AND WASTWATER SLUDGE ON SOIL BIOLOGIC ACTIVITIES

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One of the major concerns today in all over the world is the pollution and contamination of the soil. The use of agrochemical such as chemical fertilizers and pesticides has caused tremendous harm to the eco-environment. Organic fertilizer differs from chemicals in that they feed plants and adding organic matter to the soil. Organic farming technology is necessary to support the developing organic, sustainable and non-pollution agriculture. Organic matter application to soils has different effects such as speeding up of NaCl leaching, decrease of the exchangeable sodium percentage and electrical conductivity and increase of water infiltration. Meanwhile, the biosolids application increases soil microbial biomass and some soil enzymatic activities linked to C, N, P and S soil cycles. In fact hydrolytic enzymes are sensitive indicators of management induced changes in soil properties due to their strong relationship with soil organic matter content and quality. Acidity is one of the major edaphic factors limiting crop production and eco-environmental quality in acid-affected soils throughout the world. Acid soil was amended with 15 and 30% of solid waste compost (SWC) or municipal solid wastewater sludge (MSWS), and aryl-sulphatase (ARY-S), phosphatase (PHO), dehydrogenase (DEH), β-glucosidase (β-GLU), urease (URE) and catalase (CAT) activities as well as physico-chemical and biological properties were determined after 63 day of incubation under laboratory conditions. SWC and MSWS significantly improved soil physico-chemical and biological properties, especially carbon and nitrogen contents. Accordingly, overall enzyme activities were substantially promoted in presence of both amendments and the higher increases were measured at 30% of SWC (increases by 134%, 62%, 49%, 47, 43%, and 172% for, DEH, β-GLU, PHO, ARY-S, URE, and CAT, respectively). Lower beneficial effects occurred at the combination of SWC and MSWS together at 30% possibly because of the increased the presence of trace elements by MSWS application. As a general response, SWC supplied at 30% seems to be a useful strategy to enhance biological activities of acid- or salt-affected soil.

Keywords: Acid or saline soil, biological activities, solid waste compost, municipal solid wastewater sludge.

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CLIMATE CHANGE: MONITORING, DATA, METHODS AND SERVICES

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Scientific evidence for warming of the climate system is unequivocal. Experts agree that the greenhouse gases emitted by human activities are the primary driver of these changes. As a consequence the number of weather related extreme events significantly increases all over the World which has enormous socio-economic effect. This lecture outline the network of national meteorological institutes how to tackle climate change issue. Monitoring is the basic tool in environmental sciences to detect any changes. The state and the composition of the atmosphere are watched continuously by thousand kind of instrument on the earth surface and in the air. Huge amount of data are collected, quality checked and archived day by day to serve the increasing demand on weather and climate related information. Not only archived surface data, but satellite and reanalysed gridded values are available for researches. Numerical models and statistical methods are equally used to realize the changes. In Hungary the systematic regular meteorological observations started in 1870. Domestic trend data of long term temperature is 1.2 degree Celsius, which exceed the global value. This tendency will continue in the future. The number of heat waves increased by 6 days since 1901. The yearly precipitation amount decreased with 5 %, spring and autumn became dryer. Drought and flash flood can occur at the same time. Drought is known as a major climatic hazard, which can occur every second year damaging the country's agriculture. Climate models project even more intense and frequent drought. Time series of GHG concentration and PM measurements will also demonstrated. Climate-conscious aspects in business, in cities and everyday life became essential. In order to assist smart decision international communities (GFCS, Copernicus) has been developing climate services for main economy sectors. At last but not least it is important to emphasise that engineering sciences have major role in climate adaptation and mitigation.

Keywords: global warming, climate services, energy sector,

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APPLICATION OF MICROBIAL ELECTROCHEMICAL TECHNOLOGIES IN THE WASTE WATER TREATMENT AND BIOSENSOR DEVELOPMENT

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In the circular economy framework the reuse and treatment of water is a main component. By the use of MET's the current framework established for water treatment meets the demand for a waste free environment and production of clean energy. The advance of Microbial Fuel Cells makes use of natural, cost efficient materials scalable from the single home use to industrial waste water treatment and energy production. Hydrogen and electrical energy are the main byproducts by conversion of the energy in the organic matter in the substrate, using electrochemically active bacteria such as *Shewanella* and *Geobacter*. Advances in cathode and anode design has reached the stage of inexpensive carbon fiber material, easy to mold into shape and size, this optimizes the hydrogen and electricity production. Use of MFC's as a biosensor to detect different types of toxicity is a main advantage, short response times and online monitoring is possible. Different pollutants require the use of different microorganisms in the detection of heavy metals, organic waste, pesticides etc. The current rise in environmental awareness has developed the use of biosensors and biomonitoring. In wastewater the removal of BOD in a main factor, conventional BOD monitoring is not suitable for use due to the long response time (up to 5 days). With the use of MFS biosensor the response time can be reduced at a fraction of 3 to 6 hours, with a grater dynamic range and accuracy and using a multi stage coupled MFC system. The use of a multi-stage MFC system allows for precise differentiation of BOD and toxicity, with possibility of online monitoring. The different types of application of MET (Microbial Electrochemical Technologies) results in a wide range of possible determinations in and off situ. Variations of MET's include: microbial desalination cells, microbial electrolysis cell, microbial electrosynthesis system, microbial fuel cell, sediment microbial fuel cell (benthic) and microbial methanogenesis cell. The advancements, potential and scalability of Microbial Electrochemical Technologies and systems are the purpose of the current study and aim to bring the technology as a feasible option for small and industrial scale operations.
Keywords: *Waste water treatment, algae technology, microbial fuel cell, circular economy, bioelectrochemical systems, biosensor development*
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AGRICULTURAL ANSWER TO CLIMATE CHANGE - OPTIMIZING RESOURCES

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Objective: Sustainable future is our task. Site-specific crop production is compatible with sustainability from ecological, economic and social aspects. The aim of the paper is to highlight the role of innovation in optimizing resource use in agriculture. That means the use of all items of precision technology based on a certain degree of intensity and technology of production matched with a form of farming technology that is appropriate for the environment. The question to be answered is: what solutions give enough income for farmers and keep the environment in good condition if the climate is changing, in the aspect of the "de-growth' theory developed by Serge Latouche. Methods: Economic characteristics of site-specific plant production are examined based on cost-benefit analysis and the risk is estimated with simulation model. Based on content analysis a summarization is given in this paper on the 'de-growth theory'. The paper focuses on our former researches where the question was discussed as an economic question of farms, innovation and cooperation, taking into consideration attitudes and willingness to cooperate. Results: Site-specific farming is a holistic system, a technology that allows target-oriented treatments, thus managing the spatial and temporal variability within an ecosystem, by applying spot treatment applications, finding the optimum solutions, when the climate, water supply is radically changing with an increasing risk of production. And at the same time, the farmer has to be effective! How to combine the concept and practice of site-specific agriculture with sustainability in a changing word? The concept of site specific farming meets with the following thoughts of the 'de-growth' theory: (1) Allows the efficient use of natural resources (Restructurer – restructuring factors of production). (2) Each farming strategy in which the farmers' cooperation is the base of the efficient machinery use (Restructurer – restructuring of social relationships). (3) Each technology that reduces the human-health risk (Réduire – reduction) shows into the direction of 'degrowth'.

Keywords: *sustainable development renewal, site-specific agriculture, risk, answers 'de-growth theory' strategy, cooperation JEL classification: Q01; Q55; P49*

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THE EFFECTIVENESS OF PLANT COVER IN REDUCING EROSION OF STEEP SLOPES AND ITS USE FOR RECULTIVATION OF MINING WASTE DUMPS

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By a conceptual model it is evaluated, how and in which relative extent the vegetation reduces the surface layer erosion under rainwater. In consideration of the Hungarian climatic conditions, two mechanisms are taken into account: 1. the striking and splashing effect of raindrops (the soil structure breaks apart to small particles, and these are subsequently moved airborne downslope), 2. sheet erosion (the rainwater moves down the hill and carries small pieces of soil with it). The model provides a mathematical expression for the soil volume eroded per unit time. The vegetation diminishes the erosion through 4 different parameters in this expression: α: the plants retain this proportion of rainfall, therefore it cannot cause erosion, *z:* friction coefficient (roughness) by which the vegetation increases the friction work of flowing water, hereby reducing the available energy for the erosion, σ: specific erosion work, which is increased by the plants because their roots, rhizomes and stolons hold together the soil against external forces, b_1 : specific splash erosion is diminished by the plants because their shoots and leaves reduce the raindrops' kinetic energy. According to these parameters, four indicators are introduced and their 5 scale evaluation for 474 vascular plant species (with regard to their growth forms) is attempted. The results could help to select species and assemble plant communities for recultivation purposes.

Keywords: *erosion, rainwater, model, recultivation, vegetation*

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UPSCALING OF COMMUNAL SEWAGE SLUDGE VERMICOMPOSTING TECHNOLOGY

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The proper management of communal sewage sludge is a priority of environmental protection. Recently the vermicomposting technology, of using earthworm species in waste management has been increasing. Earthworms are utilizing of the bacterial components of the sludge and during of their metabolic processes, can contribute for the acceleration of full composting processes. In addition, vermicomposting increase the nitrogen (N), phosphorus (P) and potassium (K) content of the treated sludge, and eliminate of the potential pathogens. We examined the vermicomposting processes both in pilot scale (open- and closed environmental conditions) and among industrial composting conditions, where the compost piles were covered or uncovered with straw-mulch and/or with geotextile. *Eisenia foetida* worms were inoculated into the compost-piles. Samples were taken at the beginning, at half time and at the end of the experimental period. Physical and chemical characteristics, such as the pH, dry matter content, organic matter content, total salinity, total nitrogen, total phosphorus content (P_2O_5), potassium content (K_2O), calcium, magnesium, humus content (H%), humus quality and the dehydrogenase enzyme activities were determined. Temperature and redox potential were assessed twice a week in order to characterize oxidation-reduction conditions. Heavy metal concentrations (Pb, Zn, Fe, Cu, Mn) in the starting sludge, in the finished vermicompost and in the earthworms were also measured, which means, that bioaccumulation of heavy metals by earthworms can be determined. Straw-cover was the best for improving the survival ability of the worms and in increasing the total phosphorous and potassium availability in the final composts. Vermicomposting therefore can be a potential tool of the agri/horti-cultural practice for reducing the environmental risks of the increasing amount of communal sewage sludge wastes.

Keywords: *communal sewage sludge, vermicomposting, Eisena foetida*

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CLIMATE CHANGE AND SOIL MICROBIOME

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Microbial processes in soil have a key role in the global fluxes of biogenic greenhouse gases (carbon dioxide, methane and nitrous oxide) and are likely to respond rapidly to climate change. Important parameters of the soil microbiome are the number and functional diversity of microorganisms, soil respiration (CO_2 emission) and enzymatic activity. Well known that more than 1 billion tons of carbon is added to the atmosphere each year through change of land use. The purpose of our studies was to investigate the dynamics of CO_2 emission from soils of agrogenic, postagrogenic and natural ecosystems and they soil microbiome. In the transformation of arable soils to postagrogenic category changing the flow of major biogenic elements in the ecosystem, including carbon. Self-restoration of abandoned cropland can be considered as a combination of natural processes aimed at achieving homeostasis by the ecosystem. Monitoring studies of the emission of carbon dioxide from soddy-podzolic soils and analysis of soil microbiome were conducted from 2010 to 2017 in dynamics. Were isolated 468 dominating bacteria, among them 79 antibiotic resistant bacteria. All isolates were multi-drug resistant, of which greater than 74,5% were resistant to 9 antibiotics. Multi-resistance was such pathogenic and conditionally pathogenic bacteria as: *Enterococcus faecium*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa, Escherichia coli, Bacillus licheniformis, Serratia fonticola, Hafnia* alvei, *Bacillus cereus, Bacillus megaterium* and *Clostridium difficile.* The maximum level of intensity of carbon dioxide emissions from soils of the studied ecosystems was fixed from the beginning of May to the end of June, due to a favourable combination of abiotic factors for the activity of the soil microbiota. The amount of carbon dioxide produced by virgin soddy-podzolic soils averaged - 79.55 (mg CO_2 / kg soil / day); postagrogenic - 64.25 (mg CO_2 / kg soil / day); agrogenic - 52.18 (mg CO_2 / kg soil / day). In post-agrogenic soils, the value of the total CO_2 emission for vegetation was greater than in agrogenic soils. This is explained by the absence of alienation of primary production, as well as by phytogenic and microbiogenic successions, which leads to a gradual restoration of the natural state of soils and the accumulation of carbon in the post-agrogenic ecosystems.

Keywords: *soil, ecosystems, microorganisms, climate change, microbiome.*

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COSMIC DUST STUDIED BY MOSS ANALYSIS

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It is a well-established phenomenon that extra-terrestrial dust particles (micrometeorites) survive atmospheric entry and reach the Earth's surface. Collection of extra-terrestrial dust for research focuses on the environments where terrestrial sedimentation rates and input of artificial particles of anthropogenic origin is minimal, including deep-sea sediments, Antarctic ice and snow, as well as natural planchettes of mosses and peat-bog cores. Experimental observations of particles considered as cosmic dust in moss samples (*Sanionia uncinata*) collected in King George Island, highlands of Georgia, lowlands of Belarus and Tver Region of Russia are presented. Microanalysis of moss samples showed the presence of clastic, anthropogenic particles and particles of cosmic dust. The results from Georgia are compared with those for moss samples collected in pristine areas of Norway. The identification of particles as micrometeorites is achieved on the basis of their compositional, mineralogical, and texture analyses using microscopy of (SEM and EDAX techniques) and neutron activation analysis (NAA). The majority of particles undergo melting during their passage of the atmosphere. Most abundantly, particularly at large sizes, cosmic spherules, i.e. completely melted droplets, were observed. These spherical particles provide a useful proxy for the total flux of dust because they are relatively easy to identify. They are the background magnetic component of cosmic dust, mainly microspheres and particles of native metals. Most often, it was possible to detect native Fe, Fe-Ni and Fe-Cr minerals.

Keywords: *extra-terrestrial dust particles, SEM, EDAX, NAA*

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SOLUTIONS FOR NON-WASTE TAILORING METHODS

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The fashion industry after the oil industry is the second most polluting industry in the world. Both the production of clothes and the afterlife of the pieces give rise to high pollution. Developing environmentally friendly technologies for production and zero-waste efforts are a deliberate intention to alleviate the problem. More than 400 billion square meters of fabric are produced annually, but out of this is 15-20% loss. The issue that has become very important since the early age is still very important, although other reasons have proved the use of non-waste sorting methods at that time. In history, there have been many examples in which people have tried to make full or nearly full use of the fabric when making their clothing. This article presents some main stages of these, and also demonstrates student project tasks as illustrations. These tasks start with the study of the methods of cutting and then the different aspirations of contemporary designers. In the fashion designers' collections, the eco-conscious lines play key role the help of which the waste in tailoring can be minimized and the natural materials come into view. The proper use of drapery is an opportunity in this direction, while another direction seeks to use the entire material width. Third and forth year students, after completing basic professional design tasks, experiment with special shaping based on such principles. Students need to design as many variations as possible from simple geometric patterns, as far as possible from the given fabric. The design process results in creative form solutions, and this enhances students' eco-conscious thinking. The result of such experimental work is that development and understanding are considerably simpler than usual fashion-oriented design tasks, though it is a concrete solution to optimize the treatment of sartorial waste.

Keywords: *Zero-waste, ecodesign, drapery*

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TYPES OF SERVO AXES SINCHRONIZATION FOR USE IN AUTOMOTIVE RECYCLING INDUSTRY

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To optimize the recycling process in automotive industry, it is necessary to constantly innovate the machines where recycling processes take place. In recycling processes, we have selection and cutting of various materials such as: metal, glass, plastic, wood, leather, etc. Various electric drives are used for all these processes. In the past the drives were only mechanically coupled. Mechanical couplings such as gears, couplings, sprockets and other mechanical power transmissions are reliable solutions but not flexible. Changing the gear ratio between the two axes of motion would require a change in the ratio of the mechanical gears or the use of a gearbox. With the development of electronics, the gearing of the axis was moved from domain of mechanics into the domain of electronics. Thanks to the fast regulation structures inside servo drives it is possible to couple two or more axes of movement without mechanical connections, only based on the reading from the position sensor. By introducing electronic coupling, the change in the gear ratio in the software itself is possible without any changes to the mechanics during the work. The paper provides an overview of the basic concepts and parameters for synchronization of two axes in motion. Also, the necessary parameters and settings are explained for synchronizing two axes. Finally, a comparative analysis of three synchronization types was performed: Reverse motion, Synchronizing and Symmetrical, with its advantages and disadvantages on Siemens S1500T platform.

Key words: *recycling, drives, axes of movement, electronic gearing.*

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ELECTRONIC ACCELERATION SERVO OSA MOVEMENT ON THE SIEMENS S1500T PLC SET FOR THE REQUIREMENTS FOR RECYCLING THE CAR

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In order to maximize the effects of car recycling, it is necessary to constantly innovate machines where recycling processes take place. In recycling processes, we have cutting various materials such as: metal, glass, plastic, wood, leather, etc. Various drives are used for all these processes. Sometimes the drives were only mechanically shifted. Mechanical couplings such as gears, couplings, sprockets and other mechanical power transmissions were reliable solutions but were not easily interchangeable. Changing the relationship between the two axes of motion would require a change in the ratio of the mechanical gearbox or the use of a gearbox. With the development of electronics, the movement of the axis of movement is displaced from the domain of mechanics into the domain of electronics. Thanks to the quick regulation structures it is possible to mix two or more axes of movement without mechanical connections, and based on the reading from the position sensor or speed. By introducing electronic coupling, the change in the relationship in the software itself will be possible without any changes to the mechanics and during the work itself. The paper provides an overview of the basic concepts and parameters when synchronizing two axes of motion. Also, the necessary parameters and settings are explained for the purpose of synchronizing two axes of movement. Finally, a comparative analysis of three synchronization cases was performed: Reverse motion, Synchronizing and Symetrical, with its advantages and disadvantages.

Key words: *recycling, drives, axes of movement, electronic coupling.*

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MEASURING ACOUSTIC PROPERTIES OF MATERIALS WITH A MICROFLOWN SENSOR

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The issue of noise as an aggravating factor is often a topic to be discussed. This is a consequence of the growth of the human population, coupled with economic growth and the intensive use of sound-generating devices (noise). The paper deals with the use of the Microflown acoustic sensor to research the acoustic properties of materials both indoors and outdoors. It uses its ability to measure reflectivity, absorption or acoustic impedance over a few minutes, broadband, perpendicular to material or at any angle. The practical use of Microflown technology is presented in the measurement of the sound absorption coefficient of materials. The contribution is supported by project APVV - 0327 -15, Development and research of methodologies for optimizing acoustic properties and acoustic quality of noise emitting devices.

Keywords: *acoustic, noise, microflown, particle velocity*

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SPREAD OF INVASIVE SPECIES AND CLIMATE CHANGE

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In the context of intensive economic development and the strengthening of international trade over the last decade, the number of invasive species that has spread far beyond their natural habitat is rapidly increasing. To reduce the flow of invasions is quite complicated due to the latent course of infectious processes, a slight awareness of the general public, which often leads to the unauthorized import of alien species. Fire blight originated in North America but it has spread in many parts of the world, including Europe. This disease has caused major economic losses in many countries, where commercial varieties of apple and pear are often susceptible to fire blight. For many years it was believed that fire blight does not exist in Ukraine. The disease was first identified in 1997 on pear in the Chernovtsy region. In subsequent years, the Quarantine Service of Ukraine registered the disease in Transcarpathian, Lvov, Vinnitsa and Ivano-Frankovsk regions. Since 1998 we have monitored of *Erwinia amylovora* in a set of orchards in some regions of Ukraine. The materials for our research were samples of apple and pear trees (leaves, parts of twigs and branches, bits of bark, blossoms) during the spring, summer and autumn surveys of the gardens. Unfortunately, reliable control methods have not been developed, and this disease responds poorly to the few available treatments. For these reasons, prevention through the use of resistant varieties is the best possible management practice. Therefore, we studied 20 varieties of pears and 15 varieties of apple for resistance to *E. amylovora*. Pears show less variation in resistance and are generally more susceptible than apples. Cultivars «Williams», «Bukovynka» and «Noyabrska» were included in the "Moderately resistant" group. Susceptible cultivars to fire blight were «Beurre Hardy», «Berre Bosk», «Triomphe de Vienne», «Victory», «Cure» evaluation scores ranged from 4 to 5. Very strong attack symptoms were observed at cultivars «Conference», «Jeanne d"Arc», «Kucheryanka», «Olivier de Serres» and «Starkrimson». The most sensitive apple varieties: «Golden Delicious», «Idared», «Jonathan», «Landsberger Renette», «Wagener». Cultivar «Spartan» was susceptible to *E. amylovora*. «Beauty of Boskoop», «Melba» and «Prima» cultivars showed a highly resistant to *E. amylovora*. The overall strategy in fire blight management is to keep the population of fire bight bacteria low. Only is to use an integrated program to reduce the chances that fire blight will become a serious problem in the pear and apple orchards.

Keywords: *fire blight, apple and pear trees, Erwinia amylovora, control*

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LEGISLATIVE FRAMEWORK OF CLIMATE CHANGE IN THE REPUBLIC OF SERBIA

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The fight against climate change is one of the priorities in the policy of the international community. In the Serbia, the energy sector is the largest source of GHG, but it is also the sector with the greatest potential for the application of mitigation measures. In this paper are discussed legal frameworks relevant for the protection of the climate change in the Republic of Serbia (RS). There was also emphasized the need for further harmonization of national legislation with international trends in the field of climate change, as well as with the obligations arising from ratified international documents and the process of European integration. Within the RS obligations towards the EU in the field of climate change, further alignment with EU policies is necessary such as objectives 20-20-20 and requirements for monitoring and reporting. The authors suggest that there is still a need to improve institutional and legal framework at both national and local levels. RS has established important components of the institutional and legal framework for the purposes of the fight against climate change. At the same time, there remains a need for their improvement, as well as capacity and knowledge building within relevant and competent institutions both at national and local levels, but also at the level of general public.

Keywords: *climate change, legal framework, European Union, Serbia.*

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BODY POSTURE CORRECTION CLOTHES FOR CHILDREN

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More and more small children are having problems with bad body posture. In the first phase of their lives correction is easier to accomplish. Different types of body posture correctors have been developed for children but most of them do not offer attractive eyesight to children, so they do not like it. OTKA No. 112506. "3D Dynamic Modelling of the Spine", with the help of OE, BME and SOTE, provides the opportunity to develop a body posture corrector in clothes for pre-school children. The aim of the research work is to provide child-friendly children swear that can effectively help with proper posture, comfortable to wear and the good for the kindergarten children. The research work analyzes the age, physical and psychological development level of the chosen age group, the age-group of three to six years old. I listen to their movement culture, and the motifs, figures and silhouettes they like as well as the kindergarten fashion. Beside of fashion in under clothes designing the choice of raw materials is a very important aspect, because the stability and comfort, as well as the free space are equally important to children. Body comfort and proper hygiene are largely determined by the basic material, technological development and production of clothing. Using smart textiles improve comfort. The children medical aid body corrector should be wear in summer as a summer clothes, and in winter as underwear. The design must take into account the essential characteristics of the orthoses, the parents' expectations and the properties of the available materials.

Keywords: bad body posture, posture corrector, orthoses

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INFLUENCE OF MOSSES SAMPLE PREPARATION METHODOLOGY ON THE COEFFICIENT OF VARIATION (*CV*)

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The aim of the research carried out with the use of mosses was to assess the homogeneity of biological material depending on the place of sampling and the method of their preparation for exposure within the framework of active biomonitoring of urbanised areas. The research was carried out with the use of *Pleurozium schreberi* mosses, which was taken from three measurement sites in the Stobrawski Forest in the Opolskie Province. Mosses sampling sites varied in terms of exposure to heavy metal contamination by anthropogenic factors. In mosses samples selected heavy metals: Mn, Fe, Ni, Cu, Zn, Cd and Pb were determined by atomic absorption spectrometry (F-AAS). In the first stage of the study, 12 moss samples were taken from each of the 3 measurement points, from which only the green parts of moss gametophytes purified of mechanical impurities were mineralized. In the second stage of the study, green parts of gametophytes were additionally conditioned in demineralised water (κ = 0.5 μS/cm conductivity). In the next stage of the study, the influence of conditioning and averaging of mosses samples on the homogeneity of the material was checked. For comparison, the study was also carried out using brown parts of mosses gametophytes and whole plants. The results of the conducted studies were analyzed by determining coefficient of variation (*CV*). It was found that *Pleurozium schreberi* mosses are not homogeneous material. The *CV* coefficient of variation was influenced, among others, by the location of the sampling site and the level of mosses contamination of biological material, e.g. with heavy metals. Conditioning in demineralised water and averaging makes it much more homogeneous and the *CV* coefficient of variation value don't exceed 10 %. Only appropriate preparation and preparation of mosses allows their use in active biomonitoring of urban areas.

Keywords: *Pleurozium schreberi mosses, heavy metals, coefficient of variation*

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PURIFIED SEWAGE AS AN ALTERNATIVE SOURCE OF WATER

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In the 21st century, water scarcity is one of the biggest global problems affecting all societies. Almost fifth of the world's population live in a real physical water deficit, and quarter of the population face economic water shortage, which means they do not have the infrastructure that would allow for the extraction of water from surface or ground sources. Additionally, climate change has also an effect, which has already been accepted by most of the world's scientific community and found that the major cause is the greenhouse gas emissions from human activities - industrial activity, motorized transport, industrial agriculture - carbon dioxide, nitrous oxide). The consequence of this is the more acute water cycle, the change in evaporation conditions, which is further strengthened by change of the surface (change of plant cover, change in the ratio of enclosed or built-up areas, drainage of surface water, etc.) and direct heat emission of buildings, plants, vehicles, etc. in built-up areas. The growing population and the changing climate result water demand increase. This fact, and the limited access to water, plus the fierce competition for water sources, have created the need for today's so-called "non-traditional" sources of water, like low-yielding wells and springs, rain water, rainfall precipitation, urban rainwater and that's why waste water recycling should be also considered in water management. The reuse of purified sewage in safe and cost-effective manner is a valuable, but not sufficiently exploited way to enhance water supply and reduce the pressure on excessively exploited water resources. The purpose of this study is to present practical solutions that contribute to implementation of integrated water management through purified waste water recycling.

Keywords: *wastewater recycling, climate change, circular economy, sustainable water management*

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GREEN SYNTHESIS OF NANOPARTICLES: STATE OF ART AND FURTHER PERSPECTIVES

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With the development of science and technology, a growing number of scientists are merging green chemistry with nanotechnology, and these researchers see a bright future for a new field known as 'green nano'. Some want to help green up industries using nanotechnologies. Others who are working on green technologies such as solar cells, remediation techniques and water filters are turning to nanotechnology in order to achieve their goals of creating better devices to help the environment. These researchers assert that a strong marriage between nanotechnology and green chemistry/engineering holds the key to building an environmentally sustainable society. The preparation and application of nanostructured materials has become a key technology in many more fields, for example pharmacy, regenerative medicine, and food technology. The chemical methods involves the reduction of metal ions to nanoparticles and preventing the aggregation of metallic nanoparticles. Usually, with using of various reducing agents (sodium borohydride, methoxypolyethylene glycol, potassium bitartarate or hydrazine), and stabilizers (sodium dodecyl benzylsulfate or polyvinyl pyrrolidone). The major disadvantage in the physical methods is the low yield, and in the chemical method is the use of toxic solvents (2-mercaptoethanol, thioglycerol) and also the production of hazardous wests. These factors limit the applications of synthesized nanoparticles. Biogenesis refers to the biological synthesis of nanoparticles. The major implication of this biological approach is its relative simplicity in the synthesis of nanoparticles, and it is less time-consuming. In addition to this, the high yield, low toxicity, low cost and its biocompatibility adds to its value. The use of stabilizers to prevent aggregation is not required as the proteins in the system act as stabilizers. Nanoparticles with smaller radius of curvature have higher catalytic activity; hence, angular shapes are preferable due to their smaller radii of curvature compared to spherical particles of the same volume.

Keywords: *nanoscience, biosynthesis, phytosynthesis, microbiological properties*

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WORKING FACTORS AND ITS ANALYSIS IN THE „MAN – MACHINE – ENVIRONMENT" SYSTEM

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In the research literature, the work environment is often characterized as a physical, chemical, biological, social and cultural complex of factors that affect an employee at workplace. The work environment is part of the „man-machine-environment" system. In this system, „man" refers to a person as the subject in the workplace (e.g. operators, decision-makers), „machine" is the general name for any object controlled by man (including tools, machinery, computers, systems and technologies), and „environment" describes the specific working conditions under which man and machine interact (e.g. temperature, noise, vibration, lighting, radiation, chemicals, hazardous gases etc.). Environment creates a wider or narrower set of factors which are affecting this system. The goal of this whole system is to create optimum conditions to achieve required results. The three main goals of optimization are to ensure safety, high efficiency and economy of „man-machine-environment" system. From the point of view of problem solving in this system the physical factors are very important and may represent a significant risk for employees. These factors affect the human senses, burden the nervous system and can negatively affect to overall health and cause stress. Stress is a physical, mental, or emotional factor that causes bodily or mental tension and it can have negative impact on work performance. These factors can be external (from the environment, psychological, or social situations) or internal (illness). According to official statistics, more than every fourth employee in the EU is experiencing work-related stress. Examination and assessment of working conditions from the point of view of their impact on employees is challenging, time-consuming and it is essential to do it regularly (in certain cycles, e.g. annually) in order to achieve reliable results. By comparing the results from previous and current assessments, it is possible to capture developmental tendency, identify progress or regress and subsequently decide on the next steps. If the implementations of these assessments become an enterprise's rule and an integral part of the occupational health and safety management system, it can represent the one of the pillars for successful business. Also new public opinion surveys may be useful in detecting potential risks. These surveys help to understand the differences between opinions and needs of people in different age, gender, level of education, profession etc. The paper is supported by KEGA project 041TUKE-4/2018.

Keywords: *Workplace, environment, working factors, productivity, employee*

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NEW ADSORBENTS IN POLLUTION CONTROL

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The goal of the research was to elaborate new, high performance adsorbents for cleaning up the surface waters. The carbon nanotubes attract strong attention for the removal of petroleum derivatives due to their high sorption capacity. The surface modification of the carbon nanotubes aims at to improve the hydrocarbon sorption capacity of the carbon nanotubes. The surface modification of the multiwalled carbon nanotubes was implemented by microemulsion technique. The morphological and surface chemistry features of the unmodified and surface modified multiwalled carbon nanotubes were investigated by different techniques including BET, XRD and the features were correlated with the petroleum removal efficiency of the sorbents pretreated. The petroleum removal efficiency of the adsorbents prepared was tested by different analytical methods such as TOC and GC. Model hydrocarbon compounds also were used during the experiments.

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Keywords: *Carbon nanotubes, surface waters, pollution control, adsorbents*

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WATER MONITORING AND QUALITY ASSESSMENT

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The Water Framework Directive aims at reaching the good ecological status of the surface waters. The objective was to devise a method for the quality assessment of waters with special focus on the water chemistry parameters as defined in the Water Framework Directive and pertaining legal regulations. Quality classes have been defined for every water chemistry parameter in light of the legal limit values of the water parameters. In addition to these weight indices were calculated on the basis of the outcome of the paired comparison of water chemistry parameters and normalized matrix. This was followed by the parametric level analysis of the water chemistry parameters and finally the aquatic environment index (AEI) was calculated, which provided general information on the quality of water regarding the water chemistry parameters. The method was illustrated on Lake Balaton in which case water samples taken from the Lake were analyzed and evaluated with the method devised.

Keywords: *Water chemistry parameters, aquatic environment index, surface water assessment, Lake Balaton*

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REMOVAL HYDROCARBONS FROM WASTEWATER OF PETROLEUM INDUSTRIES BY USING MWCNTS AFTER MODIFICATION WITH LOADING CERIUM OXIDE

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Multi-wall carbon nanotube (MWCNTs) could be one of the most important materials which got the attention of researchers in nanotechnology recently due to the surface area very high and the best adsorbent material. Several works are done in this field and they have recognized that flow rate and the temperature had a high impact on the removal efficiency and adsorption capacity. According to results, MWCNTs can be considered as the best adsorbent for hydrocarbons removal as compare to single wall carbon nanotubes and nano activated carbons. In this research, MWCNTs has been used to adsorb hydrocarbons from wastewater which is a by-product of petroleum industries. The modification to MWCNTs has been done by preparing nano metal oxides (e.g. CeO_2) and loading at the surface of MWCNTs. Morphological characterizations, such as XRD, BET were done for newly prepared adsorbents. BET analysis has been used to determine the surface area. XRD, XRF was used to recognize the nano metal oxide at the surface of MWCNTs. According to the literature, metal oxide modified MWCNTs has shown more efficiency to adsorb hydrocarbons from wastewater. Metal oxide modified MWCNTs supposed to be more efficient to adsorb hydrocarbons from wastewater.

Keywords: *MWCNT, Adsorption, Removal hydrocarbons.*

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PESTICIDE CONTAINER MANAGEMENT: CURRENT STATUS AND PERSPECTIVES IN SERBIA

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The use of pesticides has increased rapidly in low and middle income countries over the last decade. Appropriate management of used pesticide containers, is important issue for protection of human health and the environment in these areas. In order to reduce the risk in the application of plant protection products, good management of packaging and packaging waste, before and after the use of the product in it, is of paramount importance. In Serbia, use of pesticide is growing every year. Majority of used pesticides, are not managed properly and disposed in nearby non-controlled landfills or left in field. In European Union range of actions are undertaken, through the legal framework and establishment of container management programs, to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment. Solving the problem of hazardous packaging waste from plant protection products in Serbia encounters numerous obstacles, and the lack of experience in this field requires us to be more aware of the management system for this type of waste in the EU Member States. In addition, it is important to raise awareness of the proper handling of packaging waste from plant protection products, from the manufacturer to the end users. The paper will give the overview of the current situation in Serbia regarding management of used pesticide containers. Based on EU Member States experience in this field, analyse the possibilities for management of the containers and identified the obstacles for its development. The proposal for improvement measures is based on two models of management of this type of waste: voluntary and legally prescribed, implemented throughout the EU.

Keywords: *hazardous waste management, pesticide packaging waste*

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EVALUATION AND ASSESSMENT OF GROWTH, YIELD AND UPTAKE OF VARIOUS NON LOCAL BARLEY CULTIVARS IRRIGATED WITH SIMULATED WASTEWATER

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The research was implemented in order to study the effect of irrigation with artificial wastewater on soil, plant growth and crop yield of seven barley cultivars. The experiment was conducted at the new campus of An-Najah National University. The seeds were planted in the spring season and irrigated with two types of water (Fresh water as control and artificial wastewater), with three replicates for each treatment. Chemical analysis has been used for determining the mineral contents of the soil of the experiment for each variety and each type of water for nitrogen (N), phosphorus (P), potassium (K) and total dissolved salts (TDS). Barley proved to be a tolerant crop with considerable economic importance. Highest yield was obtained from cultivars irrigated with the artificial wastewater which gave nearly twice the yield and spike weight than the cultivars irrigated with fresh water. In addition, it gives higher spikes length and higher stem weight. The growth vigor as well as the growth period (from days to emergence to maturity) were not affected with the type of water and only depend on the type of the seeds. The chemical analysis of N, K and P represents the following, (N% – Root > N% – Spike, N% – Stem), for potassium, (K% – Stem> K% – Root, K% – Spike) and the phosphorous (P% – Spike > P% – Stem, P% – Root). In addition, artificial wastewater is a promising water resource as alternatives for fresh water to be used in agriculture specially crops with high tolerance to salinity such as barley since the use of wastewater in irrigation affects the soil texture through increasing the concentrations of some constituents such as N, K and P.

Keywords: *Fresh and artificial wastewater, Barley cultivars, Plant growth, Irrigation, crop yield*

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FIELD PRACTICE OF ENVIRONMENTAL ENGINEERS IN ALSÓ-HEGY (DIDACTICAL VISUAL GUIDE, ARRANGED IN THEMATIC ORDER)

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The education of the environmental engineers (B.Sc.) includes a high quality theoretical knowledge, practical skills and ecological approaches. The main source of this paper is the slides which were made during the field practice in Alsó-hegy. The report does not follow the time schedule of the trip. The observations are separated according to their topics, to emphasize the didactical aspects of lecture. In this way, the surface karstic formations are discussed the following order: devil ploughing (limestone pavement, sinkhole, boulder, buttress, dolina, karstic plato, red mud). The vertical caves (zsomboly) are important part of thi lectures, because the Alsó-hegy is the renowned for their vertical caves. Other types of the caves of Alsó-hegy are also discussed. The report is based on a slide show. The visual education is more effective than the text based teaching. This statement is emphatically valid for Z generation. Most of the slides were made during the field practice in 2018 by students and teachers. However several pictures were adopted from other sources (e.g. map of the caves). Some pictures were made from other places to improve the demonstration strength of lecture (tropical karstic formations). The lectures can be widely used as education material, even in high schools, but also good for guide book of Alsó-hegy.

Keywords: **Karstic phenomena, slide show, improved education tool**

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GAS EMISSION AND PARTICULAR MATERIAL OF DIFFERENT ECONOMIC SECTORS IN HUNGARY BETWEEN 2000-2015

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Abstract

The study analysis of correlations is done among the different economic variances of different kind of gases and particular materials polluting the air surrounding environment of our economy. The economic sectors have been characterised by different measured gas emission and particular materials for several decades or even centuries. The study aims at analysing the role of the economic sectors from point of view of their realising pollutions [Nitrogen-oxides (NO_x), Sulphur-dioxide (SO_2), Ammonia (NH_3), Particulate matter (PM_{10}) and Particulate matter ($PM_{2.5}$)]. The Household as a main economic sector indicator has caused a large amount of pollutions for natural environment, because share of the Household has considerably increased in different gas and particular material emissions for the period of 2000 and 2015, mostly in fields of PM_{10}, $PM_{2.5}$ and NH_3. The SPSS (Special Program for Social Sciences) according to Sajtos -Mitev as the methodology, which can ensure better way of the research to discover the main and deep correlations among the economic variances as gas and pollution particular materials belonging to the different economic sectors. Analyses focus on demonstrating different gas emission and particular material conditions of economic sectors or industries/economic branches in Hungary and strengthen of correlations among economic sectors' gas emissions and particular materials. Middle correlation is between NOX1 and PM104, also middle strong correlation between SO22 and NH33, and very strong correlation between PM104 and PM255 variances. Because of the Household as family unit has remained one of the biggest responsible for the increasing gas and particular material emissions in Hungary in spite that the SO_2 gas emission has decreased at the national level for the same period, therefore the new strategy should be followed. This new environmental conservation strategy demands from all sectors to decrease their gas emission in order to follow the sustainable economic growth accompanying with sustainable environment.

Keywords: *SPSS, SO_2, Pollution, Household, Global warming, Natural environment*

1. INTRODUCTION

In general, environmental pollution is the main challenge facing all countries in the world [1]. The quality of life on earth is determined primarily by air purity. Pollutants pose a direct threat to human health, damage the vegetation and destroy our environment. One of the major environmental tasks today is to reduce air pollution, one of the underlying causes of climate change and its adverse effects. The main basis link in these processes is to link air pollution to specific industries/economic branches [2]. Hungary is a small open economy that has enjoyed strong economic growth over the last decade. In one hand, the country's dependence on oil and gas imports for energy supply, as well as intensive industrial and agricultural activities and increasing road traffic have aggravated environmental challenges. On the other hand, the share of renewable energy sources in total final energy consumption reached 14.5% in 2015, a threefold increase since 2000, and likely to exceed the national target of 2020 [3].

This case-study focuses on analysing correlations among the economic variances by the other name as gases and particular materials polluting the atmosphere of the economy. At present economic branches/industries are characterised by different measured gas emissions and particular materials. The study analyses the importance of the economic sectors resulting different measured pollutions. The Household as economic sector has resulted considerable pollutions for natural environment, because for the latest period the Household has considerably increased its share in pollutions by different gas and particular material emissions, mostly in fields of PM_{10}, $PM_{2.5}$ and NH_3. Also recently the NO_x gas emission has increased by the activities of water supply, sewerage, waste management and remediation activities, wholesale and retail trade, repair of motor vehicles and motorcycles, administrative and support service activities, the public administration and defence (compulsory social security), education, human health and social work activities, arts, entertainment and recreation, other service activities. Also activities of households as employers; undifferentiated goods- and services- producing activities of households for own use have contributed to increase more NO_x gas emission for the last one and two decades. The importance of the object in this research is the wronging negative tendency in field of the pollution measure caused by the human activities and the gas and particular materials emission of whole performance. This negative tendency can increase the more negative influences of greenhouse gas (GHG) emissions leading the danger global warming. Therefore the performance should avoid of influences of the increasing GHG and additional materials emission in the future. This force needs for the international cooperation of all nations in the world economy.

In general, acidification (NO_x SO_2, NH_3) causes damage mainly to soil, water and forest. While, the higher attention on PMs with a diameter of less than 10 micrometers (μm) results from there has adverse effect on health. So, inhalation of these substances plays a role in the formation of many serious diseases such as heart diseases and lung cancer [2]. Additionally, particles (PM_{10} and $PM_{2.5}$) are considered as potential pollutants that cause economic losses and health consequences on society [4]. Fine particles which are very small in size usually have long residence time in the atmosphere and generally tend to spread in a large geographic area and thus exert the greatest impact on vegetation and ecosystems by virtue of the mass loading of its chemical constituents and vegetation [5].

2. REVIEW OF RELEVANT LITERATURE

Air pollution is a major key issue of environmental and social problem and also, it's a complex problem that poses multiple challenges in terms of managing and reducing harmful pollutants. Air pollutants are caused by human activities and natural sources; they may be either emitted directly or formed in the atmosphere. They have a number of effects on health, the built environment and the climate [6]. Hence, under increasing numbers of population and economic growth, environmental pressures, problems and challenges are becoming more and more complicated due to excessive use of natural resources [1].

However, since the 1970s, a broad range of environmental legislation has been put in place to assessment, management and mitigation of harmful air pollutants. The body of EU environmental law - amounts to some 500 directives, regulations and decisions. Further, over the same period, the level of environmental protection has improved in most parts of Europe. And also, emissions of specific pollutants to the air have generally been reduced significantly such as SO_2. These improvements and reductions are largely the result of comprehensive environmental policies and legislation in Europe (e.g., the European Commission's proposed Clean Air Policy Package. Also, the UNECE, Gothenburg Protocol in Sweden in November 1999 and amendments Gothenburg Protocol in Geneva in May 2012) and they are delivering a range of environmental, economic and societal benefits [7]. Furthermore, the Convention on Long-range Transboundary Air Pollution of 1979 (CLRTAP) in Geneva addresses some of the major environmental problems of the United Nations Economic Commission for Europe (UNECE) region through scientific collaboration and policy negotiation, the Convention protocols identify specific measures to be taken by Parties to cut their emissions of air pollutants for protecting the environment and human health. Moreover, the UNECE, Gothenburg Protocol of 1999 in Sweden;

sets emission ceilings (e.g., SO_2, NO_x and NH_3) to regulate/control the emissions of transboundary air pollutants, which came into force in 2005. More recently, in May 2012 in Geneva, adopting historic amendments to the Gothenburg Protocol (1999) Convention's on CLRTAP. In general, this Protocol was amended (2012) to regulate acidifying compounds (e.g., SO_2, NO_x and NH_3), which include national emission reduction commitments to be achieved by 2020 and beyond. So, the EU Member States agreed to reduce emissions of SO_2, NO_x and NH_3 by 59%, 42% and 6% respectively for the EU as a whole by 2020 and beyond compared to 2005 emission level, while Hungary committed to cut these air pollutant emissions by 46%, 34% and 10% respectively for the same periods [8].

According the Hungarian force to degree the gas emission there are some international experiences in this field, for example the governments of these countries (e.g., China and Germany) are also increasing their efforts to reduce gas emissions through the Clean Development Mechanism (CDM) strategy [9, 10]. Foreign Direct Investment (FDI) inflows in Africa primarily target investments in services that are considered to be low-risk sectors, but these sectors do not require costly investments but promise a significantly more profitable business [11, 12, 13, 14].

The balance of payments consists of two parts: the current account, the capital and financial account. We must also mention the third part of the balance of payments, the central bank reserve as a balancing item, which is a kind of ultimate stabilising effect or an option concerning the environmental strategy [15]. For developing countries, financial support from developed countries and various international organisations is indispensable for their economic growth, which is complemented by investment in FDI, as they also mobilise significant financial resources for developing countries [16, 17, 14]. The development of renewable energy sources concentrated mainly on two countries, China and South Korea, and Japan has also made significant improvements in this area. China spent nearly \$ 10.8 billion in environmental investments, one of which was one of China's major investments in the Three Gorges waterworks [14]. An important task of the China CDM Foundation, with the approval of the Chinese government, is that: - integrate government and market functions, - implement national development and sustainable development in order to expand CDM cooperation under the Kyoto Agreements [9, 18].

Finally, air pollution in urban areas is an important issue with different socio-economic and climatic aspects in different parts of the World, it can cause a serious environmental problem as well as a negative impacts on human health and on climate [19, 20]. Therefore, the rapid growth in population, urban and industrial activities resulted in deterioration of air quality in urban environments [4]. So urbanisation, industrialisation and fossil fuel-based transportation have led to a significant increase in air pollution in urban areas [21].

3. MATERIALS AND METHODS

The SPSS (Special Program for Social Sciences, see more detailed in Sajtos -Mitev [22]) as the methodology, which can ensure better way of the research to discover the main and deep correlations among the economic variances as gas and pollution particular materials belonging to the different economic sectors or industries/economic branches. Analyse emphasises the unfavourable importance of the Household in field of increasing measured pollutions. The cluster analyses focuses on the similarity and difference among the different economic sectors by the measured pollutions caused by the sectors. In addition, the data base of these analyses was selected from the Hungarian Central Statistical Office [23]; Tables (STADAT) published in 2017 for the period of 2000 and 2015 in Hungary in tons (2000 = 100%). The analyses of this study focus on the demonstrating the different gas emission and particular material conditions of the economic sectors or industries/economic branches in Hungary as shown in Table 1 [23], and the name of these sectors in short form (abbreviations) for SPSS analyses as listed in Table 2.

Table 1: Emission of NO_x, SO_2, NH_3 and Particulate matters (PM_{10} and $PM_{2.5}$) by sectors (industries/economic branches) in Hungary between 2000 and 2015 (2000 = 100%) [tons]

Sectors (industries/economic branches)		**NO_x**	**SO_2**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
		2000-2015				
A 01–03	Agriculture, forestry and fishing	3.8	-98.4	-12	-5.5	-12.5
B 05–09	Mining and quarrying	-2.3	-99.8	150	0.5	-4.5
C 10–33	Manufacturing	-38	-84	-45	-37	-40
D 35	Electricity, gas, steam and air conditioning supply	-48	-98	91	-58	-44
E 36–39	Water supply; sewerage, waste management and remediation activities	91	-70.7	-88	13	11
F 41–43	Construction	9.3	-17	370	-30	-28
G 45–47	Wholesale and retail trade; repair of motor vehicles and motorcycles	150	-86	77.7	22.4	9
H 49–53	Transportation and storage	-23	-85	42	-30	-35
I 55–56	Accommodation and food service activities	15.8	-90	-38	-30	-37
J 58–63	Information and communication	0.6	-88	-22	-32	-38.5
K 64–66	Financial and insurance activities	-20	-87.4	-39	-40	-46
L 68	Real estate activities	-30.5	-90	49.6	-34	-37
M 69–75	Professional, scientific and technical activities	-5.6	-85	-22	-22	-28.6
N 77–82 O 84 P 85 Q 86–88 R 90–93 S 94–96 T 97–98	Administrative and support service activities Public administration and defence; compulsory social security Education Human health and social work activities Arts, entertainment and recreation Other service activities Activities of households as employers; undifferentiated goods- and services- producing activities of households for own use	31	-87	-14	-17	-29.5
Household		-27.4	-50	67.2	47.7	47.4
Total emissions		**-20.6**	**-94.4**	**-11**	**2.9**	**12.4**
Household/ Total emissions in 2000		21	*5.1*	*4.5*	*47.6*	*66.2*
Household/ Total emissions in 2015		19.2	*47*	*8.4*	*68*	*86.7*

Source: Hungarian Central Statistical Office (2017): Themes - Environment: Tables (STADAT) - Time series of annual data - Environment: Air pollution data. Update: 25.09.2017. *Hungarian Central Statistical Office (HCSO)*, 2017. Available at: http://www.ksh.hu; [Accessed at: 04 September 2018].

In Table 1 there are *5 variances*, which are as follows:

NOX1 NO_x Nitrogen oxides
SO22 SO_2 Sulphur dioxide
NH33 NH_3 Ammonia
PM104 PM_{10} Particulate matters with a diameter of 10 µm or less (PM_{10})
PM255 $PM_{2.5}$ Particulate matters with a diameter of 2.5 µm or less ($PM_{2.5}$)

The coordinate system, as score system, is useful to over view the distance among sectors based on volume of pollutions as gas and particular materials caused by these sectors for the period of 2000 and 2015. Therefore also the score system can select the sectors into four sessions of the score based on the increasing or decreasing gas and polluting material emission of their activities.

Table 2: Name of sectors in short form (abbreviations), of the Table 1 for SPSS analyses

Sector (industries/economic branches)		In Short Form
A 01–03	Agriculture, forestry and fishing	AgrForFish
B 05–09	Mining and quarrying	Mining
C 10–33	Manufacturing	Manufact
D 35	Electricity, gas, steam and air conditioning supply	ElectrGasSup
E 36–39	Water supply; sewerage, waste management and remediation activities	Water
F 41–43	Construction	Constr
G 45–47	Wholesale and retail trade; repair of motor vehicles and motorcycles	WholRetTrad
H 49–53	Transportation and storage	Transport
I 55–56	Accommodation and food service activities	AccomFood
J 58–63	Information and communication	Inform
K 64–66	Financial and insurance activities	FinaInsure
L 68	Real estate activities	RealEstate
M 69–75	Professional, scientific and technical activities	ScientTech
N 77–82 O 84 P 85 Q 86–88 R 90–93 S 94–96 T 97–98	Administrative and support service activities Public administration and defence; compulsory social security Education Human health and social work activities Arts, entertainment and recreation Other service activities Activities of households as employers; undifferentiated goods- and services- producing activities of households for own use	AdminOther
Household		Household

Source: Based on Table 1.

4. RESULTS AND DISCUSSION

Air pollution is one of the most important global issues which involve conducting research, policy and strategy at national and international level to improve air quality [24]. In general, energy consumption, transportation (especially road traffic), industrial processes, agricultural activities and waste management are the main sources of air pollution causes by human activities and economic growth. Additionally, European countries have significantly reduced emissions of SO_2 air pollutant in recent decades. While, in the cases of PM and reactive nitrogen substances are still a significant threat to human health, premature deaths, and damage to ecosystems [25].

In some areas of Hungary [26, 27], the PM_{10} concentration in the air is annually higher than the permissible 35-fold higher than the health limit value. During the winter, pollution in these areas can reach 4-5 times the daily limit. The impact of this meteorological situation can be traced very well with this pollutant. In those years when the so-called atmospheric inversion periods occurred in larger numbers (November 2005 to March 2006 and November 2010 to March 2011) and there was little rainfall, and air pollution more frequently exceeded the daily limit. The trend shows that the rate of exceedance of annual limit values is decreasing: in 2005-2006 the annual PM_{10} content exceeded the 20% to 30% of the PM_{10} content, while in 2010-2011 the rate of exceedances was below 10%, and overtime between 2012 and 2014 did not happen. The regular $PM_{2.5}$ study began in Hungary for 12 years. In 2012, pollutants were measured in air. It can be seen that the limit from 2015 was only exceeded in some cases but the compliance with the limit set by 2020 is challenging. It is worth noting that in the current World Health Organisation (WHO) guidelines 10 Microgrammes per cubic metre (μg/m^3) is the annual value of $PM_{2.5}$. Based on the measurement data, 50-80% of PM_{10} is particle diameter smaller than 2.5 μm [26, 27]. Concerning nitrogen oxides (NO_x) emissions continue to be driven by transport and 44% of the pollutants emitted from this sector [26, 27]. The emission of specific pollutants from newly installed vehicles has been steadily declining due to tighter regulation. The reduction in the total emissions of transport is limited by the increase in the number of vehicles and the reduction in the rate of change. The average age of road vehicles has risen again in the last 9-10 years. The nitrogen dioxide load in the air has fluctuated over the last 10 years [26, 27].

As mentioned above, the analyses of this study focus on the demonstrating the different gas emission and particular material conditions of the economic sectors or industries/economic branches in Hungary (see Table 1) and shows strengthen of correlations among economic sectors' gas emissions and particular materials (see Table 3). The Table 3 shows strengthen of correlations among main sectors, namely the middle correlation is between NOX1 and PM104, also middle strong correlation between SO22 and NH33, and very strong correlation between PM104 and PM255 variances. The strong correlation means that when the NOX1 decreases the other variance PM104 also decreases or little increases, therefore the economic development stimulates the NOX1 decrease, namely the Nitrogen oxides gas emission, so in the same time also this development stimulates little increase of the PM104 and PM255, as particular materials. When the SO22 considerably decreases the other variance NH33 also decreases little, when the PM104 and the other variance PM255 also little increase, because of the reason of the economic development.

Table 3: Correlation Matrix

		NOX1	**SO22**	**NH33**	**PM104**	**PM255**
Correlation	NOX1	1.000	.066	-.055	**.524**	.425
	SO22	.066	1.000	**.618**	.253	.323
	NH33	-.055	.618	1.000	-.001	.084
	PM104	.524	.253	-.001	1.000	**.973**
	PM255	.425	.323	.084	.973	1.000
Sig. (1-tailed)	NOX1		.407	.423	.022	.057
	SO22	.407		.007	.181	.120
	NH33	.423	.007		.498	.383
	PM104	.022	.181	.498		.000
	PM255	.057	.120	.383	.000	.425

Source: SPSS system based on the Hungarian Central Statistical Office (2017): Themes - Environment: Tables (STADAT) - Time series of annual data - Environment: Air pollution data. Update: 25.09.2017. *Hungarian Central Statistical Office (HCSO)*, 2017. Available at: http://www.ksh.hu; [Accessed at: 04 September 2018].

For the period of 2000 and 2015 the NOX1 has decreased by 20.6% and the PM104 little increased by 2.9% and PM255 also little increased by 12.4%, while the SO22 has considerably decreased by 94.4% and the NH33 little decreased by 11%. For the same period PM104 has little increased therefore the PM255 also little increased. It can be declared that in spite that the SO22 has sharply decreased, the other two variances namely PM104 and PM255 little increased according to Table 1 and Table 3 [26, 27].

The Figure 1 shows places of the different economic sectors separated in four sessions of this coordinate system. The places of the economic sectors are determined by the special gas emission of each economic sector of Hungary in the coordinate system. The each economic sector is characterised by its gas emission. The coordinate system very clearly shows differences among sectors based on their gas emission and particular materials [23].

The economic variances, as gas emission and particular materials of the Component-1 are lying at the principle line "X", namely NOX1 (Nitrogen oxides), PM104 (Particulate matters with a diameter of 10 μm or less, PM_{10}), PM255 (Particulate matters with a diameter of 2.5 μm or less, $PM_{2.5}$). The economic variances, as gas emission of the Component-2 are lying at the principle line "Y", namely SO22 (Sulphur dioxide), NH33 (Ammonia).

According to the Figure 1, in the first session of the score - coordinate system - the principle lines "X" and "Y" are positive valued, this means that two variances, namely Household and Mining are increasing or little decreasing. Generally the place of each economic sector in the score is determined by mostly the average values of the gas emissions and particular materials belonging to the sectors. Therefore the Household as economic sector is in this session, because it has had large NH33 (NH_3) gas emission increase for this period, but its other two variances [PM104 (PM_{10}) and PM255 ($PM_{2.5}$)] of Component-1 have less increased. In the second quarter session of the coordinate system the variances as NOX1, PM104 and PM255 of the line "X" in the minus share of this line decreases only in case of one economic sector, namely Constr, The other two kinds of gas emissions of this economic sector remain mostly increases concerning the positive part of line "Y". This Constr variance has highly increase in NH_3 (ammonia) gas emission. In the third quarter session of the score the variances as NOX1, PM104 and PM255 at the line "X" in the positive share of this line increased or less decreased in cases of the economic sectors, as WholRetTrad, Water, AdminOther and AgrForFish, while their gas emission concerning the Component-2 contenting SO22 and NH33 at the negative share of the Principle Line "Y" decreased or less increased in the same period. In the fourth quarter session of the score the economic variances namely NOX1, PM104 and PM255 at Principle Line "X" and Component-2 including SO22 and NH33 gas emissions at Principle Line "Y" are both of them in the negative lines. This means that those economic sectors of this session, as Manufact, ElectrGasSup, Transport, AccomFood, Inform, FinaInsure, RealEstate and ScientTech have had decreasing trends in fields of gas emissions or less increasing for the period of 2000 and 2015.

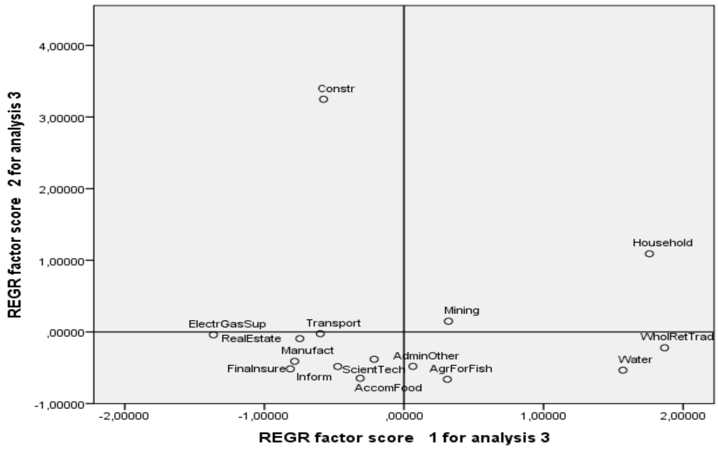

Figure 1: REGR factor score 1 and REGR factor score 2, factor analysis

Source: SPSS system based on the Hungarian Central Statistical Office (2017): Themes - Environment: Tables (STADAT) - Time series of annual data - Environment: Air pollution data. Update: 25.09.2017. *Hungarian Central Statistical Office (HCSO)*, 2017. Available at: http://www.ksh.hu; [Accessed at: 04 September 2018].

Generally in Hungary there were several kinds of different damages caused by economic sectors by their investments, for example fugitive emissions oil: refining/storage energy production and distribution; Distribution of oil products in energy production and distribution, Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other) Energy production and distribution Venting and flaring (oil, gas, combined oil and gas) Energy production and distribution, Other fugitive emissions from energy production Energy production and distribution, Cement production Industrial processes and product use, Lime production Industrial processes and product use, Glass production Industrial processes and product use, Quarrying and mining of minerals other than coal Industrial processes and product use, Construction and demolition Industrial processes and product use, Storage, handling and transport of mineral products Industrial processes and product use, Other mineral products Industrial processes and product use, Ammonia production Industrial processes and product use, Nitric acid production Industrial processes and product use, Adipic acid production Industrial processes and product use, Carbide production Industrial processes and product use, Titanium dioxide production Industrial processes and product use, Soda ash production Industrial processes and product use, Chemical industry: Other Industrial processes and product use, Storage, handling and transport of chemical products Industrial processes and product use [28].

The Figure 2 shows that there are five clusters created by the SPSS system for 15 economic sectors based on their gas and particular material emissions. The Constr sector is alone the fourth cluster, while the Household is alone as fifth cluster, because their gas emission and particular material issue are very special and different from the other sectors' one. The first cluster includes two sectors, namely AgrForFish and Mining, while the third cluster includes Water and WholRetTrad. The second cluster content largest number of sectors as nine one, namely Manufact, ElectrGasSup, Transport, AccomFood, Inform, FinaInsure, RealEstate, ScientTech, AdminOther, which have an important common behaviour, namely these sectors have decreased gas and particular material emissions more than the other sectors' one for the period of 2000 and 2015.

In addition, the five clusters (Figure 2) can be outlined as the followings:

Cluster-1 (2): AgrForFish, Mining

Cluster-2 (9): Manufact, ElectrGasSup, Transport, AccomFood, Inform, FinaInsure, RealEstate, ScientTech, AdminOther

Cluster-3 (2): Water, WholRetTrad

Cluster-4 (1): Constr

Cluster-5 (1): Household

In spite that the Hungarian economy has realised considerable decreasing different gas emission but increasing particular material emission for the latest period of 2000 and 2015 in general. The SO_2 gas emission decreased by 94.4% at the national level, while the Household as economic sector named in our research has increased its share to 8.4% by 67.2% in field of NH_3 gas emission and its share to 86.7% by 47.4% increasing $PM_{2.5}$ emission and its share to 68% by 47.7% increasing PM_{10} emission according to the Table 1. Therefore the Household as family unit remained one of the biggest responsible for the SO_2 gas emission by its share as 47% and also in fields of PM_{10} and $PM_{2.5}$ emissions by the end of 2015 in Hungary.

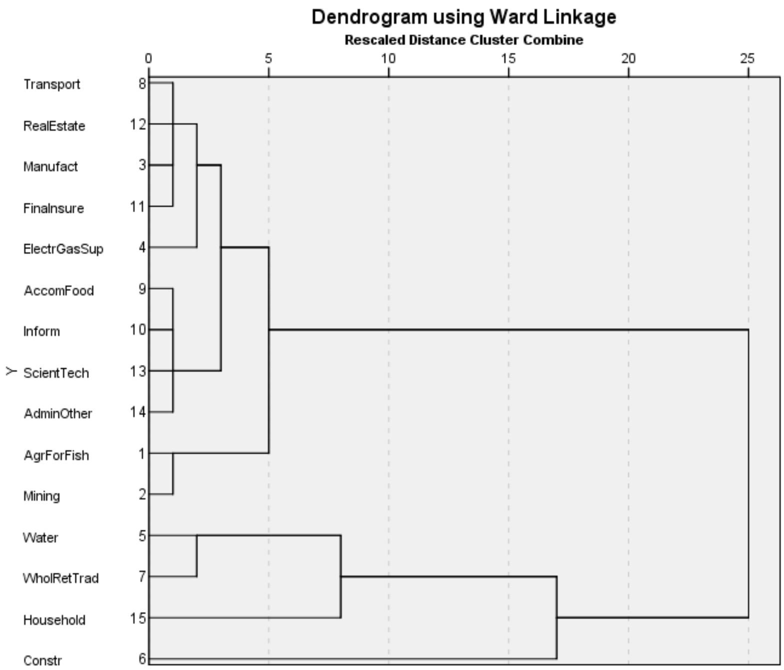

Figure 2: Dendrogram using Ward linkage. Rescaled Distance Cluster Combine

Source: SPSS system based on the Hungarian Central Statistical Office (2017): Themes - Environment: Tables (STADAT) - Time series of annual data - Environment: Air pollution data. Update: 25.09.2017. *Hungarian Central Statistical Office (HCSO)*, 2017. Available at: http://www.ksh.hu; [Accessed at: 04 September 2018].

Finally, as we know that air pollution damage the environment (i.e. acid rain), cause human diseases (i.e. lung and heart disease), and impact on climate (i.e. climate change/global warming) [29]. So, on one hand, the EU has acted at a number of levels to reduce exposure to air pollution through the EU's legislation and directive [e.g., Air Quality Framework Directive, Daughter Directives, National Emissions Ceilings Directive and the Clean Air for Europe Directive, etc.] using standards, limit values and target values, through policies and strategies, through research, through cooperation with organisations responsible for air pollution, through authorities and non-government organisations at national and regional level [30].

On the other hand, effective actions to control/reduce the effects of air pollution, needs a good understanding of their causes, how pollutants are transported and transformed in the atmosphere, and how they affect humans, ecosystems, society and the economy, as well as formulate and apply strategic policies to control/reduce the emissions of air pollutants, also, up to date knowledge of air quality status and its effect on humans, on environments and on the world's climate [6, 29].

CONCLUSION

Because of the *Household as family unit has remained one of the biggest responsible for the increasing gas and particular material emissions in Hungary,* while the SO_2 gas emission has decreased for the same period at the national level, therefore the new strategy should be followed. The new environmental conservation strategy demands from all sectors to decrease their gas emission in order to follow the sustainable economic growth accompanying with sustainable environment. Naturally the mitigation of gas and particular material emissions is important for all of the nations including the EU, therefore the international cooperation for realising this aim cannot be avoid of this cooperation and force. In spite that the SO_2 gas emission has sharply decreased, but the particular materials, as PM_{10} and $PM_{2.5}$ have increased for the period of 2000 and 2015 in Hungary, which emphasises importance of the considerable force to decrease gas and particular material emissions in order to follow the sustainable economic growth and remaining the natural environment. Also the mining, quarrying and construction have implemented considerable gas emissions for the same period, which needs for introducing new technologies for mitting the gas emissions.

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SOME ISSUES IN THE EUROPEAN UNION EMISSIONS TRADING SYSTEM

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Abstract

The present paper provides an introduction and updated background of the published information reported and discussed issued by EU Member States as a synthesis of the most contentious issues surrounding climate policy and/or climate mitigation. Climate policy is an important tool to combat the impacts of climate change caused by mankind in general. This study aims at analysing and describing of the emissions trading and the emissions taxation in the context of climate policy instruments. On one hand, it gives a good introduction to the main features of a tradable emissions system in general and of the EU Emissions Trading Scheme or Emissions Trading System (ETS) in particular. On the other hand, it summarises carbon taxes in general and of the carbon dioxide (CO_2) taxation in particular. It contributes to the existing literature in several ways, e.g., it focuses to the literature by both scientific and policy research. And also, it contributes to the literature by investigating the current policy tools and strategies regarding climate change in specific ways; on the reducing greenhouse gas (GHG) emissions especially in the EU Member States. In addition, it gives general background reviews on the climate change policies, and gives matter-of-facts presentation and references for who wishing to investigate further about climate change policy and its EU ETS. Finally, the EU ETS is a 'cap-and-trade' scheme for GHG emissions regarded as the cornerstone of the climate policy, it is a major tool aims to meet reduction targets of GHG emissions at least-cost (cost-effectively), since January, 2005. Nowadays, it operates in 31 countries (EU-28 plus Iceland, Liechtenstein and Norway), and covers about 45% of the EU's GHG emissions, and also, by 2020, it has aimed directly to cutting emissions in EU-28 by 21% compared to 2005 levels.

Keywords: *Taxation, Climate Change Policy, CO_2, GHG Reduction, Cost-effectively, 31 Countries*

1. INTRODUCTION

The most important market-based instrument in tradable permits and quotas is the ETS [1], in general, the EU ETS relies on the principle of 'cap-and-trade' as a role on economic and environmental performance of companies, also, the EU ETS acts as a main major driver of investment in clean technologies and low-carbon economy, particularly in developing countries [2]. The EU ETS was launched in 2005 as a cornerstone of EU climate policy and the key tool for reducing industrial GHG emissions in a cost-effective manner. It is the first and largest international scheme for trading emission allowances, and is open to non-EU countries on the condition that they meet the strict standards of the EU ETS [3]. With similar schemes under active consideration by a number of other countries, the share of total emissions from rich countries covered by 'cap-and-trade' or other tradable permit regimes could triple in a few years. Addressing the treatment of emission permits and offsets in both direct and indirect taxation is therefore vital [4]. The EU ETS is a 'cap-and-trade' system. It caps the total volume of GHG emissions from installations and aircraft operators responsible for around 50% of EU GHG emissions. The system allows trading of emission allowances so that the total emissions of the installations and aircraft operators stays within the cap and the least-cost measures can be taken up to reduce emissions [5]. Therefore, the primary purpose of the EU ETS is to reduce carbon emissions from power producers and energy-intensive industries [6]. Generally, the objective of the EU ETS is the mitigation of a global environmental problem [7]. Moreover, the EU ETS has changed the parameters for doing business in Europe by establishing a uniform carbon price for a large set of emitters in the power sector and energy-intensive industries. A thorough understanding of how firms respond to this policy is crucial for making informed decisions about both improvements to the EU ETS and newly implemented carbon trading schemes in other parts of the world [8]. Over the last decade the emerging global trade in carbon has become increasingly central to efforts to govern climate change [6, 9].

Carbon pricing, particularly in Europe, is achieved by a combination of ETS and carbon tax. The EU ETS is said to cover about 45% of GHG emissions in Europe. The sectors or activities not covered by the ETS should be covered in principle by the carbon tax. There is a close link between energy taxes and carbon taxes, and many European countries have reformed or are reforming their energy taxes to include a specific carbon element. Most energy taxes preceded the EU ETS and there are attempts to coordinate this system with energy and carbon taxes [10]. Nevertheless, a number of factors explain changes in ETS emissions from stationary installations during the 2005 to 2014 period. The interaction between the ETS (as an economic policy instrument) and other policies makes it difficult to identify the specific role of each factor and particularly the role played by CO_2 prices on overall reductions in ETS emissions, compared with the role of other policies [11]. Finally, the EU ETS is a ‘cap-and-trade’ scheme for GHG emissions from the 28 EU Member States and Iceland, Liechtenstein and Norway [12].

2. HISTORY AND THEORETICAL BACKGROUND OF THE EUROPEAN UNION ETS

The history of the EU ETS, which was originally known as the Emission Trading Scheme, is now longer than a decade (Table 1) [13]. An EU ETS was first introduced by Directive 2003/87/EC, which the EU Council and the European Parliament approved in October 2003 [14], this piece of legislation initially applied to a few sectors (i.e. energy activities), and to CO_2 only [15]. Later, its scope was extended to include the aviation sector with Directive 2008/101/EC [16] and subsequently the whole EU ETS scheme was revised and updated with the adoption of Directive 2009/29/EC [17], generally, the emission trading regimes can be considered the most relevant application of market solutions to environmental problems [15]. It aims to promote reductions of GHG emissions in a cost-effective and economically efficient manner [14, 12].

In the context of the global climate change negotiations, tradable emission permits have emerged as an essential policy tool [4]. Further, the EU has a range of policies to reduce emissions, promote clean energy and energy efficiency, and stimulate Europe’s transition to a low-carbon economy [18]. Furthermore, carbon pricing can persuade the most virtuous firms to invest in new technologies, with a twofold goal: firstly, to avoid purchasing costly tradable permits; secondly, to sell, and thus monetise, the available permits in excess [15]. Moreover, the EU ETS demonstrated the ability to design and launch a large-scale trading system in a short period of time. The path from initial reticence about emissions trading to implementation of the world’s largest program is an important history [19]. So, the EU ETS, as the world’s largest carbon market and as the major source of demand for international credits under the Clean Development Mechanism (CDM) and Joint Implementation (JI), is an important driver of international carbon markets and the international carbon price [5].

The EU ETS is the world’s first international company-level ‘cap-and-trade’ system of allowances for emitting CO_2 and other GHGs. Building on the innovative mechanisms (e.g., flexible mechanisms) set up under the Kyoto Protocol - international emissions trading, the CDM and JI - the mandatory system has rapidly become the dynamo behind the expansion of the international carbon market.

Table 1: Important Events in EU ETS History

Years	Important Events
2003	- EU ETS Directive adopted
2004	- EU linking Directive with Kyoto Protocol adopted
2005	- ETS Phase I (2005-2007) launched on 1 January
2007	- National Allocation Plans (NAPs) for Phase II assessed by the European Commission - Bulgaria and Romania join the EU ETS
2008	- ETS Phase II (2008-2012) begins - Norway, Iceland and Liechtenstein join the EU ETS - EU ETS aviation directive adopted
2009	- Adoption of the 2020 EU energy and climate package (Effort-Sharing Directives) with a revised ETS Directive for Phase III (2013-2020)
2011	- EC releases "Towards a 2050 Low-carbon Economy Roadmap"
2012	- Aviation included in the ETS
2013	- Beginning of ETS Phase III (2013-2020) - Croatia joins the EU ETS
2014	- Back-loading measures for auctioning EU emission allowances (EUAs) implemented - Adoption of new targets for ETS Phase IV (2021-2030)
2015	- Market Stability Reserve (MSR) approved

Source: De Paoli L. (2016): The EU Emission Trading System: For an effective and viable reform. Economics and Policy of Energy and the Environment, 1: 5-40 [13]. DOI: 10.3280/EFE2016-001001 Retrieved from: https://www.researchgate.net/publication/315969718; [Accessed at: October 2018].

Therefore, by putting a price on each tonne of carbon emitted, the EU ETS is driving investment in low-carbon technologies. It has forced the cost of emissions onto the agenda of company boards, thus marshalling the ingenuity and creativity of the business community in finding innovative and least-cost ways to fight climate change. In general, the system or the scheme is one of the EU's most important means of achieving emission reduction goals, and is based on four fundamental principles, which are as the followings [2]:

1. It is a 'cap-and-trade' system;
2. Participation is mandatory for businesses in the sectors covered;
3. It contains a strong compliance framework; and,
4. The market is EU-wide but taps into emission reduction opportunities in the rest of the world by accepting credits from emission-saving projects carried out under the Kyoto protocol's CDM and JI instrument.

In addition, a key aspect of the EU ETS is that it allows companies to use credits from the Kyoto Protocol's project-based mechanisms - the CDM and JI - to support them comply with their obligations under the system. This means the EU ETS not only provides a cost-effective means for EU-based industries to reduce their emissions but is also channelling considerable business investment into emission-reduction projects in developing countries and economies in transition. This stimulates the transfer of environmentally sound advanced technologies to these countries, giving a support to their efforts to achieve sustainable development [20].

There has been a gradual extension over time of EU policy objectives and targets relating to the reduction of GHG emissions and the transition to a low‑carbon economy. For 2020, there is a 20% reduction target for EU GHG emissions from 1990 levels, while for 2030 and 2040, 40% and 60% reductions are foreseen compared to 1990. The ultimate overall ambition is to cut the EU's emissions by 80% below 1990 levels by 2050 through domestic reductions alone [1]. Nevertheless, ETS emissions decreased by 24% compared to 2005. Emissions levels observed in 2014 were the lowest since the scheme was launched in 2005. Consequently, the 2020 target level set for stationary installations (represented by the cap in 2020) was already reached in 2014 [11]. General, the 20-20-20 targets were established using economic modelling to imply least-costs for the EU economy as a whole in moving towards a low-carbon economy [5]. Additionally, climate change and energy sustainability - reduce GHG emissions by at least 20% compared with 1990 levels, increase the share of renewable energy (e.g., wind and solar) in final energy consumption to 20%, and encourage a 20% increase in energy efficiency as strategy targets to be achieved by 2020 in Europe [21].

3. SOME ISSUES IN THE EUROPEAN UNION ETS

The EU ETS sets a cap on the total amount of CO_2 and other GHGs [Nitrous oxide (N_2O) and Perfluorocarbons (PFCs)] that can be emitted by power plants, manufacturing installations and aircraft operators in the system. In general, the cap is reduced over time so that total annual GHG emissions covered by the system decrease. Further, within the cap, companies receive or buy emission allowances that they can trade. They can also buy limited amounts of international credits from GHG emission-saving projects. Each allowance gives the holder the right to emit one tonne of CO_2 or the equivalent amount of N_2O or PFCs. In addition, after each year, a company must surrender enough allowances to cover all its verified emissions subject to the EU ETS, otherwise fines are imposed. If a company reduces its emissions, it can keep the spare allowances to cover its future needs for surrendering allowances or else sell these allowances to another company that is short of allowances [22].

During the second trading period (2008-2012), the accelerated use of offset credits and the effects of the economic crisis (which resulted in lower emissions than initially anticipated) resulted in the accumulation of a large surplus of around 1.8 billion allowances [23]. In 2014, ETS emissions exceeded the quantity of ETS emission credits (allowances) which had been auctioned or freely allocated to operators. It was the first time since 2008 that the demand for EUAs was greater than the existing supply. This was a direct consequence of the decision to postpone the auctioning of 400 million EUAs for the year 2014 (back-loading). Taking into account the additional supply of allowances resulting from the use of international emission credits generated under the Kyoto Protocol, overall supply and demand of allowances were balanced in 2014. The overall surplus of allowances (accumulated over recent years) therefore remained at a level of about 2.1 billion EUAs [11]. In addition, operators of stationary installations newly included in the scope of the EU ETS in the third trading period, which did not receive free allocations or entitlements for international credit use during the second trading period are able to use international credits up to a maximum of 4.5% of their verified emissions during the third trading period, adding another estimated 40 million units. The same holds for operators of installations that are new entrants to the EU ETS, the total effect of which will be known only once the total emissions of these installations are confirmed at the end of the third trading period [24].

Generally, in October 2014, the European Council concluded that “a well-functioning, reformed [25] ETS” will be the primary instrument with which to achieve the EU target of at least a 40 % reduction, compared with 1990, in GHG emissions by 2030 [12]. Further, in July 2015, the European Commission presented a legislative proposal for the revision [26] of the EU ETS for the period 2021-2030 (phase 4). The proposed changes include an increase in the pace of emissions cuts (the overall number of allowances will decline at an annual rate of 2.2 % from 2021 onwards, compared with 1.74 % currently) as outlined in Table (2), the better targeted and more dynamic allocation of free allowances, and several support mechanisms to help the industry and power sectors meet the innovation and investment challenges of the transition to a low-carbon economy [12].

Furthermore, the European Commission is responsible for producing a carbon leakage list of exposed sectors or subsectors, which is primarily based on both carbon cost (i.e. direct and indirect carbon costs/gross value added (GVA)) and trade intensity (i.e. imports and exports/production and imports). These indicators are updated every 5 years. The second carbon leakage list (the first carbon leakage list applied from 2013 to 2014), which applies for the years 2015-2019, was adopted by the European Commission in October 2014. Since a carbon price of EUR 30 per tonne CO_2-equivalent (CO_2-eq) was assumed for the assessment of the risk of carbon leakage, more sectors and subsectors were included in this second carbon leakage list than would have been had current carbon prices considered. The European Commission justifies the choice of a higher carbon price by the expectation that introducing an MSR will increase carbon prices in the medium and long term by managing the supply of allowances in circulation [28, 24].

Table 2: Development in phases or 'trading periods' of the EU ETS

Trading Period (Phases)	Development in phases (phase 3 and phase 4)
Trading period 2013-2020	This phase (3), running from 1 January 2013 to 31 December 2020 it's the third phase and it is now running. This longer trading period for 8 years contribute to the greater predictability necessary for encouraging long-term investment in emission reductions as well as in achievement of the EU's climate and energy targets for 2020 [2]. Therefore, major reform took effect (1.1.2013). The biggest changes have been the introduction of an EU-wide cap on emissions (reduced by 1.74% each year) and a progressive shift towards auctioning of allowances in place of cost-free allocation. Croatia joined the ETS in the first of January 2013 [27]. Here we can concluded that a major reform of the system is occurring and there is an EU-wide cap on emissions (which is reduced by 1.74% each year). Auctioning is the default mode of allocation [12].
Trading period 2021-2030	In this phase (4), just a legislative proposal [26] for the revision of the EU ETS was presented by the European Commission in July 2015 [27]. Finally, it is proposed that the cap will be reduced by 2.2% each year in this phase [12].

Source: [2, 27, 12].

Moreover, the Commission presented a legislative proposal [26] to revise the EU ETS for the next decade. Reforming and revising the EU ETS constitutes an integral part of the work on achieving a resilient Energy Union which is a key policy area in the current Commission. So, the key aspects of this proposal on the revision of the EU ETS for trading period 2021-2030 (phase 4) are: the overall number of allowances is to decline at an annual rate of 2.2% from 2021 onwards, compared to 1.74% currently; better targeted allocation of free allowances, such as update of benchmark values and more targeted carbon leakage groups; and, several support mechanisms help the industry and the power sector meet the innovation and investment challenges of the transition to a low-carbon economy. These support mechanisms including two new funds; innovation fund - extending existing support for the demonstration of innovative technologies to breakthrough innovation in industry. And, modernisation fund - facilitating investments in modernising the power sector and wider energy systems and boosting energy efficiency in 10 lower-income Member States [29].

The free allowances under Article 10c are deducted from the quantity that the respective Member State would otherwise auction. Depending on the national rules for the implementation of the derogation, electricity generators can receive free allowances of an equivalent value to the investments they carry out or have carried out from investments listed on the National Investment Plan, or to payments made into a national fund through which such investments are financed [29, 30].

In general, since 2013 (phase 3), auctioning is the default method of allocating emission allowances. This means that businesses have to buy an increasing proportion of their allowances at auction. Auctioning is the most transparent method of allocating allowances and puts into practice the principle that the polluter should pay [27]. So, for allowances allocated for free, harmonised allocation rules, which are based on EU-wide benchmarks of emissions performance, apply [12]. As well as electricity production no longer receives any free allowances. And also, an EU-wide New Entrants' Reserve (NER) is foreseen equivalent to 5% of the total amount of allowances for phase 3 (monetisation of 300 million allowances from this reserve funded NER300 programme) [29].

Additionally, for the third trading period (2013-2020), free allocation is implemented by applying new EU-wide, fully harmonised, allocation rules. Member States are still required to prepare an "allocation plan", known as the National Implementation Measures (NIMs) document which contains all of the detailed information about the allocations planned for each installation in the country. Member States remain responsible for data collection and final allocation. The Commission is responsible for approving or rejecting the NIMs or parts thereof, requiring amendments where necessary. While the NIMs determine the amount of allowances to be allocated to individual installation, the method of allocation is determined by the EU ETS Directive and implementing Commission Decision (Commission Decision 2011/278/EU [31]) "on determining transitional Union-wide rules for harmonised free allocation of emission allowances" [5]. So, on the basis of these harmonised allocation rules, governments submitted to the European Commission preliminary calculations (NIMs) of the number of free allowances to be allocated to each installation in their jurisdiction. As the preliminary allocation through the NIMs exceeded the maximum number of allowances laid down in Article 10a (5) of the ETS Directive [32, 24], a cross‑sectoral correction factor - equal to 5.73% in 2013 and rising to 17.56% in 2020 - is applied to non‑electricity generators, in order to comply with these rules. Allocations for heat production by electricity generators, in accordance with Article 10a (4) of the ETS Directive, are not subject to the above-mentioned maximum amount, and are instead reduced by the linear reduction factor of 1.74%. After applying those factors, the final allocations to installations in each country were calculated, inscribed in the national allocation tables and published on the EU Transaction Log [24, 33, 34].

Generally, GHG emissions from industry are dominated by two main sources: the first of these is GHG emissions from the direct use of fossil fuels (e.g., energy intensive industry such as cement, iron and steel); the second is the indirect use of fossil fuels via electricity consumption (e.g., air-handling, space conditioning and lighting). Smaller sources of GHG emissions in industry include 'non-energy' uses of fossil fuels, such as the use of fossil fuels as feedstocks in chemicals processing; as well as emissions from industrial processes [35]. However, since 2005, the EU ETS has been the cornerstone of EU strategy for reducing GHG emissions from industry and the power sector cost-effectively [29]. On one hand, GHGs and sectors covered by the EU ETS, which including, firstly, CO_2 from: power and heat generation; energy-intensive industry sectors (e.g., oil refineries, iron and steel, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals); and, from civil aviation. Secondly, N_2O from: production of nitric acid; adipic acid; and, from glyoxal and glyoxylic acid production. And thirdly, PFCs from: aluminium production [27]. On the other hand, the EU ETS is one of the key climate policy instruments implemented in the EU to reduce GHG emissions [22]. Additionally, The EU ETS is based on a recognition that creating a price for carbon through the establishment of a market for emission allowances offers the most cost-effective way for countries to move towards the low-carbon economy and achieve the deep reductions in global GHG emissions that are needed to prevent climate change from reaching dangerous levels [20].

As mentioned above, the EU ETS covers approximately 45% of the EU's total GHG emissions. In 2014, emissions covered under the EU ETS amounted to 1 868 Mt CO_2-eq, with stationary installations representing the largest share (97%, 1 813 Mt CO_2-eq) and the remainder being attributed to aviation activities (3%, 55 Mt CO_2-eq). Further, the EU ETS covered approximately 514 aircraft operators in 2014. The total emissions of aviation covered by the EU ETS in 2014 were equal to 55 Mt CO_2-eq. Furthermore, stationary ETS emissions decreased from 2 375 Mt CO_2-eq to 1 813 Mt CO_2-eq between 2005 and 2014. This is equivalent to a 24% decrease [11].

Since the cap for stationary installations amounts to 1 816 Mt CO_2-eq in 2020, this target level was already reached in 2014 [11]. So, in terms of the total reduction in GHG emissions, European countries are leading the global climate change mitigation effort by a wide margin [3]. Moreover, ETS emissions from stationary installations declined by 5% in 2014, compared to 2013. This decline was caused mostly by the reduced combustion of fossil fuels, where power plants play a predominant role. It was driven by a relatively mild winter in 2013 and 2014, leading to a weak demand for heating, combined with an increased use of renewables [11]. In 2016, the GHG emissions covered by the EU ETS declined by 2.9% compared with 2015. The majority of this reduction was delivered by emission cuts in large power plants, which reflects factors including the phasing out of coal use in several Member States. In the other industrial sectors, a large drop in emissions occurred in the iron and steel sector, primarily reflecting changes in output levels. In addition, the total emissions of aviation activities covered by the EU ETS in 2016, increased compared with the previous year, as the number of passengers continues to grow [36].

The European legislators recently approved the use of a MSR from 2019 onwards. The supply of allowances in circulation will be regulated by transferring surplus allowances into and out of the MSR, based upon a set of predefined rules. By adjusting the supply of allowances to be auctioned, the MSR is expected to reduce the surplus of allowances available for trading, in order to support carbon prices. Taking into account the proposed change in the linear reduction factor of the ETS cap after 2020 (in order to achieve a 43% reduction of emissions by 2030 compared to 2005), the surplus could be completely absorbed by the MSR by 2030 [11]. In general, allowances vary depending on specific industry, the relative share of free and purchased allowances, and the relative costs entailed in additional purchase [37]. The emission target of the EU ETS - the cap - is determined by the total amount of EUAs which are available to the regulated entities either through free allocation or purchases or auctions [23]. Moreover, EU allowances, necessary for compliance under the EU ETS, can be allocated to operators in several ways. The proportion of allowances to be auctioned is expected to increase every year over the period 2013-2020, which means that firms have to purchase an increasing number of allowances (via auctions/primary market sales or in the secondary market). As a consequence of the back-loading decision, the volumes of allowances auctioned in 2014 and 2015 were significantly lower than in 2013 [24]. Overall, to contribute cost-effectively to the adopted 40% reduction target by 2030, compared to 1990, EU ETS emissions will have to be reduced by 43% compared to 2005, and the annual factor to reduce the cap on the maximum permitted emissions will be changed from 1.74% to 2.2% from 2021 onwards. Applying a linear reduction factor of 2.2% from 2021 until 2050 would lead to emission reductions in the EU ETS sectors of 84% below 2005 levels in 2050 (for all countries participating in the EU ETS) [33].

Finally, the objective of the EU ETS is to help EU Member States achieve their commitments to limit or reduce GHG emissions in a cost-effective way. Allowing participating companies to buy or sell emission allowances means that emission cuts can be achieved at least cost [38]. The basic idea is that one emission allowance is needed for every tonne of GHG emissions produced [37]. In addition, since 2005 the system provides a price signal for power plants and other installations, to promote research, development and investment in clean, low-carbon technologies. So, under the revised rules which are proposed to apply as of phase 4 according to the Table 2 (2021-2030), the EU ETS will continue to be a cost-effective driver for low-carbon investments for the years to come. A stronger, better functioning European carbon market has the potential to make a major contribution to the transition to a low-carbon and more energy-secure economy in Europe. It will also contribute to the global low-carbon transition which is already underway and gaining momentum, following the adoption of the first universal climate change agreement at the Paris Conference in the end of 2015. Hence, the Paris Agreement is a legally binding international treaty. It entered into force on the 4th of November 2016, following its ratification by the EU [29, 39]. Generally, this agreement provides the basis for emissions mitigation and adaptation from 2020 onwards [40]. Ultimately, in order to achieve the goal of the Paris Agreement, parties will prepare, communicate and maintain successive nationally determined contributions [41].

Conclusion

The EU ETS is the cornerstone of the EU's climate policy strategy to reduce GHG emissions as well as its one of the key climate policy instruments in the EU to combat climate change and also, its key tool for reducing industrial GHG emissions in a cost-effective way, it was established by the Emissions Trading System or Emissions Trading Scheme Directive, launched at the start of 2005, is now in its third phase, which runs from 2013 to 2020. In addition, between 2005 and 2014 GHG emissions from stationary installations covered by the system or the scheme have shown significant decreases by 24 %. This reduction was caused mostly by the reduced combustion of fossil fuels as well as increased use of renewables. Additionally, the system covers around 45% of total GHG emissions from the EU-28 and is aimed directly at cutting emissions by 21% below 2005 levels by 2020. And also, by 2030, the EU has committed to cut emissions in EU territory by at least 40% below 1990 levels. Finally, the world's first and biggest international emissions trading system, the EU ETS has made climate change a boardroom issue for firms by putting a price on their carbon emissions [42].

