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DETERMINATION OF TRITIUM LEVEL OF SUBSURFACE WATER AS EDUCATIONAL TOOL

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Abstract:

The tritium content of subsurface water depends on the age of water and its contamination with surface water. The tritium content of subsurface water also refers to the quality of sampling.

Generally the level of tritium is very low in the nature, therefore the measure of tritium content requires concentration steps and dedicated instrumentation. An appropriate measurement needs precise manipulation and statistic evaluation, which can be learned with well constructed education and manual training. The education methodologies of different steps of tritium determination are emphasized in this work.

Keywords:

Environment, sampling, tritium, education methodology

INTRODUCTION

Isotope hydrology belongs to hydrology, that uses isotopes to estimate the age and the origins of water. These techniques are used for water-use policy, mapping aquifers, conserving water supplies and controlling pollution.

The isotope hydrology measures the followings:

- **Tritium**
- Radiocarbon

Tritium was discovered by physicist Ernest *Rutherford*. Willard Libby used the tritium for age determination of water and wine the first in 1934.

Tritium is the radioactive isotope of hydrogen. It consists of one proton and two neutrons. It decomposes to ^{3}He stabile isotope with half life 12.32 years.

Natural abundance of tritium are formed by the interaction of the atmosphere with cosmic rays (14N + n →12C + 3H). The **anthropogenic t**ritium is produced in nuclear reactors by neutron activation of lithium-6, and in the 1960-s **n**uclear weapon tests. Activity concentration unit of tritium is 1 TU, where the ratio of tritium to hydrogen is (^{3}H/^{1}H) 10^{-18}. One TU is equal to 0.118 Bq/l (1.11 x 10^{-16} mol/kg) in water.

Recently the surface waters have 7-28 TU activity with seasonal deviations. In nuclear test sequentially activity concentration of tritium on surface elevated to 1000-2000TU. (Figure 1).

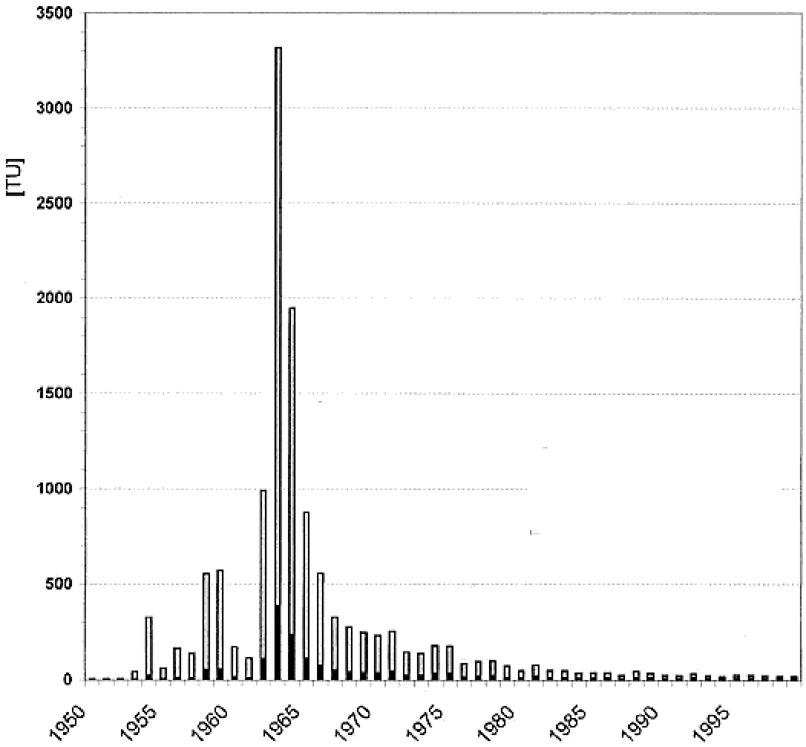

Figure 1: The tritium yearly levels increased steeply in surface water during the fifties and sixties as the consequence of the air nuclear bomb tests. The tritium level of surface water is decreasing, because the nuclear tests were stopped at the end of sixties. Signals:□, original precipitation; ■, remaining activity in 2000 (dr. Deák József).

On the other hand, the TU level is much less in the subsurface water, which had no contact with surface water since fifties. That is the reason, why the TU can be used for determination of the sampling quality from the subsurface water. The increased TU of subsurface water shows the mixing of the surface and subsurface water. The increased TU is caused by the bad sampling, or pollution of subsurface water with surface water before sampling.

