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Pb(Po)-210 concentration of tobacco samples grown in the vicinity of a remedied uranium mine

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Abstract. The environmental monitoring of waste heaps, sludge reservoirs is an important task. The Pb(Po) accumulation of tobacco has been known for long. Knowing familiar with the accumulation capability can be suitable for bio-monitoring the tailing ponds of the remedied uranium mine, as isotopes may be bound on the skin surfaces or may be absorbed via the roots.

Our research investigates the Pb(Po)-210 concentration values of tobacco plants grown for experimental purposes in the remedied uranium-mine area.

During the work the Pb(Po)-210 concentration values of 73 tobacco and soil samples, grown between 2002-2009 were determined using a semi-conductor (PIPS) detector alpha-spectrometer. The source for measurement was prepared using spontaneous deposition process following the combined acidic leaching using Po-209 tracers.

Based on the results it can be stated that the Pb(Po)-210 activity concentration values of tobacco and soil samples altered between 2.12 ± 0.8 – 1866 ± 98 mBq/g.

Processing the measurement data of the previous years it was apparent that with the changes of the Pb(Po) concentration values of the soil samples the activity concentration values of the tobacco samples also changed proportionally. Therefore, later the migration of radioisotopes disengaged from the tailings dump can also be traced.

1. INTRODUCTION

Nowadays, the use of plants as bio-indicators of contamination is quite wide-spread. Among the naturally occurring radionuclides of Pb and Po involved in the decay series of U-238 are the easiest to mobilize even in a weakly acidic medium.

Tobacco is a widely used bio-indicator. Its heavy metal-absorption related to soil type and other conditions of growth was previously inspected by several researchers [1, 2].

Tobacco is generally used such as a Po and Pb bio-indicator for a great number of reasons; several studies were published on the Po-content of cigarette smoke during the 1960s-70s [3, 4]. Pb(Po) may enter tobacco in two routes. One route is through the skin of the tobacco leaf, which is a large adsorption surface further increased by the hairs (trichomas) on it, so one way of entering is when the Pb(Po)-210 content of the aerosol deposited on the leaf sticks to the surface and gets absorbed [5]. The other way is the absorption through the roots, as in several cases high concentration levels were measured in strongly fertilized territories [6, 7]. However, the exact route of the mechanism has not yet been identified.

In this case the question is not about the entering of Po-210 but that of its parent element with a long half-life that is Pb-210. During the growing season of tobacco Po-210 partly decomposed due to the 138-day long half-life. Therefore, if the Po-210-concentration is measured 1-2 years after sampling ($T_{eq} = 438$ days), this concentration will also express the concentration of Pb-210 in secular equilibrium.

The objective of this research was the inspection of the Pb(Po)-210 concentration levels of tobacco plants experimentally grown in the area of the uranium mine started the remedy of which in 2001 and completed by 2008. Besides, our task was to identify the Pb(Po)-accumulating capability of tobacco

Table 1. The origin of the samples with GPS coordinates.

The origin of the samples	GPS LON	GPS LAT
Tailings dump	E18° 08' 02.01"	N46° 01' 45.90"
Water treatment plants	E18° 07' 28.07"	N46° 02' 12.83"
Pellérd village	E18° 09' 06.57"	N46° 01' 49.66"
Kővágószőlős village	E18° 07' 35.00"	N46° 04' 60.00"
Bakonya village	E18° 04' 58.94"	N46° 05' 08.40"
Veszprém city	E17° 54' 31.55"	N47° 05' 48.06"

and the value of the transfer factor between the soil and the tobacco as the effect endangering the water base and the nature can be inspected from the changes of the Pb(Po) concentration levels. The achievements of our work are quite important as agricultural fields are located in the 50–100 vicinity of the recultivated areas, and there are a lot of small settlements and water bases in the surroundings, and there is no experience of several decades or centuries on the possible environmental effects.

2. MATERIALS AND METHODS

2.1 Sampling and sample preparation

Since 2001 we have been continuously cultivating tobacco samples on the closed uranium mine area (on the tailings dump, and on the water treatment plants), on three close villages (Pellérd – 5 sites, Kővágószőlős and Bakonya) and analyzing the Pb(Po)210 concentration of different parts of the plant and soil samples. In the course of the examinations concentration values in 31 pieces of samples (soil, roots, stems and leaves) were measured.

The tobacco samples were dried at room temperature – so that the concentration of polonium is not reduced – then they were milled with coffee mill. The soil samples were shredded with mortar to fine granules.

2.2 Po-210 source preparation and Po-210 detection

During the determination of the Po-210 activity concentration the first step was to add a known amount of Po-209 tracer to 2 g of each sample. Then combined classical acid leaching was used, i.e. at first 3 times evaporation with cc. HNO_3, then 3 times with cc. HCl and finally 3 times with ultrapure Millipore distilled water to approximately 5 ml [8]. The source preparation process meant the spontaneous deposition onto stainless steel plate with high nickel content.

For the detection "Ortec Soloist alpha-spectrometer" semiconductor (PIPS) detector was used in vacuum [8]. The measurement time was set to 80 000 s.

The detection limit of the measurements – by 95% confidence level – altered between 0.48 to 2.10 mBq [9].