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SOME ASPECTS OF CLIMATE CHANGE WITH EMPHASISING ON REDUCING GREENHOUSE GAS EMISSIONS

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Abstract

In recent decades, changes in climate have caused impacts on human and natural systems, such as human diseases and environmental problems. The aim of the present paper is to give an overview, over the past decades and up-to-date in the climate change and its impacts as well as global warming in general, it serves as an introduction assessing atmospheric concentrations of greenhouse gases (GHGs) and gives general background reviews on the environmental policies of reducing GHG emissions at international levels for the climatic and environmental changes. Influences of human on the climate and environmental systems are clearly and recently man-made GHG emissions globally are the largest in history. So, the earth's average temperature has been increasing since the industrial revolution. Therefore, meeting the Paris Agreement's climate objectives will require and needed drastic reductions in global GHG emissions and global transition towards decarbonisation of human activities, as well as moving towards a low-carbon economy of the future. At the same time, evidence of climate change impacts is clear and the problem will become more and more urgent as the GHG accumulation continues and the costs of damages and adaptation to climate change arise. So, an effective response to the climate change problem at global level requires both a concerted international response and national efforts to reduce GHG emissions as well as much more robust and effective action than it was before. Nevertheless, the EU and its Member States have decreased their emissions by 21% between 1990 and 2013, while Gross Domestic Product (GDP) has increased by 45% over the same period and thus contributed to the overall positive EU performance as well as the EU has a range of policies to reduce emissions, promote clean energy and energy efficiency, and stimulate Europe's transition to a low-carbon economy.

Keywords: *Climate Change, GHG Emissions, Environmental Policy, Global Warming,* CO_2

1. INTRODUCTION

The Earth System provides the basis for all human societies and their economic activities. Nevertheless, the 7 billion humans alive today is collectively exploiting the Earth's resources at accelerating rates and intensities that surpass the capacity of its systems to absorb the adverse effects on the environment [1]. There is unequivocal evidence that the Earth's climate is warming. Nowadays, the atmospheric concentration of carbon dioxide (CO_2), the most important and threatening GHG, is at its highest level for at least 800 000 years [2]. Scientific evidence suggests that man-made GHG emissions, especially CO_2 emissions, are a factor contributing to global climate change. This global climate change negatively impacts our Earth planet [3]. Therefore, by 2012, the average global surface temperature was 0.85 degree Celsius (°C) higher than in 1880, according to the UN Intergovernmental Panel on Climate Change (IPCC), which brings together thousands of the world's leading climate scientists. Each of the past three decades has been warmer than any preceding decade since records began in 1850 [2]. According to three different observational records of global average annual near-surface (land and ocean) temperature, the last decade (2006-2015) was 0.83 to 0.89 °C warmer than the pre-industrial average, which makes it the warmest decade on record. Of the 16 warmest years on record, 15 have occurred since 2000. The year 2015 was the warmest on record, around 1 °C warmer than the pre-industrial level, followed by 2014 [4]. In fact, over the past century, releases of gases and particulates derived from industrial processes and other human activities have led to significant changes in the composition of the atmosphere, many of which have been linked to detrimental effects on human health, ecosystems and the built environment [5].

Climate change is a global problem that people are faced with in this century. Nowadays scientists mostly agree on the fact that climate change really occurs. Every country in the world will be affected in some way by climate change [6]. The consensus among climate experts is that it is extremely likely that the main cause of recent warming is the 'GHG's emitted by human activities, in particular the burning of fossil fuels - coal, oil and gas - and the destruction of forests [2]. Therefore, the main sources of man-made GHG emissions globally are the burning of fossil fuels for electricity generation, transport, industry and households - which together account for about two-thirds of total global emissions [7]. Finally, there is a need to reduce global GHG emissions substantially to avoid the most adverse impacts of climate change. However, even with substantial reductions in GHG emissions, the climate will continue to change, and the impacts will be felt across the world, including in Europe [4]. Overall, climate change continues to be a significant threat for the future of humanity, and mitigation is needed to avert those threats as much as possible [8].

2. MATERIALS AND METHODS

The global atmosphere is at a critical stage, particularly in relation to climate change. There is considerable scientific evidence of the causes and solutions that could protect human health and ecosystems, and effective action has resulted in the achievement of some internationally agreed goals. The phase-out of ozone-depleting substances and lead in petrol by implementing relatively simple and cost-effective solutions demonstrates that, when most major stakeholders agree, significant progress is possible [1]. And also, there are significant improvements in existing fossil alternatives as well as the penetration of a number of new advanced fossil technologies, thus increasing their efficiency and performance in the longer-term [9]. Moreover, a coal phase-out would lead to a devaluation of existing coal assets, which go beyond mitigation of climate change as well as improve air quality and benefits for human health. However, a gradual phase-out of coal is needed, recognising that coal-based power generation will remain significant for a number of both developing and industrialised countries until at least 2030 [10]. Hence, to mitigate climate change, we must reduce or prevent GHG emissions [11], and policymakers must implement climate change policies in an effort to decrease carbon emission and mitigate its negative impacts. As such, several countries have implemented carbon taxes in an effort to curb the potential destruction from increasing carbon in our atmosphere [3].

In general, failure to deal with potential tax obstacles could make the desired reductions in GHG emissions excessively costly and impede the global integration of carbon markets [12]. Nevertheless, a first proposal about a CO_2 tax was drafted in 1992; although it was withdrawn five years later. Despite this failure, the same year was the inception of a global commitment on climate change: The United Nations Organisation under the Framework Convention on Climate Change (UNFCCC) involved 160 parties endorsing to adopt global agreements on climate issues. The Convention is composed of the Conference of the Parties (COP) which includes all the countries that are Parties to the Convention. The third COP adopted the Kyoto Protocol in the year 1997, which became the most important document ever drafted on climate change and are still the baseline for future negotiations [13]. So, the Kyoto Protocol is an international agreement linked to the UNFCCC and has the objective of curbing global warming [14].

Currently, the Paris Agreement on Climate Change of the UNFCCC, at the 21st COP in December 2015, is the first universal, legally binding global deal to combat climate change, mainly by reducing GHG emissions to keep the global temperature rise well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C, compared with pre-industrial levels. Having met the ratification threshold, it entered into force on the 4th of November 2016 and will be operative from 2020 [15]. Generally, to meet the Paris Agreement's goal to limit global temperature to no more than 2°C, and aim to hold warming to 1.5°C, global emissions must peak around 2020 and then rapidly decline in the following three decades, approaching zero by 2050 [16]. The magnitude of future climate change and its impacts from the middle of the century onwards depend on the effectiveness of global climate mitigation efforts [4]. In addition, Put on equal footing, the adaptation goal focuses on ability to adapt to the adverse impacts of climate change and on climate resilience, so contributing to sustainable development (Articles 2 and 7). The Paris Agreement also comprises commitments on finance flows consistent with a pathway towards low GHG emissions and climate-resilient development. Beyond that, emphasis is placed on averting, minimising and addressing loss and damage associated with the adverse effects of climate change (Article 8) and on the need to cooperate and enhance understanding, action and support in various areas such as early warning systems, emergency preparedness, comprehensive risk assessment and management, and risk insurance [15].

3. CLIMATE CHANGE AND ITS IMPACTS

The climate is changing globally and in Europe [4]. So, as mentioned by EEA climate change is already happening: temperatures are increasing, rainfall patterns are shifting, glaciers and snow are melting, the global mean sea level is increasing [11], as well as increased flood risk for urban areas and ecosystems, ocean acidification, and extreme climatic events including heat waves [7]. Hence, the Earth's climate is changing, these abnormal changing weather conditions are having an increasing impact and causing serious damage [17]. Therefore, in the longer term these changes threaten to cause serious damage to our economies and the environment we depend on, putting the lives of millions of people in danger and causing the extinction of many animal and plant species [2]. And also, in future, GHG emission and global warming will be key issues for society [18]. Generally, most of the warming is very likely due to the observed increase in atmospheric GHG concentrations as a result of emissions from human activities [11].

Moreover, one of the main issues of this century is the climate change; nowadays the scientists mostly agree on the fact that this climate change really occurs and that is a problem we need to solve [19]. And also, climate change is the most important atmospheric issue. While there is considerable concern about this complex problem, progress has been slow due to varying levels of motivation and because some low-carbon technological solutions are considered expensive. Despite attempts to develop low-carbon economies in a number of countries, atmospheric concentrations of GHGs continue to increase to levels likely to push global temperatures beyond the internationally agreed limit of 2°C above the pre-industrial average temperature [1]. Additionally, EU climate change mitigation policy aims to put the EU on track towards a low-carbon economy and to reduce EU GHG emissions by 80 to 95% by 2050. The EU is on track towards its 2020 climate targets [20, 4], but to achieve the longer term goals of the EU for 2030 and 2050 new policies and a more fundamental change are needed in the way the EU produces and uses energy, goods and services [4].

The burning of fossil fuels such as coal, oil and natural gas has a negative effect on the climate. The combustion of these fuels generates CO_2 and other GHGs. The two primary sources of GHGs are the energy and transport sectors. So, as people burn more fossil fuel they add more CO_2 to the atmosphere [21]. In general, the biggest share in the structure of final energy consumption in EU-28 in 2015 was for petroleum products (39.6%), followed by gas (21.8%) and electricity (21.7%). Solid fossil fuels contributed only 4.3% to the final energy consumption at the end-use level [22: p. 53]. Nearly 80% of the EU's emissions come from the production and use of energy, including in transport [2]. Further, global CO_2 emissions from fossil fuel combustion, cement production and other industrial processes account for about 70% of total global GHG emissions, and were estimated at a total of 35.8 Gigatonne of CO_2 ($GtCO_2$) for the year 2016. Generally, there is increasing evidence that these emissions have remained more or less stable for the past three years, reversing the previous tendency of increases each year. This may indicate a decoupling of energy- and industry-related CO_2 emissions from economic growth during these years, in which global GDP increased by between 2 and 3% annually. The main drivers have been reduced growth in coal use since 2011, especially in China and in the United States [10].

Furthermore, changes in the atmospheric concentration of GHGs, aerosols, solar radiation and land surface properties alter the energy balance of the climate system. These changes result in the greenhouse effect. The six GHGs, groups of gases or gas compounds, are namely: CO_2, methane (CH_4), nitrous oxide (N_2O) and the three fluorinated gases (F-gases); hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) [21]. In General, at global, the combined share of CH_4, N_2O and F-gas emissions is around 28% in total GHG emissions in 2016, therefore, most of the emissions consist around 72% of CO_2, while CH_4, N_2O and F-gases make up substantial shares of 19%, 6% and 3%, respectively in 2016 [23: p. 4; p. 8]. Each type of GHG has a different warming capacity, referred to as the global warming potential of the gas. CH_4 has 25 times the global warming potential of CO_2 and HFCs have more than 1 000 times the potential of CO_2 [21]. In addition, CO_2 has the lowest global warming potential of the six GHGs. However, emissions of CO_2 were far greater in the EU-28 than for any of the other GHGs even when adjusted for global warming potential [14].

Generally, human activities release large amounts of GHGs, increasing the atmospheric concentrations of these gases, which in turn enhances the greenhouse effect and warms the climate. The main sources of man-made GHGs in general are the: burning of fossil fuels (coal, oil and gas) in electricity generation, transport, industry and households (CO_2); agriculture (CH_4), agricultural soils (N_2O) and land-use changes, e.g., deforestation (CO_2); land filling of waste (CH_4); and use of industrial F-gases [11].

Recently, in 2016 [23: p. 5]; the five largest emitting countries (China, the United States, India, the Russian Federation, and Japan) and the EU, which together account for 51% of the world population, 65% of global GDP, 68% of total global CO_2 emissions and about 63% of total global GHG emissions. Furthermore, most of the large countries showed a decrease in CO_2 emissions in 2016; most notably the United States (-2.0%), the Russian Federation (-2.1%), Brazil (-6.1%), China (-0.3%), and, within the EU, the United Kingdom (-6.4%). The CO_2 emissions in the EU as a whole remained flat. While, the largest increase in CO_2 emissions in 2016 were in India (+4.7%) and Indonesia (+6.4%). In addition, emissions from international transport (aviation and shipping) constitute about 3% of global total GHG emissions in 2016 [23: p. 5].

In general, the EU has been at the forefront of introducing ambitious mitigation-related policies, and the results can already be witnessed in terms of a decline in emissions by 21% between 1990 and 2013, with an absolute decoupling from GDP that increased by 45% over the same period [5]. More recently, between 1990 and 2016, the EU reduced its net GHG emissions by 22.4% (and by 24% if emissions from international aviation are excluded). This decrease was a combined result of policies (e.g., increasing renewable energy sources and improvements in energy efficiency), economic factors (e.g., structural changes in the economy and economic crisis) and climatic conditions in general [24]. Additionally, the economic impacts depend on the levels of international energy prices, the mechanism used to recycle revenues, and country specifics such as carbon and energy intensity and the structure of energy consumption [25].

In the EU both CO_2 and non-CO_2 GHG emissions have decreased considerably since 1990 [23]. So, almost all EU Member States reduced their emissions over the past 26 years (1990-2016) and thus contributed to the overall positive EU performance [24]. Since the 1970s, the level of environmental protection in most parts of Europe has improved measurably. Emissions of specific pollutants to the air, water and soil have generally been reduced significantly. These improvements are to a substantial degree a result of the comprehensive environment legislation established across Europe, and they are delivering a range of environmental, economic and societal benefits [20]. And also, this is mainly the result of lower coal consumption from fuel switches to natural gas and increased renewable power generation. Further, coal power in the EU is replaced by increasing wind and solar power, in particular in the United Kingdom,

Germany and Italy. In addition, Table (1) shows emissions of CO_2 and other GHGs in the EU in 2016 [23: p. 32]. Overall, EEA [24] stated that emissions decreased and are expected to decrease further as GDP increases. This confirms that GHG emissions can decrease alongside an increase in GDP and that attempts to mitigate climate change do not necessarily conflict with a growing economy. GDP over the 2015-2030 period is projected to grow significantly faster than during the 2005-2015 period. Projections by Member States suggest a continued decoupling of GHG emissions alongside higher economic growth [24].
The average concentration of CO_2 in the atmosphere in 2016 reached 400 ppm, which is the highest level for at least the last 800 000 years and about 40% higher than the pre-industrial levels [4].

Table 1: Emissions of CO_2 and other GHGs in the European Union in 2016

European Union	**CO_2**	**Non-CO_2**	**CH_4**	**N_2O**	**F-gas**
Total sectors (Mt CO_2-eq)	3432	1018	553	269	196
Energy	3232	160	131	29	0
Industrial processes	189	208	1	12	196
Agriculture	7	459	254	205	0
Waste	4	179	167	12	0
Indirect and other	0	1	0	11	0

Source: Olivier J.G.J. et al. (2017): Trends in global CO_2 and total greenhouse gas emissions: 2017 report. PBL Netherlands Environmental Assessment Agency, The Hague [23: p. 32]. Retrieved from: https://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2017-trends-in-global-CO_2-and-total-greenhouse-gas-emissons-2017-report_2674.pdf; [Accessed at: October 2018].

Further, the average surface temperature has risen by around 0.8 °C since 1880 globally, but Europe's land area has warmed more, by around 1.3-1.4°C - Europe is warming faster than many other parts of the world [17, 26]. Furthermore, overwhelming scientific evidence has demonstrated the link between increasing atmospheric concentrations of GHGs and increasing global temperatures. Average temperatures have increased over the past 50 years at a rate of 0.2°C per decade, largely as a result of human activity [21]. As well as, scientific evidence suggests that an average world temperature rise of more than 2°C above the pre-industrial level - equivalent to around 1.2°C above today's temperature - will greatly increase the risk of large-scale, irreversible changes in the global environment. The international community has therefore agreed on the need to keep global warming below 2°C [2, 17]. So, the climate imperative is clear: we must act now and with ambition to decarbonise human activities in order to meet global climate goals [16].

Moreover, Climate scenarios produced by the world's leading international scientific bodies show that our window to prevent dangerous global warming is rapidly narrowing as humanity's carbon budget - the total amount of CO_2 that can be emitted for a likely chance of limiting global temperature increase - diminishes year on year [16]. As reported by IPCC's [27], without additional efforts to mitigate and reduce GHG emissions (baseline scenarios), CO_2-equivalent (CO_2-eq) concentration levels are likely to exceed 450 parts per million (ppm) CO_2-eq by 2030 and reach CO_2-eq concentration levels between 750 ppm CO_2-eq and more than 1300 ppm CO_2-eq by 2100. If this happens, than the global mean surface temperature increases of 3.7°C to 4.8°C in 2100. However, if the CO_2-eq concentrations in 2100 reaching about 450 ppm or below are likely to maintain warming below 2°C over the 21st century relative to pre-industrial levels. Therefore, mitigation leading to approximately 450 ppm CO_2-eq in 2100 are also likely to keep warming below 2°C relative to pre-industrial level [27]. So, as mentioned above, the IPCC [27] stated that the world will warm by between 3.7°C to 4.8°C by 2100 if humanity pursues a "Business-as-usual (BAU)" pathway. This level of warming, scientists agree, would be disastrous for human civilisation. To give us a better than 66% chance to limit global warming below 2°C - the scientific community's agreed upon threshold for what societies could reasonably manage - the IPCC reports that atmospheric CO_2 concentrations cannot exceed 450 ppm by 2100. This limit means that the world's carbon budget through the year 2100 is less than 1.000 $GtCO_2$-eq [27, 16]. On one hand, the latest IPCC assessment's Representative

Concentration Pathways scenario RCP8.5 (representing the highest radiative forcing) is frequently adopted as a proxy for a BAU scenario [9, 28, 5]. Based on this, emissions of GHGs will continue to increase until the end of the 21st century [5]. On the other hand, RCP2.6 is representative of a scenario that aims to keep global warming likely below 2°C above pre-industrial temperatures [27]. Additionally, climate models project further increases in global average temperature over the 21st century (for the period 2081-2100 relative to 1986-2005) of between 0.3 and 1.7°C for the lowest emissions scenario (RCP2.6) and between 2.6 and 4.8 °C for the highest emissions scenario (RCP8.5) [4].

In their report EEA's [15] mentioned that the impacts of weather- and climate-related hazards on the economy, human health and ecosystems are amplified by socio-economic changes and environmental changes (e.g., land use change and climate change). In general, impacts represent the effects on natural systems (e.g., ecosystems and biodiversity) and human systems (e.g., lives, livelihoods, health, societies, services and infrastructures) [15]. So, harmful environmental changes are taking place in an increasingly globalised, industrialised and interconnected world, with a growing global population and unsustainable production and consumption patterns [1]. Therefore, efforts to reduce disaster risk and at the same time adapt to a changing climate have become a global and European priority. The total reported economic losses caused by weather- and climate-related extremes in the European Environment Agency member countries over the 1980-2015 period amounted to over EUR 433 billion. Weather- and climate-related, hydrological, and geophysical natural hazards (Table 2) cause sizeable and growing financial and economic losses. Generally, the largest share of the economic impacts are caused by floods (38%) followed by storms (25%), droughts (9%) and heat waves (6%). On one hand, increase in the frequency and intensity of extreme weather- and climate-related events may lead to greater impacts on ecosystems and their services. On the other hand, climate change has caused noticeable effects on human health in Europe, mainly as a result of extreme events (e.g., heat waves), an increase in climate-sensitive diseases, and deterioration of environmental and social conditions [15]. Generally, changing climate patterns, population growth, rapid urbanisation, economic development and increasing use of natural resources are putting pressure on terrestrial ecosystems as never before, and virtually all of them are under stress [1]. Hence, global climate change has substantially increased the probability of various recent extreme weather and climate events in Europe [4]. Over the past decades, Europe has experienced many summer heat waves, droughts and forest fires characterised by lasting conditions of high temperatures and low precipitation. While, heavy precipitation events leading to floods and landslides, have increased and also, are projected to increase in the future.

*Table 2: Classification of 10 selected natural hazards**

Category of hazards	Specific natural hazard
Hydrological	River flood
	Landslide
	Avalanche
Meteorological	Heat wave
	Heavy precipitation
	Windstorm
	Storm surge
	Hail
Climatological	Drought
	Forest fire

Note: *some natural hazards can be allocated to more than one category (e.g. heat waves are both meteorological and climatological).

Source: European Environment Agency (2017): Climate change adaptation and disaster risk reduction in Europe - Enhancing coherence of the knowledge base, policies and practices. EEA Report No 15/2017, Luxembourg: Publications Office of the EU, 2017 [15: p. 25]; based on Integrated Research on Disaster Risk classifications [29]. Retrieved from: https://www.reteclima.it/wp-content/uploads/Climate-change-adaptation-and-disaster-risk-reduction-in-Europe.pdf; [Accessed at: October 2018].

Therefore, heavy precipitation events are projected to become more frequent in most parts of Europe [15]. Overall, GHGs emitted by human activities are warming the Earth and causing changes in the global climate. These changes are having increasingly severe human, economic and environmental impacts and will continue to do so over the coming decades [2], so, if not addressed, these impacts could prove very costly, in terms of ill health, adverse effects on the environment and damaged property and infrastructure. As mitigation cannot prevent all of the impacts of climate change, there is also a need to adapt to our changing climate [4]. The cost of not adapting to climate change is estimated to reach at least €100 billion a year by 2020 for the EU as a whole [17]. In addition, large-scale reductions of GHG emissions can only be achieved, however, through a tightly coordinated and coherent combination of different policies targeting different economic sectors and sources of emissions [1, 30].

Due to the diversity of production processes and energy end-uses, there are numerous mitigation options for the industrial sector. Some options are generic and sector wide (e.g. improvements in electric motor driven systems) and some are specific to a certain production process (e.g. for iron and steel or cement). Therefore, GHG emissions can be reduced by: increasing renewable energy sources and improvements in energy efficiency; fuel switching to energy sources with lower emissions (e.g., natural gas, biomass, low carbon electricity); power recovery through co-generation, pressure recovery turbines, gasification, etc.; waste minimisation, recycling and recovery; product change and substitution; and, CO_2 sequestration. Further, more fundamental technical changes will be needed in the long term after 2020, when energy efficiency and fuel switching are exhausted. Such long-term technical options include, e.g., new types of cements/concretes, and hydrogen from renewable sources for reducing iron ore or for producing nitrogen fertilisers [31]. Generally, there are different basic ways to reduce emissions, for example, changing the structure of economic growth; increasing energy efficiency through technology or lifestyle changes; and, changing energy supply including using zero-carbon energy options [1].

Furthermore, CO_2 removal remains an important set of undertakings following the Paris Agreement, to supplement immediate and aggressive mitigation action. In order to achieve the goals of the Paris Agreement, to keep the global mean temperature increase well below 2°C (or even below 1.5°C), CO_2 removal is likely a necessary step. So, CO_2 removal from the atmosphere can provide an additional mitigation element to conventional emission abatement strategies. Biological CO_2 removal through afforestation, reforestation, forest management, restoration of degraded lands, soil carbon enhancement and biochar application in agriculture can play an immediate role, and can also significantly contribute to achieving several other Sustainable Development Goals [10]. Moreover, the inherent limitations of “end of-pipe” solutions such as carbon capture and storage re-enforce the need to reduce GHG and exploit alternative management options for CO_2, especially in the circular economy. Additionally, the world is on a new course to combat climate change and unleash actions and investment towards a low carbon, resource-efficient, resilient and sustainable future. At the same time, the 2030 Agenda for Sustainable Development provides a clear pathway to a world in which everyone can enjoy prosperity within the ecological limits of the Earth planet [5].

In general, from the above mentioned, climate changes are a latent issue which has to be addressed in a correct way in order to mitigate it; to have a climate policy is important to work against the effects of climate change which have been caused by human activities [19]. On one hand, six specific categories of measures have the potential to reduce emissions between 15 to 22 $GtCO_2$-eq/year in 2030, which is more than half of the total emission reduction potential. These categories include solar and wind energy (renewable energy sources), efficient appliances, efficient passenger cars, afforestation and stopping deforestation [10]. On the other hand, for economists, the obvious choice is to move toward market-based environmental mechanisms that put a price on GHG emissions. The two main approaches are a carbon tax and a cap-and-trade system of marketable permits for emissions [32]. The use of market-based policy instruments at national and international levels can support environmental objectives at least cost to the economy, as well as to control GHG emissions. Therefore, climate policy is important to combat the effects of climate change caused by mankind [6]. An important policy principle suggests that it is more efficient to promote practices that do not damage the environment rather than spending on cleaning up after a problem has been created [33]. Overall, the prospect for improving human well-being in general is critically dependent on the capacity of individuals and countries as well as the global community to respond – through mitigation and adaptation – to climatic and environmental changes [1, 34]. In addition, responses to climate change mitigation and adaptation have both direct and indirect health benefits; for example, burning fewer fossil fuels reduces respiratory diseases and active transport, while walking and cycling cut pollution and road traffic accidents and reduces rates of diabetes, heart disease and stroke as well as reduces rates of obesity [35, 5].

Ultimately, climate change is one of the key drivers of global environmental change and has far-reaching consequences [36]. So, climate change impacts are projected to increase in future years, which may result in major environmental changes as well as economic and social difficulties. The scientists mostly agree that further increase in the emission of harmful GHGs will result in global warming and would cause more damage than ever before in the climate system and that is a problem we need to solve. Finally, reaching climate stabilisation of the world economy must be totally transformed in a climate friendly and sustainable manner, as well as people should have much more aware of and concerned with environmental issues and more willing to act in environmentally responsible and friendly ways.

CONCLUSION

Anthropogenic GHG emissions have increased since the pre-industrial era, driven widely by increasing numbers of the population, economic structure, human activities and economic growth and causes of the environmental pressures, influences and challenges. Influences of human on the climate and environmental systems are clearly and recently man-made GHG emissions globally are the largest in history. Recently, CO_2 concentrations in the atmosphere reached 400 ppm, which representing the highest levels in 800 thousands of years. Further, as included in the IPCC reports if the atmospheric CO_2 concentrations in 2100 reaching approximately 450 ppm or below are likely to maintain warming below 2 degrees Celsius over the 21st century relative to pre-industrial levels. This limiting will require significant and sustained reductions in GHG emissions at global levels. And also, there is an urgent need to address the underlying drivers of the human pressures and influences on the climate and environmental systems. At the same time, scientists from all over the world are realising that the Earth is becoming warmer than ever before. Nowadays, the almost share of these scientists is concerned that rising temperatures are closely related to the use of fossil fuels and anthropocentric GHGs, particularly CO_2. Nevertheless, in the EU GHG emissions have decreased considerably since 1990. So, almost all EU Member States reduced their emissions compared with 1990 and thus contributed to the overall positive EU performance.

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LEGISLATIVE FRAMEWORK OF CLIMATE CHANGE IN THE REPUBLIC OF SERBIA

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Abstract

The struggle against climate change is one of the priorities in the policy of the international community. In this paper the authors have analyzed legal framework relevant for the protection of climate change in the Republic of Serbia. In the Republic of Serbia, the energy sector is the largest source of greenhouse gasses, but it is also the sector with the greatest potential for the application of mitigation measures. The country has already established important components of the institutional and legal framework for the purposes of the struggle against climate change. At the same time, there remains a need for further harmonization of national legislation with international trends in the field of climate change, as well as with the obligations arising from ratified international documents and the process of European integration, as well as capacity and knowledge building within relevant and competent institutions both at national and local levels, but also at the level of general public. Within the Republic of Serbia the obligations towards the European Union in the field of climate change, further alignment with European Union policies, are necessary such as objectives 20-20-20 and requirements for monitoring and reporting.
Keywords*: climate change, legal framework, European Union, Republic of Serbia.*

1. INTRODUCTION

In recent decades, the data on average annual temperatures have shown an alarming situation, as until 2012, the temperature rose by 0.8% compared to the pre-industrial period, but in the past thirty years there were recorded the highest temperatures in the last 1.400 years. The growth rate of average global temperature has increased to 0.1°C per decade and in the past 10 years up to 0.2 °C per decade [1]. Average annual temperatures at the European level in the past 50 years have grown faster than the global average. The measured medium increase in temperature annually is 1.4 °C. The projections for the end of the 21st century show an annual increase in temperature from 2.1°C to 4.4°C, while in the Southern Europe the temperature may locally rise up to 6°C [2].

Global climate changes are reflected in the climatic characteristics of the geographical area of the Republic of Serbia, so that, based on measuring of the Republican Hydro-Meteorological Service of Serbia (RHMS), there was observed a positive trend of temperature [3, 4, 5]. The increase amounts up to 0.04°C per year, while in some areas in the east and southeast Serbia a negative trend of -0.05°C was recorded. The highest temperature rise was recorded in autumn [6].

The state of the climate system that includes statistical description of its variations in period from few months to few millions of years is defined as **"Climate"** [7]. The term '**climate change'** refers to changes caused by the presence of greenhouse gasses (GHG) whose presence is solely linked to *human activities* (Intergovernmental Panel on Climate Change (IPCC).

According to the data of the IPCC, the most important source of GHG emissions is electricity and heat production with a share of 25% in total emissions of GHG, followed by agriculture, forestry and other land use (AFOLU) with 24%, industry 21%, transport 14%, buildings with 6.4%, and other energies which refers to all GHG emission sources in the energy sector other than electricity and heat production with 9.6% [8].

The world concentrations of the CO_2 in the atmosphere have been constantly increasing since the period of the industrial revolution. The data indicate that the CO_2 emission with 910 $GtCO_2$ for the period of 1750-1970 increased to 2000 $GtCO_2$ for the period of 1740-2010. A noticeable increase was recorded in the period from 2000-2001. In this period, GHG emissions rose by an average of $GtCO_2$ eq/year, while for the period from 1970-2000 the increase was 0.4 $GtCO_2$ eq/year [1].

In the Republic of Serbia the most common gas of GHG is carbon dioxide (CO_2) [9]. The main GHG 2014 was carbon dioxide (CO_2), accounting for 79.7% of total GHG emissions [10]. According to the International Energy Agency (IEA), the Republic of Serbia emits about 60 million tons of CO_2 per year. Out of this, production of electricity from the two largest lignite depots in Kolubara and Kostolac emit about 40 million tons of CO_2 [11].

In this paper legal frameworks relevant for the protection of the climate change within the Republic of Serbia borders are discussed.

2. BACKGROUND

In the recent decades, climate change, one of the greatest environmental, social and economic threats has taken great attention of the scientific and political public. Great efforts have been invested in the creation of policies that would affect the reduction and mitigation of climate change as climate change represents a global risk which requires a reaction on the global level.

The United Nations (UN) globally directs the activities in the field of climate change. United Nation Framework Convention on Climate Change (UNFCCC) was adopted in 1922 at the Earth Summit in Rio de Janeiro in Brazil, as the first step towards solving this problem [12]. The main objective of the UNFCCC is to stabilize concentrations of GHG at a level that would prevent negative anthropogenic interference with the climate system.

In addition to UNFCCC, in December 1997 in Kyoto, the Kyoto Protocol was adopted aiming to achieve better implementation of this Convention [13]. The Kyoto Protocol sets emissions targets for developed countries which are binding under international law. The main objective of the Kyoto Protocol is to reduce global anthropogenic GHG emissions by at least 5% compared to 1990 levels, in the first commitment period, 2008-2012. The peculiarity of the Kyoto Protocol is that it established three main mechanisms for realizing the stated objectives: *joint implementation* – JI (Art. 6), *clean development mechanisms* – CDM (Art. 12) and *emissions trading* – ET (Art. 17).

In addition to the Kyoto Protocol (and its amendment) and the Paris Agreement, parties to the Convention agreed to further commitments during UNFCCC Conferences of the Parties. The 21st regular annual session of the UNFCCC and the 11th meeting of the signatories of the Kyoto Protocol is the 21st Conference of Parties – COP21, held in Paris from 30 November to 20 December 2015. The Paris Agreement is a new global legally binding agreement on climate change for the period after 2020.

The Paris Agreement includes a plan for action in order to limit the global temperature increase at less than 2°C. While the long-term goal of the governments is the agreement to keep a level of global temperature at a level less than 2°C compared to the pre-industrial level and will make efforts to limit the increase to 1.5°C. In addition to reducing emissions (mitigation), the Paris Agreement also includes other key issues, or adaptation to changed climatic conditions (adaptation) and financing of mitigation and adaptation in the developing countries, as well as capacity building and development and transfer of technology. The Paris Agreement entered into force on November 4, 2016, i.e. after its ratification by at least 55 member states of the Convention, which makes up at least 55% of global emissions of GHG.

The obligations of the Member States of the UNFCCC within the Paris Agreement are determined by the objectives of reducing GHG emissions the countries submitted as a preparation for the Conference (Intended nationally determined contributions-INDCs). The Republic of Serbia submitted its reduction target for 2030 in relation to 1990, which is 9.8% [14].

2.1. EU Political and Legislative Framework

Activities in the struggle against climate change and mitigating their effects have been identified as priorities in the EU [15]. Ever since 2007, the EU integrally regulates the fields of climate and energy through "EU climate and energy package" which includes a set of binding legal instruments in this field. The objectives of the "20-20-20" set three key objectives for the EU by 2020: reducing emissions of GHG by 20% compared to 1990 levels, increasing the share of energy consumption from renewable sources to 20% and increasing energy efficiency by 20%. These targets were set in 2007 in order to make Europe a highly energy-efficient economy with low carbon emissions, and they were adopted through climate-energy packet in 2009. After the Renewable Energy Directive, Member States have taken binding national targets for increasing the share of renewable sources in its energy consumption by 2020. National targets, which range from 10%-49% (10% in Malta to 49% in Sweden) will enable the EU as a whole to reach its goals for renewable energy sources by 2020. In addition to this, these objectives will contribute to reducing emissions of GHG and reduce the EU independence on imported energy. The element of the climate-energy package is a directive that creates a legal framework for the environmentally safe use of technology for capturing and storing carbon (CSC).

In October 2014, the EU leaders reached an agreement on a political framework for 2030 in the field of climate and energy which should make climate and energy system of the EU prepared for the future and keep Europe competitive and safer which will enable progress in achieving economic development with low carbon dioxide emissions. 2030 climate and energy framework sets three key targets for the year 2030. The first key objective of the framework is the obligation of reducing emissions of GHG at the EU level by 2030 for at least 40% below 1990 levels.

This objective should enable the EU to find itself on the profitable path to fulfilling the universal goal of reducing emissions by at least 80% by 2050. To achieve the target of 40%, the sectors that fall under the EU ETS system should reduce emissions by 43% compared to 2005. The emissions of the sectors not included in the EU ETS should reduce emissions by 30% compared to the 2005 level, which should be transferred to national objectives as well. The framework helps driving progress towards a low-carbon economy and builds an energy system that ensures affordable energy for all consumers, increases the security of the EU's energy supplies, reduces EU dependence on energy imports and creates new opportunities for growth and jobs. It also brings environmental and health benefits – e.g. through reduced air pollution. In addition to this, EU ETS will be reformed and improved.

The *EU Roadmap* [16] to 2050, towards an economy with *low emissions.* The European Commission is considering cost-effective ways to adapt the European economy to climate change [17].

By 2050, the EU predicts to significantly reduce the majority of emissions of GHG. The *Roadmap* to 2050 is a set of planning policies which should enable sustainable use of resources at the EU level. Clean technologies play an important role.

The Roadmap indicates that by 2050, the EU at the national level should reduce emissions by 80% compared to 1990 levels. By the way, a greater use of clean technologies will drastically reduce air pollution in European cities.

3. DISCUSSION AND RESULTS

Cooperation with the UN aims at strengthening the institutional and human capacities in the Republic of Serbia in the area of climate change. The Republic of Serbia ratified UNFCCC in 2001 [18] and Kyoto Protocol in 2008 [19] and ever since it has established its legal, institutional and political framework aimed at fulfilling the obligations arising from the Convention and the Protocol.

As a non-Annex and Member State to the UNFCCC, the Republic of Serbia is under no obligation to reduce emissions of GHG, but it submits information on emissions and removals of GHG, as well as information on the activities undertaken in order to implement the Convention and activities aimed at integrating climate change issues into the broader planning of country's development.

The Republic of Serbia reports on their activities aimed at fighting climate change and changes and adjustments (adaptation) to changed climate conditions. Initial National Communication (INC) of the Republic of Serbia to the UNFCCC, as an important national strategic document was published in 2010. INC gives an overview of activities in the field of climate change, including information on current and expected levels of greenhouse gasses, the possibilities and ways to reduce it, on the monitoring, reporting, and verification, as well as about the flaws and needs. The INC contains concrete and adaptive measures for certain sectors, although it does not list institutions responsible for the proposed measures or stated deadlines for their implementation. The Second National Communication Report of the Republic of Serbia to the UNFCCC, include an inventory of GHG, as well as screenings and action plan to mitigate climate change by 2020.

Ministry of Agriculture and Environmental Protection (MAEP) published the First Biennial Updated Report (FBUR) of the Republic of Serbia to UNFCCC in February 2016 [20]. The FBUR provides the Republic of Serbia obligations towards UNFCCC, national characteristics of the Republic of Serbia, the inventory of GHG, emissions projections up to 2020, the activities for their reduction, monitoring, reporting, verification and gaps and priority needs. In the FBUR of the Republic of Serbia to UNFCCC, inventories of GHG have been revised and improved (including GHG inventory for 1990), and the GHG inventory for the period 2010-2013 was prepared. Also, there was published the FBUR with the results that the inventory of the GHG for the period of 2010-2013 is prepared as well as an action plan for mitigation by 2020, and promoted national system of monitoring, reporting, and verification.

Today, the Ministry of Environmental Protection (MEP) is responsible for climate change issues. The Republic of Serbia submitted the Second National Communication (SNC) under the UNFCCC on October the 23rd, 2017. The goal of the Second National Communication (SNC) of Republic of Serbia under the UNFCCC, is to prepare GHG inventories, to carry out the assessment of mitigation measures and the action plan of mitigation up to 2030 and 2050, to analyze the vulnerability of sectors and systems and adaptation to changed climate conditions, especially in the sectors of agriculture, forestry and water resources, to strengthen national capacities for the implementation of the Convention, and to involve the problem of climate change more effectively into all sector and national priorities. The data given in the SNC was used in the development of the Climate Change Strategy with the Action Plan [21]. The Program for the Implementation of the Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030, for the period 2017-2023, was adopted in October 2017. In the Republic of Serbia, the energy sector is the largest source of GHG, but it is also the sector with the greatest potential for the application of mitigation measures.

3.1 Projections of the Total GHG Emissions

Although adaptation to climate changes in the past few years has been the focus of scientists and politicians, because the IPCC reports have shown that climate change and their effects cannot be stopped in the short term. It is necessary to develop specific adaptation systems, i.e. adaptation to emerging climate conditions [22]. Adaptation strategies are needed at all levels of administration, from the local to the international level.

The Serbian Agency for Environmental Protection developed the 2000-2014 national GHG inventory [23]. Based on the GHG inventory, in 2014 estimated total emissions in the Republic of Serbia without removals were 67,148.23 Gg CO_2eq. Since 2000, total GHG emissions without removals have increased by 7.8%. In 2014, the total GHG emissions with sinks were 49,299.24 Gg CO_2eq, which is a 2.4% increase compared to 2000. Emissions from the **energy sector** have the largest share (80.0%) in total emissions in 2014, which is a slight increase of 0.8 % compared to 2000. The second largest GHG emitting sector is the Agriculture, Forestry and Land Use (AFOLU) [10]. Due to lack of data for 2014 caused by disastrous floods, the data collection system has not been complete. Thus, the GHG inventory will have to be updated in the near future [**MEP]**.

In metodology, estimations of the total GHG emissions and GHG emissions for sectors were made through three scenarios: a baseline scenario, scenario "with measures" and scenario "with additional measures". The estimations were made by 2030, with a cross-section in 2015, 2020 and 2025. The year 2010 was chosen as a starting point. The LEAP (Long range Energy Alternatives Planning System) model was used for developing all projections.

The basic scenario implies implementation of policies and measures that were in force in 2010, until 2030. The scenario "with measures" entails improving the implementation of the existing policies and measures to be in accordance with the commitments under the EU accession process. The scenario "with additional measures" implies a further reduction in final energy consumption.

In order to achieve consistency and compliance of projections for 2020 and 2030, in preparation of the three scenarios (for total emissions and emissions per sector) the same assumptions were taken into account as those used for drafting of the FBUR of the Republic of Serbia to the UNFCCC. Some of the reporting priorities to the UNFCCC include: projection improvements, the definition of specific activities for reduction of GHG emissions, reducing emissions estimates by gases and the monitoring of the GHG emission reduction potential.

Levels of total GHG emissions in 2030, including 2015, 2020 and 2025, determined on the basis of three scenarios (baseline scenario, the scenario 'with measures" and scenario "with additional measure"), are summarized in Table 1.

Table 1. Levels of total GHG emissions in 2030, including 2015, 2020 and 2025, for three scenarios, Gg CO_2eq [10]

Total emissions ($Gg\ CO_2\ eq$)	**2015**	**2020**	**2025**	**2030**
Basic scenario	70,783.23	79,442.37	80,661.99	87,099.71
Scenario "with measures"	68,410.42	70,966.54	70,749.05	75,293.72
Scenario „with additional measures"	66,015.15	65,164.09	63,475.53	67,613.66

Trends of total GHG emissions in the period 2010-2030 developed from the three scenarios are presented in Figure 1.

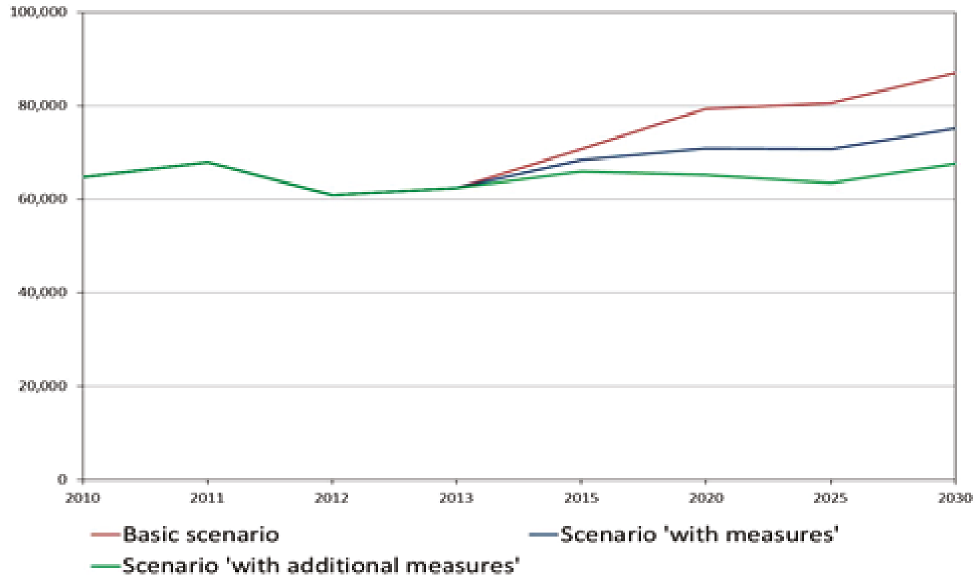

Figure 1. GHG emission trend in the period 2010-2030 for three scenarios, Gg CO2eq [10].

According to SNC data, in 2030, if applying the scenario "with measures" GHG emission will decrease by 14.37% compared to the basic scenario, and by 23.50% under the scenario "with additional measures".

In 2012, the Republic of Serbia identified NAMAs and submitted to the NAMA Registry projects that were taken into consideration during the development of scenarios "with measures" and "with additional measures (Figure 1)

Estimated reduction in total GHG emissions by 2050, like in the case of projections made by 2030, relied on three scenarios: a basic scenario, a scenario "with measures" and a scenario "with additional measures" (Figure 2). The year 2010 was chosen as a starting point for projections, and was used LEAP model.

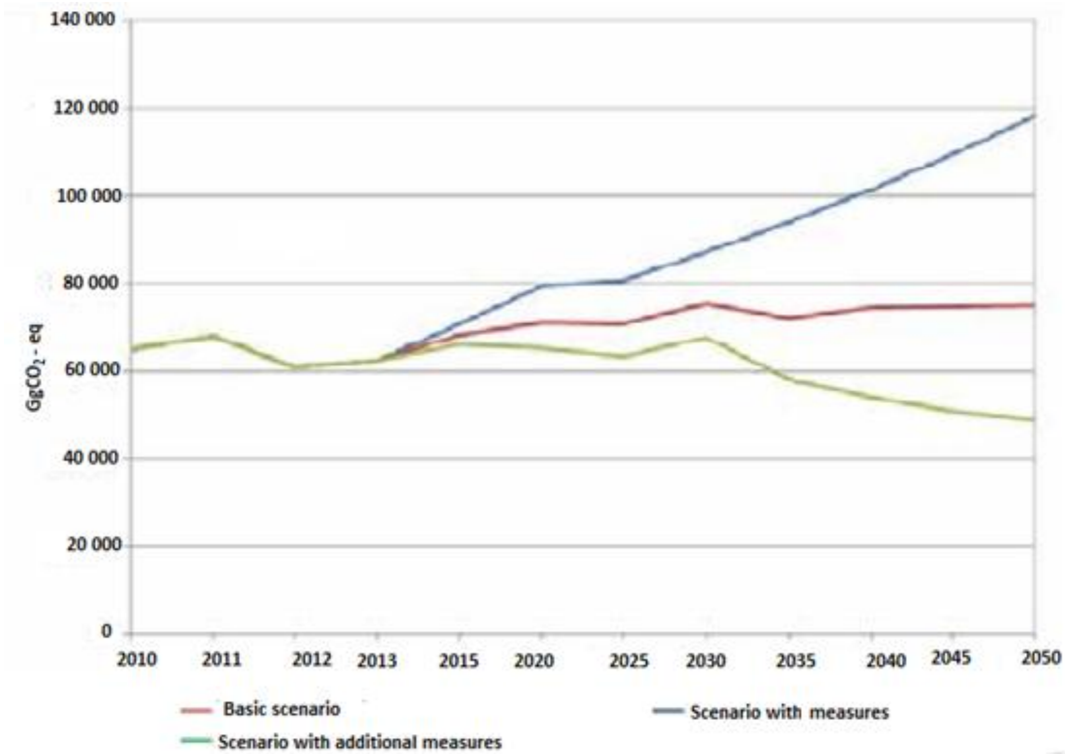

Figure 2. Emission projections of greenhouse gases in the Republic of Serbia by 2050 [10].

The first estimates have shown a reduction in GHG emissions by 35% if applying the scenario "with measures' compared to the basic scenario and by 49% under the scenario "with additional measures". According to the scenario "with additional measures", emissions in 2050 will be 42% lower than 1990 emission levels and 22% lower than 2013 emissions [10].

3.2 Activities in the field of Climate Change

Specific activities that will ensure the reduction of GHG emissions were identified through the Nationally Appropriate Mitigation Actions (NAMA) projects.

In addition, there was established a Central Registry of Energy Passports (CREP). The HMSS, where the center is located, has significantly improved its capacities so that today it is one of the key institutions for the monitoring of climate change, as well as for planning adaptation. However, the level of knowledge and quality of data on climate change has significantly promoted the formation of the South East European Virtual Climate Change Center-SEEVCCC within the Republic Hydro Meteorological Service of Serbia was established (2008).

Activities in the field of climate change, especially adaptations have not been developed on the local level so far so that the availability of information on locally specific consequences of climate change is very limited.

As a non-Annex and Member State of the Convention, the Republic of Serbia has access to the Clean Development Mechanism (CDM). In accordance with the obligations, there was established a National Authority for the implementation of the CDM of the Kyoto Protocol (DNA). So far, there have been registered seven CDM projects in Republic of Serbia.

Following new features to combat climate change under the auspices of UNFCCC, the RS has developed (NAMA). The Republic of Serbia supported Copenhagen Accords and in 2012 identified 12 NAMA actions, seeking support for their implementation. The concept of nationally adjusted mitigation actions is one of the key components of climate change mitigation at the international level and it involves policies and actions to reduce emissions of GHG, in accordance with their capacities and different responsibilities.

In the context of the EU accession, and in order to implement Directive 2009/29/EC on the system of emission trading, there was established a system for monitoring, reporting, and verification (MRV) indispensable for the successful implementation of the EU ETS [24]. This requires implementation of the legislative and institutional framework for the implementation of the Directive. So far, there were prepared a preliminary list of installations falling under the EU ETS, preparation of relevant laws and regulations necessary for full implementation of this system; there was also made an estimate of possibility of transitional measures to comply with the system, cost analysis for the energy sector and the implementation plan for stationary equipment and airline operators for the period prior to EU accession. The law on the system of monitoring, reporting, and verification needed for EU ETS, which should introduce the obligation of monitoring, reporting, and verification of data on GHG emissions from industrial and power plants, has not been adopted. The transposition of the Directive on Emissions Trading in our legislation and transposition of the Directive 2009/31/EZ on the Geological Storage of Carbon Dioxide have not started yet.

The Republic of Serbia has enacted laws and by-laws that are important to mitigate climate change, arising from obligations in the process of EU integration. Within the Republic of Serbia obligations towards the EU in the field of climate change, further alignment with EU policies is necessary, such as objectives 20-20-20 as well as requirements for monitoring and reporting.

Conclusion

Despite the activities and efforts to establish a systematic, permanent and functional system required for efficient UNFCCC reporting, capacity building and financial resources, as well as bilateral and multilateral cooperation and assistance will be necessary. Since it belongs to the developing countries (non-Annex I countries), the Republic of Serbia is not obliged to reduce GHG emissions, nor it is obliged to submit regular reports to the Conference of the Parties to the Convention, which includes the assessment of the sector and the system to changed climate conditions, calculations of GHG emissions, proposed measures of mitigation, as well as including the problem of climate change into sector and national development strategy.

In its NSC of the Republic of Serbia to UNFCCC, as an important national strategic document, among other things it was noted that the **energy sector** is the largest source of GHG, but it is also the sector with the greatest potential for the application of mitigation measures.

The introduction of reporting after the UNFCCC has significant implications for strengthening of technical and institutional national capacities in the field of climate change. However, although it is strongly committed to the implementation of the Convention, the Republic of Serbia is faced with many restrictions such as lack of capacity and lack of complete operational system for monitoring, reporting, and verification (MRV) activities in the field of climate change. However, as a non-Annex I Member State of the UNFCCC, the Republic of Serbia has access to CDM and so far, there have been CDM projects in the Republic of Serbia through which industrialized countries (Annex I countries) invest in projects that contribute to sustainable development and the reduction of GHG emissions in the developing countries (non-Annex I countries).

In addition, the Republic of Serbia has developed NAMA projects. But there is comprehensive strategic document dealing with climate change in the Republic of Serbia. Activities in the field of climate change, in particular, adaptation have not been developed at the local level in the Republic of Serbia yet so that access to information on locally specific consequences of climate change is very limited.

Significant progress in the struggle against climate change began with the process of the Republic of Serbia integration in the EU and harmonization of its national legislation with the EU laws, especially bearing in mind that the basic principles of the EU legislation are based on the struggle against climate change. Preparations for harmonization of legislation in the field of trade with emissions show progress with the support of Instruments for Pre-accession Assistance (IPA).

Since it is necessary to assign priority to the establishment of a system for monitoring, reporting, and verification (MRV) of GHG emissions, the Republic of Serbia has initiated and implemented IPA projects and activities. Another important initiative relevant for the establishment of MRV is the establishment of the monitoring, reporting and verification system required for successful implementation of the European Union Emission Trading System (EUETS). This System will secure collection of data on GHG emissions at the level of industrial and power plants. The establishment of a complete MRV system is expected in 2019.

In the end, we can conclude that the Republic of Serbia has established some important components of the institutional and legal framework for the purposes of the fight against climate change. At the same time, there remains a need for their improvement, as well as capacity and knowledge building within relevant and competent institutions both at national and local levels, but also at the level of general public.

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POTENTIAL IMPACTS OF CLIMATIC CHANGES ON THE TOURISTIC ACTIVITY SECTOR IN LIBYA: A REVIEW AND FUTURE RESEARCH

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Abstract

This study showed the effect of climate on tourism sector especially for the beach, nature and winter sport tourism segments. Climate change at tourist destinations and generating countries can significantly affect the tourist's comfort and their travel decisions. Changing demand model and tourist flows will have impacts on tourism industry, host communities and knock off effects on related sectors, like, agriculture, handicrafts or construction. There is a need for local, region and global cooperation so that the businesses and individuals in the tourism sector will be able to adapt to weather changes. The tourism industry has to adopt measures so that natural resources are protected. These measures should also contribute to the protection of the global environment. The vast lands of Libya have been settled by many civilisations across its history, including the Phoenicians, Greeks, Romans and Arabs amongst others. They have left some amazing ruins of their ancient cities, most notably the Roman ruins at Leptis Magna, one of the most impressive such sites in the world. Away from the lush Mediterranean coast lie the harsh but dramatic landscapes of the Libyan Desert, with the picturesque Acacus Mountains and Ubari Sand Sea as well as ancient desert towns and fascinating rock art paintings. Libya is well off the main tourist trails of North Africa and receives only a fraction of the visitors of its neighbours which, combined with its many attractions, makes it an ideal travel destination. These factors make Libya a centre of tourism in Middle East. There is now a wider recognition of the urgent need for the tourism sector to adapt to the climate changes and to take preventive actions for future effects, as well as to mitigate tourism's environmental impacts contributing to climate change.

Keywords*: Touristic activity, impacts of climatic changes, Libya, economic sector.*

1. INTRODUCTION

Tourists are attracted to Libya's climate, extensive long beaches on the Mediterranean Sea, and the wonderful Greek and Roman ruins. Globally, the tourism sector is one of the largest and fastest growing global industries and is a significant contributor to national and local economies around the world. Because tourism is strong connected with the natural environment, it is very sensitive to climate change. The tourism sector has a key role to play in confronting the challenges of climate change. Climate change can affects the touristic sector especially in mountain and coastal regions. Also, the tourism sector is contributing to greenhouse gas emissions (GHG) through the transport of tourists.

The tourism sector is characterized by large diversity and a fragmented structure. While varied conceptualizations of the subsectors e.g., transportation, accommodation, food and hospitality services, travel agents and tour service operators, visitor attractions and tourist focused retail or service suppliers. Touristic operators differ in terms of ownership, size and purpose and also they have adapted to provide tourism services in every climatic zone from deserts and high mountains to the Tropics and Polar Regions. Due to these variations, there are extensive varied in the nature of climate sensitivities and abilities of global touristic operators to incorporate climate services into decision-making.

2. CLIMATE CHANGE AND TOURISM SECTOR

This study review shows the impacts of climatic change on tourism based on reports of the World Tourism Organization (UNWTO), the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), the information for the 2nd International Conference on Climate Change and Tourism (Davos, Switzerland, 13 October 2007). The study offers the impacts of climate change on the global tourism sector, likely suggestions for tourist request, current stages and trends in GHG emissions from the tourism sector. The Intergovernmental Panel on Climate Change (IPCC) [1] showed that 'warming of the climate system is unequivocal.' The global mean temperature has increased approximately 0.76°C between 1850–1899 and 2001–2005 and the IPCC [1] mentioned that most of the recognized increase in global average temperatures since the mid of the 20th century and the result of human activities that are increasing GHG concentrations in the atmosphere. The impacts of human activities influences on climate, including ocean warming, continental average temperatures, temperature extremes and wind patterns [1]. The general drops in glaciers and ice tops and warming ocean surface temperature have contributed to raise the level of sea of 1.8 mm/year from 1961 to 2003, and roughly 3.1 mm/year from 1993 to 2003. The IPCC proved that the pace of climate change is accelerated with continued GHG emissions at or above current rates, with the best estimate that globally be around surface temperatures will raise by 1.8°C to 4.0°C by the end of the 21st century [1]. The magnitude of climate change probable for the 21st century on the environmental and economic risks of is featured obviously in recent international policy discussions [2-4]. It is clear that the climate change will become gradually as changing subject which influencing the tourism development and management [5-10].

Gössling [11] mentioned that the biological response to this continued warming and sea level rise (Figure 1) would continue for several centuries [1] one of the Libyan coast. With the close relations between the environment and climate, tourism is imitated to be a highly climate sensitive economic division similar to agriculture, insurance, energy, and transportation [12]. The tourism sector is a non-negligible contributor to climate change through GHG emissions resulting from the transport and accommodation of tourists [9, 13].

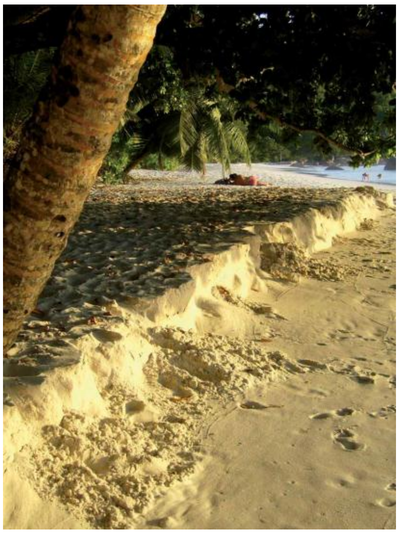

Figure 1. Coastal Erosion can be Caused by Sea Level Rise, Environmental Change or a Combination of Both'. Sourse: Gössling, S. (2008). Hypermobile travellers. In Gössling, S. and Upham, P. (eds) Climate Change and Aviation. Earthscan, to appear 2008. [11]

Tourism must seek to significantly decline its GHG emissions in harmony with the 'Vienna Climate Change Talks 2007' [14]. The UNWTO and UNEP convened the 1st International Conference on Climate Change and Tourism in Djerba, Tunisia in 2003. This event was a crisis in terms of raising awareness about the inferences of climate change within the international tourism community. The Djerba Declaration documented the complex inter-linkages between the tourism sector and climate change and established a framework for future research and policy making on adaptation and mitigation [5].

A number of individual tourism industry associations and businesses have also shown leadership on climate change, voluntarily adopting GHG emission decrease targets, appealing in public education operations on climate change and supporting the governmental law of climate change.

3. IMPACTS ON TOURISM PURPOSES

Climate changes a wide range of the environmental resources that are critical attractions for tourism, e.g., snow, wildlife productivity and biodiversity, water levels and quality. Climate has an important impacts on environmental conditions that can prevent tourists, including infectious disease, wildfires, insect or waterborne disease. There are many broad groups of climate change influences tourism and its competitiveness and sustainability such as:

Direct climatic impacts: Tourism has an important influence on operating costs, such as heating, cooling, etc. Thus, changes in the length and quality of climate dependent tourism seasons could have considerable implications for competitive relationships between purposes and the profitability of tourism enterprises [15-17].

Indirect environmental change impacts: Changes in water availability, biodiversity loss, compact landscape beautiful, changed agricultural production, increased natural hazards, coastal erosion and inundation, damage to infrastructure and the increasing rate of vector borne diseases will all influence tourism to changing grades. Mountain, island, and coastal destinations are considered mostly sensitive to climate change [2, 5-8]. UNESCO has identified several World Heritage Sites that are critical tourist destinations; to be weak to climate induced environmental change [18].

Impacts of mitigation policies on tourist mobility: local or global mitigation policies have an impact on tourist flows and lead to an increase in transport costs and may foster environmental attitudes that lead tourists to change their travel outlines [19-21].

Indirect societal change impacts: Climate change is supposed to pose a possibility to future economic growth and to the political stability of some nations [22]. Climate change is a reflected as a national and international security risk that will steadily intensify under greater warming circumstances [23-25]. Tourists are averse to political instability and social unrest [26, 27] and the negative tourism demand repercussions for the climate change security hotspots 6 are very evident.

Destination Vulnerability Hotspots: The inferences of climate change for any tourism business or purpose will depend on the impacts on its competitors. The impact on the tourism sector may strongly parallel that of the global economy, where a 1ºC temperature rise may result in a net benefit for the global economy, but it shows net declines [4].

Destination Level Adaptation: Destination communities and tourism operators with large investment in permanent capital effects have the least adaptive capacity. The dynamic nature of the tourism industry and its ability to manage with a range of recent major shocks, including SARS, terrorism attacks in a number of nations, or the Asian tsunami, suggests a relatively high adaptive capacity within the tourism industry overall. Simpson et al. [28] mentioned that the capacity to adapt to climate change (Figure 2) is thought to vary substantially between subsectors, destinations, and individual businesses within the tourism industry [29, 30].

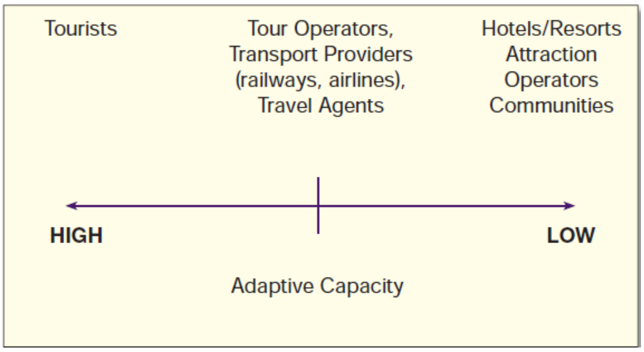

Figure 2: Relative Adaptive Capacity of Major Tourism Sub-sectors
Sourse: Simpson, M.C., Gössling, S., Scott, D., Hall, C.M. and Gladin, E. (2008) Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices. UNEP, University of Oxford, UNWTO, WMO: Paris, France. ISBN - 978-92-807-2921-5 [28]

Climate change is gradually entering into decision-making of a range of tourism stakeholders. Studies examined the climate change risk appraisal of local tourism officials and operators have consistently found relatively low levels of concern and little evidence of long-term strategic planning in anticipation of future changes in climate [28, 30, 31-34]. There is some evidence that tourism operators may be overestimating their adaptive capacity. The incorporation of adaptation to climate change into the collective minds of private and public sector tourism decision-makers remains several steps away. Consequently, there is a real need for effective communication between the climate change science community and tourism operators at the regional and local scale, particularly with respect to the development of climate change scenarios and indicators catered toward local tourism decision-making.

Specific requests were made for training events focussing on adaptation and mitigation techniques, tools and methods. UNEP and UNWTO aim to bring efforts on climate change and tourism into their mainstream environment activities, building on the Davos Declaration [35] and demanding action to adapt tourist businesses and destinations to climate change and to mitigate the impacts of tourism on climate change. In addition it builds on the Bali Strategic Plan to enhance the provision by UNEP of capacity building assistance to developing countries and countries with economies in transition [36] and broader concerns over the need for global institutional leadership with respect to tourism-related climate change adaptation and mitigation activities, as expressed in the Helsingborg Statement on Sustainable Tourism [37].

4. INNOVATION STRATEGIES

Tourism firms themselves have a major role to play in adaptation to climate change as part of systems of innovation. The notion of adaptation as a form of innovation that is understandable in the context of tourism business practice has not been well articulated, but it is an essential component of understanding the capacities of destinations to adapt and respond to the challenges of climate change [38]. Much of the focus of climate change adaptation is on technical responses to climate change. However, the development and transfer of innovative technology is only a small element of what constitutes innovative tourism business practice [39]. Research on innovation in tourism and similar service firms indicate that there are a range of other measures that firms can adopt to respond to external stimuli and stresses, such as those brought about directly and indirectly by climate change, in order to survive and, ideally, maintain or even increase profit margins. Innovating at all the various levels of tourism will bring greater potential returns and enhance the likelihood of survival; it will also contribute to the resilience of the destination as whole. Moreover the ability to innovate represents a capacity to adapt and attract new markets in light of the turbulence that climate change is anticipated to bring to tourism patterns and flows. Heymann [40] believed that the tourism industry will still be a growth engine in the world, experiencing average annual increases of around 3.5% to 4% in international tourist arrivals through 2020, but he forecasts substantial changes in tourist flows by region and within regions of the world based on a comparative scoring model developed by DBR. The DBR model compares the most important countries in the mainstream tourism sector to 2030. The model is based on four quantitative and qualitative parameters:

1. Consequences of climatic changes, including substitution effects;
2. Consequences of regulatory measures to slow climate change and/or mitigate its negative effects;
3. Possibility of adaptation to the changing conditions opens to individual regions;
4. Economic dependence of tourist destinations on tourism.

Nearly all European regions are anticipated to be negatively affected by some future impacts of climate change and these will pose challenges to many Economic sectors [41]. According to a research carried out by UNWTO [42] CO_2 emissions from international tourism including all forms of transport accounted for just under 5% of the world total or 1,307 million tonnes in 2050.

Weather and climate information provide input into a several decision-making contexts for tourism developers, operators and destinations. Scotta and Lemieux [43] mentioned that the historic climate information can be used for strategic planning of tourism infrastructure, including location analysis for new resorts, architectural and landscape design and construction scheduling in remote locations (Figure 3).

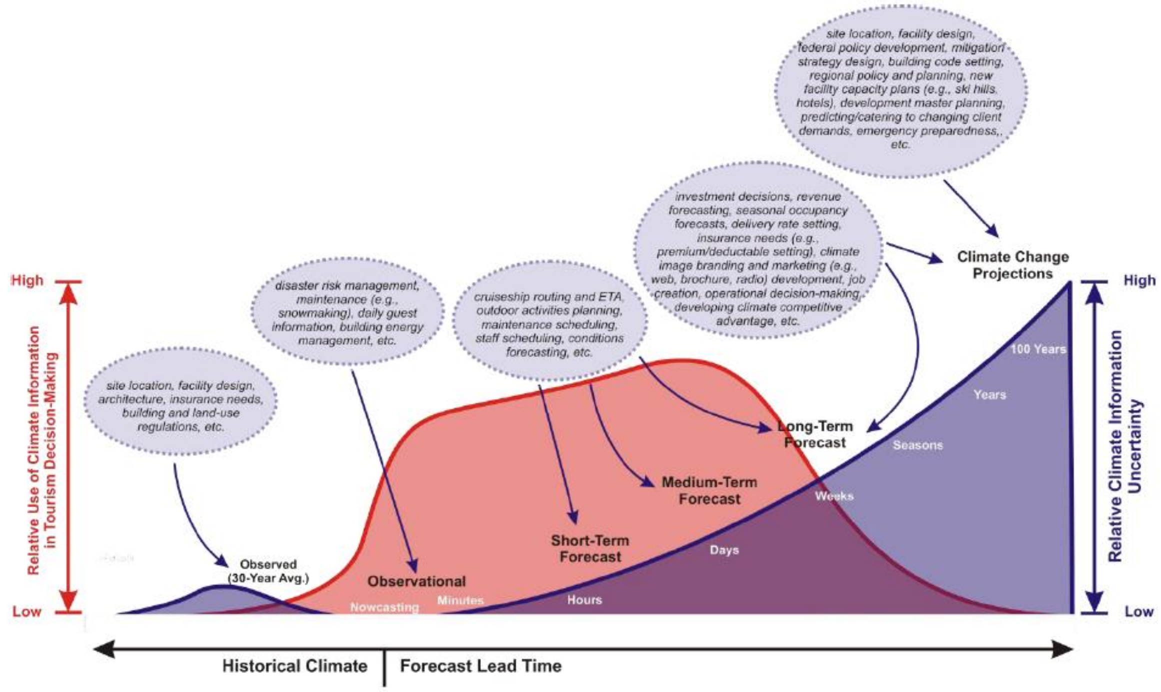

Figure 3. The uses of weather and climate information by tourism operators and destinations. Source: Scotta D., Lemieux C. (2010). Weather and climate information for tourism. Procedia Environmental Sciences 1 (2010) 146–183. doi:10.1016/j.proenv.2010.09.011 [43]

The link between climate change and tourism implies complex interactions and can be described as a two-way relationship. On the one hand, tourism activity contributes to climate change [44]. The UNWTO [45] estimates that emissions from global tourism, including transport, accommodation and tourism activities subsectors make up 5% of total CO_2 emissions.

The major contributor is the private automobile and air transport [46], followed some way off by other forms of transport and the accommodation subsector [45]. In 2005, CO_2 emissions originating from transport accounted for 75% of tourism-based emissions, with the most of this attributed to air transport. This means that air transport is responsible for between 2.5% and 3.5% of total anthropogenic emissions causing global warming [47].

Tourism depends on natural resources, such as water, coastlines, landscapes, biodiversity, etc. These influence the potential attraction of destinations. However, climate change threatens the loss of some of these relevant natural resources [48].

Therefore, these two facts, the contribution of tourism to economic growth and the complex two-way relationship between tourism and climate change, suggest that research on the implications of climate change on the tourism industry and vice versa is of significant interest and relevance.

5. CLIMATE CHANGE IMPACTS ON COASTAL CITIES

Coasts are highly dynamic and geo-morphologically complex systems, which respond in various ways to extreme weather events. Coastal floods are regarded as among the most dangerous and harmful of natural disasters [49]. It is well known that the urban areas adjacent to the shorelines are associated with large and growing concentrations of human population, settlements and socio-economic activities. Considering the fact that 21% of the world’s population lives within coastal zones [50], the potential impacts of sea-level rise are significant for the wider coastal ecosystem [51].

There is a need for a readily calculated and easily understood method to calculate flood vulnerability in such areas. Balica et al. [52] build on earlier work on a flood vulnerability index in river basins to establish a flood vulnerability index using a composite method. This index can then be used to identify the most vulnerable coastal cities, develop adaptation measures for them and assess the effects of future change scenarios. Climate change is expected to cause accelerated sea-level rise with elevated tidal inundation, increased flood frequency, accelerated erosion, rising water tables, increased saltwater intrusion, increasing storm surges and increasing frequency of cyclones. Apart from this, population growth and increasing urbanisation cause marine and coastal degradation [53]. Coasts are dynamic systems, undergoing adjustments of form and process (termed morphodynamics) at different time and space scales in response to geo-morphological and oceanographical factors [54, 55]. Human activity exerts additional pressures that may dominate over natural processes. Coastal landforms, affected by short-term perturbations such as storms, generally return to their pre-disturbance morphology, implying a simple, morphodynamic equilibrium [56].

Balica et al. [57] are focused on large urban areas situated in deltas. Deltas are biologically rich and diverse systems with waterfowls, fish and vegetation, and they support a large economic system based on tourism, agriculture, hunting, fishing, harbour and industry development [58].

Many people in deltas are already subject to flooding from both storm surges and seasonal river floods, and therefore, it is necessary to develop further methods to assess flood vulnerability of coastal cities. Large populations are found in coastal areas where the exposure to coastal floods is high [59]. Smith and Ward [60] showed that rising sea levels will raise flood levels; it is also estimated that the number of people flooded in a typical year by storm surges would increase 6 times and 14 times given a 0.5- and 1.0-m rise in global sea levels, respectively [61].

This increase in the sea level can expand throughout the beach and can affect the touristic activities and industries in the coastal cities like in case of Libya. The most important touristic cities are present at the sea coast.

6. ATTRACTIONS OF LIBYA

Libya's strategic, geographical position and profound history make it a vital link between the eastern and western parts of the Arab world, and between Europe and Africa. The country has known its ups and downs, but the historical monuments are a testimony of the great Libyan civilization of old. Libya can be divided into three regions: (west) Tripolitania, with the capital, Tripoli; (east) Cyrenaica (Barqa, in Arabic), with its main city of Benghazi; and (south) Fezzan with its main city of Sabha.

The map of Libya demonstrates the defining feature of the country: the long, open coastline with no natural geographical barriers on land except for the Sahara Desert. The Sahara, which occupies most of the country, is the dominant geographical feature. Narrow strips of fertile land along the western and eastern coasts contain most of the human population.

The cities of Jarma, Zakakra, and Sabha are in the south, and the historical city of Ghirza in the centre. Libya has played host too many civilizations, and has enriched civilization in its turn, with writings, drawings and engravings in the caves of Tadrart Mountains, and archaeological treasures from Ataft.

The Phoenician, Roman, and Byzantine ports were at Tripoli, Sabratha, Shah's, Susah, Tukrah, and Talmitha. The old Islamic cities such as Sirt, Darnah, and Ajdabiya, and other cities were found in the heart of the desert, including Ghadames, Zuwayla, Jalu, Aujla, Ghat, and Fezzan. Not forgetting the places and fortresses of Gharyan, Mizdah, Al-Qaryat, Yifran, Jadu, Nalut, Misallatah, and Awinat. The first site most tourists visit is Tripoli.

Libya has two thousand kilometres of splendid beaches, and some beautiful small cities each with its typical architecture and special characteristics, like Auwarah, Tubruq, Misratah, Az-Zawiyah, Al-Khums, and Zlitan. Explore Libya's desert in Wadi Ash Shati, the plain of Awaynat, Brak, Murzuq, and the oasis of Al Kufrah, Zallah and Bazimah. Then cool off in Al-Bayda or near Al-Marj, or on the plain of Darnah. In desert, there are waves and waves from the great sand sea, but then there are the refreshing oases.

The history, the monuments and tales told by the locals make this place unique. It is a feast for the senses. The jewel of the desert is Ghadames, a mélange of natural beauty, important monuments and a distinctive architectural style for which it is famous. Libya may be the land of ancient civilizations, but it also looks to the future. It is a country of peace.

7. THE MAJOR MOUNTAIN REGIONS IN LIBYA

The highest mountains in Libya are the Bikku Bitti (2,266 metres), on a spur of the Tibesti Mountains in far southern Libya, an extremely inaccessible area near the Chad border and the isolated Jebel Uweinat (1,934 metres) in the extreme south-east, on the border with Egypt and Sudan. In Libya, There are six major mountain regions (Figure 4).

Figure 4. There are six major mountain regions

In the northern part of the country there are the Jebel Akhdar area (Green Mountain range) in the north-west, and the Jebel Nafusa area in the east, which forms the southern boundary of the Jifara plain (also known as Al-Jebel Al-Gharbi: the Western Mountain). These volcanic remnants, 600–1,000 metres high, capture significant rainfall, creating a fertile environment for cultivation, particularly of olives. In the south-west there is the massif of the Acasus Mountains (Tadrart Acacus, in Berber), in Fezzan, near Ghat on the Algerian border. It is a region of more than 250 km^2, with an extraordinary variety of desert scenery: dunes isolated stone towers emerging from the sand that have been eroded into strange shapes, rock arches, and canyons that were the beds of ancient rivers. This was once a wet region and contains a rich store of rock art and inscriptions dating to between 12,000 BCE and 100 CE and a large quantity of ceramics and stone tools. It was named a World Heritage Site in 1985.

8. CLIMATE IN LIBYA

In the coastal lowlands, where 80% of the population lives, the climate is Mediterranean, with warm summers and mild winters. The climate in the desert interior is characterized by very hot summers and extreme diurnal temperature anges. Summer temperatures in the north of Cyrenaica range from 26.7°C to 32°C. The Mediterranean and the Sahara together have a large influence on the climate (Figure 5) [62].

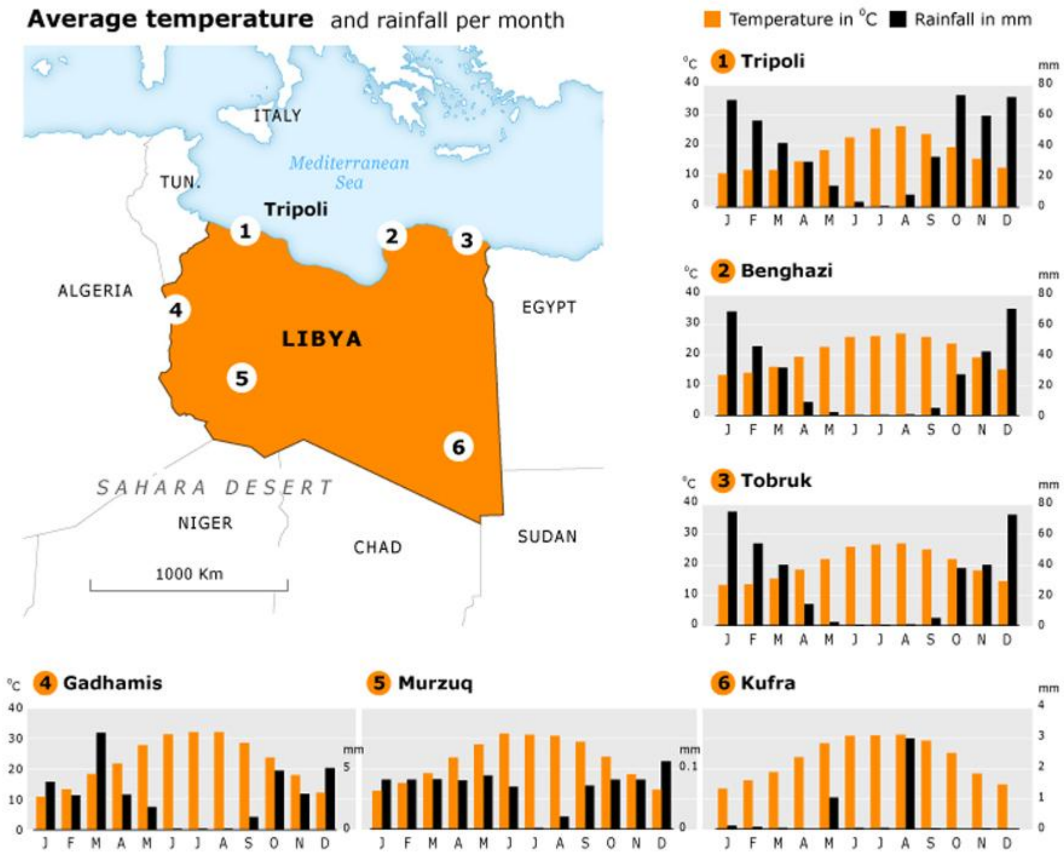

Figure 5. Climate in Libya. Source: Fanack Home / Libya / Geography, October 24th, 2018 [62]

The Greek historian Herodotus wrote, in the 5th century BCE: 'In the higher parts of Libya it is always summer', and this is still true. Along the coast there is a Mediterranean climate with hot summers and mild winters. Tripoli has an average winter temperature of 14°C. In early summer temperatures reach 30°C, with high humidity. In July and August the temperature can reach 40°C. From October till March, rain falls along the coast.

The highlands, such as Jebel Nafusa and Jebel Akhdar, are generally cooler. In winter, the temperatures sometimes fall below freezing. Snow falls occasionally; Jebel Nafusa was snow-covered in 1994. In the interior, the climate becomes dryer, and the desert is extremely arid. Temperatures can reach 50°C in summer, and night-time temperatures drop drastically. On the coast, the wind usually blows from the north-east or north, hot in summer and colder in winter. In spring and fall, the ghibli, a hot, dry, dust-laden desert-wind, which can last one to four days, can change temperatures by 17°C to 22°C in both summer and winter.

This south wind lasts from one to four days, and the dust storms and sandstorms it raises often affect the countries north of the Mediterranean. The winds have eroded the Libyan mountain ranges, as exemplified in the Tibesti Mountains. Precipitation ranges from light to negligible. Less than 2% of the country receives enough rainfall for settled agriculture. The Jabal areas of the north receive a yearly average of 381 to 508 millimetres. Other regions get less than 203 millimetres.

Rain usually falls during a short winter period and frequently causes floods. Winters can be bitterly cold, with temperatures below 0°C. Frost and snowfalls sometimes occur in the mountains. Evaporation is high, and severe droughts are common.

9. TOURISM IN LIBYA

Tourism in Libya is an industry heavily hit by the Libyan Civil War. Before this war tourism was developing, with 149,000 tourists visiting Libya in 2004, rising to 180,000 in 2007, although this still only contributed less than 1% of the country's GDP. There were 1,000,000 day visitors in the same year [63]. The country is best known for its ancient Greek and Roman ruins and Sahara desert landscapes. Cultural tourism is Libya's biggest draw as a tourism destination.

There are five UNESCO World Heritage Sites in the country, three of which are classical ruins. The Roman cities of Sabratha and Leptis Magna in Western Libya and the Greek ruins of Cyrene in the East are big tourist attractions. One of the attractions of Libya's archaeological sites, is that one located in the west south side of the country which called and known by The Jowely of the desert “The Old City of Ghadames” they are not as heavily populated by tourists as are other ancient sites in North Africa and southern Europe.

Libya is a hotspot for research into the human past. The Sahara, the largest hot desert in the world, was once green and hosted until a few thousand years ago the biggest freshwater lake on Earth [64].

Some depictions of crocodiles and cattle engraved and painted on the walls of rock shelters in the Sahara date back 9000 years. The desert is a laboratory for investigating links between past climate changes and developments in human history [65, 66]. These include the dispersal of modern humans across Africa about 130000 years ago [67], the oldest evidence [68] of milking in Africa around 5200 BC and the establishment of the first Saharan state [69] during the first millennium BC. Archaeological fieldwork in Libya is at a standstill. Libyan monuments have been seriously damaged, including the Karamanli mosque, built in 1738 in the capital, Tripoli, and Islamic tombs that date to between the 10th and 12th centuries at Zuwila, near the west-central town of Murzuq.

10. ARCHAEOLOGICAL SITES

Libya has an extraordinary archaeological heritage (Figure 6) [70]. There are important prehistoric sites, including some of the world's earliest rock and cave art, and underwater archaeological sites along the Mediterranean coast.

Libya is home to five World Heritage sites, designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO):

1. the ancient Greek archaeological sites of Cyrene;
2. the Roman ruins of Leptis Magna;

3. the Phoenician port of Sabratha;
4. the rock-art sites of the Acacus Mountains in the Sahara Desert; and
5. the old town of Ghadames, an oasis city that has been home to Romans, Berbers and the Byzantine civilization.

Figure 6. Map of Libya's principle tourist attractions (Source: http://www.shati-zuara.de/english/Libya/libya.html) [70]

Leptis Magna was enlarged and embellished by Septimius Severus, who was born there and later became emperor. Leptis Magna (Figure 7) was widely regarded as one of the most beautiful Roman cities and its excellently preserved remains make it one of the best Roman sites. Founded by the Phoenicians in the 5th century BC, Leptis Magna came under Roman control in the 2nd century BC.

Figure 7. Archaeological Site of Leptis Magna (Libya) ©UNESCO/Francesco Bandarin

It flourished under the reign of its native son, Septimius Severus, in the 3rd century AD who enlarged and embellished the city, becoming second only to Rome with a population of 100000. Among its many highlights are the Gladiator Circus, amphitheatre, marketplace, theatre (Figures 8 and 9), basilica and the many forums, baths, streets and arches (UNESCO World Heritage Site: Archaeological Site of Leptis Magna).

Figure 8. The theatre at Leptis Magna *Figure 9. The Arch of Septimius Severus and Market place*

11. ARCHAEOLOGICAL SITE OF SABRATHA

Once a Phoenician trading-post that served as an outlet for the products of the African hinterland, was part of the short-lived Numidian Kingdom of Massinissa before being Romanized and rebuilt in the 2nd and 3rd centuries A.D. It prospered as a trading centre for gold, ivory, leather, spices and slaves brought to the Mediterranean from central Africa which saw the city rebuilt with many impressive monuments. Sabratha today has some excellently preserved Roman ruins in a beautiful (Figure 10) setting on the Mediterranean coast.

Most famously, its theatre has a capacity of 5000 and the stage area has been renovated with a three storey, marble-columned frons scena. Other features include the large forum surrounded by the temples of Liber Pater, Serapis, Hercules and Isis, the Christian basilica of Justinian and the Capitolium (UNESCO World Heritage Site: Archaeological Site of Sabratha).

Figure 10. Archaeological Site of Sabratha

Cyrene and Apollonia

A colony of the Greeks of Thera, Cyrene (Figure 11) was one of the principal cities in the Hellenic world.

It was Romanised and remained a great capital until the earthquake of 365. A thousand years of history is written into its ruins, which have been famous since the 18th century. Founded as a Greek colony in the 7th century BC, Cyrene soon became one of the wealthiest and most important cities in the Hellenic world before coming under Ptolemaic and then Roman control. One of the most impressive and varied complex of ruins anywhere, Cyrene's highlights include the Temples of Zeus (Figure 12) and Apollo, the Acropolis and the Agora, as well as its baths, gymnasium and theatre. Its port at Apollonia lies 18 km away on the Mediterranean coast, with further Greek, Roman and Byzantine remains including a Greek theatre overlooking the sea (UNESCO World Heritage Site: Archaeological Site of Cyrene).

Figure 11. Archaeological Site of Cyrene (10/09/2007) ©UNESCO / Francesco Bandarin

Figure 12. The temple of Zeus in Cyrene, Eastern Libya

Libyan Sahara - UNESCO World Heritage Sites

Ghadames

Ghadames is an oasis town located some 550 km southwest of Tripoli. The site was an important stop along the old caravan routes across the Sahara. Ghadames is an historic town located in an oasis in the desert near the border with Tunisia and Algeria. Once known as the 'Pearl of the Desert', Ghadames was an important stopping of point in the trans-Saharan trade routes between Timbuktu and the Mediterranean and is renowned for unique layout and architecture. Buildings (Figure 13) were constructed from sun-baked clay bricks and connected together to form covered alleyways which linked the main streets and open air terraces at the top that formed rooftop 'streets'.

Figure 13. Old Town of Ghadamès (Libya) © Federica Leone

The lower streets were reserved for men and the rooftops for women during daylight. The old town is now deserted but the museum, traditional houses and mosques can be visited (UNESCO World Heritage Site: Old Town of Ghadames). The Old City, shown here, was organized spatially and socially into seven clans. Buildings are built (Figure 14) directly adjacent to each other, which insulates the streets and living spaces below from the beating sun.

Figure 14. The traditionally decorated mud brick architecture of Ghadames' Old City is designed for natural cooling.

Ubari Sand Sea

The Ubari Sand Sea (Figure 15) is a vast area of towering sand dunes in the desert notable for the 11 salt water lakes known as Ramlat Dawada. The lakes, such as Gebraoun and Umm al-Maa, are beautiful palm-fringed oases that appear miraculously amidst the harsh desert environment.

Libya has observed its annual Ghat Festival of culture and tourism in Ghat (Figures 9 and 10), about 1,360 km south of the Libyan capital, Tripoli. At the festival, currently in its 19th edition, Tuareg tribes, the primary inhabitants of the region, celebrate Tuareg traditional culture, folklore and heritage.

Figure 15. A lake in the Ubari Desert

Ghat

Ghat is the capital of the Ghat District in the Fezzan region of south western Libya. The annual festival: Camel racing forms a major part of the Ghat Festival (Figure 16) of this desert town, located on the border near Libya's border with Algeria, celebrates the essence of northern Africa's music and dance.

Figure 16. Tuareg men ride camels in the desert during Ghat Festival of Culture and Tourism

The Ghat Festival saw glory like the old days with tourists enjoying the local culture as exhibitions of traditional handicrafts and performances added to the festive fervour. Check out below the pictures from the latest edition of Ghat Festival in Libya (Figure 17).

Figure 17. Ghat Festival of Culture and Tourism

Conclusion

Climate is extremely important for tourism. The tourism sector must rapidly respond to climate change, within the evolving UN framework and progressively reduce its GHG contribution if it is to grow in a sustainable manner; this will require action to: 1. mitigate its GHG emissions, derived from transport, accommodation, etc. activities; 2. adapt tourism businesses and destinations to climate changes; 3 apply new technologies to improve energy efficiency; 4. secure financial resources to help poor countries. Actual impacts of climate change on tourist destinations are potentially much further reaching, as they affect the resource base of tourism, both directly and indirectly. Since the 1st International Conference on Climate Change and Tourism, convened by UNWTO in Djerba, Tunisia in 2003, a growing body of knowledge has been generated addressing the complex relationships between the tourism sector and climate change with important research activities on this subject.

There is now a wide recognition of the urgent need for the tourism industry, national governments and international organizations to develop and implement strategies to face the changing climate conditions and to take preventive actions for future effects, as well as to mitigate tourism's environmental impacts contributing to climate change. Furthermore, such strategies should take into account the needs of all countries in terms of poverty alleviation and other Millennium Development Goals.

Libyan heritage is the expression of a shared memory of the country, and its respect represents a corner stone for long lasting national reconciliation. I therefore urge all parties, as well as the Libyan population, to commit to and act for its safeguarding. Parties should refrain from using cultural property and its immediate surroundings for military purposes likely to expose it to destruction or damage as well as to abstain from any act of hostility directed at such property. UNESCO has to invite the experts from both in- and out-side of Libya to urgently investigate the preservation of cultural heritage in the country, notably measures to safeguard cultural sites; prevent illicit trafficking, protect museums and strengthen cultural institutions.

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A COMPARATIVE STUDY ON SOME STATISTICAL INVESTIGATIONS ON POPULATION AND ECONOMIC SECTORS IN LIBYA: Past and Future

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Abstract

The growing international awareness about the fast pace of climate change taking place on our planet, together with the impacts that such changes are having on the natural environment, on humans and their economic activities have become evident. This study on data collection and statistics on population and economic sectors in Libya provides a preliminary inventory of the national institutions and procedures involved in the management and collection of data on population and economic status (1960-2018) in Libya and the currently available proposals for improving the systems. This statistic shows the population change in Libya from 2007 to 2017. In 2017, Libya's population increased by approximately 1.28% compared to the previous year. The CIA World estimates that the Libya Population in 2012 was 6,733,620. Based on the CIA's estimate, Libya was therefore the 101st largest country in the world. The UN's estimate in 2018 is that there are 6.47 million people in Libya, dropping it down to the 109th most populous country. It is important to evaluate how climate has varied and changed in the past (1901-2015). The monthly mean historical rainfall and temperature data can be mapped to show the baseline climate and seasonality by month, for specific years, and for rainfall and temperature. Libya is the country with the largest oil reserves in Africa, thus making the oil sector among the most successful ones in the continent, accounting for 80% of the country`s GDP and 97% of its exports. The statistic shows gross domestic product (GDP) in Libya from 2012 to 2016, with projections up until 2022. GDP denotes the aggregate value of all services and goods produced within a country in any given year. GDP is an important indicator of a country's economic power. In 2016, Libya's gross domestic product amounted to around 18.54 billion USD.