Measuring of TU is a very precise and sensitive method. This method, however, needs dedicated instrumentation and well trained sample handling. Moreover, the low level of the radiation requires statistical data treatment. This poster shows an educational scheme for the high quality determination of TU values of subsurface water.

DETERMINATION METHODS OF TRITIUM LEVEL

The decay of tritium produces low energy, β-decay (18,590 keV). This means the β-ray has less than one millimeter track in liquid and solid phases. Therefore it is hard to make direct interaction among the beta particle and detector. The solutions are the indirect techniques:

- using transmitting compounds
- determination of ^{3}H decomposition product.

1. Determination of tritium with liquid scintillation β-counting (LSC) method:

These measurements are simple well automated methods. The generally used transmitters are aromatic compounds in the liquid scintillation cocktails. Without concentration steps, the measurements have small deviations.

2. Determination of tritium with T-^{3}H method

The ^{3}H decay product is determined by mass spectrometry. The method is time consuming (3-6 months). It is required long time to collect enough materials for precise detection. This method has one magnitude bigger sensitivity than LSC method.

Using concentration steps (distillation, electrolysis) LSC methods meet the regulation requirements of authority with detection limit (0.12 – 1 TU). The electrolysis method achieves one magnitude sensitivity increases with 60- 80 % recovery (Figure 2).

The sampling and concentration steps, however, are source of many mistakes.

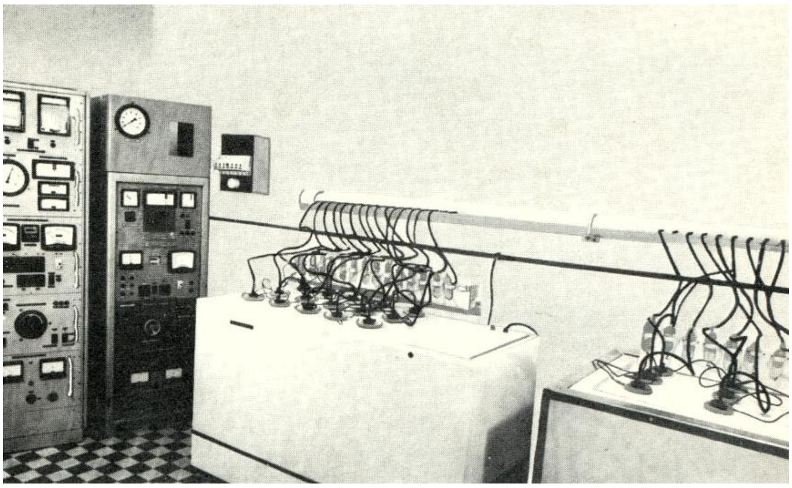

Figure 2: The concentration of tritium using electrolyses., During the electrolysis the heavy molecules of water (containing tritium) migrate slower to the anode than water molecule without tritium.

TEACHING OF THE GOOD SAMPLING OF SUBSURFACE WATER

The sampling is the most critical step of the environmental analysis. There are several official standards for sampling. These procedures neither contain practical tricks, nor troubles which can arise during a field study. More than 50% of the occasions produce such troubles, which are not referred in standards. The solutions of these difficulties require routine in field work. Even a well educated engineer can not solve the difficulties without manual practice. The data of TU measurements refer the correctness of sampling of subsurface waters. That is the reason of the tritium measurement can use as education tool for right sampling.

- The most frequent mistakes are the following during the sampling a monitoring well:
- Identification of location of well,
- Opening of well,
- Determination of well parameters (static well level, depth of borehole),
- Inappropriate use of pump,
- Inadequate volume of water pumping before sampling,
- Inappropriate labeling of sample bottles,
- Bad quality, non-standard report.

A good sampling requires pumping out the water in more than 3 times volume of the well before the sampling. In the case of karst cave, 50 minutes pumping period is necessary before sampling (Figure 3).