***Keywords**: Libya, population sector, economic sector, relationships.*

1. INTRODUCTION

Libya is categorized by the World Bank as an upper-middle-income country. The economy is dominated by oil and gas industries. In 2010, total oil production (crude plus liquids) was approximately 1.8 million barrels/day [1].

The oil revenue allows the government to spend munificently on infrastructure, education, and job creation.

One of the most important aims is to examine the relationship between economic growth, employment, inflation, production function and the population growth in State of Libya. The second aim of this study to investigate the challenges faced a strategic policy that would aim to achieve sustainable development of the Libyan economy, particularly in view of the current official tendencies for the restructuring of the Libyan economy by increasing the role of the private economic sector in the economy under the climatic changes.

Thought of the impact of variations oil prices on the structure and performance of the Libyan economy is mostly driven by the oil sector. Saleh [2] investigated the variation of oil prices and its influence on the employment in Libya, finding a negative impact on the movement of skilled non-Libyans and a dramatic decrease in the number of non-Libyan workers in 1980, when the price of oil fell sharply. The economic growth is usually categorized by growths in actual gross domestic product (GDP) or actual GDP/capita that occur over the long-term. The Libyan economy has been exposed to numerous shocks and regime changes, such as (1) In September 1969 the new revolutionary government implemented policies to transform the economy from being capitalist-oriented to being socialist-oriented, (2) the 1973–1974 oil shock, (3) the critical eight-year (1980–1988) war with Chad, (4) the instability of the international oil market, (5) economic sanction imposed by US and United Nation from the early 1990s (Because of the Pan Am 103 crisis) which caused in the freezing of the country's foreign assets, and (6) the current state in Libya (since February 2011) and ongoing of insecurity State Conditions.

Libya's economy can be described as a socialist type, centrally managed, and relying primarily on the oil export revenue which in fact is the major foreign exchange employee and contributes over half of the nation's real GDP. Libya manages to achieve one of the highest per capita incomes in Africa, because of its low population and large oil reserves [3]. Since the elimination of the UN authorizations, Libya has realised very favourable growth rates: in 2010, it was estimated at 8.1%. The Libyan economy is still designated as having very high ranks of interdependence with the international market, especially in trade exchange. It is heavily dependent on oil export [4]. All these shocks have a negative impact on the employment and economic growth in Libya.

Economic changes in Libya are bringing beneficial outcomes to achieve sustainable investment in the non-petroleum industry sector, mainly manufacturing and agricultural practice. The main economic development aim of Libya is to reach greater variation in capital, products, and imports, the non-oil sector and raw material, it is likely that the economy will be self-sustainable and will grow at high speed, like other emerging economies [5].

The efficiency of the nation's variation's strategies can be appreciated from the fact that the influence of the manufacturing industry to the nation's real GDP was only 5% in the 1970s then had risen to 15.2% by 2005; the role of the agricultural sector to the GDP increased from 6% in the 1970s to 9% in 2005. These variations appear small but the real GDP/capita raised enormously, from 4,380 USD to 44, 820 USD, between 1970 and 2005 [6].

The country's value of import rose significantly as the real GDP increased, to highpoint in 1975 at 28.5% and settling at 18.5% in 1980s. With the UN authorizations in the 1990s the Libyan's economy practically collapsed when its capital abroad was frozen. The GDP export ratio reduced to 16.11%. The value of imports increased significantly, becoming very expensive for the nation [7].

Libya faces an unemployment rate estimated to be 30% in 2010. This high unemployment rate is mainly predominant among the younger generations. Inflation is also a problem for the Libyan economy which is currently at 10.4% in 2010 [1]. Different local and international sources for data are used:

- Central Bank of Libya (CBL), Economic Bulletin: http://www.cbl.gov.ly/en/
- Secretariat of the General People's Committee for Planning
- National Authority for Information and Documentation: http://www.gia.gov.ly/
- OPEC Annual Statistical Bulletin: http://www.opec.org/
- International Monetary Fund (IMF)
- World Bank (WB), and Penn World Table 5.6 (PWT 5.6)
- Key Indicator for Labour Market (KILM)

2. Libyan economic Background of Libya

In Libya, had long suffered from deficiencies in the economy, especially in areas such as inflation, balance of payment deficit, low rate of employment and growth, all of which has created and imbalance in the economy. Problems of irregularity in supply and demand had a negative impact on prices and balance of payments [8].

The economic sectors during the 1950s went through a period of situation and economic development, as did the agricultural sector, resulting from poor quality land, lack of water and weather conditions [8].

In the industrial sector, the manufacturing process was limited due to non-availability of raw materials, lack of a skilled labour force, local market narrowness and inability to process the product. The economy was not able to provide the necessary investments to change the backwardness into progression [9].

After discovering oil and starting to export it in 1962, the problem of development in Libya centred on the search for development alternatives for the economy specifically in relation to viability in capital and rarity in labour element.

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After discovering oil and starting to export it on a commercial basis in 1962, the problem of development in Libya centred on the search for development alternatives for the economy specifically in relation to viability in capital and rarity in labour element. Since the beginning of 1980s, when the oil revenues were reduced due to the problems facing the international oil market, the growth problem in Libya faced other difficulties, and efforts were taken towards providing growth and improving the continuing lack of technology and efficient workforce. This study aims at explaining the economic policy exercised by Libya and the role of private capital in the national economy. As the efficiency of the financial market is determined by the success of various productive projects, it is considered to the main factor to be established. An economic expert of the United Nations, Farley [10] mentioned that the Libyan economy before discovery of petrol was a backward economy because there were no indications of economic growth existing at that time. Libya achieved real steps towards the economic growth in recent years. In addition, there are a number of studies on Libya which emphasis that oil revenues contribute to mostly of GDP growth in Libya and represent 97% of total GDP [11].

Foreign Direct Investment (FDI) can promote the economic growth by increasing productivity, generating technologies, expanding the base of exports that can provide a long-term growth to the host economy [12]. The priority in the first development plan 1973-1975 was the agricultural sector taking precedence over the industrial sector, and the Libyan economy achieved a high growth rate during the seventies which peaked 9.2% of the GDP. The priority in the second and third plans, 1976-1980 and 1981-1985 was the development of the industrial sector which achieved growth rates equal to 21% and 23%, respectively which were less than the growth in the population rate that reached 3.5% during 1998-2001. Decrease in oil prices was one of the most important reasons behind the low production rates of the industrial sector, as its contribution to GDP declined from 77.4% in 1973 to 24.9% in 1997 and to 27.9% in 2002 [13]. One of the studies indicated that the increase or decrease in oil prices with 10% caused an increase or decrease in the GDP with 3% [14]. The investment expenditure on industrial, agricultural and staple goods sectors reached 11 million LYD in 3 decades 1970-2002, which equals 36 milliards USD by used exchange rate 3.3 as follows:

- Investment in the industrial and mineral sector equals 5.5 million LYD.
- Investment in the agricultural and livestock production sectors equals 5.5 million LYD.
- Investment in marine fisheries equals 170 million LYD.

The investment value in the industrial sector was about 4249.9 million LYD during the period 1969-1996. The level of investment rate was about 157.4 million LYD [15]. The actual growth of the sector still did not exceed 3%. The incorporation of the total local production did not reach 8% during the 1970s. This proves that the industrial sector depends strongly on the oil sector, as in investment operations or to gain raw materials due to reduction in oil revenues during the 1980s and 1990s [16].

Despite Libya’s relatively strong recent (before 2012) economic growth, unemployment remains high as the country's population grows rapidly and new jobs are not created quickly enough.

On 28 June 2004 the United States renewed diplomatic relations with Libya direct and presented the interests of the United States of communication. On September 2004, USA terminated the state of emergency against Libya by executive orders. This action eliminated most of the economic sanctions imposed on Libya, and led to the release of Libyan assets frozen in the United States.

UK, eagerness to assist in the development of the Libyan economy, as it had previously assisted the Libyan government by providing a suitable environment for Libya to deal with the western world. UK praised the steps taken by the Libyan government to return to the global society, stressing on the fact that Libya would recover economically in a few years.

England was willing to play a major role in developing the Libyan economy on being the first and essential partner with Libya, and UK had achieved economic and trade revenues with Libya in the year 2003 estimated at 240 million sterling pounds, with an increase of 20% in its favour according to the trade balance with Libya. In developing the structure and the reframing of the Libyan economy, the economic and political policy on various environmental and social factors has moved forward (Table 1).

Table 1: Libya entering a new stage of its development

Libya’s past	Libya’s emerging future
Significant isolation from the outside world	Increasing integration with the outside world
Focus on equality of living conditions and social standards	Greater opportunities for individual achievement and involvement in the productive sector
Oil revenues as the main source of national prosperity	Oil revenues supplemented by wealth created in other parts of the economy
Government’s central focus on the distribution of oil revenues to address social needs	Government increasingly working with the private sector to enable the creation of wealth in competitive markets

3. Libyan economic status during the period 1955-1969

This stage is recognised as financial to a large extent, starting in the mid-1950s when the oil companies started to enter Libyan territories for excavation and oil was believed to be there. They started exporting oil in 1962, consisting of about 30% from the local product in total. It’s the main resource for the currency [17]. This sector is relevant indirectly for the other economic sectors such as education, health, electricity, construction, the building industry and agriculture, etc. The growing expenditure on these sectors comes completely from the oil and natural gas revenue, providing the economy with foreign currency to support the country’s liabilities for the imports of commodities, services and exchanges. The supply of revenue to the social, economic and development allocations increased as well as the expenditure on public and private consumption which resulted in the improvement of the standard of living; the average income per person rose to 6171 dollars in 1987 and then increased to 8014 dollars per capita in 1992 [18].

Libya's economic growth rate during this period was one of the highest growth rates in the world. The gross domestic product GDP increased at an average rate of 22.6%/annum. Also, gross fixed investment had increased at an average rate of 15.6% per annum with the share in non-oil GDP reaching 63%. The two major factors that consolidate the development of the Libyan economy are:

Firstly, the Libyan economy is a growing one in the oil and gas sectors, in a geographical area of about 1087 km2. The population increased during the last decade from 3225.1 thousand in 1980 to 4524.4 thousand in 1990, and finally reached 5426.8 thousand in 2000. The annual growth rate of population during the period 1970-2000 was about 3.8% due to the improvement of standards of living [15] and it has a coastline in the about 2000 km, on the Mediterranean. The geographical depth of Libya is North Africa making it as a strategic link between east and west. It is also surrounded by a group of countries where the economy and a labour surplus provide some civilised, historical and natural resources.

Libya, as an archaeological country, has to establish and sponsor tourist activities through building tourist hotels, tourist villages, health centres, banks, companies and leisure places. The investment could be through providing political services, like travel agencies, naval transport, air and land transport.

Secondly, the Libyan economy developed within the last three decades to adopt a socialist philosophy, which encourages public ownership and variant national income due to the independence of oil wealth. This in a way has enabled the country to change to productive assets and to replace the achieved revenues from new resources instead of the oil revenues, continuously and regularly [19]. However, laws were issued from the trade economy organisation. Regulations controlling trade and economic policy are as follows:

- Law supervising the issued finance in 1955 and its item no. 1 in 1957
- Export and import law no. 59 in 1957
- Law to regulate export and import no. 59 in 1957
- Treasury minister's decision no. 2 in 1962 for the customs.
- Supervision on foreign expenditure
- Quantity limitations on imports (import permits).

4. Libyan economic status during the period 1970-2010

The planning of this period was not just a means to provide development, but was considered as a means to execute social changes happening in Libya. The social tension started to appear, as it was during the 1950s and 1960s, and the development plan 1973-1975, considered to be the first plan to provide the requirements for social changes, concentrated on basic food industries. The transformational economic plans during the period 1973-1985 gave priority to the industrial sector so that it can play a vital role. The main idea was to reduce dependence on oil, to tackle unemployment, and to decrease dependence on exported commodities. It was a plan to build a domestic industrial basis. Therefore, the government designed the economic development from 3 to 5 year plans whose major goals are:

1. The structural design of the Libyan economy limited the interest of industry and the agriculture sector.
2. It reduced the oil sector gradually and limited its exports to ensure providing the needs for other sectors.
3. It reached the point of being self-sufficient in the necessary industrial and agricultural products.
4. It established industries depending on oil and natural gas to invest in activities directed to export.
5. It created job opportunities for the nationals for the sake of reducing the foreign labour force.

However, during the first five year plan, for social and economic transformation between 1976-1980 more focus was put on the petrochemical and industrial sector. Assignments during this period were 1513.4 million LYD, continuing to 21.1% from the total objective assignments. Priority was given to food industry and consumer items (including consumption intermediate) in an attempt to reduce imports. In the second five year plan for social and economic transformation between 1981 and 1985, priority was given to investment and improvement of petrochemical and export industries such as oil refineries. During this period the gross fixed investment had increased at an average rate of 14.5% per annum within an average annual share in the non-oil GDP of about 58%. For the same period the GDP and the percentage had increased at an average rate of 12.6%/annum, respectively.

Following a strategic policy to encourage exports, the Libyan government established a board for developing exports and marketing then in foreign outlets.

But Libyan exports were subject to three basic shocks during the two decades 1970s and1980s; yet the impact of those shocks was generally positive on the Libyan economy:

Firstly, the 1973/1974 oil crisis led to the nationalisation of Libyan oil companies (Table 2). The maximum oil production capacity was 3.32 million barrels per day by 1970, and the barrel price increased from 2.2346 dollars to 26.2 dollars just one year later. The increase in oil prices increased was four times during the period between 1970 and 1973, sustaining economic growth and prosperity [20] (Table 2).

Table 2: The main political factors affecting oil production during the period between 1973 and 1992

Year	Political Factors	Results
1973	Israeli Arab war	Increased oil prices
1979	Iranian crisis	Increased oil prices
1980s	Different measures taken by industrialised countries to reduce their dependence on OPEC oil	Reduced oil production
	OPEC operation to control prices and oil production and oil exports quantities	Reduced oil production and oil exports
1986	The USA's ban on importing oil from Libya	Reduced oil exports
1992	The UN sanctions on Libyan economy	Reduced oil production and oil exports

Source:
Calculated from CBL Central Bank of Libya (1966-2000) Research and Statistics [21, 22].

Secondly, the oil prices had increased sharply during the period 1979/1980 due to the Iran–Iraq war (Table 2). Fisher [23] argued that during the 1980s, the Libyan economy has been deeply affected by the low price of oil. This in turn negatively affected the general budget of the government along with the international economic depression and most importantly, the embargo of the United States on Libya.

Because it was the first importer of the Libyan oil, the US economic sanctions affected the Libyan economy to a large extent (OPEC). This situation affected the economic transformation plans to a great extent.

During the 1970s and early 1980s, for example, the amount designated for the fifth plan 1981-1985 was to be 18.5 million LYD or equivalent to 55 billion USD; but it had to wait until 1981 so that the conditions could be met. After that, the increase in public expenditure weakened the transformation plan from 2705.1 million LYD for 1981 to 176 million LYD in the 2000. Due to the expansion in transformation plans to include projects of construction a rise between 234.5 million LYD was needed in 1980 and 1500.7 million LYD in 1999. Therefore, the Libyan government had to fill the financial gap between what was planned for and the amounts available for those projects [24].

The following Table 3 summarised the Libyan economic growth during the 1962-1990 period (Table 3).

In addition, by the end of the 2008 period, as structural and macro-economic reforms progress and the non-oil economy starts to develop, the authorities could consider the desirability and feasibility of switching to a more flexible exchange rate regime that would give them more room of manoeuvre to respond to sharp changes in oil prices. In particular, opening up the banking sector to external competition, strengthening the judicial system to speed up and improve conflict resolution and reforming the existing legislation in the areas of accounting, bookkeeping and bankruptcy are critical to strengthen the development of, and competition within, the banking sector, and improve financial deepening [25].

Table 3: Annual growth rates of the Libyan economy by sectors during the period between 1962 and 1990

Factors	1962-1969	1970-1982	1983-1990	1962-1990
Gross Domestic Product (GDP)	22.6	13.2	-2.5	11.8
Agriculture forestry and fishing	4.1	4.6	11.8	6.70
Mining and quarrying (Inc. oil)	46.7	14.3	-7.8	17.8
Manufacturing	8.4	18.6	7	13.0
Construction	19.9	15.3	-1.8	12.0
Transport and Communication	16.6	18.1	-0.4	13.1
Wholesale and Retail Trade	12.7	17	-2.1	10.9
Services Gathering	13.4	14.0	2.7	11.1

Source:
Calculated from CBL Central Bank of Libya (1966-2000) Research and Statistics [21, 22]

However, in view of the various interests on the Libyan economy, particular concern is put on, the key factors which contribute to increasing the economic growth during the reform, the relationships between major macro variables and how they behave during the special process of transition and how to evaluate the position of the Libyan economy in the world economic framework.

The applicability of the FDI-led export and Export-led growth hypothesises to Libya was tested using relevant data and analytical methods. This result supports the FDI-led export (FLE) and Export-led growth hypothesises in the case of Libya [26].

5. GDP and unemployment

However, most of the dealing with employment in Libya assumes a macroeconomic perspective, focusing on the evolution of labour demand and supply in the context of sustained growth. Moosa [27] tested Okun's proposition for Egypt, Tunisia, Morocco and Algeria and found that unemployment and output were unrelated and statistically insignificant.

When Swane and Vistrand [28] examined the relationship between GDP growth and employment in Sweden using the employment population ratio as a measure of the extent of employment generation, they found a significant and positive relationship between GDP and employment growth. This result supports the strand of theories suggesting that a positive relationship between GDP and employment is normal, and that any observed anomaly in unemployment might be a temporary deviation.

Yogo [29] mentioned that theoretical and empirical survey of the relationship between employment and growth in sub-Saharan Africa countries raises three interesting points. First, the employment subject in sub-Saharan Africa is more a matter of quality than of quantity. Secondly, no reason for weak employment acts could be found in the labour market institution. Third, the observed increase in working poor could be explained by slow economic growth and low labour demand. Kapsos [30] conferred the growth rate of GDP and employment in developed countries and estimated employment elasticity, result that the employment elasticity has reduced in some countries in the Middle East and North Africa.

6. Inflation and output

There are insufficient studies that have examined the relationship between inflation, unemployment and economic growth for Libya. Osama [31] presented a positive relationship between inflation and economic growth in Jordan by using structural break point. He determined that if the rate of inflation drops to 2%, the relationship between the variables becomes negative.

7. Aspects of the Libyan economy

A minor number of investigators have attempted to inspect the economic growth and its determinants for Libya. Their emphasis has mainly been on investigative microeconomic factors; e.g., numerous have observed the influence of oil price variations on the labour force [1, 4, 32].

8. Privatisation programme

Masoud [8] mentioned that the transfer of ownership in Libya started in 1987 by sharing the returns on investment with the employees: profits are divided among the elements of production (worker, machine, capital) according to a specific accounting system.

The transfer was governed by the People's Committee decree no.447 for 1987, which is based on a chapter from the Green Book (partners not workers), the Law no.9 for 1985, and the People's Committee decree no.313 for 2003. The transfer process was carried out as follows:

1. Ownership was transferred to employees
2. It took the form of exemplary partnerships
3. It was sold by its book value with annual instalments according to the return on the sold unit.
4. Total value of sold assets was 98 million LYD.

The most important achievements of this phase are:

1. 30% of the national labour force that were employed by the public sector, moved to the private sector.
2. Recovery of nearly 80% of the assets owned.

The number of transformed units reached 295 units; the value of their assets equalled 98.000.000 LYD. The transformation process continued from 1987 to 1992 as shown in Table 4, which had many positive results such as the retrieval of 75% of the assets' value owned by these units, including the transfer of 30.000 products to the national sector.

Table 4: Transfer of ownership of a number of factories and production units during the 1987-1992 period [33]

Sectors	Number of Units	Value of Assets
Industrial sector	150	52.000.000
Agricultural sector	50	6.000.000
Marine fisheries sector	50	29.000.000
Livestock sector	45	11.000.000
Total	295	98.000.000

During the period 1/1/2004 to 31/12/2005 many units were privatised as follows, General People's Committee [34]:

1. 46 economic units that can't be developed.
2. 10 agricultural projects were divided and sold as farms.
3. 12 units were sold to Libyan and foreign investors as joint investments.
4. 192 units will be able to continue its activities but after elevating financial burdens imposed by banking sector, social security fund, taxes, customs, and electrical power company, which hindered its production. The debts of these units will be covered by the National Production Support Fund and the State's Treasury. The total amount of public debt on these units reached 549 million LYD

9. Manpower in the government sector, private sector and foreign companies in Libya State

The majority of Libyan employees are employed in the public (government) sector and the wages levels in the public sector were not increased6 during the period 1980-2010. Table 6 shows that in 2010 approximately 80.3% of the labour force was employed in the public sector. In 2006, the proportion was approximately 85.2%. The Libyan labour force is interested in working in the government sector, especially educated youth, who will defer employment elsewhere while they wait for a public sector position to become available. According to the African Economic Outlook report [35], nearly 60% of youth will consider only a public sector job. Less than 10% of the labour force was employed in the private sector in 2009. Although there are many foreign companies in Libya, the percentage of Libyans employed by them is very low: it was approximately 10.6% in 2010 (Table 5).

Table 5: Distribution of manpower in the government, private and foreign sectors in 2010 (thousands)

Sector	Libyan labour force	%
Public	15595.2	80.3
Foreign companies	210.0	10.6
Private	180.0	9.1
Total	1985.2	100.0

Source:
Public Authority of Civil Information, 2006 and 2010, State of Libya [36]

Table 6 classifies the Gross Domestic Product (GDP) of the Libyan economy by type of the economic activity. Table 6 shows that the petroleum and mining sector is the mainstay of the economy.

Table 6: Libyan real GDP by economic activity

	1972%	1980%	1998%	2010%
Petroleum and Mining	52.5	64.2	26.7	75.4
Agriculture	2.5	1.6	11.5	3.0
Manufacturing	2.4	2.6	6.4	2.1
Constructions	10.4	9.1	5.9	3.2
Wholesale, Retail Trade	5.5	4.7	14.1	3.6
Transport & communication	5.7	3.3	5.8	3.5
Other services	21.0	14.5	29.6	9.2
GDP at Market Prices	100.	100.0	100.0	100.0
Official Exchange Rate (LD/USD)	3.040	3.377	2.2205	0.8037

Sources: Libya: National Authority for Information and Documentation (1970–2010) [36]
Libya: Ministry of planning, economic and social indicator 1970–1994. [9]
Central Bank of Libya, Quarterly Statistical Bulletin, 1970–2010, Libya [38]
World Bank 'World Tables, 1980–2011, Washington DC [45]

Oil production makes a greater contribution to GDP than all other economic activities combined. The percentage of oil's contribution to GDP differs in various periods due to fluctuations in oil price. It was high in 1980 (64.2% of real GDP) before the second oil shock, and lowest in 1998 (26.7% of real GDP) before the recovery. The percentage of oil contribution to GDP in Libya in 2010 was higher than in 1980.

10. Libyan population

Tables 7 and 8 provide statistics on the composition of the Libyan population according to Libyan and non-Libyan and then by male and female over the period 1972–2008. These data reveal that:

- The Libyan total population in 2008 was made up of more than 6.3 million nationals and about 333, 000 expatriates, compared with only 2.2 million nationals in 1972.
- Libya depended on expatriates to conduct its economic activities from 1972 until 1980.
- The proportion of non-Libyans to the total population is very small (around 5% in 2008).
- The Libyan fertility rate is among the highest in the world in 1980. This is the one of the main reasons that the proportion of Libyan nationals has increased so dramatically over the last three decades, from less than 88% of the total population in 1972 to more than 95% in 2008.
- The rise in oil prices during the eight years of the oil boom (1972 to 1980) attracted expatriates to work in Libya.
- From 1972 to 1980, the number of expatriates improved by over 340 000/annum.

Table 7: Libyan and non-Libyan population (in thousands)

	1972	Percentage of total (%)	1980	Percentage of total (%)	1998	Percentage of total (%)	2008	Percentage of total (%)
Total population	2150	100	2760	100	5060	100	6650	100
Nationals	1888	87.8	2158	78.2	3957	89.4	6317	95.0
Expatriates	262	12.2	602	21.8	511	10.1	333	5.0

Sources:
Libyan: Annual Statistical Abstract (1980-2007) [42]
Libyan: National Authority formation and Documentation (1975-2000) [36]
Libyan: Ministry of planning, economic and social indicator 1970-2008. [9]
Statistical Abstract for Arab Countries (1972-1980; 1980-1990; 2000-2007) [42-44]

Table 8 shows that the percentage of Libyan males is almost equivalent to that of females. The percentage of female expatriates is nearly half that of male expatriates; this suggests that the State of Libya attracts more males for working purposes.

Table 8: Total Libyan population according to gender and nationality (in thousands)

Years	Libyan					Non-Libyan					Total population
	M	%	F	%	Total	M	%	F	%	Total	
1972	974	51.6	914	48.4	1888	203	77.3	59	22.7	262	2150
1980	1105	51.2	1053	48.8	2158	518	86.1	84	13.9	602	2760
1998	1990	50.3	1967	49.7	3957	451	88.2	60	11.8	511	5060
2008	3133	49.6	3184	50.4	6317	302	91.0	31	9.0	333	6650

Sources:
Libyan: National Authority for information and Documentation (1975-2000) [36]
Libyan: Ministry of planning, economic and social indicator (1970-2008) [9]
Central bank of Libya, Quarterly Statistical Bulletin (1975-1980; 1990-2000) [18, 19]
Statistical Abstract for Arab countries (1972-1980; 1980-1990; 2000-2007)

Figure 1 gives the literacy rate among adults in the state of Libya. The World Bank defines the adult literacy rate as the percentage of people 15 and older who can read and write. The rate is approximately equal between males and females, with 81.3% of females literate and 94.9% of males. The illiteracy rate decreased from 31% in 1994 to 22% in 2010 due to the increase spending on the education sector [41].

Table 9 depicts the Libyan population according to age. It can be seen that the percentage of children (0–14) has decreased dramatically while that of adults (15–64) has gradually risen from 57.8% in 1998 to approximately 66.8% in 2009. This demographic change has placed pressure on the supply side in the labour market.

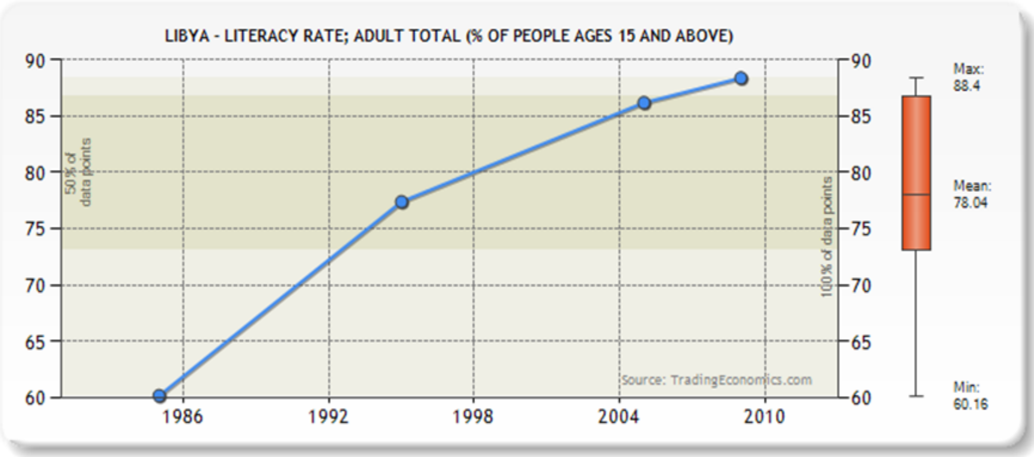

Figure 1: the percentage of literacy among Libyans aged 15 and above
(Source: http://www.tradingeconomics.com/libya/literacy-rate-adult-female-percent-of-females-ages-15-and-World-Bank, 2010)

Table 9: Percentage of population according to age

Year	0-14 Years	15-65 Years	65 and above
1998	39.2	57.8	3.0
1999	38.4	58.5	3.1
2000	33.9	62.7	3.4
2001	33.5	63.0	3.5
2002	33.1	63.3	3.6
2003	32.6	63.8	3.6
2004	32.1	63.9	4.0
2005	30.1	64.1	5.8
2006	29.5	65.4	5.1
2007	28.2	65.8	6.0
2008	27.1	66.1	6.8
2009	26.3	66.8	6.9

Source: World Bank annual report [46]

Figure 2 presents the population growth which has been declining in Libya since the 1980s, from an annual rate of 4.6% in 1980 to 1.9% in 2010. The drop in population growth has resulted mainly from a sharp decline in the fertility rate, falling from 7.3 children per woman in 1980 to 2.7 in 2010.

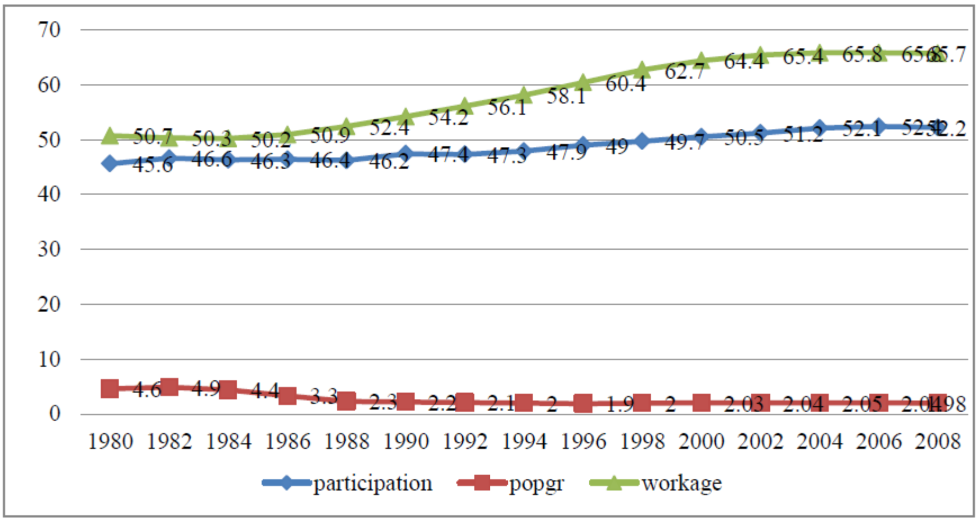

Figure 2: Percentage of working age, population growth and participation rate during 1980 and 2008.
(Source: World Bank annual report [46])

The growth of the working age population increased on average by 1.2% annually, raising the labour supply and creating the potential for employment and growth. Labour force participation also increased as young and female workers entered, putting pressure on the labour market. The participation rate increased from 45.6% in 1980 to 52.2% to 2008, mainly from the entry of young workers, but increasing female participation also has affected the size of the labour force in Libya. Table 10 reviews the main community indicators in the State of Libya. The life expectancy rate is 71 years for males and 76 for females. The infant mortality rate is actual low compared with the world average in 2010. Yasmen [47] mentioned that the main reason is the sharp drop in early marriage by women in the mid-1990s, as well as the cost of living in Libya, which has become a main problem for adults who request to marry.

Table 10: Libyan social and development indicators

	1980	2000	2010	World average in 2010
Life expectancy at birth for male and female	male (62) female (67)	male (64) female (68)	male (71) female (76)	69
Fertility rate (births per woman)	7.3	3.3	2.7	3.2
Infant mortality rate	18	23	29	59
Population per physician	457	502	601	N/A
Access to safe water (% of population)	84	92	75	N/A
Illiteracy	31	28	22	N/A

Source:
World Bank: Social Indicators of Development (1980-2010). [46]
UN Development Program, Human Development Report, (1980–1990; 2000–2010). [14]

11. Economic activity of Libyan population

The effect of the public sector on national employment is high in Libya State. The Libyan labour market is considered by strong supply-side pressures attributable to the speedy growth of the 15–65 age group, the low productivity of labour, limited employment in small-scale establishments, wages that have been frozen by the government since 1981 (law NO: 15/ 1981), and high rates of unemployment. Table 11 demonstrates the allocation of the labour force in the State of Libya by economic sectors.

Table 11: Libyan labour force by economic sector

	1972(%)	1980 (%)	1998(%)	2010(%)
Agriculture, livestock & fisheries	13.39	11.83	9.98	7.84
Petroleum & mining	1.12	1.34	1.22	1.36
Manufacturing	4.90	5.75	5.68	6.22
Electricity, gas & water	1.88	2.31	2.56	2.91
Construction	1.23	1.36	1.44	1.78
Wholesale, retail trade	7.73	7.89	8.74	10.1
Transport & communication	4.57	5.73	6.31	6.39
Finance & insurance; real estate & business	0.92	1.38	1.61	1.95
Community, social & personal services	48.88	50.85	49.71	49.88
Unclassified	15.38	11.56	12.75	11.54
Total	100.0	100.0	100.0	100.0

Sources:
Libya: National Authority for Information and Documentation (2000–2010) [36]
Libya: Annual Statistical Abstract (1980–2010) [43]
Central Bank of Libya, Quarterly Statistical Bulletin, (1972–1980; 1980–1990). [38]
Libya: Ministry of planning economic and social indicator 1970–2010 [9]
Statistical Abstract for Arab countries (1972–1980; 1980–1990; 2000–2010)

Information in Table 11 proposes the following:

- The agricultural, livestock and fishing sector employed around 7.84% of the total labour force during various years to 2010.
- The petroleum and mining sector, which produces 30–40% of the GDP, employed less than 1.4% of the labour force in the period 1998–2010.
- The percentage of the labour force employed in the manufacturing sector increased from 4.9% in 1972 to more than 6.2% in 2010.
- The percentage of the labour force employed in electricity, gas and water has increased from 2.56% in 1972 to more than 2.9% in 2010.
- The percentage of the labour force employed in the construction sector increased from 1.23% in 1972 to 1.78% by 2010.
- The percentage of workers in wholesale and retail trade increased from 7.73% in 1972 to 10% in 2010.
- The percentage of the labour force employed in the transportation and communication sector increased from 4.57% in 1972 to 6.39% in 2010.
- Other service sectors have absorbed a significant proportion of the labour force, increasingly so over the last three decades. The proportion of employment in these sectors has increased from 5.47% in 1972 to 8.34% in 2010.
- The community, social and personal services sectors are by far the biggest employers and have seen the biggest increase in the share of workers between 1972 and 2010.

12. Libyan economy in terms of the relationship between RGDP, inflation and unemployment

Table 12 compares the contribution of the Libyan oil and non-oil sectors over the last four decades. The economy depends heavily on the production and exportation of oil, which provides a greater contribution to real GDP than all other economic activities. It is clear from the table that the contribution of oil is around 57% to 61%. Producing and exporting oil is the dominant factor in the economy.

Table 12: Percentage contribution of real GDP from each sector

Period of time	Oil	Agriculture	Manufacturing	Service	Construction	Total
1962–1970	57.4	3.7	2.3	29.3	7.1	99.8%
1971–1975	56.9	2.2	2.2	28.4	6.9	96.6%
1976–1986	50.4	3.1	3.8	31.8	10.7	99.8%
1987–1993	31.8	6.5	7.3	48.5	5.6	99.7%
1994–2001	30.9	8.5	7.1	47.5	5.7	99.7%
2002–2009	61.9	2.5	4.7	25.4	5.3	99.8%

Sources:
Libya: Annual Statistical Abstract (1990–1995; 2000–2007) [43-44]
National Authority for Information and Documentation (2000–2006) [36]
Libya: Ministry of planning economic and social indicator (1970–2007). [9]

Table 13 shows the average growth of real GDP, inflation and unemployment for different time periods. The inflation rate, measured by the percentage change in the annual consumer price index (CPI), shows a decreasing trend from 7.6% to 6% in the period 1971–1975, caused by policy changes imposed by the Central Bank of Libya.

Table 13: Average inflation, real GDP growth and unemployment growth

Period of time	Inflation	real GDP growth	Unemployment growth
1962–1970	7.6%	22.8%	-6.5%
1971–1975	6.0%	7.2%	-2.6%
1976–1986	7.7%	1.6%	6.3%
1987–1993	7.5%	1.9%	14.2%
1994–2001	10.6%	4.1%	10.7%
2002–2009	3.2%	8.3%	8.2%

Sources:
Libya: Annual Statistical Abstract (1990–1995; 2000–2007) [43-44]
National Authority for Information and Documentation (2000–2006) [36]
Libya: Ministry of planning economic and social indicator (1970–2007). [9]

13. DETERMINANTS OF LONG-RUN GROWTH IN LIBYA

Economic growth is probably one of the most important research topics in modern economics. Like many developing countries, the primary focus of policies in Libya is to have a high growth rate, and for this to happen policy makers need to understand the determinants of growth as well as how polices affect growth. Over the last two decades, the performance of Libya has been disappointing in comparison with other MENA countries.

It has been remarkably volatile and, at times, lowers than that of poorly performing regions such as sub-Saharan Africa. This growth pattern is believed to be linked to several characteristics such as Libya's heavy dependency on oil and hydrocarbon exports, high population growth, dramatic increase in unemployment rates, and low rates of return on investment in physical and human capital as most investments are carried out by the public sector.

The relatively better growth performance in the 1970s and the first half of the 1980s can be largely attributed to a favourable external environment, in this case high energy export prices. This situation reversed in the second half of the 1980s and early 1990s, resulting in sharp declines in domestic investment, savings and growth.

14. Limitations of the study for further research

This review has assessed the connection between inflation, economic growth, population and unemployment in the State of Libya, and examined the balances between real GDP-unemployment, inflation-unemployment; and inflation-output. The study moves from an examination of Libya to estimate the production function in the short and long run for the period 1962 to 2009.

The results of this review are limited because of the lack of data on output, labour, physical, and population. Future study can focus on the entire economic sector and in deep the new human economic activities under the new condition in Libya after 2011.

The measurement of inputs, especially physical and human capital, is somewhat problematic and involves many assumptions. As a measure of the labour input, the total hours worked obtained by multiplying employment times the average hours actually worked serves as a reasonable substitution for the flow of labour services. However, research can make a correlation between labour force and total economically active population (population between the ages 15–64) under the climatic changes in the area of Libya.

Conclusion

This study has given a comprehensive analysis of the macro-environment of Libya and the performance and the evolution of starting the financial sector development in Libyan economy. The Libyan economy has experienced rapid expansion during the period of the 1970s and the early part of the 1980s as real GDP grew by more than 10% on average. This enlargement was largely backed by the oil revenue sector. After the lifting of the economic embargo on Libya in 2003, Libya has entered a new economic phase carrying the labels of economic openness and freedom. One of the main indicators of the transformation is the privatisation of more than 360 major economic units over three stages, starting from 2004 to 2008 within the framework of privatisation of these projects. There have been significant changes in the structure and characteristics of the Libyan population and labour force over the last two decades. The ratios of Libyan population and labour force have increased substantially; the education levels for both men and women have significantly improved, and the ratio of employees in various jobs has witnessed a moderate increase. However, the great majority of Libyan employees are still working in the public sector and their average wages and salaries are very low, regulated by law since 1980, and in fact this is causing a lot of dissatisfaction among Libyan public sector employees. The country has depended heavily on expatriate labour for the last two decades, although their numbers have decreased dramatically in most economic activities. Overall, Libya still has some way to go with its macro-economic situation such as: a high rate of unemployment, low rate of domestic saving and low ratio of investment to GDP including key governance indicators: regulatory and corruption.

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CASE STUDY OF ENVIRONMENTAL IMPACT ASSESSMENT OF NO_2 CONCENTRATIONS EMITTED FROM LINE SOURCES (TRAFFIC) IN KOMÁROM, HUNGARY

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Abstract

Air pollution after the industrial revolution and the population explosion has increased dramatically. However, air pollution is not a newer phenomenon it starts before the industrial revolution and has taken different forms when people on past used firewood for heating and cooking. Our bodies cannot adopt with contaminations increasing. One of the best solutions to meet the sustainable development goals is the application of Environmental Impact assessment approach (EIA). This study gave an assessment on air quality inside the city of Komárom, Hungary after operating the new bypass road No. 131 in 2015. The differences of air quality between the two years 2010 and 2015 before and after operating the bypass road were investigated during the application of EIA. The EIA study was done by using IMMI software which is a widespread noise and air pollution modelling software provided by the German Wölfel GmbH. Traffic network graphic elements, traffic data (numbers of cars and heavy trucks), emission factors for different pollutants and meteorological data (wind speed, wind direction, and stability categories) were prepared and imported to the software. The modeling was done depending on Gaussian dispersion approach. The average concentrations of NO_2 *were simulated for the whole area and for specific receptor points in case of different wind speed intervals, wind direction, and different stability categories. The obtained results from model showed only small differences in air quality between 2010 and 2015 due to the traffic motion in the bypass road No. 131 but it indicate the changes in traffic and environmental developments on air quality.*

Keywords: *environmental impact assessment, air pollution, Gaussian dispersion model IMMI software.*

1. INTRODUCTION

Air pollution stars before the industrial revolution in different ways when people in past used firewood for heating and cooking [1]. After the industrial revolution and the population explosion, air pollution has increased dramatically [2]. Air pollution is becoming a hot topic in the scientific world since we start seeing lots of changes in weather and the environment. Air pollution and climate change linked to each other. Chaudhuri and Chowdhury [3] stated that air pollution has harmful impacts on the health of the human population and ecosystems, as well as on the earth's climate. Undoubtedly, climate change becoming very fast day after day. More importantly, air quality needs to be understood from two viewpoints the management of air quality and the consequence of the climate change on the community [4]. Definitely true that to achieve the sustainable development goals it is necessarily important to apply Environmental Impact Assessment (EIA) approach. There are several explanations of EIA. In 1992 Turnbull gave a definition for EIA: "A mechanism for all interested parties to be consulted and provide a framework within which agreement may be reached between the developers causing the impacts and those who are affected by the impacts" [5]. Environmental protection Agency defined EIA as a process of examining the anticipated environmental effects of a proposed project - from consideration of environmental aspects at design stage, through consultation and preparation of an Environmental Impact Assessment Report (EIAR), evaluation of the EIAR by a competent authority, the subsequent decision as to whether the project should be permitted to proceed, encompassing public response to that decision [6]. EIA for short-term help the decision makers in making the proper decision. However, EIA not limited only for short term but also important for the long term. For examples, long-term objectives of EIA are to protect human health, preservation of natural sources and keep the environment far away from damages [7]. There are several EIA tools and techniques which can be classified from the simplest one: checklists, matrices, and networks to the most complicated one: map overlays, geographic information systems (GIS) and task-specific computer modeling [8]. Anthropogenic activities by humans caused the increase in greenhouse gases and global warming. Motor vehicles, marine vessels or aircraft (emission of jet fuel) always takes a capacious range of interest. High air pollution levels depend on and vary with the traffic density, rush hours, the urban structure and meteorological circumstances [9] [10]. NOx (nitrogen oxides) emitted to the air by fuel burning at high temperatures and combustion of the engine industries [11]. Recent research shows that how could passenger cars play a negative role in the increasing of the NO_x in 8 European countries and how extreme concentrations form in the city centre due to the high traffic jam [12] [13].

In this study, the main aim was to carry out an EIA study of air pollution of bypass road No. 131 in Komárom, Hungary by measuring the concentrations of air pollutants in 2010 before operating the new bypass road and 2015 after the operating, in order to simulate the effects of the new road on air quality in and around the city of Komárom. The main aim of the construction of the new bypass road in 2015 was to reduce the environmental load in the city caused by traffic.

Technical details for the study area

The new main bypass road No 131 is planned in Komárom city in North-Western Hungary on the south bank of the Danube River in Komárom-Esztergom County. It is branching out of main road No 13 and ends at the roundabout of road No 1. The bypass road is 3.69 km long. Concentration loads have been defined for the breathing zone in z= 2 m height (Figure 1).

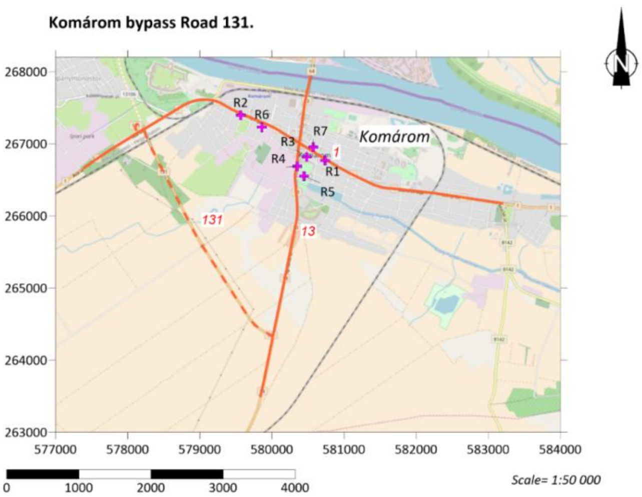

Figure 1: The study area (Komárom city) with receiver points (source: open street map.)

The population of Komárom is around 20 thousand people. The geographical environment of Komárom is threatened by floods. The Komárom Industrial Park was chosen because it is the proper location for large industrial activities. The concentrations of NO_2 pollutant showed high levels inside the city and the main source of air pollution inside the city from traffic especially on the main road No.1., while outside the city, the industrial park is the main emission source. Attention should be also focused on transboundary effects [14].

2. MATERIALS AND METHODS

For modelling the transmission in the air, the IMMI software has been used according to Reiche [15]. The IMMI is a widespread noise and air pollution modelling software provided by the German Wölfel GmbH, which integrates air dispersion models (for gases, dust, odours) and outdoor sound propagation (road, traffic, and railway, industrial and recreational noise) including interfaces to CAD and GIS [16]. The programme calculates the concentration of different air pollutants on EOV (Egységes Országos Vetület - Unified National Projection) coordinates. The immission has been defined within the 268000–263000 and 577000–584000 EOV coordinates (about 7 km × 5 km = 35 km^2). For simulations, traffic network graphic elements, traffic data (v/h) for to classes of cars and heavy trucks, emission factors for different pollutants and meteorological data (wind speed, wind direction, and stability categories) were used.

The average concentration fields of Nitrogen dioxide (NO_2) was simulated for the whole area and for specific receptor points in case of different wind speed intervals and different stability categories by using a Gaussian dispersion model in IMMI software. The Gaussian model was chosen because of its simplicity and fast calculation time, and it does not require sophisticated meteorological data, therefore this tool is suitable for small projects. For simulations, all previous data require importing to IMMI. Calculation reference points have been defined in a 10 × 10 m grid, by the contouring of which graphics on immission have been generated. Concentration loads have been defined for the breathing zone (where people live) in z = 2 m height.

Baseline data collection

- Road network graphics elements, background map: the Komárom–Esztergom County road map obtained by using Open Street Map with the help of MicroStation software and Surfer software. MicroStation was used for preparing a georeferenced background image for the IMMI software and for digitized the roads (segmentation). For the visualization of our results, Surfer software was used, because of this software capable to attach the background map and geo-related dataset.

***-Traffic data preparation*:** the traffic data are related to roads No.1 and No.13, and bypass road No.131 which was opened in 2015, and all data sheets were prepared for 2010 [17] and 2015 [18] to import to IMMI software.
Road No. 1, No. 13 and No. 131 were divided into 4, 6 and 1 segments, respectively and each segment represents a few (3–8) km on the roads. From the input database, the following information is required: road number, county, cross section [km+m], codes, and a number of vehicles and heavy trucks per day on each code (Table 1).

The traffic data (traffic factor, and percentage of heavy trucks) were obtained from the previous data (Table 2).
The Traffic factor means the largest hourly traffic, which occurs at least 50 times a year (vehicle/hour). The heavy trucks percent was calculated from the following formula:

$$\text{Heavy trucks percent \%} = \frac{\text{(number of all heavy trucks)/day}}{\text{(number of vehicles per day)/day}} * 100\%$$

Table 1: Number of vehicles and all heavy trucks per day for 2010 and 2015

Road No.	Counter Station code	Number of vehicles per day (2010)	Number of all heavy trucks (2010)	Number of vehicles per day (2015)	Number of all heavy trucks (2015)
1	3816	5456	843	5813	715
1	4561	12201	805	12028	889
1	4562	7931	513	6643	417
1	7948	5615	367	5647	364
13	9	7750	194	10267	263
13	3446	9067	947	10915	281
13	4565	10113	1200	6568	514
13	3349	6842	1257	8130	892
13	6890	5338	819	5703	553
13	3350	3523	455	3409	298
131	2547	-	-	905	110

Table 2: Summary of the traffic data which need to import to the IMMI software

Road No.	Code	Traffic factor 2010	Heavy trucks (%) 2010	Traffic factor 2015	Heavy trucks (%) 2015
1	3816	653	15.0	665	12.0
1	4561	1165	6.6	1266	7.0
1	4562	761	6.0	695	6.0
1	7948	582	6.5	614	6.4
13	9	699	2.5	1020	2.5
13	3446	942	10.4	1092	2.5
13	4565	1064	11.8	696	7.8
13	3349	827	18.3	943	10.9
13	6890	630	15.3	669	9.6
13	3350	403	13.0	411	8.7
131	2547	-	-	108	12

-Emission Factors for Road Traffic from HBEFA database: the emission factor data were imported from the Handbook on Emission Factors for Road Traffic (HBEFA) version 3 German databases [19]. The emission factors were calculated for the two traffic classes, for cars and heavy trucks.

The emission of pollutants can be changed in the function of vehicle speed, but in this study the same speed value (50 km/h) were used for the whole area, but considering the change of emission between 2010 and 2015 due to the change of the fleet composition based on HBEFA (Table 3).

Table 3: Emission factors (in g/km) for cars and heavy trucks for speed of 50 km/h, in 2010, and 2015 (Source of data: HBEFA)

	Cars		**heavy trucks**	
	2010	**2015**	**2010**	**2015**
NO_2	0.090	0.100	0.345	0.260
CO	0.270	0.170	1.110	0.800
PM	0.010	0.004	0.020	0.040
HC	0.020	0.010	0.170	0.070
NOx	0.270	0.300	4.160	2.570

Climate and meteorological data: The site is located on a terraced plain. The climate here is generally temperate. The yearly temperature averages are 10.4°C. The yearly precipitation amount is 531 mm (for period 1982–2012) [20].
For the simulations, meteorological data obtained from Tata Meteorological Station (about 20 km from Komárom) of Hungarian Meteorological Service (HMS). The frequency of wind speed categories for 10-degree resolution of wind direction and for different stability categories for the period 2012–2016 was used in the model. The German and Hungarian stability groups are shown in Table 4.

Table 4: The stability categories

Stability	Klug/Manier	Pasquill/Gifford
		G
Very stable	I	F
stable	II	E
indifferent	III/1	D
indifferent	III/2	C
unstable	IV	B
Very unstable	V	A

For the whole period, the most frequent wind direction is SE. Figure 2 shows the distributions of wind speed and stability categories for the whole dataset.

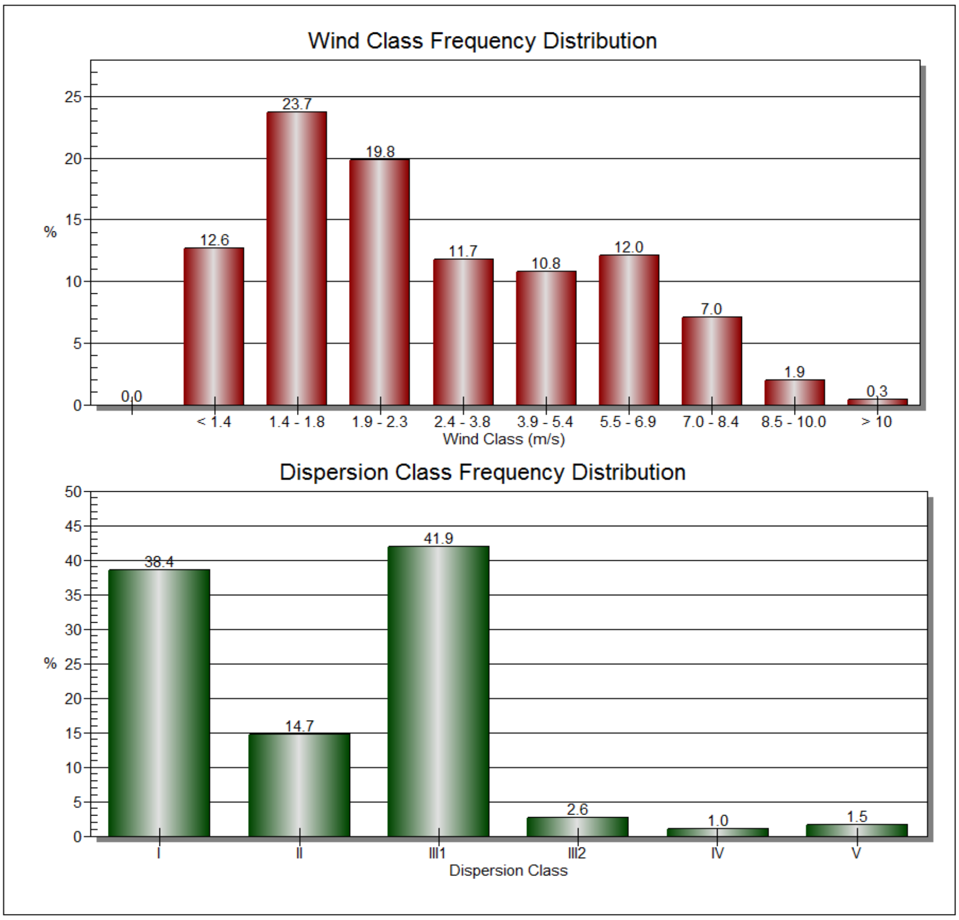

Figure 2: Wind Class Frequency Distribution, Dispersion Class Frequency Dispersion, Source of data: Hungarian Meteorological Service

It was found that the most frequent wind speed interval is between 1.4 and 1.8, while the most frequent categories are III/1 (D - Pasquill) and I (F - Pasquill). Figures 3 and 4 show the wind rose for these two stability categories.
In the case of D stability the most frequented wind direction is north-west and for F stability the south-east.

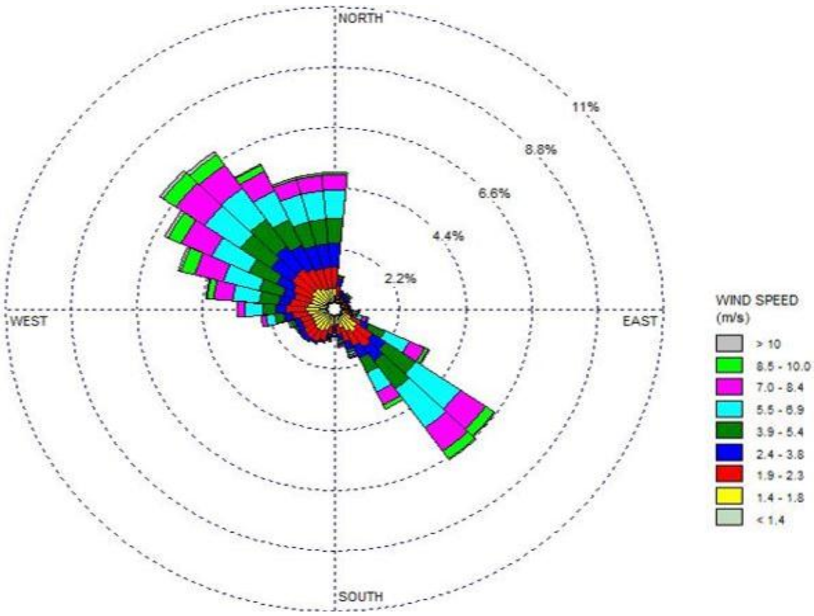

Figure 3: Wind rose for D stability category for Tata Station for the period 2012–2016 with the frequency of wind speed. Source of data: Hungarian Meteorological Service

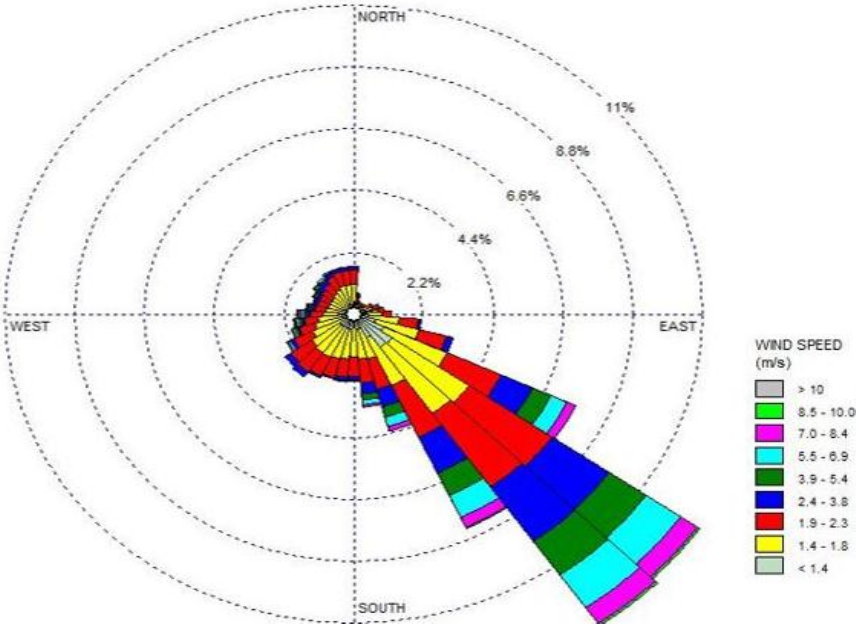

Figure 4: Wind rose for F stability category for Tata Station for the period 2012–2016 with the frequency of wind speed. Source of data: Hungarian Meteorological Service.

Calculation of the transmission: The programme calculates the concentration of different air pollutants on EOV (Egységes Országos Vetület - Unified National Projection) coordinates. The immission has been defined within the 268000–263000 and 577000–584000 EOV coordinates (about 7 km × 5 km = 35 km^2). Calculation reference points have been defined in a 10 × 10 m grid; by the contouring of which graphics on immission have been generated. Concentration loads have been defined for the breathing zone (where people live) in z = 2 m height. Some receiver points, such as school, kindergarten, and medical points were picked. Table 5. consists of the receiver points and the EOV coordinates for each point.

The immission of pollutants (grid calculations) calculated for several scenarios for years 2010 and 2015 for 1.5 m/s wind speed and for D and F stability, the most frequented categories according to Tata station. But the focus was on NO_2 because it is a critical point in Europe. The EU Council Directive 1999/30/EC of 22 April 1999 set the hourly and annual limit values of projection of NO_2 for the protection of human health. The limit value for NO_2 is 100 µg/m³ (in Hungary) not to be exceeded more than 18 hours in a calendar year (that is approximately the 99.8-percentile) [21].

Table 5: Receiver points

Code	Name	Description	x	y
R1	Petőfi Sándor Általános Iskola	School	580734	266770
R2	Egressy Béni Elementary Art School	School	579568	267393
R3	Helen Doron Early English Nyelviskola	Kindergarten	580483	266820
R4	Komáromi Gesztenyés Óvoda	Kindergarten	580351	266689
R5	Komáromi Tóparti Óvoda	Kindergarten	580442	266553
R6	Extra-med Health and Sport Kft	Medical	579861	267229
R7	Selye János Hospital - Clinic	Medical	580571	266953

Several scenarios have been done also for receiver points as sensitive sites. The concentrations of five pollutants for years 2010-2015 were calculated for A, C, D, E, F stability and for 1.5, 2, 3, and 5 m/s wind speed.

3. RESULTS AND DISCUSSION

In the following, we present the model results for NO_2. The figures of the other pollutants showed only very small differences in concentrations. For the presentation, 1.5 m/s wind speed and D and F stability categories were chosen.

Figure 5 and 6 show the concentration field of NO_2 in the area for D stability (neutral stratification) and for the year 2010 and 2015, respectively.
The highest can be found near the main roads.

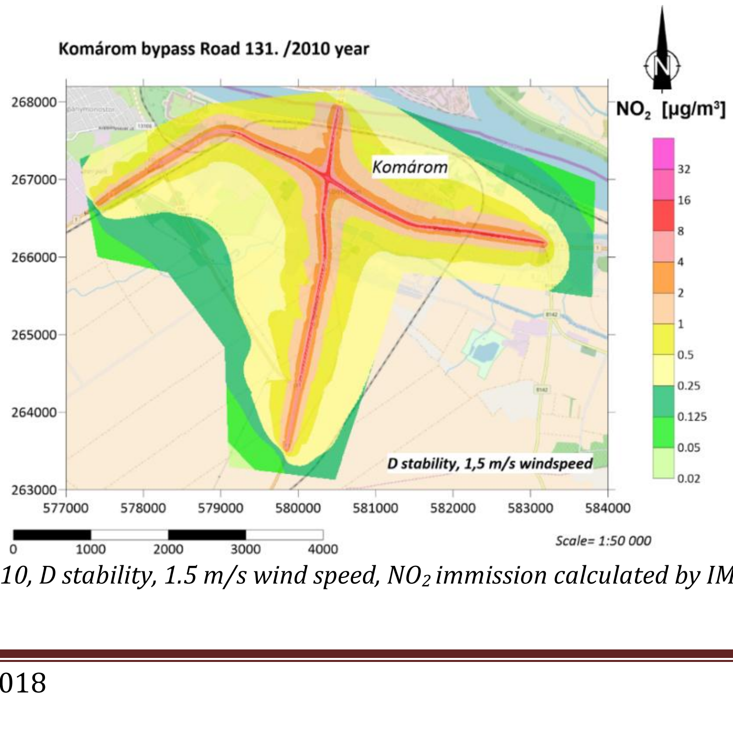

Figure 5: 2010, D stability, 1.5 m/s wind speed, NO_2 immission calculated by IMMI software

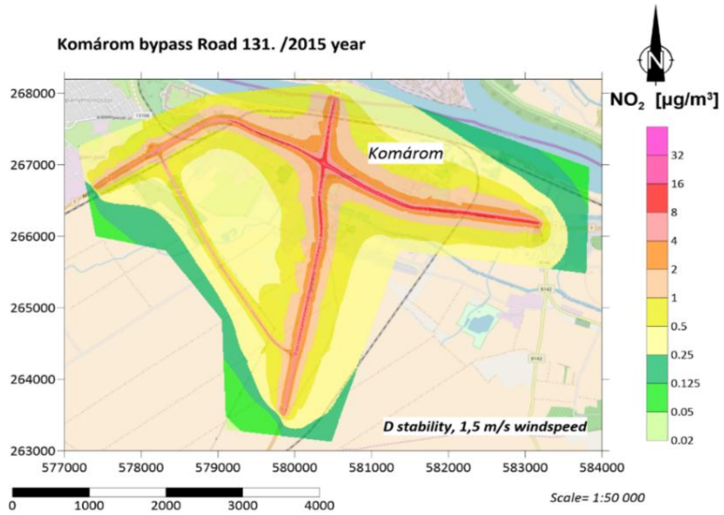

Figure 6: 2015, D stability, 1.5 m/s wind speed, NO_2 immission calculated by IMMI software

In the case of F stability (stable stratification, which is the critical situation for air quality) highest concentration values were noticed (see Figures 7 and 8 for the year 2010 and 2015, respectively).

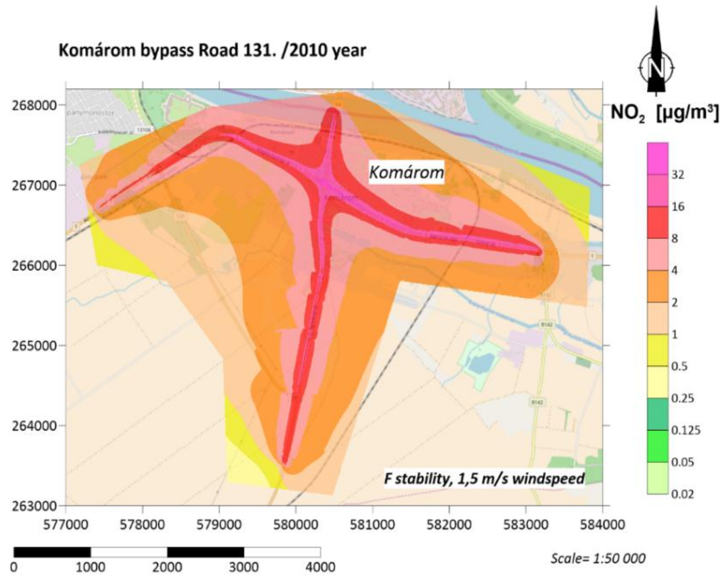

Figure 7: 2010, F stability, 1.5 m/s wind speed, NO_2 immission calculated by IMMI software

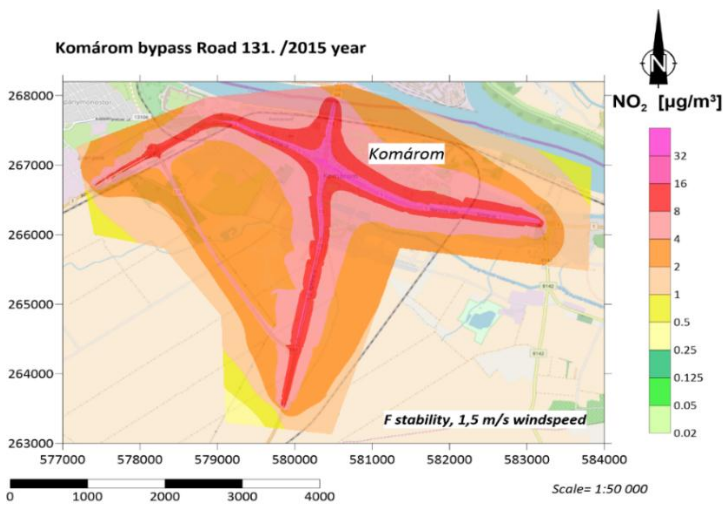

Figure 8: 2015, F stability, 1.5 m/s wind speed, NO_2 immission calculated by IMMI software

The difference maps (see Figures 9 and 10) show the concentration differences between 2010 and 2015. The better air quality could be noticed in the segments of the roads numbers 13 and 1 with D stability and the utmost dissimilarity with the F stability. High immission differences can be found near the new bypass road (No. 131) and around a part of road No.1, the latter is due to the larger traffic in 2015 near the border of Slovakia.

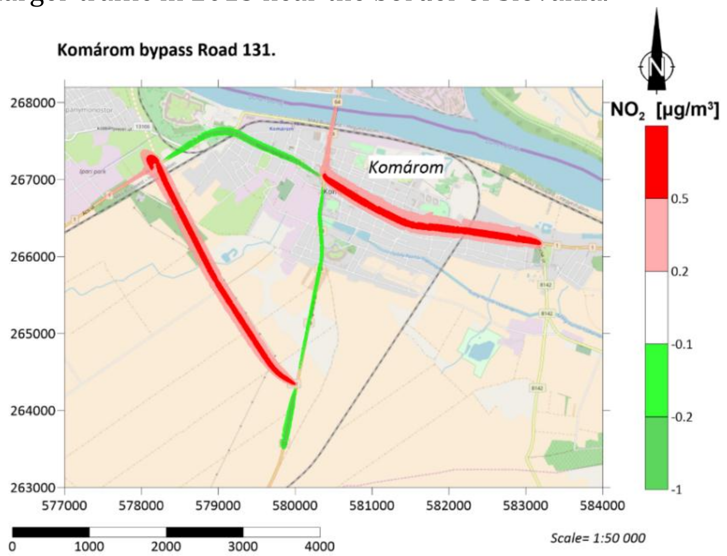

Figure 9: Difference map between 2010- 2015, D stability, 1.5 m/s wind speed, calculated by IMMI software

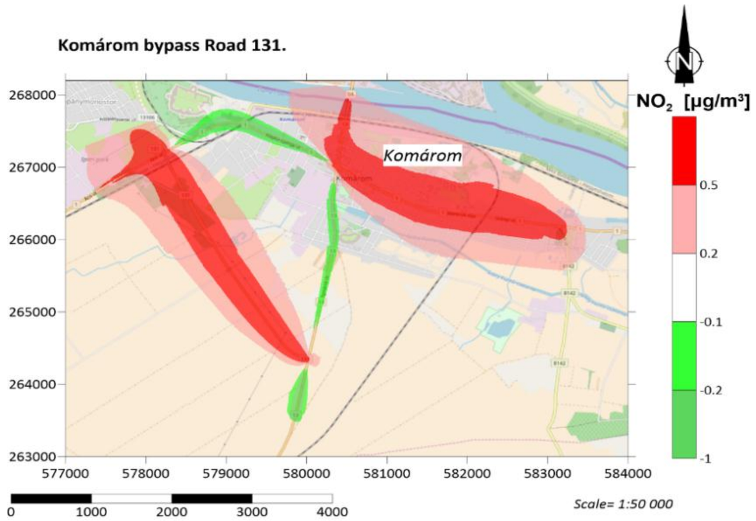

Figure 10: Difference map between 2010- 2015, F stability, 1.5 m/s wind speed, calculated by IMMI software

Concentration values were also calculated for receiver points for different scenarios. Figures 11 and 12 shows the calculated immission data for the year 2010 and 2015, for NO_2 at three receiver's points with different wind speed (1.5, 2, 3, 5 m/s) and same stability D, while Figures 13 and 14 display the same values for stability category F. Lower wind speed (1.5 m/s) showed the high immission concentrations, while the higher wind speed (5 m/s) showed lower concentrations.

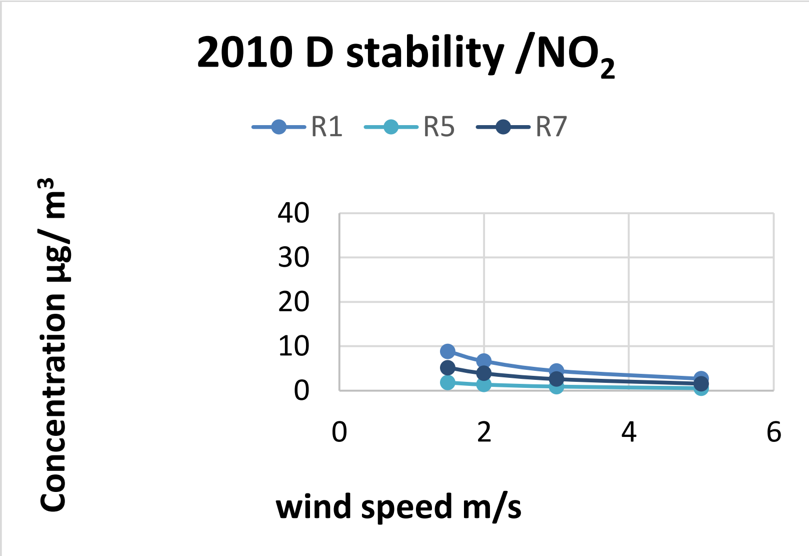

Figure 11: Calculated concentration values for receiver points for 2010 for NO_2, for D stability and for different wind speed

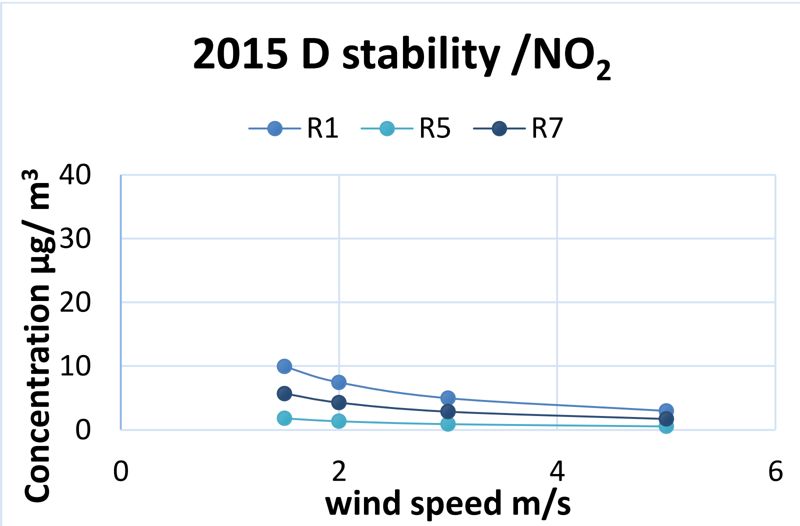

Figure 11: Calculated concentration values for receiver points for 2015 for NO_2, for D stability and for different wind speed

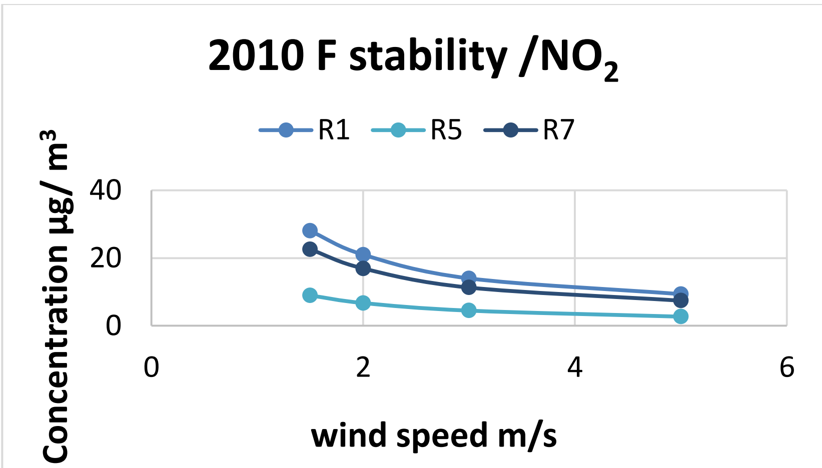

Figure 13: Calculated concentration values for receiver points for 2010 for NO_2, for F stability and for different wind speed

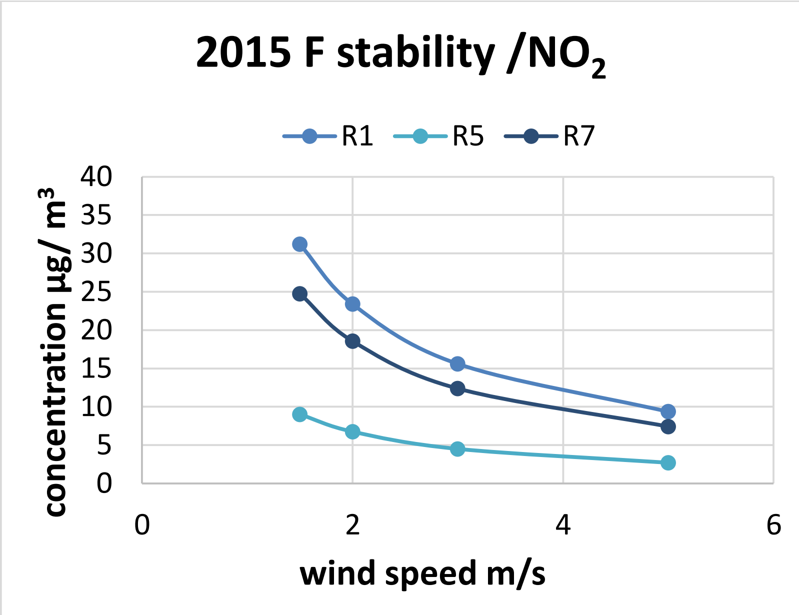

Figure 14: Calculated concentration values for receiver points for 2015 for NO_2, for F stability and for different wind speed

To distinguish the effects of each stability categories, NO_2 concentration values were calculated for A, C, D, E, F categories, where the wind speed was fixed at 1.5 m/s for two years (Fig.15 and Fig.16). The maximum was 31.18 µg/ m³.

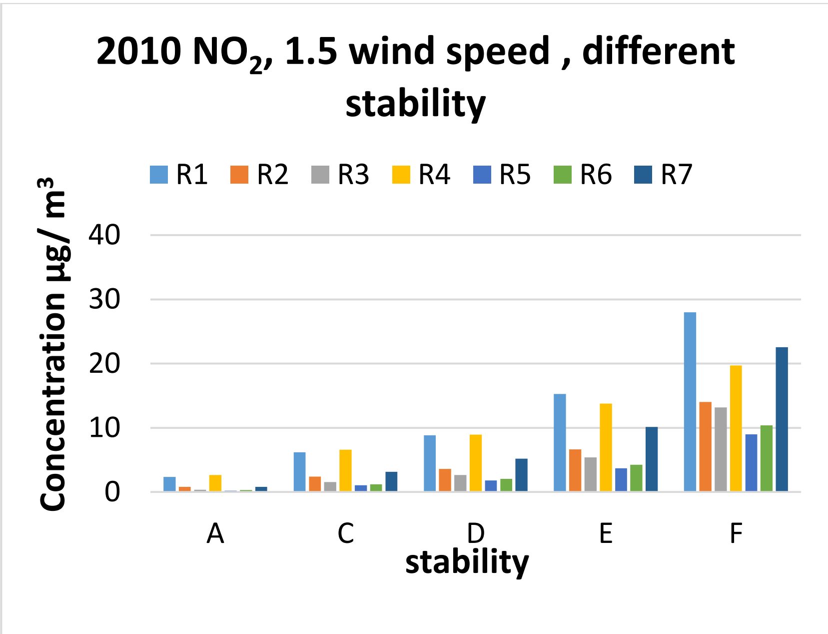

Figure 15: Calculated concentration values for receiver points for 2010 for NO_2 and different stability categories, for 1.5 m/s wind speed

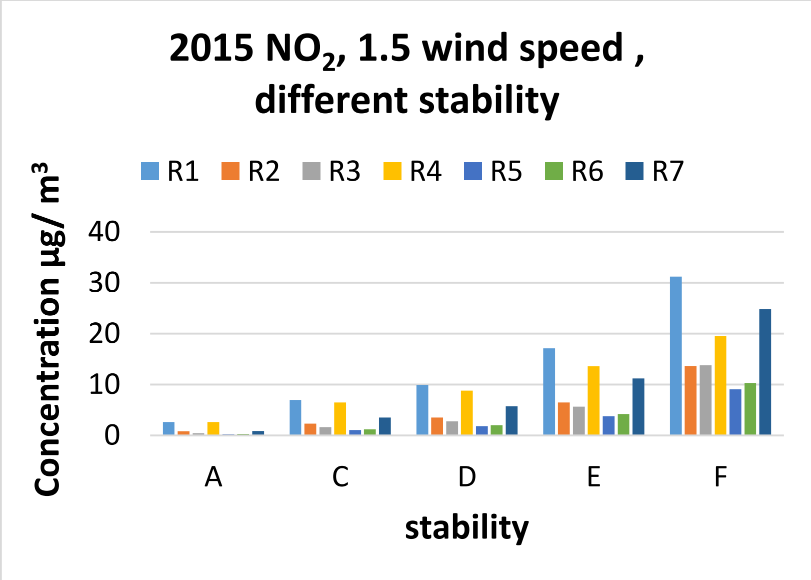

Figure 16: Calculated concentration values for receiver points for 2015 for NO_2 and different stability categories, for 1.5 m/s wind speed

Conclusion

The dispersion model results show only small differences in air quality between 2010 and 2015, but indicate the impacts of the changes in traffic and environmental developments on air quality. In addition, these concentrations were the maximum generated concentrations of NO_2 from one emission source (line sources) and these concentrations shall be added to the background concentration to comply with the immission concentration limits (the max of NO_2 on the scale 32 µg/m^3). Based on the simulations, the new bypass road help in the reduction of the pollutants inside the city, because somehow in segments of the road No.1 and road No. 13 undoubtedly better air quality acquired.

Based on the model simulation we can conclude that for receiver points, R1 school (Petőfi Sándor Általános Iskola - Komárom) and R4 kindergarten (Komáromi Gesztenyés Óvoda) demonstrated the highest immissions in all scenarios. Immissions in some points for the year 2015 show higher concentrations than the year 2010.

No. 131 starts to be in use by heavy trucks and cars instead of the roads No. 1 and 13 to reach the industrial park. However, in one of the segments of road No. 1, high concentrations can be noticed due to the difference of the traffic in the 2 years, wherein 2010 there was a few traffic and in 2015 the traffic increased. In addition, road No.1 is used by traffic to cross to Slovakia.

The meteorological data for simulations were used in the format of annually averaged. Using more detailed input data (e.g. the hourly time series data) could give more precise information and better comparison between the two years and could provide more precise scenarios. For line sources, F stability category (very stable stratification) and low wind speed (1.5 m/s) is the most critical situation for air pollution. Using dispersion models in EIA is an excellent choice for sustainable development. It helps in taking the proper decision by making several scenarios to know the worst situations. Such an example knowing the critical scenarios with the exact occurrence time help the decision makers to take the correct decision and save the health of residents especially the respiratory disease people for example by banning them from going outside till the quality of air getting better. Further investigations are needed especially in schools and kindergartens that located near to the traffic roads to assist the effect of air pollution on the children health and take proper decisions, especially that several studies related the childhood diseases with the exposure to NO_2 air pollutants from traffic such as asthma [22, 23], decrease in cortisol levels and concentrations in adolescents [24], childhood cancer [25]. Finally, in my lovely country, Syria EIA applicable for projects (industrial, residential…etc.) by the Ministry of Local Administration and Environment on the other hand atmospheric dispersion models are not used in assessing the air quality and it is necessarily true that using dispersion models would be beneficial for Syria future especially after the civil war.

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APPLICATION OF MICROBIAL ELECTROCHEMICAL TECHNOLOGIES IN THE WASTE WATER TREATMENT AND BIOSENSOR DEVELOPMENT

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Abstract

The advance of Microbial Fuel Cells makes use of natural, cost efficient materials scalable from the single home use to industrial waste water treatment and energy production. Hydrogen and electrical energy are the main byproducts by conversion of the energy in the organic matter from the substrate, using electrochemically active bacteria such as Shewanella and Geobacter. Advances in cathode and anode design has reached the stage of inexpensive carbon fiber material, easy to mold into shape and size, this optimizes the hydrogen and electricity production. Use of MFC's as a biosensor to detect different types of toxicity is a main advantage, short response times and online monitoring is possible. Different pollutants require the use of different microorganisms in the detection of heavy metals, organic waste, pesticides etc. The current rise in environmental awareness has developed the use of biosensors and biomonitoring. In wastewater the removal of BOD in a main factor, conventional BOD monitoring is not suitable for use due to the long response time (up to 5 days). With the use of MFS biosensor the response time can be reduced at a fraction of 3 to 6 hours, with a grater dynamic range and accuracy and using a multi stage coupled MFC system. The use of a multi-stage MFC system allows for precise differentiation of BOD and toxicity, with possibility of online monitoring. The different types of application of MET (Microbial Electrochemical Technologies) results in a wide range of possible determinations in and off situ. Variations of MET's include: microbial desalination cells, microbial electrolysis cell, microbial electrosynthesis system, microbial fuel cell, sediment microbial fuel cell (benthic) and microbial methanogenesis cell.
***Keywords**: Waste water treatment, Algae technology, Microbial Fuel Cell, Circular Economy, Bioelectrochemical systems, Biosensor development*

1. INTRODUCTION

Current advances in technology pave the way for better understanding in how we see renewable energy. Energy demand in rising and sustainable approaches are to be used that integrate not only the production of clean energy but the ability to harness this energy in a way that we can have a positive impact on the environment.

Pollution has proven a challenge in many aspects as clean air, water and land define the quality of life as urban population is expected to reach more than 5 billion in the next decade.

Waste is a main concern in so many areas of our industry, the ability to harness clean energy and regulate environmental concerns in waste management will prove essential in coming years.

The European Union has presented the directive to aid in this step to reuse, recycle and manage resources in adopting the Circular Economy package. This includes revised legislative proposals on waste for sustainable economic growth also generating green jobs from production to consumption and waste management.

Water and energy are a main concern to our lifestyle as traditional methods of water treatment are energy consuming (between 950 and 2850 kJ/m^3 of water treated) and often costly. A new approach to wastewater treatment is harness the energy potential available, estimated at 9.3 times more energy in the wastewater than was used to treat it. [1] The concentration of organic compounds found in municipal wastewater and can be a source of energy, however high strength industrial wastewater has a concentration above 2000 mg (BOD)/L [2] and higher energy density. Wastewater generated in the food industry provides a good source of easily degradable carbohydrates and organic acids and have a low concentration of organic nitrogen. The highest organic compounds found in wastewater come from the animal industry (approx. 100.000 mg (COD)/L) [2]. Despite considerable variability in the characteristics of wastewater depending on their sources, the following general characterization parameters were defined:

– "Soluble" wastewater, non-settleable and non-coagulable, composed of readily biodegradable COD, readily hydrolysable COD, and inert substrates.

– "Colloidal" wastewater, non-settleable, composed of heterotrophic biomass, inert substrates, and slowly-biodegradable COD substrate.

– "Particulate" wastewater, settable, composed of biomass, slowly-biodegradable COD, and inert substrates. [2]

The common technology used today for biological treatment is activated sludge, in which microorganisms (aerobic) metabolize the organic waste. This is an energy consuming process, pumping and aeration only demands for 30 to 55 % of the total energy consumption. Recently a new technology emerged in the form of membrane, this is an expensive technology used for non-renewable fossil fuels. Because of the greenhouse gas production these are harmful to the environment and not a cost effective method for waste water treatment.

The interest in MFC as an effective waste water treatment method comes as an answer to the more demanding market for technology that has a low impact on the environment is self-powering and capable of offering a standalone unit, scalable for home, mobile or industrial use. [3]

2. MICROBIAL ELECTROCHEMICAL TECHNOLOGIES, BIO-ELECTOCHEMICAL SYSTEMS (BES)

In the following a model setup is provided for a better understanding of the technology and modular possibility of a BES system. Description of the system and types of modules is provided in the work of Bruce E. Logan and the group of researchers that have analyzed the potential of different BES. Used as a modular system, these can harness not only sustainable energy but also a great number of chemicals from the organic matter found in wastewater. The process removes, transforms and provides treatment for the organic substances via oxidation-reduction reaction.

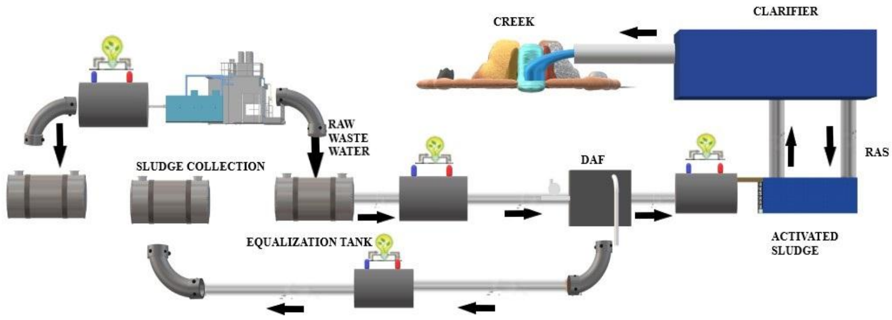

Figure 1: Integration of BES in wastewater treatment [graphics by Claudiu Iulian Barbu]

2.1 Examples of Different Microbial Electrochemical Technologies (METs)[4]:

- MDC: - microbial desalination cells can use electrodialysis stacks (MEDC, microbial electrodialysis cell), or forward osmosis (MOFC, microbial osmotic fuel cell) membranes.
- MEC - microbial electrolysis cell typically used for hydrogen gas production from the cathode, but also used for metal reduction.
- MEDCC - microbial electrolysis desalination and chemical production cell (MEDCC) includes a bipolar membrane, so energy must be input for chemical production.
- MES - microbial electrosynthesis system an MEC that is designed to produce soluble organics such as acetate.
- MFC - microbial fuel cell electrical power production.
- MxC-MBR - MFC with a cathode membrane, the cathode serves a dual function, reduction and filtration of the water using either MFCs or MECs.
- MMC - microbial methanogenesis cell methane production from the cathode.
- MREC - microbial reverse electrodialysis, RED stack inserted into an MEC electrolysis cell.
- MREEC - microbial reverse electrodialysis, electrolysis and chemical production cell. An MEDCC that includes a RED stack and is used for production of acid and bases; can be used for carbon capture; can produce hydrogen gas; can also be used for desalination
- MRFC - microbial reverse electrodialysis fuel cell, RED stack inserted into an MFC
- MSC - microbial struvite production cell, designed to precipitate struvite on the cathode
- sMFC - sediment microbial fuel cell also known as a benthic MFC [4]

2.2 Microbial Fuel Cells

Given the potential of converting organic waste into electricity and scalable, flexible design of the technology MFC (Microbial Fuel Cells) have been tested and further developed by the scientific community. The process of converting the chemical energy of organic matter in the substrate into electrical energy is a main opportunity for the demand in green energy and treatment of wastewater.

This conversion can be obtained when bacteria oxidize the substrate (electron donors, such as oxygen, nitrate or Sulphur species), in the anodic chamber and generate electrons and protons. The electrons are absorbed by anode and flowed through a resistant or a power user to the cathode, where they can reduce the electron acceptor. Cations, preferably protons, flow from the anodic to the cathodic chamber through an ion selective membrane such as salt bridge or proton exchange membrane (PEM) to complete the charge balance. In the cathodic chamber, the protons combine with oxygen and form water. Anodic chamber is anaerobic and carbon dioxide is produced as an oxidation product. [3]

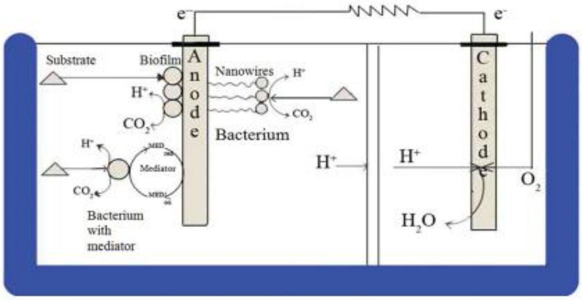

Figure 2: Design of a two-chamber MFC, M. Aghababaie et al. [3]

MFC uses electrochemically active bacteria such as *Shewanella* and *Geobacter*, by transporting electrons extracellularly in the process of organic carbon consumption they flow to the cathode delivering electricity.

Temperature, pH, the materials use for the construction of the parts as well as the ionic strength of the medium are key factors for optimal results. Advances have been made in the design and materials used in MFC in recent years that lead to better performance and results of the systems developed.

Fermentation and respiratory chain are the main pathways in the anodic chamber. The MFC electrical potential depends on the positive redox potential of the substrate, the high energy gain is given by the higher positive redox.

The use of microorganism allows for a multiple substrate with multiple enzymes, these are optimal for biofuel cells. One other option is purified enzymes, these can be used better I biosensor application, as described in later pages of this article. In laboratory testing and modelling MFC have made use of organic matter substrates that vary from glucose, cellulose, butyrate, acetate to lactate in the work done so far.

Anode material and characteristics

Choice of material for the anode is essential conductivity, stability, biocompatibility, non-corrosive manner and surface area are main characteristics that ensure operational stability and potential. Previously used materials (Au, Ag, Pl) have a weak adhesion to microbes and high cost, alternative electrodes that report better performance include Ni, Cu, Rh, Ir. Recent advances have made use of flexible carbon-based anodes, these output best results in conductivity and durability in combination with a titanium core wire.

Cathode and biocathode

Platinum has long been used as the primary material for the electrode however these have proven unsustainable and costly, recent research had made use of carbon and graphite based electrodes. Biological cathodes are inexpensive and sustainable, enzymes and microorganisms can be used as biological catalysts for oxygen reduction however they prove limited capacity of electron transfer fo rm the cathode to the microorganisms.

Marzieh Aghababaie has detailed the process implemented in his research with MFC. In recent models the anodic and cathodic chambers are separated by a salt bridge or membrane, Nafion used as material, newly tested separators include disulphonated poly(arylene ether sulphone), carbon nanofibre/Nafion nanocomposite, activated carbon nanofibre/Nafion nanocomposite membranes, earthen pot and sulphonated poly(ether ether ketone) (SPEEK) in poly(ether sulphone) (PES) membranes at various compositions of SPEEK. [3]

Biosensor development in MFC technology

By use of an MFC-based biosensor, the bacteria can sense the analyte and then give a corresponding response on its output electric current, in which the sensing step and electrical signal transition step are integrated and can be completed in one step without a signal transducer and external power source. [8] As a result this gives opportunity for a portable biosensor device for use in long term and remote measurements. In testing it has proven to be superior operational stability to conventional BOD sensors.

For the detection of toxic components an MFC-based biosensor makes use of all control methods (resistance, anode potential, current control). The given response depends on the method utilised and the control level of each method. A noticeable change in signal is observed when using >0.5 mA current and >-0.4V anode potential. In the case of the two mentioned methods (current control and anode potential control) there is a long recovery time, this lead to the observation for choosing the specific settings of control level of the sensor. A faster recovery is possible by use of bacteria that can adjust anode potential and current. When using an external resistor there is benefit in recovery time and signal change.

Sumaraj and Ghangrekar M. M [5] publish the results from there study on MFC as a biosensor using 2 units for testing. In the first unit (MFC -1) the response rate was 120 minutes for detection of 22.43 mg/L COD concentration. The second unit took the same time to detect a concentration of 64.28 mg/L COD. The research and findings can be found in the cited publication.

Conclusions

A rapid development of the MFC technology can be observed from the existing research and findings. The technology is a basis for scaling models directed at home and industrial use. The necessity of a easy to use system in wastewater treatment has come to the awareness of the scientific community for some time. Current development of the technology is aiming for use as a biosensor and further development is necessary.

In his publication of Z. Baicha provides insight to the use of microalgae as a substrate and also the growing use of phototrophic microorganisms in the cathode of an MFC. Increased use is caused because of their numerous advantages such as oxygen production and ability to capture the CO_2 generated. Photosynthesis allows phototrophic microorganisms to produce oxygen, which is consumed at the cathode, while carbon dioxide is used as carbon source during the process. The use of bio-cathodes based on algae allows expensive noble catalysts usually employed for the oxygen reduction to be replaced with natural materials. [7]

MFC technology has become a sustainable option in wastewater treatment as one of the most promising MET applications, a primary use in wastewater of the MFC is as biosensor. Application of MFC as a biosensor for BOD measurements and toxicity can prove a viable solution for online chemical toxicity detection. Conventional BOD measurement methods are time consuming with a response rate of 3 to 5 days, the response delay is improper for monitoring use and information processing. As BOD is directly converted to electricity by the MFC this accounts for a fast response rate between 2 to 5 hours.

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MEASURING ACOUSTIC PROPERTIES OF MATERIALS WITH A MICROFLOWN SENSOR

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Abstract

The issue of noise as an aggravating factor is often a topic to be discussed. This is a consequence of the growth of the human population, coupled with economic growth and the intensive use of sound-generating devices (noise). The paper deals with the use of the Microflown acoustic sensor to research the acoustic properties of materials both indoors and outdoors. It uses its ability to measure reflectivity, absorption or acoustic impedance over a few minutes, broadband, perpendicular to material or at any angle. The practical use of Microflown technology is presented in the measurement of the sound absorption coefficient of materials.

Keywords*: acoustic, noise, microflown, particle velocity.*

1. INTRODUCTION

The issue of noise as an annoying factor is much discussed topic in the last decades. It is caused by population growth linked with an economy growth and the utilization of the sound producing devices. The significant environmental source of noise is traffic, specifically road transport [5, 6, 10]. Noise effects in urban areas have influence on human health and their well-being, what is the most important reason for minimization of all the forms of noise pollution [1].

Sound is a hearing, produced by small pressure vibration that propagates through the air or an elastic medium. Each sound field is defined by two mutually complementing acoustic properties. By a scalar value that is the acoustic pressure and by a vector value that is the particle velocity. The Microflown is the acoustic sensor that, in addition to the acoustic pressure (common microphones), measures the velocity of particles in an elastic environment. It is utilized for measuring of one-way flows that are used at the particle velocity ranging from 0 Hz [3].

2. THE PRINCIPLE OF OPERATION

The Microflown was used for the first time at the University of Twente in 1994. The first research was oriented to elaborate a design and calibration of the method itself. Later, the cooperation was expanded to the operation of scientific groups and industry, with the aim to develop it.

The research itself includes, in addition to the development of individual applications, also the materials behaviour modelling and their study, which would lead to an improvement of signal-to-noise ratio and also lower energy consumption. This method does not measure a fluctuating air pressure, but the air velocity through two small platinum resistance strips, which are warmed up to temperature of approximately 200 °C. In the dynamics, the movement of gas or liquid particles is called a flow, thus the name Microflown is used. The device is sensitive to the movement of the air particles more than to the pressure. It became available only a few years after it had been invented.

The Microflown is manufactured with the utilization of microtechnology, which is linked to the microelectronics, which started to develop after a transistor had been invented by Shockley in Bell laboratory in 1947.

It was manufactured in three variants: a cantilever type, bridge type and medziprírubový typ. The first manufactured type was the bridge type, where the measuring cables should have been free in the sound field. It is important the cable to have fixed boundaries and also to achieve high frequency and to be as thin as possible. Today, the bridge type (Figure 1) is the most used one. It is able to fulfil the actual demanding requirements. The cables of this sensor are fastened to both sides, what improves the mechanical stability.

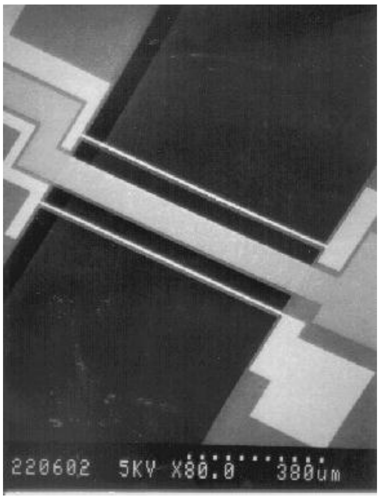

Figure 1. The bridge type of the Microflown [2]

The Microflown technology is suitable to address the acoustic properties of materials in both environments, indoors and outdoors. The reflection factor, absorption or acoustic impedance could be measured within minutes, using the broadband, perpendicular to the material or at any angle. It enables to measure the acoustic pressure and acoustic velocity of particles in-situ on the material surface.

the Microflown sensor is capable to measure the major acoustic parameters ranging from 20 Hz to 10 kHz. In the case of the frequency ranging from 10 - 20 kHz, a special calibration is required. In some specific cases, it is possible to measure within the frequency range from 0,1 to 10 kHz [7].

Maximum natural noise of acoustic pressure level PU and PU of mini probe of the sensor is 10 dB at 100 Hz. For sensors of the particles velocity PU and PU of mini probe there is a maximum of 10 dB at 15 Hz. The intensity of sound and particle velocity are changing in the distance of 5 – 10 cm from radiating surface in order to prevent the errors of reactivity. The particle velocity is the most suitable indicator for a placement of the source itself. The measurement performed in the distance of 1 - 5 cm provides better results [7].

The calibration in the acoustics related to the Microflown is necessary, since it determines the quality of measuring. The aim of the calibration is to determine the output voltage, when a certain acoustic signal is put on the Microflown or microphones. In other words, it is necessary to determine the amplitude reaction.

The calibration Microflown differs from the classical microphones. In the present, the piston is developed, which is placed on the calibrator ball for the Microflown calibration. It is recommended to carry out the calibration every two years. The simplest way how to calibrate is to use the reference particle velocity of the microphone. Due to lack of the sensors of this type, it is necessary to use other measuring device. The most suitable is a pressure microphone, where the problem is focused on the searching for the environment with the specific acoustical impedance. If the acoustical pressure is measured using the particle velocity, it will be calculated by division of this pressure per the specific acoustical impedance. If this impedance is dependent on the place and frequency of the setting measuring, it is possible to obtain many parameters that measure and calculate the particle velocity.

The drawbacks of the Microflown sensors:

- measuring of the complete sound band is time consuming, since it is necessary to change the distance several times,
- it is necessary to carry out the calibration after each change,
- the lower frequencies are hardly to measure (lower than 100 Hz), especially within a reflective environment and
- it is not possible to measure high frequencies (over 10 kHz),
- the measurements carried out using the sensor within near field of sound source are not exact, since the sound intensity is changing along the sensor.

The Microflown consists of two extremely thin wires, the platinum resistors, which acting as the thermal sensors. The diameter of conductors is approximately 0.5 μm, the distance between them is 40 μm and their length is 1 mm. The increase of sensor temperature leads to the resistance increase. If there is particle velocity, both the sensors have common operational temperature, approximately 200°C to 400°C and all the heat will be transferred to the ambient air. In the case that the particle velocity is spreading perpendicular through the wires, the transfer of temperatures changes asymmetrically around the resistors. The difference of the resulting resistance provides the width of band (from 0 Hz to 20 kHz) of the linear signal with an "8" shaped directivity, which is proportional to the particle velocity up to the level of 135 dB. The lower level of noise is ranging from - 10 dB at the band spread of 1 Hz to 1 kHz [2].

If an acoustic wave passes through certain air band, the particles do not vibrate in one place, but move according to the pattern determined by the acoustic wave shape. Depending on the activity of particles, Microflown detects their velocity. It is not possible to perceive high tones as well as it is possible at low tones. The amplitude of the particle movement in the acoustic wave is very small, within the range of 50 nm/s to 1 m/s. The amplitude can be increased at the sensors with correctly selected cover. This phenomenon can be defined as „cover gain". The regular levels of acoustic pressure ranging in intervals around 60 dB. At these levels, the temperature difference of two Microflown sensor differs only in ten thousandth of centigrade degrees. Specific sensing wires are thin – 200 nm (approximately 600 atoms) with width of 10 μm, therefore it is almost impossible to see them with the naked eye (a human hair diameter is 80 nm, thus Microflown sensor is four hundred times thinner than a human hair).

Since the Microflown sensor does not include moving parts, it has no resonances. Is very resistant against extreme ambient conditions, such as high humidity, impurities and high temperatures. It is manufactured in clean premises, which are most commonly utilized in scientific research and have low level of environmental pollutants, such as dust, various microbes, aerosol particles and chemical vapours. This sensor enables to perform measurements in the areas that are usually problematic for traditional sensors.

The Microflown has increased sensitivity in the sources near field. The difference at the measuring of acoustic pressure with the ability of measuring the particle velocity at surface is that the background of acoustic field is suppressed and the acoustic field of surface is more intense. This function is very useful for the methods of localization of noise sources in real environment.

The particle velocity can be detected immediately. It can be measured in 3D space bandwidth (10 Hz - 20 kHz). At one point, you can determine sound intensity, acoustic impedance, and acoustic energy intensity. The sound intensity is related to the sound pressure and particle velocity and quantifies the amount of sound that spreads. The acoustic energy is connected with the quantity of acoustic pressure and particle velocity. The intensity of acoustic energy defines how much energy is included in an acoustic wave, the intensity of sound defines how much acoustic energy is transferred and specific acoustic impedance defines the options of transferring of acoustic energy.

The frequency range for measuring of sound intensity, acoustic pressure and particle velocity using the Microflown sensor depends on the distance from surface and a method of measuring:

- particle velocity: 0,1 - 10 000 Hz,
- intensity: 400 - 10 000 Hz,
- pressure: 20 to 10 000 Hz.

Sound velocity is not influenced by noise and reflections. It provides information about the location of sound source. A minimum distance of reflection area for correct measuring of sound intensity depends on the distance from measured surface in the near area (2 - 3 cm from surface).

A minimum size of sample for good measurement of absorption is 0,3 x 0,3 m, what is suitable for the utilization and comparison with other methods, such as the method with utilization of Kundt tube. The type of material used can determine or decrease a usable frequency range of setting to low frequency and high frequencies, however, according to the definition; it is possible to use any material.

The use of Microflown sensor of particle velocity is available or all the spheres of acoustics, where the particle velocity differs from acoustic pressure. This difference is usually added to the knowledge of sound field or sound source, which is the subject of research. The differences occur especially in the vicinity of sound source or sound field related to directivity. Considering the working principle of Microflown, the medium used would be electrically nonconductive and if possible, with a gas similar to air [4].

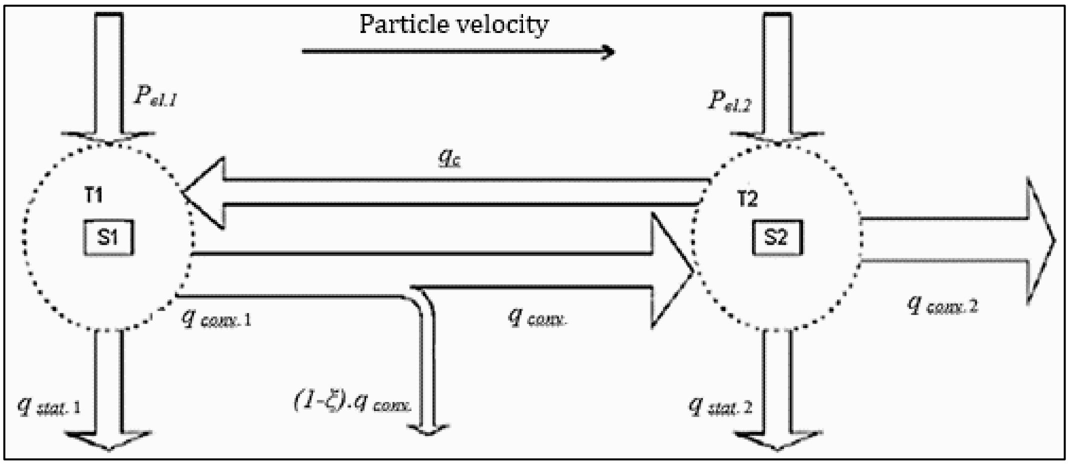

Figure 2. Schematic drawing of the heat flow around a Microflown sensor [4]

On Figure 2, the two rectangles S1 and S1 represent two temperature sensors Microflown. The temperature sensors are implemented as platinum resistors and are powered by electrical current what leads to operational temperature ranging from 200 °C to 300 °C. If the temperature increases, the thermal resistance will also increase. When particle velocity is present, the temperature distribution around resistor is changing. The temperature difference is the measuring gauge for the flow. An electrical current absorbs electric power (Pel.), which heats both temperature sensors. When no particle velocity is present, the temperature of both sensors will rise to approximately 200 °C and all heat will be dissipated into surrounding air (qstat.). When particle velocity is present, a convective heat transfer of both sensors (qconv1&2.) will result in a temperature drop of both sensors. However, the upstream sensor will cause the temperature decrease. A temperature difference will be the result. The temperature difference is proportional to the particle velocity. Not all heat losses of S1, are useful for S2, a certain percentage (ξ) can be lost. This percentage will rise if the sensors are placed further apart from each other. If those sensors are brought together, another phenomenon will become considerably dominant. The particle velocity induced temperature difference will result in a change of thermal flow to the opposite direction. This feedback heat flow will change the sensitivity. Other sensors are placed together, what will increase the effect of heat flow.

3. MANUFACTURING OF MICROFLOWN

The Microflown is manufactured in clean premises, what requires a certain number of working actions. In the beginning, it is important to clean the plates in order to prevent the device contamination. After cleaning, a thin layer of silicon nitride (300 nm) will be places on the plates. This layer fulfils the function of a shield for wet etching and as a carrier for sensor, see Figure 3a. The board will be covered by silicon nitride layer and subsequently it will be placed on a photo-resistant layer. This layer is deposited in a liquid state, since it rotates at a certain speed, where the speed and viscosity of photo-resistant liquid define the thickness of a photo-resist (a light-sensitive plastic material). If the board gets warm as a consequence of hardening, it will be placed and lightened. The lightened profile will be removed by a growth of the photo-resistant layer. The Microflown is a sensor, which is processed by hot wire of the air velocity measuring device, but on the basis of two wires, not one wire, as it is in a classic air velocity measuring device. Those wires are thin and short, produced from silicon nitride and covered by platinum and warmed by direct current up to 300 °C. Their total resistance depends on the temperature [2].

The signal of particle velocity in the perpendicular direction changes the temperature distribution immediately, since the wire will cool down more than the follow-up wire of air flow. The resulting resistance measures the differences in the bridge circuit, which provides the signal proportional to the oscillation velocity.

In order to create sensors and connecting boards, a platinum layer with thickness of 200 nm is needed with the use of so called "sputtering method". This layer is monitoring one and connecting boards are to make an electrical connection with the board printed circuits. The platinum layer is marked by lift off method (the way of creation of structures from target material on the substrate surface, e.g. on the board surface using the sacrificed material – the photoresist) if the photo-resistant layer is removed and the platinum layer remains, what is shown on Figure 3b. After the platinum layer is completed, the layer of silicon nitride will be etched. The free steel beams are inserted by wet etching. Where the photo-resistant layer is removed, the layer of silicon nitride will also be removed. This principle is shown on Figure 3c. Wet anisotropic etching will create a channel and determine the free cantilever bridges shown on Figure 3d.

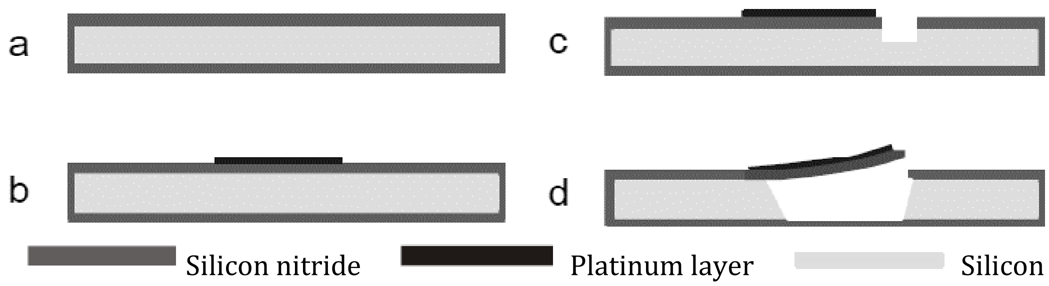

Figure 3. Schematical drawing of particular steps of the Microflown cantilever [4]

The sensors of total acoustic energy are useful for the systems of noise attenuation, since they minimize total density of energy, which can be more effective than a control strategy of noise minimization. As it was stated, the directional information of the particle velocity measuring found the application in the acoustics. Those sensors are also used in the analysis of complicated noise sources, where the mutual experiments are very useful for a characterization of noise sources of machines.

Other applications also include the measurement of impedance and the coefficient of material absorption inside and the measurement of specific acoustical impedance in a tube.

It seems that the sensor of particle velocity, Microflown, has a potential in the measurement of acoustical performance. It is very small, even smaller than standard two microphones of the intensity sensor. It is possible to use it for measuring in the close vicinity at oscillating surfaces. The measuring of sound intensity becomes increasingly popular. In present time, the sound intensity sensor consists of two pressure microphones (p-p sensor). The sensor, which measures the intensity of sound in one direction is very exact measuring device.

4. MEASURING PROBES

Probe PU regular

Probe PU regular consists of two sensors. It is made up of a traditional microphone and the Microflown. The Microflown is a sensor, which directly measures the acoustic particle velocity. Probe PU regular shown on Figure 4 is used for a variety of applications such as the determination of sound intensity, sound absorption, sound leakages. The sensors are applicable to use in reverberant conditions and can be used within closed cavities, such as a car interior [4].

Figure 4. Monitoring probe PU regular [4]

Probe PU mini

The probe PU mini also consists of two types of sensors: a traditional microphone and the Microflown. The probe PU mini - Figure 5 is used for variety of applications. It is mainly used as scattered array for panel noise contribution analysis, free or fixed grid arrays for near field acoustic camera. Also it is used for the determination of sound intensity, sound power or acoustic absorption [4].

Figure 5. Monitoring probe PU mini [4]

Probe USP match

This sensor is one of the state of the art sensor, also called USP sensor – the Ultimated Sound Probe. The tree-dimensional ½ inch USP sensor, Figure 6, consists of three orthogonally placed Microflown sensors and one acoustic pressure microphone. The USP sensor is mainly used when the material size matters. The size of this sensor without its cap is less than 5×5×5 mm^3. It is mainly used as AVS – acoustic vector sensor, it can also be used in the near field for 3D sound intensity, energy, power and acoustic impedance [4].

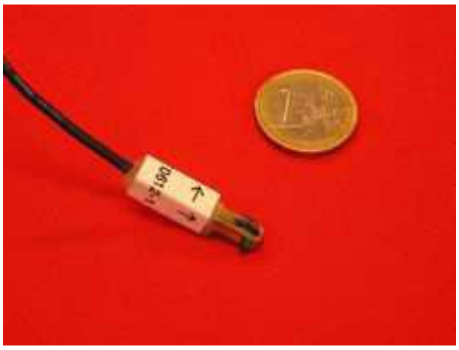

Figure 6. USP match probe [4]

5. THE OPTIONS OF A PRACTICAL UTILIZATION OF THE MICROFLOWN TECHNOLOGY IN MEASURING OF THE MATERIAL NOISE REDUCTION COEFFICIENT

At the methods of a surface impedance of free field we can use the combined sensor of acoustic pressure and particle velocity (PU). Both the sensors are placed in one casing and it is necessary to position them in close vicinity from the material measured. The manual tool for measuring of the noise reduction coefficient by the principle of acoustic pressure and particle velocity measurements, is shown on Figure 7 [3].

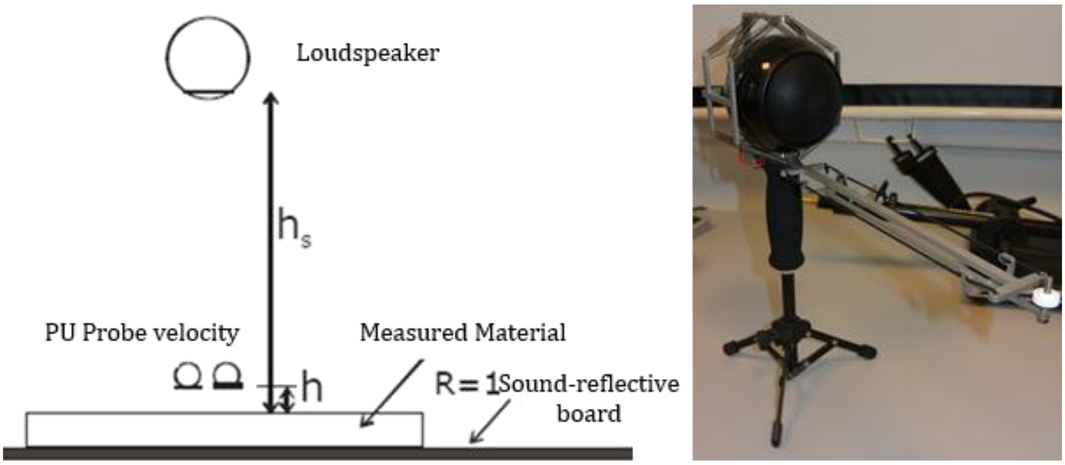

Figure 7. Schematic drawing and demonstration of PU probe and device [9]

The result of those measurements is the frequency dependence of the noise reduction coefficient (α). Figure 8 shows the procedure α of the sample of an acoustic material, which is used as the sound-absorptive covering in the appliances such as washing machines, drying machines or dishwashers. The measured dependence α using the Microflown sensor, which was placed 2.5 cm from the material sample, is graphically compared with mathematically calculated simulation and the measurement carried out using the impedance (Kundt) tube with sensors for measuring of acoustic pressure, thus, using the classical microphones. The measurement in the impedance tube can be, in this case, considered to be the reference one, since this method of measuring and evaluation of the noise reduction coefficient is considered to be more exact.

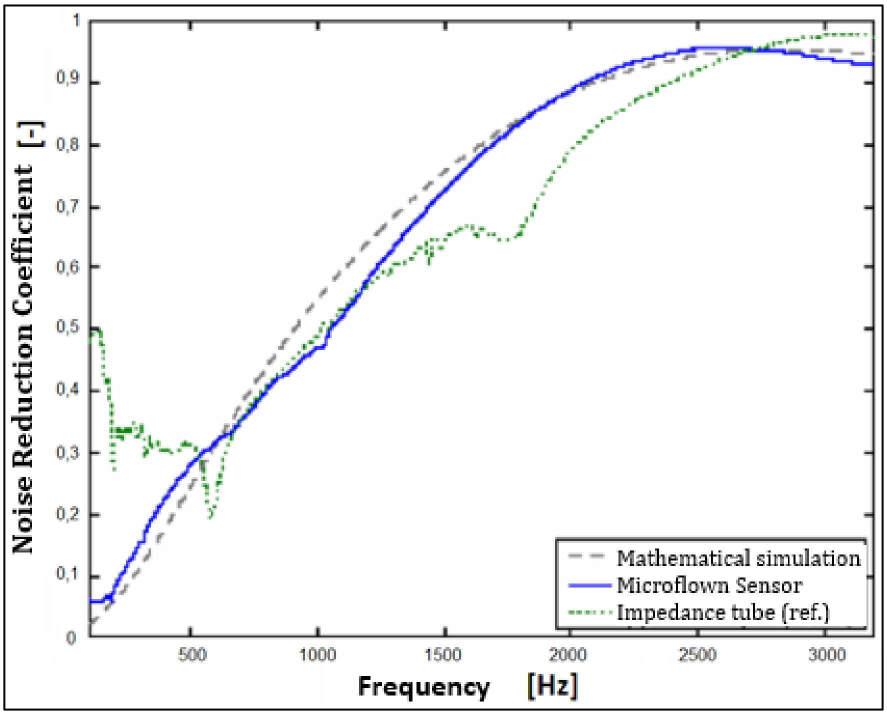

Figure 8. The comparison of results of the noise reduction coefficient [9]

It is obvious from the results that the Microflown technology is from a practical point of view suitable for the determination of the noise reduction coefficient of materials within the frequency range from 300 ÷ 400 Hz to 10 kHz.

Conclusion

The Microflown is a sensor, which creates the new occasions in the sphere or acoustics. The utilization of new acoustical and physical parameters enables to create new applications and improve already existing ones. It is resistant against extreme conditions in surroundings and has no resonances, since it does not contain any moving parts. The Microflown is used mainly in the environment, which is considerably problematic for the classical sensors. The paper also includes the practical section, which deals with a practical utilization of this sensor in measuring of the noise reduction coefficient of materials.

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UTILISATION OF PSYCHOACOUSTICS IN TECHNICAL PRACTICE

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Abstract

Psychoacoustics is currently a powerful tool for optimizing the acoustic properties of sounds of machines, equipment and products in industry and in the home by thorough analysis and subsequent correction of psychoacoustic parameters (such as roughness, sharpness, volume, sound color, etc.) in order to achieve acceptability for man. It should be noted that the perception of sound (noise) by man is of a subjective nature and heavily depends on a particular person and his current disposition. The psychoacoustic parameters (roughness, sharpness, volume, color, tone, fluctuation force, subjective duration, and sound height) provide the foundation for solving many technical problems in practice. With respect to the application of psychoacoustics in practice, a relatively new scientific department has created a so-called acoustic product design that aims to optimize the acoustic effects of products on its potential users and their surroundings. Its important role is to objectively assess the sound quality of the product, which is a certain acoustic product card, even it can be seen as the product's image. Acoustic quality can be understood as the adequacy (soundness) of the product's sound, in terms of its useful value and function. Adequacy of the sound of a product is important from the point of view of its users, required as low noise level as refrigerator, washing machine and others. Also as a product sound feature that allows the user to identify the presence of the product, its kind, brand, operating status, or malfunction. As well as the sound of the product (so-called "loudness") to the user and his surroundings, for different user groups (in terms of age, gender, social status and other criteria), it is often a completely different sound. Psychoacoustics are currently most used to solve noise-related problems in areas such as the automotive industry, the design and manufacture of telecommunication products, the design and manufacture of home appliances and other areas.

***Keywords**: acoustic, noise, psychoacoustics, psychoacoustic parameters, properties of sounds*

1. INTRODUCTION

The term psychoacoustics has been used exceptionally in the past. Psychoacoustics, as a relatively new area of acoustics, focuses on the subjective perception of sound, its effects on humans as well as the analysis of its possible effects. An important area of psychoacoustics is experimental psychoacoustics, which assesses the subjective response of a human being to the sound studied. The human body perceives noise not only through the hearing organ, but also throughout the body. The nature of the noise determines the level of the body's load. An important role plays the frequency, the width of the sound spectrum, the volume, the color, the roughness, the sharpness and other sound parameters. [6]

Noise acts negatively not only on hearing but also on the central nervous system, the vegetative system, and through them also on sight, heart rate, blood pressure, digestive system, and so on. Noise reduces the possibility of speech communication and thus increases voice effort, adversely affects the psyche, stresses, exhausts and stands in the background of many psychosomatic diseases. Noise also disrupts concentration, social relationships, and leads to sleep disorders in humans. This issue also deals with psychoacoustics. [1]

2. THE USE OF PSYCHOACOUSTICS IN THE AUTOMOTIVE INDUSTRY

Sound engineering in the field of automotive research, development and production is a link between physics, design characteristics (vibration and transmission) and psychology, expressed through acoustic comfort, a sense of health and well-being. Acoustics are considered to be a component of successful vehicle development in connection with the transmission of noise and vibrations to the interior of the car but also to the outside environment. At the same time, new quality criteria are emerging with regard to societal changes, which should be taken into account when developing a car. If pragmatic, material and functional criteria were originally crucial, in recent years the emotional and sensory demands and appetites of car users have been stepping up. The style, character and value of the vehicle can only be achieved through a consistent, balanced and consistent overall image.

A high level of overall driving comfort is essential for its crew from the point of view of driving comfort. Comprehensive thinking and planning is required to make the final product - the car - to provide passengers with versatile comfort and good driving pleasure. It is not sufficient to partially optimize the noise of individual car components. The acoustic quality of a car must be solved as a whole, and also the interaction of all generated noise.

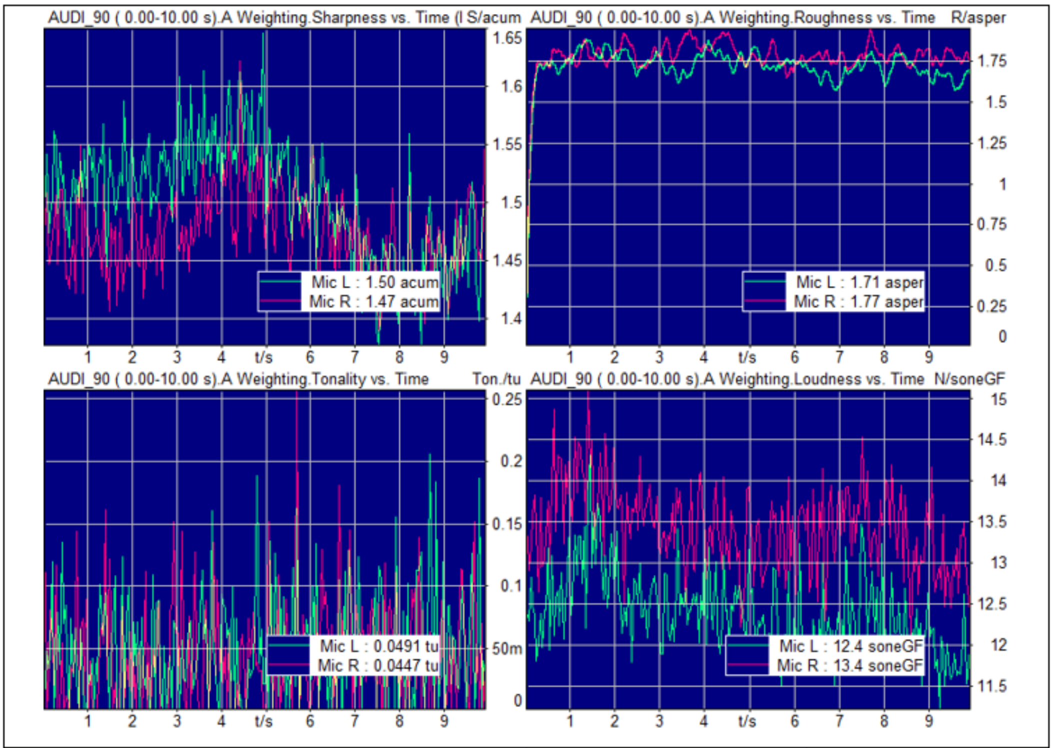
The focused development of vehicle acoustics is a highly complex, integrated task assignment in terms of driving comfort. The perception of the comfort characteristics of a particular vehicle is basically carried out as perceiving the effect of these properties through one or more human perception channels.

Individual perception of sound is very subjective. It can be objectively described only using purely physical, objective, measurable variables. On the one hand, it depends on the characteristics of the vehicle being watched or on a certain situation, and on the other hand, on the socialization of the assessment and the surrounding environment in which the assessment takes place.

The driving comfort provided by the vehicle to the driver and the passenger is therefore different, due to different customer expectations in different world markets.

Figure 1: Measurement of psychoacoustic parameters in an automobile interior

Customer requirements for driving comfort and thus vibration and vibration-acoustic properties - so-called NVH (Noise, Vibration, Harshness) - Vehicles have been steadily rising in recent decades and are still considerably higher. [4] The subject of research is also the external sound of the vehicle, which is an acoustic message for neighbours, through which information on the significance of values and quality is conveyed.



Ekvivalentná hladina A akustického tlaku $L_{Aeq,t}$	Mikrofón ľavý: 64,9 dB	Mikrofón pravý: 66,7 dB

Figure 2: An example of measuring psychoacoustic parameters in an automobile interior

Therefore, the car manufacturer should also deal with the vehicle's external noise from its perspective as an "acoustic advertiser" and should partly transfer the determination of acoustic target values from the interior of the vehicle to external noise.

Besides the typical acoustic characteristics of the vehicle, such as the sounds of the vehicle in the interior and the exterior, the sounds of the full load, partial or continuous driving, the sounds of the tire when riding in different road conditions, wind sounds and the like also play an important role operating sounds such as window trigger sounds, sound when positioning seats, and so on. However, even spontaneous sounds such as whining, snapping and whistling also create a quality impression of driving comfort perceived by motorists.

3. USE OF PSYCHOAKUSTICS IN THE DEVELOPMENT AND MANUFACTURE OF TELECOMMUNICATION EQUIPMENT

Psychoacoustics are now increasingly used in the development and production of telecommunication devices such as mobile phones, wired and wireless phones, as well as communication devices in cars, households, companies, special purpose equipment such as, for example, emergency eCall, etc. [3] The main aspect of all communication devices is call quality (audio transmission). Speech quality assessment in mobile phones is relatively demanding due to various types of signal processing (eg echo cancellations and noise reduction algorithms, various types of speech enhancements, speech processing, transmission delay, etc.). All of these aspects have a significant impact on speech speech quality. Using hardware and software tools, HEAD Acoustics GmbH, Herzogenrath, Germany, it is possible to evaluate all aspects of the speech quality attributes after the effects of using various mobile devices and carriers, for example, in cars.

Figure 3: The use of psychoacoustics in the development and production of telecommunication devices - mobile phones

Application area in communications, respectively. Telecommunications is also optimizing radio reception. Incomplete reception of the radio may cause undesirable customer experience. In this context, auditory subjective and objective methods of assessing (testing) the quality of the received audio signals.

In connection with the implementation of the so- smart areas of flats, offices, hotels and more, comes to the fore in the natural language. Many elements in buildings, doors, blinds, air conditioning, lighting and many more can now be controlled by voice.

Figure 4: Binaural sound measurement in space

Psychoacoustics in this context can help analyze all relevant aspects of speech quality and optimize the communication process. Speech quality and speech recognition for internal communication systems can be tested. Speech recognition, wireless and wireless communications tests, hardware and software tools make it possible to perform binaural measurements of the sound generated by different audio techniques in 3D space to optimize the sound quality.

4. THE USE OF PSYCHOACOUSTICS FOR THE DESIGN AND PRODUCTION OF HOUSEHOLD APPLIANCES

Today, many household appliances are used in the home. Modern households and without them can be very difficult to imagine. Helping, facilitating work and shortening work time.

These devices also cause daily harassment because they are the source of noise. Many people see this noise as annoying, unpleasant. The degree of inconvenience is influenced not only by the sound pressure level but also by the psychoacoustic noise parameters such as sharpness, roughness, colour, tone of sound and more. Acoustic design is becoming more and more popular with many manufacturers that are required not only to reduce the noise level of household appliances, but also to optimize (sound) psychoacoustic sound characteristics (parameters). [2]

Figure 5: Examples of selected types of household appliances

An example of the measurement of these psychoacoustic parameters, such as the roughness, sharpness, tone and volume of selected household appliances, namely the Bosch, AEG, Miele and Samsung brands, as well as an example of the final output of a particular psychoacoustic parameter measurement in a washing program called centrifugation is shown in the following figures, [6] Measurement of psychoacoustic parameters was performed in a non-waste chamber using technical devices.

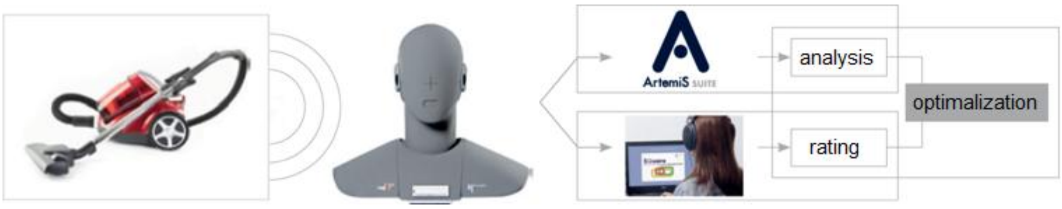


Figure 6: Optimize the sound of home appliances

Figure 7: Measurement of psychoacoustic parameters of washing machines in a wireless chamber

Noise reduction issues and solutions to acoustic product design are now the focus of global home appliance manufacturers. It is a significant advertising and business phenomenon.

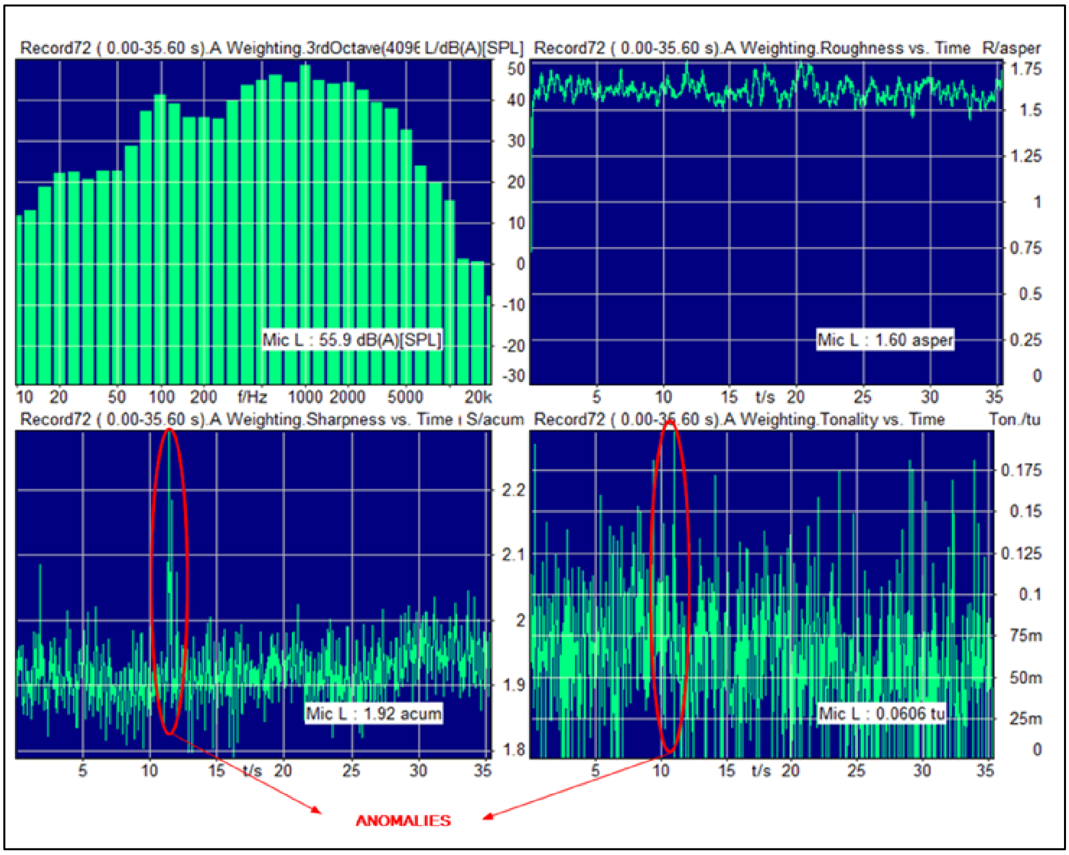


Figure 8: Example of washing machine results (centrifugation phase)

Conclusion

Noise surrounds us all around us, at home, at work, during relaxation or sleep and constantly affects us by its negative influences. In order for a person to be able to withstand all the negative effects of sound, he must know the sound based on common physical parameters such as acoustic intensity level, sound pressure level or sound power level, or also psychoacoustic parameters. From the engineering point of view, it could be said that these parameters could be less "trusted" due to their subjective nature, but their existence was proved experimentally. It is important to emphasize that psychoacoustic parameters play a very important and important role for a person as they directly affect his / her hearing perceptions. [5]

Psychoacoustics as a disciplinary discipline identifies, quantifies and examines the impact of individual psychoacoustic parameters on the overall hearing of a human being, on the chain of its psychoacoustic reactions to the sound stimulus, thereby helping to model the sound design of products to suit the psychoacoustic properties of most target group consumers.

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A MODELLING OF THE COUPLED TRANSPORT PROCESSES THROUGH POROUS MEDIA AT PRESENCE OF ANOMALOUS DIFFUSION

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Abstract

The mathematical modelling of various types of coupled transfer processes plays nowadays a role of continuously increasing importance for understanding problems related to global energetic supply and dynamics of energetic systems in order to make them sustainable. Such methods are based on principles of the contemporary non-equilibrium thermodynamics, and are continuously re-examined and improved. In the present study, we will demonstrate a novel-type solution of the problem of coupled heat-, and mass transfer processes taking place through porous media, since this basic-type transport problem has countless number of applications ranging from e.g. modelling and simulation of drying processes till fundamental research calculations in the extended irreversible thermodynamics. The crucial novelty in our modelling method is the following one: it will be assumed, that the heat transfer may be described - as earlier – by a simple extension of the initial Fourier-type partial differential equation, while in the case of the diffusion, instead of the earlier usually applied Fick-type equations, the generalized version of its, able to describe anomalous diffusion processes must be incorporated into the initial coupled system of the relevant partial differential equations. Finally, following an earlier our own modelling method, we have solved this coupled system of partial differential equations by the usually applied operational calculation methods and have incorporated the effect of the anomalous diffusion effects, too. It was assumed, that the manifestations of the concentration changes due to anomalous diffusion are of second-order magnitude, but even under this assumption they influenced the final solution form of the problem very significantly.

Keywords: *thermodynamics, anomalous diffusion, environmental transport processes*

1. INTRODUCTION

It is known, that the contemporary theories of coupled transport phenomena through porous media require simultaneous application of methods of both non-equilibrium thermodynamics and many ones from the confident, well-established results of the contemporary theories of critical phenomena relevant for percolative systems [1-4]. Although the attempts to apply these two powerful physical theories in a common, hybridized form (in order to characterize the conductivity and coupling coefficients by their stochastic state-dependence – with particular care to their "crossover" behaviour, i.e. in the vicinities of critical points relevant for percolative phase transitions) has given us [3-4] some valuable results, this program is far from being completed.

Some recent very detailed modelling studies about applications of laser light – induced wave propagation treated the separate heat transfer (described by hyperbolic-type PDEs [5]) only, but not the simultaneous coupled heat and mass transfer in this sense. Therefore, this topic even nowadays represents a completely open research domain, despite of the above cited founding results, from which there are also some ones, existing for decades, too.

Firstly, we recall here a frequently used system of PDEs for mathematical modelling of drying processes (which represent an archetype of coupled transport processes) e.g. [6]:

$$
\begin{aligned}
\frac{\partial M}{\partial t} &= \nabla^2 a_{11} M + \nabla^2 a_{12} T + \nabla^2 a_{13} P, \\
\frac{\partial T}{\partial t} &= \nabla^2 a_{21} M + \nabla^2 a_{22} T + \nabla^2 a_{23} P, \\
\frac{\partial P}{\partial t} &= \nabla^2 a_{31} M + \nabla^2 a_{32} T + \nabla^2 a_{33} P,
\end{aligned}
\tag{1}
$$

where M denotes the moisture content, T the temperature and P the pressure. The system of PDEs describing the coupled heat and mass transfer through capillary-porous bodies is usually based on the application of the zone picture, i.e. it is assumed, that the whole porous bulk may be divided into thin enough layers (the so-called zones) inside which the conductivity and coupling coefficients (incorporated into matrix elements a_{ij}) have constant values.

Moreover, the system of equations (1), as well as its simplified variants, is usually written in "criterial" form, i.e. the time t is to be understood as the Fourier-criterion ($t \to \frac{a_T t}{l^2}$, where a_T denotes the heat conductivity coefficient of the mixture and l is the characteristic length of the body being dried).

The relevant systems of coupled PDEs derived from (1) have been studied extensively in the literature of transport processes and permanently represent a very active research object from the point of view of modelling of such phenomena e.g. [6]. Another, frequently applied simplified version of (1) is [7]:

$$
\begin{aligned}
\frac{\partial c}{\partial t} &= D\nabla^2 c + K\nabla^2 T, \\
\frac{\partial T}{\partial t} &= E\nabla^2 T + L\nabla c,
\end{aligned}
\tag{2}
$$

where c denotes now the concentration and T the temperature, D is the diffusion-, and E is the heat conduction coefficient. From the remaining coupling constants K is related to thermodiffusion (i.e. Soret-effect), and L to the heat amount carried by diffusion (i.e. Dufour-effect). Firstly, it will be assumed here, that in this coupled system of PDEs all coefficients are of constant value.

THE METHOD APPLIED

In this sub-section we will summarize briefly some essential mathematical features of the anomalous diffusion following [7], since at the end of the 13th Chapter of this well-known monograph about contemporary thermodynamics, the basic information about this active research area are presented concisely. Accordingly, the solution (at initial conditions described by Dirac's delta-functions) of the generalized variant $\frac{\partial c}{\partial t} = D\frac{\partial^2}{\partial x^2} c^{q-1}(x,t), (q \in ˇ)$ of the diffusion equation has the following form:

$$c(x,t)=t^{-\frac{1}{q}}\cdot f\left(\xi=x\cdot t^{-\frac{1}{q}}\right), \tag{3}$$

resulting in $\left\langle(\Delta x)^2\right\rangle : t^{\frac{2}{q-1}}$ of the average value of the mean-square displacement, i.e. it generalizes the usual expression corresponding to the ordinary diffusion processes described by parabolic-type PDEs . Then, the following main particular cases are to be distinguished:

Normal diffusion:

$$q=2\Rightarrow f(\xi)=K\cdot e^{-\frac{\xi^2}{4D}}, K=\text{const.}, \tag{4}$$

Superdiffusion:

$$q>2\Rightarrow f(\xi)=B\cdot\left(A^2-\xi^2\right)^{\frac{1}{q-2}}, A=A(q), B=B(q), \tag{5}$$

Subdiffusion:

$$q<2\Rightarrow f(\xi)=B\cdot\left(A^2+\xi^2\right)^{\frac{1}{2-q}}, A=A(q), B=B(q), \tag{6}$$

i.e. the possible values of the real-number parameter "q" are of decisive importance within frame of this modelling method. In order to demonstrate applicability of the above-sketched formalism, the limit situation of superdiffusion will be incorporated into solution formulae of the basic system (2).

Then, it was possible to calculate directly the relevant analytical solution formula of the superdiffusion transfer (by use of the MAPLE 10 system), given by the following expression [8-9] explained according to the Lagrangian representation [6] of continuum mechanics:

$$\begin{aligned} c_{\text{SupDiff}}(x,t_f)=&\left[\frac{B\cdot\left(A^2\right)^{\frac{1}{q-2}}}{3A^2(q-3)(q-2)}\cdot F\left(\left[\frac{1}{2},-\frac{1}{q-2}\right],\left[\frac{3}{2}\right],-\frac{t_f^{-2/q}\cdot x^2}{A^2}\right)+\right.\\ &\left.+\frac{2(q-3)x^2}{t_f^{3/q}}F\left(\left[\frac{q-3}{q-2},\frac{3}{2}\right]\left[\frac{5}{2}\right],-\frac{t_f^{-2/q}\cdot x^2}{A^2}\right)+6vxq\cdot F\left(\left[\frac{3}{2},-\frac{q}{2}\right],\left[\frac{5-q}{2}\right],-\frac{t_f^{-2/q}\cdot x^2}{A^2}\right)\right], \end{aligned} \tag{7}$$

i.e. the results are explained by effective use of the hypergeometric special function $F([a,b],[c],x)$, and solution in the case of superdiffusion is less complicated, which fact is in complete agreement with the expected general experimental characteristics of the problem (because the convective flow contribution may in this case – in contrast to the convection – subdiffusion case - to suppress the superdiffusion contribution transfer in a much smaller amount, than it is characteristic in the case of subdiffusion).

The time parameter value t_f in (7) denotes the interval, during which the superdiffusive-type transfer of moisture has been observed in a given bulk porous material. In order to combine all these preliminary modelling results successfully, we will firstly apply here the extended version of (2), which – in agreement with WAT – can be written as:

$$\begin{aligned} \tau_1\frac{\partial^2 c}{\partial t^2}+\frac{\partial c}{\partial t}&=D\nabla^2 c+K\nabla^2 T,\\ \tau_2\frac{\partial^2 T}{\partial t^2}+\frac{\partial T}{\partial t}&=E\nabla^2 T+L\nabla c, \end{aligned} \tag{8}$$

i.e. in the form of hyperbolic-type PDEs, instead of the usually applied coupled systems of parabolic-type PDEs. In agreement with our earlier result [4], it will be assumed here, that the relaxation time constant τ_1 relevant for moisture level changes is much more significant, than τ_2 corresponding to the temperature function.

Then, the general solution of the problem being discussed can be obtained as a solution of the following integro-differential equation of general character, under given initial-, and boundary conditions:

$$\tau_1 \frac{\partial^2 c(x,t)}{\partial t^2} + \frac{\partial c(x,t)}{\partial t} - D \frac{\partial c^{q-1}(x,t)}{\partial x^2} +$$
$$+ \frac{1}{4\sqrt{\pi} t^{3/2}} \cdot \frac{K}{E^{3/2}} \int_\Omega T_0(\xi) \left[1 - \frac{(x-\xi)^2}{2Et} \right] \cdot e^{-\frac{(x-\xi)^2}{4Et}} d\xi +$$
$$+ \frac{1}{4\sqrt{\pi} t} \cdot \frac{K}{E^{3/2}} \int_0^t \frac{1}{\sqrt{t-\eta}} \int_\Omega \frac{\partial^2 M(\xi,\eta)}{\partial \xi^2} \left[1 - \frac{(x-\xi)^2}{2Et} \right] \cdot e^{-\frac{(x-\xi)^2}{4Et}} d\xi d\eta = 0,$$

where, for the sake of simplicity only the „x" is used as a spatial coordinate.

Conclusion

In the present work the limit situations of anomalous diffusion processes are studied in the case, when thermodynamical cross-effects are also present in a given macroscopic dissipative continuum. It has been shown, that this newly proposed modelling method can be incorporated into the earlier, classical mathematical descriptions of the coupled heat and mass transfer processes taking place in bulk porous matter.

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METHODS FOR TESTING QUALITY OF VARIOUS PAPER COMPONENTS BY THERMAL ANALYSIS

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Abstract

Knowing a suitable paper quality of packaging structures is an element process in the packaging industry. [1] The base-papers, produced from wood components are the most significant constituent of Corrugated Cardboards, contain mainly organic substances (e.g. cellulose, hemicellulose and lignin etc.) which are appropriate for thermo-analytical studies. The quality of the base-papers mainly defined by the primer cellulose, recycled paper and incrust materials content. At the same time, it is difficult for users to precisely separate base papers that exhibit differences in mechanical and quality properties, as their ulterior identification is virtually impossible. [2] The testing methods such as CCT, RCT, FCT, COBB, bursting etc. are supported by empirical technique, and do not provide accurate results. [3]. In this paper, we publish the primary results of the thermoanalytical research for determination of different components of wood and paper types. Applying a Differental Scanning Calorimetries (DSC) method, it is possible to study endotherm and exotherm spectrums of paper's raw materials. During a heating process each component react in different ways, both of their physical and chemical characteristic. Due to their various organic substances content, these values are different referring for similar results of the finished products, which determines their mechanical and quality properties during their use. [4] The results show that this method on the one hand can be helpful to testing the paper during packaging producing process on the other hand after using as a packaging. Using a DSC apparatus helps showing the differences between the various organic substances, which allow to measure obvious and exact results for identification each base-paper. This test method can help classify base paper types in a simple and transparent manner and be of use in tracing quality problems of papers.

Keywords *Corrugated Cardboard, Base-paper, Cellulose, Thermo-analytical technique, Heatflow, DSC.*

1. INTRODUCTION

The main chemical components of the wood using for are cellulose, hemicellulose and lignin. This finished material involves other incrust materials and extenders which constitute a complex chemical system. [4] Knowing the exact components of recovered wood are elementary for industrial processes and for consumers, because the mechanical and physical properties of these final products like paper based packaging, based on the chemical structure of it. [1]

The thermo-analytical scanning calorimetry (DSC) analyzers allows the identification of each substances according to its natural origins which behaves on different ways during the test. Physical and chemical properties of each component can paraphrase accurately the investigated paper, independently from the condition of papers and effects of the environment on it. Contrary to currently used test methods (CCT, RCT, FCT, COBB etc.) can provide reproducible test results from the same samples.

2. THERMO-ANALYTICAL DSC METHOD

Using a DSC (Differential Scanning Calorimetry) apparatus is type of the Thermo-analytical test methods. The DSC measures the physical and chemical changes as a function of temperature. The thermal analysis provides information for the typify temperature peaks, which refer to characterization changes for each components. On the other hand derivative values proportional to the quantity of the transformed material, can be obtained. [5]

The method based on energy changes which can be monitored occurring in a given component during the heating and temperature keeping or cooling period. The test can measure the heat flow differences between the sample and the reference jars due to absorbed and released heat in function of temperature. In the most widespread DSC equipment a constant heating rate is used, and the heat flow differential between the sample and the reference material is registered as a temperature differential ratio. The formula for the measure heat flow is shown below:

$$\frac{dH}{dt} = C_p \frac{dT}{dt} + f(T,t) \quad (1)$$

where dH/dt is DSC heat flow signal
Cp is a sample heat capacity (heat specific x weight)
dT/dt is heating rate
f (T,t) is heat flow that function of time at an absolute temperature (kinetic)

Figure 1: DSC equipment apparat

During the test a differential thermal analysis curve of the sample is recorded, where the abscissa represents temperature or time, with the heat flow (set according to the exothermic or endothermic nature of the change) shown on the ordinate. For example, Figure 2 shows the characteristic curve of an high cellulose content paper's examination result.

The temperature at which a transformation takes place (initial temperature) is shown by the intersection of the extension of the base line and the tangent to the inflexion point. The conclusion of the temperature-dependent transformation is shown by the peak of the curve.

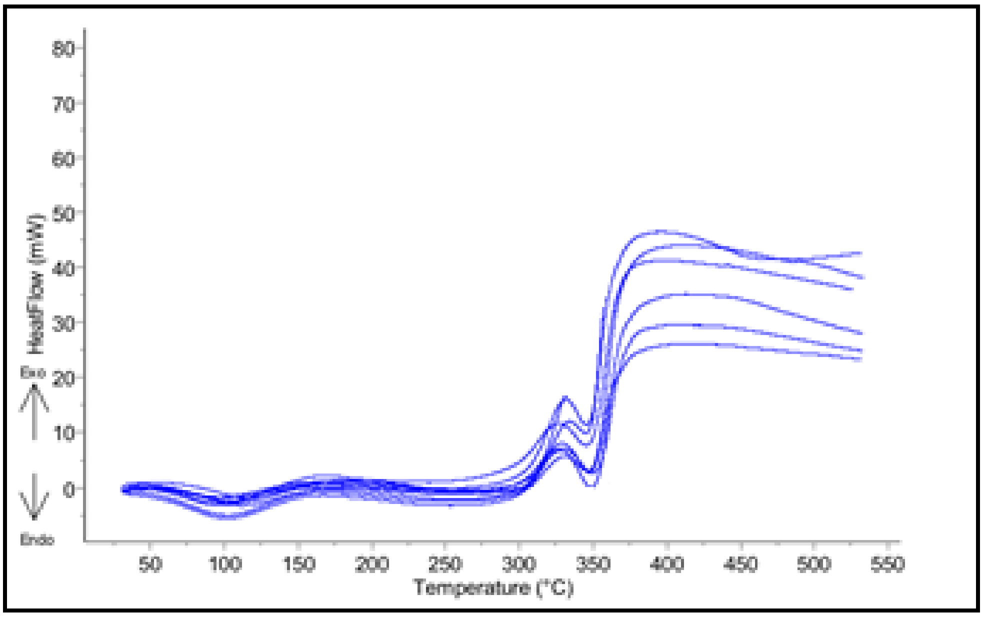

Figure 2: DSC curves of Pure cotton samples

The enthalpy of the transformation is proportional to the area between the curve and the baseline (the correct ratio can be defined through measuring a known material). Through the post- measurement analysis the temperature interval, peak temperature, heat flow, and heat in ratio of mass for the transformation can be expressed.

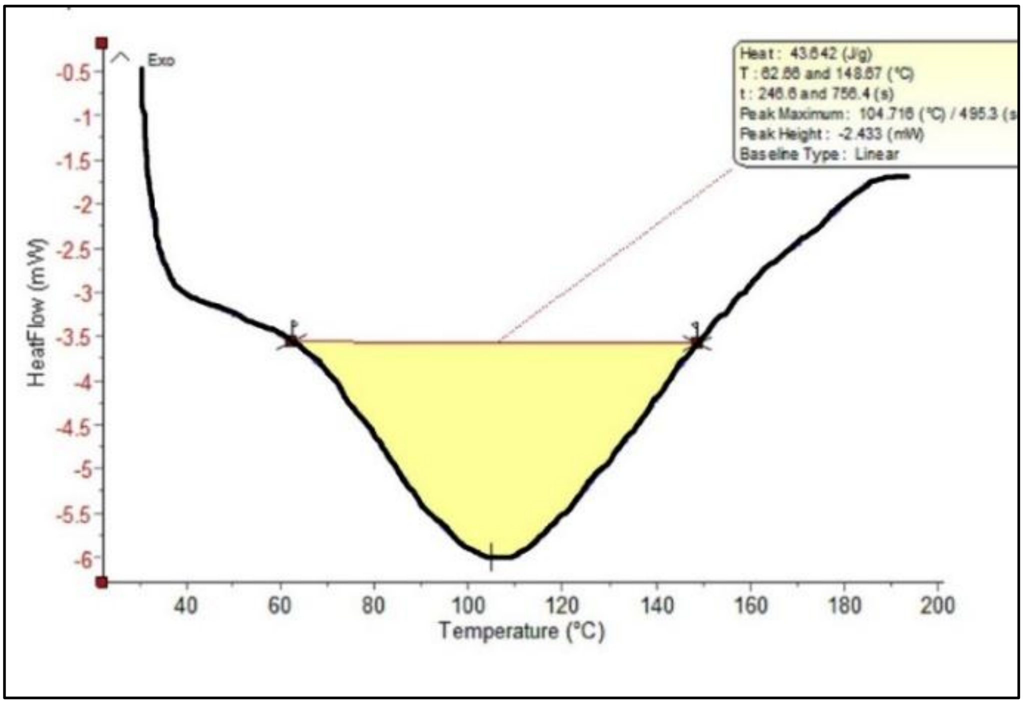

Figure 3: A particular DSC curve at the measurement of a Kraft liner base paper sample

3. MEASUREMENT AND ANALYSIS

There are 5 different materials tested, pure cotton, soft wood sulphite pulp, “Kraft liner” base paper, filler material I., filler material II.

Table 1: Tested materials list with specific properties.

Tested	Source	Content
Pure Cotton	Natural cotton treated with NaOH	Cellulose
Soft wood Sulphite pulp	Pine treated by sulphite method	Cellulose, hemicellulose, lignin
"Kraft liner" base paper	Pine treated by sulphate method	Cellulose, hemicellulose, lignin & inorganic
Filler material I.	Mined minerals	Kaolin
Filler material II.	Mined Minerals	$CaCO_3$

Test procedure

1. Preparation of test samples 8-20 mg sample take place in 30 µl jar, which exact weight measure with precision mg weight measurement apparatus.
2. A reference jar and a jar filled with the sample have to be placed into the Setaram DSC measuring device.
3. A predefined test program have to be performed.
4. Using nitrogen purge during examination.
   a. Heating the test chamber of the measuring device to 30°C and keeping it at this temperature for 10 minutes.
   b. Heating the test chamber up to 540°C at a rate of 10K/min.
   c. Recording temperature differentials between the sample to be examined and the reference jar.
   d. Analyzing the data on the basis of peak temperatures and heat flow.
5. Performing the measurement on 5 samples per base paper and presenting the results obtained and their averages graphically.

3. RESULTS AND DISCUSSION

Table 2: DSC results of the tested materials

Tested materials	Avg.	T max [°C] endo-thermic	T max [°C] exo-thermic	Heatflow [mW]	Mass [mg]
Pure Cotton	Avg.	350	400	38	9,8
Soft wood Sulphite pulp	Avg.	275	400	65	12
"Kraft liner" base paper	Avg.	325	370	20	11
Filler material I.	Avg.	500	-	-	20,24
Filler material II.	Avg.	490	-	-	20,24

As the results show in Table 2. Most measured temperature peaks belong to endotherm and exothermal processes refer to the tested materials. In case of pure cotton shows accurate temperature peak at 350°C as a specific endotherm peak and shows another peak at 400°C as an exothermal. The Soft wood Sulphite pulp behave under the test nearly identically, produced same peaks endo- and exothermal at 275°C and 400°C.

The examination adverts to “Kraft liner” base paper at 325°C as an exothermal and 370°C as a endotherm result. In the table are several dates are missing because it was not detected any exothermic maximum and heat flow value. The tested material with a higher cellulose content resolved on higher temperature on about 400°C and its thermal degradation starts at a higher temperature than the hemicellulose and lignin contain pulp. Results can be explained the structural different between the cellulose and hemicellulose. The cellulose it is a longer and more pure polysaccharide chain molecule than the hemicellulose which is a shorter polysaccharide and it is contained different hexoses and pentoses. The studied extenders mined minerals (kaolin & $CaCO_3$) show no significant temperature peaks or thermal degradation in this examination range.

Conclusion

Table 3: Test zones with temperature range, peaks and reaction types

Zones	Temperature range [°C]	Temperature peaks [°C]	Reaction types
I.	0-100°C	100°C	Chemically bound water leaving
II.	100-250°C	250°C	Decomposition of extractable materials
III.	250-350°C	275°C	Decomposition
IV.	350-550°C	325°C & 350°C; 400°C	Decomposition
V.	Over 550°C		Decomposition

Results can be explained that at lower temperature, the samples behave on similar way, mainly the chemically bonded water leave from each materials. [6,7,8,9] At higher temperature between 200 to 400 °C decomposition of extractable materials shown due to weight loss processes with different temperature peaks. [7] In case of “Kraft liner” base paper the decomposition starts at 250°C and has its temperature peak at 325°C. Pure cellulose starts to decompose at 275°C and lasts until 350°C. The soft wood sulphite pulp starts decomposition at 220°C and it has its own temperature peak at 400°C hemicellulose and lignin behave nearly similar way in the examined temperature range. Extenders show no significant endotherm or exothermal changes under the test. [8]

Figure 4 shows the various DSC curves summarize on which the differences between the results of tested materials are shown. The reactions based on the content of cellulose. Samples which contain greater amount of cellulose, their cellulose molecules start its decomposition under a shorter range of the test -in opposite of lower cellulose content-and shown their typify temperature peaks by the results of the end of an exothermal reaction chain, which lead to its total charring. [8,9]

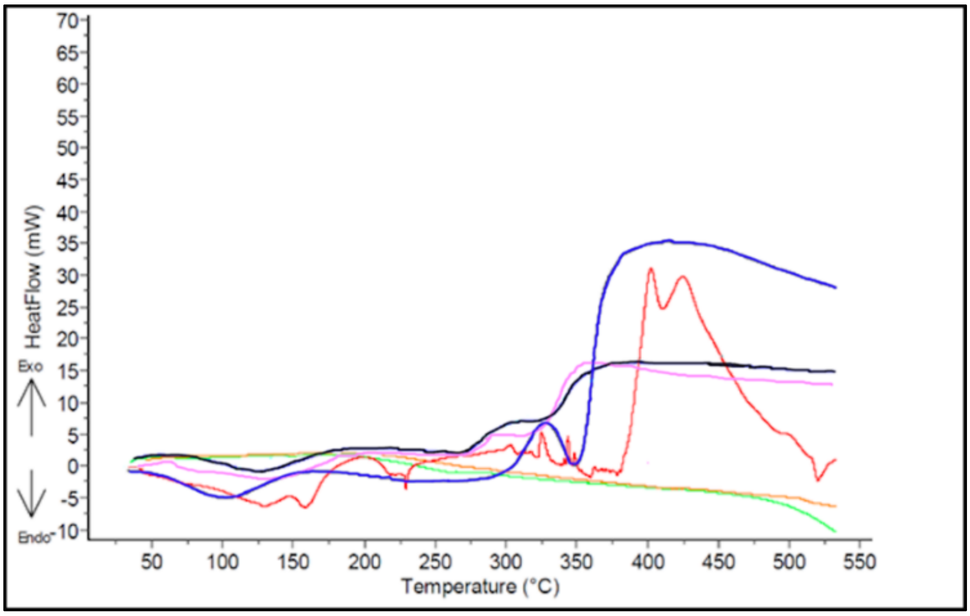

Figure 4: DSC curves of Pure cotton-blue, Kraft liner base paper-black, Soft wood Sulphite pulp-pink, resin-red, Kaolin-green and $CaCO_3$ with orange colour

This conclusion can explain the results of the examined materials and shown its main differences and coherences in substances, which can be used for an accurate thermo-analytical identification independently from its multiple chemical components.

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IMPACTS OF COMPOST AND WASTEWATER SLUDGE ON SOIL BIOLOGIC ACTIVITIES

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Abstract

The use of agrochemical such as chemical fertilizers and pesticides has caused tremendous harm to the eco-environment. Organic matter (OM) addition to soil often leads to a rapid increase in the activities of various enzymes and reactivation of biogeochemical cycles in soil. One of the major concerns today in all over the world is the pollution and contamination of the soil. In fact hydrolytic enzymes are sensitive indicators of management induced changes in soil properties due to their strong relationship with soil organic matter (OM) content and quality. An experiment was conducted to study the impacts of combined fertilizer on soil properties in comparison with adding organic as solid waste compost (SWC) of plant origin or municipal wastewater sludge (MWWS) to sandy loam brown forest soil. Soil amendments were: control, 15 or 30 kg/ha dry organic fertilizer. Microbial compositions were determined by culture enrichment technique. Enzyme (β-glucosidase, cellulase, urease, and aryl-sulphatase) activities were estimated. Fluorescein diactate activity as well as physico-chemical properties as well as some microbial parameters were determined after 63 day of incubation under laboratory conditions. The results demonstrated that the SWC and MWWS significantly improved soil physico-chemical properties such as soil pH, moisture content, total C and N contents as well as biological properties. Accordingly, overall enzyme activities were substantially promoted in presence of both amendments and the higher increases were measured at 30% of SWC. Lower beneficial effects occurred at the combination of SWC and MWWS together at 30% possibly because of the increased the presence of trace elements through MWWS application. As a general response, SWC supplied at 30% seems to be a useful strategy to enhance biological activities of soil. Finally, soil biologic activities can be used as an index of soil fertility and organic fertilizer stimulates the natural soil microbiotas and reactivates the biogeochemical cycles.

Keywords: *biological activities, solid waste compost, municipal solid wastewater sludge, soil.*

1. INTRODUCTION

Soil is the major component of agroecosystems specifying the level of their biological productivity and transforming matter and energy fluxes. Current interest in examine the soil quality has been triggered by increasing awareness of soil as a component of the biosphere. Crop responses to wastewater sludge (WWS) application vary by source, application rate, plant species, soil type, climatic conditions, and management practices [1]. However, soil quality is defined as the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health [2].

Several factors make soil quality very difficult to define, because soils are inherently variable [3]. There is growing recognition for the need to develop sensitive indicators of soil quality in promoting appropriate soil management strategies for long-term sustainability of terrestrial ecosystems.

Monitoring is needed to encourage the use of wastewater sludge in agriculture and to regulate its use to prevent harmful effects on soil, crop, animal and man [4]. Therefore, treated wastewater sludge can be defined as biological, chemical or physical treatment of long-term storage or any appropriate process significantly to reduce its fermentability and the health hazards resulting from its use.

Organic fertilizer differs from chemicals in that they feed plants and adding organic matter to the soil. Organic farming technology is necessary to support the developing organic, sustainable and non-pollution agriculture. Excessive amounts of salts have adverse effect on physical and chemical properties and on biologically mediated processes in the soil, such as C and N-mineralization.

Due to climatic changes, global warming is considered to promote the decomposition of soil OM, and thereby to increase the C flux from soil to the atmosphere. Various organic treatments such as solid waste compost (SWC) or municipal wastewater sludge (MWWS) have been investigated for their effectiveness in acidic soil remediation. Meanwhile, the application of WWSs increases soil microbial biomass and some soil enzymatic activities such as urease and β-glucosidase linked to C, N, P and S soil cycles [5, 6].

In fact hydrolytic enzymes are sensitive indicators of management induced changes in soil properties due to their strong relationship with soil OM content and quality [7].

According to Rao and Pathak [8] and Liang et al. [9], the incorporation of organic treatments to soil stimulate dehydrogenase activity because the added material may contain intra- and extracellular enzymes and may also stimulate microbial activity in the soil. These parameters are the most sensitive to the changes which occur in acid-affected soil, and provide rapid and accurate information on changes in soil quality.

A simulated acidified experiment was performed in this study to examine the effects of MWWS and SWC incorporated in acid affected soil on the activity of some soil enzymes related to nutrient cycling such as aryl-sulphatase, phosphatase, dehydrogenase, β-glucosidase, urease and catalase.

Wastewater is a waste product produced at the end of municipal and industrial wastewater treatment processes and is being produced in gradually large volumes global due to increasing population and growing urbanization.

The application of WWS on soils has been widespread in agricultural areas. It depends on soil properties, HM levels and characteristics, plant species and climatic conditions.

Wastewater sludge is usually reflected as waste, the recycling and reuse of valuable nutrients contained in the WWS are currently being measured as important resources for sustainable development [10]. Treated WWS can be reprocessed in numerous ways including its use as fertilizer with important nutrient additions improving plant growth and as a soil conditioner for improving the physical and chemical properties of soils [11-13].

The estimated percentages of WWS applied to agricultural soils have been mentioned as 29% in the USA, 40% in the UK, 60% in France, 30% reuse potential in Russia and 230,000 ton/year in Japan [14-17]. In developing countries, the experience of using WWS application for agricultural purposes is often kept to communal farms. There is a supposed risk to the environment that prevented wastewater sludge from existence application to agricultural soils.

The utilization of WWS in agriculture and forestry is becoming a widespread practice. Municipal WWS are increasingly used as soil organic amendments, especially to agricultural lands with low OM content to maintain or improve soil quality. This practice can, however, increase the concentration of heavy metals and organic toxins in soil. Heavy metals can reduce soil microbial activities including respiration, ammonification, nitrification and enzyme activities.

Oxidative enzymes (especially dehydrogenase) were proposed as a measure of overall microbial activity. Dehydrogenase being an intracellular enzyme related to oxidative phosphorylation process that occurs in all intact, viable microbial cells [6]. Incorporation of both SWC and WWS stimulated dehydrogenase activity because the added material may contain intra- and extracellular enzymes and may also stimulate microbial activity in the soil [9].

In fact, some studies indicated that high doses of some organic materials can introduce into the soil toxic compounds such as heavy metals which could have a negative effect on enzyme activities [18].

The biological activity of soil may serve as an informative indicator of the ecological state of biocenosis. The aim of the present study was to examine the effects of SWC and WWS application on some soil biological activities such as the microbial content and enzymatic activities as well as soil pH, moisture contents, total organic carbon and total nitrogen content.

2. MATERIALS AND METHODS

In a greenhouse study, the soil samples used in pot experiment were clay loam brown forest collected from farmland surface layer (0–200 mm) of an agricultural area of Gödöllő (Hungary). One sample of WWS was selected depending on its low HMs content originated from Nyíregyháza wastewater treatment plant and the compost sample SWC was originated from garden plant residue. The main physico-chemical parameters of soil and WWS are shown in Table 1.

Fresh soil samples were sieved through a 4 mm sieve and mixed with WWS or SWC to form 10 and 30% (soil : Waste; w/w), and then placed into plastic pots with 42 cm in height and 23 cm in diameter. All treatments were designed in triplicates and submitted for statistical analysis. The study was conducted to determine the effect of WWS or SWC or in mixture on the biological activities of the soil after 4 weeks of incubation.

Table 1: Physico-chemical properties of soils and wastewater sludge samples

Parameters	Soil	Wastewater sludge
	Clay loam brown forest	
$pH_{(H2O)}$	5.12	7.99
Dry matter, %	22.4	74
Organic matter, %	1.27	25.6
Humus content, %	1.24	-
Salt content, %	0.74	-
$CaCO_3$, %	1.01	-
Total N content, mg kg^{-1}	84.11	75.700
NO_3-N, mg kg^{-1}	133.08	-
NH_4-N, mg kg^{-1}	410.69	-
Ca, mg kg^{-1}	856	5707
Mg, mg kg^{-1}	203	2810
Na, mg kg^{-1}	21	1290
AL-P_2O_5, mg/kg	121.31	9700
AL-K_2O, mg/kg	107	3120
Zn, mg kg^{-1}	38.1	453
Cu, mg kg^{-1}	22.9	100
Cd, mg kg^{-1}	0.18	1
Ni, mg kg^{-1}	0.064	15
Pb, mg kg^{-1}	15.1	30

AL: Ammonium lactate soluble P and K

Soil moisture content and pH were measured according to the method of Brzezinska et al. [19] and Pérez de Mora et al. [20], respectively. Total organic carbon (TOC) was analyzed by dichromate ($K_2Cr_2O_7$) oxidation and titration with ferrous ammonium sulphate according to Walkley and Black [21]. Total nitrogen content in soil was determined by Kjeldahl digestion–distillation procedure [22].

Determinations the enzymatic activities were carried as following:

Fluorescein diacetate (FDA) hydrolysing activity of the control and amended soil subsamples were determined by measuring the released fluorescein at 490 nm according to Alef [23].

Dehydrogenase activity was determined by the method of García et al. [24].

Urease activity was determined in 0.1 M phosphate buffer at pH 7; 1 M urea and 0.03 M N α-benzoylargininamide was used as substrate.

The activity was determined by the NH4+ released [25].

β-glucosidase activity was determined using p-nitrophenyl-β-D-glucopyranoside (PNG, 0.05 M) as substrate [26].

Similarly, aryl-sulphatase activity was determined as proposed by Tabatabai and Bremmer [27], after the soil incubation with p-nitrophenyl sulphate and measured at 400 nm.

Furthermore, the enumeration of microbial population in soil amended with SWC or WWS was done using the serial dilution plate method. The total colony forming units (CFU) of bacteria and fungi were recorded on Ken Knight and Munaier's agar [28] and Martin's Rose Bengal agar [29] media, respectively.

Enumeration of cellulose decomposers was determined according to Hendricks et al. [30]. For phosphate solubilized microorganisms, method of Goldstein [31] was applied. The plates were incubated at 28°C and microbial population densities were calculated and expressed as $\log_{10}$ of CFU x 10n g^{-1} air dried soil, where 10n was dilution factor.

3. RESULTS AND DISCUSSION

Utilization of WWS in agriculture increases the concentration of HMs in soil and HMs–rich MSS drastically reduced the biologic activity in soil. These critical limits depend on the source, WWS application rate and frequency.

Phyto- and rhizo-bioremediation using plants and related microorganisms are the promising approach to clean up the contaminated environment. Soil pollution by HMs is a serious worldwide problem and can be potentially harmful to human health via the food chain. The results of pot experiment illustrated the followings:

Table 2 shows that the effect of soil amendment with SWC and WWS on some important terms of soil characteristics from agriculture. It was found that application of SWC and WWS on soil pH has a positive influence, they significantly increased the pH and the combination of the two organic matters rose up the pH value better than in single application.

Similar results also obtained in term of moisture content and it is economically important to keep the soil more moisted for longer time too. In case of total organic carbon, the data of the experiment showed that the amount of TOC increased more when both organic matters were combined together. Also, the amount of total nitrogen content increased significantly more than they applied alone.

The best combination can be selected is 30% from SWC and 10% from WWS and in this case we reduced the risk of heavy metals effects on soil biodynamic properties.

The major factor affecting the productivity of the biocenoses is the level of the soil N supply, because N is the main element limiting the production of plant and animal food on the Earth.

Table 2: Effect of compost and sludge amendment on some physico-chemical properties of soil samples

Parameters	Compost (C)		Sludge (S)		Combination			
	10	30	10	30	10C+10S	10C+30S	30C+10S	30C+30S
pH	5.78	5.84	5.78	5.97	5.89	6.09	5.99	6.25
Moisture, %	10.5	20.7	12.8	22.4	14.7	23.5	22.7	25.9
TOC, mg/kg soil	0.89	2.15	0.96	2.42	1.28	2.11	1.73	2.65
TNT, mg/kg soil	35.6	57.4	35.1	68.2	36.2	62.4	65.8	72.1

Table 3 clarifies the important of the application of organic matter to the soil which increases the soil fertility and makes nutrients available for plant growth and development. The increasing enzyme activity in soil plays an important role for mineralization of organic matter, and in this case the soil quality will be increased.

Table 3 also, illustrates that the investigated enzymes are more active when SWC is in combination with WWS added to the soil. For more safety, 30% of compost matter in combination with 10% of sludge can prevent any contamination of the soil by heavy metals. All enzymes were more active when the soil was amended with both organic matters together.

Table 3: Effect of compost and sludge amendment on some enzymatic activities in soil samples

Parameters	Compost (C)		Sludge (S)		Combination			
	10	30	10	30	10C+10S	10C+30S	30C+10S	30C+30S
FDA	130	204	147	313	143	277	292	337
Dehydrogenase	139	306	171	326	151	332	351	355
Urease	1.79	2.91	1.88	3.67	1.87	3.12	2.71	3.89
β-glucosidase	130	228	142	304	139	304	325	348
Aryl-sulphatase	70	165	78	209	83	184	191	229

Soil OM has a great influence on the chemical and physical properties of soil and makes up, together with the clay, most of the cation exchange capacity and this is the key parameter describing the sorption and desorption of plant nutrients and contaminants from soil.

The major input sources of OM to soil are manure, litter-fall and crop residues, but the equilibrium content of soil OM is influenced by climate, land use and management, over time. Organic contaminants in WWS are not expected to pose major health problems to the human population when sludge is re-used for agricultural purposes.

Table 4 demonstrates the important of addition of organic matter to the soil as energy source and help the microbial content to be more active and established well in the soil. It was found that the microbial population increased by increasing the rate of application and in combination the population is more and it is important for soil fertility too.

Table 4 shows that the cellulose-decomposers and phosphate-solubiliers are more public in the combination of the two organic matters.

Table 4: Effect of compost and sludge amendment on some microbial population in soil samples

Parameters	Compost (C)		Sludge (S)		Combination			
	10	30	10	30	10C+10S	10C+30S	30C+10S	30C+30S
Aerobic heterotrophic bacteria (10^6)	9.54	28.7	13.5	36.2	10.8	30.8	35.3	41.3
Filamentous fungi (10^4)	5.95	23.6	7.65	31.4	7.21	29.67	29.4	33.4
Cellulose-decomposers (10^3)	5.5	16.5	7.07	20.3	6.84	18.71	22.57	26.6
Phosphate-solubilises (10^2)	4.4	22.1	4.5	26.9	5.21	24.61	27.3	30.19

It was found that WWS had a positive effect on the enzymatic activities. More studies are needed to deeper our knowledge of the effect of HM contamination on enzymatic activities. However, our results indicated that there are positively related correlation between the investigated enzymes and OM in the applied WWS or SWC or in combination. This indicates that an aggregate of multi-enzymatic activities may be better correlated with soil fertility than a single enzyme.

Particularly, the enzymatic activities in soil amended with WWS-LHM content were markedly higher than those in the soil amended with WWS-HHM content.

The soil microbial populations were far higher under WSS application than in case of the control and SWC treatments. Bacteria showed a marked increase in population size with increasing WWS mixing rate levels, other soil microbes; fungi in population size responded similarly to bacteria, although all treatments showed significant difference on population size in comparison between the WWS of LHM and SWC contents compared to control.

Further research is required with plant trials to test the effects of the WWS or SWC applied to different soil environments and measure the soil productivity under these applications as organofertilizer as well as soil conditioner.

However, as it seemed from the result of the experiment, that there is a good potential for using the WWS and SWC as soil improving agents. Considering the nutrient and soil conditioning values of the WWS and reusing them for agriculture is an economical and environmentally sound option and deserves given greater attention.

The results suggest that WWS addition induces a reactivation of soil quality and activity, as indicated by microbial content and enzymatic activities. According to this, our results are in good agreement with the results of Singh and Agrawal [32] who established that the mature municipal solid waste compost might be used as conditioner for clay soil, but not for sandy soil.

Monitoring soil quality by means of bioindicators can be helpful for the management and sustainability of soils that received WWS application. It should be concluded that the accumulative concentration of HMs in WWS amended soil should be calculated after every application of MSS.

Conclusion

In conclusion, both SWC and WWS affected soil physical and chemical properties and biological activities. The positive effect of the organic treatments on soil biological quality is due to the stimulation of microbial communities and growth and/or to the addition of microbial cells or enzymes with the amendment.

This hypothesis seems to be reliably supported by the increase observed for more than one soil enzyme activity that very likely behaved as valid indicators of soil biological activity. However, a balance between adequate fertilization and the possible environmental risks caused by over fertilization must be considered. Organic matter application increases soil microbial biomass and soil enzymatic activities linked to C, N, and S soil cycles.

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CHEMICAL PROPERTIES AND TOXICITY OF SOILS CONTAMINATED BY APPLICATION OF WASTEWATER SLUDGE OF HIGH HEAVY METALS CONTENT

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Abstract

Heavy metal (HM) contamination of agricultural soils is a worldwide ecological problem. Wastewater sludges (WWS) produced from communal wastewater treatment plants is commonly recognized as a significant basis of nutrient and soil conditioner for cultivating use. Determination of intensities of HMs in WWS is essential prior to application of the sludge to agriculture for of the intrinsic risk of HM toxicity to soil. Wastewater sludge created from different WW sources were analysed for a range of total HMs using ICP-AES. Most of the samples analysed show agreement with respect to the regulatory parameters established by the USEPA, South Africa and EU guidelines for levels of HMs in WWS envisioned for agricultural soil application. In this study, the concentrations of HMs (Cd, Cu, Ni, Pb, and Zn) were investigated in the agricultural soils before and after WWS applications. Wastewater sludge produced from the Hódmezővásarhely WW treatment plant in general has high HMs due to the presence of several industries in the area. The variations in the HM concentrations were due to the application ratio of WWS to the soil. Considering the nutrient and soil conditioning values of the WWS and reusing them for agriculture is an economical and environmentally sound option and deserves given greater attention.
Keywords: *Soil, Heavy metals, Toxicity, wastewater sludge*

1. INTRODUCTION

Soil is a complex amalgam, a non-renewable natural resource because it cannot be re-created except within the context of geological timescales. It can be simply defined as the unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants [1].

Heavy metals (HM) are elements with an atomic density greater than 6 g/cm3; they are one of the most persistent pollutants in wastewater. Heavy metals also known as trace metals, are one of the most persistent pollutants in wastewater. Heavy metals are highly hazardous to the environment and organisms.

It can be enriched through the food chain. The persistence of HMs in WW is due to their non-biodegradable and toxicity nature [2]. Once the soil suffers from HM contamination, it is difficult to be remediated [3].

Heavy metal contamination of agricultural soils is a worldwide ecological problem. Heavy metal contamination of agricultural soils has become a significant environmental problem [4]. This remarkable industrialization has led to the continuous accumulation of HM ions in eco-environment and caused deterioration of many ecosystems and social health. Anthropogenic inputs such as agricultural activities, energy conversion and production, metallurgy and mining, microelectronics, solid and liquid waste disposal have been the major sources of HM ions accumulated in our environment.

Wastewater is a waste product produced at the end of communal and industrial wastewater treatment processes and is being produced in gradually large volumes global due to increasing population and growing urbanization. Wastewater sludge (WWS) originated from industrial estates contains toxic substances such as HM, recalcitrant organics and other undesirable pollutants which may accumulate in the edible parts of food crops and pose serious threats to human life. These are hazardous to water resources, agriculture, ecosystems and the human population [5]. Wastewater sludge contains HM which may be lethal for animals and humans if their concentrations exceed the permissible limits [6]. Wastewater irrigation, solid waste disposal, sludge applications, vehicular exhaust and industrial activities are the most important sources of HM contamination of soil and food crops grown on contaminated soils [7].

The most common toxic HMs in WWS include arsenic (As), lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), silver (Ag), and zinc (Zn). The release of high amounts of HMs into water bodies creates serious health and environmental problems and may lead to an upsurge in WW treatment cost.

Some of the negative impacts of HMs on plants include decrease of seed germination and lipid content by Cd, decreased enzyme activity and plant growth by Cr, the inhibition of photosynthesis by Cu and Hg, the reduction of seed germination by Ni and the reduction of chlorophyll production and plant growth by Pb [8]. The impacts on animals include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases, death.

Soils may become contaminated by the accumulation of HMs and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, WW irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition [9, 10].

The application of WWS on soils has been widespread in agricultural areas. It depends on soil properties, HM levels and characteristics, plant species and climatic conditions. Several studies have been carried out on the impacts of WW irrigation on the accumulation of HM in soil and plant systems around the world [7].

Removal of WWS presents a problem that touches a set of complex concerns including health and environment as well as economics. The European Union Directive (91/271/EEC) for example prohibits removal of sludge to the marine environment [11]. Soil application is simple and economical but soil is becoming scarce.

Wastewater sludge is usually reflected as waste, the recycling and reuse of valuable nutrients contained in the WWS are currently being measured as important resources for sustainable development [12]. Treated WWS can be reprocessed in numerous ways including its use as fertilizer with important nutrient additions improving plant growth and as a soil conditioner for improving the physical and chemical properties of soils [13-15].

The estimated percentages of WWS applied to agricultural soils have been mentioned as 29% in the USA, 40% in the UK, 60% in France, 30% reuse potential in Russia and 230,000 ton/year in Japan [16-19]. In developing countries, the experience of using WWS application for agricultural purposes is often kept to communal farms. There is a supposed risk to the environment that prevented wastewater sludge from existence application to agricultural soils.