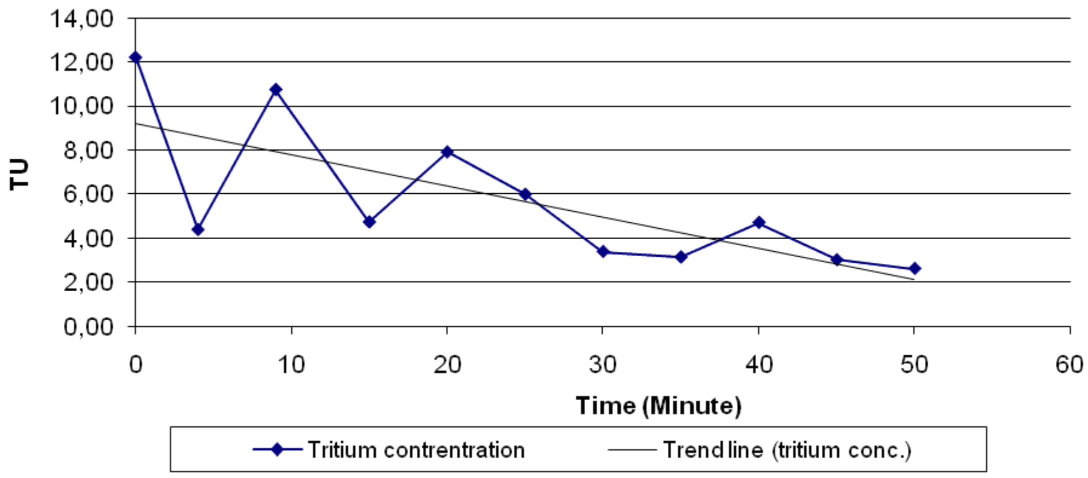

Figure 3: The tritium activity of the samples from a cave as function of pumping time. The cross contamination diminishes only after 50 minutes pumping.

On the other hand it can be over pumped, a monitoring well of the shallow aquifer (Figure 4).

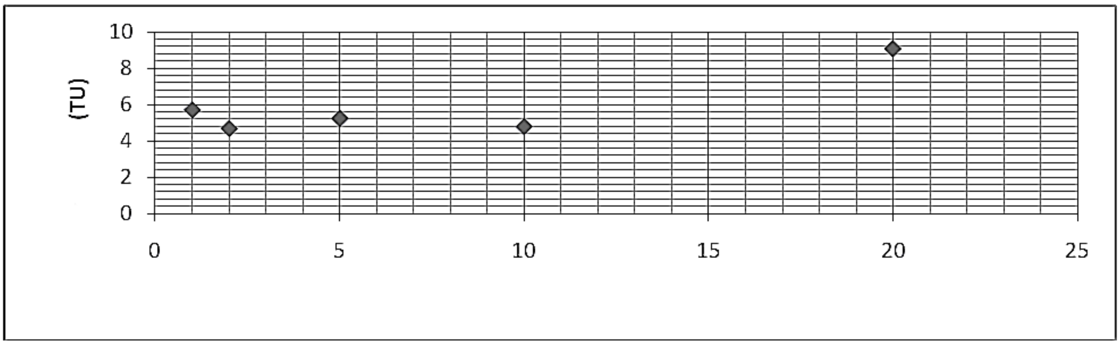

Figure 4: Over pumping a monitoring weel of shallow auifer. Surface water pollution has been sucked after 20 minutes.

SAMPLE TREATMENT

The mistakes of sample treatments produce the 30 % errors in environmental analyses. Avoiding the cross contamination is very important in the analysis of radioactivity of environmental samples. A laboratory works dealt with not only samples having natural radioactivity levels. A mismanaged highly active sample can totally pollute the whole laboratory and apparatus. Such pollutions require laborious, time and money consuming decontaminations.

Most frequent mistakes during the sample treatment of tritium determination process:

- Contaminated glass wares (bakers, tubes, cuvettes, pipettes, often with K),
- Too fast distillation,
- Cooling water pollution,
- Cross contamination from neighboring samples,
- Contaminated laboratory,
- Light memory in the prepared sample,
- Improper scintillation cocktail, quenching,
- QC samples having inadequate range.

DATA EVALUATION

The radiation level is rather low of the uncontaminated subsurface water samples. The gained data are close to background level, and the counted value shows rather high deviation. The correct data evaluation requires several repeats and statistical data treatments. The tritium measurements are also good to became familiar to statistical methods.

Only the manual practice gives the appropriate knowledge to overcome the difficulties of sampling and sample treatment. The tricks and critical steps can be taught only experts having strong theoretical and experimental background.

On the other hand, the sampling and sample treatment knowledge, which has been got during the analysis of tritium samples, are very useful in the cases of the other samples too.

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