In addition to heavy metals and pathogens, other harmful and toxic pollutants such as pharmaceuticals, detergents, various salts, pesticides, toxic organics, flame retardants and hormone disruptors can also be present in wastewater sludge [20-22]. Wastewater sludge can inoculate in soils extreme amount of nutrients, pesticides and can increase soil salinity [23].

Heavy metals are mainly originated in WWS since due to their hydrophobic nature; they are related with the solid portion of the WW [24]. Frequently, communal wastes have lesser HM contents than industrial wastes. As a result, toxic metals such as Pb, Cd, Hg, Ni and Cr may be current present in municipal WW due to heavy urbanization and the entry of raw industrial WW into the municipal WW system [25, 26]. On the basis of relative toxicity to plants and animals, two groups of heavy metals can be recognized. The first group including Cd and Pb are highly toxic to humans and animals on the other hand, they are less toxic to plants. The second group containing Zn, Ni and Cu are, when present in excess concentration, more damaging to plants than to humans and animals [27]. The long-term use of WWS can cause HM accumulation in soils [28]. Even after a short term WWS application, the HMs levels in soils can increase significantly. For example, Oliveira and Mattiazzo [29] observed increases in Cu, Cr, Ni and Zn concentrations in soils amended for 2 years with WWS. Wastewater sludge application rate is an important factor that determines the extent of accumulation of HMs in soils and their absorption by plants. Increased concentrations of Pb, Cd, Ni and Cr have been observed in plant seeds as a result of increased application of sludge [30]. The level of plant uptake, bio-accumulation and tolerance of plants to HMs varies among different crops at different rates of application of WWS [31]. The regulatory limits of HMs in WWS from a number of countries are summarized in Table 1.

Table 1: Regulatory limits of heavy metals in wastewater sludge intended for agricultural application [32-33]

Heavy Metal	EU Directive (86/278/EEC)	Chinese Regulation (GB 18918 - 2002)	USA Regulation (40 CFR Part 503, 503.13)	South African Guideline (Pollutant Class a)	Heavy Metal	Units	EU Directive (86/278 /EEC)	Chinese Regulation (GB 18918-2002)
	Limit value (mg/kg)	Limit value (kg/ha. year)	Acidic soil pH<6.5	Neutral and Basic soil pH>6.5	Pollutant dose Limits (mg/kg)	Annual pollutant loading rate (kg/ha. year)	Pollutant limit mg/Kg (Class a)	Pollutant limit mg/Kg (Class b)
Zn	2500 - 4000	30	500	1000	2800	140	2800	7500
Cu	1000 - 1750	12	250	500	1500	75	1500	4300
Cd	20 - 40	0.15	5	20	39	1.9	40	85
Ni	300 - 400	3	100	200	420	21	420	420
Pb	750- 1200	15	300	1000	300	15	300	840

Additional risk of contamination in the environment is observed through leaching of HMs from soils to ground water. The risk increases with time as metals are persistent in soils over a longer time and many metals do not suffer biochemical degradation thereby increasing the risk of bioavailability of metals and their leaching to ground water table [34].

At present large amounts of WWS are being produced and stored in several WW treatment plant premises in world and agricultural application is being careful as a future practical choice of removal. This research is aimed at assessing the effects of metals such as Cd, Cu, Ni, Pb and Zn and toxicity of soil subjected to strong human pressure associated with pollution.

2. MATERIALS AND METHODS

In a greenhouse study, the soil samples used in pot experiment were clay loam brown forest and chernozem meadow collected from farmland surface layer (0–200 mm) of an agricultural area of Gödöllő and Szeged (Hungary), respectively. Three different WWSs were selected depending on their HMs content. One is characterized as low (LHM) and the second is medium (MHM) HMs content originated from Nyíregyháza wastewater treatment plant and the third sample of high HMs content (HHM) was collected from Hódmezővásárhely wastewater treatment plant. The main physico-chemical parameters of soil and WWSs are shown in Table 2. Fresh soil samples were sieved through a 4 mm sieve and mixed with WWSs to form 15 and 60% (soil : sludge; w/w), and then placed into plastic pots with 42 cm in height and 23 cm in diameter. All treatments were designed in triplicates and submitted for statistical analysis. The study was conducted to determine the adverse effect of HM pollution in the soils amended with communal WWS for 16 weeks.

Table 2: Physico-chemical properties of soils and wastewater sludge samples

Parameters	Origin of Soil Samples		Origin of Wastewater Sludge		
	Gödöllő	Szeged	Nyíregyháza		Hódmezővásárhely
			LHM	MHM	HHM
Soil type	clay loam brown forest	chernozem meadow			
$pH_{(H2O)}$	5.12	6.02	7.99	7.17	7.8
Dry matter, %	22.4	28.6	74	70	42.9
Organic matter, %	1.27	2.87	25.6	48.2	20.4
Humus content, %	1.24	3.55	-	-	-
Salt content, %	0.74	0.81	-	-	-
$CaCO_3$, %	1.01	2	-	-	-
Total N content, mg kg^{-1}	84.11	134.7	75.700	98.900	43311
NO_3-N, mg kg^{-1}	133.08	39	-	-	-
NH_4-N, mg kg^{-1}	410.69	4.5	-	-	-
Ca, mg kg^{-1}	856	443	5707	29724	27333
Mg, mg kg^{-1}	203	257	2810	5072	11860
Na, mg kg^{-1}	21	53	1290	1349	1441
AL-P_2O_5, mg/kg	121.31	378	9700	9100	20104
AL-K_2O, mg/kg	107	428	3120	3596	2908
Zn, mg kg^{-1}	38.1	1.1	453	634	1068
Cu, mg kg^{-1}	22.9	2.4	100	161	182.3
Cd, mg kg^{-1}	0.18	1.02	1	2.4	4.168
Ni, mg kg^{-1}	0.064	0.077	15	39.2	56.9
Pb, mg kg^{-1}	15.1	0.96	30	83	540.7

AL: Ammonium lactate soluble P and K

Soil samples were analysed for physico-chemical properties. Total carbon content was measured by using a dry combustion method [35]. Total organic matter (OM) content was calculated by multiplying the total C values by 1.72 [36]. The pH of the soil suspension with soil : water at the ratio of 1:5 was measured by using a pH meter. Heavy metals in soils were fractionated by a modified procedure of Amacher [37]. The parameters include: pH, moisture content, nitrogen (N), phosphorous (P) and potassium (K).

The total heavy metal determination was done using two methods for comparison and quality assurance purposes. The methods used were atomic absorption spectrometer (Varian–AAS) and inductively coupled plasma atomic emission spectrometry (ICP-AES). The heavy metals analysed include: Cd, Cu, Pb, Ni, and Zn.

Total organic carbon (TOC) was analyzed by dichromate ($K_2Cr_2O_7$) oxidation and titration with ferrous ammonium sulphate [38]. The water soluble C (WSC) contents of the liquid fractions were determined spectrophotometrically at 590 nm after addition of $K_2Cr_2O_7$ and H_2SO_4 (digestion at 150°C for 15 min) according to Sims and Haby's [39] method. The hot-water extractable C (HWEC) fraction of SOM can be determined quickly by simple analytical method. The HW extraction technique delivers a fractionation according to turnover rates of SOM by keeping a soil : water mixture (1:5 w/v) for 60 min under reflex [40].

3. RESULTS AND DISCUSSION

Investigation of HMs fractions in soils amended with WWS would ascertain their availability and contamination level in soils. This study investigated HM fractions in soils after 8 weeks incubation in the greenhouse at 25+2°C with moisture content 40%.

The ranges of HM concentrations in soils amended with WWS were apparently wide. All fractions were significantly higher in the soil samples amended with HHM content WWS of Hódmezővásárhely than the samples treated with Nyíregyháza WWS. Heavy metal concentrations varied in the soils as Pb > Cu > Ni > Zn > Cd after WWS amendment.

In LHM and MHM concentrations differed in soils as Zn > Pb > Cd > Cu > Ni. Repeated WWS treatments increased pH values of the soils. The higher EC of soil indicated an accumulation of salts in the soils due to WWS amendment. The results of analysis of the physico-chemical characteristics of the soil : sludge mixture are summarized in Table 3.

Summaries of the results of the ICP-AES analysis of HMs in the WWS samples collected from the two WW treatment plants are given in Table 3A, 3B and 3C.

The results showed that HM fractions were significantly ($P < 0.05$) higher in soils amended with HHM-WWC of Hódmezővásárhely as compared to the soils samples treated with WWS originated from Nyíregyháza.

In general, most of the HMs are present in low concentrations and below the regulatory limits provided by the USEPA, South Africa and the European Union. These concentrations of Cu are generally low and well below the USEPA, South African and EU guidelines. This indicates that the sludge samples carry lower risk with respect to Cu toxicity.

Table 3: Physico-chemical characteristics and heavy metals content in soil samples and incubated for 16 weeks with different application ratios of wastewater sludge samples with different heavy metals contents

Parameter	A. Soil samples amended with LHM-WWS			
	15%		60%	
	Gödöllő	Szeged	Gödöllő	Szeged
pH	4.8	6.14	5.07	6.29
Moisture content, %	12	13.5	18.6	25.1
Organic carbon, %	1.47	3.13	1.96	3.87
Organic matter, %	2.53	5.38	3.37	6.66
Nitrogen, %	90.04	137.18	99.12	160.17
AL-P_2O_5, mg/kg	143	432	171	690
AL-K_2O, mg/kg	121	488	143	601
Zn, mg kg^{-1}	40.7	2.01	48.9	4.1
Cu, mg kg^{-1}	26.4	3.01	35.2	3.6
Cd, mg kg^{-1}	0.41	1.12	0.67	2.76
Ni, mg kg^{-1}	0.07	0.08	0.09	0.11
Pb, mg kg^{-1}	17.9	1.99	24.2	4.76
Parameter	B. Soil samples amended with MHM-WWS			
	15%		60%	
	Gödöllő	Szeged	Gödöllő	Szeged
pH	4.95	6.38	5.34	6.57
Moisture content, %	13.6	14.4	19.6	26.4
Organic carbon, %	1.55	3.46	2.39	4.15
Organic matter, %	2.67	5.95	4.11	7.14
Nitrogen, %	99.7	144.5	103.72	179.7
AL-P_2O_5, mg/kg	155	513	185	725
AL-K_2O, mg/kg	133	497	161	684
Zn, mg kg^{-1}	48.1	3.44	53.7	5.2
Cu, mg kg^{-1}	34.7	5.08	41.5	4.8
Cd, mg kg^{-1}	0.55	1.87	0.95	3.17
Ni, mg kg^{-1}	0.08	0.09	0.11	0.16
Pb, mg kg^{-1}	19.4	2.59	33.2	5.96
Parameter	C. Soil samples amended with HHM-WWS			
	15%		60%	
	Gödöllő	Szeged	Gödöllő	Szeged
pH	5.16	6.61	5.66	6.82
Moisture content, %	15.5	16.7	21.6	30.1
Organic carbon, %	1.67	3.78	2.95	4.99
Organic matter, %	2.87	6.50	5.07	8.58
Nitrogen, %	112.2	164.3	133.8	201.1
AL-P_2O_5, mg/kg	165	572	192	767
AL-K_2O, mg/kg	145	512	176	714
Zn, mg kg^{-1}	53.3	5.76	61.2	6.6
Cu, mg kg^{-1}	45.4	5.77	49.1	5.5
Cd, mg kg^{-1}	0.64	2.04	1.32	3.78
Ni, mg kg^{-1}	0.09	0.109	0.14	0.19
Pb, mg kg^{-1}	21.1	2.99	38.8	6.49

The Chinese guidelines are exceeded but the limiting concentrations given by Chinese regulations are generally low.

Copper is among the trace elements that are essential to life although at high concentrations Cu is toxic. Copper may be derived from cleaning products, cosmetics and shampoos, fuels, inks, medicines and ointments, food products, oils and lubricants, paints and pigments, polish and wood preservatives, electronics, plating, paper, textile, rubber, fungicides, printing, plastic, and brass and other alloy industries and it can also be emitted from various small commercial activities and warehouses, as well as buildings with commercial heating systems.

The Ni concentrations are mostly below the Chinese and South African guidelines. These results also indicate that the sludge samples carry very low risk with respect to Ni toxicity. Nickel is toxic to humans and both can reach the food chain via plant uptake from contaminated soil [37]. The Pb concentrations as are low and well below all the regulatory guidelines considered. Lead is known for its immobility and limited translocation in plants.

The results indicate once again the low risk of the WWS samples collected from the two treatment plants with respect to lead toxicity on the basis of total Pb metal concentrations. Lead is defined by the United States Environmental Protection Agency (USEPA) as potentially toxic to most forms of life [41]. A major source of Pb in WWS could be from Pb-containing dust fall-out, which reaches the drainage system with rain. Concentration of Pb from such source would vary widely depending on traffic density, industrial emissions and climatic factors [42].

The Zn concentrations for the two wastewater treatment plants are below the limits provided by South Africa, USEPA and EU guidelines indicating again the relatively low risk the of the WWS samples with respect to Zn toxicity based on the regulatory limits specified in terms of the total Zn metal concentrations.

Zinc is an essential trace element for humans, animals and plants. However, high concentrations of Zn are potentially toxic to plants, humans and animals [43]. Though Zn has relatively low toxicity to humans and animals, studies have shown some allergies associated with Zn at high amounts and Zn poisoning could occur along the food chain, which may interfere with Cu metabolism [43]. Zinc can be derived from natural, domestic and industrial sources. Cities with metal industries and high traffic can contribute to high levels of Zn in sewage sludge [44].

Heavy metals have been proved to be toxic to environmental health. Wastewater sludge presented high quantities of nutrients, organic matters and almost neutral pH, appropriate to be used in agriculture. Heavy metals uptake by plants and successive accumulation in human tissues and biomagnifications through the food chain causes environment concerns.

Irrigation of agricultural soils by effluent and sewage sludge for several years increased HMs in soils and plants. The concentration of HMs increased significantly in the soil and plants of plots compared with control. Control of WWS pollution with HMs is therefore of great concern. Thus, it is essential to study the pollution sources of wastewater [45].

It has been mentioned by several researchers that limits based on total metals concentrations may be too restrictive as metals have different levels of mobility in soil and some of the HMs are present largely in the immobile fraction. Therefore, the regulatory limits based on total metals will have to be interpreted in terms of the relative mobility of the different heavy metals.

Further research is required with plant trials of the WWS applied in different soil environments and plants and with different degree of treatment of soils with WWS in order to determine the actual degree of toxicity of the HMs and their translocation within the plant structures. However, as it seemed from the result of the experiment in this investigation, that there is a good potential for the WWS from the wastewater treatment plants to be used for agricultural application. This positive information can be good news to the handling plants which presently store large loads of WWS in their WW treatment plants premises in globe with the possible future option of using the WWS for agricultural applications. Considering the nutrient and soil conditioning values of the WWS and reusing them for agriculture is an economical and environmentally sound option and deserves given greater attention.

Conclusion

This study investigated the effect of HM fractions in agricultural soils amended with WWS. The total metal concentrations present in WWS samples taken from the two wastewater treatment plants in Hungary showed a range of variations in accordance with the characteristics of the WWS generated from the respective cities and the level of industrial establishments present in the cities.

The WWS samples from Hódmezővásarhely wastewater treatment plant showed generally higher heavy metal concentrations compared with the two WWSs samples taken from the Nyíregyháza wastewater treatment plants. This is apparent as Hódmezővásarhely is an industrial area and several of the effluents generated from the industries have minimal treatments such as equalization basins before being discharged to the communal sewer system.

In terms of the regulatory limits of total metal concentrations mentioned in the USEPA, South Africa guidelines and EU directives, the sludge samples largely show compliance for agricultural application with respect to the majority of HMs. The experimental data by and large specified that most of the investigated HMs are present in moderate or at low concentrations well below the regulatory limits specified based on total metal concentrations and the WWS generated from the WW treatment plants may be considered further for agricultural application.

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TYPES OF SERVO AXES SYNCHRONIZATION FOR USE IN AUTOMOTIVE RECYCLING INDUSTRY

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Abstract

To optimize the recycling process in automotive industry, it is necessary to constantly innovates machines where recycling processes take place. In recycling processes, we have selection and cutting of various materials such as: metal, glass, plastic, wood, leather, etc. Various electric drives are used for all these processes. In the past the drives were only mechanically coupled. Mechanical couplings such as gears, couplings, sprockets and other mechanical power transmissions are reliable solutions but not flexible. Changing the gear ratio between the two axes of motion would require a change in the ratio of the mechanical gears or the use of a gearbox. With the development of electronics, the gearing of the axis was moved from domain of mechanics into the domain of electronics. Thanks to the fast regulation structures inside servo drives it is possible to couple two or more axes of movement without mechanical connections, only based on the reading from the position sensor. By introducing electronic coupling, the change in the gear ratio in the software itself is possible without any changes to the mechanics during the work. The paper provides an overview of the basic concepts and parameters for synchronization of two axes in motion. Also, the necessary parameters and settings are explained for synchronizing two axes. Finally, a comparative analysis of three synchronization types was performed: Reverse motion, Synchronizing and Symmetrical, with its advantages and disadvantages on Siemens S1500T platform.

Keywords: *recycling, drives, axes of movement, electronic gearing.*

1. INTRODUCTION

In the process of recycling, it is necessary to cut the time of recycling, use less energy and to protect people from work in dangerous environment. To do this, it is necessary to use modern technologies as robotic separators and cutters. Modern automatic selection lines, known as sortex lines has cameras for classification of different types of materials. After detection of different types of material, it is necessary to put those different materials in appropriate containers. To optimize further these processes, it is necessary to make synchronization between conveyers and robots. Also, in the process of cutting various materials to obtain desired shapes and dimensions, axis synchronization is required. Synchronization of different axes is in the most cases coupled mechanically. Mechanical couplings for power transmission are reliable solutions but not flexible. To increase the productivity, quality and flexibility of modern recycling systems, it is necessary to drive it electronically and make it flexible [10,11].

Electronically coupled servo-driven axes will be presented for the case of two independent axes of movement. First axis will be the master axis, and second one will be slave axis. The leading axis -master gives the value that represents the reference for the slave axis, while the slave axis follows this value according to the defined requirements. Requirements can be in terms of: gear ratio, scaling or different functions between the master and the slave axis.

From the standpoint of mechanics, the synchronized movement of the two axes implies a pair of gears in a relationship. For complicated non-linear relations, curves were used. Curves allows the motion in a non-linear relation. Electronically coupled drives introduces the possibility of defining different curves of motion without complex machine elements and a simple change in the relationship of complex motion by changing the function that defines the connection between the two axes. In the following figure, you can see a block diagram of master and slave axes electronically coupled.

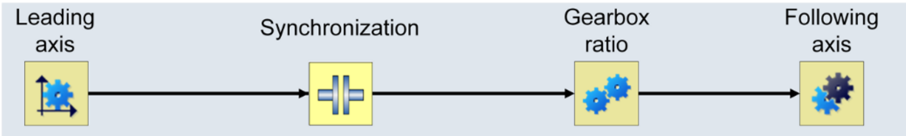

Figure 9: Block diagram of electronic gearing of axes

The setup for demonstration of the principles of electronic gearing is shown in Figure 2 [1, 2].

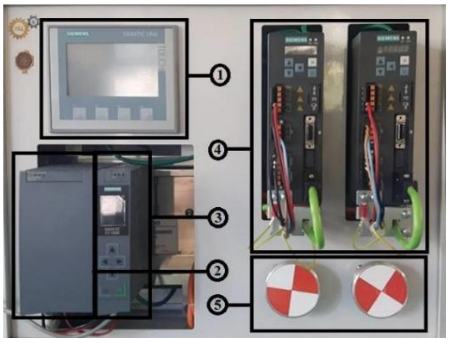

Figure 10: The setup for axes synchronization demonstration 1) SIMATIC HMI-KTP400 BASIC (6AV2123-2DB03-0AX0) operator panel, 2) Power module PM 190W 120/230 VAC (6EP1333-4BA00), 3) PLC SIMATIC S7-CPU 1511T -1 PN (6ES7511-1TK01-0AB0), 4) Servo drivers SINAMICS V90 PN (6SL3210-5FB10-1UF0) and servo motors SIMOTICS S-1FL6 (1FL6022-2AF21-1AA1) [1,2]

2. MOTION CONTROL EXAMPLE OF ON THE FLY MATERIAL SELECTION

In accordance with the Open Motion standard [3], there are functional blocks that are standardized and customized for use in industrial applications which include and motion applications. In addition to the general blocks used to turn the servo axis on, homing, resetting errors, etc. There are several special functional blocks that allow synchronization of the movement which are shown in the Table 1.

Table 1: Special functional blocks for synchronization

MC_GearIn	Runs relative synchronization.
MC_GearInPos	Runs absolute synchronization.
MC_PhasingRelative	Relative positioning using MC_GearIn and MC_GearInPos.
MC_PhasingAbsolute	Absolute positioning using MC_GearIn and MC_GearInPos.
MC_Camin	Runs coupling with CAM profiles.

Electronic coupling can be relative and absolute. Relative coupling is the coupling without definition of the phase between the axes in movement. Gearing is executed right after the synchronization request is received, and in accordance with the dynamic capabilities of the process itself. Absolute coupling is the coupling where the phase between the axes in movement is defined. The coupling is performed according to the requirements for the position between the axes or according to the dynamic parameters of the system [4, 5].

The following figure shows the principle of the selection process of different types of recycled materials on the fly, without stopping conveyor by using synchronization. The selection line system has two axes. Conveyor as master axis brings recycled parts. Servo drive with spindle moves carts which is equipped with robotic griper [6 - 9]. This concept can be applied to modern recycling systems [11].

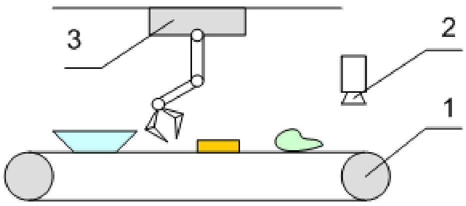

Figure 3: System for on the fly recycling 1) conveyor as master axes, 2) high speed camera for position detection of different types of materials, 3) servo axis with robotic griper as slave axis

The cart is defined as a linear axis with software and hardware limit switches. The process of selection on the fly has four phases:

1. Synchronization of the carts by speed and/or position
2. Synchronization movement of servo axis with conveyor when the taking operation is performed
3. Go to the appropriate container position
4. Go to waiting position or in the new cycle

This type of application can be realized by using absolute synchronization, i.e. using the functional block MC_GearInPos. Table 2. shows the appearance of the functional block and gives the meaning of the input parameters. Using the MC_GearInPos functional block, the synchronization is performed in relation to the leading position and the following axis. There are two types of synchronization using this block. SyncProfileReference = 0 - represents a synchronization type 0 using dynamic system parameters and SyncProfileReference = 1 - represents the type 1 of synchronization using the distance axis value.

Table2. Inputs of functional block for position synchronization

Master	Leading axis
Slave	Following axis
Execute	Signal for execution of function block
Ratio Numerator	Gear ratio on the master side
Ratio Denominator	Gear ratio on the slave side
Master Sync Position	Master axis synchronization position
Slave Sync Position	Slave axis synchronization position
Sync Profile Reference	The type of synchronization mode
Master Start Distance	Master axis traveled path during synchronization
Velocity, Acceleration, Deceleration, Jerk	Motion parameters
Sync Direction	Direction of motion for synchronization

Master distance (synchronization type 1) - By applying this type of synchronization, it is necessary to define the position of synchronization as well as the path traveled during synchronization. The start and end positions of the synchronization are clearly defined. Dynamic parameters are in the second plan. The processor performs a calculation based on the position of the slave axis and master axis. Depending on the values of the initial and final position parameters, three different cases can be observed. 1. Reverse motion, 2. Synchronizing and 3. Symmetrical.

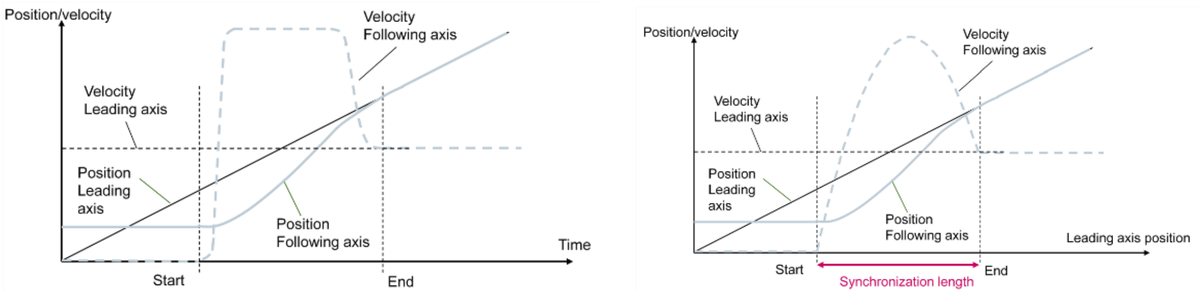

Figure 4. Synchronization Type 0 and Type 1

3. RESULTS AND DISCUSSION

3.1 Revers motion

The first case of synchronization is given in Figure 5. From the diagram there is a movement of the slave axis backwards to achieve synchronization. When recording this diagram, the values of the parameters were as follows:

Master Sync Position = Slave Sync Position = Sync Position = 0mm

Master Start Distance = 100 mm

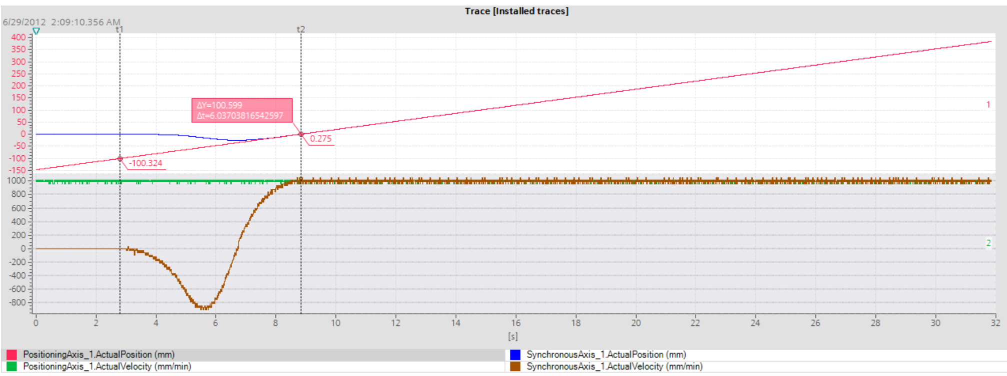

Figure 5. Diagrams of speeds and positions in the synchronization of Revers motion

As can be seen on the diagram, the master axis is moving at a constant speed. Slave axis isn't moving until the master axis achieves the position for the synchronization start.

Start Sync = Sync Position – Master Start Distance

In this case, the start of the synchronization is in the -100 mm position, because:

Sync Position – Master Start Distance = -100mm

Typical for this type of the synchronization is that the slave axis moves in both directions during the synchronization phase. In some applications, this can be a problem, and this kind of synchronization mode is avoided.

3.2 Synchronizing synchronization

The second type of synchronization is the synchronization of the two servo axes in the manner shown in Figure 6. The diagram shows values for this type of synchronization.

Master Sync Position = Slave Sync Position = Sync Position=500 mm

Master Start Distance = 200 mm

As can be seen on the diagram, the master axis is moving at a constant speed. Slave axis isn't moving until the master axis achieves the position for the synchronization start

Start Sync = Sync Position – Master Start Distance
In this case, the synchronization start is in the 300 mm position, because:
Sync Position – Master Start Distance = 200 mm

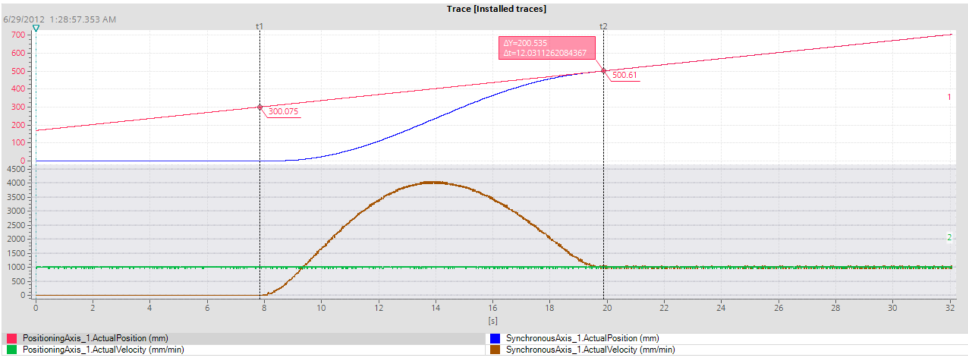

Figure 6. Diagram of speeds and positions during synchronization

3.3 Symmetrical (Optimal) synchronization

Figure 7 shows the appearance of the speed and position diagram during this type of synchronization. For recording these diagrams, the following values are set:

Master Sync Position = Slave Sync Position = Sync Position = 500 mm
***Master Start Distance* = 200 mm**

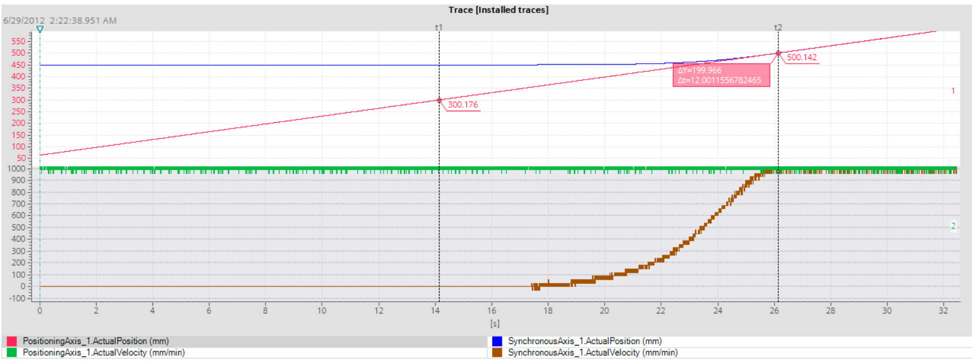

Figure 7. Symmetrical synchronization and speed and position diagrams

As can be seen on the diagrams, the master axis is moving at a constant speed. Slave axis isn't moving until the master axis achieves the position for the synchronization start.
Start Synchronization = Sync Position – Master Start Distance
Sync Position – Master Start Distance = 300mm

Typical for this type of synchronization is that the slave axis is moving only in forward direction during synchronization and the speed is not higher than the speed of the master axis. This synchronization method has the longest synchronization path. However, the advantage of this kind of synchronization is reflected in the fact that the slave axis does not reach the speed greater than the master axis, as well as the movement is only in one direction during synchronization. In the literature, the name optimal synchronization can often be found for this type of synchronization.

Conclusion

An analysis of the development of world experiences in the field of material flow management in the recycling of vehicles show constant progress. The most important is constant improvement of existing processing systems and its response to new challenges. To improve the performance of recycling systems, it is necessary to implement the latest technologies. In this work three types of synchronization which can be implemented in real industrial applications for automotive recycling were presented. By using this concept, given in this paper, the performance of automotive recycling systems can be significantly improved.

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DETERMINATION OF THE ACCUMULATION OF HEAVY METALS OF RIVER SEDIMENT BY PLANTS

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Abstract

Danube is the main river of Hungary. Danube and its floodplains and oxbow lakes are operating as ecological corridors, although their industrial, logistic and touristic role is not negligible. It is well known, that from the source to the estuary of the river Danube there are many industrial facilities. This heavy industrial pollution had effected on the water quality. The most dangerous components of the sewage water of these facilities are heavy metals, which can be found in the water as well as in the sediment. These toxic elements can cause significant health risks, because they can accumulate in the food-chain. The main aim of our research is to investigate the accumulation rate of the heavy metal content of the river sediment in the different parts of the test plants. The main sampling place of our research was a sediment dump was created by excavation from the Open Beach of Dunaújváros in 2009. During our measurements we analysed the cadmium, nickel, lead, chromium, copper and zinc concentration of the sediment and the plants. The test plants, which are growing on this sampling place, were parella (Rumex patientia), perennial rye-grass (Lolium perenne), sedge (Carex riparia), bistort (Persicaria maculosa). The extraction of the heavy metal content of the samples was made according to the MSZ Hungarian standard. The concentration of heavy metals were analysed with AAS (atom absorption spectrometer). According to our results we determined that parella could accumulate cadmium, nickel, chromium and zinc in its upper stem, on the other hand bistort could accumulate these elements mainly in its leaves. This information will be important in the case of the in-situ remediation of a polluted area in the future.

Keywords*: heavy metals, sediment, phytoaccumulation, remediation*

1. INTRODUCTION

It is well known that the industrial and communal pollution along banks of the river Danube has affected on the water quality of the Hungarian surface and groundwaters. The conservation or the rehabilitation of the environmental state of these areas means huge tasks and high costs for the governments. Between the inorganic pollutants of the waters heavy metals can be very harmful. These elements can be found both in the sediment and the water furthermore they can accumulate in the food-chain and cause toxic, mutagenic, carcinogenic or teratogenic effects. Between the heavy metals, some chemical elements (zinc, copper) are essentials, but their high concentrations can be harmful for the health. The toxicity of the heavy metals can depend on the presence or the absence of the other elements which also appear in the environment [1]. Nowadays many physical, chemical and biological methods are available for the decontamination of the polluted areas. During our research work our main aim was to confirm the positive effect of the phytoremediation. We analysed the heavy metal content of different kinds of plants which are growing on the river sediment.

2. MATERIALS AND METHODS

The first sampling area (M1-M3, T) was the sediment dump of Dunaújváros (Figure 1/a.), which is located on the northern part of the town. This dump was made in 2009, when the local municipality wanted to rehabilitate this old Open Beach area of the town, therefore the sludge of this beach was dredged out onto the floodplain which is located on the right side of the river Danube. In the southern part of the dump a stream flows, which flows into the river Danube. In addition, a water channel surrounds the whole dump. The second sampling area was the estuary of the Felső-Foki-streamlet (FFS) (Figure 1/a.). This streamlet is flowing through many agricultural fields before its end. The third sampling area is an oxbow lake (OL) (Figure 1/b.) which is located on the southern part of Dunaújváros. Between the four oxbow lakes the sediment and plant samples were taken from the second lake.

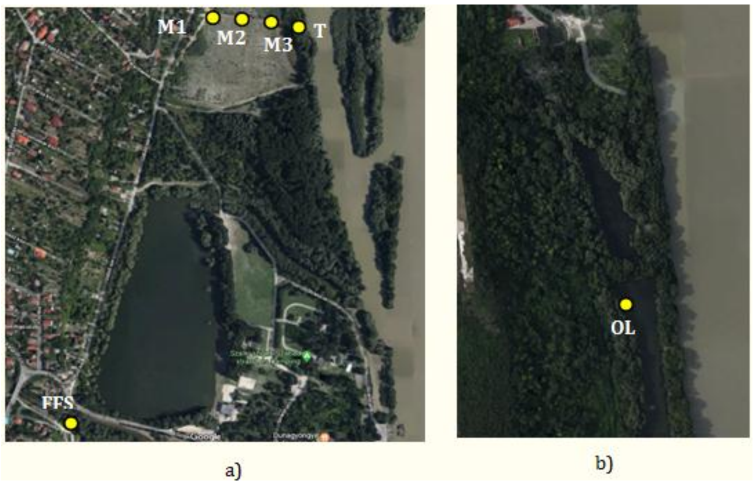


Figure 1 The sampling points of the sediment dump (a) and the oxbow lakes (b) (Source: Google Earth)

The area of the sampling points was 1 m^2. The sediment samples were collected from the depths of 0-10 with a standard soil sampler. Five sediment samples were taken from every place.

The parella *(Rumex patientia)* (Figure 2/a) samples were collected from the M1, M2, M3 and T points of the sediment dump. The bistort *(Persicaria maculosa)* samples (Figure 2/d) were taken from the T point of the sediment dump. The perennial rye-grass *(Lolium perenne)* samples (Figure 2/b) were taken from the estuary of Felső-Foki-streamlet (FFS), and the riparian sedges *(Carex riparia)* samples (Figure 2/c) were taken from the oxbow lake (OL) place.

Figure 2. The photos of the test plants

The extraction of the heavy metal content of the river sediment was made with acidic destruction according to the MSZ 12739/4-78 Hungarian Standard. Following the directions of the Standard, firstly the organic parts were removed and the samples were dried. Thereafter, during the destruction process, the heavy metal content was extracted with concentrated nitric acid and hydrogen-peroxide in a rotating evaporator (Heidolph Laborota 400). After filtration, the concentration of the heavy metals was analysed with an atomic absorption spectrometer (AAS, Perkin Elmer AAnalyst 400). Among the heavy metals, cadmium, nickel, lead, chromium, copper and zinc were measured [2].

For the determination of the heavy metal content of the plants the samples were also destructed with concentrated nitric acid and hydrogen peroxide. During the preparation process the main parts of the plants were washed with deionised water, and then they were dried. After that the plants were cut into pieces and these parts were treated with concentrated nitric acid for 12 hours and with hydrogen peroxide for additional 3 hours.

After filtration the heavy metal concentration of the samples was also measured by atomic absorption spectrometer (AAS) [3].

Our results were compared to the limit values of the heavy metals which can be found in the appendix of the 6/2009. (IV. 14.) KvVM-EüM-FVM law.

The sufferable levels of the element in plants were determined in the Hungarian Forage Codex (2003) and the related literatures [4-7].

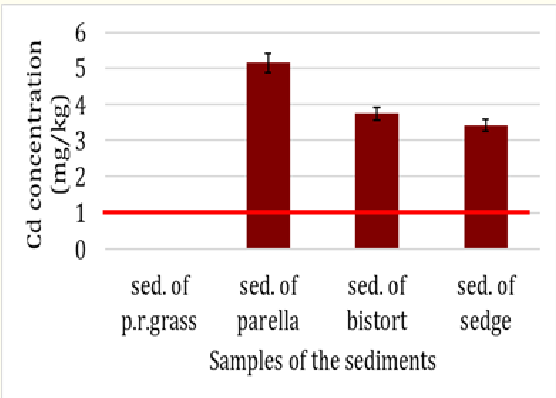
3. RESULTS AND DISCUSSION

3.1. The cadmium content of the sediment and plant samples

Based on Figure 3 it was determined that the cadmium content of the sediment of the parella, sedge and bistort exceeded the Hungarian standard level (1 mg/kg).

Among the four test plants cadmium was detected in the leaves of sedge and perennial rye-grass, and the upper stem of the parella. The cadmium concentration was higher in the test plants than the tolerable limit, 0.5 mg/kg.

When the concentrations of the sediment and the parts of the plants were summarized, it is determined that cadmium remained mainly in the sediment, only 30-40% of the total cadmium content could accumulate in the plants [4-9].



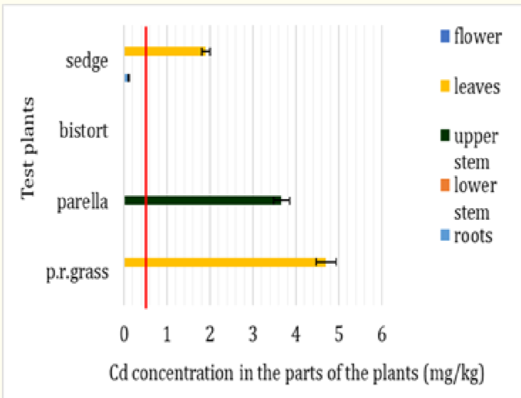


Figure 3 The cadmium content of the sediment and plant samples

3.2. The nickel content of the sediment and plant samples

This element was not detected only from the sediment of the riparian sedge (Figure 4). The Ni contents of the other sediment samples were lower than the standard limit (40 mg/kg).

This pollutant was measured only from the parts of the parella and bistort. The Ni contents of the parts of the plants did not exceed the tolerable limit (10-100 mg/kg).

The nickel concentration was the highest in the upper stem of parella and the leaves of bistort. Bistort contained the 53%, parella contained 70% of the total Ni content of the sediment and plant system [4-9].

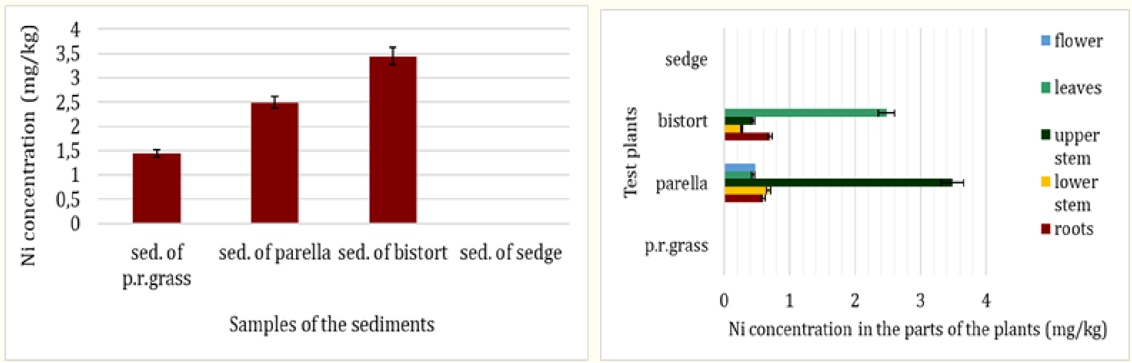


Figure 4 The nickel content of the sediment and plant samples

3.3. The lead content of the sediment and plant samples

The Hungarian standard level for lead content is 100 mg/kg. According to Figure 5 it is determined that the Pb content of the sediment samples of bistort and parella exceeded the standard limit (100 mg/kg).

From between the four test plants only bistort could accumulate this element. The highest Pb concentration was detected from the roots and the leaves of this plant. In these parts the Pb concentration was higher than the tolerable limit (30-300 mg/kg). In bistort the 88 % of the total lead content of the plant-sediment system was observed [4-9].

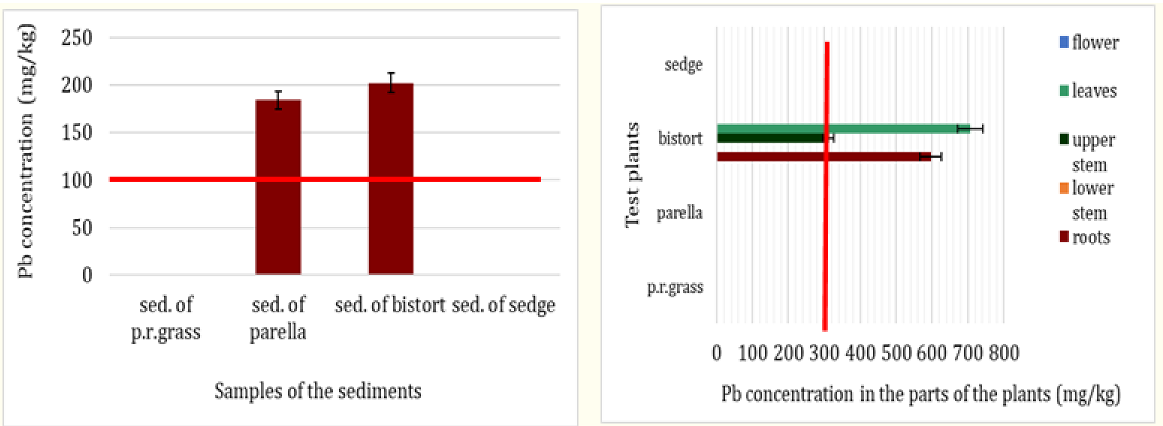


Figure 5 The lead content of the sediment and plant samples

3.4. The chromium content of the sediment and plant samples

According to Figure 6 chromium concentration was measured only from the sediment sample of the parella and bistort. The concentration of this element was higher in the sediment samples than the Hungarian standard level (75 mg/kg).

The distribution of chromium between the parts of parella was uniform. The roots and the leaves of bistort could accumulate chromium in the highest concentration. The concentration of this pollutant was higher in the test plants than the tolerable limit 1-10 mg/kg. Parella and bistort could accumulate 80% of the total chromium content of the sediment and plant system [4-9].

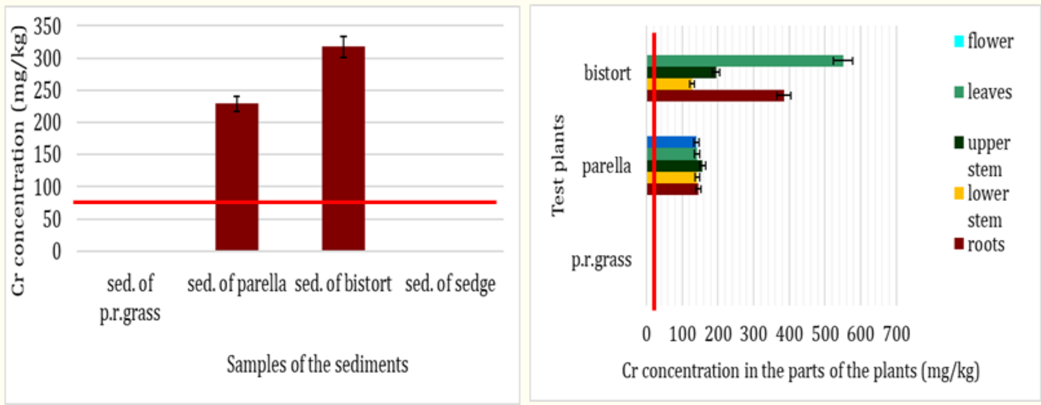


Figure 6 The chromium content of the sediment and plant samples

3.5. The copper content of the sediment and plant samples

Cu concentration was higher than the standard limit (75 mg/kg) in the sediment of the sedge sample. The sediments of the other plant species had lower copper concentrations (Figure 7).

In plants the copper concentration was higher than in the sediment samples. Every plant could accumulate this element. In the case of sedge and perennial rye-grass, the roots contained in higher rate this pollutant. On the other hand, we could detect copper in higher concentration from the upper stem of parella and the lower stem of bistort. The copper concentration of the plants was higher than the sufferable value (35 mg/kg). Plants could accumulate 70-90% of the total Cu concentration of the sediment and plant system [4-9].

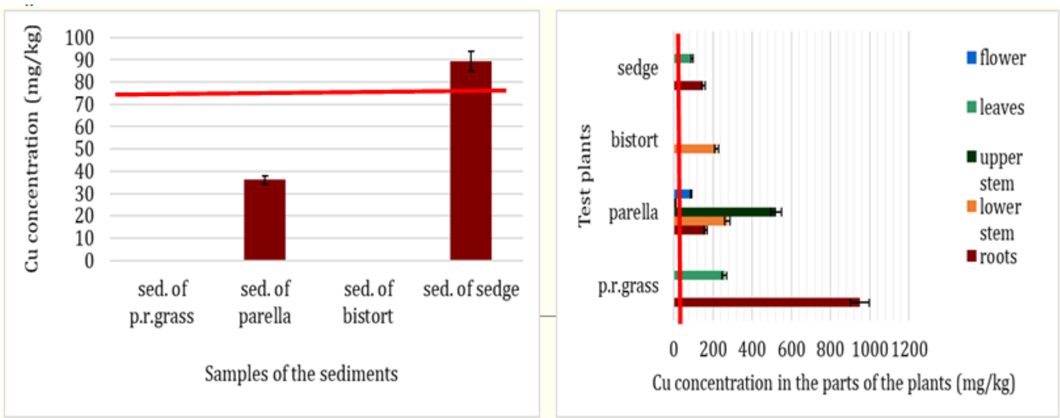


Figure 7 The copper content of the sediment and plant samples

3.6. The zinc content of the sediment and plant samples

The zinc content of the river sediments exceeded the standard limit (200 mg/kg) (Figure 8). Every test plant could accumulate this element. In the case of the perennial rye-grass and sedge samples the higher zinc concentrations were measured from their leaves. Higher zinc content was detected from the upper stem of parella and bistort. The content of this element exceeded the tolerable value (250 mg/kg) only in the upper stem of parella and in the leaves of perennial rye-grass. Plants could uptake the 30-40% of the total Zn content of the plant and sediment system [4-9].

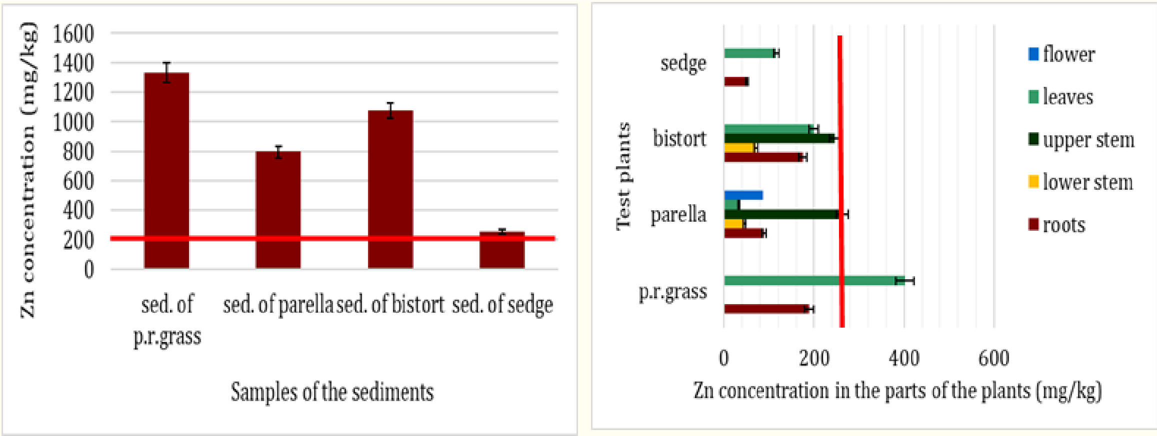


Figure 8 The zinc content of the sediment and plant samples

Conclusions

The mobilization of cadmium between the sediment and plants was insignificant, it remained mainly in the sediment. Only the 30-40% of the total cadmium content could accumulate in the stems and leaves of test plants. Nickel (50-70 %) and chromium (80%) could accumulate in the upper parts of parella and bistort. 50-70% of the total nickel content and 80% of the total chromium content were detected from these plants. Test plants could uptake in higher rate copper (70-90%) and zinc (30-40%), because these elements are essential. Copper was detected mainly the lower parts (roots) of the test plants. On the other hand the highest zinc concentration was observed in the upper parts (stems and leaves) of the test plants.

According to the results of the heavy metal content of the test plants, parella and bistort are recommendable for the phytoremediation of the sediment of the river Danube.

We are planning to make more laboratory experiments on other kinds of plant species to measure the continuous phytoextraction of the heavy metals from river sediments or industrial sludges.

ACKNOWLEDGMENT

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ROLE OF PLANT-MYCORRHIZA SYMBIOSIS IN REVEGETATION OF DISTURBED MINING SITES IN INDIA (NORTH TELANGANA)

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Abstract

Extensive mining activities develops with energy requirements of globalizing World. Both underground- and open cast mining are resulting disturbed soil surfaces, which need to revegetate for environmental safety. Coal mining sites at North Telangana region of India was investigated. Soils there are poor habitats for any plant establishment, the growth and survival of revegetated plants are possible only with arbuscular mycorrhiza (AM) fungal inoculation. Two leguminous agroforestry tree species were selected (Acacia nilotica, A.n. and Albizia lebbeck, A.l.). AM fungal spores were isolated and based on their morphological structures, 5 different types of AM species, the Glomus/Rhizophagus-, Gigaspora-, Acaulospora-, Scutellospora- and Sclerocystis sp. were identified. We have investigated the AM colonization rates, efficiency of selected strains in greenhouses and also at coal mine dumps by inoculation experiments on two test plants. AM fungal strains was found to be effective for the selected leguminus tree species both in their natural forests and at disturbed soils. Glomus sp. was the most dominant among the five different AM fungal species, more particularly G. aggregatum, G. fasciculatum showed the best colonization and biomass production with the test plants. The AMF isolates from natural forests are supporting the revegetation of the disturbed mining sites. Preselection is needed for considering the environmental protection and the best soil functioning.

Keywords: *mining sites, revegetation, AM fungi, isolation, inoculation.*

1. INTRODUCTION

Coal is extracted from the earth by opencast and underground mining. Opencast mining is considered one of the most dramatic disturbances in terrestrial ecosystems. The disturbance of green vegetation due to mining it has been reported that there is a difficulty with restoration [1], because of three major macronutrients, namely nitrogen, phosphorus and potassium are generally found to be deficient in overburden dumps [2, 3], heavy metals on the other hand can be accumulating very frequently in mining sites [27].

The AM fungi and other poetential microsymbionts helps the plants to grow in disturbed sites for improvement of environment [4]. By using indigenous AMF from forest systems is essential for reclamation of these mine spoils and overburdens include re-establishment of sustainable plant community [5, 28]. Mycorrhizal symbiosis are very important for survival and growth of plants and plant uptake of nutrient such as phosphorus and nitrogen, especially P deficient soils [6, 27]. In the colonization of arbuscular mycorrhizal (AM) fungi, several species of arbuscular mycorrhizae fungi occur which helps in plant growth and assists them in their mineral uptake. Plant and microbial growth processes in disturbed mine spoils requires stable nutrient cycles for reclamation [7, 8, 25].

Arbuscular mycorrhizae create the wide spread plant fungi symbiosis that occurs in nature and therefore mycorrhizal fungi are key components of natural ecosystems. They are considered indispensable for ecosystem functioning [9, 27], because they play a fundamental role in soil fertility and in the maintenance of stability and biodiversity within plant communities [10, 11]. AMF play a significant role in the maintenance of ecosystem. Forest soil supports a great diversity of AM fungal flora. Agricultural, disturbed, polluted soils have already lost much of the diversity of AMF. Due to industrialization and mining activities, the forests are fast dwindling. Along with forest flora, the beneficial AM flora is also likely to eliminated. Hence there is a need to identify and conserve these fungi for different forestry programmes. Mining activities result in severe disturbance in the soil and huge mine overburdens.

The coal mine overburden soils are poor in organic carbon, available nitrogen and available phosphorus because of lower measure of microbial functioning in the overburden soils. Soil nutrient and physico-chemical properties also affect plant communities [12, 13, 14, 27].

The pH of the overburden sites is slightly acidic in nature, under these (acidic) conditions of dump materials growth of plants severely affected in various ways. The dump material at all the sampling sites was not found suitable for plant growth. The data reveals that dump soils are deficient in N, P which doesn't support proper plant growth.

Reclamation of these mine spoils and overburdens include re-establishment of plant community. Therefore, a study on possible application of AMF excavated from forest systems is essential.

2. MATERIALS AND METHODS

The AMF cultures were isolated from the native soil samples and identified morphologically [15]. AMF monocultures were mass cultured in the substrate of sterile soil:sand (1:1) mixture for 2 months in green house. P-deficient Hoagland solution was used for the nutrition used on a weakly frequency.

Two test plants *A.n* and *A.l* were treated with five different AM fungal monoculture inoculum treatments. There were 4 grams of inoculums used with root fragmants and spores of the AMF per 1 kg of sterile soil medium. Treated plants were raised in green house for six months and watered accordingly.

Transplantation of AM inoculated seedlings

Inoculum treated seedlings of 2 test plants [*Acacia nilotica A.n)* , *Albizia lebbeck (A.l)* were transplanted at Ellandhu fresh open cast dump soil (OCD) sites. The Pits were 40x40x30 cm and the distance between each plants was 1.5mx1.5 m. The inoculums treated plants were transplanted on to the site along with farmyard manure in the month of June.

Sampling

After one year of growth in OCD the rhizosphere soil samples and plants were randomly collected from each treatments of two test plants. The rhizosphere soil samples along with the root bits of test plants were collected from the experimental plots at Ellandhu coal mine dumping area. Soil samples from 0-20 cm depth were collected in polyethylene bags and air dried afterwards.

Soil physico chemical characateristics

Soil pH assessment: Air dried soil of 20g was taken in a beaker and 50ml water was added. The mixture (1:2.5 ratio of soil:water) was stirred for 10 min and was allowed to stand for 30 min. The pH was measured by using the electronic digital pH meter.

Organic carbon (OC) content was determined using titration method of Walkley and Black [16]. Total nitrogen (TN) content was determined by Kjeldahl method [17].

A part of the samples was used for spore count and taxonomic analysis. The root samples were cut into 1 cm pieces, washed with tap water, preserved in 70% ethanol and stored at 4^oC for further analysis.

The mycorrhizal roots were stained [18], fifty root segments were randomly selected and mounted on microscopic slides and observed under microscope to study the hyphae, vesicles and arbuscules. The length of infection was assessed in mm or cm for each root piece and averaged for ten pieces, and expressed in percentage of colonization. The presence or absence of infection was also recorded in groups of ten each and results expressed in percentage.

There was 50 root fragments observed in each replicate sample. The percentage colonization was calculated by the following formula.

$$\textbf{Percentage of AMF root colonization} = \frac{\text{Number of root segments colonized}}{\text{Total number of root segments observed}} \times 100$$

AM fungal spores in the rhizosphere soils were extracted by wet sieving and decanting method [19, 20]. $100g^{-1}$ of soil was mixed in a water beaker (1000ml) and stirred with a glass rod to make uniform suspension and left for five minutes. The suspension was passed through different sieves. This process is repeated until the top layer of sediment soil become clear. After that we have collected the spores by washing them and mounting spores on a slide. The AMF spores were observed and identified based on morphology [15] and website (http://fungi.invam.wvu.edu/the-fungi/species-descriptions.html).

Estimation of plant biomass

Plants were carefully schooped out of the pots at the time of flowering. The shoot and root system were separated and the root system was thoroughly washed in slow running tap water, to remove the adhering soil particles. Then the roots were pressed between dry filter papers to remove the excess water. These were carefully packed in separate papers and are kept in an oven at 80^oC for 48 hours until a constant weight is obtained. Later they were weighed on a balance and weights are recorded.

Estimation of Phosphorus

P-content in the oven dried (shoot and root) samples was estimated by molybdate-vanadate method [22]. 1g of the oven dried sample was digested in 10 ml of triacid mixture (750 ml conc. HNO_3 + 150 ml conc. H_2SO_4 + 300 ml HNO_4) for $2_{1/2}$ hours.

The digested mixture was made up to 50ml with distilled water and filtered through whatman No. 1 filter paper. 2ml of the diluted sample solution was taken in a test tube, 2ml of 2N HNO_3 and 5ml of distilled water were added. Then 1 ml of molybdate-vandate solution was added. The yellow color was allowed to develop for 20 min.

The intensity of yellow color was recorded in spectrophotometer at 420 nm against a blank which contained all the reagents except sample whose volume was substituted by distilled water. P content was calculated bye standard graph prepared with KH_2PO_4.

3. RESULTS AND DISCUSSION

The pH of the soil solution is very essential because soil solution carries in it nutrients such as nitrogen, potassium, and phosphorus that plants need in specific amounts to grow, thrive, and fight off diseases. The pH of the present study site is showing less than pH 7 (slightly acidic). Plants were unable to utilize the N, P, K and some micro nutrients if the soil solution pH is acidic.

In the present investigation soil samples with clay loam having very low organic matter (0.14%) as considered it as a depleted soil. Percentage of organic matter range is 1.4%, indicating less accumulation of humus matter in the dump samples of Ellandhu.

Nitrogen was found to be 69.1 kg/ha in selected study site of Ellandhu. Available phosphorus content of the dump materials was recorded in low amount 7.6 kg/ha. This might be due to slightly acidic nature of samples which restricted the microbial functioning resulting in very poor mineralization and organic decomposition process (Table 1).

Table 1. Soil physico chemical characteristics of the studied site

Soil type	**Sample collection area**	**Soil texture**	**pH** (H_2O)	**EC** (mhos /cm)	**Organic matter** (%)	**Available Phosphorus** (kg/ha)	**Available Nitrogen** (kg/ha)
Coalmine open cast soil	Yellandhu (JK-5 ocp)	Clay loam	6.1	0.149	0.14	7.6	69.1

Effect of native AM fungi on the mycorrhizal intensity in terms of root colonization and spore population in rhizospheric soil of *A.l* and *A.n* has been presented in Table 2 & 3 respectively. In the comparative studies all the *Glomus* species showed a significant difference in colonization.

Biomass of treated plants in the form of fresh weight recorded in *Albizia lebbeck* (*A.l)* and *Acacia nilotica* (*A.n)* is ranging from 90.0 to 142.6 g and 72.8 to 168.1 g , respectively. Likewise root/shoot dry weight ranging from 62.4 to 116.3 g and 59.1 to 141.9 g, respectively, at the time of one growth in the transplanted site.

Minimum root/shoot growth was recorded in control plants. In comparison to control, all other treated plants showed a highest root/shoot growth. Maximum root/shoot growth of *Albizia lebbeck* (142.6g) was recorded in *Glomus/Rhizophagus aggregatus* treatment. In *Acacia nilotica* (168.1) the highest growth was observed in *Glomus fasiculatum* and followed by *Gigaspora gigantea.*

In the present study all the five treatments gave best results when compared with control (non inoculated tree species) *Glomus/Rhizophagus aggregatus* supports *Albizia lebbeck* showed highest root colonization and helps the plants to uptake the nutrients such as root/shoot Phosphorus content (0.42/0.38 mg/g).

In *Acacia nilotica* the highest shoot/root phosphorus content (0.46/0.34 mg/g) showed by treatment with *Glomus fasiculatum*.

Among all the five monoculture treatments *Glomus/Rhizophagus fasciculatum* and *Rhizophagus aggregatus* gave best plant growth in all the parameters records plant height, biomass and Phosphorus content. In this study Percentage of AMF root colonization is directly propotional to the biomass and phousphorus content.

The results of this plot experiment is carried only for short period (one year) so there was no significant difference in treatments. Addtion of bioinoculants/helper bacteria along with AM fungi helps the plant growth PGPR [23-25] including N_2-fixing bacteria [26-27] are involved.

Table 2. Screening of Albizia lebbeck for efficient strains of AM fungi

	Treatments	**Root colonization** (%)	**Height of plant** (cm)	**Biomass** (g)		**Phosphorus** (mg/g)	
				Fresh wt.	**Dry wt.**	**Shoot**	**Root**
1	*Glomus fasciculatum (Rhizophagus fasciculatum)*	72.6	112.1	125.2	108.8	0.36	0.12
2	*Glomus aggregatum (Rhizophagus aggregatus)*	76.4	120.2	142.6	116.3	0.42	0.38
3	*Gigaspora gigantea*	50.2	83.2	111.1	86.2	0.36	0.16
4	*Acaulospora foveata*	52.4	96.6	128.3	110.6	0.26	0.18
5	*Sclerocystis sp.*	39.7	86.5	98.2	65.3	0.14	0.10
6	*Control*	--	76.0	90.0	62.4	0.32	0.15

Table 3. Screening of AM fungal treatments with Acacia nilotica

	Treatments	**Root colonization** (%)	**Height of Plant (cm)**	**Biomass (in grams)**		**Phosphorus content (mg/g)**	
				Fresh wt.	**Dry wt.**	**Shoot**	**Root**
1	*Glomus fasciculatum (Rhizophagus fasciculatum)*	70.0	160.1	168.1	141.9	0.46	0.34
2	*Glomus aggregatum (Rhizophagus aggregatus)*	62.4	148.9	152.6	133.6	0.32	0.27
3	*Gigaspora gigantea*	69.6	154.2	156.1	139.2	0.41	0.29
4	*Acaulospora foveata*	50.4	120.2	136.2	99.3	0.25	0.16
5	*Sclerocystis sp.*	37.6	97.0	111.2	84.5	0.32	0.22
6	*Control*	--	68.8	72.8	59.1	0.22	0.12

Conclusion

Seedlings inoculated with the indigenous AMF monoculture showed the highest biomass and phosphorus content. When compared to non-mycorrhizal controls, those plants grew very poorly. Within the AM fungi selection of perfect efficient indigenous mycorrhiza inoculations are needed for revegetation of disturbed sites. By the efficient AMF inoculation the agroforesty tree species showed best results in the form of increasing biomass and phosporus uptake.

Inoculation of multi agent bioinoculants such as nitrogen fixers and K solubulizers, as helper bacteria along with AMF inoculations should be also suggested. Fast growing host plants which has more association for mycorrhizal colonization in their roots, are required to be studied for mine site restoration.

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AGRICULTURAL ANSWER TO CLIMATE CHANGE - OPTIMIZING RESOURCES

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Abstract

Objective: Sustainable future is our task. Site-specific crop production is compatible with sustainability from ecological, economic and social aspects. The aim of the paper is to highlight the role of innovation in optimizing resource use in agriculture. That means the use of all items of precision technology matched with a form of farming technology that is appropriate for the environment. The question to be answered is: what solutions give enough income for farmers and keep the environment in good condition if the climate is changing, in the aspect of the "de-growth' theory developed by Serge Latouche. Methods: Based on content analysis a summarization is given in this paper on the 'de-growth theory'. The paper focuses on our former researches where the question was discussed as an economic question of farms, innovation and cooperation, taking into consideration attitudes and willingness to cooperate. Results: Site-specific farming is a holistic system, a technology that allows target-oriented treatments, thus managing the spatial and temporal variability within an ecosystem, by applying spot treatment applications, finding the optimum solutions, when the climate, water supply is radically changing with an increasing risk of production. And at the same time, the farmer has to be effective! How to combine the concept and practice of site-specific agriculture with sustainability in a changing word? The concept of site-specific farming meets with the following thoughts of the 'de-growth' theory: (1) Allows the efficient use of natural resources (Restructurer – restructuring factors of production). (2) Each farming strategy in which the farmers' cooperation is the base of efficient machinery use (Restructurer – restructuring of social relationships). (3) Each technology that reduces the human-health risk (Réduire – reduction) shows into the direction of 'degrowth'. Conclusions: Site-specific agriculture is and can be one of the solutions as good answer to climate change.
Keywords: *sustainable development renewal, site-specific agriculture, risk, answers 'de-growth theory' strategy, cooperation*
JEL classification*: Q01; Q55; P49*

1. INTRODUCTION

The sustainability of agricultural production is one of the most important issues of our time, and the agricultural innovation would be a very important aspect. The aim of sustainable agriculture is to define the balance between economic, social and environmental expectations, to establish both the ecologic and economic sustainability. All over the world the common challenges of the agriculture are to satisfy the growing food necessity on smaller and smaller agricultural area in view the avoidance environmental damage. One of the main tasks of society to find the appropriate answers, to use those technologies that fit both these requirements, in agriculture, too. [1-4]

To be successful in economy efficient resource use, strategic thinking and cooperation is required. Sustainable economy includes viable, developing agriculture, with competitive farms.

One of the key driving forces of this development is the farmer itself. Cooperation, sharing the resources helps to meet the requirements of sustainable economy.

The question arose: „What kind of business model do we need?" To find and adopt those farming activities, solutions and technologies that are suitable for effective production, ensuring the viability for the farmers by the product chain is one of the basic tasks of a sustainable economy. A safe food production and establishing the food security are tasks in which all actors in the food chain should be active involved. Higher is the need of thinking together, cooperation if we take into consideration climate change, growth of population, migration questions. More food we need less arable land we reach, less water with higher rainfall fluctuation we face – more questions arose. Really sustainable is the word? Kurt Vonegut, the writer said some when, good place is our planet, what pity it is we have not taken enough care of her. Let see, what kind of possibilities we have to give good answers?

The future of the agricultural production is to keep the input (artificial or natural) usage within a reasonable level and spread out only the amount which is necessary for the produced plant considering the heterogeneous conditions of the field and not more. Many new or rediscovered technologies have appeared against the harmful effects of the artificial chemical use of the agricultural production without yield loss or with yield similarity (for example ecological farming, mid-tech farming and precision farming technology). Among natural resources arable land is one of the key factors in agriculture and in the life of rural areas as well. Another key factor has become more important recently: the water and the question of irrigation. Without going deeply into the question of economy of resource limitation, here should be highlighted the need for increased efficiency both of land and water use. There is a paradigm change need in not only the economy but in our life as well. The so-called linear model of resource consumption, based on the "take-make-consume-dispose" pattern, does not meet the requirements of sustainability.

The limitation of natural resources, the contradiction between the need of today's generation for resources, goods, environment, the unlimited consumption and the need(s) of future generation was well-discussed in the last years in several literatures [5] Also important issues are the depletion of the nature and the pollution of the environment. The new thoughts of circular economy appeared in the last decade. [7-10] Main message of circular economy from the point of view of our topics is, that agriculture – the farm itself – should be considered as a holistic, regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing energy and material loops. In other words the artificial inputs are limited, but at the same time the optimal use should be meeting with the yield requirements. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, recycling, and up cycling.

A safe food production and establishing the food security are tasks in which all actors in the food chain should be active involved. Questions of food safety, food traceability, environment pollution or the increasing food demand have been discussed from several aspects by agricultural economists. In our paper we highlight the role of site-specific plant production. [11-14]

Traceability guarantees the food safety from farm to fork. The materials and products flow must be linked with the professional information' flow along the entire chain and they must move together. Stakeholders who cannot suit the requirements based on food security, may drop out from the market. Here appears the role of site-specific – with more common words – precision agriculture (PA). [15]

Efficiency has a technical meaning: yield efficiency for the given land, soil and climatic conditions. Based on the analysis of production functions, can be stated that many inputs (variables) the farmer as a decision maker has no impact, so more information and knowledge is needed to adopt farming practice the eco-system.

The responsibility of agricultural production means to find the appropriate species, technologies from the point of view of agro-eco potential. The meaning of production efficiency is a term that is closer to economic efficiency and includes the questions of market (demand, price, subsidies etc.), farm facilities (property, ownership, size, market connections, memberships, geographical localization, level of capital and machinery, management skills etc.). In this case the responsibility of agricultural production means to find the proper market where there is solvency and willingness of consumers to by the products at an equilibrant price. The task is not too easy to solve at the same time, but all managerial decisions should be made under the agro-ecological and economic circumstances. [16-19]

The term 'sustainable development' includes the current and long-term sustainable production and the controversies of environmental protection that assurance the right quality of life, and difficult to prevent, but rather tolerated conflicts. [20-23] The basic figure of sustainability includes three pillars: ecological, economic and social sustainability, based on the Brundtland Report. [24] What we add: the role of innovation in giving the appropriate answers to changes. (Figure 1)

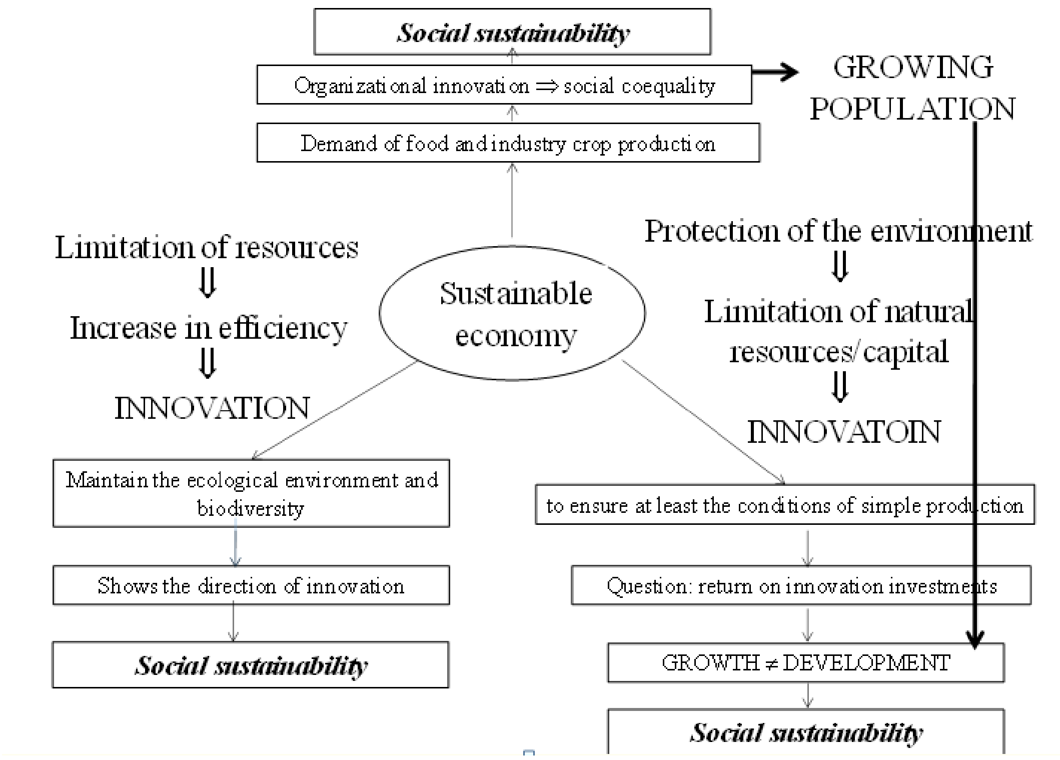

Figure 1. Sustainable economy in the context of innovation
Source: own construction [25]

Sustainability must include farming that adopts the new, innovative, more efficient technologies which allows the easy reproduction of assets needed for production. The future of the agricultural production is to keep the input (artificial or natural) usage within a reasonable level, to apply water saving technologies (not only in the case of irrigation, but land cultivation, amelioration, genetically transferred or modified species, etc.) and spread out only that amount of inputs which is really necessary for the produced plant considering the heterogeneous conditions of the field. [26-28]

Now we got to the stage of food channel participants. The responsible behaviour of all participants (producer, consumer and society) has to find a degree of intensity and technology of production matched with a form of farming technology that is appropriate for the environment (such as organic, conventional, integrated and precision (a further developed form of integrated) farming strategies.

Here should be highlighted the role of up-to-date technologies that allow to optimize the input use (i.e. seed, chemical, water). [29-31] To find the new ways of agricultural development and innovation it is also important to focus on sustainable economy that is nothing else than social sustainability.

2. MATERIAL AND METHODS

The aim of this paper is to define and highlight the characteristics of precision farming as an agricultural innovation, as one way of digitalization of agriculture in the aspect of the "de-growth' theory developed by Serge Latouche. [32-33]

With the method of content analysis, agricultural efficiency and sustainability are characterized from the point of view of precision technology as a potential answer to climate change, focusing on economic efficiency. Logical modelling was used to apply the 'de-growth' theory to agriculture.

3. RESULTS

How PA reduces the risk of production?

We should use such combination of the tools having plant protection effect that will allow the expected yield at a lowest cost, with the lowest environment and human burden. The tools of integrated plant production – here we are meaning wider aspect of production, including a lot of technological elements – we must combine. From economic point of view the direct items needs energy surplus to a system – increase the production cost, like chemicals, mechanical weed management, biotechnical tools, etc. –, while the indirect tools are integral parts of the whole technology (resistance species, protection of useful organism, etc.).

Based on the threshold principle, the treatment is needed when the potential economic loss due to the density of harmful organizations is equal or higher than the cost of treatment (direct tool, energy surplus). That is one role of plant protection: reducing the yield uncertainty, from this aspect it is a variable of yield uncertainty.

$$Y = f(V_1,\ldots,V_n;\ V_{n+1},\ldots,V_k;\ V_{k+1},\ldots,V_m),$$

where

$V_1,\ldots,V_n$ = decision variables (fertilizer, seed, several herbicides);

$V_{n+1},\ldots,V_k$ = predetermined variables (soil conditions);

$V_{k+1},\ldots,V_m$ = variables of yield uncertainty (dynamics of predetermined variables, dynamics of infection, weather, etc.). [based on 34]

From this context, on-line site-specific plant production can be considered as more than simple variable of yield uncertainty, it become a real decision variable of yield. [35]

Efficiency and sustainability in agriculture

By 'efficiency' we will consider the economic meaning that is connected to the question of sustainability. The principle of sustainability, the harmony must be achieved between the needs of society, population growth, the natural resources and environmental pollution in a sustainable society by the limitation of consumption, thrift in the use of inputs (materials, energy etc.). The definition of sustainability of the environment comes from the Brundtland Report. [36] Pearce and Atkinson's (1995) understanding is that the natural resources and human-made capital are complementary to each other in the production process, so that natural resources are creating the limiting factors to increasing production and, at the same time, they should be used rationally during production. [37] By the turn of the millennium, sustainability has a broader interpretation:

- Protection of natural resources;
- Food production (fitting to the increasing demand);
- Maintenance of viable rural communities;

- Improvement of human and animal health (conditions);
- Environment protection ('polluter pays' principle);
- Suitable subsidy system(s);
- Diversity of land use;
- Less harmful territorial usage;
- Local solutions in territorial land (resource) usage;
- More efficient institutional background to ensure the multifunctional territorial usage ('territorial cohesion policy').

During recent decades, the new paradigm of agricultural research and development has been built on the interaction of three factors: ecological sustainability, economic efficiency paired with equal opportunities, and mutual assistance of governmental and non-governmental sectors in order to improve the performance and profitability of farming systems. In the future we should extent the question of sustainability with the question: how to react to climate change?

Innovation in agriculture – mainly coming from machine and chemical industry, biotechnology, digitalization, managerial sciences, etc. – gives a good base for the farmers to extend their knowledge, practice and find the appropriate way,
that meet the three pillars of sustainability. The main characteristics of such agriculture are:

- up-to-date information and knowledge about facilities the farmer has (soil and weather parameters, technical efficiency, market prices, movements, etc.)
- appropriate technologies to the given circumstances (with wide assortment from ecological production to site-specific production or individual feeding);
- reduced use of water (drip and precision (planed) irrigation);
- energy saving systems and renewable energy use;
- optimization of chemical use (precision farming, site-specific usage if needed, based on field experiences and prediction of degradation, etc.);
- harmonized with the environment (wild animal protection, shelterbelts; preserving biodiversity, etc.)
- focus on quality production (including the questions of safety food), meeting the market need;
- importance of human capital, human skills (including the IT usage).

In other words, to be genuinely sustainable, agricultural production, land use should be sustainable from the point of view of land, soil, water, biodiversity (environment), from the economic point of view (how to be viable, competitive, giving enough income for the farmers, for the rural communities) and also sustainable in terms of social aspects ('Feed the world') (Figure 1).

Theory of 'de-growth' – how to implement it for agriculture?

This chapter is based mainly of the Authors' former scientific publications. [38-40] The wide expanded interpretation of sustainability and has strong connection to the new paradigm: 'de-growth'. This new theory connected to the question of a sustainable future in the economy came to mind at the very beginning of the 21st century. The main meaning of 'de-growth' is not unknown for society, it is a movement towards a sustainable future, combining ecological economics, anti-consumerist and somehow anti-capitalist thoughts. The roots of the movement go back to the antecedents: The Club of Rome report of 1971 entitled 'Limits to Growth'. Estimates suggest the population will exceed 9.2 billion in 2050 and this is projected to increase demand for food by 50-70 per cent, while the internal structure of consumption is evolving towards high quality food. The Earth's growing population generates increasing demand not only for the limited natural and artificial resources, especially food, energy, drinking water, but also for the liveable areas. To this must be added the question of migration due to climate change. For agriculture, the main task is not only to ensure food safety but safe food and viable rural areas as well. In maintaining the above-mentioned aims the economy, agriculture and environmental management all have a significant role. [40-45]

Decades before the (re)appearance of the moral economists, an etologist, Konrad Lorenz (1973), wrote his novel *Die acht Todsünden der zivilisierten Menscheit* (in English (1974): Civilized man's eight deadly sins). [46] The environmental, ecological and social processes the author is referring to have some economic consequences for business life: degradation of biodiversity, decreases in agricultural and rural areas have huge effects on individual enterprises, on production structure, technology, direction of innovation etc. To be successful participants of business life they need to give appropriate answers, trying to reach their optimal behaviour. On the other hand, the increase in consumption (the over-consumption itself) can be a leading force of economic development, but the question is: why increase the use of limited resources, what is the limit of the current usage? The limitation will increase the production cost, so many enterprises will leave the market if they will not meet the acceptance of the consumers. To be accepted, to keep them, trust is also an important factor. Business must change some moral attitudes (such as being altruist, paying more attention to environment and social responsibility etc.). All the thoughts and questions are beyond themselves and in strong connection with innovation, with the capability to be renewed.

Serge Latouche (2007) summarized the principles of 'de-growth' in his book 'Petit traité de la décroissance sereine' (in English: Farewell to growth). According to these principles, population growth is not the only cause of environmental problems. The allusion of this hides the ethical and moral questions which need common society action. In the view of Latouche, a revolution in culture and behaviour is need to 'de-growth'. Some of the latest economic trends content to these principles. The necessary steps for 'de-growth' are the following:

- Re-evaluate: in our age the individualist megalomania, a rejection of morality, a liking for comfort, and egoism is agreed and we feel it normal. [47 p. 220] It is necessary to go back to the old 'bourgeois' values of honour, public service, the transmission of knowledge, 'a good job well done', frankness and mutual trust, the respects for human rights, and nature and society. It is necessary to re-evaluate the idea of poor or rich and developing or developed.
- Reconceptualise: 'We must for instance and redefine the concepts of wealth and poverty; deconstructing the infernal couple of scarcity/abundance on which the economic imaginary is based, is a matter of urgency'. [48]
- Restructure: adapt the productive apparatus and social relations to changing values. Make equitable policies in production tools and social sources. For example, some car factories need to be converted to make products for recuperating energy through cogeneration. The question is how much does it cost and who will pay for it.
- Redistribute: it means the redistribution of access of natural heritage at the global, social, generational and individual levels. Direct effects of redistribution weaken the power of 'world consumer class' and especially the power and wealth of the big predators. It helps to solve the problem of distribution between North and South and pay back the earlier ecological debt. Thanks to the redistribution the developed countries can give an example and avoid the resistance of 'North' countries.
- Relocalise: producing on a local basis. Relocalization is an economic, political and cultural issue. Fortunately, there are more and more positive examples for growth of local economies. For example: direct marketing, short supply chains and local service nets. The free movement of ideas are not restricted but it is necessary to minimize the movement of physical resources. All production needs should be carried out at the local level. The 'Think global – Act local' philosophy is equivalent to the relocalize principle.
- Reduce: Reduce our habitual overconsumption and the incredible amount of waste. Think the products which goes together a social demand and artificial enkindle needs. Need to reduce the health risk and the prevention need to be placed in the foreground. Recommended to change the 'mass tourism' to regional travel.
- Re-use: we have to reduce conspicuous waste, fight the built-in obsolescence of appliances and recycle waste that cannot be re-used directly. The Olympic Basketball Stadium in London (2012) is a good example because it was the biggest temporary

building and after the Olympic Games it was dismantled and sub-divided for reuse elsewhere.
- Recycle: recycling is part of our everyday life. There are many good examples of it. For example, the parts refurbishing program for Peugeot. In this program the parts are renewed so that the price of service will be low but the quality is the same. Another example is the waste cloth which made from waste paper. The secondary use of biomass energy is also a good example.

These principles could lead our life to another society where free cooperation and self-imposed rules are not a utopia. Re-evaluation is emphasized because this is the basis for the other seven principles. Co-operation should be exchanged for the competitive methods in the business and everyday life too. Latouche does not use the term 'co-opetion' but his idea is equivalent to this. Egoism needs to be exchanged for altruism, and hedonism needs to be replaced by chivalry. It is necessary to change the aim of our life. The new aim will be the share of assets and not the getting of property. The tone could be on the social links and not on the consumption. To realize 'de-growth' it is very important to reduce consumption, recapture reasonable production and increase free time (and intelligent activities in the free time). According to Latouche, localization is a very important issue. His aim is to spread the ideology of local production and local consumption all over the world. Owing to the limitation, the concept of 'Consume less, share more' is only mentioned, without any discussion.

The main conclusions of the First International Conference on Economic Degrowth for Ecological Sustainability and Social Equity in Paris in 2008 and the so-called Barcelona Conference of 2010 must be added to the question of 'de-growth'. [49-50] T the first event the financial, social, cultural, demographic, environmental crisis caused by the deficiencies of capitalism, and the main principles of 'de-growth' were discussed.

At the second, the main focus was how to implement the 'de-growth' theory in society, in daily life. Some practical solutions are the following (not all are listed): promotion of local currencies, reforms of interest; transition to non-profit and small-scale companies; increase of local commons and support of participative approaches in decision-making; reusing empty housing and co-housing; elimination of mega infrastructures, transition from a car-based system to a more local, biking, walking-based one.

Some suggestions have become practice, such as the solutions of the sharing economy (Uber, Airbnb etc.), local currencies (including Soproni Kékfrankos and Balatoni Korona in Hungary) or the increase of local communities, but the conclusion of the conference after six years is that society has not had a big influence on the responsible economists and politicians.

Other authors, i. e. Fukuyama, Sedlaček highlight the importance of learning the new principles of economic cooperation. [51-52] The basis of cooperation is moral economy instead of benefit economy. [53] Transition from the economy of even more to the economy of enough is of the utmost necessity. The role of cooperation, to share resources, strengthen the market position with concentrated products is an important element of current agriculture and farming. [54-58]

Sustainability – based on the three pillars – means that the use of nowadays resources allows to satisfy the present need at a limited level and will serve for the futures generations. Sustainability does not contradict 'degrowth'. Here, in agriculture we need to produce safe food, to ensure food safety with preserving the earth, environment (soil, water, landscape, biodiversity) at the same time. The connection between the 'degrowth' concept and the use of new, innovative technologies in plant production is the ensured food production with less environment burden, less waste, somehow the strengthening of local production – local consumption.

Conclusion

"*Who wins*?" – the question arose. It can be stated that for all participants of the economy/agriculture and rural territories, the sustainable operation means today: appropriate answers to changes, focusing on the future, finding new solutions, ways to reach and keep the consumers, at a viable farm size. Going back to thought of Latouche, site-specific plant production is a tool to meet the expectations of "de-growth" theory in agriculture.

Food security and safe food are non-separable questions from the climate change, the increasing demand of healthy water. Yes, the questions of food safety, food traceability, environment pollution or the increasing food demand have been discussed from several aspects by – agricultural – economists. In this paper, we tried to highlight the role of new solutions in plant production (i.e. site-specific plant production as innovation), as a potential, good answer to climate change. Based on some ideas coming from Serge Latouche, can be stated that changing the behaviour of farmers, consumers, all participants of food chain ('from farm to table') and of policy makers (governments), humanity is able – and should – to find such solutions – like precision farming – that is in line with the concept of sustainable intensification can contribute to sustainable food system.

We believe that it will not be possible to maintain a sustainable economy without strengthening the rural areas, helping farmers to find successful ways/strategies for being competitive, innovative and to cooperate with each other. Values, attitudes, networks, trust and openness are important to both individual and social utility coincidence that promotes the sustainability of being viable, competitive in wider meaning: future orientation, ability to renew (development, imitation, synthesis), economic/social cooperation.

To reach these goals, all individual farms should operate in an efficient way, that means at least to be of a viable size, so that revenue covers all the costs – including the personal/family income at the average social level – and ensures the necessary investments. By 'viable size', we mean that farming size (at certain production structure and yield level) when the given economic environment allows at least such income to be reached that covers all the production costs, including the necessity investment and ensuring the satisfactory standard of living for the farmer. The basic principle of a real market requires from a farm to reach the viable size without subsidies.

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INVESTIGATION OF EMISSION OF NOx, SO_2 AND CHLORINE BY BIOMASS-BURNING

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Abstract

It is well known that burning biomass is somewhat CO_2 neutral, but it is not widely known that that process is still a serious environment polluting one. For the investigation of the emission of some biomass material such as energy willow, bamboo, energy cane was burnt and the emission of NOx, CO, CO_2, SO_2, and Chlorine were measured and analysed. The results show that the generation and emission of SO_2 observed at the beginning of the burning process, while the chlorine is leaving the fire at the end of the process. The emission of NOx is rather at the middle of the process. The sum of the SO_4^{2-} and the overall chlorine ion are more than those materials in the biomass, indicating that these elements are present in the material in different form.

Keywords: *biomass burning, SO_2, NOx, Chlorine*

1. INTRODUCTION

Nowadays one of the most interesting industrial problems is the application of renewable energies, and within this the usage of biomass in energy production. In many cases there are some misbelieves about the burning of biomass materials especially about the emission of pollutant. It is well known that burning biomass is somewhat CO_2 neutral, but it is not widely known that that process is still a serious environment polluting one. For the investigation of the emission of some biomass materials, such as energy willow, bamboo, energy cane were burnt, and the emission of NOx, SO_2, and Chlorine were measured and analysed. The results show that the generation and emission of SO_2 observed at the beginning of the burning process, while the chlorine is leaving the fire at the end of the process. The emission of NOx is rather at the middle of the process.

The pulsed corona discharge process (PCDP) is an effective method to remove hazardous chemicals from exhaust gases. The unipolar corona discharge is a stable, self-maintaining gas discharge, characterized by low gas temperature, and high electron temperature. During the discharge, the free electrons are accelerated by the electric field, and according to the drift they can lose the energy by inelastic collision. The collision of energetic electrons with gas molecules give the formation of chemically active species to initiate chemical reactions, leading to the removal of gaseous pollutants. [1], [2], [3]

2. EXPERIMENTAL ARRANGEMENT

During the experiments energy cane, bio-briquette, and energy willow were burnt, and the electrostatic decomposition of the produced hazardous exhaust gases was examined by gas analyzer.

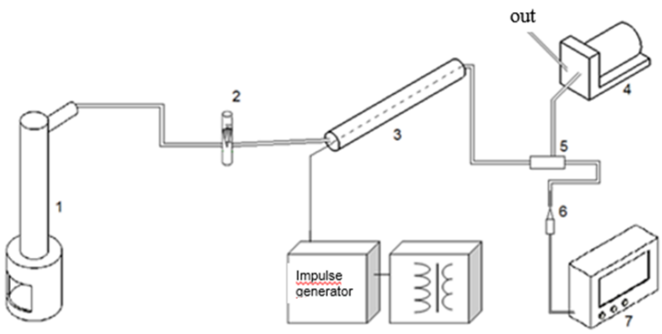

Figure 1 The experimental arrangement
1: owen; 2: flowmeter; 3: reactor; 4: pump; 5: sampler; 6: probe; 7: gas analyzer

The experiments were performed using a cylindrical type reactor, which consists of a grounded steel tube and a tungsten wire of diameter 0.2 mm, placed along its axis. The length of the cell was 120 cm, its diameter was 6 cm.

The high voltage pulses were generated by capacitive circuit (Figure 2) [4]. The pulse capacitor is charged via the charging resistance to direct voltage, and then discharged by rotary spark gap ignition. To achieve the desired impulse voltage, (rise time 50 nsec) the damping resistor was 100

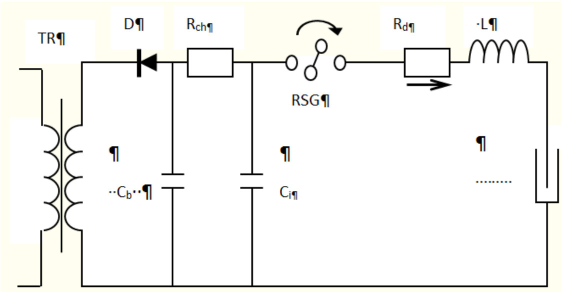

Figure 2 The schematics used to generate fast rising electric pulses
Tr: transformer, D: diode, R_{ch}: charging resistor, R_d: damping resistor, R: reactor, RSG: rotary spark gap, C_b: buffer capacitor, C_i: impulse capacitor, L:inductance

The high voltage pulses were connected to the discharge electrode of the reactor. Because of the high gradient of electric field between the electrodes, a corona discharge is produced at the vicinity of the discharge electrode. If the free electrons gain enough energy from the electric field, they can break the molecular bonds by collision [5],[6],[7]. Figure 3 shows a typical voltage waveform at the discharge electrode.

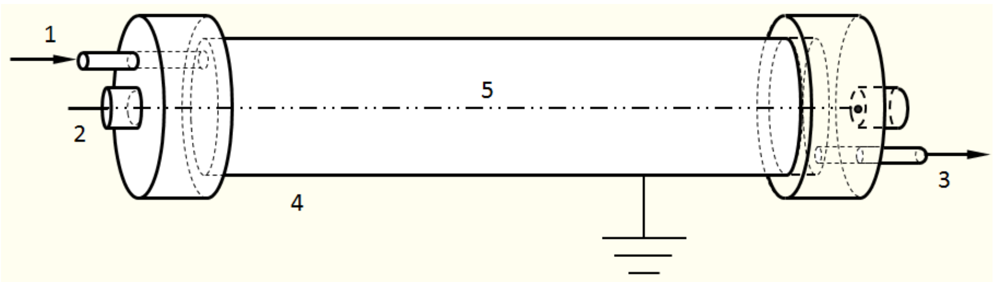

Figure 3 An example of the voltage pulse waveform used

The quantity of the biomass was exactly 100 g in each experiment. The exhaust gas was connected to the reactor through a flowmeter, the purified gas was taken out from the reactor, to the sampler. The concentration of NO, SO_2, Cl_2 components were determined by the ENVIRO 51 gas analyzer, the data were processed by the Envisoft software.

The program recorded the data every 3 seconds, and tabulated them. This was necessary because during the combustion the concentration of the emitted gas mixture was not constant, it changed constantly. By using the table, the concentration-time graphs, were prepared, which are later used for the calculation of the mass of the hazardous gas components.

Several reference measurements were performed in case of off-reactor, in order to calculate the amount of pollutant gas. Finally, the decomposition ratio was calculated as the ratio of the mass of the decomposed gas component and the mass of the total gas component. Since the concentrations were not constant in time, we had to use the mass in the equation.

3. RESULTS

During the measurements the three types of fuels were examined in different points of view. The flow intensity of the exhaust gas was a 100 l/h, the pulse frequency of 100 Hz, the mass of fuel burned was 100 g in each case. The results are presented in each plant in the following graphs.

Energy cane (bamboo)

The decomposition ratio of NO and SO_2 is growing with increasing pulse peak voltage (Figures 4 and 5)

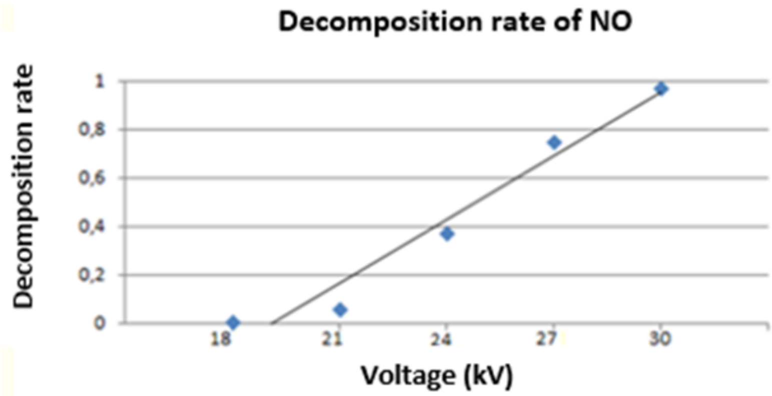

Figure 4 The result of decomposition experiment for NO in the case of energy cane burning

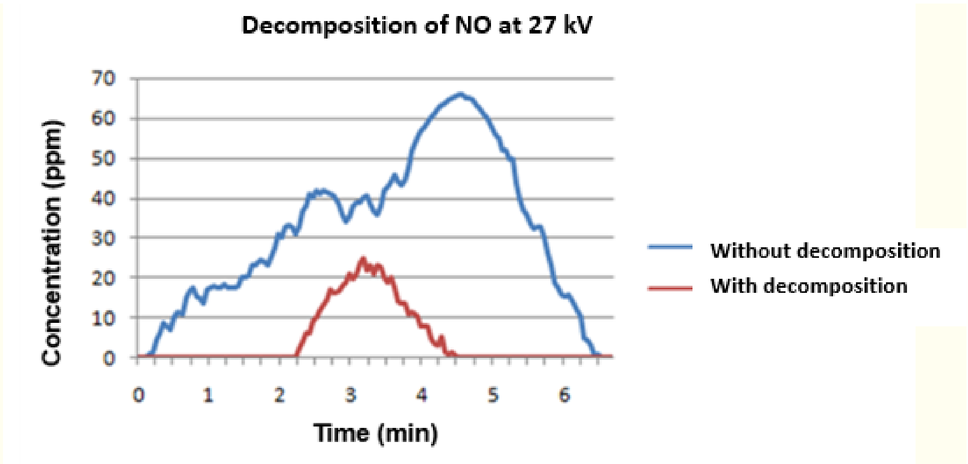

Figure 5 The change of the NO concentration in the case of energy cane

Based on the areas below the graphs, the decomposition ratio can be calculated. In this case the produced NO is 36.84 mg, but only 8.26 mg was released when the PCDP reactor had been operated.

Figure 6 represents the decomposition ratio of SO_2 versus pulse peak voltage.

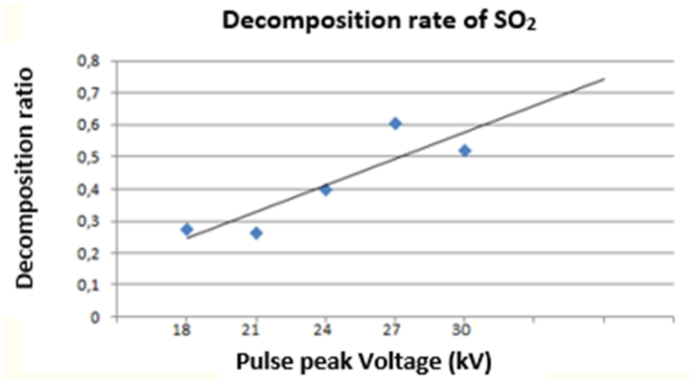

Figure 6 The decomposition ratio of SO_2 versus pulse peak voltage

Figure 7 shows the chlorine concentration in the exhaust gas during the burning of energy cane.

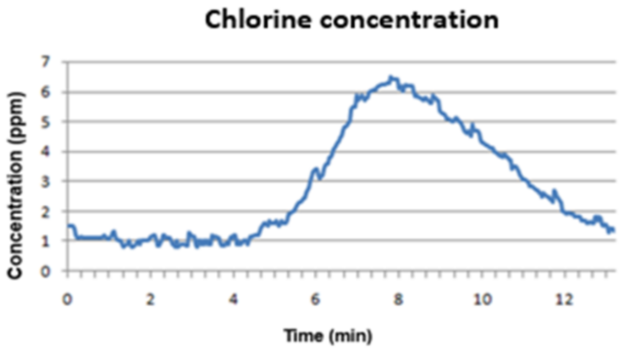

Figure 7 The chlorine concentration versus time

It is clear that its maximum was reached in the second half of the measurement, but the peak value was only 6.5 ppm. A total mass of 7.6 mg of Cl_2 was released during the whole burning.

Energy willow

In case of energy willow the decomposition ratio of NO is also rises with increasing voltage. The results clearly show that the ratio of NO destruction increases with voltage, but the curve is not so steep as in case of energy cane. The measured results show that the destruction ratio changes between 0.3 and 0.7 depending on the voltage. Figure 8 shows the destruction of SO_2 versus time for willow. The decomposition ratio is also growing as expected with increasing voltage. The measuring points are scattered, but the regression straight line indicates relation between the decomposition and the pulse peak, As in case of NO, the results here also varied between 0.3 and 0.72.

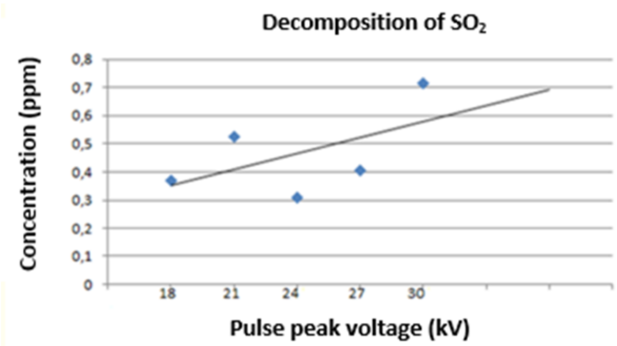

Figure 8 The decomposition ratio of SO_2 versus pulse peak voltage

Biomass-briquette

Biomass briquettes, mostly made of green waste and other organic materials, are commonly used for electricity generation, heat, and cooking fuel. These compressed compounds contain various organic materials, including rice usk, bagasse, ground nut shells, municipal solid waste, and agricultural waste. Environmentally, the use of biomass briquettes produces much fewer greenhouse gases, specifically, 13.8% to 41.7% CO_2 and NO_X. There was also a reduction from 11.1% to 38.5% in SO_2 emissions when compared to coal. The chlorine emission was also examined for biomass briquette; the results are shown in the Figure 9.

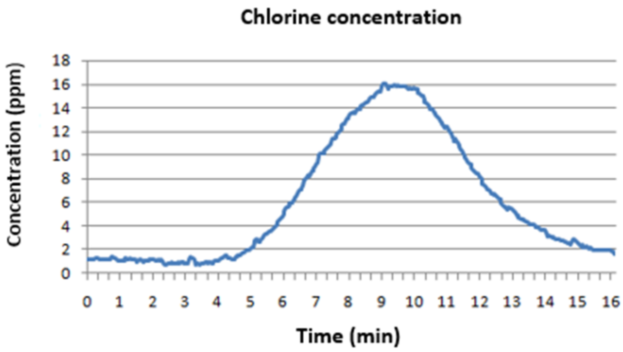

Figure 9 The concentration of emitted chlorine for burning of biomass briquette.

Compared to the chlorine emissions of the briquette to the emissions of the other two energy plants, it is clear that the chlorine concentration peak is the highest in case of briquette. It is 16 ppm, which is almost twice as much as for willow. All chlorine emissions were also the highest, 19.87 mg.

The temperature in the combustion chamber was also measured as a function of time. Figure 10 shows these data.

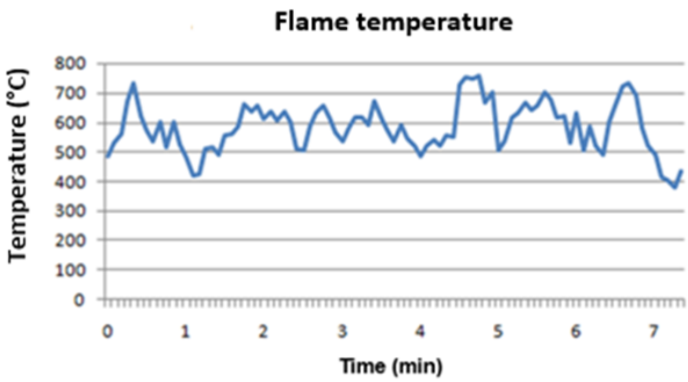

Figure 10 The temperature in the combustion chamber of the owen vs. time

During the combustion, the temperature has been irregularly changed between 400 and 750°C. The NO gas appears at the temperature of 800°C during combustion, so if the material is heated at a higher temperature, than probably much more NO would have been generated in the flue gas.

Determination of the quantity of chloride and sulfate ion in the dry matter

Other measurements were also made to detect the harmful content of plants. Before and after the combustion, the chloride ion and sulphate ion content were determined (Figures 11, 12). The chloride content was measured by photometer and the sulphate content by wet mass determination.

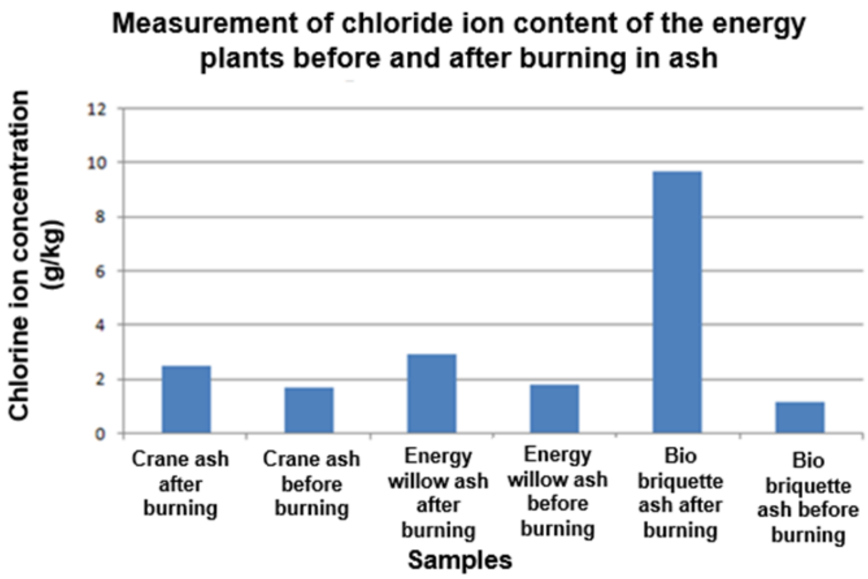

Figure 11 The chloride ion content of different plants before and after burning

The Figure shows clearly, that the burned ash of the biomass briquette contained the highest concentration of chlorine; this concentration was lowest before combustion.

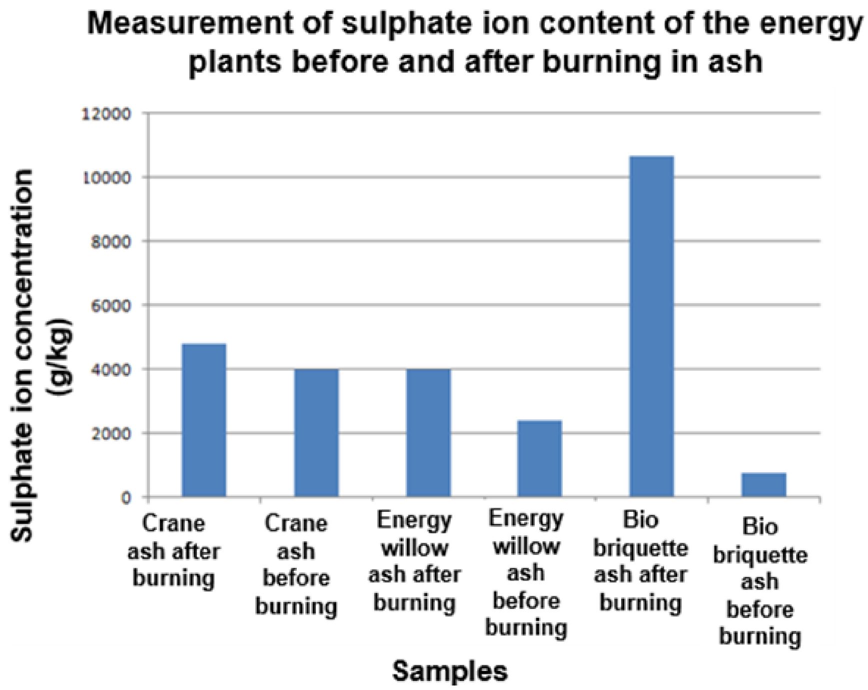

Figure 12 The sulphate-ion content of different plants before and after burning

The concentration of sulphate ion in plants is similar to that of chloride ions. Here the concentration of sulphate ion is the highest in the in the ashes of the burned bio-briquette and also in the pre-combustion bio-briquette.

Conclusion

Our measurements show and the related literature also reveals that the energy plants contain a significant amount of sulfur and chlorine. This is mentioned in the literature, but unfortunately it does not known in public. People did not realize that the burning of energy plants is also pollute the environment, and apart from the NO, sulfur dioxide and chlorine are released into the air. Nitrogen oxide appears at each combustion because in the presence of oxygen, and the nitrogen is oxidized in the air. The photometric measurement showed that, post-combustion ash has a higher concentration of chloride than before combustion at each plant. There are several reasons for this. It is obvious that, 80-90% of the material was removed during the combustion, and a significant amount of chlorine remained in the ash, so concentrations increased. In case of determining the sulfate ion, the concentration in the ash is higher after combustion than before. The explanation is the same, sulfur was in a form that could not be detected by the available methods.

However, it is not necessary to give up the use of energy plant, there is a technology to decompose these air pollutant gases, to purify the flue gas generated by combustion. By using the pulsed corona discharge technology, 70-99% of the resulting nitrogen oxide and 50-70% of the sulfur dioxide can be decomposed so that air pollution can be significantly reduced. According to our results, the efficiency of the method increases with increasing peak voltage of the corona pulses, so the appropriate reactor can be designed and dimensioned for combustion of energy plants. This technology can be used not only for domestic heating system, but also in the energy industry and the exhaust gas of thermal power plants can be efficiently cleaned.

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ANALYSIS OF THE WORKING FACTORS IN „MAN – MACHINE – ENVIRONMENT" SYSTEM

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Abstract

In the research literature, the work environment is often characterized as a physical, chemical, biological, social and cultural complex of factors that affect an employee at workplace. The work environment is part of the „man-machine-environment" system. In this system, „man" refers to a person as the subject in the workplace (e.g. operators, decision-makers), „machine" is the general name for any object controlled by man (e.g. tools, machines, computers), and „environment" describes the specific working conditions under which man and machine interact (e.g. temperature, noise, vibration, lighting, radiation, chemicals, hazardous gases etc.). Environment creates a wider or narrower set of factors which are affecting this system. The goal of this whole system is to create optimum conditions to achieve required results. The three main goals of optimization are to ensure safety, high efficiency and economy of „man-machine-environment" system. From the point of view of problem solving in this system the physical factors are very important and may represent a significant risk for employees. These factors affect the human senses, burden the nervous system and can negatively affect to overall health and cause stress. Factors can be external (from the environment, psychological, or social situations) or internal (illness). Examination and assessment of working conditions from the point of view of their impact on employees is challenging, time-consuming and it is essential to do it regularly in order to achieve reliable results. By comparing the results from previous and current assessments, it is possible to capture developmental tendency, identify progress or regress and subsequently decide on the next steps.

Keywords*: workplace, environment, working factors, productivity, employee*

1. INTRODUCTION

Humans spend in average 33 percent of their lifetime in the workplace. It is safe to say that job has a huge impact on quality of life whether positive or negative. The topic of negative impact of environmental hazards in workplace is more and more used in experts discussions as the time goes by. Employers can no longer underestimate this topic and must realize that it is necessary to ensure comfort and safety at workplace for the benefit of the whole organization [1]. Creating clean and healthy workplace environment with modern technical equipment is very important and it is not a low-cost matter for the employer. Many researches, projects and analyzes are focused on this topic due to its importance. The workplace must meet the required conditions which are set out in the legislation. Safety at the workplace can reduce numbers and possibilities of accidents and health issues of employees and improve business productivity. The creating of a suitable work environment enhances the ability of employees to become more productive. Interpersonal relationships and the relationships between work environment factors and workers are playing more dominant role in the overall job satisfaction and at workers performance [2].

Physical and mental health, motivation, well training of employees along with workplace conditions reflects on product quality and productivity of employees. About 116 thousand people in Slovakia have a risky job that can have serious impact on their life, these people have the highest chance to have workplace accidents and suffer from occupational diseases. An average of 600 employees in Slovakia suffers from occupational diseases per year. Excessive noise, high dustiness and chemical hazards are the one of the most common causes of these diseases. Up to 88 thousand people worked in excessively loud conditions in 2015. It is estimated that one third of European employees (more than 60 million people) are exposed to high levels of noise for more than a quarter time of their workday [3].

General duty of employers is to ensure the health and safety of employees in all aspects and to carry out a risk assessments. The EU framework directive emphasizes the crucial importance of the risk assessment and sets out the essential provisions for employers.

2. WORK ENVIRONMENT QUALITY

Work environment is one of the most important factors in recruiting and retaining employees. It should create sense of safety and comfort so it can help to improve employees performance, reduce occurrence of human errors, work incapacity and occupational diseases. Achieving the right balance to satisfy everybody is not easy. It is important to realize, that employees are integral part of the workplace and they help to create work environment and can change or affect it with their behaviour [4].

The safety and health management systems are essential for business sustainability and the success of the company. Nowadays a strong emphasis is placed on modernization but aesthetics and practicality also should not be forgotten. With the knowledge of many external and internal factors of the work environment that directly affect the performance of the employee, requirements for creating a suitable workplace are increasing [5].

Only employees who are satisfied with the work and social conditions at the workplace can perform high-quality work. The level of employee satisfaction therefore impacts on the efficiency of their work, but also on their stability. In the context of the improvement of the working environment, it is recommended that the management of companies implement tools for improving and adjusting work environment with regard to quality.

Even such details as seamless and neat entrance to the building, reception appearance, lift quality and speed, look and equipment of common spaces, amount of parking places, it all create corporate image [6]. The first impression of entering the company is very important. Therefore the interior spaces should reflect the purpose the company management wants to achieve. The quality of the work environment is also influenced by a number of partial aspects such as superiors, co-workers, colleagues, clients, etc., Figure 1.

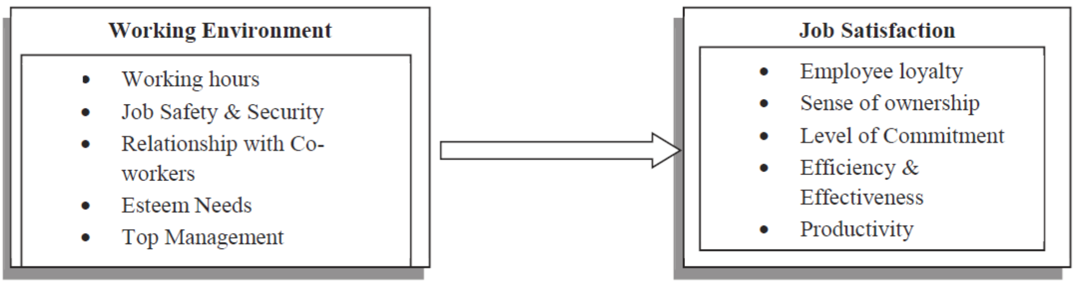

Figure 1. Work environment factors and job satisfaction

People stays indoors for most of their life approximately 70-80%, it is safe to say that design of workplace interior has significant effect on life quality. Some authors say that the loss of aesthetic sensation is closely related to a loss of ethical perception [7].

Creating and obeying work ethics is closely related to the transformation and adaptation of the work environment to provide a sense of safety and comfort. The benefit of providing a good working environment to the employees is significant for both the organization and its employees.

The perception of workplace environment is subjective; it depends on an individual's emotional state, his nature, aesthetic feeling and needs. Employee may perceive the work environment positively or negatively and it is important factor for job satisfaction. According to human resources research, up to 42% of the interviewees decided to leave their jobs because of unpleasant and unsuitable conditions at the workplace. It is known that most of the people would prefer a comfortable work environment before higher salary. Clean, comfortable and aesthetic environment is a basic condition for human health and development. Organization and composition of the workplace environment in last decades has radically changed and this trend will continue. Major challenge will be to reduce monotonous tasks and time pressure because of their negative health impacts. Other stressful factors are fear of job loss, lack of appreciation or bullying. The 33% of male and 22% of female respondents said their health or safety is at risk due to their job [8].

3. „MAN-MACHINE-ENVIRONMENT" SYSTEM

All three parts of the system are equally important and influence each other, and therefore it is necessary to look at them as a whole and pay enough attention to every single one of them. In the literature, the work environment is often characterized as a set of physical, chemical, biological, social and cultural factors that may affect a person at workplace, Figure 2.

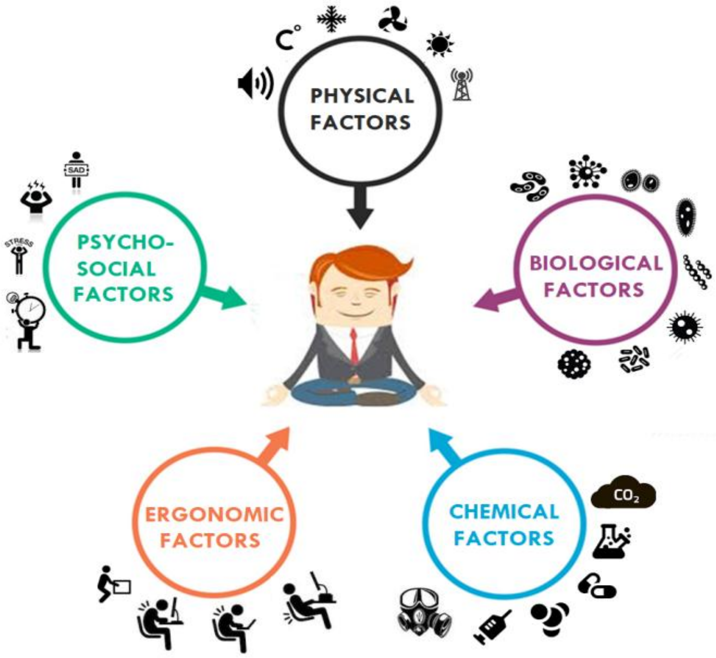

Figure 2. Men and influence of factors at workplace

Many work environmental factors influence the human capability and ability to perform physical work:

- Physical factors (noise, climate, lighting, vibrations)
- Biological factors (viruses, bacteria)
- Chemical factors (dustiness, toxicity)
- Psychosocial factors (workplace relationships)
- Ergonomic factors (body position)

Their negative impact depends on their intensity, duration and frequency. The most frequent factors of the working environment are noise, vibration, lighting, climatic conditions, radiation and chemicals.

4. STRESS AND EXHAUSTION

According to official statistics, more than every fourth employee in the EU is experiencing work-related stress [9]. Stress is a physical, mental, or emotional factor that causes bodily or mental tension and it can have negative impact on work performance. Job stress and job satisfaction are important factors affecting workforce productivity [10].

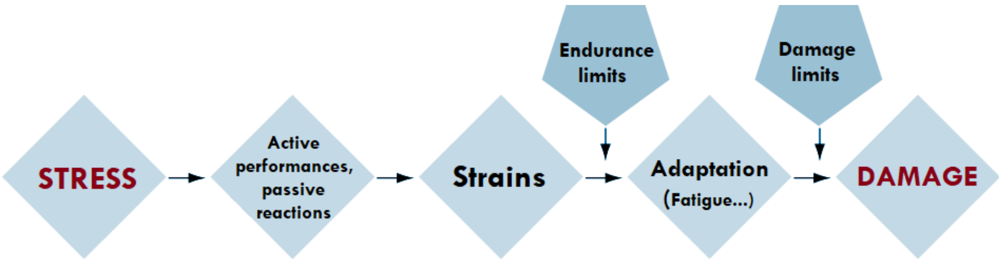

Figure 3. Stress development

The level of stress is directly proportional to the difficulty of the work task, the negative impact of work environment factors and workplace conditions. The presence of stress leads to unwanted burden of employee and its intensity depends on concentration, duration and composition of stress factors. This combined stress can be managed actively or passively, it depends on the behaviour and character of the individual. The active case will include activities to improve conditions at workplace and eliminate causes of stress, while in the passive case stress effects will be managed by natural body response. The ability of stress resistance depends on various factors, for example employee motivation, concentration, mental and physical health, character traits etc.

Conclusion

Examination and assessment of working conditions from the point of view of their impact on employees is challenging, time-consuming and it is essential to do it regularly (in certain cycles, e.g. annually) in order to achieve reliable results. By comparing the results from previous and current assessments, it is possible to capture developmental tendency, identify progress or regress and subsequently decide on the next steps which will help to ensure continuous improvement, achieve business objectives and customer satisfaction. If the implementations of work environment factors assessment and protection against its negative influence become an enterprise's rule and an integral part of the occupational health and safety management system, it can represent the one of the pillars for successful business. Public opinion surveys may be useful in detecting and eliminating potential work environment risks for employees in different sectors. These surveys also help to understand the differences between opinions and needs of people in different age, gender, level of education, profession etc. and to create optimal conditions which will also meet the legislative requirements.

Work environment has a positive impact on job satisfaction of employees. Bad conditions at work limit the employees from using their capabilities and reaching their full potential. This paper may contribute to the awareness of the importance of a positive work environment for the company's success. Optimization of the work conditions can help to increase the motivation of employees and their commitment level towards management. This will reflect on the productivity, quality and profitability. It also ensures that employees of the organization will have easy work in a relaxed environment without the burden or pressure that would cause them stress. Progress in business will directly help the country's economy as productivity increases. The benefits of providing a positive work environment for employees are significant for both the organization and its employees.

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THE EFFECTIVENESS OF PLANT COVER IN REDUCING EROSION OF STEEP SLOPES AND ITS USE FOR RECULTIVATION OF MINING WASTE DUMPS

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Abstract
By a conceptual model it is evaluated, how and in which relative extent the vegetation reduces the surface layer erosion under rainwater. In consideration of the Hungarian climatic conditions, two mechanisms are taken into account: 1. the striking and splashing effect of raindrops (the soil structure breaks apart to small particles, and these are subsequently moved airborne downslope), 2. sheet erosion (the rainwater moves down the hill and carries small pieces of soil with it). The model provides a mathematical expression for the soil volume eroded per unit time. The vegetation diminishes the erosion through 4 different parameters in this expression: α: the plants retain this proportion of rainfall, therefore it cannot cause erosion, z: friction coefficient (roughness) by which the vegetation increases the friction work of flowing water, hereby reducing the available energy for the erosion, σ: specific erosion work, which is increased by the plants because their roots, rhizomes and stolons hold together the soil against external forces, b_1*: specific splash erosion is diminished by the plants because their shoots and leaves reduce the raindrops' kinetic energy. According to these parameters, four indices are introduced and their 5 scale evaluation for 475 vascular plant species (with regard to their growth forms) is attempted. The results could help to select species and assemble plant communities for recultivation purposes.*
Keywords*: erosion, vegetation, model, indicator, recultivation*

1. INTRODUCTION

The environmental impacts of mining within the confines of Pécs (Hungary) were examined by Lehmann [1]. Morphological, microclimatic, hydrologic, pedologic and botanical modifications were distinguished. The most adverse states of ground were revealed on steep slopes of mine walls and waste dumps, because of the intense surface as well as linear soil erosion and extreme microclimatic conditions. The aim of present study is to evaluate by a conceptual model, how and in which relative extent the vegetation reduces the surface layer erosion under rainwater.

2. MATERIALS AND METHODS

In the course of surface layer erosion nearly uniform carrying down of soil happens, or at most a shallow network of water-courses is formed. It is produced by several partial processes.

Micro-solifluction: a thin layer of the fluid (pulpy) soil surface moves down the slope toward the local erosion basis, at a significant area [2]. In Hungary this happens only at the most rainy regions, and can be entirely prevented by perennial vegetation, therefore it is not treated here in detail.

The striking and splashing effect of raindrops (in the beginning, the dry soil granules burst into small particles, then the pulpy soil surface splashes, and resulting particles are subsequently moved airborne downslope).

The sheet erosion: the rainwater moves down the hill and, due to its kinetic energy, carries small pieces of the sloppy soil toward the local erosion basis).

As only the surface downslope flowing water can cause sheet erosion, first of all the local water balance will be studied. A mathematical model taking into account these processes is presented. It provides an expression for the soil volume eroded per unit time.

For the evaluation of plant species by virtue of this model, data pertinent to growth forms in [3-5], besides the author's own observations are used.

3. RESULTS AND DISCUSSION

The model

As only the surface downslope flowing water can cause sheet erosion, first of all the local water balance will be studied.

From the perspective of downslope flowing part (w) of rainfall at unit surface and unit time, the following components are taken into account:

P: rainfall at horizontal surface unit at unit time

α: the proportion of rainfall retained by the vegetation,

Q: rainfall infiltrating into soil at t time. It is given by an empirical formula [6]:

$$Q = S \cdot \sqrt{t} + A \cdot t \qquad (1)$$

Its time derivative is needed for the water balance equation. Taking all described above into account,

$$w = \left(P \cdot [1-\alpha] - \frac{S}{2 \cdot \sqrt{t}} - A \right) \cdot \cos\beta \qquad (2)$$

where β is the angle of the slop. The expression is valid for time

$$t > \frac{S^2}{4[P \cdot (1-\alpha) - A]^2}$$

and

$$P \cdot (1-\alpha) > A,$$

otherwise w = 0 (the full rainfall infiltrates).

Further notations:

l : distance from the slope top downward,

d : width of the slope,

S,A : proportion factors of the empirical infiltration formula (1),

ρ_v : water density,

ρ_h : density of the slope substance,

g : gravitational acceleration

σ : specific work of erosion

μ : specific work of drift transport

z : proportion factor of drag

E : energy for the striking and splashing effect of raindrops

γ_0 : proportion factor of resistance of water sheet against the striking raindrop

B : volume of eroded substance at unit time

b : specific soil erosion (ablated substance at unit surface and time)

b_0 : specific erosion by washing out,

b_1 : specific raindrop erosion at the slope top.

The supposed relationship between the last three quantities:

$$b(l) = b_0 + b_1 \cdot e^{-\gamma \cdot \sqrt[3]{l}} \tag{3}$$

This can be seen by taking into account that the raindrop can only reach the slope surface lower down through the water sheet flowing downslope. Upon the raindrop moving by speed v, a drag proportional to v^2 acts, therefore

$$\frac{dv}{dt} = -\frac{\gamma_0}{2} \cdot v^2 \tag{4}$$

Solving this differential equation,

$$v = \frac{2 \cdot v_0}{\gamma_0 \cdot v_0 \cdot t + 2} \tag{5}$$

where v_0 is the speed of the raindrop when it reaches the surface of water sheet. The expression shows how the drop speed depends on the time underway in the water sheet. Integrating this expression we obtain the path traversed by the drop as

a function of time. The inverse function gives the time span needed to cross the water sheet of width h:

$$t_1 = \frac{2}{\gamma_0 \cdot v_0} \cdot \left(e^{\frac{\gamma_0 \cdot h}{2}} - 1 \right) \tag{6}$$

The kinetic energy of drop is diminished by the work against drag. The energy remaining for the raindrop erosion:

$$E = \frac{1}{2} \cdot m \cdot v_{0^2} - \int_0^{t_1} \frac{1}{2} \cdot m \cdot v^2 \cdot \gamma_0 \cdot v \cdot dt \tag{7}$$

Substituting (5) for v and performing the integration

$$E = \frac{1}{2} \cdot m \cdot v_0^2 \cdot e^{-\gamma_0 \cdot h} \tag{8}$$

that is the energy for the raindrop erosion decreases exponentially with the width h of water sheet. However the latter changes with distance on the slope, because the quantity of water flowing through the cross-section accumulates downslope,

$$h = \frac{w \cdot l}{u} \tag{9}$$

but the u flow velocity also changes. Water is a Newtonian viscous fluid [7] in present cases of interest, so

$$\frac{du}{dz} = \frac{\rho_v \cdot g \cdot \sin\beta}{\eta}(h-z) \tag{10}$$

where z is the distance perpendicular to the slope, and η is the coefficient of viscosity. Taking into account the no-slip condition we obtain after integration

$$u = \frac{\rho_v \cdot g \cdot \sin\beta}{\eta}\frac{h^2}{2} \tag{11}$$

and putting this into (9) provides the expression for width h of water sheet as a function of distance l on the slope:

$$h = \sqrt[3]{\frac{2 \cdot w \cdot l \cdot \eta}{\rho_v \cdot g \cdot \sin\beta}} \tag{12}$$

So the drop erosion as a function of distance:

$$cs(l) = b_1 \cdot e^{-\gamma \cdot \sqrt[3]{l}} \tag{13}$$

where

$$\gamma = \gamma_0 \cdot \sqrt[3]{\frac{2\eta \cdot tg\beta}{\rho_v \cdot g}\left(P \cdot [1-\alpha] - \frac{S}{2 \cdot \sqrt{t}} - A\right)} \tag{14}$$

(13) provides the second term in equation (3). The volume of eroded substance at unit time, on the slope of length l and width d

$$B = d \cdot \int_0^l b(x)dx = b_0 \cdot d \cdot l + \frac{3b_1 \cdot d}{\gamma^3} \cdot \left[2 - e^{-\gamma \cdot \sqrt[3]{l}}\left(\gamma^2 \cdot \sqrt[3]{l^2} + \gamma \cdot \sqrt[3]{l} + 2\right)\right] \tag{15}$$

According to (11) and (12) the flow velocity as a function of distance on the slope

$$u(l) = C \cdot \sqrt[3]{l^2} \tag{16}$$

where

$$C = \sqrt[3]{\frac{\rho_v \cdot g \cdot \sin\beta \cdot w^2}{2\eta}} \tag{17}$$

The quantity of water flowing at unit time on a slope of length l and width d is $w \cdot l \cdot d$. So, considering also (12), its potential energy changes at unit time by

$$\int_o^l \rho_v \cdot w \cdot d \cdot g \cdot \sin\beta \cdot C \cdot \sqrt[3]{x^2}dx = \frac{3}{5}D \cdot \sqrt[3]{l^5} \tag{18}$$

where

$$D = \rho_v \cdot g \cdot w \cdot d \cdot \sqrt[3]{\frac{\rho_v \cdot g \cdot \sin^2\beta \cdot w^2}{2\eta}} \tag{19}$$

The erosion power of flowing water:

$$\sigma \cdot b_0 \cdot l \cdot d \tag{20}$$

The drift power

$$\int_0^l \mu \cdot b(x) \cdot d \cdot \rho_h \cdot g \cdot u(x) dx = \int_0^l \mu \cdot d \cdot \rho_h \cdot g \cdot C \cdot (b_0 + b_1 \cdot e^{-\gamma \cdot \sqrt[3]{x}}) \cdot \sqrt[3]{x^2} dx =$$
$$\mu \cdot d \cdot \rho_h \cdot g \cdot C \cdot \left(\frac{3b_0}{5} l \cdot \sqrt[3]{l^2} + b_1 \cdot I_2 \right) \quad (21)$$

where

$$I_2 = \frac{72}{\gamma^5} - \left(\frac{3}{\gamma} \sqrt[3]{l^4} + \frac{12}{\gamma^4} l + \frac{36}{\gamma^3} \sqrt[3]{l^2} + \frac{72}{\gamma^4} \right) e^{-\gamma \sqrt[3]{l}} \quad (22)$$

The drag (e.g. [8]) power:

$$\int_0^l \frac{1}{2} \cdot \rho_v \cdot u^3 \cdot d \cdot z dx = \int_0^l \frac{1}{2} \cdot \rho_v \cdot C^3 \cdot z \cdot d \cdot x^2 dx = \frac{1}{6} \cdot \rho_v \cdot C^3 \cdot z \cdot d \cdot l^3 \quad (23)$$

The energy balance equation based on (10-13) relating to unit time:

$$\frac{3}{5} D \cdot \sqrt[3]{l^5} =$$
$$\sigma \cdot b_0 \cdot l \cdot d + \mu \cdot d \cdot \rho_h \cdot g \cdot C \cdot \left(\frac{3b_0}{5} l \cdot \sqrt[3]{l^2} + b_1 \cdot I_2 \right) + \frac{1}{6} \cdot \rho_v \cdot C^3 \cdot z \cdot l^3 \cdot d \quad (24)$$

from which

$$b_0 = \frac{\frac{3}{5} D \cdot \sqrt[3]{l^5} - \mu \cdot d \cdot \rho_h \cdot g \cdot C \cdot b_1 \cdot I_2 - \frac{1}{6} \cdot \rho_v \cdot C^3 \cdot z \cdot l^3 \cdot d}{\sigma \cdot l \cdot d + \mu \cdot d \cdot \rho_h \cdot g \cdot C \cdot \frac{3}{5} l \cdot \sqrt[3]{l^2}} \quad (25)$$

Substituting into (11) and using (2) we obtain the following expression for the volume of eroded substance at unit time, on the slope of length l and width d:

$$B = \frac{\frac{3}{5} D \cdot \sqrt[3]{l^5} - \mu \cdot d \cdot \rho_h \cdot g \cdot C \cdot b_1 \cdot I_2 - \frac{1}{6} \cdot \rho_v \cdot C^3 \cdot z \cdot l^3 \cdot d}{\sigma \cdot l \cdot d + \mu \cdot d \cdot \rho_h \cdot g \cdot C \cdot \frac{3}{5} l \cdot \sqrt[3]{l^2}} \cdot d \cdot l +$$
$$\frac{3b_1 \cdot d}{\gamma^3} \cdot \left[2 - e^{-\gamma \sqrt[3]{l}} \left(\gamma^2 \cdot \sqrt[3]{l^2} + \gamma \cdot \sqrt[3]{l} + 2 \right) \right] \quad (26)$$

where

$$\gamma = \gamma_0 \cdot \sqrt[3]{\frac{2\eta \cdot w \cdot \sin\beta}{\rho_v \cdot g}}$$
$$C = \sqrt[3]{\frac{\rho_v \cdot g \cdot \sin\beta \cdot w^2}{2\eta}}$$

$$D = \rho_v \cdot g \cdot w \cdot d \cdot \sqrt[3]{\frac{\rho_v \cdot g \cdot \sin^2 \beta \cdot w^2}{2\eta}}$$

$$w = \left(P \cdot [1-\alpha] - \frac{S}{2 \cdot \sqrt{t}} - A \right) \cdot \cos\beta$$

The term $\frac{S}{2 \cdot \sqrt{t}}$ may be important only for a relatively short time, thus usually can be neglected for long rainfalls.

According to this model, the vegetation diminishes the erosion through 4 different parameters in expression (26): α: the plants retain this proportion of rainfall, therefore it cannot cause erosion, *z:* friction coefficient (roughness) by which the vegetation increases the friction work of flowing water, hereby reducing the available energy for the erosion, σ: specific erosion work, which is increased by the plants because their roots, rhizomes and stolons hold together the soil against external forces, b_1: specific splash erosion is diminished by the plants because their shoots and leaves reduce the raindrops' kinetic energy.

Evaluation of some plant species according to the model parameters

According to these parameters, four indices are introduced and their 5 scale evaluation for 475 vascular plant species (with regard to their growth forms) is attempted. In the followings, the evaluation of 474 vascular plant species (with regard to their growth forms) is attempted. Of course, the exact quantitative effect of vegetation on the parameters α, z, σ and b_1 could be elucidate only by experiments.

However, the plant's growth form, morphologic, habit features and position, role in the vegetation make it possible to find out some supposed orders in respect of the effect on the parameters in question. For sake of simplicity, this effects will be evaluated at a 5 grade scale (1: small, 2: slight, 3: medium, 4: strong, 5: excellent).

In regard of the index IA, the effect on α parameter (ability to retain rainfall), first of all species with dense foliage and shoot system, able to prostrate on soil, for example densely tufted species are efficient. Their connected plant cover carries off a part of the rainfall at its own surface without touching the slope soil. When the precipitation is plentiful, some part of the retained amount gradually falls on the soil. In forests, an unbroken forest litter renders additional protection in such cases.

The index IZ refers to parameter z (roughness). Chiefly, dense growing species are important in this regard. These exert namely considerable drag on the flowing water.

IS indicates the enhancing of parameter *σ* (specific erosion work). It is greater for plant species developing dense, ramifying, powerful root system and/or subterranean shoot system near the surface, exerting intense resistance against forces of erosion.

The ability to diminish parameter b_1 (specific splash erosion) is taken into account by index IB. In particular, species with great leaf, dense foliage, and ramifying shoot system put a stay upon movement of the falling raindrops. These structures are more efficient, if they are placed rather low, because the raindrops can accelerate between them and the soil surface. Therefore, all other things being equal, a lower tree is more favourable than a long-boled tree.

The results of evaluation of plant species in the abovementioned respects are contained in Table 1.

The last column (*Σ*) contains an integrated evaluation of a certain kind. This is valid only if the indices are taken into account with equal weights, and should be treated with reservations. Of course, departures are possible, depending on the concrete field situation.

Table 1: Five scale species indices IA, IZ, IS, IB and Σ

Species	IA	IZ	IS	IB	Σ
Acer campestre*	3	2	5	3	3
Acer tataricum*	2	2	3	4	3
Achillea collina	1	2	3	2	2
Achillea pannonica	1	2	3	2	2
Achillea setacea	1	2	2	2	2
Acinos arvensis	1	4	4	2	3
Aconitum anthora	1	1	3	3	2
Adonis vernalis	1	2	4	2	2
Agrimonia eupatoria	1	3	2	3	3
Agropyron repens	2	2	3	3	2
Agrostis capillaris	1	2	3	3	2
Ailanthus altissima	1	1	5	3	2
Aira caryophyllea	1	3	3	2	2
Ajuga genevensis	1	3	3	2	2
Ajuga reptans	1	2	4	2	2
Alcea biennis	1	1	3	3	2
Allium flavum	1	1	1	1	1
Allium oleraceum	1	1	1	1	1
Allium scorodoprasum	1	1	1	1	1
Allium sphaerocephalon	1	1	1	1	1
Allium vineale	1	1	1	1	1
Althaea cannabina	1	3	3	3	2
Althaea hirsuta	1	2	2	2	2
Alyssum alyssoides	1	1	3	1	1
Alyssum montanum	1	2	3	2	2
Alyssum turkestanicum	1	1	3	1	1
Amaranthus patulus	1	1	2	3	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Amorpha fruticosa	1	4	5	4	3
Ambrosia artemisiifolia	1	1	3	2	2
Anacamptis pyramidalis	1	1	1	1	1
Anemone sylvestris	1	3	3	3	2
Anchusa barrelieri	1	2	3	2	2
Anchusa italica	1	2	3	3	2
Anchusa officinalis	1	1	2	3	2
Androsace maxima	1	2	1	1	1
Anthemis tinctoria	1	2	3	2	2
Anthericum ramosum	1	2	2	2	2
Anthoxanthum odoratum	2	3	5	2	3
Anthyllis vulneraria	1	3	1	3	2
Arabidopsis thaliana	1	1	2	1	1
Arabis auriculata	1	1	2	1	1
Arabis glabra	1	2	2	2	2
Arabis hirsuta	1	2	3	2	2
Arabis turrita	1	2	3	2	2
Arenaria leptoclados	1	2	2	1	1
Arenaria serpyllifolia	1	2	2	1	1
Arrhenatherum elatius	1	2	3	3	2
Artemisia campestris	1	4	3	2	2
Artemisia scoparia	1	1	2	2	1
Artemisia vulgaris	1	1	3	2	2
Asperula cynanchica	1	4	5	2	3
Asplenium adianthum-nigrum	1	3	4	2	2
Asplenium javorkeanum	1	3	5	3	3

Asplenium ruta-muraria	1	3	4	2	2
Asplenium trichomanes	1	3	4	2	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Asplenium viride	1	3	4	2	2
Aster amellus	1	2	3	2	2
Aster linosyris	1	1	3	1	1
Astragalus austriacus	1	2	2	2	2
Astragalus cicer	1	3	3	3	2
Astragalus onobrychis	1	3	2	3	2
Atriplex sagittata	1	1	2	3	2
Berberis vulgaris	1	2	5	5	3
Betonica officinalis	2	5	3	3	3
Berteroa incana	1	1	2	2	1
Betula pendula*	1	1	3	2	2
Bombycilaena erecta	1	2	1	1	1
Botriochloa ischaemum	2	3	4	3	3
Brachypodium rupestre	3	2	3	4	3
Brassica elongata	1	2	2	2	2
Brassica nigra	1	2	2	2	2
Briza media	3	5	5	1	3
Bromus erectus	1	4	4	3	3
Bromus inermis	1	2	2	3	2
Bromus hordaceus	1	2	2	2	2
Bromus japonicus	1	2	2	2	2
Bromus secalinus	1	2	2	3	2
Bromus squarrosus	1	2	2	2	2
Bromus tectorum	1	2	3	3	2
Buglossoides purpureo-coerulea	1	3	3	3	2
Bupleurum affine	1	1	1	1	1
Bupleurum falcatum	1	2	2	3	2
Bupleurum praealtum	1	1	1	2	1
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Calamagrostis epigeios	3	3	3	4	3
Calepina irregularis	1	2	1	2	1
Camelina microcarpa	1	1	2	1	1
Campanula bononiensis	1	1	3	3	2
Campanula cervicaria	1	1	3	3	2
Campanula glomerata	1	1	2	3	2
Campanula rapunculus	1	1	2	2	1
Campanula rotundifolia	1	3	4	2	2
Campanula sibirica	1	2	2	2	2
Capsella bursa-pastoris	1	2	1	1	1
Cardaminopsis arenosa	1	2	3	2	2
Carduus acanthoides	1	2	2	2	2
Carex caryophyllea	2	5	4	2	3
Carex divulsa	1	3	3	3	2
Carex flacca	1	2	3	3	2
Carex hirta	1	2	3	3	2
Carex humilis	3	4	5	3	4
Carex montana	3	4	5	3	4
Carex muricata	1	3	3	3	2
Carex praecox	1	2	3	2	2
Carex tomentosa	1	1	3	2	2
Carpinus betulus*	5	4	5	5	5
Carthamus lanatus	1	1	2	2	1
Carlina vulgaris	1	2	2	2	2
Centaurea biebersteinii	1	2	2	2	2

Centaurea jacea	1	2	2	3	2
Centaurea pannonica	1	2	2	3	2
Centaurea sadleriana	1	2	1	3	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Centaurea scabiosa	1	2	1	3	2
Centaurea spinulosa	1	2	1	3	2
Centaurea triumfettii	1	2	2	3	2
Cephalaria transsylvanica	1	2	3	3	2
Cerastium brachypetalum	1	1	2	1	1
Cerastium fontanum	1	3	3	2	2
Cerastium glomeratum	1	1	2	1	1
Cerastium pumilum	1	1	2	1	1
Cerastium semidecandrum	1	1	2	1	1
Cerinthe minor	1	2	2	2	2
Chamaecytisus austriacus	1	3	3	3	2
Chamaecytisus ratisbonensis	1	3	3	3	2
Chamaecytisus supinus	1	3	3	3	2
Chenopodium opulifolium	1	2	2	2	2
Chondrilla juncea	1	2	1	2	1
Cirsium pannonicum	1	1	3	3	2
Cleistogenes serotina	1	2	3	2	2
Clematis recta	1	2	3	4	2
Clinopodium vulgare	1	2	3	2	2
Colchicum autumnale	1	1	1	3	1
Colutea arborescens	1	3	2	4	2
Consolida orientalis	1	1	2	2	1
Convolvulus arvensis	1	2	2	2	2
Convolvulus cantabrica	1	2	3	2	2
Cornus mas	3	1	5	4	2
Cornus sanguinea	3	3	4	4	3
Coronilla coronata	1	3	2	3	2
Cotinus coggygria	3	4	5	5	4
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Cotoneaster tomentosus	1	3	5	4	3
Crataegus monogyna	3	2	5	4	3
Crepis nicaeensis	1	2	2	2	2
Crepis praemorsa	1	2	2	3	2
Crepis pulchra	1	2	2	2	2
Crepis rhoeadifolia	1	2	1	2	1
Crepis setosa	1	2	2	2	2
Crepis tectorum	1	2	2	2	2
Cruciata laevipes	1	3	4	2	2
Cruciata pedemontana	1	2	1	1	1
Cuscuta epithymum	1	1	1	1	1
Cynodon dactylon	1	3	3	2	2
Cynoglossum hungaricum	1	3	2	3	2
Cynoglossum officinale	1	3	2	3	2
Cytisus scoparius	1	4	5	4	3
Dactylis glomerata	2	4	3	4	3
Dantonia decumbens	1	2	4	2	2
Daucus carota	1	1	2	3	2
Dianthus armeria	1	2	3	2	2
Dianthus giganteiformis	1	3	1	2	2
Dictamnus albus	1	3	3	4	3
Doronicum hungaricum	1	1	3	3	2
Dorycnium germanicum	1	3	3	3	2
Dorycnium herbaceum	1	3	3	3	2

Draba muralis	1	1	2	1	1
Draba nemorosa	1	1	2	1	1
Echinops sphaerocephalus	1	1	2	3	2
Echium italicum	1	2	2	3	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Echium vulgare	1	2	2	3	2
Equisetum ramosissimum	1	2	3	2	2
Erigeron acer	1	1	4	2	2
Erodium ciconium	1	3	2	2	2
Erodium cicutarium	1	3	2	2	2
Erophila spathulata	1	1	2	1	1
Erophila verna	1	1	2	1	1
Eryngium campestre	1	1	1	4	2
Erysimum diffusum	1	1	3	1	1
Erysimum odoratum	1	2	3	2	2
Euonymus europaeus	1	3	5	4	3
Euonymus verrucosus	2	3	5	5	4
Euphorbia cyparissias	1	1	4	2	2
Euphorbia epithymoides	1	2	2	3	2
Euphorbia esula	1	1	3	3	2
Euphorbia salicifolia	1	2	3	3	2
Euphorbia seguierana	1	3	2	2	2
Euphorbia virgata	1	1	2	3	2
Falcaria vulgaris	1	1	2	3	2
Fallopia convolvulus	1	1	2	2	1
Festuca dalmatica	3	4	5	3	4
Festuca heterophylla	3	4	5	3	4
Festuca pseudovina	3	4	5	3	4
Festuca rubra	2	4	3	3	3
Festuca rupicola	3	4	5	3	4
Festuca valesiaca	3	4	5	3	4
Filago arvensis	1	1	1	1	1
Filago lutescens	1	2	1	1	1
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Filipendula vulgaris	1	4	3	3	3
Fragaria viridis	2	2	3	4	3
Fraxinus ornus*	3	2	5	4	3
Fumana procumbens	1	3	2	1	2
Fumaria parviflora	1	2	1	1	1
Fumaria rostellata	1	2	1	1	1
Fumaria vaillantii	1	1	1	1	1
Gagea pratensis	1	1	1	1	1
Galium erectum	1	2	4	1	2
Galium glaucum	1	2	4	2	2
Galium lucidum	1	2	4	1	2
Galium mollugo	1	2	4	2	2
Genista pilosa	1	3	4	1	2
Genista tinctoria	1	3	3	2	2
Geranium columbinum	1	3	2	2	2
Geranium dissectum	1	3	2	2	2
Geranium pusillum	1	2	2	2	2
Geranium sanguineum	1	4	3	3	3
Geranium rotundifolium	1	3	2	2	2
Glechoma hederacea	1	2	3	3	2
Globularia punctata	1	3	3	3	2
Gypsophila muralis	1	2	2	2	2
Helianthemum canum	1	5	3	3	3

Helianthemum nummularium	1	4	3	3	3
Helianthemum ovatum	1	4	3	3	3
Helichrysum arenarium	1	3	2	2	2
Helleborus odorus	1	2	3	4	2
Heracleum sphondylium	1	2	1	5	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Hieracium bauhini	1	3	3	2	2
Hieracium bifidum	1	2	3	2	2
Hieracium echioides	1	2	3	2	2
Hieracium hoppeanum	1	2	3	2	2
Hieracium cymosum	1	2	3	2	2
Hieracium pilosella	2	2	3	2	2
Hieracium racemosum	1	1	3	3	2
Hieracium sabaudum	1	1	3	3	2
Hieracium umbellatum	1	1	3	3	2
Hippocrepis comosa	1	3	2	3	2
Holosteum umbellatum	1	1	2	1	1
Hypericum perforatum	1	2	3	2	2
Hypochoeris maculata	1	1	2	4	2
Hypochoeris radicata	1	1	2	2	1
Inula conyza	1	1	3	4	2
Inula ensifolia	1	5	3	2	3
Inula hirta	1	5	4	3	3
Inula oculus-christi	1	5	4	3	3
Inula salicina	1	5	4	3	3
Inula spiraeifolia	1	5	4	3	3
Iris graminea	1	4	2	3	2
Iris pumila	1	3	3	2	2
Iris variegata	1	3	2	3	2
Jovibarba globifera	2	4	2	4	2
Juniperus communis*	1	2	5	5	3
Jurinea mollis	1	2	3	2	2
Knautia arvensis	1	3	2	4	2
Koeleria cristata	2	4	4	2	3
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Koeleria glauca	3	5	5	3	4
Laburnum anagyroides	1	2	5	4	3
Lactuca quercina	1	1	3	2	2
Lactuca viminea	1	1	1	2	1
Laser trilobum	1	2	2	4	2
Laserpitium latifolium	1	2	2	4	2
Lathyrus hirsutus	1	1	2	3	2
Lathyrus latifolius	1	3	2	4	2
Lathyrus nissolia	1	1	2	3	2
Lathyrus pannonicus subsp. collinus	1	2	2	3	2
Lathyrus sphaericus	1	2	2	2	2
Lathyrus tuberosus	1	1	2	4	2
Lavatera thuringiaca	1	3	3	4	3
Lepidium perfoliatum	1	2	1	1	1
Lepidium ruderale	1	1	2	1	1
Ligustrum vulgare	1	4	5	5	4
Linaria genistifolia	1	1	2	2	1
Linaria vulgaris	1	2	1	2	1
Linum austriacum	1	3	3	2	2
Linum catharticum	1	2	1	1	1
Linum flavum	1	2	3	2	2
Linum tenuifolium	1	3	2	1	2

Lithospermum officinale	1	2	2	3	2
Lolium perenne	2	4	4	3	3
Lotus corniculatus	1	3	3	2	2
Luzula campestris	1	3	4	2	2
Lychnis coronaria	1	2	3	3	2
Lycium barbarum	3	5	5	5	4
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Marrubium peregrinum	1	3	3	2	2
Medicago arabica	1	2	3	3	2
Medicago falcata	1	3	3	3	2
Medicago minima	1	2	1	1	1
Medicago prostrata	1	3	3	2	2
Medicago rigidula	1	3	3	2	2
Melampyrum arvense	1	1	2	2	1
Melampyrum barbatum	1	1	2	2	1
Melampyrum cristatum	1	1	2	2	1
Mercurialis ovata	1	2	4	3	2
Minuartia rubra	1	2	2	1	1
Minuartia verna	1	3	2	2	2
Muscari botryoides	1	1	3	2	2
Muscari racemosum	1	1	3	1	1
Myosotis discolor	1	1	2	1	1
Myosotis ramosissima	1	1	2	1	1
Myosotis stricta	1	1	1	1	1
Nonea pulla	1	3	2	2	2
Onobrychis arenaria	1	3	2	3	2
Ononis spinosa	1	3	2	3	2
Onosma arenaria	1	3	1	2	2
Orchis simia	1	1	1	2	1
Orchis tridentata	1	1	1	1	1
Orchis ustulata	1	1	1	1	1
Origanum vulgare	1	3	4	3	3
Orlaya grandiflora	1	2	2	2	2
Ornithogalum kochii	1	1	1	1	1
Ornithogalum pyramidale	1	2	1	2	1
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Ornithogalum sphaerocarpum	1	2	1	2	1
Ornithogalum umbellatum	1	1	1	2	1
Orobanche alba	1	1	1	1	1
Orobanche elatior	1	1	1	1	1
Orobanche caryophyllacea	1	1	1	1	1
Orobanche lutea	1	1	1	1	1
Orobanche minor	1	1	1	1	1
Orobanche purpurea	1	1	1	1	1
Orobanche reticulata	1	1	1	1	1
Orobanche teucrii	1	1	1	1	1
Papaver argemone	1	2	1	1	1
Papaver hybridum	1	1	1	2	1
Petrorhagia prolifera	1	2	2	2	2
Petrorhagia saxifraga	1	3	3	2	2
Peucedanum alsaticum	1	2	2	3	2
Peucedanum carvifolia	1	2	2	2	2
Peucedanum cervaria	1	2	2	4	2
Peucedanum oreoselinum	1	2	2	3	2
Phleum phleoides	2	4	4	3	3
Phlomis tuberosa	1	4	3	5	3
Picris hieracioides	1	1	3	3	2

Pimpinella saxifraga	1	1	2	2	1
Pinus nigra*	5	5	4	5	5
Pinus sylvestris*	5	5	3	5	4
Plantago argentea	1	1	3	4	2
Plantago lanceolata	1	1	3	4	2
Plantago major	2	1	3	4	2
Poa annua	1	2	2	2	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Poa bulbosa	1	3	4	2	2
Poa compressa	1	2	4	2	2
Poa angustifolia	2	3	4	3	3
Poa nemoralis	1	2	3	3	2
Polygonatum odoratum	1	1	3	3	2
Polypodium vulgare	2	2	4	4	3
Potentilla arenaria	1	3	2	2	2
Potentilla argentea	1	3	2	2	2
Potentilla collina agg.	1	3	2	2	2
Potentilla heptaphylla	1	2	2	2	2
Potentilla inclinata	1	3	2	2	2
Potentilla micrantha	1	3	2	2	2
Potentilla neglecta	1	3	2	2	2
Potentilla recta	1	2	2	3	2
Primula veris	1	3	3	3	2
Prunella laciniata	1	3	3	2	2
Prunus fruticosa	2	5	5	5	4
Prunus mahaleb*	1	2	5	4	3
Prunus spinosa*	2	5	5	5	4
Prunus tenella	1	3	4	4	3
Pseudolysimachion spicatum	1	2	3	3	2
Pulmonaria mollis	1	3	4	4	3
Pulsatilla grandis	1	2	2	2	2
Pulsatilla pratensis	1	2	2	2	2
Pyrus pyraster*	1	1	3	4	2
Quercus cerris*	4	4	4	4	4
Quercus petraea*	4	4	3	4	4
Quercus pubescens*	4	4	5	4	4
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Ranunculus bulbosus	1	1	3	3	4
Ranunculus illyricus	1	1	3	3	4
Ranunculus polyanthemos	1	1	2	3	2
Rapistrum perenne	1	2	3	3	2
Reseda phyteuma	1	2	2	2	2
Robinia pseudo-acacia*	1	1	5	3	2
Rosa canina agg.	1	2	3	3	2
Rosa gallica	1	2	3	4	2
Rosa rubiginosa agg.	1	2	3	4	2
Rosa spinosissima	1	3	5	3	3
Rubus fruticosus agg.	2	3	3	5	3
Rumex acetosa	3	4	3	3	3
Rumex acetosella	1	3	2	2	2
Rumex pulcher	1	2	2	2	2
Salvia austriaca	1	2	2	3	2
Salvia nemorosa	1	3	1	3	2
Salvia pratensis	1	3	2	3	2
Salvia verticillata	1	2	2	3	2
Sanguisorba minor	1	4	3	2	2
Saxifraga tridactylites	1	2	1	1	1

Scabiosa ochroleuca	1	4	2	3	2
Scorzonera laciniata	1	2	1	1	1
Scutellaria columnae	1	3	4	3	3
Securigera varia	1	3	2	3	2
Sedum acre	1	2	2	2	2
Sedum album	1	2	2	2	2
Sedum rupestre	1	2	2	2	2
Sedum sexangulare	1	2	2	3	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Senecio jacobaea	1	1	3	3	2
Senecio vernalis	1	2	1	1	1
Serratula tinctoria	1	1	3	3	2
Seseli annuum	1	1	2	3	2
Seseli hippomarathrum	1	2	2	2	2
Seseli osseum	1	2	2	2	2
Sherardia arvensis	1	2	2	2	2
Sideritis montana	1	1	3	2	2
Silene nutans	1	3	3	2	2
Silene otites	1	2	2	2	2
Silene vulgaris	1	2	2	2	2
Smyrnium perfoliatum	1	1	3	4	2
Sorbus danubialis*	3	2	5	4	3
Sorbus domestica*	2	1	3	3	2
Spiraea media	1	5	5	4	4
Stachys recta	1	1	3	2	2
Stipa capillata	1	4	4	2	3
Stipa pennata	1	4	4	2	3
Stipa pulcherrima	1	4	4	2	3
Sisymbrium altissimum	1	1	3	2	2
Sisymbrium loeselii	1	1	3	2	2
Symphythum tuberosum	1	1	3	4	2
Taeniatherum asperum	1	1	2	2	1
Tanacetum corymbosum	1	2	3	3	2
Taraxacum erythrospermum	1	2	2	2	1
Taraxacum serotinum	1	2	1	2	1
Teucrium chamaedrys	1	2	3	2	2
Teucrium montanum	1	3	3	2	2
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Thalictrum minus	1	3	3	2	2
Thesium linophyllon	1	3	2	2	2
Thlaspi perfoliatum	1	1	2	1	1
Thymus odoratissimus	1	3	3	2	2
Thymus pannonicus	1	3	3	2	2
Thymus pracox	1	3	3	2	2
Tilia cordata*	5	5	3	5	4
Tilia tomentosa*	5	5	5	5	5
Tordylium maximum	1	1	2	4	2
Tragopogon dubius	1	1	2	3	2
Tragopogon pratensis	1	1	2	3	2
Trifolium alpestre	1	2	4	3	2
Trifolium arvense	1	1	2	2	1
Trifolium aureum	1	1	3	2	2
Trifolium campestre	1	1	3	2	2
Trifolium montanum	1	2	3	3	2
Trifolium ochroleucum	1	2	4	3	2
Trifolium repens	1	2	4	3	2
Trifolium retusum	1	2	2	2	2

Trifolium rubens	1	1	2	3	2
Trifolium striatum	1	1	2	2	1
Trinia glauca	1	3	2	2	2
Trinia ramosissima	1	3	2	3	2
Tussilago farfara	1	2	3	3	2
Valerianella carinata	1	1	1	2	1
Valerianella coronata	1	2	1	1	1
Valerianella dentata	1	1	1	2	1
Valerianella pumila	1	1	1	1	1
Species	**IA**	**IZ**	**IS**	**IB**	**Σ**
Verbascum lychnitis	1	2	2	4	2
Verbascum phoeniceum	1	2	2	3	2
Verbascum speciosum	1	2	2	4	2
Verbascum thapsus	1	2	2	4	2
Veronica austriaca	1	1	3	2	2
Veronica chamaedrys	1	2	3	2	2
Veronica dillenii	1	1	1	1	1
Veronica hederifolia	1	1	1	1	1
Veronica officinalis	1	2	3	2	2
Veronica persica	1	1	1	1	1
Veronica praecox	1	1	1	1	1
Veronica prostrata	2	3	2	2	2
Veronica verna	1	1	1	1	1
Viburnum lantana	4	3	4	5	4
Vicia lathyroides	1	2	2	2	2
Vicia grandiflora	1	1	2	3	2
Vicia hirsuta	1	1	2	2	1
Vicia narbonensis	1	1	2	3	2
Vicia tenuifolia	1	2	2	4	2
Vinca herbacea	1	2	3	3	2
Vincetoxicum officinale	1	2	3	3	2
Viola hirta	1	5	3	3	3
Viola kitaibeliana	1	1	1	1	1
Viscaria vulgaris	1	3	3	2	2
Waldsteinia geoides	1	3	3	3	2
Xeranthemum annuum	1	1	2	2	1
Xeranthemum cylindraceum	1	1	2	1	1

*The indicated values are valid only for fully developed plants, together with the litter accumulated below them.

Conclusion

The results could help to select species and assemble plant communities for recultivation purposes. Other ecologically relevant parameters (exposition, base rock, soil, etc.) should be considered too. For reducing erosion (and promoting soil formation) the establishment of layered vegetation as structured as possible, in accordance with the habitat, is suitable.

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UPSCALING OF COMMUNAL SEWAGE SLUDGE VERMICOMPOSTING TECHNOLOGY

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Abstract

The proper management of communal sewage sludge is a priority of environmental protection. Recently the vermicomposting technology, of using earthworm species in waste management has been increasing. Earthworms are utilizing of the bacterial components of the sludge and during of their metabolic processes, can contribute for the acceleration of full composting processes. In addition, vermicomposting increases the nitrogen (N), phosphorus (P) and potassium (K) content of the treated sludge, and might eliminate of the potential pathogens. We examined the vermicomposting processes both in pilot scale (open- and closed environmental conditions) and among industrial composting conditions, where the compost piles were: 1) uncovered and covered with 2) straw-mulch and 3) with geotextile. Eisenia fetida worms was mixed into the compost-piles. Samples were taken at the beginning, at half time and at the end of the experimental period. Physical and chemical characteristics, such as the pH, dry matter, organic matter, salt, nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), Ca, Mg, humus (H%), H quality and the dehydrogenase enzyme activities (DHA) were determined. Temperature and redox potential were assessed twice a week. Heavy metal concentrations (Pb, Zn, Fe, Cu, Mn) in sludge, in finished vermicompost and in earthworm biomass were analysed. Straw-mulch cover was the best for keeping water balance, improving survival and propagation of worms and increasing phosphorous and potassium availability in the final composts. Earthworms could reduce the amount of heavy-metals by bio-accumulating those toxic elements. Vermicomposting can be a potential tool of the agri/horti-cultural practice for reducing environmental risks and supporting the applicability of nutritive composts, prepared from communal sewage sludge.

Keywords: *communal sewage sludge, vermicomposting, Eisenia fetida*

1. INTRODUCTION

Vermicomposting is an effective and environmental friendly method of organic waste management technologies. During vermicomposting process different worm species are used to transform organic matters. Red worm (*Eisenia fetida*) is one of the most commonly used worm species in vermicomposting of dewatered and putrefied municipal sewage sludge [1]. The worms remove old bacterial cells from the sludge due to their metabolic processes; therefore new bacterial colonization can develop which contribute for the acceleration of composting. In addition, vermicomposting increases the nitrogen (N), phosphorus (P) and potassium (K) content of the treated sludge, and eliminate of the potential pathogens. These parameters are essential for further agricultural use of compost. Maintenance of earthworm culture is relatively simple and inexpensive, and worms can be easily separated from the finished vermicomposts for further use [2, 3]. Vermicomposting technology has some advantages compared to traditional waste composting systems:

- It is one of the most effective way of recycling organic matter and nutrients from wastes
- The compost can be ready for use by 50% faster [1].

- Particle size distribution and texture are more favorable for the agricultural use, since feces of worms improve the aggregate stability of soil particles [4].
- Contains nutrients (N, P, K, Ca and Mg) in higher plant-available forms [5, 6].
- No additives are required for reducing water-content; the sludge can be vermicomposted up to 91% moisture [7].
- Greater microflora, higher microbial and metabolic enzyme-activities [7, 8].
- Increased plant growth by PGA (Plant Growth Activators) and by PGRs (Plant Growth Regulators), synthetized by the gut microflora of earthworms. Other composts does not have this positive effect on plant growth [9-11]
- Contains high amount of humic acids and humates of promoting plant growth [12-14].
- During vermicomposting abundance and risks of potential pathogens might be efficiently reduced [15, 16].

These advantages means that vermicomposting technology can be applied for stabilization and disposal of municipal sewage sludge without any pretreatment and additives. However, vermicomposting can be integrated to traditional composting technology, since it improves the quality of compost as an additive [6, 17, 18].

During traditional composting, concentration of toxic elements are higher in finished compost than in raw material, while at vermicomposting, at the use of suitable earthworms, concentration of toxic elements are decreased in final composts [19-21].

Shahmansouri et al. [22] investigated the heavy metal (Cr, Cd, Pb, Cu and Zn) accumulation with two groups of *Eisenia fetida* in sewage sludge. The results indicated that heavy metal concentrations in the vermicompost decreases with increasing time.

Among two earthworm groups, one of them accumulated significantly higher amounts of micronutrients (Cu, Zn), however the non-essential elements (Cr, Cd, Pb) was significantly greater in the other group. It was concluded that earthworms can accumulate heavy metals at relatively high concentrations in their tissues [22].

2. MATERIALS AND METHODS

Pilot scale experiment

Pilot scale experiment was conducted in Sóskút (at Szigépszerk GmbH.), where the vermicomposting processes were examined both in open- and closed environmental

conditions. Thus, effects of environmental conditions (e.g. temperature, precipitation intensity and moisture of compost) on vermicomposting technology can be studied. The experimental period lasted for 15 weeks. 21 compost prism were examined in the experiment: 4 prisms (2 prisms in open conditions and 2 prisms in closed condition) did not contain worms, and 17 prisms (8 prisms in open conditions and 9 prisms in closed condition) contained them. Each prism contained 3000 worms/m^3. At the beginning of the experiment composite samples were taken from all compost prisms, and the samples were measured by different physical and chemical methods. Next sampling was taken at half time of the experiment, and the last sampling was taken from the finished vermicompost. In the experiment, we did not use any other organic materials or green waste.

Industrial scale experiment

Industrial scale experiment was also carried out in Sóskút. Three different composting technologies were applied: the compost piles were covered with straw-mulch or geotextile or were uncovered. 3 prisms contained worms, and 1 prism did not contain in all three technology. The experimental design is in *Figure 1*. The experimental period, the number of worms and the samplings were the same as in the pilot scale experiment.

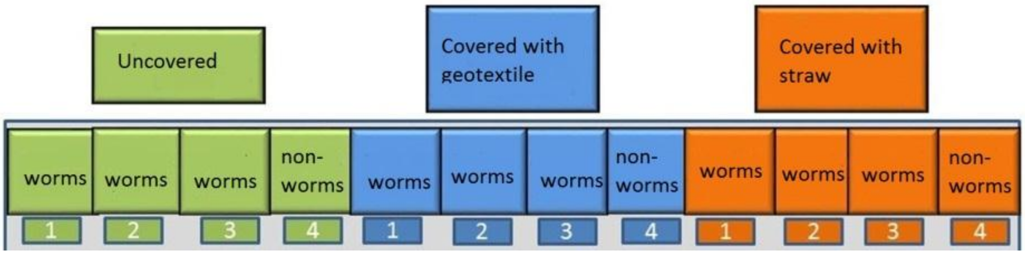

Figure 1. Experimental design of industrial scale experiment

Materials

Municipal sewage sludge used in our experiment originated from Érd (Hungary). According to previous measurements the dry matter content of the sewage sludge was 15-20 %, and half (50%) of the dry matter content was organic matter. Toxic element content of the sewage sludge did not exceed the limit of the permitted toxic elements and harmful substances in sewage sludge for agricultural use according to the Hungarian Government Decree 50/2001. (3. IV.).

The tested species was *Eisenia fetida* (Genus: *Eisenia*, Family: *Lumbricidae*, Order: *Haplotaxida*, Class: *Clitellata*, Phylum: *Annelida*). This worm species is a well-adapted specialist to certain conditions: is an important participator in exploration of degrading organic matter and is a resident of manure or compost which provides nutrients and energy to its organism.

Analytical methods

During samplings and analytical measurements Hungarian regulations were taken into consideration. Samples of sewage sludge, compost and earthworms were dried and sieved (<2 mm) for the measurements. Both pilot scale and industrial scale experiment the following parameters were examined: pH (H_2O), EC (electrical conductivity), from which the total salt content could be calculated, phosphorus content (P_2O_5), potassium content (K_2O), humus content (H%) humus quality and dehydrogenase enzyme activity. Temperature and redox potential were assessed twice a week in order to characterize oxidation-reduction conditions. In this study, only the most important chemical parameters (EC, phosphorus-, potassium- and humus content) will be analyzed, which are essential for the potential agricultural use of vermicompost.

Heavy metal concentration (Pb, Zn, Fe, Cu, Mn) in the starting sludge, in the finished vermicompost and in the earthworms (at the starting and ending of the experiments) were also measured, which means, that bioaccumulation of heavy metals by earthworms can be determined. Samples were examined after nitric acid – hydrogen peroxide digestion with AURORA AI1200 Atomic Absorption Spectrometer (*Figure 2.*), and FP910 (PG Instruments) Flame Photometer (*Figure 3.*).

Figure 2. AURORA AI1200 Atomic Absorption Spectrometer

Figure 3. FP910 (PG Instruments) Flame Photometer

3. RESULTS AND DISCUSSION

According to our results vermicomposting process could be completed and finally ripened compost was developed in all of the treatments, used both in pilot scale and in industrial scale experiments. The finished composting was confirmed by physical and chemical parameters and enzyme activities. The produced vermicompost could be beneficial for agricultural use.

Table 1 shows the results of the pilot scale experiment. Total salt content (mg/kg) reduced more in open environmental condition compared to closed environmental condition.

Phosphorus content was increased during the vermicomposting procedure. In closed condition it increased from 1573±234 mg/kg to 2859±197 mg/kg, while in open condition it changed from 2799±102 to 3289±588.

Potassium content of the vermicompost also increased more in closed environmental condition, where it increased from 2173±546 to 4079±822.

In open condition it raised from 2309±662 only to 3437±444. Humus content increased only slightly in both condition.

Table 1. Measured chemical parameters during pilot scale experiment

		Closed environment		**Open environment**	
		Mean	SD	Mean	SD
Salt content (mg/kg)	starting stage	14706	1772	16645	3231
	middle stage	14025	1389	10327	1075
	final stage	11784	2389	6895	558
P_2O_5 (mg/kg)	starting stage	1573	234	2799	102
	middle stage	2789	222	3153	676
	final stage	2859	197	3289	588
K_2O (mg/kg)	starting stage	2173	546	2309	662
	middle stage	3993	834	2763	540
	final stage	4079	822	3437	444
H (%)	starting stage	27,66	6,18	29,37	4,50
	middle stage	27,35	4,91	30,35	5,14
	final stage	27,72	4,39	31,36	4,96

Table 2. shows the results of the industrial scale experiment. Similar results were observed than in pilot scale experiment. Composting was more effective if the compost prism contained earthworms in all three technologies. Total salt content was decreased in all compost.

In covered compost salt content reduced more than in uncovered compost. Phosphorus content were increased significantly during the experimental period. The highest increase was noticed in uncovered compost, which is followed by the straw covered compost. Potassium content was increased in covered technologies; however, it was reduced in uncovered compost. Increasing of potassium content was higher in straw covered compost than in geotextile covered one. Humus content increased in all three technologies. According to industrial scale experiment straw covered compost was the most effective in terms of agricultural use of vermicompost.

Table 2. Changing of chemical parameters during industrial scale experiment

		Uncovered		Geotextile covered		Straw covered	
		Mean	SD	Mean	SD	Mean	SD
Salt content (mg/kg)	starting stage	14233	1650	15417	104	16733	333
	middle stage	18150	1150	17017	1115	16633	3177
	final stage	14917	1422	14667	765	11728	2811
P_2O_5 (mg/kg)	starting stage	627	28	991	464	755	88
	middle stage	7076	306	5406	775	5414	393
	final stage	4688	162	4457	199	4649	108
K_2O (mg/kg)	starting stage	1888	436	1312	266	1195	69
	middle stage	1312	67	1118	65	1120	67
	final stage	1466	66	1351	66	1312	66
H (%)	starting stage	20,79	9,44	22,44	5,41	18,59	3,89
	middle stage	19,57	4,51	22,26	8,26	24,83	3,06
	final stage	31,30	10,98	37,24	11,45	35,03	2,00

In pilot scale experiment, both in open and closed environmental condition, worms bio accumulated heavy metals, since higher metal concentrations was observed in worms at final stage compared to starting state. Results shown in *Table 3.* suggests that Cu and Fe accumulated at highest rate in worms. Cu concentration increased by 83.99% in open environment, while only by 69.93% in closed environment.

Table 3. Heavy metal accumulation in earthworms in pilot scale experiment

Open environment					
Heavy metals (mg/kg)	starting stage		final stage		
	Mean	SD	Mean	SD	%
Zn	55,28	4,58	79,12	3,52	43,13
Pb	61,91	4,68	69,76	8,75	12,68
Mn	36,91	2,47	46,21	5,66	25,18
Fe	296,53	47,66	469,74	79,87	58,41
Cu	27,01	1,29	49,69	1,45	83,99
Closed environment					
Heavy metals (mg/kg)	starting stage		final stage		
	Mean	SD	Mean	SD	%
Zn	53,28	4,77	63,18	3,17	18,58
Pb	56,99	4,75	63,26	7,85	10,99
Mn	33,14	2,07	41,10	4,62	24,03
Fe	286,69	42,56	439,70	51,87	53,37
Cu	31,01	1,86	52,69	1,19	69,93

Fe concentration increased by 58.41% in open environment and by 53.37 in closed environment. Other metal concentrations in worms were increased by less than 45% in both environmental conditions.

Bioaccumulation of heavy metals in worms was also observable in industrial scale experiment, since highest concentrations of metals were measured in worms after the experiment than before with the application of all three technologies. The results are shown in *Table 4*. Cu accumulated at the highest rate, its concentration increased by 81.4; 63.7 and 84.2%. The concentration of Fe and Mn increased by 38.7 % to 55.75 %, while Zn and Pb concentrations in worms increased by less than 34.2 % in all three technologies.

Table 4. Heavy metal concentration in earthworms in industrial scale experiment

Uncovered					
Heavy metals (mg/kg)	starting stage		final stage		
	Mean	SD	Mean	SD	%
Zn	40,35	3,78	49,31	3,53	22,20
Pb	62,33	4,68	65,23	6,81	4,65
Mn	30,91	2,14	44,21	3,07	43,01
Fe	242,92	40,66	359,92	76,46	48,16
Cu	29,62	2,96	53,73	1,94	81,44
Geotextile covered					
Heavy metals (mg/kg)	starting stage		final stage		
	Mean	SD	Mean	SD	%
Zn	47,99	3,56	59,77	3,47	24,55
Pb	63,93	4,82	67,23	7,24	5,16
Mn	30,54	2,31	43,39	5,95	42,08
Fe	229,85	475,61	344,74	79,87	49,98
Cu	30,62	1,92	50,12	1,33	63,70
Straw covered					
Heavy metals (mg/kg)	starting stage		final stage		
	Mean	SD	Mean	SD	%
Zn	45,56	4,04	61,12	3,53	34,15
Pb	65,91	4,08	69,69	8,12	5,74
Mn	31,94	2,53	44,29	5,41	38,67
Fe	236,53	47,56	368,39	77,50	55,75
Cu	27,01	1,27	49,73	1,43	84,16

Conclusion

Vermicomposting of municipal sewage sludge were examined in pilot scale and among industrial composting conditions. Vermicomposting were completed successfully in both technological condition. Cooperation between earthworms and microbes resulted more effective conversion of organic matter [1]. It is confirmed by the result of dehydrogenase enzyme activity and humus content and quality from the compost prisms which did not contain worms. It was concluded that salt content decreased, and phosphorus, potassium and humus content increased during the vermicomposting process. The increase of nutrients was also observed in previous studies [5, 6]. These results mean that vermicompost can be an effective soil amendment, since it can decrease the necessary amount of fertilizer and manure applications. Moreover, previous studies show that vermicompost is a PGA (Plant Growth Activators), which is also a great advantage in agricultural use of this type of compost [9-11].

Both in pilot scale and industrial condition earthworms bio accumulated the measured heavy metals (especially Cu and Fe), however the accumulation was higher in open conditions. As the results shows using earthworms for composting can decrease the heavy metal concentration of organic waste, which is confirmed also by other studies [19-22].

In practice, straw covered compost piles could be the best technology for vermicomposting, since it was the best for improving the survival ability of the worms and in increasing the total phosphorous and potassium availability in the final composts.

Based on our results vermicomposting can be a potential tool of the agri/horti-cultural practice for reducing the environmental risks of the increasing amount of communal sewage sludge wastes. Our further assessment is to measuring heavy metal balance, which can contribute to the precise monitoring of heavy metal concentration of communal sewage sludge.

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SOLUTIONS FOR NON-WASTE TAILORING METHODS

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Abstract

The fashion industry after the oil industry is the second most polluting industry in the world. Both the production of clothes and the afterlife of the pieces give rise to high pollution. Developing environmentally friendly technologies for production and zero-waste efforts are a deliberate intention to alleviate the problem. More than 400 billion square meters of fabric are produced annually, but out of this is 15-20% loss. [2] The issue that has become very important since the early age is still very important, although other reasons have proved the use of non-waste sorting methods at that time. In history, there have been many examples in which people have tried to make full or nearly full use of the fabric when making their clothing. This article presents some main stages of these, and also demonstrates student project tasks as illustrations.
These tasks start with the study of the methods of cutting and then the different aspirations of contemporary designers. In the fashion designers' collections, the eco-conscious lines play key role the help of which the waste in tailoring can be minimized and the natural materials come into view. The proper use of drapery is an opportunity in this direction, while another direction seeks to use the entire material width. Third and fourth year students, after completing basic professional design tasks, experiment with special shaping based on such principles. Students need to design as many variations as possible from simple geometric patterns, as far as possible from the given fabric. The characteristics of the textiles are analyzed and the varied shapes that provide solutions to the most up-to-date clothing and features are also in the focus. The design process results in creative form solutions and this enhances students' eco-conscious thinking. The result of such experimental work is that development and understanding are considerably simpler than usual fashion-oriented design tasks, though it is a concrete solution to optimize the treatment of sartorial waste.
Keywords: *Zero-waste, ecodesign, drapery.*

1. INTRODUCTION

1.1. Historical background of zero waste

The history of costumes gives plentiful examples of clothing made with the application of non-waste tailoring. We have different source materials at hand to present them. On the one hand, in addition to the examination of survived original clothes, there are written documents and depictions in creations of fine arts, on the other one. These are completed by pattern books, sometimes difficult to interpret, available to us.

In history, there have been many examples in which people tried to make full or nearly full use of the fabric when making their clothing. The prehistoric men wore garments, fastened onto his body only for protection and possibly wizardry. They wore bottom cloth, loin cloth or skirt, made of leather, fur and plant fibres to get protection against adverse weather conditions. As these pieces were fully made of natural materials they were organic, thus their degradation was fast and posed no problem on the environment.

In the ancient Egypt, due to the nice weather, only light linen clothes were typical and they were mostly white. Men wore shenti that is loin cloth, wound on their hips and knotted in the front. Women wore *kalasiris* a straight lined sheath dress worn down to the knee or the ankle.

The clothes of the Greeks typically consisted of rectangle sheaths of different materials and sizes draped and secured with ornamental clasps. These clothes were worn by men and women as well. Chiton was a typical piece of clothing fastened on the shoulders. The himation was made of wool and it was worn like a cloak wound on the chiton. The peplos was typical attire for women. Its folded top edge was pinned on both shoulders. (Figure 1)

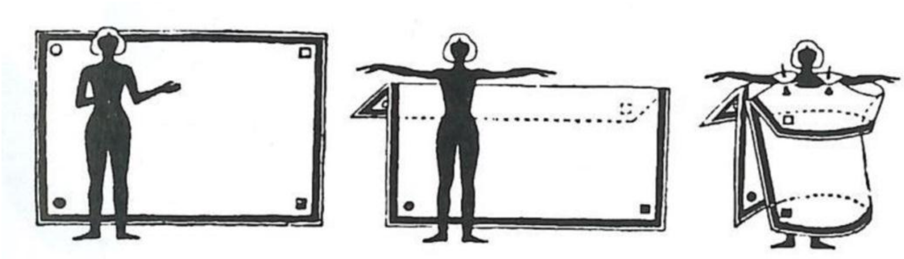


Figure 1. Chiton wear

Clothing in the ancient Rome was greatly similar to the Greek one. Roman people used their clothing to show their status and luxurious lifestyle. Both women and men wore full-length *tunic* sewn from two pieces. The tunics were with or without sleeves. The poor and the soldiers wore short tunics. *Toga* was the privilege of the Roman citizens. The costumes of the ancient Greeks and Romans clearly exemplify how the most diverse clothes can be made of a single rectangle by folding and draping the material.

In the middle ages the costumes of the conquering Magyars greatly depended on their geographical location. The riding and wandering lifestyle determined their lives. They wore shirts or underwear with wrist and neck straps with baggy trousers the wide legs of which were tucked into their boots. Their outer clothing was a knee-length caftan clamped with a decorated belt. The geometric lines of the caftan suggest a sparing cut. [7]

1.2. Traditional costumes

Among the traditional costumes of different peoples the intention of the best possible utilization of the fabric can be observed, Nowadays the Japanese word kimono is meant for a narrow and long garment having angular T sleeves. In a narrower interpretation this piece is the *kosode* that is the "small sleeve" that, until the 19th century, was a general casual wear in Japan for both women and men. The pattern of the *kosode* followed simple straight lines but it was richly decorated in the process of weaving or subsequent dyeing. (Figure 2)

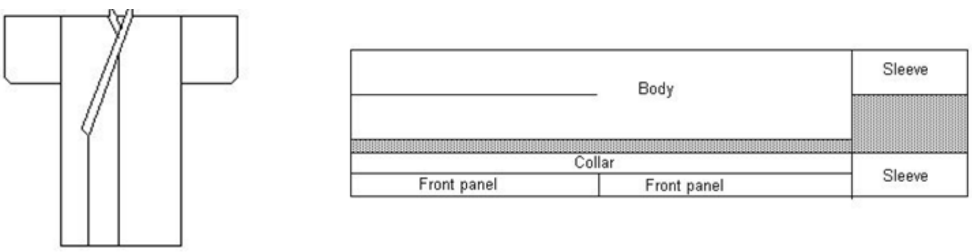
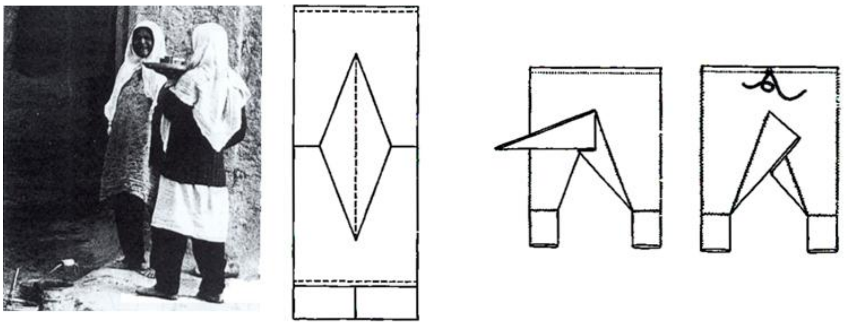


Figure 2. Kimono and layout drawing of kimono

The Arab women wear trousers under their long shirt. Only the part of the trousers, falling below the knees, is visible. The full width of the material is used for tailoring the baggy trousers. The rhomboid form, cut out in the process of tailoring, will be sewn between the inner legs. (Figure 3)



a.) b.) c.) d.)

Figure 3. Costume of the Arab women (a), Marker of the parts of the trousers (b), Steps of sewing the parts of the trousers together (c-d) [5]

1.3. Hungarian folk costumes

Until the end of the 19th century the Hungarian peasants made their clothes of extremely durable homemade materials. These clothes could serve several generations. The decorated textiles, festive pieces, clothes, intended for the layette were made by women. As the preparation of the fabric required a lot of time and effort, the full use of the fabric can be clearly observed. This makes logical the almost wasteless cutting of parts, following simple geometric forms, of the clothes. When cutting the individual pieces, one part closely follows the other (Figure 4).

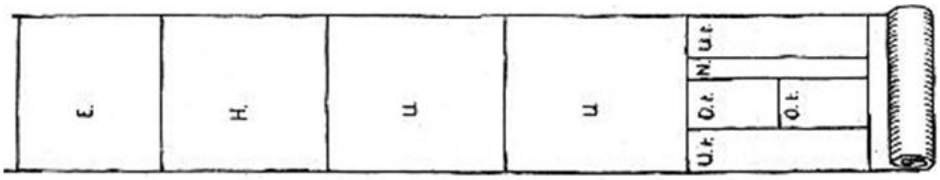


Figure 4. Markings of the patterns of shirt parts on the fabric
(E: front, H: back, U: sleeve, Ut: fitting-in of the sleeve, Ot: side gusset, N: neck strap)

The thrifty use of materials was also sought when sewing shirts, baggy trousers and skirts. The free motion of the arms was ensured by gussets which was a linen square sewn into the armpit of the shirt having set in sleeve or sided sleeve. The differences between the cutting lines, to be sewn together, were usually eliminated by gathering which had a strong decorating function as well. [3]

Basically two types of shirts are distinguished:

- shirts with set in sleeves (tunic type)
- shirts with sided sleeves (renaissance type)

The cut of the shirt was decisively influenced by the dimensions of the fabric. The formation of the shirts with set in sleeves is characterized by the linen, folded in two with a T shaped opening at the neck. The sleeves are sewn to the bodice at right angle (Figure 5).

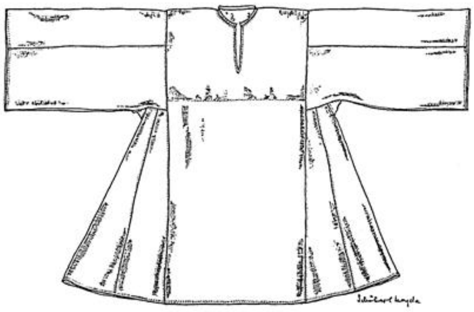


Figure 5. Shirt with set in sleeves [3]

The parts of the shirts with sided sleeves are also rectangle or square shaped. However, when sewing their parts together, the sleeves are sewn beside the front and the back part (not at right angle). Gussets are necessary for this type of shirt, too (Figure 6).

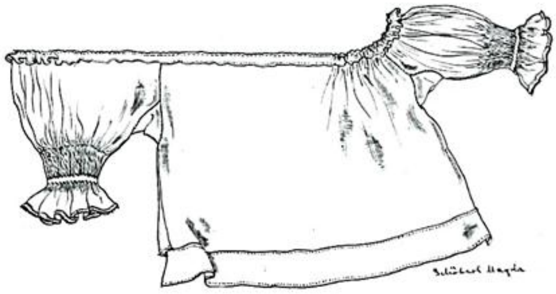


Figure 6. Shirt with sided sleeve [4]

Occasionally, the name gusset was used for the bottom part of the baggy trousers. Here the use of the gusset also resulted in a wider range of motion. The two legs of the trousers were formed from a single piece of linen, either keeping their full width or making them narrower downward. After sewing the legs together, the square shaped bottom part (gusset or leg part) was subsequently sewn between the legs (Figure 7).

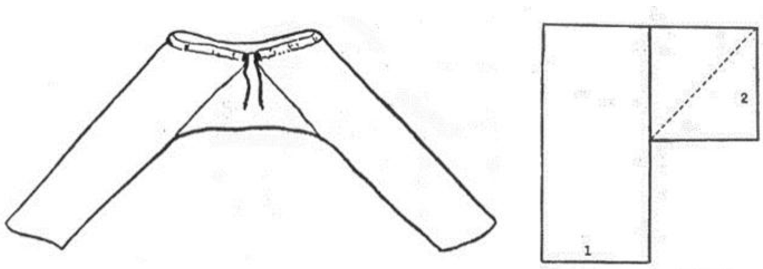


Figure 7. A pair of trousers and its pattern

The so-called *szűr* (embroidered felt coat) was a garment with a large collar. This garment was also made of rectangles. At the beginning, its material was leather, later on fine felt was used. When folded on the head, its large square collar protected its wearer from the rain.

The szűr was never put on; it was always worn slung on the shoulders. Its festive variant was the so-called *cifraszűr* (embroidered peasant cloak). It was characterized by abundant decoration. The loose short coat of angular cutting lines, used on the Great Hungarian Plain, was called *Guba*. Rarely it was made of woven wool fabric and contained wool clusters as well. [3]

2. OBJECTIVE

Eco-solutions involve not only technical but social, cultural, economic and political dimensions. Eco-logical design, as an approach to social and environmental problem solving, deals with complex, open systems. Reduce, reuse and recycle are the three essential components of environmentally-responsible consumer behavior.

The recovery of the waste is a key element in the environmental strategy of the companies. Taking into account the environmental effects this kind of product design and development covers the entire life cycle of the products.

In the 20th century, environmental ideas continued to grow in popularity and recognition and gained rapid speed around the world from the early nineties. Eco fashion began to look less like a funny spectacle and more like a serious business proposition. One of the strongest trends in fashion nowadays is the expression of ecological, social and community consciousness. In the education we musn't disregard this phenomena and we have to prepare students for these kind of conceptual ways of thinking. [1]

It is a big challenge for students who study fashion design mainly from the industrial part of it, to develop a specific approach in design methods. After their one year's professional studies of fashion they research new and innovative ways to become more sustainable.

The eco-product design is a new, responsible approach, new attitude, and new philosophy, the problems of which all the student have to be well aware. Through a one semester project they learn to identify themselves with ecological, social and community consciousness.

This research highlights the accumulated sources worth dealing with and the eco-conscious way of thinking. For obtaining the theoretical background of this growing sustainable design philosophy fourth year students get a practical reuse/redesign project.

3. THE PROCESS OF METHOD

In the sense of zero waste, students can experiment on two different lines. One is the non-sewing dressing created by drapery, and the other is to design coat forms experimented with folding.

Study of historic costumes and the latest trends is essencial for starting this project. This experimental work is based on the connection between the body and the differently draped/folded fabrics and students try to work without any previous idea.

The silhouettes should be in harmony with the fabrics therefore they target to use the final products as real dresses/coats. No cheep calico is used but crispy woven cotton, chiffon, transparent organza, silk, muslin and soft knitted jersey for drapery and soft wollen fabrics for the coats. [6]

Draped dresses can be created by using:

- pleats, gathers and tucks,
- draping around the body,
- rubbers,
- stiching,
- straps,
- studs,
- buttons and buttonholes,
- maximum three cuts on the fabric.

Folded coats can be realised by using:

- stiching,
- overlapping,
- buttons and buttonholes,
- belts.

4. CASE STUDIES

4.1. Form studies for the folded coat types

In the course of carrying out the studies the student tried first to form the textile around a body, using a trapezium shaped part and two triangle shaped parts. Later the fabric was divided into several pieces but the student took care of avoiding the effect of frittering the product away.

The first studies were performed in small size to save both material and time. The mock ups were made for a wooden dummy. From a certain aspect the dummy properly followed the proportions of the human body, although from sartorial point of view it proved imperfect, it was suitable as a starting point. The width of the fabric was determined on the basis of the distance between the arms of the dummy. The mock ups resulted in exciting silhouettes even in the case of mock ups having identical patterns.

4.1.1. List of requirements

For the designing of the collection it is important to summarize the general quality and technological expectations to be met by the pieces. Zero waste: The goal is that the individual pieces could be constructed without the formation of sartorial waste.

Longevity: It should not contain the extreme style features of the current fashion and it could be blended in the existing fashion trends.

Simplicity: Application of pure forms and lines that facilitate and shorten the manufacturing process.

Comfort: The cut and form of the coat should satisfy the ergonomic and physiological requirements, make the free motion of the body possible. The coat should be manufactured with the use of high-quality materials.

Uniqueness: Novel use of Geometric lines in the spirit of zero waste (Figure 8).

Figure 8. A prototype from the collection of Daniella Bolla [8]

4.2. Form studies for draped dresses

The global shape is formed by applying local rules.

4.2.1. Form 1

For gaining a Greek silhouette 3 meters of chiffon was used but in this case with the help of strap-keepers and rubber-keepers. The sculpted look needed two diagonal and two horizontal keepers in the front and in the back while the fabric was gathered on the shoulder as well. In the middle of the fabric 30 centimetres long cut hole was made for the head. The only decoration is the lilac satin ribbon. (Figure 9)

Figure 9. The greek silhouette by Anna Herendi [8]

4.2.2. Form 2

Straps play important role in the folded mini dresses as looping them in a very decorative way. 5 pieces of 170 centimetre long straps were laced up thought three strap-keepers with the help of which several different shapes could be gained. (Figure 10)

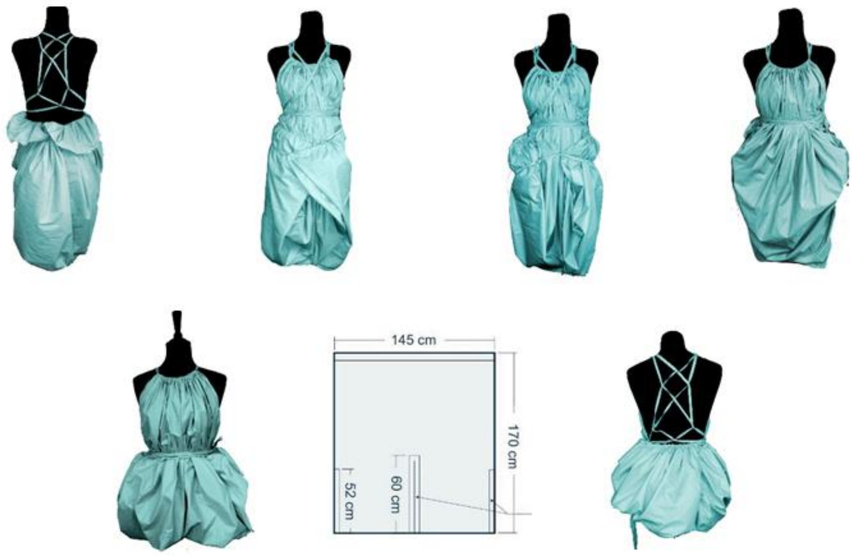


Figure 10. Draping with straps by Krisztina Szegedi [8]

CONCLUSIONS

We all know that sustainability isn't just one thing like organic cotton or wind energy, or not using PVC or genuine leather, but involves thousands of other small steps that help to replace what we have taken from the environment. Fashion designers have to consider the impact they have on the planet as they design clothing, and manufacture products considering the future of ethical design. The highest quality they create the better step they do.

In the course of doing their research work of this type the students bear in mind, all the time, the question of corporate social responsibility. The pieces of their collections can be constructed with zero waste and their technologies bring not only environmental protection benefits but also they have positive consequences concerning manufacture and economy.

The zero waste tailoring improves the manufacturability. As a result of using the geometric cut lines, the work processes become shorter and the production gets cheaper. The cost of textile waste management ceases, too, as no unnecessary waste remains in the course of the manufacture, thus the time and energy, to be spent on this, can also be saved. The prototypes of students demonstrate that the subject of these studies is really very inspiring and leading to different solutions with the help of the method used. This is a creative process which is a real design problem and the conclusions give solutions for further ideas.

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PESTICIDE CONTAINER MANAGEMENT STATUS AND PERSPECTIVES IN SERBIA

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Abstract

Objective of the paper is to give the overview of the current situation in Serbia regarding management of used pesticide containers. Based on EU Member States experience in this field, analyze the possibilities for management of the containers and identified the obstacles for its development. The use of pesticides has increased rapidly in low and middle income countries over the last decade. Appropriate management of used pesticide containers is important issue for protection of human health and the environment in these areas. In order to reduce the risk in the application of plant protection products, good management of packaging and packaging waste, before and after the use of the product in it, is of paramount importance. In Serbia, use of pesticide is growing every year. Majority of used pesticides, are not managed properly and disposed in nearby non-controlled landfills or left in field. In European Union range of actions are undertaken, through the legal framework and establishment of container management programs, to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment. Solving the problem of hazardous packaging waste from plant protection products in Serbia encounters numerous obstacles. Main problem is the lack of experience in this field requires us to be more aware of the management system for this type of waste in the EU Member States. In addition, it is important to raise awareness of the proper handling of packaging waste from plant protection products, from the manufacturer to the end users. We can conclude that improvement of pesticide packaging waste should be based on two models of management of this type of waste: voluntary and legally prescribed, implemented throughout the EU.

Keywords*: waste management, hazardous waste, pesticide containers, EU accession country*

1. INTRODUCTION

In particular phases of intensive farming, use of pesticides are common, and they results in the generation of hazardous waste. Due to lack of knowledge and guidelines for management of pesticide waste packaging, hazardous chemicals pose a great environmental risk. In many developing countries, frequent reuse of contaminated pesticide packaging has been identified as well, which pose a health risk [1].

Over the past 50 years, the use of pesticides in the world has undergone changes and it has grown as result of high population demand for food, because of population growth [2].

Fungicides, herbicides and insecticides are the most important products for the protection of plants in agriculture. The most dominant group of pesticides are fungicides and herbicides, while insecticides are less used [2].

Europe is the largest pesticide consumer in the world, while Asia is second, followed by North and South America. China, the United States, Argentina, Thailand and Brazil are at the same time, individually by country, the world's largest producers and consumers of pesticides [3].

The total quantity of pesticides sold in tonnes of active substance in 20 European countries in 2005 was about 340.000 tons. The total quantity of pesticides sold in 2008 and

2009 was 330.814 and 291.406 t, respectively, while in 2010 it amounted to 281.000 t. Based on these data, there is a clear tendency of declining pesticide sales. Total reduction of the amount of pesticides on the European market for 2009 is 12.8% or 43.000 t and the downward trend is much similar in the past few years [4].

In 2014, the total amount of pesticide sales in the EU-28 amounted to close to 400.000 tonnes. Fungicides and bactericides were the most sold group of pesticides with a 44% share, followed by herbicides [5].

Pesticide packaging waste due to its origin, composition and/or concentrations of dangerous substances has hazardous characteristics (toxicity, ecotoxicity, flammability, etc.) and is harmful for the health and lives of people, as well as the environment [6]. First of all, pesticide residues pollute the water and soil ecosystems and can affect the health of humans and animals. Furthermore, pesticide containers are made of plastic, which degrades very slowly and affect the quality of the environment.

However, there are very few data on collected and recycled containers from pesticides. In most countries, different container management programs are established, for containers collection, depending on the empty containers classification (hazardous or non-hazardous waste).

2. METHODOLOGY

Pesticide packaging waste management in eu

In the packaging industry, since the 1980s, an approach that focuses on the life cycle of packaging has been followed and has been developed to include a wide range of actors. Its main goal is to achieve a safe and sustainable management of waste packaging material from plant protection products throughout Europe, whereby it is considered as a potential valuable resource [7].

The European Plant Protection Association (ECPA) estimates that around 34.000 tonnes of packing material from the plant protection products (PPP) is being marketed every year on the European market. France, Italy, Spain, Germany, UK, Portugal, Poland and Turkey are placing the largest quantities of packaging on the market. At least 80% of the packaging of plant protection products consists of plastic packs, mostly HDPE (high density polyethylene) and PET (polyethylene terephthalate), while the rest is based on paper and thin film. Plastic packaging is most often used for the packaging of liquid preparations and composites, and paper for solid formulations [7].

According to a study on the classification of this type of packaging waste in European countries, which was carried out by ECPA in 2006 a different approach has been identified for the classification of the rinsed packaging waste within the EU, with at least a third of countries classifying this packaging as hazardosus waste. In some countries it was not possible to get data, because this problem has not yet been considered by the competent institutions. This level of inconsistency across Europe has major current and future consequences for the collection and reuse programs of the pesticide packaging waste [7].

Regarding the handling the packaging waste, ECPA member companies have developed and implemented a voluntary industry standard relating to the plastic packaging of PPP and subsequently accepted by the industry as a whole. This standard ensures easy discharging of the packaging, swelling of the product from it, rinsing and recycling [7].

The result of the implementation of this standard allows farmers to effectively decontaminate the packaging by washing and drying. The rinse water can then be applied to the crops so that additional waste is not generated. In addition, complete discharge of the packaging is achieved by rinsing, so that there is no residual content in it [7].

The handling, storage and transport of pesticides are regulated by a series of European and national regulations preceding the Directive, and NAPs in many cases provide little detail in this area.

All six members have systems for safe disposal of empty packaging and pesticide residues. Germany and the Swedish pesticide industry apply a voluntary system for the disposal of empty pesticide packaging. In the Netherlands, the system is jointly implemented by industry and public authorities, and almost 100% of packaging is disposed of in this way. On the other hand, the system of safe disposal of empty packaging in Poland is a legal requirement, without any costs for farmers, and only half of the total used packaging is collected and disposed of using this system [8].

In Germany, the pesticide industry has established a voluntary system for the disposal of empty pesticide packaging more than 20 years ago. All 17 types of packages accepted under this scheme must be triple rinsed. There is no fee for this scheme and it is estimated that 75% of the total pesticide packaging is being disposed of through this scheme. Italy provided an example of reducing administrative burden for professional pesticide users. In their case, all companies involved in the storage, processing and disposal of waste, including empty containers for pesticides and residues, must be authorized and must keep records of hazardous waste on behalf of their clients. This record-keeping is carried out at the national level using the Web Waste Tracking Platform, which facilitates the monitoring of empty pesticide and hazardous waste packaging from the user to the collection centre, and on the other hand reduces the administrative burden for individual professional users [8].

Based on the EWC (European Waste Catalog) it is possible to establish the classification of waste packaging from the PPP because the EWC links the classification of certain categories of hazardous waste with the concentration of hazardous substances in the waste. The classification of waste packaging from the PPP depends on the quantity of hazardous substances that remain in the bottle after rinsing, in accordance with the European waste catalog [4].

Packaging from PPP is considered hazardous waste if it contains biocides and agrochemical preparations (pesticides) in a certain percentage, and the limit values of the amount of residue in the packaging varies from 1.000 to 250.000 ppm depending on whether the substance is very toxic, corrosive, irritant or harmful [9].

According to ECPA analysis of data from the survey involving 180 samples of rinsed packaging from the PPP, it was concluded that the average rinsing efficiency, whether triple or integrated, is 0.008% of the contaminating residue. These claims are confirmed by other studies that have shown that the percentage of the contaminating residue in the packaging by rinsing is reduced to below 0.01%. These results clearly point to the fact that packages of PPP, and even those containing residues classified as very toxic, can be classified as non-hazardous waste after adequate rinsing [4].

Within European Union, there is several legal documents which regulate management of pesticide packaging. Directive 2009/128 / EC of the European Parliament and of the Council on sustainable use of pesticides, was adopted on October 21, 2009 under the Thematic Strategy on Sustainable Use of Pesticides from 2006. The Directive determines a series of actions to achieve sustainable use of pesticides in the European Union. The emphasis is on reducing the risks and impacts of pesticide use on human health and the environment, as well as promoting integrated pest control and alternative approaches or techniques, such as non-chemical alternatives to pesticides [10].

In order to obtain comprehensive statistics on the sale and use of pesticides in the EU, Regulation (EC) No 1185/2009 sets out the rules for the collection of data for each Member State.

Article 13 of the Directive 2009/128/EC requires Member States to ensure that the handling and storage of pesticides and treatment of their packaging and remnants do not endanger human health or the environment. The Directive identifies specific measures that Member States are required to include in their plans for proper implementation. The main actions relate to training of users, advisors and distributors, inspection of pesticide application equipment, the prohibition of aerial spraying, limitation of pesticide use in sensitive areas, and information and awareness raising about pesticide risks. A cornerstone of the Directive is the promotion of integrated pest management (IPM), for which general principles are laid down in Annex III to the Directive [10].

The deadlines established by the Directive for implementation of all above measures were phased over the period November 2011 to November 2016. Since November 2016, (when inspection of pesticide application equipment inspection became compulsory), Member States have been required to implement all the relevant measures of the Directive. Member States were required to adopt National Action Plans (NAPs) to implement the Directive for the first time by November 2012. These plans should contain quantitative objectives, targets, measurements and timetables to reduce the risks and impacts of pesticide use [10].

Systems for controlling the handling and storage of pesticides are in place in nearly all Member States, their effectiveness cannot always be assessed due to the lack of measureable targets (Report to EU). In 2016, 25 Member States had put in place systems for the collection and safe disposal of empty containers and packaging of PPP, and in 21 Member States, these systems extend to the collection and safe disposal of obsolete and expired pesticides and their remnants.

In Serbia, by entering into force of the Law on Packaging and Packaging Waste and defining the National Packaging Management and Packaging Waste Management Objectives, all responsible entities for packaging and packaging waste management; importers or producers of plant protection products are obliged to ensure adequate disposal of packaging waste.

The Law on Waste Management defines the management of packaging and packaging waste in which it is stated that materials used for packaging must be produced and designed in a way that they fulfill conditions of environmental protection during their life cycle, safety and health of people, health safety of the packaged product, as well as conditions for transport of products and waste management. As well as packaging and packaging waste is managed in accordance with a special law [11].

According to Article 70 of the Law on Plant Protection, a pesticide or fertilizer can be placed on the market only in the original packaging of the prescribed species for the purposes specified in the permit for its placing on the market, the manner specified in the user guide [12].

The conditions for pesticide trade are given in Article 31 of the Law on Plant Protection Products stating that registered plant protection products can be put into traffic if their packaging is safe for human health and the environment.. The declaration and the instructions for the use of plant protection products must also include specific labelling of risks and warnings for humans and the environment [13].

Law on Chemicals, Ordinance on types of packaging for pesticides and fertilizers and on the destruction of pesticides and fertilizers and the Ordinance on the contents of the declaration and instructions for the use of plant protection products as well as the specific requirements and labels of risks and warnings for man and the environment and the way of handling the empty packaging of plant protection products also prescribe the requirements that the pesticide packaging must meet [14][15][16].

Regarding, management of pesticide waste containers in Serbia, Envipack, Secopack and PWW that takes over the pesticide packaging on the territory of the Republic of Serbia (at the expense of foreign and domestic producers of chemical plant protection products) are the operators who are invited by consumers, and the arrangement and assistance in the organization can be provided by associations, local communities, producer groups and agricultural pharmacies.

From 2006 to 2014 (data from the Ministry of Agriculture, Forestry and Water Management, Plant Protection Directorate), the amount of imported plant protection substances increased from 2.356 tonnes to 10.811 tonnes. Also, there are 947 registered companies that distribute and import plant protection products in Serbia [17].

In 2017 Envipack collected and disposed of 43.6 tons of discharged packaging produced by GalenikaPhytopharmacy, which was 23.5% more than in 2016. From the location of GalenikaPhytopharmacy, about 37 tons of raw materials for the production of plant protection products were collected during the year, which is 40.3% less than in 2016, when it was collected about 62 tons [17].

The total number of registered pesticides in 2017 on the Serbian market was around 1.250. The largest number of registered products are by foreign generic companies (51.5%), followed by products of development research companies (24.1%) and products of domestic producers (24.4%). GalenikaPhytopharmacy, as the largest domestic producer, participates with 138 products in the Serbian market or 45% of the total number of domestic registered products. Individual market participation of companies is difficult to determine precisely because official data are not available [17].

3. RESULTS AND DISCUSSION

Based on European practice in management of packaging waste pesticides, we have identified obstacles to implementation of PPP waste management. There are a number of facts that pose the greatest challenges for the establishment of a system for disposal of hazardous packaging waste. First of all there is no warehouse for the storage of hazardous PPP packaging waste and there is no a company that has a license for the export of hazardous waste from Serbia. Another problem is lack of cement factory in Serbia with adequate equipment and permission for destruction of hazardous packaging waste from PPP. The problem of wastewater due to possible contamination of soil and water during the rinsing of the packaging also must be solved and the procedures for sampling and analysis of collected packaging waste (eco-test) on plant protection agents (maximum residue: 0.01%) must be adopted. Besides all this, the lack of experience in this area is also a problem.

The most important expected challenges in the process of realization of the system for disposal of non-hazardous packaging waste are adequate rinsing of the packaging, inspection during the collection of packaging that should be carried out by an independent and trained person and poor experience in recycling this type of waste: qualified and reliable recycling (recycler).

Throughout the EU there are two models for managing this type of waste: voluntary and legally prescribed.

The model of a voluntary system is a model on the principle of a voluntary agreement, that is, a model by which the system is formed by a polluter without a legal obligation or pressure from the authorities to do so. Organizations that have established systems based on a voluntary agreement have included manufacturers, wholesalers and small and non-governmental organizations. Manufacturers and sellers have established many such systems based on a voluntary agreement around the world as a component of a program for managing finished products. Non-governmental organizations initiated the creation of an operator for the management of packaging waste from pesticides as pilot projects. Later, these pilot projects turned into mature systems that solved the issue of this type of packaging waste. Operators based on a voluntary agreement can be successful, especially where all suppliers are part of a trade association and participate in the system. However, some stores are also supplied with pesticides whose producers are not members of trade associations and do not want to be part of a voluntary system. Financing the collection of their packaging is currently underway. In the long run, this is unacceptable. Companies that are part of the system are discouraged by this and it can easily happen to slowly exit one at a time from the system.

A sustainable collection system for packaging waste from pesticides is only feasible if funding is provided. This is most easily achieved when the operator is legally authorized. Legally authorized operators are those operating within the framework of national legislation. Generally, as it is mandatory to register and authorize the preparation, it is therefore necessary to participate in the collection system for packaging waste, to be a member of the operator. If the state chooses to legally authorize the operator, a viable source of funding may be established by legal or sub-legal acts. Where a pesticide supply fee is established, they are all obliged to fund the system. This avoids the problem of "free-riders" (companies outside the system) that appear in the voluntary agreement system, as mentioned above. Threats to be established by legally prescribed operators by the state, it is very often sufficient to approach the establishment of a system based on a voluntary agreement.

Legally authorized distributors can specify the level of services they offer to their clients. A system where it is easy to return empty containers will be much more efficient.

The system must be economically independent if it wants to be sustainable. For legally authorized operators, the government should determine the way in which the system is to be financed: Compensation to suppliers; Tax on the sale of pesticides and General tax.

The system should avoid paying the bail that end users will get back when they return empty containers. The place of return of the empty packaging should be suitable and not too far from the end users.

Whatever the legal basis for the establishment of the system is, it must work in accordance with all applicable laws in the field of environmental protection, waste management and transport.

Of course, it is necessary to promote the waste management hierarchy, so that the collected packaging waste should be treated in the following order of priority:

1. Recycling
2. Thermal treatment:

- incineration: Serbian legislation on incineration should be developed and implemented in accordance with the process of issuing permits for incineration plants, all in accordance with the Waste Disposal Directive.
- co-incineration in the process of clinker production in cement plants. In this case, plants from Serbia should continue to invest in order to fulfill all the necessary legal requirements needed to become hazardous waste operators.
- plastic packaging can also be used as an alternative fuel in high-speed furnaces for the production of steel in the process of reducing iron ore.

3. Disposal at an adequate landfill for that type of material, if any.

Taking into account the above recommendation, it is necessary to implement the system of primary pesticide packaging with triple rinsing of primary pesticide packaging with an operator that would be controlled by the ministry responsible for environmental protection, following the fact that recycling is done only in plants that can to ensure the traceability of finished products or to co-incineration in cement factories. The last option is conditioned by the fact that the cement industry is granted a permit for the re-use of such waste.

However, management of hazardous waste, including pesticide waste packaging should be collected separately to ensure that such half-empty packaging does not reach the system of collection and treatment of non-hazardous municipal waste. Other legal acts, including NAP, that will be adopted in the future in the Republic of Serbia need to strength the legal framework, increase the capacity building for sustainable pesticide waste management, including management of pesticide waste containers.

Conclusions

The Serbian authorities need to develop a collection system for hazardous packaging waste, taking into account lessons learned from EU Member States in combination with specific national conditions. In addition, in order to ensure the sustainability of the hazardous packaging waste system, the legal framework need to be further developed under the Law on Packaging and Packaging Waste and also to be implemented in other area, i.e. agriculture legal framework.

Municipal hazardous packaging waste should be collected in a special way, especially one containing active substances. Combined collection is also one of the options that can be proposed (certain days to organize collection by the local government or companies entrusted with these jobs or/and through collecting points where citizens would bring such a type of waste). Information campaigns should emphasize the need for adequate collection, storage and treatment in order to reduce the negative impacts on the environment.

The largest number of EU member states has implemented a separate collection for municipal hazardous waste since the early nineties of the last century. Some countries have introduced separate collection through strategic documents, not through regulations. Various collection systems have already been established, but most countries rely on active public participation, such as free collecting in collection centers.

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TOXIC EFFECTS OF HEAVY METALS (CU, ZN, PB, CD) ON EARLY GROWTH OF THREE TAGETES SPECIES

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Abstract

Objective: Heavy metals in soil pose potential threats to the environment, therefore remediation of heavy metal contaminated sites is an important issue. Tagetes species have been proposed as potential plants for phytoremediation of heavy metal contaminated soil. Although much research has been carried out previously to investigate the bioaccumulation ability of Tagetes species, little information is available on the toxicity of metals on these plants. Therefore, our objective was to investigate the toxic effects of heavy metals on these plants. Methods: In our study a seed germination test was conducted to measure the toxic effects of four heavy metals (Cu, Zn, Pb and Cd) on early growth of three different Tagetes species (Tagetes erecta, Tagetes patula and Tagetes tenuifolia). Results: Our results showed that all tested heavy metals had significant ($p<0.05$) toxic effects on seed germination and root/shoot elongation of the three plants. On the basis of IC_{50} values (concentration of a heavy metal which causes 50% inhibition) the following series of phytotoxicity was observed: Cd>Cu>Zn>Pb. Tagetes tenuifolia was the most sensitive plant to heavy metals, while Tagetes erecta and Tagetes patula were able to tolerate low concentration of metals (below 400 mg l^{-1} Cu, Zn, Pb, and below 16 mg l^{-1} Cd) without considerable decline in the measured growth parameters. However, our experiment was carried out under laboratory conditions, and the seeds were germinated in hydroponic solution, which means that these values could be much higher in natural soils. Conclusion: Our results indicate that Tagetes erecta and Tagetes patula could be suitable for remediating moderately heavy metal (Cu, Zn, Pb and Cd) contaminated soils. With the advantage that these plants can also beautify the environment, using them for phytoremediation has an important and practical significance.

Keywords: *heavy metals, phytotoxicity, Tagetes erecta, Tagetes patula, Tagetes tenuifolia, phytoremediation*

1. INTRODUCTION

Numerous studies have shown that heavy metals in soil pose potential threats to the environment [1-4]. Pollution sources of heavy metals mainly derive from anthropogenic sources such as agriculture, urbanization, industrialization, and mining [4-8]. Some heavy metals such as Zn and Cu are essential elements for many physiological progresses in low quantities, while others like Cd and Pb are without known biological function.

In excessive concentrations both essential and non-essential metals can be toxic to living organisms and endanger the health of humans and animals through the food chain [2, 3, 7, 9, 10]. In addition, heavy metals cannot be chemically or biologically degraded as organic pollutants, therefore they can be accumulated at relatively high concentrations in the topsoil [2, 11]. For these reasons, increasing attention has been paid in recent years to the remediation of heavy metal contaminated soils [10-12].

Phytoremediation is proposed as a cost-effective, environmental friendly and sustainable technique for restoration of these sites [13-15]. In recent years much research has been conducted to investigate the phytoremediation ability of ornamental plants [10, 12-14, 16, 17]. These plants have some advantages compared to other kinds of remediation plants: 1. They are apart from the food chain; 2. They can beautify the environment; 3. they usually have high biomass; and 4. ornamental plant industry improve new plant varieties with great stress tolerance and disease resistance [10, 12, 17, 18] Therefore, soil remediation with ornamental plants could be useful, especially in contaminated urban areas, where people have greater environmental requirements [10, 12].

Marigolds have been proposed as potential plants for phytoremediation of heavy metal polluted areas [19-21]. In most of the experiments common marigold (*Calendula officinalis*) were used as a test plant, but remediation potential of *Tagetes* species were also investigated.

Previous studies shown that African marigold (*Tagetes erecta*) can be utilized for the remediation of soils polluted by Cd, because it can accumulate high Cd content in its above-ground tissues [14, 21-24]. In Goswami & Das's (2017) study *T. erecta* accumulated Cd in the range 1719 to 3519 mg kg^{-1} dry weight, which is far above the average toxic (5–10 mg Cd kg^{-1}) ranges in other plants [21, 25]. According to other studies French marigold (*Tagetes patula*) can also hyperaccumulate Cd from combined contaminated soils [26, 27]. *T. erecta* and *T. patula* have also shown quite good capability to accumulate Pb [23, 28, 29]. According to Shah et al. (2017) Pb accumulation potential of *T. erecta* is higher at lower concentrations of Pb [29]. Afrousheh et al. (2015) classified *T. erecta* as a Cu tolerant species [30]. *T. erecta* can accumulate Cu within 2438 to 3767 mg kg^{-1} dry weight, which is far beyond the toxic (20–100 mg Cu kg^{-1}) ranges in other plants [21, 25]. According to Castillo et al. (2011) *T. erecta* colonized with *Glomus intraradices* can potentially phytostabilize Cu in contaminated soils [31]. *T. patula* also can accumulate Cu in its root tissues [26, 28]. Other studies have also revealed that *Tagetes* species bioaccumulate Zn, Cr, and Fe in its tissues [20, 24, 26].

High levels of heavy metals have the potential to become toxic to plants [7, 25, 32]. Much research has been conducted to investigate the bioaccumulation ability of *Tagetes* species, however, little information is available on the toxicity of heavy metals on these plants. According to Lal et al. (2008) and Goswami & Das (2017) both Cd and Cu stress reduce *T. erecta* biomass, which is unfavorable at phytoremediation [14, 21]. Wang & Zhou (2005) observed that 10 mg l^{-1} Cd in hydroponic solution had an obvious toxic effect on the root elongation of *T. erecta*, however it had little effects on seed germination and shoot elongation [16]. According to Shah et al. (2017) Pb accumulation *in T. erecta* had a very less negative effect on its growth parameters [29].

Seed germination tests are widely used to assess acute toxicity effects of different chemicals. Besides the germination rates of seeds, short-term shoot and root elongation are also often measured. The aim of this study was to compare the effects of selected metals on seed germination and shoot/root elongation of African marigold (*Tagetes erecta*), French marigold (*Tagetes patula*), and Signet marigold (*Tagetes tenuifolia*). In addition, we would like to determine which *Tagetes* species can tolerate the greatest amounts of heavy metals, and we would like to assess what is the highest amounts of metals which can be tolerated by tested plants without considerable decline in germination and shoot/root elongation. Results of this study provide new information for using *Tagetes* species to remediate heavy metal contaminated soil.

2. Materials and methods

Three different marigold species were used in the experiment: African marigold (*Tagetes erecta*), French marigold (*Tagetes patula*) and Signet marigold (*Tagetes tenuifolia*). Seeds were obtained from Rédei Kertimag Seed Trading Ltd. Heavy metal concentrations used in this experiment were based on previous studies [12, 14, 16, 21, 23, 29]. Pb, Zn, and Cu concentrations in the test solution were 0, 50, 100, 200, 400, 800, 1600, 3200, 6400 mg l^{-1}, while Cd concentrations were 0, 1, 2, 4, 8, 16, 32, 64, 128 mg l^{-1}. Heavy metals were added as $Pb(NO_3)_2$, $ZnSO_4*7H_2O$, $CuSO_4*5H_2O$, $Cd(CH_3CO_2)_2*H_2O$, which were obtained from Reanal Laboratory Chemicals LLC.

The experimental procedure was as follows: 3 g cotton-wool was placed in plastic pots (height: 40 mm, diameter: 120 mm) and moistened with approx. 50 ml test solution with a specific heavy metal concentration.

Twenty-five seeds were laid on cotton-wool pads and exposed to the solutions under controlled conditions. The pots were sealed with cellophane and set under a photoperiod of 12 h light and 12 h dark, and 25±1 °C temperature. After six days (144±1 h), the number of germinated seeds was recorded, and plant root and shoot elongation were measured. The experiment was conducted in a completely randomized design with four replications.

The data were recorded as means±standard deviations and analyzed by SPSS (version 25) and Graphpad Prism (version 6). Two-way analysis of variance (ANOVA) and Tukey multiple comparisons were carried out to test for any significant differences between the means. IC_{50} values (heavy metal concentration that cause 50 % inhibition effects on seed germination and root/shoot elongation) were determined after normalization with a log-logistic dose-response model. A 95 % significance level ($P < 0.05$) was used for all statistical analysis.

3. Results

Toxic effects of heavy metals on seed germination

Effects of heavy metals on seed germination of *Tagetes* species are shown in Figure 1. Germination rates were 89±3.83 %, 91±2.00 % and 55±3.83 % for *T. erecta*, *T. patula* and *T. tenuifolia* in control. Increasing concentration of heavy metals in the test solution significantly ($p<0.05$) decreased the germination rates of all tested species.

T. erecta and *T. patula* had significantly ($p<0.05$) higher germination rates than *T. tenuifolia* in all heavy metal treatments except for above 800 mg Cu l^{-1} concentration. There was a slight increase in germination rate of *T. tenuifolia* at 50 mg Cu l^{-1} concentration, however all three plants had less germination rates at 100 Cu mg l^{-1} compared with control. At highest Cu treatment dose (6400 mg Cu l^{-1}) germination was not noticeable. Zn also significantly reduced germination rates firstly at 100 mg Zn l^{-1} concentration compared with control, however the decline in germination rates of *T. erecta* and *T. patula* was less than Cu in all concentration. On the contrary, Zn was more toxic to *T. tenuifolia* than Cu. *T. tenuifolia* was not germinated above 800 mg Zn l^{-1}. Pb was the least toxic heavy metal to *T. erecta* and *T. patula*, because germination rates of these plants were the highest in all treatment concentration.

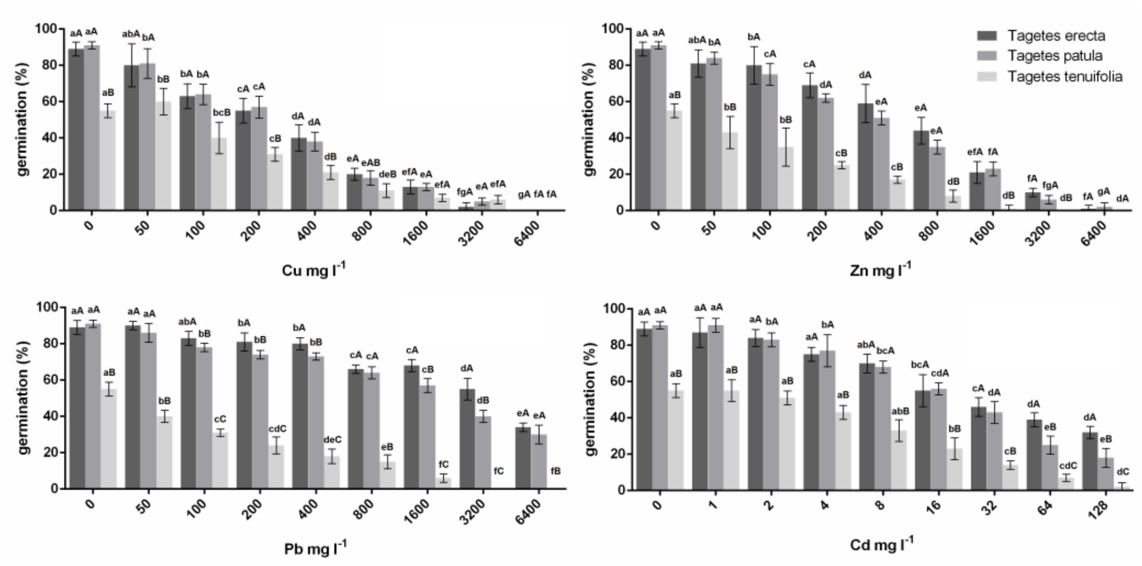

Figure 1. Seed germination (%) of *Tagetes* species exposed to different concentrations of heavy metals. The error bar represents standard deviation (n = 4). The same small letter above the column means there is no significant difference between the means of seed germination at different heavy metal concentration, and the same capital letter means there is no significant difference between the means of seed germination among plants by Tukey's multiple test (P <0.05).

From 100 to 3200 mg Pb l^{-1} concentration (except for 800 mg Pb l^{-1}) *T. erecta* had higher germination rates than *T. patula*. *T. tenuifolia* was more sensitive to Pb than the other plants, and it was above 1600 mg Pb l^{-1}. Cd toxicity is tested in much lower concentrations than other heavy metals. 4 mg Cd l^{-1} concentration significantly decreased the germination rates of all plants compared with control. At higher Cd treatment dose (64 and 128 mg Cd l^{-1}) germination rates of *T. erecta* were significantly higher than *T. patula*.

Toxic effects of heavy metals on root elongation

All tested heavy metals had a significant effect ($p<0.05$) on root lengths of the three plants. Root lenghts were 3.29±0.27 cm, 3.25±0.11 cm and 1.95±0.29 cm for *T. erecta*, *T. patula* and *T. tenuifolia* in control, and they were significantly reduced with increasing heavy metal concentration. Inhibition on root elongation was firstly observed at the lowest concentration (50 mg l^{-1}) of Cu, Zn and Pb, and at 2 mg Cd l^{-1}. The results are shown in Figure 2.

T. erecta and *T. patula* had significantly ($p<0.05$) higher root lengths than *T. tenuifolia* in all treatments except for those receiving more than 100 mg Cu l^{-1} and 1600 mg Zn l^{-1} concentration. Cu was the most toxic heavy metals to plant root formation. 100 mg Cu l^{-1} caused more than 50 %, while 800 mg Cu l^{-1} caused more than 90 % decline in root lengths of all plants. Zn had very similar effects to Cu. It decreased root lengths by 50 % firstly at 200 mg Zn l^{-1}, and by 90 % at 200 mg Zn l^{-1}. Pb also inhibited root elongation; however it was less toxic than Cu and Zn. More than 50 % inhibition on root elongation of *T. tenuifolia* was observed at 400 mg Pb l^{-1}, while it was occurred only at 800 mg Pb l^{-1} in the case of *T. erecta* and *T. patula*. Similarly to the results of germination rates, Cd was the most toxic heavy metals to plant root formation. 8 mg Cd l^{-1} decreased root lengths by more than 50 %, while 128 mg Cd l^{-1} decreased it by more than 90 %.

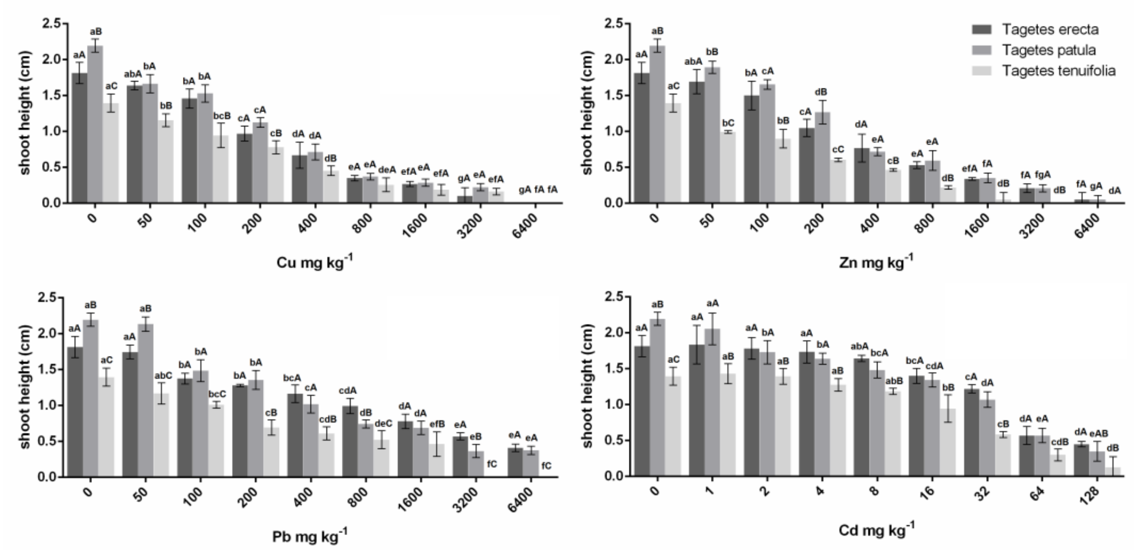

Figure 2. Root lengths (cm) of Tagetes species exposed to different concentrations of heavy metals. The error bar represents standard deviation (n = 4). The same small letter above the column means there is no significant difference between the means of root lengths at different heavy metal concentration, and the same capital letter means there is no significant difference between the means of root lengths among plants by Tukey's multiple test (P <0.05).

Toxic effects of heavy metals on shoot elongation.

Effects of heavy metals on shoot elongation are shown in Figure 3. Shoot heights were 1,82±0.15 cm, 2.20±0.10 cm and 1.40±0.13 cm for *T. erecta*, *T. patula* and *T. tenuifolia* in control. Shoot elongation was also significantly ($p<0,05$) inhibited by increasing concentration of heavy metals,
however less toxic effects were observable compared with the results of root elongation.

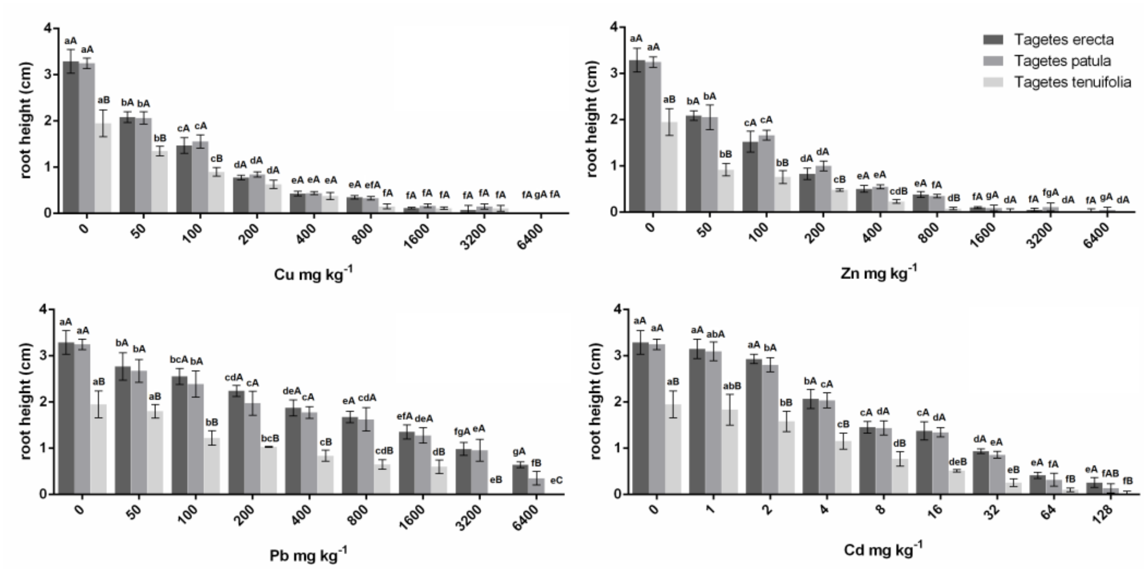

Figure 3. Shoot heights (cm) of Tagetes species exposed to different concentrations of heavy metals. The error bar represents standard deviation (n = 4). The same small letter above the column means there is no significant difference between the means of shoot heights at different heavy metal concentration, and the same capital letter means there is no significant difference between the means of shoot heights (cm) among plants by Tukey's multiple test (P <0.05).

T. erecta and *T. patula* had significantly ($p<0.05$) higher shoot heights than *T. tenuifolia* in all treatments except for above 400 mg Cu l^{-1} and at the highest concentration of Zn (6400 mg Cd l^{-1}) and Cd (128 mg Cd l^{-1}). Cu and Zn significantly reduced shoot heights of *T. patula* and *T. tenuifolia* firstly at 50 mg l^{-1} concentration compared with control. 400 mg Cu l^{-1} caused more than 50 %, and 3200 mg Cu l^{-1} caused more than 90 % decline on shoot heights of all three plants. Similarly to Cu, Zn also decreased plant shoot heights by 50 % at 400 mg l^{-1} concentration; however 90 % decline was observed only at the highest concentration (6400 mg Zn l^{-1}). Pb was toxic to plants firstly at 100 mg l^{-1} concentration. Shoot heights of *T. patula* and *T. tenuifolia* is decreased by 50 % firstly at 400 mg Pb l^{-1}, while only 1600 mg Pb l^{-1} reduced shoot heights of *T. erecta* at such a rate. At 50 mg Pb l^{-1} *T. patula* had significantly higher shoot heights than *T. erecta*, however at 800 and 3200 mg Pb l^{-1} *T. erecta* had higher shoot heights. Cd was the most toxic heavy metals to plant shoot heights. 2 mg Cd l^{-1} concentration significantly decreased the shoot heights of *T. patula* compared with control, while inhibition of shoot elongation was observed firstly at 16 mg Cd l^{-1} concentration for *T. erecta* and *T. tenuifolia*. 50 % decline on shoot heights were firstly at 32 mg Cd l^{-1} for *T. patula* and *T. tenuifolia*, and at 64 mg Cd l^{-1} for *T. erecta*.

Ecological toxicity based on IC_{50} values

IC_{50} values confirm previous results. All heavy metals used in this experiment were the most toxic to root elongation. Cu, Zn and Pb were least toxic to seed germination, while Cd was least toxic to shoot elongation (Table 1.).

Table 1. IC_{50} values of heavy metals (heavy metal concentration that cause 50 % inhibition effects) in *Tagetes* species based on seed germination and shoot/root elongation.

IC_{50} (mg l^{-1})		African marigold (*Tagetetes erecta*)	French marigold (*Tagetes patula*)	Signet marigold (*Tagetes tenuifolia*)
Cu	Seed germination	290.0	277.0	233.9
	Shoot elongation	261.4	199.5	220.5
	Root elongation	79.9	85.1	97.1
Zn	Seed germination	644.9	446.6	167.6
	Shoot elongation	310.4	249.8	158.6
	Root elongation	82.1	90.2	51.9
Pb	Seed germination	1462.0	812.7	154.5
	Shoot elongation	418.8	231.6	302.6
	Root elongation	349.2	380.8	286.3
Cd	Seed germination	12.2	15.5	11.2
	Shoot elongation	27.57	12.84	20.95
	Root elongation	7.3	7.7	5.9

IC_{50} values were determined after normalization with a log-logistic dose-response model.

There was no considerable difference in IC_{50} values among the three plants at Cu treatment. IC_{50} values were between 233.9 and 290.0, 199.5 and 261.5, 79.9 and 97.1 for seed germination, shoot elongation and root elongation. *T. erecta* was the least, and *T. tenuifolia* was the most sensitive plant to Zn treatments. The IC_{50} values based on seed germination were shown the greatest difference among plants. These values for *T. erecta*, *T. patula* and *T. tenuifolia* were 644.9, 446.6 and 167.6 mg Zn l^{-1}.

Large differences in IC_{50} values of the three plants were also observed at Pb treatments. The highest IC_{50} value of the experiment was based on seed germination of *T. erecta* (1462.0 mg Pb l^{-1}), but *T. patula* also had a high IC_{50} value (812.7 mg Pb l^{-1}).

On the contrary, for *T. tenuifolia* IC_{50} value based on seed germination was only 154.5 mg Pb l^{-1}, which is less than at Cu and Zn treatments. The IC_{50} values based on root elongation were 349.2, 380.8 and 286.3 mg Pb l^{-1}, based on shoot elongation were 418.8, 231.6 and 302.6 mg Pb l^{-1} for *T. erecta*, *T. patula* and *T. tenuifolia*. Among the three plants and based on shoot elongation as an indicator, *T. patula* was the most sensitive plant (IC_{50} = 12,84 mg Cd l^{-1}), however based on seed germination and root elongation *T. tenuifolia* was the most sensitive to Cd (IC_{50} = 11,2 and 5,9 mg Cd l^{-1}). *T. erecta* was the least sensitive plant to Cd in all indicator.

4. Discussion

The results showed that all tested heavy metals had significant ($p<0.05$) inhibitory effects on seed germination and root/shoot elongation of the three plants. It is expected, since plant seeds were in direct contact with the toxicity of heavy metals in the hydroponic solution, and inhibition effects of heavy metals on growth parameters of *T. erecta* has been also observed in previous studies [14, 16, 21, 29]. The reason for this is that excessive amounts of heavy metals may cause substantial inhibition of photosynthetic and enzymatic activity, or modification of mineral uptake and internal translocation [7,32].

According to our results heavy metals were the least toxic to seed germination. It is possible that plants absorbed nutrients internally from seed stored materials during germination or heavy metals could hardly penetrate seeds [16, 33]. Heavy metals had the greatest adverse effect on plant root lengths. Root elongation is known to be more sensitive than shoot elongation to heavy metal toxicity, because roots are responsible for absorption and accumulation of metals [7, 33]. In addition to this, roots of *Tagetes* species can accumulate higher amounts of heavy metals than its shoots [12, 29]. Heavy metals had less effect on shoot elongation. Probably, nutrition was provided by seeds after root elongation was inhibited [16].

On the basis of the IC_{50} values (average ranking of the three growth parameters) the following series of phytotoxicity was observed: Cd>Cu>Zn>Pb for *T. erecta* and *T. patula*, and Cd>Zn>Cu>Pb for *T. tenuifolia*. As the results show, Cd is the most toxic and Pb is the least toxic heavy metal to the tested species. Di Salvatore et al. (2008) assessed similar toxicity scales for various species (including lettuce, broccoli and tomato), however in Wong & Bradshaw (1982) studies Cu and Pb was more toxic to ryegrass than Cd [34, 35].

In our experiment seed germination and shoot heights of *T. erecta* were decreased by 50 % compared with control at 64 mg Cd l^{-1}, while root length at 8 mg Cd l^{-1}. Goswami & Das (2017) observed approximately 50 % reduction on root length and shoot/root dry biomass of *T. erecta* only at 300 mg Cd kg^{-1} dose on clay loam soil [21]. In Lal et al.

(2008) experiment shoot heights of *T. erecta* was reduced by 23 % at 32.6 mg Cd kg^{-1} dose on sandy loam soil [14]. Wang & Zhou (2005) determined a 16.1 mg Cd l^{-1} IC_{50} value for root elongation of *T. erecta* in hydroponic solution, which is higher than in our result (7.3 mg Cd l^{-1}) [16]. According to Wang & Zhou (2005), increasing Cd concentrations (0 to 15 mg Cd l^{-1}) increase shoot elongation of *T. erecta*, however there was a significant decline on shoot heights between these Cd concentrations in our experiment [16]. In Goswami & Das (2017) experiment 40 % decline was observed on root lengths and shoot/root dry biomass of *T. erecta* at 400 mg Cu kg^{-1} dose on clay loam soil [21]. Our results showed that 400 mg l^{-1} Cu in hydroponic solution reduce root lengths and shoot heights by 87 % and 63 %. According to Shah et al. (2017) 2500 mg Pb kg^{-1} in soil decrease root lengths and shoot heights of *T. erecta* less than 5 %, however in our experiment 1600 mg l^{-1} Pb concentration in the test solution decreased root lengths and shoot heights by 59 % and 57 % [29].

These comparisons show that in previous studies heavy metals were less toxic to growth parameters of *T. erecta*. The reason for this that hydroponic solution is quite different from natural soils. In soils heavy metal could be tied up in insoluble forms, and they are less available to plants [36]. In addition to this, many factors influence the uptake and the toxicity of metals in natural soils, such as temperature, soil pH, soil aeration, the type of plant and its size, the root system etc. [7, 37]. Although hydroponic experiments have very limited relevance to the natural environment, these researches can be useful in demonstrating the tolerance of a species to heavy metals [38].

Based on our results, *T. tenuifolia* is the most sensitive plant to the tested heavy metals among the three species. In addition, *T. tenuifolia* produce less biomass than *T. erecta* and *T. patula*, which decrease its phytoremediation potential [10, 39]. Between the effects of heavy metals on *T. erecta* and *T. patula*, no considerable differences were observed, however *T. erecta* was more tolerant to high levels of Pb (above 1600 mg Pb l^{-1}) and Cd (above 64 mg Cd l^{-1}). According to our results, these two *Tagetes* species can be used to remediate heavy metal (Cu, Zn, Pb and Cd) contaminated soils, because these plants have higher biomass production and can tolerate higher levels of heavy metals. Moreover, previous studies shown that *T. erecta* and *T. patula* have good capability to accumulate different heavy metals in their tissues [14, 21-23, 26-30].

High levels of heavy metals decrease above-ground biomass of plants, which result in less effective phytoremediation. In our experiment results of shoot heights can indicate the reduction of biomass. IC_{50} values based on shoot elongation (average of the three plants) were 227.1, 239.6, 317.7 and 20.5 at Cu, Zn, Pb and Cd treatment. It means that phytoremediation using *Tagetes* species could be effective below these heavy metal concentrations in soil.

However, our experiment was carried out under laboratory conditions, and the seeds were germinated in hydroponic solution, which means that these values could be much higher in natural soils [36].

It was concluded that all tested heavy metals were toxic to the plants, however *T. erecta* and *T. patula* were tolerant to low concentrations of heavy metals, which means that these plants could remedy moderately contaminated soil.

Therefore, with the advantage that these plants can beautify the environment, using them for phytoremediation in urban areas has an important and practical significance [10, 12]. Adding chelators, applying fertilizers or inoculating plant growth-promoting rhizobacteria (PGPR) to soil may increase the biomass and the phytoremediation ability of *Tagetes* species [10, 22, 40, 41].

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BODY POSTURE CORRECTION CLOTHES FOR CHILDREN

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ABSTRACT

More and more small children are having problems with bad body posture. In the first phase of their lives correction is easier to accomplish. Different types of body posture correctors have been developed for children but most of them do not offer attractive eyesight to children, so they do not like it. OTKA No. 112506. "3D Dynamic Modeling of the Spine", with the help of OE, BME and SOTE, provides the opportunity to develop a body posture corrector in clothes for pre-school children. The aim of the research work is to provide child-friendly children's wear that can effectively help with proper posture, comfortable to wear and the good for the kindergarten children. The research work analyzes the age, physical and psychological development level of the chosen age group, the age-group of three to six years old. I listen to their movement culture, and the motifs, figures and silhouettes they like as well as the kindergarten fashion. I also analyze the possibilities of improving the childish neglect, the aids used, their design, their raw materials and their operating principle. In design the choice of raw materials is a very important aspect, since stability and comfort, and the free space are equally important to children. Body comfort and proper hygiene are large determined by the basic material, technological development and production of clothing. Using smart textiles to improve comfort, we plan to develop maintenance clothing.

Key words: *bed body posture, body comfort, body correction clothes*

1. INTRODUCTION

Good body posture is important for everyone. Bad body posture can eventually lead to severe spinal problems, so it is important to pay attention to correct posture and to correct the problems that are already present. The most common problem is bad body posture or different spinal injuries. There may be several reasons for their development: this may be due to sedentary lifestyle, weakness of the muscles, anatomical problems or just bad habit.

In today's state of science, orthosis supplies already include compression garments made of a special material that is able to stimulate muscles and provide an effective support level to maximize posture stability.

The aim of the research work is to design a child-friendly children swear that can both help the correct body posture, comfort and aesthetically pleasing children's tastes.

During the design of the dress, I analyze the most common childhood spinal problems and the existed medical aids which their used, their raw materials as well as their operating principles. During planning, it is important to choose the raw material, since stability and comfort, and the free space are equally important for the child.

2. CHARACTERIZATION OF 3-6 YEARS OLD CHILDREN

During this time, the child becomes a sensomotorous person who already talks and can interact with other people. Higher intellectual skills develop after two years of age and their development is faster and better if the sensory-motor functions are well developed. In the third to seventh year, it is the most important period of sensory motor integration. The brain of children is the most receptive to the various sensations during this period, and can best handle them at this time.

The children have strong urge to learn. They are interested in everything they are very active. He also learns a lot about his own body. The child's responses are adaptive and become more and more complex. Its sensory-motor integration capacity is developed by each complex response.

The child enjoys movement. They are often seen in running, galloping, jumping. These activities will make them happy because it develops their sensory motor skills. They are regularly pushing their boundaries, trying dangerous things, as they also sharpen their senses, learning through them. Games on the playground also help to improve their nervous system. They sense gravity; they learn to fall, their movement more and more skilful. Children of three or six are already using tools. They use to learn the spoon, fork and knife, but also the shovel, rake, and sieve. Learning all these tasks will build upon the information you have learned and stored previously. For adults, these actions are natural, but body sensations are needed to make the brain aware of how to dig a hole in the sand, pluck the soup into the mouth and put it in our clothes.

At the end of this period, you can see clearly, especially for girls, the refinement of motor skills. They play games like hopping school, jumping rope, clapping hands games for which advanced motor skills are required. Boys in this age are more concerned with building games or with sports. (1)

2.1. The fashion of kindergarten children

At the beginning of kindergarten, children learn how to dress on their own, how to use a zipper, wrap a shoelace, and knit buttons. It is practical to give clothes that are easy to pick up, remove, provide enough freedom to jump, play games and of course easy to clean. Especially they wear a little top with pants, and skirts.

At design, however, it should be noted that at this time the relative size of the head is large enough for the body, so it is advisable to secure a closure at the shoulder of the garment with a button or patent so that the small one can easily hide on the neck of the garment. Most children are dressed in patterns that are applied by different techniques to garments. Many printed textiles are already used, but are also popular with screen printing, printed patterns and puff prints.

In this age, children like to express their own taste, have a strong opinion about what they like and what they do not. They like to express this in their dress, they have definite ideas about what they want to wear. Naturally, they are influenced by the media and various tales and animated films. They like to wear the latest games and fashion garments decorated with patterns that their best friend is wearing.

2.1.1. Girls

Most of the nursery girls love to dress. They love to try their mother's clothes, shoes (especially high heels) or dress up for the characters of their favourite fairy tale: princess, fairy, or ballerina with teddy bears, crowns and swimsuit. If they could do these clothes would wear every day, but the majority of the parents are more conservative, so usually in the street or kindergarten they wear only the average clothes in general.

- Colours: The girls' absolute favourite colour is pink, all shades of it are very popular from the worst pinks to the pale, pastel pink. In addition, purple, red, yellow, lighter colours are in the favourites. Of course, everything that is glittering, sequined, pearly, and cute is the desire of the heart of the little girls of the ages.

- Patterns: If we go to a children's clothes shop, we can hardly see uniforms without patterns in for this age group, although there are some simple geometric patterns clothes, like spotted. Most favourite patterns include dressed in fairy-tale figures, princess patterns, and animals (mostly kitten, dog, jasmine, fox) representing pieces of flowers, scents and fruits.

It is very important that in this age group gender identity begins to become aware, so girls love to dress completely differently from boys. First, when time lets you dress in skirts or dresses, and you can also start using accessories: hair bows, haircut, necklace, apron, etc.

2.1.2 Boys

Boys in the kindergarten age also like to hide in the skin of others, to try their daddy's tie, shoes, or dress up as a superhero, princess or athlete.

- Colours: They mostly like to wear "sweeter" colours: blue, green, brown, khaki, orange, and all these shades of cultivation. Among the boys, the sparkling pieces of girlish are less popular.
- Patterns: The absolute favourite of the ages is the super hero pattern. They want to identify with them, be super strong, fly, protect other people. They are also very popular with the design of other figurines and cartoons, dinosaurs, monsters, animals, machines, technical devices (robots, computers, telephones)

3. CHANGES BODY AT KINDERGARTEN AGE

During the three or four years of the kindergarten, spectacular body changes occur, the children are prolonged, the size of the head decreases with respect to body size. (2)

The 4-7 age-old children are scaled, age is decisive, but dress sizes match the height meter in centimetres. The reason for this is that during this period there may be large differences in the height of the children of the same age. This dimensioning helps parents to find the size appropriate to their child. (3) The table 1. shows the changes in the body size of the kindergarten age children.

Table 1: Size chart(3)

Size (year)	**3**	**4**	**5**	**6**	**7**
Body high	98	104	110	116	122
Chest	58	60	62	64	66
Waist	58	59	60	60	61
Hip	64	66	68	68	70

3.1. The body posture

The spine is the axis of the human body, its most important role is the formation of posture. It provides the body free movement at one time and maintains balance and stabilizes the body. Its static role is to dampen the physical forces and vibrations of the body. It also carries the full body weight, protects the spinal cord and internal organs. The backbone connects the lower and upper limbs, as it is connected to the bones of the chest and the pelvic bone. It serves as a stable frame for the bony formulations that attach to the bony formulation, to the tonsils and to the muscles.

The spine is comprised of 33-35 vertebrae and 23 disc intervertebral discs. The spine can be divided into 5 sections, which are the cervical, dorsal, lumbar, sacral and tail bones. In these sections, the vertebral structural features specific to the particular phase can be observed. These differences explain the different functions of each section, but they have the same structure in their bases as the basic

The body posture is the relative position of individual parts of the body. The posture-retaining muscle, associated tendons, joints, and ribbons are involved in continuous and manifold activity in this dynamic equilibrium state.

The functions of human posture should work together to ensure proper holding and movement. Static and dynamic functions have a mutually beneficial effect on each other.

Posture sensation and later control is also a very important task for the body. This requires the help of the sense organs of the human body. With the eyes and our eyes, we perceive how our body stands, and the ear and the balancing body help in the correction process.

One of the prerequisites for correct posture detection is that all joints of the body can be fully and freely moveable because any joint movement may have a negative effect on posture.

Good body posture is when the physiological spine curves show an adequate, harmonious image, and if the body reinstates it as necessary, it improves incorrect holding. To accomplish this, it is essential to have the proper features of the spine and the effective functioning of the body's dynamic parts, muscles, tendons and ribbons.

In the case of proper posture, the human body can be characterized by the least muscular effort to maintain balance; ergonomically this posture is most favourable to the whole body.

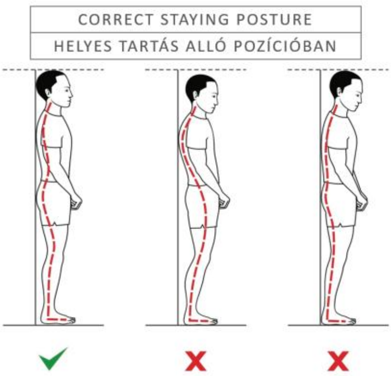


Figure 1. Correct staying posture

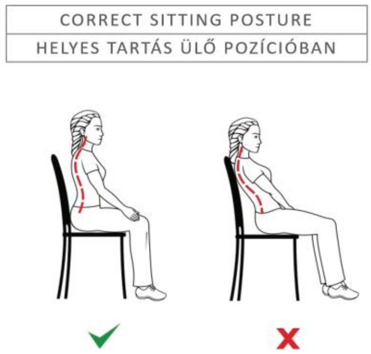


Figure 2. Correct sitting posture

The reflexes in addition to our will and thoughts control the proper functioning of the muscle groups that hold the support. These balancing movements continue to take place when the body appears to be motionless.

The center of gravity also wanders, depending on how some of our muscles work now. In addition, posture is affected by the respiratory technique.

The spinal column's physiological curvatures evolve in parallel with human motion and result in the formation of forces acting on the body as an elastic force.

When the curvature increases, the muscles of the spine need to hold the body in the same position against a greater force, and greater effort is needed. In the case that the curvature of the spine is smooth, the spine loses its elasticity, the function and location of the muscles that move the spine are different. Thus, the muscles become inactive and weaken. In these cases, the spinal column is overloaded.

Balanced equilibrium is essential for posture-retaining muscles so that they can hold the body. The coordination of the transverse muscles is necessary for the joints to be able to stand in the middle position. This co-operation ensures that the joints can move around the entire physiological trajectory.

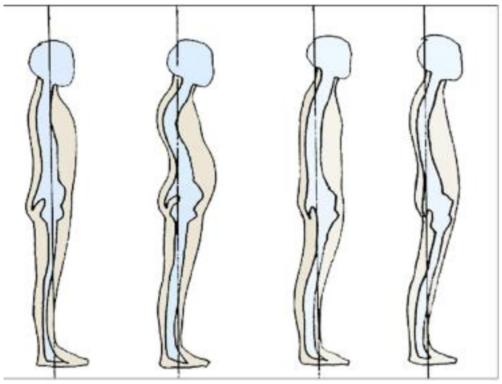
If the muscles leave something out of the equilibrium for some reason, the uneven loading of the joints will begin, which will lead to dust and other lesions. There may be several causes for the breakdown of the muscle mass, which can be caused by the lack of sport and movement from everyday life, the steady-state static or dynamic force, but can also be caused by tiredness or pain.(4)

3.2. Bed posture

Bad body posture is mention when a scoliosis has not yet, but bad posture is beginning. After a while, it is about to be a constraint, and this can be permanent if it develops in childhood. Neglect and delay treatment for scoliosis and lead to back pain in adulthood. In the case of abnormal support, there is no alteration in the vertebrae, in particular the muscles supporting the spine, the weakness of the musculature of the back. Sometimes, for example, when a child grows suddenly and muscles suddenly cannot stand the bigger weight. However, psychological reasons may be the cause of obtuseness.

There are four types of bed body posture:

- flat back: the back of the back rib and the lumbar cuff decrease, therefore the back flat
- kypholordic back: the degree of thorax is normal but the lumbar spine is increased
- sway back: dorsal bump is normal, but lumbar is enhanced
- convex back: the dorsal rib spreads to the lumbar spine (4)



Normal posture | Kyphosis-Lordosis | Flat Back | Sway Back

Figure 3. Body postures

4. BODY POSTURE CORRECTION AID

The body posture problems in childhood, first, the physician should consult with you about the movement or use of medical aids. The most commonly recommended forms of motion are the special spine gymnastics, the child's yoga and swimming.

Spine corrector aids are also designed for adults and children. There are devices that provide proper "hold" and strengthen muscles in different parts of the body. In the following chapters, I will present some of the features without completeness.

4.1. Body posture supporting straps

Both straps and pants of different designs are widely used to improve the posture of children and adults. Their principle of operation is that they mimic the body for a good posture with a slight pull and grip, and muscles are motivated to function and strengthen.

– Backing of shoulders
– Adjustable (Velcro, Fittings)
– Stable fastening but at the same time comfortable to move
– Flexible, strong air permeable raw material
– Sponge for convenience
– Suitable for everyday wear, does not weaken the muscles, it only reminds the wearer of the correct holding

– Reverse 8 format
– They often use magnets in them (5)

Figure 4. Posture supporting straps (5)

4.1.1. Body posture supporting belts

There are several solutions to the maintenance belts, which are recommended to relieve the lower back of the spine at the beginning of the problem or in the case of backbone or lower back pain.

- Compression
- Strong canvas, side with rubber bands, or elastic but strong material
- Breathable material
- Adjustable, generally Velcro closure
- Removable scaffolding provides support
- At the back of the sacrum, on the site between the hip and the large moles and the symphysis on the front

Figure 5: Body posture supporting belts (6)

4.1.2. Body posture supporting clothes

Analysis of these tools reveals that devices must be free to move, but they must also keep the body. For this purpose, the DMO system was developed, that is, the dynamic medical orthoses. Their appearance has been made possible by the development of material technology, has been present in foreign practice for more than 10 years, only in Hungary for a few years. The method can be used effectively for over-movement disorders, muscle development disorders and balance problems. (9)

Figure 6: Body posture supporting clothes (7)

5. DESIGN

The main concept of design, using well-known maintenance techniques, is designed to design a child's outfit that has a strong aesthetic function besides its health function; it also meets the tastes of the children and the trends. In the present phase of the research, the design process fulfills only the functional requirements.

5.1. General expectations

When designing children's clothes, we want to take the children's taste in the future. The colours and patterns are tailored to the trend of 2018/19 children's wear, the harmony of colours and patterns, and the children's taste.

The most important requirement for underwear products is that it does not have any health-damaging effect. Parents prefer natural materials (cotton). Children love to wear clothes made of materials that are comfortable to wear and breathability. To create a functional outfit, you will need a high elastic Polyester Lycra blend material, with elasticity providing convenient compression and maintenance support. Strengthening of the reinforcements with additional components, in contact with the skin, does not cause irritation.

It is an important expectation that it is easy to give up on the child and ensure proper holding after taking the picture. During cleaning, do not deteriorate product quality, easy to clean, washable. Do not deteriorate the quality of the material during extended periods of use. The longer you keep your original status.

5.2. Functional clothes design

For the functional design of the dress, I have two models, a little boy (6 years old) and a little girl (5 years old). For both of them, the orthopedic physician diagnosed the negligent condition. Their throats are pressed, their backs convex.

Both children need 3-point correction. The dress is tailored to a unique size. During the first test the metering has taken place. Experimental work is being carried out in the current phase of research work. There are three possible configurations of Figures 7, 8, 9.

front back

Figure 7: Back cross model with elastic pant in front

front back

Figure 8. Back cross model +forced pant and elastic pant in waist

front back

Figure 9. Double corss back with elastic pant in front

Conclusion

When designing maintenance-enhancing children swear, the goal is to provide a child-friendly medical aid and wear it as a down jacket in winter and as a t-shirt in summer. The design must take into account the essential characteristics of the orthoses, the parents' expectations and the properties of the available materials. During the research work, the raw materials have been purchased; the patterns are finished for the two models. We are also planning to prepare and test the presented dresses for the children, of course, in consultation with an orthopaedic doctor. In addition, the tests are based on the rehearsals of the clothes, as well as tensile tests, which can turn out to be effective. We want to document the effectiveness of the dress with the instruments developed by BME for this purpose. The research work is carried out by the OTKA 112506 supported by the competition.

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PURIFIED SEWAGE AS AN ALTERNATIVE SOURCE OF WATER

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Abstract

Water scarcity is one of the biggest global problems affecting all societies in the 21st century. Climate change has already been acknowledged by most of the world's scientific community and found that it's primarily caused by the greenhouse gas emissions from human activities, industrial activity, motorized transport, industrial agriculture. The consequence of the climate change is the more acute water cycle, the change in evaporation conditions, which is further strengthened by change of the surface (change of plant cover, change in the ratio of enclosed or built-up areas, drainage of surface water, etc.) and direct heat emission of buildings, plants, vehicles, etc. in built-up areas. The growing population and the changing climate result water demand increase. This fact, and the limited access to water, plus the fierce competition for water sources, have created the need for today's so-called "non-traditional" sources of water, like low-yielding wells and springs, rain water, rainfall precipitation, urban rainwater and that's why waste water recycling should be also considered in water management. The reuse of purified sewage is an important and cost-effective element of water scarcity, an option to counter water scarcity. The purpose of the study is to provide a practical example of waste water recycling in various use cases that will help countries with fresh water shortage or countries in favour of environment friendly policies to reduce water shortage and water abstractions.

Keywords: *climate change, sustainable water management, water demand, wastewater recycling*

1. INTRODUCTION

Water is an indispensable for life, but despite of the significant water resources available, persistent and severe water shortage prevails in many regions of the world. The reason is that potential water resources are distributed unevenly in both space and time, water supply maturity is low and water resources available are inadequate.

Water scarcity will worsen due to unsustainable use and management of the resources as well as the climate change.

The forecasts show a significant increase in water demand between 2000 and 2050. (Figure1) Demands are expected to grow mostly in the manufacturing industry by about 400%, in electric energy by 140% and in household consumption by 130%. [1.]

Due to the increased demand in other areas, agriculture is expected to get less water, which is augmented by the fact that around 3.9 billion people, more than 40% of the population of the earth, will live in drought-stricken territories by then. [1.] Population of these areas will face agricultural and food security problems.

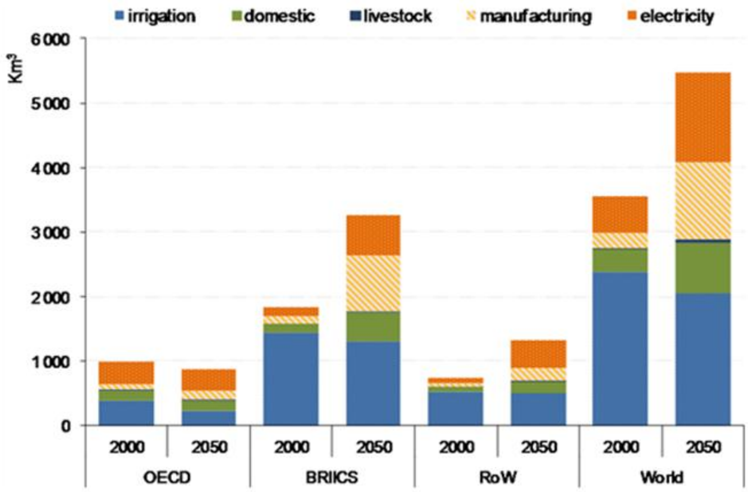


Figure 1: Global water demand: Baseline scenario, 2000 and 2050. [1.]

Climate change will make the growth of water demands even more significant. The climate of the Earth has also changed in the history, but the changes were still natural and had taken place over a long period of time. With the developing industry, use of fossil fuels has been multiplied and over the last 150 years, atmospheric carbon dioxide concentration has increased by 33%, [2.] resulting increase in the surface temperature too.

Climate models predict that between 2021 and 2050 the biggest change in temperature is expected in summer when the temperature increase may reach 2 ° C and may exceed 3.5°C by the end of the century. In southern and eastern territories higher temperature increase are expected. The frequency of warm extremes increases heavily, and the occurrence of cold extremities decreases slightly. [3.] Temperature increase makes water circulation more intense (evaporation, precipitation, leaching, infiltration / drainage). The average rainfall is expected to be 3.9% higher than in the period 1961-1990 [2.].

The potential impacts of climate change on waterways are presented in Table 1.

In longer dry periods due to climate change the decreasing precipitation rate has a negative effect on water resources, which results in less water available and can also lead to deterioration in water quality.

Table 1: Climate change and water management contexts [4.]

Weather	Regime
Warming	Increasing water temperature, falling ice levels, increasing evaporation
Increase in aridity	Declining annual drainage, decreasing useful surface and underground water resources, deteriorating water flow
Melting glaciers	Change in the course of Danube during the year
Rearrange of precipitation	The runoff is growing in winter, larger rivers suffer from uncertain flood waves
Great rainfall	More common and intense flash flood
Dry periods	More frequent, more extensive drought

Considering all these factors, finding and developing alternative water supplies is becoming increasingly important today. The solution can be recycling of purified sewage and rainwater to the most extent, and the implementation of circular farming.

"Well purified" sewage (new water) is not just an "alternative water resource", but a positive regional water management element, which is particularly important in drought and water scarcity areas, and its benefits must be exploited. Sewage can serve not only as a soil supporter, but it can also complement the missing moisture content. The water "extracted" at high cost shouldn't be disposed after use but must be retained and utilized sensibly [5].

The purpose of this study is to present practical solutions that contribute to implementation of integrated water management through treated sewage recycling.

2. EXAMPLES OF WASTEWATER RECYCLING

During recycling, the recoverable materials contained in the purified wastewater and the water itself are reused.

This can be done directly when the purified sewage from the wastewater treatment plant is introduced straight into the distribution system or indirectly, when purified sewage from the wastewater treatment plant flows into a watercourse, pond, reservoir, etc. and will be used later. Use of sewage is possible in the following areas ensuring the preservation and replacement of water resources [6]:

- production of drinking water with high efficiency cleaning, direct or indirect technology
- filling the aquifer, the production of drinking water with recharge of an aquifer
- using non-drinking water quality in agriculture, industry and urban environments,
- with agricultural, energetic utilization of sewage sludge from sewage purification.

Growing population and associated urbanization, especially in developing countries, are new water management challenges. Increasing water use and, therefore, pressure on existing water resources are urging reuse of water, especially in countries where there are limited resources available or apply stock-friendly environment policy.

Utilization of industrial sewage through the cooling process more and more widespread, and some industries (e.g. paper industry, thermal power plants) can recycle used technological waters into manufacturing processes to the largest degree. Circular water management is already the most effective method in this area. However, industrial recycling from purified communal sewage is only 6-15% worldwide, but the annual growth rate is 15-20%. [6].

Urban sewage utilization is mainly applied to irrigation of parks, golf courses and gardens with purified sewage, and to a small extent it provides alternative water use in toilet flushing. Environmental and recreational wastewater recycling can be achieved by creating artificial lakes and filling natural lakes with rich and aesthetic landscapes.

The use of purified sewage from communal sewage treatment plants as an increasing source of water is evidenced by the fact that in the United States the amount of recycled purified communal sewage is increased by 15% [7].

The amount of recovered and recycled water has been increasing worldwide over the past two decades. Today, 3700 wastewater recycling plants operate in the world, producing a total of 19 million m3 of water per year for different uses [8]. In some countries it's no longer visible only in irrigation, but also in the production of indirect or direct drinking water.

During recycling, the most important aspect is to exactly specify quality requirements for sewage and make everyone being compliant with them, thus ensuring the protection of human health, soil, plants, and groundwater. Only having realized all of these we can expect favourable public acceptance. To do this, it is necessary to develop a comprehensive regulatory system and limit values for recycling.

2.1. Recycling for drinking water

Reuse of sewage can be done indirectly or directly for drinking water production. Utilization as indirect drinking water is the oldest practice in countries, where wastewater is brought to the drinking water system, after extraction and purification to drinking water quality from the natural recipient (streams, rivers, groundwater).

However, the main purpose of this technology is not the utilization of wastewater, but the disposal of waste water after cleaning. The first technology for drinking water was established in Los Angeles, in 1962, where the main purpose was not to place sewage, but to use it after purification [6]. Ground water enrichment improves groundwater resources by utilizing natural cleaning processes in the soil, prevents or reduces the compaction of aquifers, prevents salt water from entering the coasts, and provides additional pre-use treatment. Soil Aquifer Treatment (SAT) is used to leak through the soil to the aquifer.

2.1.1. Indirect drinking water production with Soil Aquifer Treatment technology

The technology allows groundwater replenishment through the soil to allow reuse of water. The method has been developed in the US and has been applied in many parts of the world. The pre-treated waste water is leaked into the aquifer (Figure 2) and by adsorption, ion exchange and bacterial degradation in soil, the concentration of contaminants during filtration and biodegradation decreases [9].

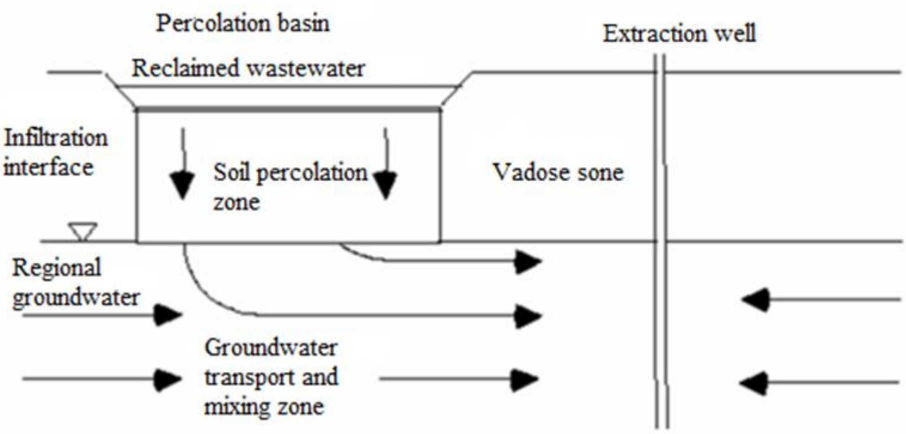


Figure 2: Soil Aquifer Treatment technology [9]

The disadvantage of this technology is that a clogged, contaminated layer appears relatively soon on the surface of the filter layer due to splicing, which prevents further infiltration.ng. During cleaning, the removal of organic compounds is the most effective; it depends on the residence time, the leakage path and the pre-treatment concentration.

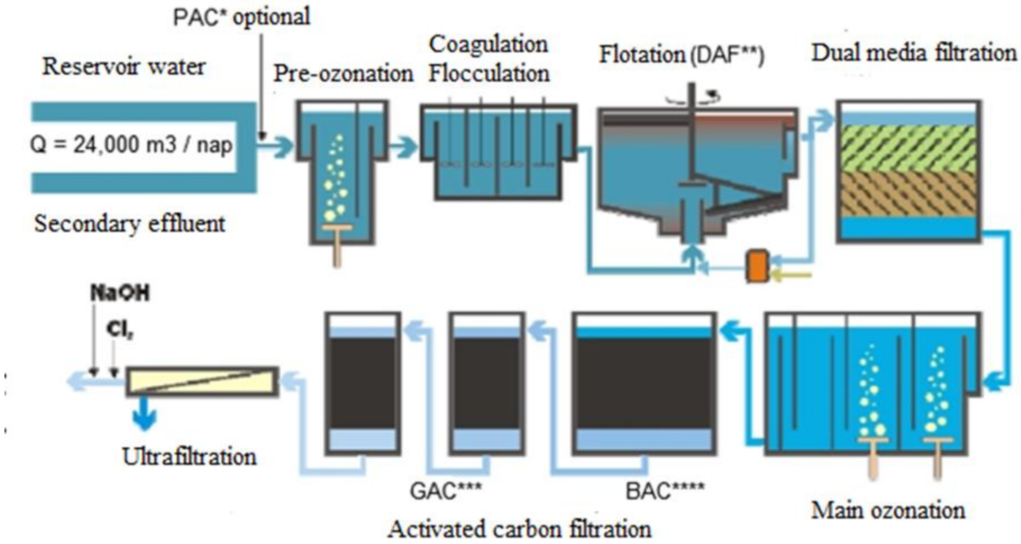
The removal efficiency of organic materials increases by the residence time and the depth, as there is enough time and water path for chemical, physical and biological processes. To make this happen, good quality soil with good.

2.1.2. Drinking water production by direct method from purified communal sewage

NGWRP (New Goreangab Water Reclamation Plant) technology is used to produce direct drinking water e.g. in Windhoek, Namibia, where drinking water is produced using purified sewage due to scarcity of water resources. It takes about 25% of total urban drinking water [10]. The technology operated by a consortium of Vivendi Water Systems, Berliner Wasser and Wabag produces 24,000 m3 of drinking water per day, combining sewage water and reservoir water in 50-50 % proportion.

Proper water quality is ensured by multiple ozone treatment, coagulation, sand filtration, ultrafiltration, activated carbon treatment and disinfection. (Figure 3)

Ultrafiltration and disinfection are highlighted in the technology, these steps make possible to remove the components dangerous to human health with the greatest efficiency. We can remove one of the most resistant pathogenic agents, Cryptosporidium with this technology by means of ozone, coagulation, dissolved oxygen intake, double sand filtration through ultrafiltration and chlorine disinfection processes [10].



*PAC: powdered activated carbon, **DAF: dissolved air flotation, ***GAC: granulated activated carbon , ****BAC: biological activated carbon

Figure 3: NGWRP process flow diagram [10]

2.2. Replenishment of water resources with purified sewage

Similarly to the indirect drinking water production, groundwater supply, seaside saltwater inrush control, seasonal stocking can utilize by pre-treated sewage into the soil by leakage. The technology is based on natural self-cleaning ability of the soil [11].

During leakage, a large part of the water content is taken up by the plants, evaporated, and the non-recoverable parts reach the groundwater. Organic substances are oxidized, transformed into inorganic materials, nitrogen compounds are utilized as nutrients by the plants and the remainders degrade. However, decomposition products may become hazardous, so it is important to regulate the process and implement pre-recovery treatment. The trace elements and bacteria are screened with great efficiency, but the same is not valid for viruses. Therefore, disinfection is an important technological step in pre-treatment.

2.3. Utilization of sewage in agriculture

The origin of agricultural utilization of sewage goes back to times, when the precipitation and sewage of the settlements were consciously collected and channelled. The technology created this way was called sewage drainage, the purpose of that was clearly utilization. Today, however, it is more appropriate to talk about agricultural landfilling and utilization of sewage, since its purpose is not primarily recovery but rather cleaning and placement [12].

During the agricultural utilization process, purifying of sewage is a productive process in which renewable energy sources (solar energy, soil organisms) provide the necessary energy for the decommissioning process and at the same time return biomass materials to natural circulation.

The purification process takes place in the soil ecosystem, as a result of the degradation processes, the water is purified, some evaporates through the evapotranspiration, the other part is incorporated into the plants, stored in the soil and, through the soil, infiltrated into the groundwater, water circulation [13]. The most ancient natural cleaning on the ground for millennia. Pollutants are adsorbed on the surface of soil particles and pores, microorganisms convert organic pollutants into inorganic nutrients, and they are utilized in plant capture.

Municipal wastewaters are suitable for sewerage, that requires strict public health standards and compliance with them, particularly because of their pathogenic agents.

Industrial waste water is suitable for agricultural use only, if it contains mainly pollutants of natural origin and organic substances, but no toxic substances or only the amount below the permitted limit value. E.g. sewage effluents from food industries like sugar, starch, spirits, beer, cereals, dairy production and canning. They can be used well in some sectors of the light industry, e.g. hemp, lencing, paper, pulp and wood industries.

From the chemical industry the wastewater produced in the fertilizer production can be utilized in agriculture, since it is practically diluted fertilizers. Cooling waters from the energy industry and construction industry wastewaters still meet the quality requirements of usability.

In the wastewater produced by agriculture there are many useful nutrients, for example in sewage sludge, but there may also be many substances that make their use limited. Wastewater from agriculture cannot be utilized if it contains poisonous or radiant substances more than the permitted limit values that originate from plants that process infectious diseases or animal products.

During the complex disposal and utilization of sewage, we use the self-purifying ability of the ecological system. To make this process happen in specified soil, soil layers and time are required, because in the absence of any of them, the groundwater is contaminated with age-destroying microorganisms and undegraded organic materials. Soils are capable of physical filtration, biological transformation and chemical processes, of course, up to a certain level of load.

The end products of the self-cleaning process are the different inorganic salts and humus. From the soil point of view, the suitability of sewage for irrigation is determined by its toxic content and the concentration of all dissolved salts.

The latter is important because the increase in the salt content of the soil can lead to salinization. Central and lighter loam soils are the most suitable for sewage drainage [14]

They can accommodate relatively large amount of water and their adsorption capacity is adequate.

Better quality sand soils are also suitable for filtering large amount of wastewater, but their adsorption capacity is low, therefore their cleaning capacity is lower. According to the EU Water Recycling Guide, sand and sandy soils are the best for wastewater utilization. It is not recommended to use purified sewage for irrigation purposes in areas heavily or moderately affected by inland waters [15].

Purified sewage is a valuable source of growth in plants, containing water, nutrients and organic substances in the appropriate composition. Therefore, to assess its possible utilization it is important to examine how the nutrition and water balance of a given area would be affected.

The following options are available for irrigation utilizing the liquid phase of purified pre-treated waste water:

- reed, grassland,
- forestry (e.g. poplar plantation) and natural vegetation,
- special tree plantations (e.g. energy plantation)
- in areas under field cultivation, with different irrigation methods,
- in vineyards and orchards.

Tree plantation (poplar, willow) sewage treatment and disposal sites are, the most suitable for treating waste water economically and environmentally based on the experience. Utilization on energy plants (crown-post, chainsaw, energy grass, etc) primarily serves the production of biomass for wood plantation supplemented by water and vegetable nutrition.

Additionally, the disposal of prepared, good quality waste water after soil purification can be used to supply water (and partly nutrition) for perennials and one-year crops. Cultivated crops are like e.g. corn, sugar beet, sunflower, seed. In this case, the collection and temporary storage of the sewage outside of the irrigation season must be also solved.

In case of field utilization, it should be prepared that in some parts of the area permanent vegetation, i.e. tree plantation, is necessary for those periods when the crop rotation does not allow field placement.

The environmental, climatic and soil conditions, plus the economic structure of Hungary give us the opportunity to utilize biomass to a high extent, cultivation of energy crops can supply materials for production.

Increasing the yield of energy crops by exploiting the ability of these plants to absorb high levels of nutrients and, therefore, to produce large-scale biomass, is a wastewater disposal opportunity. The limiting factors of the large-scale biomass production of woody plants are the soil nutrient supply and precipitation at about 80% of Hungary's territory. About two-third of the country has regular summer droughts, when a lack of water is clearly a limiting factor, so then the unclean or partially purified sewage can play important role. Tree plantations, such as crop cultivations, are beneficial because they can take a greater load and can be irrigated throughout the year.

The energy tree plantation is the plantation where trees are planted for energy tree production. It is important that the forest law is not applicable to energy tree plantations.

Plantations are created in flat or hilly areas, in good quality sites, where large-scale production is possible, and landscape allows machine harvesting (combinable area) [16]. Thus, this variant of tree plantation cleaning has dual purpose, on the one hand, the natural cleaning and disposal of sewage, on the other hand the production of biomass with significant energy efficiency.

The water and plant nutrients supply to the tree plantation is provided by the waste water. The most common trees plantations are poplar and willow, which create the possibility of irrigation with sewage water by drought or rainwater-like irrigation. Essential aspects of establishing plantations: the assessment of environmental impact, the energy balance and the specific energy price.

Research is nowadays under way for Chinese reed species (Miscanthus spp.), the results so far show that they are the most productive plants in Europe [17]. In the areas taken off from agricultural utilization, energy wood plantations can be established with fast growing species of trees, whose growth can be controlled by adequate nutrient intake.

SUMMARY

Problems arising globally in water supply, population growth, urbanization, climate change and the wasteful use of inventories are increasingly urging to develop and apply technologies that can mitigate water scarcity and reduce the amount of water exploited.

Since clean water is limited in nature, wastewater recycling can be a solution to the production of sufficient drinking water and use water. Modern sewage treatment technologies can help to solve these problems. Their purpose is to hold the detrimental solutes and solids in the effluent economically so that they do not jeopardize the ecological conditions of the water bases and the environment, especially conditions of the intaking water bodies. The emphasized aspect of sustainable water management is the greater recyclability and energy utilization of retained materials. Thus, a sewage management process is implemented that protects and assists in preserving human health, does not harm the environment, does not absorb natural resources, has a proper technical and institutional background, economically viable and socially accepted. The liquid phase of purified sewage can provide opportunities for countries with fresh water shortages to seemingly expand their freshwater resources. It also provides a favourable alternative to advanced, environment friendly policy, considering that the largest water user is agriculture, so the amount of water extracted and used in the field of irrigation can be effectively reduced. At present, due to healthcare reasons it is more accepted socially the use in the production of less risky energy crops, which can be further developed and made more versatile in the future with adequate regulation.

Climate change poses a new challenge to water management, which also plays an important role in recycling waste water through which the effects of drought can be mitigated, and water retention can be solved by maintaining water.

The three most important functions of modern sewage management and sewage treatment are the protection of public health, the re-circulation of plant nutrients and the protection against environmental degradation, which are now required to meet high quality technology. This is important primarily because society can no longer miss the used water recycling, but responsibility to maintain water quality is left to the society.

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ANALYSIS OF THE PRESENT STATE OF TRAFFIC NOISE IMPACT ON HUMAN

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Abstract

Traffic noise cause adverse effects on health and quality of life of population exposed to it, including annoyance, sleep disturbance, decreased performance at school/work, stress, hypertension, and ischemic heart disease. This paper reviews existing literature, evidence and policies related to traffic noise impact on human and combine them to different studies of mapping noise and population exposure levels.

1. INTRODUCTION

In the EU countries, the issue of harmful effects of noise in recent decades has become a worrying topic at both professional and political levels. It is currently one of the most widespread harmful factors in the living and working environment. A major problem has happened especially in recent years, particularly in the context of the advanced development of transport and industry. The noise burden of the population is generated in 40% of work and in 60% of the environment. In residential agglomerations, transport noise is dominated. According to the data published by the World Health Organization, an equivalent noise level exceeding 50 dB has an easily interfering and exceeding 55 dB, a very disturbing effect on humans. 40% of the EU population is exposed to traffic noise, which exceeds this level and 20% to traffic noise, which is above 65 dB (A) over the day. During nighttime, more than 30% of the population is exposed to an equivalent level of noise that exceeds 55 dB (A), resulting in disturbing and negative effects on healthy sleep. [1]

2. PROJECTS RELATING TO TRAFFIC NOISE

Over the past decades, road transport noise has been tackled by European research projects co-funded by the European Commission, each of which has focused its attention on the so-silent road surfaces. It belongs to them: [2]

- **SILVIA (2002-2005)** - the project focused on three areas: designing procedures for classification and conformity of low-noise roads for production, study and improvement of the functional and structural life of low-noise roads, compilation of cost-benefit analysis in the low-noise road life cycle. The final result of the project is the "European guide to the use of low-noise roads", which integrates low-noise roads with other noise control measures.
- **INQUEST (2006-2008)** - the aim of the project was to support the use of low-noise roads in Europe by disseminating the tools proposed in the SILVIA project. This was done through seminars for decision-makers, road administration authorities, road construction suppliers, road engineers and policy-makers.

- **ROSANNE (2013-2016)** - the main objective of this project was to improve the harmonization of standards for common European methods of measuring road resistance against slipping, rolling resistance, noise emissions and preparing for world standardization in this area.
- **HEALROAD (2015-2020)** - the project deals with the development of mixtures that can be inductive heated, which increases the life of asphalt roads by 30%. A few days normally needed to repair microcracks lasts for a few seconds with this method.

The purpose of Directive 2002/49 / EC of the European Parliament and Council is to establish a unified approach to prevent, control or eliminate the adverse effects of environmental noise. It recommended to member states to proceed according to action plans based on noise map results. These countries must compulsorily develop strategic noise maps for all agglomerations with more than 250,000 inhabitants, for airports, wider roads and railways. Consequently, strategic noise maps and APs are made available to the general public in accordance with the relevant legislative. [1]

Issues of noise exposure in the environment, risk assessment and health effects have been devoted to the LFUK Hygiene Institute (Bratislava) for decades. In their study of objective and subjective noise perception, they studied and compared college students from selected student homes in Bratislava (noisy area) and students living in quieter areas. The time range of the noise levels during the day and night was observed both inside the house and around. In the noisy area, equivalent levels of noise over the day occurred in the health-damaging risk zone, of absolute noise >65 dB (A), maximum levels climb to 84 dB (A). Measurement results indicated an increase in the average of 2 dB (A) with each additional floor. Equivalent level values significantly exceeded the statutory limits set for indoor areas. Subjective interference was evaluated by a questionnaire. In addition to the basic questions, it included items aimed at obtaining information about the characteristics of the living environment and the health status of the respondents. Trafficking, industry, neighboring flats, airports, railways and noise from entertainment companies were assessed.

Part of the questionnaire looked at the physiological and psychological impact of traffic noise and its interferences with different activities. As the assessment method was used the risk calculation for different types and consequences of environmental noise annoyance with special regard to traffic noise. The analysis showed that respondents from student homes, from noisy sites are much more disturbed by environmental noise. In addition to traffic noise, there was a significant disturbance in noise coming from nearby entertaining businesses, neighboring flats and industrial activities. Since respondents were juveniles, they could not be considered for health consequences, but only for a higher risk of neurovegetative deviations. [3]

3. HARMFUL EFFECTS OF NOISE

Harmful, disturbing and damaging effects of noise are dependent on many acoustic and non-acoustic factors listed in table 1. [4]

Table 1: Acoustic and non-acoustic factors of noise

Acoustic factors	Non-acoustic factors
• noise intensity	• the subjective attitude of a person towards the source of noise
• uniformity of noise	• time of perceiving noise by man (day, evening, night)
• the frequency of exposed noise	• immediate disposition of man
• tone components of the noise spectrum	• the need for noise associated with activities
• frequency spectrum	• social status
• exposure time	• past experience with noise

• sound pressure level	• economic dependence on the noise source
• frequency of noise interruption	• the overall health of a person

Acoustic waves effecting on humans have physical effects on their acoustic organs, physiological effects on the whole organism that depending of the intensity of acoustic energy and the psychological effects that stand on the qualitative characteristics of acoustic waves. The effects of noise exposure on a human organism can be divided into the effects of infrasound, the effects of audible sound and the effects of ultrasound (Figure 1). [5]

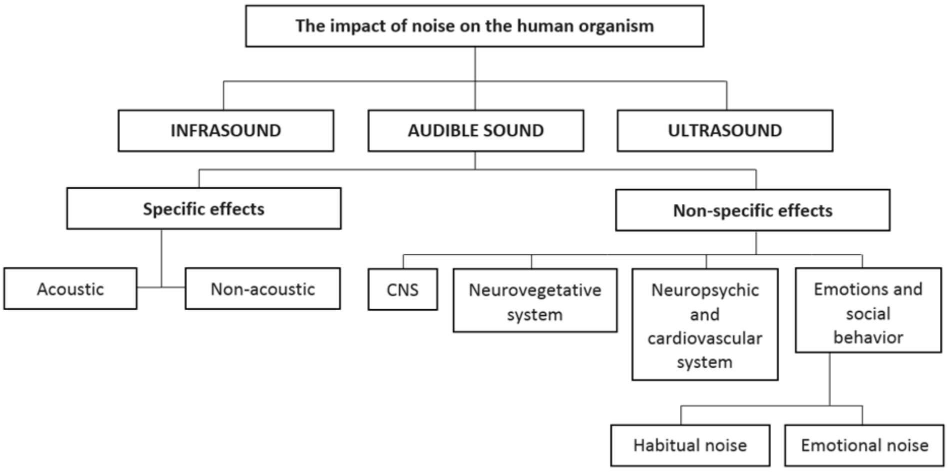

Figure 2 The impact of noise on the human organism [5]

From the point of view of the noise effects on the human organism, we divide the noise into: [6]

- **Habitual noise -** is perceived as common, familiar and normal. It is, for example, about noise on workplace, car, ordinary street traffic, sound background of home day, etc. It can cause blood pressure to rise to a sound pressure level of LA = 65 dB.
- **Emotional noise -** unexpected extraordinary noise causing reactions of the "what's happened" type, warning of danger or causing unpleasant experiences from the past. It works from the audience threshold.

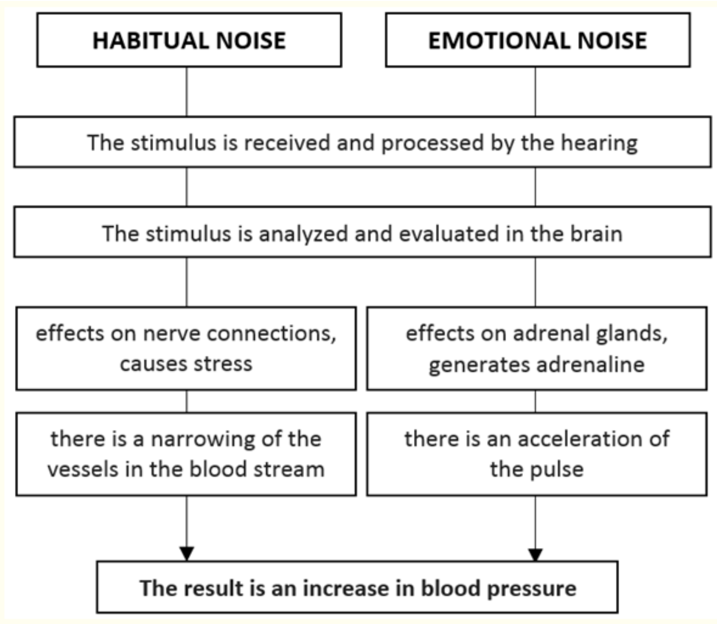

Figure 2 The impact of habitual and emotional noise [6]

4. STUDIES DEALING WITH THE HARMFUL EFFECTS OF NOISE ON HUMAN

Remarkable results have led to studies addressing the effect of traffic noise on the cardiovascular system, obesity, learning ability or the relationship of subjective noise assessment. Some of these are listed in the following table.

Table 2 Studies dealing with the harmful effects of noise on human

<table>
<tr><th>Author of study</th><th>Type of study</th><th>Country</th><th>Age range</th><th>No. of participants</th></tr>
<tr><td>Argalášová, Ľ. et al., 2017 [7]</td><td>Case study</td><td>Slovakia (Bratislava)</td><td>19-25</td><td>484 (2015-2016)</td></tr>
<tr><td colspan="5">Study results:
The study looked at the relationship between traffic noise and obesity markers in university students (average age 22.9 ± 2). 188 (38.8%) of students were resident in the road showroom (exposed area: LAeq, 24h = 67 ± 2dB) and 296 (61.2%) inhabited a non-noise board (control area: LAeq, 24h = 58.7 ± 6 dB). Students in the exposed area were more distraught: Odds Ratio (OR) = 4.1 (95% Confidence Interval (CI): 3.2-5.2), neighbors and entertainment facilities. The noise disturbed their sleep and caused wake-up: OR = 2.3 (95% CI: 1.48-3.58). The study showed a higher level of obesity markers in the exposed sample than in the treated. The percentage of body fat determined by Near Infrared Radiation (NIR) tends to be related to exposure to traffic noise in multiple linear and logistic regressions: beta = 1,320, p = 0,02, r2 = 0,14, Adjusted Odds Ratio (AOR) = 1, 76 (95% CI: 1.77-2.66) taking into account gender and other behavioral, psychosocial and nutritional factors affecting cardiovascular risks.</td></tr>
<tr><td><u>Kahkashan</u>, A. et al., 2015 [7]</td><td>Case study</td><td>India (Bangalore)</td><td>6-15</td><td>160</td></tr>
<tr><td colspan="5">Study results:
The research sample was divided into 2 groups. The first group (80 children) learned 80.4 dB in the noisy environment and the second control group (80 children) learned at a noise level of 56.28 dB. Attention and memory were evaluated using performance tests. It has been shown that exposure to high levels of noise during learning has significantly reduced attention, working memory with auditory component and logical memory. For visual memory, this reduction did not occur. Overall results indicate that a high level of noise is a disadvantage of children's educational abilities and therefore the learning environment must not be neglected.</td></tr>
<tr><td><u>Thiesse</u>, L. et al., 2017 [7]</td><td>Laboratory research</td><td>Switzerland (Basle)</td><td>19-33</td><td>23 (6 days)</td></tr>
<tr><td colspan="5">Study results:
The short-term effect of transport noise at a constant level of Leq 45 dB (A) during sleep on glucose metabolism was observed. On the first night, the sample was spent without noise (N1), 4 nights with noise (N2-N5) during which scenarios were changed: scenario1 - distant motorway, dense traffic and scenario2 - short distance, residential street or railroad. The study ended with a noisy night (N6). Metabolism of carbohydrates was evaluated by oral glucose tolerance test performed in the morning after N1, N5 and N6 nights. The glucose level increased overnight N2-N5 compared to night N1 (+12 ± 3%, p = 0.004 for scenario1N5 and +16 ± 3%, p = 0.0003 for scenario2_N5). After one regenerative night, the glucose level returned to the base line level for scenario1_N5, while for scenario2_N5 (A1-C6: p = 0.0004) it remained higher. The percentage increase in disease incidence was 31 ± 12% for the SC2_N5 group (p <0.036) and for scenario1 only 7 ± 8% compared to N1.</td></tr>
<tr><td>Paunović, K. et al., 2018 [8]</td><td>Laboratory research</td><td>Serbia (Belgrade)</td><td>19-32</td><td>112 (30 min.)</td></tr>
</table>

Study results:
The experiment consisted of three 10 min. Phase: resting in silent conditions (Leq = 40 dBA), exposure to road traffic noise (Leq = 89 dBA) and noise rest (Leq = 40 dBA). The participants' blood pressure decreased during the quiet phase before the noise, increased in the first minute of exposure to noise, and then gradually decreased towards the end of exposure to noise. After exposure to noise, it continued to decrease to baseline. The heart index showed a gradual decrease during the experiment, while the total vascular pressure steadily increased during and after exposure to the noise.

5. FACTORS FOLLOWING THE LEVEL OF TRANSPORT NOISE

There are several factors involved in the creation and level of road traffic noise, which are a necessary part of a car or a result of natural physical patterns of the external environment. The spread of noise depends on the layout of the surrounding terrain as well as on climatic conditions. The resulting noise is further influenced by a range of vehicle technical parameters, road conditions and driving patterns. Although the noise levels have fallen sharply in recent years (mainly for passenger cars), road transport has continued to play a significant role in the complex increase of the noisy background of towns and villages. [9]

The sources of road noise are mainly: [10]

- **engine** - this type of noise is most favorable at speeds of 50 km/h, acceleration or deceleration,
- **tire rolling down the road - The noise generated thus dominates at speeds of 50 km/h (passenger cars)**
- **air flow around the vehicle - occurs at speeds of 200 km/h,**
- **to a lesser extent, the air movement of the vehicle's ventilation system.**

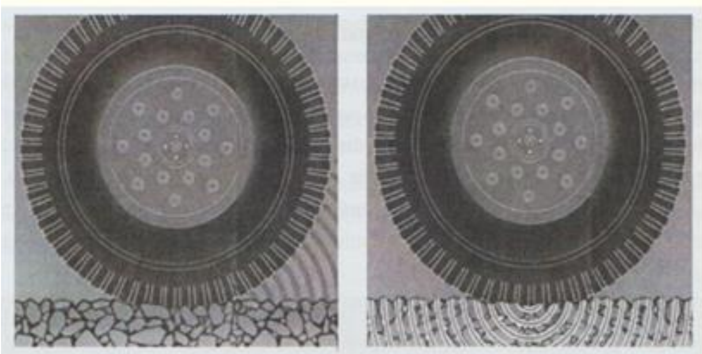

Figure 3 SMA LA blend - rolling noise and air-pumping effect. Right: mix PA - absorption of rolling noise and air-pumping effect [12]

Car noise recorded at a distance of 7.5 m from the source is: [10]

- passenger car - 79 dB (A),
- bus - 84 dB (A),
- truck - 91 dB (A),
- double driving speed increases noise by 8-10 dB (A).

The range of noise generated on the road is determined by its structure and pattern of tires, i. spacing on their surface. Research conducted not only in Europe but also in the US has confirmed that it is possible to create so- low-noise road surfaces that partially absorb the noise emission of vehicles: [10]

- drainage asphalt carpet (PA) - noise reduction of 5 to 8 dB,
- Mastic asphalt carpet (SMA LA) - noise reduction of 4 to 6 dB,
- thin asphalt carpet (VIAPHONE®) - noise reduction of 2 to 5 dB (thickness 1.5-2.5 cm),

- bituminous mixtures modified with rubber granulates - reducing the noise level by 4 to 6 dB.

For the purpose of designing ways to reduce noise on individual types of road surfaces, acoustic measurements should be made to provide reliable results. There are several methods for these measurements, but at the same time none is too universal to be used in different situations. That is why it is very important to choose it right. The individual guides and procedures for measuring all existing methods are detailed in the relevant standards and technical regulations. In Europe, we most encounter using the SPB, CPB and CPX methods. [11]

Conclusion

In the urban environment, exposure to harmful effects affects not only healthy adults within a certain time limit, as is the case with professional exposure (8-hour working time), but practically has no time limit on all parts of the population, including children, the sick and the elderly.

The most general response of the population to "perishable" noise levels is "annoyance". It is a psychic state that arises from an involuntary perception of influence, or when subjected to circumstances to which an individual has a negative attitude, because it breaks his privacy, interferes with the activity performed, or influences the quality of the rest.

The impact of noise on the human organism can be divided into 2 groups: [9]

1. Specific effects (> 90dB (A)), which manifests as a professional acute or chronic hearing impairment after repeated and long-term excessive noise.

2. Non-specific effects of noise (60-90 dB (A)) that affect the functions of various body systems as a result of the stress response. They often prevent specific damage to the hearing organ. (balance disorder, respiratory and digestive tract disorder, circulatory system, menstrual cycle disorders, high blood pressure, obesity, neurovegetative system, headache, malaise, sleep disturbances, behavioral changes, etc.).

Acknowledgment

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EVALUATION OF GROWTH AND YIELD OF VARIOUS BARLEY CULTIVARS IRRIGATED WITH ARTIFICIAL WASTEWATER

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Abstract

The research was implemented in order to study the effect of irrigation with artificial wastewater on soil, plant growth and the crop yield of seven barley cultivars. The experiment was conducted at the new campus of An-Najah National University. The seeds were planted in the spring season and irrigated with two water types (Fresh water as control and artificial wastewater), with three replicates for each treatment. Chemical analysis have been used for determining the mineral contents of the soil of the experiment for each variety and each type of water for nitrogen (N), phosphorus (P), potassium (K) and total dissolved salts (TDS). Barley proved to be a tolerant crop with considerable economic importance. Highest yield was obtained from cultivars irrigated with the artificial wastewater which gave nearly twice the yield and spike weight than the cultivars irrigated with fresh water. In addition, it gives higher spikes length and higher stem weight. The growth vigour as well as the growth period (from days to emergence to maturity) were not affected with the type of water and only depend on the type of the seeds. The chemical analysis of N, K and P represents the following: (N% – Root > N% – Spike, N% – Stem), for potassium, (K% – Stem> K% – Root, K% – Spike) and the phosphorous (P% – Spike > P% – Stem, P% – Root). In addition, artificial wastewater is a promising water resource as alternatives for fresh water to be used in agriculture specially crops with high tolerance to salinity such as barley since the use of wastewater in irrigation affects the soil texture through increasing the concentrations of some constituents such as N, K and P.

Keywords: *Fresh and artificial wastewater, Barley cultivars, Plant growth, Crop yield*

1. INTRODUCTION

Water is a vital resource for human life and activities including industry, reaction, and agriculture, but a severely limited one in most countries of the Mediterranean region such as Palestine. Therefore, there is an urgent need to conserve and protect fresh water and to use the water of lower quality for irrigation [1]. The use of treated artificial wastewater (sewage water) in countries poor in water resources is less expensive and considered an attractive source of irrigation water and the interest in reusing artificial wastewater for irrigation is rapidly growing in these countries [2]. Consequently, the reuse of artificial wastewater for agriculture is highly encouraged [3]. Irrigation with treated artificial wastewater is considered an environmentally sound wastewater disposal practice compared to its direct disposal to the surface or ground water bodies [4]. In addition, artificial wastewater is a valuable source of plant nutrients and organic matter needed for maintaining fertility and productivity levels of the soil [5]. On the other hand, artificial wastewater may contain undesirable chemical constituents and pathogens that pose negative environmental and health impacts [6]. Consequently, mismanagement of artificial wastewater irrigation would create environmental and health problems to the ecosystem and human beings [7]. The majority of the research conducted on artificial wastewater reuse in agriculture focuses mainly on its short-term effect on plant growth and development with little attention to the changes induced in the soil fertility and chemistry parameters.

Many states and local governments have reacted by placing restrictions on the use of potable water for irrigation, instead requiring the use of reclaimed or other secondary saline water sources [8].

The first use of artificial wastewater in irrigation was historically backed to two thousand years ago in Greece. Artificial wastewater reuse in agriculture is recognized worldwide as an alternative water and nutrient source [9]. Recycling artificial wastewater is one solution in facing up to the increasing demand for water resources for irrigation. At the same time, it is a natural way of reducing the environmental impacts and providing the nutrients (mainly nitrogen and phosphorous) which will fertilize the soil [10]. The increasing usage of brackish, low quality, and treated effluent water in agriculture increased the need to quantify the impact of irrigation water quality on the irrigated crops. Rapid urban population growth has put enormous pressures on limited freshwater supplies. Wang and Chang found that the use of reclaimed simulated wastewater in irrigation reduce the porosity of soil and reduce nutrient holding capacity [11]. In Jordan, researchers attempted to use saline water for the irrigation of barley and onion. Feigin et al. [12] found that irrigation with artificial wastewater increases soil salinity, nutrient contents, pathogens, and trace metal concentrations in soil. They found also that suspended solids clog the soil pores. Dojlido [13] observed that high levels of sodium in irrigated water can effects on soil structure, infiltration, and permeability rates. Sadeh and Ravina [14] applied a model to field crops in the Negev, in three case studies, using existing linear and non-linear relationships between yield and irrigation and between yield and salinity. Model coefficients were estimated from experimental data. Results were consistent with actual yield of corn and cotton in the single season cases. Simulation of wheat growing in the winter with supplemental irrigation with brackish water for 13 years showed interesting results of accumulation of soil salinity and reduction of yield. The model can be easily applied to other crops and growing areas. It can be used for the analysis of long-term soil salinization processes. Viviani and Iovino [15] carried out a laboratory experiment to investigate the effect of using artificial wastewater in irrigation on the hydraulic conductivity of loam and clay soils. The loam soil hydraulic conductivity was reduced to about 80% of the initial value after infiltration of 175 mm of municipal artificial wastewater with total dissolved solids in the range of 57 to 68 mg/l. Reductions in hydraulic conductivity were more remarkable in the clay soil. Irrigation with wastewater was common in Germany in the sixteenth century and in England in the nineteenth century, while in the United States, the use of synthetic wastewater is back to the seventies of the nineteenth century [16] Agriculture accounts for 70 - 95% of the water taken in certain developing countries.

Sharma and Agrawal studied the effect of using treated and untreated artificial wastewater for irrigation on soil and vegetable contamination by heavy metals in India. The study concludes that irrigation by treated or untreated artificial wastewater has increased the heavy metal concentrations of Zn and Mn in soil and plants of receiving area. Cadmium concentration in irrigation water was found to be above the permissible limit as set by world health organization (WHO) for irrigation of agricultural land at Dinapur and Lohta sites. Heavy metal concentrations in plants show significant spatial and temporal variations. Cadmium (Cd), lead (Pb), and nickel (Ni) were above the Indian permissible Limits [16]. Katerji et al. investigated the classification and salt tolerance of six barley varieties in a greenhouse experiment; it was found that varietal salt tolerance clearly affects the water use efficiency and the salt tolerance classification. Variety Melusine was the best for its combination of high yield and salt tolerance. Variety ISABON3, a salt tolerant land race originally from Afghanistan showed a larger grain and straw yield under non-saline and saline conditions [17]. Katerji et al. designed an experiment that deals with leaching requirements for barley growth under saline irrigation.

Hamdy analyzed soil samples for Ece, pH and SAR and they created the required ECw through mixing freshwater with saline by the proper ratio. He separated plots from each other by space with 2 meters between each plot and using drip irrigation. He found that crops response to salinity depends on plants species, soil texture, water holding capacity and composition of salts [18]. Herpin and Gloaguen [19] used secondary treated artificial wastewater over 3 years and 7 months to irrigate coffee (Coffea arabica L). The study revealed that treated artificial wastewater can effectively increase water resources for irrigation, however, innovative and adapted fertilizer/treated artificial wastewater management strategies are needed to diminish sodicity risks and to sustain adequate and balanced nutritional conditions in the soil plant system [19].

The objective of this study was to evaluate the impact of short-term application of synthetic (artificial) wastewater on soil fertility parameters and possible accumulation of metals in the soil-plant system by comparing several cultivars irrigated with both fresh and synthetic wastewater.

2. MATERIALS AND METHODS

A plastic containers (35 x 50 x 15 cm) filled with agricultural soil were used for sowing the plants. All barley varieties were sown in three complete randomized blocks each accession was represented by 15 plants per replicate. The experiment was carried out using seven varieties of barley, S42IL107, BW281, BW284, Scarlett, BW290, Bowman and G400.

Plants were irrigated twice per week by adding nearly 8 litres of water / container / week from sowing until the second leaf was fully expanded, 128 litters of artificial wastewater was used during the period and this amount determined according to the average rainfall in the city and the container space, after that the irrigation with artificial wastewater was started using the same water regimen and quantity.

In this experiment, and based on the definitions of artificial wastewater, artificial wastewater (not domestic simulated wastewater) was used by using animal waste with special characterization (BOD = 400 and salinity of 1% ds/m). BOD was measured for small sample of animal waste by using BOD device, then (NaCl) was added to reach the required salinity. This water with its characterise (BOD and TDS) used to simulate the artificial wastewater in this experiment (Table 1), which defined to be any water with waste (animal waste in our case and not domestic water).

Table 1: Chemical analysis of fresh water, synthetic wastewater and soil used through the experiment.

Parameter	Fresh Water (FW)	Simulated wastewater (WW)	Soil
TDS (mg/l)	384	1492	350
K (ppm)	4.8	88	210
N (%)	0.0072	0.0163	0.46
P (ppm)	0.62	3.30	1.5

The harvesting was done manually in order to be sure that there were no impurities in the harvest and to insure accuracy. After harvesting grains of each sub block were separated and weighted. Chemical analysis has been used for determining the mineral contents of the soil of the experiment for each variety and each type of water for N, P, K and TDS, 170 samples were analyzed during this experiment, 85 samples For freshwater and 85 for artificial wastewater divided as: 63 plant samples (21 root, 21 spike and 21 stem), 21 soil samples and finally the water sample. These tests were performed at An-Najah National University Laboratories. Each test was done in accordance to standard methods of analyses for soil and water [20].

Ms-Excel and SPSS programs were used to manipulate and analyze the data. Model was developed to express the results. Analysis of variance (ANOVA) and mean separation were conducted using procedure of SPSS software, version 15.0. Multiple comparisons among pairs of lines were performed using the Duncan-test.

3. RESULTS AND DISCUSSION

Growth Results

The growth nature and vigour of the different barley cultivars irrigated with both fresh and artificial wastewater were observed during the experiment period are shown in Table (2). Results showed that the growth nature was divided into two types: erect growth and prostrate growth.

Table 2: Growth nature for the barley irrigated with fresh and wastewater.

Line	Growth Vigour Order (1-7)		Growth Nature (erect-prostrate)		Average tiller no.	
	FW	WW	FW	WW	FW	WW
S42IL107	7		Prostrate		3	4
BW281	5		Erect		1	5
BW284	4		Erect		1	5
Scarlett	3		Prostrate		2	5
BW290	6		Prostrate		3	6
Bowman	2		Erect		2	6
G400	1		Erect		1	2

(1) Strong growth, (7) weak growth

The growth results showed that G400 was the strongest in both freshwater (FW) and artificial wastewater (WW) whereas it was the lowest in average tiller number, where S42IL107 showed the weakest growth vigour among the cultivars with an average tiller number of 3 and 4 in fresh water and artificial wastewater respectively.

Table (3) shows the growth parameters of the seven cultivars irrigated with both water types.

Table 3: Growth results for the barley irrigated with fresh and wastewater.

Barley cultivars	Days from sowing to emergence		Days from sowing to stem elongation		Days from sowing to maturity	
	FW	WW	FW	WW	FW	WW
S42IL107	11.00^{a}	10.67^{a}	62.33^{b}	61.00^{b}	153.00^{a}	152.67^{a}
BW281	8.67bc	9.00^{bc}	47.00^{c}	47.00^{c}	152.33^{ab}	151.33^{b}
BW284	10.33^{a}	10.67^{a}	40.33^{d}	39.67^{d}	151.33^{b}	151.00^{b}
Scarlett	9.33^{b}	9.67^{ab}	39.00^{e}	37.67^{e}	150.00^{c}	149.76^{c}
BW290	10.33^{a}	10.33^{a}	71.67^{a}	71.33^{a}	151.33^{b}	152.00^{ab}
Bowman	8.33^{cd}	8.67^{c}	38.67^{e}	38.00^{e}	149.33^{c}	148.76^{cd}
G400	7.67^{d}	8.33^{cd}	36.33^{f}	35.67^{f}	147.67^{d}	147.76^{d}

* Means with the same letter per column are not significantly different ($p \leq 0.05$).
* Days to (emergence, stem elongation, flowering , maturity) are **not significant** relating to the water type at $p \leq 0.05$ %.

It was found that the growth of barley cultivar type (G400) that irrigated with fresh water during the planting period (four month nearly) indicates that this cultivar type was the strongest type in growth among the seven cultivars, it required 8 days to emergence, 36 days for stem elongation, 52 for flowering and 148 days to mature since the planting day, when the same barley type (G400) irrigated with artificial wastewater, it was noticed that the growth was better in terms of yield. However, it required the same time for emergence, stem elongation, flowering and mature as well as fresh water.

The growth of barley cultivar type (S42IL107) that irrigated with fresh water during the planting period (four month nearly) indicate that this cultivar type was the weakest type in growth among the seven cultivars, it required 11 days to emergence, 62 days for stem elongation 70 for flowering and 153 days to mature since the planting day. When the same barley type (S42IL107) irrigated with artificial wastewater, it was noticed that the growth was better in terms of yield. However, it required the same time for emergence as artificial wastewater, 61 days stem elongation, 60 flowering and153 to mature.

The results shows that both cultivars irrigated with freshwater and simulated wastewater had nearly the same time for flowering and mature, it is important to combine yield and growth result to improve that plants irrigated with artificial wastewater had higher yield than that irrigated with fresh water and mature at the same period.

Yield Components

Variations in yield and quality can occur because of variations in genetics, treatment, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among types is real or whether it might have occurred due to other variations in the field. S42IL107 was the best cultivar in the spike/plant when irrigated with freshwater with percent (2.86), while in artificial wastewater, scarlet was the best with (5.3) spike/plant. For both fresh and artificial wastewater, G400 was the worst with (1.13) spike/plant .in freshwater and (1.7) spike/plant in the artificial wastewater.

Among the types, nearly no significant could be observed, S42IL107 had the higher yield (average spike/plant), while BW284, Scarlett, Bowman, BW281, BW290, and finally G400 had nearly the same average with no significant (Means with the same letter are not significantly different). Figure (1) below summarize the results obtained. For the average spike length (cm), high significant could be observed among the type of water, the plants irrigated with artificial wastewater gave higher spikes length than that irrigated with fresh water and that’s lead to that there was significant increase in spikes length for the artificial wastewater if compared with freshwater. High significant could be observed among the type of water, the plants irrigated with artificial simulated wastewater gave nearly twice weight of spikes higher than that irrigated with fresh water. That is lead to that there was significant increase in spikes weight for the artificial wastewater if compared with freshwater (See the Figures 2, 3, and 4).

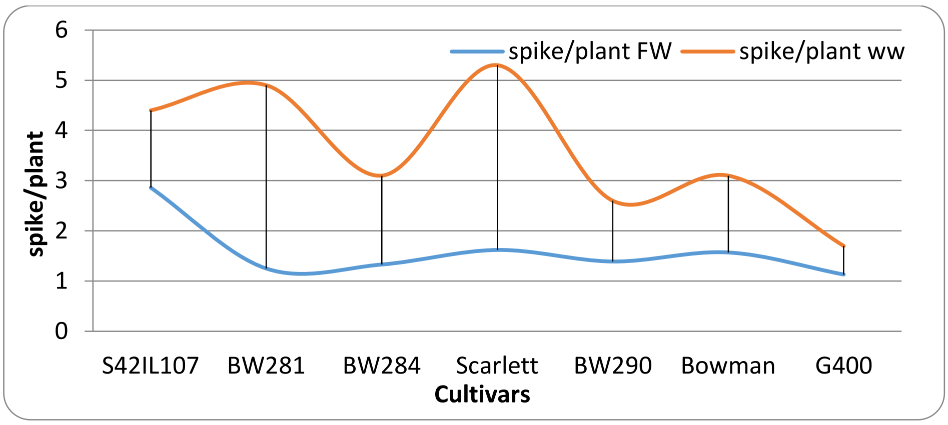

Figure (1) Average spike/plant of barley irrigated with freshwater and artificial wastewater.

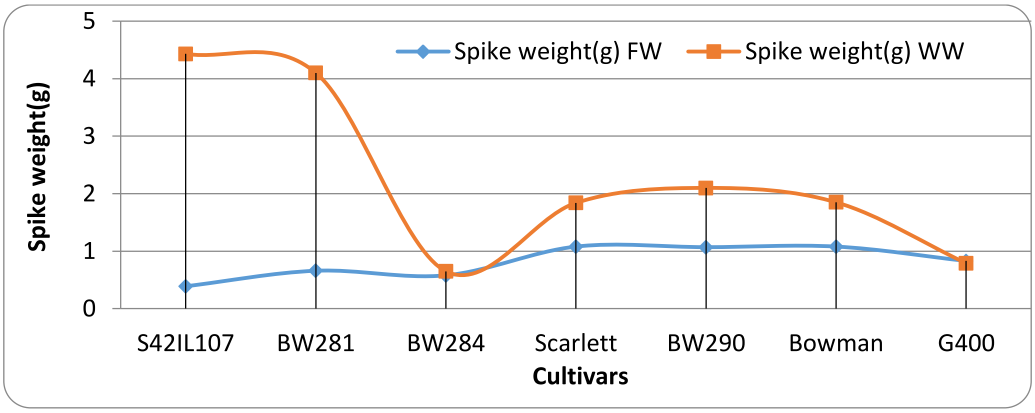

Figure (2) Average spike weight of barley irrigated with freshwater and artificial wastewater

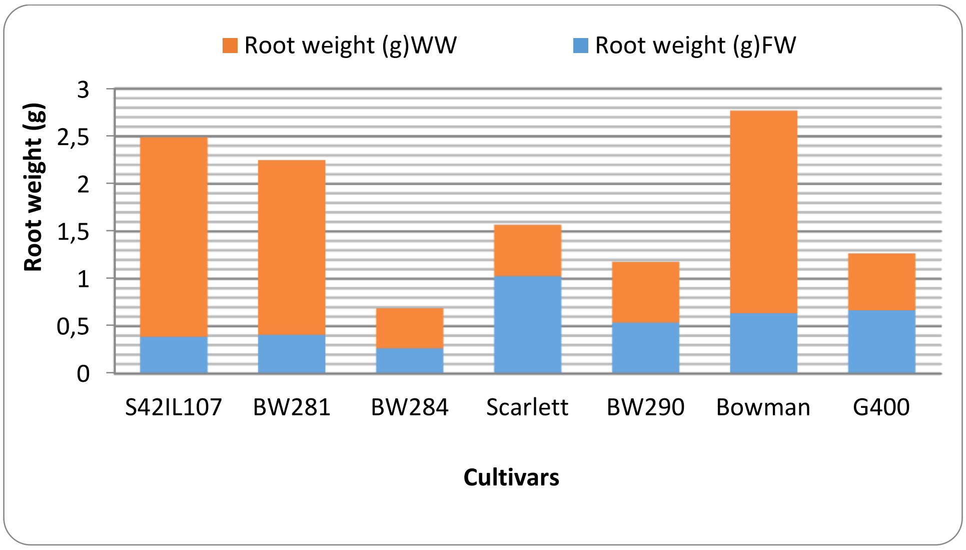

Figure (3) Average root weight (g) of barley irrigated with freshwater and artificial wastewater.

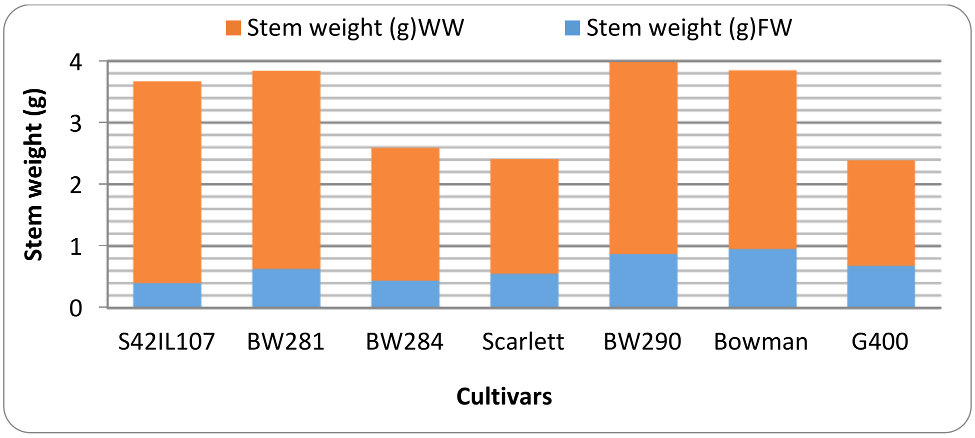

Figure (4) Average stem weight (g) of barley irrigated with freshwater and artificial wastewater.

Barley Uptake of nutrient
1. Nitrogen

Nitrogen comparison between barley cultivars irrigated with fresh water and simulated wastewater after and before irrigation process in Table 4. Nitrogen concentration in plant shoots was reported to be higher when grown with artificial wastewater; and it is found that N recovery in plants with artificial wastewater was higher than the N recovery in plant material grown with fresh water. These results were attributed to significant increase in soil N with artificial wastewater irrigation compared with the control. These results were attributed to significant increase in soil N with artificial wastewater irrigation compared with the control.

On the other hand, Papadopoulos and Stylianou [22] reported that during the third irrigation season for trickle irrigation cotton (Gossypium hirsutum L. cv.), the NO_3-N in petioles was greater with the treated effluent supplemented with no N, also in lamina; NO_3-N was greater at sampling of the lower N level. Our results are in agreement with the result of Papadopoulos and Stylianou [22].

Table (4): Nitrogen data of barley irrigated with freshwater and artificial wastewater

Cultivar line	N%-Soil After		N%-Root		N%-Spike		N%-Stem	
	FW	WW	FW	WW	FW	WW	FW	WW
S42IL107	0.14^{e}	0.17^{c}	0.49^{f}	1.07^{d}	1.37^{f}	1.60^{f}	0.56^{c}	0.63^{f}
BW281	0.13^{f}	0.15^{d}	0.62^{a}	0.93^{e}	1.41^{e}	1.70^{e}	0.65^{b}	0.63^{f}
BW284	0.17^{b}	0.19^{b}	0.45^{g}	0.95^{e}	1.58^{b}	2.10^{b}	0.82^{a}	0.85^{d}
Scarlett	0.14^{d}	0.21^{a}	0.53^{d}	0.70^{f}	1.56^{c}	1.90^{c}	0.54^{e}	0.88^{c}
BW290	0.14^{f}	0.22^{a}	0.60^{b}	1.43^{a}	1.45^{d}	1.80^{d}	0.36^{f}	0.94^{b}
Bowman	0.15^{c}	0.15^{d}	0.51^{e}	1.22^{b}	1.55^{c}	1.80^{c}	0.56^{c}	0.79^{e}
G400	0.21^{a}	0.22^{a}	0.59^{c}	1.12^{c}	1.78^{a}	2.50^{a}	0.55^{d}	0.99^{a}

* Means with the same letter per column are not significantly different ($p \leq 0.05$).

2. Potassium (K)

Plant absorbed the K through the root and the spike and stem and that is related to the fact that the K is slowly move in the soil in addition to that it react with the elements found in the artificial wastewater and thus decreased in the plants. The results showed that (K% – Stem> K%- Root, K% - Spike), the cultivars irrigated with artificial wastewater absorb less K content by the spike than the cultivars irrigated with freshwater. For freshwater, Scarlett cultivar absorbed the higher K content by the spike among the other types with K=72.33 ppm while Bowman absorbed the lower K content with K of (35.93) ppm. For artificial wastewater, Scarlett cultivar absorbed the higher K content by the spike among the other types with K=93.1ppm while G400 absorbed the lower K content with K of (22.4) ppm.

Table (5): Potassium data of barley irrigated with freshwater and artificial simulated wastewater

Cultivar line	K-Soil After (ppm)		K-Root (ppm)		K-Spike (ppm)		K-Stem (ppm)	
	FW	WW	FW	WW	FW	WW	FW	WW
S42IL107	12.77^{g}	83.30^{f}	28.67^{b}	7.50^{d}	64.33^{abc}	39.60^{c}	116.67^{b}	106.70^{b}
BW281	15.17^{f}	173.00^{c}	31.67^{ab}	26.50^{b}	66.00^{ab}	58.40^{b}	136.33^{a}	113.70^{a}
BW284	36.67^{b}	136.70^{d}	16.03^{c}	8.70^{d}	61.00^{bc}	40.20^{c}	104.00^{c}	68.90^{d}
Scarlett	29.13^{c}	103.40^{e}	37.53^{a}	21.40^{c}	72.33^{a}	93.10^{a}	114.00^{b}	50.80^{e}
BW290	44.43^{a}	193.70^{b}	27.33^{b}	36.30^{a}	57.17^{c}	91.40^{a}	105.10^{c}	84.70^{c}
Bowman	20.13^{e}	112.20^{e}	11.77^{c}	8.60^{d}	35.93^{d}	45.50^{c}	95.17^{d}	87.40^{c}
G400	25.83^{d}	234.00^{a}	12.83^{c}	4.30^{e}	42.00^{d}	22.40^{d}	69.30^{e}	20.90^{f}

*Means with the same letter per column are not significantly different ($p \leq 0.05$).

It could be observed from the results that the spike absorbed more K than the others part of the plant that irrigated with the same type of water, also it could be noticed that the plants irrigated with artificial wastewater absorbed less K content than the cultivars irrigated with freshwater.

3. Phosphorous (P)

The soil of the cultivars irrigated with artificial wastewater contain more phosphorous than the soil irrigated with freshwater, the phosphorous absorbed mainly in the spike whish had the higher P% compared with amount absorbed by both the stem and the root ,where the P% of the root was nearly higher than the stem (P% – Spike > P%- Stem, P% - Root) .No significant observed in the soil P before the irrigation, where a significant could be observed among the type of water for the soil P after the irrigation process .

It was also noticed that the plants irrigated with artificial wastewater had higher P than that irrigated with fresh water, there was a significant increase in P content in soil for the concentration artificial wastewater if compared with freshwater.

From the phosphorous (P) data of the soil, it is observed that the phosphorous content of the plants irrigated with artificial wastewater was nearly 2 times more than that irrigated with freshwater. For freshwater, G400 cultivar absorbed the higher phosphorous content by the soil among the other types with P=0.92 ppm while BW290 absorbed the lower phosphorous content with P of (0.19) ppm. For artificial wastewater, G400 absorbed the higher phosphorous content with P of (1.7) ppm, while S42IL107 absorbed the lower amount (0.3) ppm. There is a differences observed among the cultivars types irrigated with fresh water , G400 was absorbed the highest amount of phosphorous content by the soil with (0.92) followed by Scarlett and Bowman that had (0.37)ppm , followed by BW284, and BW281 and finally S42IL107 which had the second lowest amount of phosphorous content.

For the artificial wastewater, S42IL107 was the lowest with (0.3) ppm where G400 was the highest with (1.7) ppm

Table (6): Phosphorous (P) data of barley irrigated with freshwater and artificial wastewater

Cultivar Line	P-Soil After (ppm)		P-Root (ppm)		P-Spike (ppm)		P-Stem (ppm)	
	FW	WW	FW	WW	FW	WW	FW	WW
S42IL107	0.20^{d}	0.30^{f}	0.27^{b}	3.70^{c}	0.47^{c}	5.10^{a}	0.09^{d}	3.50^{b}
BW281	0.23^{d}	0.40^{e}	0.15^{bc}	5.20^{a}	0.26^{d}	4.00^{ab}	0.21^{cd}	4.20^{a}
BW284	0.24^{d}	0.40^{e}	1.35^{a}	4.50^{b}	0.32^{cd}	3.20^{b}	1.30^{a}	4.20^{a}
Scarlett	0.63^{b}	0.80^{c}	1.30^{a}	3.20^{c}	0.45^{c}	4.00^{ab}	0.47^{b}	2.60^{c}
BW290	0.19^{d}	1.30^{b}	0.10^{c}	1.30^{d}	2.66^{a}	4.00^{ab}	0.09^{d}	0.60^{d}
Bowman	0.37^{c}	0.70^{d}	0.28^{b}	0.90^{de}	0.22^{d}	4.60^{a}	0.26^{c}	0.80^{d}
G400	0.92^{a}	1.70^{a}	0.29^{b}	0.74^{e}	1.69^{b}	4.60^{a}	0.33^{c}	0.72^{d}

*Means with the same letter per column are not significantly different ($p \leq 0.05$).

DISCUSSION

Decreasing fresh water in the world has become a critical problem in many countries. Groundwater and surface water sources are the single largest water use in arid and semiarid regions for crop irrigation. One potential irrigation water resource is treated wastewater for agricultural fields located near urban centers. In addition, treated wastewater can contribute an appreciable amount of necessary nutrients for plants. The suitability of reclaimed water for specific applications depends on water quality and usage requirements. The main factors that determine the suitability of recycled water for agricultural irrigation are salinity, heavy metals, and pathogens, which cause adverse effects on human, plants, and soils [21].

The most appropriate wastewater treatment to be applied before effluent use in agriculture is that which will produce an effluent meeting the recommended microbiological and chemical quality guidelines both at low cost and with minimal operational and maintenance requirements [22]. The biomass production of barley as an animal feed measured as fresh weight and dry weight in farm per one meter, compared to crops grown in the control (where artificial wastewater was never applied) biomass production was significantly higher. Both added artificial wastewater and nutrients provided with artificial wastewater application can be attributed to such increase in biomass production.

Similar results were reported by Day et al. [23] who observed that wheat irrigated with simulated wastewater produced taller plants, more heads per unit area, heavier seeds, higher grain yields than did wheat grown with pump water alone. They attributed this increase to the nitrogen and phosphorus in the added simulated wastewater. The results showed that the barley cultivars irrigated with both fresh and artificial wastewater had in general the same growth vigour and growth nature, G400 had the best erect growth vigour while S42IL107 had the weakest prostrate growth, also the branch numbers of cultivars irrigated with artificial wastewater was more than that for freshwater. Plants irrigated with both artificial wastewater and freshwater required the same time to (emergence, stem elongation, flowering and maturity) with no significant observed among the water types, while a significant observed among the barley types.

It is clearly observed that plants irrigated with artificial wastewater gave nearly twice yield higher than that irrigated with fresh water. Although, plants irrigated with both artificial wastewater and fresh water had nearly the same height with slightly different in mean, high significant could be observed among the types. BW281 had the higher plant height. The spikes average weight increased for the plants irrigated with simulated wastewater and also gave higher spikes length than that irrigated with fresh water, and this prove that the simulated wastewater is better in irrigation to obtain higher yield since it contain more useful nutrients that improve the plants growth and give higher yields .Plants irrigated with artificial wastewater had nearly the same root weight while plants irrigated with artificial wastewater gave higher stem weight than that irrigated with fresh water. In the average, the artificial wastewater is alkaline with basic pH value of 7.3 and had a moderate level of total dissolved solids (TDS) of 1490 mg L^{-1}. Simulated wastewater can provide N, P, and K in amount equal to 4, 10 and 8 time of the fertilizers requirement of the forage crops [24] The artificial wastewater contains considerable amount of nitrate, phosphate and potassium, which are considered essential nutrients for improving plant growth and soil fertility and productivity levels. Artificial wastewater irrigation increased significantly the soil N, P, and K. Several researchers reported accumulation of N, P, and K in the soil with artificial wastewater application, which was attributed to the original contents of these nutrients in the artificial wastewater, applied [25]. These results agree with those reported by, who found that extractable phosphorus was higher in soils irrigated with simulated wastewater than in soil irrigated with fresh water or rainfall water.

Plant essential nutrient (total N, P, and K) were higher in plants grown in soils irrigated with artificial wastewater for different cultivars. The soil of the types irrigated with artificial wastewater absorbed more nitrogen than the soil irrigated with freshwater, the increase in N content of artificial wastewater was nearly twice than that of freshwater. On the other hand, the roots, stems and the spikes of the plants irrigated with artificial wastewater absorbed higher nitrogen than that irrigated with fresh water. The enhancement of plant N content with artificial wastewater application indicates that wastewater application provided the soil with these nutrients, which enhanced required for plant growth and soil fertility.

However, nitrate content should be monitored periodically to avoid its accumulation to critical levels that might affect its quality for animal feeds.

The increase in K content of artificial wastewater was nearly 3 times more than that of freshwater which related to the amount of K found in the artificial wastewater. The roots of the plants irrigated with fresh water absorbed higher K content than that irrigated with artificial wastewater; the same results were obtained for the stem and the spike. The plants irrigated with artificial wastewater had higher P content than that irrigated with fresh water. The roots of the plants irrigated with artificial wastewater absorbed higher P content than that irrigated with fresh water; the same results were obtained for the stem and the spike.

Soil and crop quality parameters are significantly affected by artificial wastewater irrigation. The management of artificial wastewater irrigation and its composition mainly determines this. In addition, continuous irrigation with artificial wastewater may lead to accumulation of salts, plant nutrients and heavy metals beyond crop tolerance levels. Therefore, these concerns should be essential components of any management of artificial wastewater irrigation. On the other hand, plant growth, soil fertility and productivity can be enhanced with properly managed artificial wastewater irrigation, through increasing levels of plant nutrients and soil organic matter. It can be concluded, based on these results that proper management of artificial simulated wastewater irrigation and periodic monitoring of soil fertility and quality parameters are required to ensure successful, safe and long-term reuse of artificial wastewater for irrigation.

Conclusion

The following are the research main conclusions:

1- The yields vary relating to the type of water used for irrigation. The highest yield were obtained in the plants irrigated with artificial wastewater, the cultivars irrigated with artificial wastewater gave nearly twice the yield of that irrigated with freshwater. BW290 cultivar showed the best highest yield among the seven types.
2- The use of artificial wastewater in irrigation increases the N, P and K contents in soil profiles. The quality of water used in irrigation affects the soil through increasing the concentrations of some constituents such as N, K and P.
3- Soil irrigated with artificial wastewater contain more N than the soil irrigated with freshwater, the increase in N content of artificial wastewater was nearly twice than that of freshwater and that results in increase of the N content in the plant parts. The N accumulate mainly in the root which had the higher N% compared with amount accumulated by both the stem
and the spike, where the N% of the spike was nearly higher than the stem (N% – Root > N% – Spike, N% – Stem).
4- Plant absorbed the K through the root and the spike and stem and that is related to the fact that the K is slowly move in the soil in addition to that it react with the elements found in the artificial wastewater and thus decreased in the plants (K% – Stem> K% – Root, K% – Spike).
5- The soil of the cultivars irrigated with artificial wastewater contain more P than the soil irrigated with freshwater, the P absorbed mainly in the spike whish had the higher P% compared with amount absorbed by both the stem and the root, where the P% of the root was nearly higher than the stem (P% – Spike > P% – Stem, P% – Root). 2- Build up stations for treating wastewater for facing the water crises especially in arid regions.

Further studies are recommended about the crops that could be irrigated by the artificial wastewater by considering the health and safety aspects for the use of crop production and workers.

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FIELD PRACTICE OF ENVIRONMENTAL ENGINEERING B.SC. STUENTS IN ALSÓ-HEGY (A DIDACTICAL VISUAL KARSTIC GUIDE, ARRANGED IN THEMATIC ORDER)

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Abstract

The education of the environmental engineers (B.Sc.) includes a high quality theoretical knowledge, practical skills and ecological approaches. A field practice is the best method to get practical knowledge in the nature. Alsó-hegy and its surrounding, where the field trip concentrated, is an excellent place to observe the karstic phenomenon. The report does not follow the time schedule of the trip. The observations are separated according to their topics, to emphasize the didactical aspects of field practice. The vertical caves (zsomboly) are important part of this lecture, because the Alsó-hegy is the famous for their vertical caves. This paper contains demonstrative pictures to help to understand the discussed phenomena. The overwhelming part of pictures was taken during the field practice. The figures of this paper were made by the participants of the field practice.

***Keywords**: Field practice, karstic phenomena, cave genesis, demonstrative examples*

1. INTRODUCTION

The overwhelming parts of the drinking water come from the subsurface water sources in Hungary. Meaning full part of them are karstic springs. Therefore, it is important to know the karstic phenomena well for the environmental engineers in Hungary. A field trip is the best way for the students to be familiar with real environmental situations [1-3].

Aggtelek National Park (Aggteleki Nemzeti Park, ANP), including Alsó-hegy, is a typical karstic region, which is excellent for the observations of the karstic phenomena [4-6]. This area belongs to shallow see Wetterstein formation (Limestone). The rocks of this area deposited approximately 220 million years ago in Mesozoic, Triassic period [5]. The five million years genesis has produced the recent formations. The amount of rainfall is about 680 mm in an average year, which is enough for the recent, permanent karstic activity.

2. DISCUSSIONS

2.1 Basic chemistry of lime stone

The limestone can be solved by water. The solvation processes become intensive in the presence of carbon dioxide according to the equilibrium equation (1).

$$CaCO_3 + H_2O + CO_2 \leftrightarrow Ca(HCO_3)_2 \qquad \text{Eq (1)}$$

The solvation process is intensive in the surface and in the cracks of rocks. The equilibrium goes into the right direction under these conditions. The source of the water is the rain and snow. The source of the carbon dioxide is the atmosphere, and decomposition of living creatures on the soil. The calcium hydrogen carbonate has good water solubility, which results in the degradation of limestone. The carbon dioxide cannot escape from the water solutions in the rock fissures, because the cracks are closed systems and the weight of the water columns produce bigger pressure than one atmosphere.

2.2 Solution process of the limestone

The solution of limestone has a positive feedback character. It means, if the limestone starts to dissolve produce a small hole somewhere, the solution processes become more intensive in the hole, than in the smooth surface. The solution processes go further in the bottom of the hole instead of the higher points. In the bottom of the holes the residence time of the water is longer than in the crests, therefore the solvation is more intensive in the holes. In this way the holes become deeper and deeper, and the crests remain relatively unsolved. This positive feedback processes result in uneven, bumpy surface formations. It is called devil plowing. The solutions can be directed and amplified the small tectonic fissures and soft (more soluble) rocks. The bigger formation of this positive feedback is the dolines, where a circle shaped valleys have their deepest points close to their center. The water of rain and snow-broth flows dawn into the deepest point of the dolines. The solvation of the limestone is the most intensive in the deepest point, because it meets the biggest amount of the water. The big flow of the water can produce solvation under the surface, so called sinkholes (Figure 1). The sinkholes are frequently the entrance of caves. The high speed water flow results in an improved genesis of underground holes in the sinkhole caves. The chemical solution processes are amplified with the mechanical corrosive effects.

The water flow drags rock particles rubbing and broadening the holes. There are some caves in Alsó-hegy, which have such geneses (e.g. Meteor, Pócsakő, Bába völgy, 404 caves)

Figure 1. The Pócsa-kői-víznyelő Barlang sinkhole cave. The explored cave is 51 m deep and 81 m long [6].

There is another form of the caves: the pit holes or vertical caves (zsomboly) formation. These caves have deep vertical shafts. The entrance of these cave can be a small hole, but the shafts are freqently more than 50 m deeps (Figure 2). The entrance of these caves generally are in the upper part of the dolines. The layers of limstone are in vertical positions in Alsó-hegy. The soft layers are solved intensively, which have enlarged solving the harder layers too, if the crack get enough water supplies. The pits become broader and broader with the depth of caves, producing conical shapes. If the thick watertight sediments deposite on the bottom of the shaft, the deepening of this saft could not go further.

In this case, the water solves a next shaft from the nearby rocks, which deepens the cave further [7]. A typical pithole cave in Alsó-hegy consist of the parallel vertical holes in different depths. The Vecsem zsomboly of Alsó-hegy, one of the deepest cave in Hungary, has 6 vertical shafts with 236 m depth. The Alsó-hegy is an excellent terrain to study the vertical caves, because their occurences are very dense there [6, 8].

Figure2 The narrow entrance of Tektonik Cave. The explored cave is 51 m deep and 81 m long [4].

2.3 Deposition of limestone in the caves

On the other hand, the carbon dioxide can escape from the water solution to the air in the caves and springs. The equation 1 goes to the left direction, which result in the precipitation of the solid limestone, producing dripstone, popcorn and tufa formations.

The hanging dripstones are called stalactites. If the water solution slips along a narrow fissure, the formation of dripstone started with a straw (Figure 3). The straws are tube, where the water solutions flow inside of the tubes and the calcite crystals precipitate at the end of the tubes. The pressure decreases in free open space at the end of the straw. This pressure drop results in bubbling out the calcium dioxide from the solution, and precipitation of calcium carbonate.

Figure 3Straw dripstones in Baradla Cave. This picture show the starting phase of stalactites.

Later, the holes of straws clog and the water flow dawn outside of stalactites. The stalactites can be several meter long (Figure 4). The water loses their carbon dioxide contents during flowing down on the surface of stalactites. The escaped carbon dioxide also produces precipitation, creating limestone layer on the surface of stalactites. The dropping or flowing water produce stalagmites on the floor of caves (Figure 5). The stalagmites are columns, which are built up from dripstones. The stalagmite can be bigger, than stalactites, because the too heavy stalagmites fall down from the ceiling of caves.

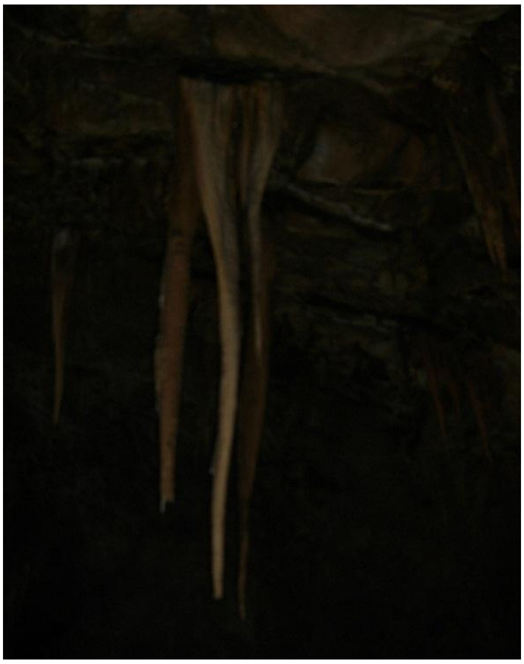

Figure 4Stalactites in Baradla Cave. The tips of stalactites were broken by floods.

The atmospheres of the caves are saturated with water vapor, creating aerosol. The drops of the aerosols also contain calcium hydro carbonate and carbon dioxide, which also produce precipitations of calcite crystals. However these precipitations are not regulated by the gravitation forces, but the peak effects play important role in genesis of helictite formations. The helictites are narrow needle shaped formations in various directions. They frequently show bended shapes.

Figure 5A characteristic stalagmite in Baradla Cave. The black color is an anthropogenic effect.

The stagnant water in the pool of the caves is oversaturated with calcium carbonate. This oversaturation also causes precipitations producing tufa, fresh water limestone depositions. The precipitations happen in the surfaces (Figure 6). The most typical shapes of these precipitations are the cascades of pools.

Figure 6 Tufa dam in Béke Cave. The tufa dams separate the pools being different levels.

The precipitations can be realized on the surface of the pools and on the stalactites and stalagmites (Figure 7). The stagnant pool can produce big crystals.

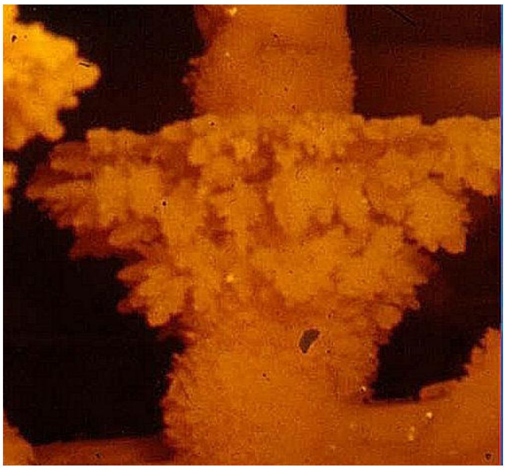

Figure 7 Crystal precipitations from a pool in Big Winds Cave (Italy)

The tufa type precipitations can also be results of decreased solubility power of cooled down water. The best example for this precipitation is the Pamukkale in Turkey.

The cooling water produces another underwater precipitations formation, called popcorns (Figure 8). These pea shaped formations have aragonite crystals instead of calcite.

The color of pure calcium carbonate is white, but several dripstones show other colors. The black colours of dripstones are the results of anthropogenic effects as the Figure 5 demonstrates well. The Baradla cave has been visited since the Stone Age. Up to the middle of 20th century the people light with torch. The torches produce not only light, but a big amount of soot. The soot deposited on the dripstones and colored them. The white spots are, the own color of calcite. These white deposition have born after the electric illuminations had been introduced, which had not produced soot. On the other hand, the intensive lightening results in green color, algae deposition on dripstones. The brownish yellow colours of dripstones come from clay residues of limestone. The red colors come from the painting effects of iron oxide (rust) traces.

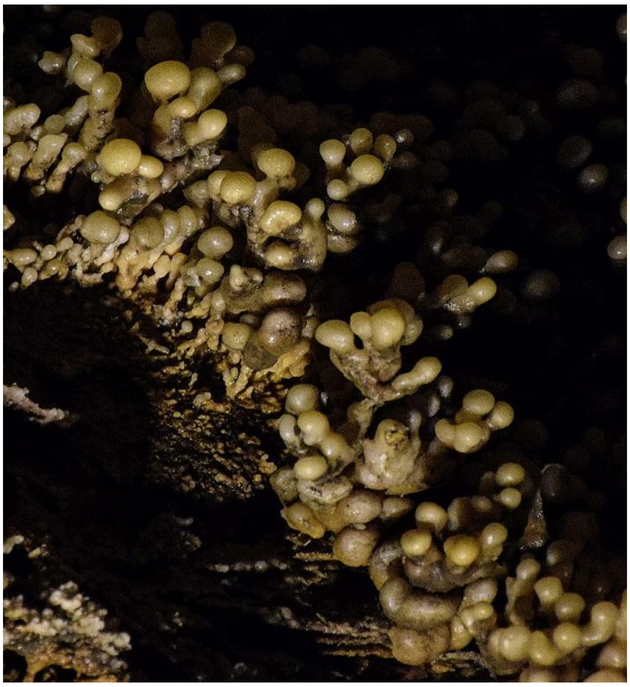

Figure 8 Popcorn formations in Rákóczi Cave. The popcorn aragonite precipitations are results of cooling thermal water.

Conclucion

It is necessary to hold field practice to get a realistic knowledge of karst phenomena for students. A visual guide helps a lot to understand the observed formations. We are preparing a complete more detailed audio-visual guide for karstic phenomena. It will be very useful not only for environmental engineer students, but it will give good information for others too (e.g. tourist, high school students).

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CLIMATE CHANGE ACTUAL SITUATION, AND RISKS IN ALBANIA

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Abstract

As it is known Albania is a small country where the main economy is services, some industry and agriculture and there are many challenges in addressing the climate changes risks. Actually main problems are heavy floods and landslides. Also the weather is changing in Albania bringing increase of temperature, extreme weather, floods, drought, waves, rainfall, etc. This papers gives an overview of climate actual situation, and risks in Albania. It brings information on how climate change impact main resources and infrastructure in Albania. It gives also a general overview on sectorial impacts and vulnerabilities to climate change, the policy context and information regarding ongoing climate change recently development in Albania. The paper ends with conclusion and recommendations.

***Keyword**: Climate change; flood; fire; lanslides; pollution*

1. INTRODUCTION

Albania is a small country with a population around 3 million. The economy is still very fragile and the most important sectors are services, industrial and agriculture. Because of not right implementations and policies the country faces many challenges in addressing climate change risks.

There are many factors which make the climate change as a priority for the future planning. Mains are energy supply system, agriculture sector, heavy floods, landslides, etc.

Climate change in Albania has started to feel in the second half of the nineties, becoming more evident in 1997, the year when winter came less, and in many areas with no snow. Usually, in the mountainous areas of Albania was snowing during winter (sometimes it ranged up to 2-3 meters in height), but in 1997 all winter was warm, and spring came hot, with a hot March. Since that year, the winters in Albania have become increasingly shorter and warmer, while the summers are made longer and hotter, sometimes with temperatures above 40^0C. The hot summer accompanied by autumn flooding, have been made a yearly phenomenon.

The climate change impacts have already become apparent visualy in coasts along the Adriatic where are crumbling across the length of the coast due to rising sea levels - in some areas, the sea has advanced to 50 m inland, destroying coastal forests and vegetation as well as enhancing the salinity of lagoons and fields along the coast. Sea level rise has led to serious injuries all over the Adriatic cost.

Many of the trees are dry and continue drying out of salinity growth. At other points, the amount of salt in coastal water wells has increased considerably, destroying the economy of these villages.

2. ACTUAL SITUATION OF CLIMATE CHANGES IN ALBANIA

According of the experts in the field the predictions of climate change will be temperature increases, the weather will be more extreme, with floods, droughts, heat waves, and rainfall will be decreasing in summer. Actually the protection of Albania's environment is behind the rythm of economic development. The increased demand for natural resources and uncontrolled exploitation has caused significant damage to the environment. More than 30% of the forests in Albania is destroyed. Reasons are different but more important are: extension of agriculture land, cutting the tree for heating and construction. It is interesting to know that 90% of *energy production* is from hydropower, but from the other side agriculture dependent on irrigation. This brings a serious problem on the country's water resources. Considering this situation, the government is promoting other forms of renewable energy – such as solar energy and biomass energy. Because of the pollution of water resources and lack of insufficient wastewater collection and treatment, leaking sewers and waste dumps the *safety of drinking water* is becoming serious problem. The national objective has been to have 98% of people access to safe drinking water, but this target is still to far to be reached. Another problem, trying to be solve for a long time is *Sanitation*. In rural areas, only a small proportion of the areas with piped water supply is equipped with sewer networks. This situation is very critic and not well addressed from the authorities. One of the biggest pollution source is *waste*. For a long time has been a strong debates concerning this issue. Actually there are more than 35 hotspots around the country. Albania is one of the most vulnerable countries in the region to a changing ***climate.*** It is estimated that summer *rainfalls* will decline by about 10% by 2020 and 20% by 2050[i]. This will bring a big impact on energy production and agriculture with an estimated loss of 60% of power generation capacity. This situation will have a big social impact and affect poor and rural people because of their greater dependence on agriculture. Concerning the *hazards*, Albania ranks as one of the countries with the highest economic risk in the world. Actually around of 86% of its territory prone to two or more disasters. This situation gives impact on vulnerable family. The *floods* in 2010 and 2015, 2017 showed that Albania's national disaster preparedness is reactive rather than preventive and that investments are needed to develop and implement national and local measures to adapt to changing climate conditions and reduce risks from future disasters.

3. RISKS IN CLIMATE CHANGE IN ALBANIA

As many other countries, Albania is becoming increasingly vulnerable to impact of Climate changes. The most significant hazards related with Climate Change are: *Extreme temperature; Wildfire; Windstorms; Landslides; Drought; Floods.* From the sectorial point of view the most vulnerable sectors are: *Energy; Agriculture; Water resources; Forestry; Toursim and setlements*. The vulnerability is driven in part by recent extremes in climate variability but also by past practices, socioeconomic conditions, or legacy issues. Two sectors that are acutely impacted by these shifts in climate are *energy* and *agriculture*.

Increasing temperatures; Climate change is increasingly affecting the nature and life of Albania. Measurements show that the number of days with temperatures of 20 degrees Celsius has doubled and the number of tropical nights has tripled, compared to the perennial average. It is expected to increase by 1.5 degrees Celsius by 2050. Temperatures continue to remain high even in November, while the usual falls for the fall season are still far from perennial averages. Climate change has resulted in mild winters that has favored the growth of tropical plants in Albania and has made it possible to show mosquitoes in altitude over 400-500 m above sea level. The winter is relatively short and mild and wet in the vicinity of the coastal areas. The summer lasts very long and is hot and dry.

Forestry and Fires**;** Climate change has also increased the number and intensity of *fires* in Albania. The causes of frequent fires can be very high temperatures in summer, long-lasting droughts and melting of the snowfall in the mountains. Albania is one of the Mediterranean countries most affected by fires. It is thought that in Albania in the coming years, because the average temperatures will increase coastal and southern areas, like Albania, will be always hotter and drier during the summer season, a season that will be extended even more over the years. Over the last two decades, the phenomenon of forest fires has increased in number and also in the size of the affected areas. Albanian forests are affected by forest fires especially at the end of spring and during hot and dry summer. The causes of these fires can be anthropogenic (human carelessness, burning pastures by shepherds, etc., and to a lesser extent, intentional or criminal fires) or natural (lightening).

Figure 1
Fire in Gjirokastra, Albania 2017
Source: https://www.koha.net/uploads/koha.net/images/2017/July/09/auto_2C122206-0FBC-4CF7-A65A-8EE9583D2084_cx24_cy8_cw77_w1023_r1_s1499633335.jpg?v=2

Climate Change and Energy*:* As we said before, 90% of *energy production* is from hydropower. This brings a serious problem on the country's water resources. Considering this situation, the government is promoting other forms of renewable energy – such as solar energy and biomass energy.

Climate Change and Agriculture*:* Actually in Albania Climate change already started and this situation needs immediate, medium, and longterm solutions. Changes in precipitation, rising temperatures, and increases of natural disasters are forcing Albania to address these impacts in new and innovative ways and begin adapting to a changing climate. One way used is working with farmers to help better understand the consequences of these changes, and helping to mitigate many of the most serious consequences resulting from shifts in climate. Grape production, for example is expected to have a severe impact - falling to 21 percent in some areas. However, winter wheat production is predicted to improve across the country - as climate change is likely to result in a prolonged season of cultivation, higher temperatures; seasoned in autumn and winter, and greater precipitation and greater water availability during the season of cultivation.

Food security remains a major development challenge in Albania. On the other hand, irrigation water availability is largely restricted by the change of the climate. This will greatly aggravate the effects of climate change on crops - particularly crops with irrigation. Ensuring food security in a changing climate is an important and pressing challenge in Albania. As part of efforts to address the challenges of food security and climate change, a new approach to agriculture is developing. This new approach, known as "*climate-aware agriculture*", highlights the need for agricultural practices that can simultaneously increase productivity in today's climate, build resilience to climate change and reduce greenhouse gas emissions.

Land slides**:** Among natural disasters, flooding and landslide created the biggest economic damage to Albania during 1990-2014. Over the course of 24 years, around of 33.5% economic damage was caused by *landslid*. Albania is in urgent need for afforestation of bare surfaces from trees over the last two decades and the protection of existing forest areas from fires. Researchers claim that afforestation will protect the soil from massive earthquakes. According to experts, the level of soil erosion by rains has increased 12 times; there were 14 tons of ground for hectares and we have gone 180 tons of rubble for acres. (Figure 5).

Earth's instability in Albania comes mainly as a result of heavy rain or snow precipitation. Frequent slides (rock slides and cliffs or instant deposits) are often marked along the steep slopes close to national and regional roads, drainage channels, irrigation and other engineering works. Problems due to geological causes also have often occurred in engineering facilities, almost in any case lacked a geological-engineering study or rarely taken into consideration by designers or investors (the study has been done formally). Bad examples are Tirana-Elbasan highway where is a huge landslide, ande where because of that the building of the highway is stoped (Figure 2, 3, 4).

Floods: The river system in Albania poses the greatest flood risk, because of the fact that during the November-March period, about 80-85% of the annual rainfall falls. In the last 40 years between 1980 and 2010, nine floods of large hydrometeorological floods were recorded, mainly in the northern area. About 86% of its territory is exposed by two or more natural disasters. Among natural disasters, flooding and landslide created the biggest economic damage to Albania during 1990-2014. Over the course of 24 years, 38.2 percent of economic damage was caused by floods and 33.5 percent, from landslide and 7 percent were damage caused by rapid floods. The remaining damages of about 20 percent are shared among the damages that have caused earthquakes, storms, fires, snow storms, etc. Since 2009, where floods have continued with high intensity, the total damage to net value created by the end of 2015 is estimated at about 200 million euros. Only from the rainfall of 6 January 2015 that created floods in some areas in Central and Southern Albania, the damage was estimated at about 15 million euros, of which about 9 million euros were created by the collapse of roads and bridges (Figure 6).

Rainfall: Researchers claim that alsmot every year rainfall is half the year before, droughts are added, and the rainfall trend is declining. They add that global warming and climate change threaten Albania from the western lowland, because with only 5 cm sea level rise there are flooded large areas of land close to zero or below its level. Albania does not affect the climate of the globe, but is undergoing the activities of other states. "*The part of our coastline is equal to or slightly lower than the sea level. So, if the sea rises, not with the 100 cm, 50 or 20 scenarios, but even if it rises to the minimum scenario currently taking place at 5 cm, then the coastal line penetrates the country down to Lezha - Mamuras road and up on the Fier - Rrogozhinë - Durres road. Our country is undergoing what is happening today in the world. Albania is a victimized country (S.Guri)* "[ii]- "*Albania has a level of rainfall of 1200-1400 mm per year. In areas such as Malesia e Madhe ranges 3500-4000 mm of rainfall per year. In areas such as Korça and Erseka, precipitation ranges from 800 to 900 mm per year. These have an uneven distribution during the months of the year. The most recent period of the year shows a decrease, while in the summer we have an increase of the drought period (P.Zorba)*"[iii]

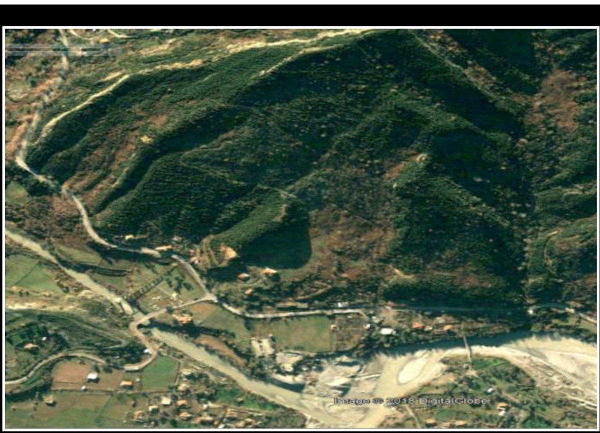

Figure 2 *Situation of the area on 2005 before Highway construction.* [***Source***: Google earth]

Figure 3 *Slided area after the Tr-El highway constructed (2016)* [***Source***: Hoxha E]

Figure 4 *Actual situation (2018) of the slided area, Tr-El highway.* [***Source***: Google earth]

Figure 5 – *Landslides in Blinisht village, Reps* [***Source***:http://top-channel.tv/2018/03/30/ rreshqitja-e-tokes-zhduk-nje-fshat-te-tere/

Shifting Coastline: The effects of climate change have begun to become apparent to Albania, where the coastal line is displaced inland with an average length of 50 meters, destroying the vegetation, the usable seaside for tourism, as well as rolling large areas of land. In some regions, the introduction of the sea into the earth is very seriously threatening the inhabited areas seriously by destroying the vegetation, the usable seaside for tourism.

In the multitude of studies on sea level growth, scientists have predicted that growth will range from 3 to 6 meters worldwide until 2100. So in five or six generations, Albania will face a sea that will grow in one meter. As shown on the map (*Figure 7*) entire areas of these areas, including inhabited areas and agricultural land, and beaches will be flooded. These floods will find their way into important segments of local and national roads. Sources of drinking water supply as well as many tourist accommodations and structures will be affected also.

Figura 6 *Photo from flood in Shkodra, Albania, 2015* [***Source***: http://www.panorama.com.al/wp-content/uploads/2015/06/Permbytjet_Shkoder_243019784.jpg]

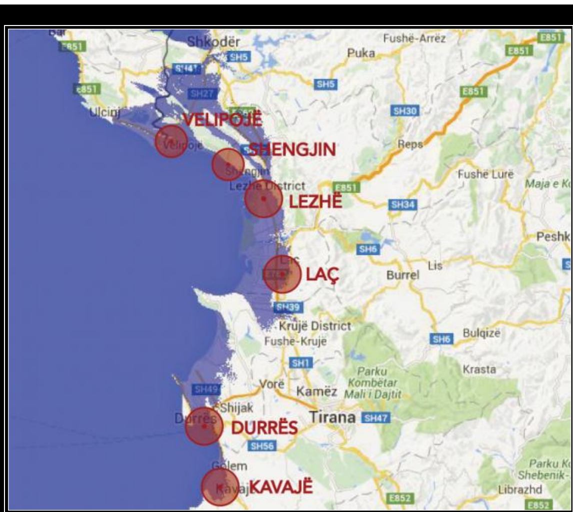

Figure 7 *Adriatic areas in flood risk from the see level increased* [***Source***: http://agroweb.org/archive// fo/10/20160129162 3579001057.png]

Risks in human health: This geographic shift (coastline) has led to the appearance of mosquitoes and infectious diseases spreading through this insect, such as hemorrhagic fever or Nile fever. Climate change has resulted in mild winters favoring the growth of tropical plants in Albania as well, while temperature fluctuations are undergoing drastic changes. All these changes like extreme warming, drought, fires, storms, floods directly affect human health. *Challenges in this area are*: capacity building to understand the health risks from climate change;

preparation of health systems to respond to threats to health; Climate-related emergencies management in health care institutions; Monitoring of air pollution to reduce respiratory diseases; improvement of alert mechanisms for infectious diseases; improving the health information system related to climate change. Over the last decades the evidence shows that there has been an increase in the prevalence of allergy from pollen in Albania, which appears in symptoms of polynomial and asthma in about 10% of the population with significantly higher prevalence rates in some countries, especially in the age groups new.

***Humanitarian risk*:** Climate change is expected to cause and increase disasters. The humanitarian consequences of climate change have a wide, multisectoral impact as they affect people in low-income areas disproportionately. Poor people and communities are reluctant to seek emergency humanitarian aid, as they face an increased frequency and intensity of weather related hazards. Excessive heat poses a serious threat to the entire population, but special groups are more vulnerable. These groups include the elderly and preferably all individuals with reduced ability to take care of themselves, such as young and disabled children, those with pre-existing cardiovascular, respiratory and renal disease, diabetes, neurological disorders and psychiatric illness. Extreme weather events have direct and indirect health effects on people and indirect costs for the economy.

***Discharging gases into the atmosphere*:** Albania is now rated by international institutes as a decarbonized country because of the closure of old metallurgical industries and not the release of gases into the atmosphere, but from the other it has damaged its forests and is not carrying out long-term investments in environmental conservation and development hers. Currently Albania *emitted 2.76 tons* CO_2 per capita which compared to EU 9.9 tons per capita make it the lowest country, but they are some new projects which projected to increase in the coming years, mainly from transport followed by agriculture and waste sector.

***Informing the public*:** Albania is not a good user of meteorological and hydrological information, and according to researchers, officials and business companies underestimate scientific evidence in projects to protect nature with long-term plans. Awareness of the Albanian public about the dangers of climate and the environment is still not at the leve it must be.

4. ALBANIAN STRATEGY FOR ADAPTING WITH CLIMATE CHANGE

There are some existing strategies to adapt with Climate changes as:

(1) National Strategy for Development and Integration 2015-2020, Second draft, 31 July 2015;

(2) National Integrated Water Resources Management (IWRM) Strategy, draft, July 2015;

(3) Albanian Strategy for Health System Adaptation into the Climate Change 2011-2021, October 2011;

(4) National Strategy on Energy, draft, 2015 Environment Crosscutting Strategy (2015 – 2020);

(5) Integrated Crosscutting Coastal Plan (draft) National Territorial Plan (draft).

The Albanian strategy for adapting the health system with climate change includes: Strengthening health services to improve their response to climate change impacts; Public awareness of the effects of climate change on health; Adapting the information system in order to detect the risks of climate change, in order to assess their effects on health in time; Encouraging scientific research on health and climate change; Strengthening of air pollution monitoring systems with special focus on particulate matter and ozone; Increasing the capacity to cope with health problems expected to be caused by heat waves and extreme cold weather; Improve the cooperation and integration of the health system into national emergency structures responsible for floods and fires, landslides and other natural disasters under the influence of climate change; Adapt and integrate surveillance and control systems for contagious diseases; Strengthen services for the prevention and management of health problems caused by increased exposure to pollen; Strengthen monitoring and prevention of health problems arising from ultraviolet radiation.

Conclusions and Recommendations

Conclusions

- Considering all above results that Albania is seriously affected by the climate changes.
- Analysing the existing situation and actions taken results that the Climate Change impact it is not a high priority for the authorities.
- The awareness of the public it is not in the requested level.

Recommendations

- It is recommended to make a concrete and updated Plan of Action on climate change mitigation and adaptation across sectors;
- To support the development of a National disaster risk reduction strategy;
- To support the disaster early warning systems and the vulnerable groups living in areas affected by climate change;
- To enhance local capacities for sustainable forest management and protected areas and biosphere reserves;
- To support school, administrations, civil society organizations, youth and children in promoting environmental education, and developing initiatives aimed at natural resources preservation;
- To promote innovative technologies for renewable energy and integration of health and environmental;
- To support the regional cooperation.
- To support for enforcement of environmental legislation;
- To rehabilitate and increase irrigation and drainage capacities and the variation of crop varieties and optimize the use of fertilizers.

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