3. RESULTS

3.1 Samples from the mining site

In 2001 experiments were carried out in the uncovered tailings dump. Tobacco samples were planted into 100% sludge, into 50% soil-sludge mixture and into 10% sludge-90% soil mixture. In the 100% sludge the plants did not survive. In the case of the mixtures the activity results give the expected profile, while approximately 100 mBq/g Pb(Po) concentration was detected in the case of the leaves. The data concerning the years 2002 and 2009 clearly show (Figure 1. part a) that the cover of the tailings dump

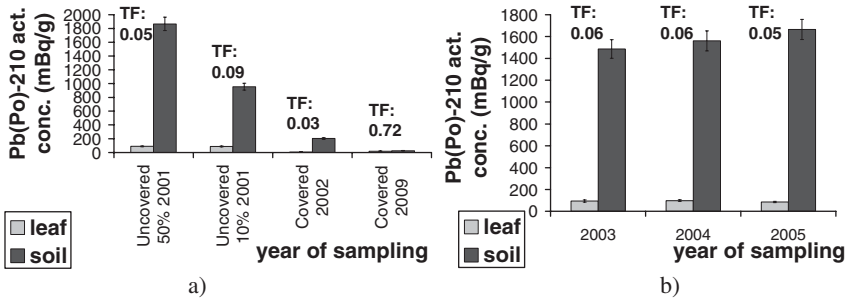

Figure 1. a) The results of tobacco and soil samples from the tailings dump b) The results of tobacco and soil samples from the water treatment plants.

works properly, radionuclide migration did not occur. By 2009 the isotope concentration of the soil had reduced to 30 mBq/g and around 20 mBq/g tobacco isotope concentration belong to this value.

On the other hand, the results in the case of water treatment plants are presented in part b) of Figure 1. It is to be known of the water treatment plants that the high radionuclide content sludge of the radium and lead elimination process of spill water collects there. As it was expected the relatively high (1500 mBq/g) Pb(Po) concentration of soil also indicates a relatively high (100 mBq/g) Pb(Po) concentration in the tobacco leaf.

3.2 Surrounding communities

Tobacco were planted in 5 different locations in the Pellérd village, nearest the closed mine. The above figure (Figure 2. part a) shows the annual average of the 5 samples with the annual maximum and minimum values. As it can be seen in Figure 2 all of the samples in a year are relative in the average standard deviation, and on the other hand in different years there are no significant difference between the values measured, the Pb(Po)-210 concentrations of soil samples are between 30–40 mBq/g, while in the case of the leaf samples they are between 10–20 mBq/g.

A few km away from the mine at Bakonya and Kővágószőlős similar values – in the case of soil samples between 25–35 mBq/g, in the case of leaf samples 8–20 mBq/g Pb(Po) concentrations – were measured.

3.3 Comparison of the samples from the villages with samples from another region of Hungary

According to the above figure (Figure 3) it can be stated that the mean values of the measured results in the case of the villages compared to a sample from a different area of the country (from Veszprém), no significant difference is obtained, i.e. radionuclide migration in the area had not occurred, the cover of the tailings dump functions properly, the slurry has not released radionuclides so the nearby communities are not exposed to contamination.

4. CONCLUSION

Summarizing the results of our work: since 2001 more than 200 tobacco and soil Pb(Po) activity concentrations were determined.

On the basis of the results the following fact can be seen: the Pb(Po) activity concentration of samples from the covered tailings dump and from the nearby villages do not notably deviate from the other Hungarian (Veszprém) sample examined i.e. Pb(Po) migration did not occur on the monitored area and the covering of the tailings dump is suitable for remediation.

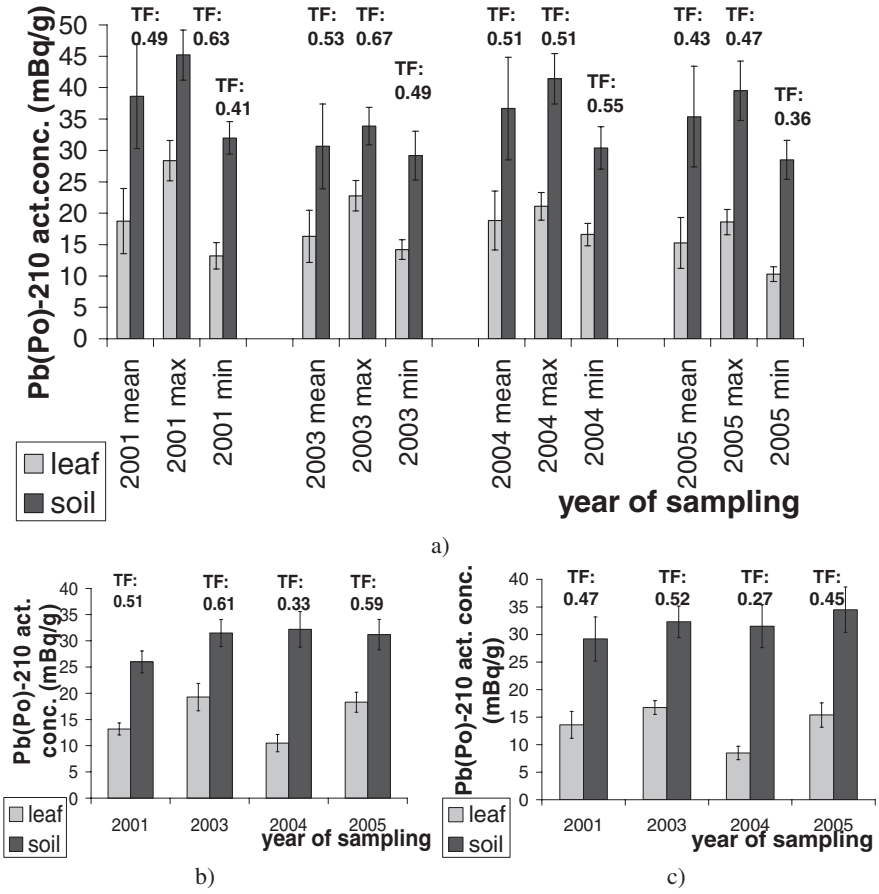

Figure 2. a) Results of samples from Pellérd village b) Results of samples from Kővágószőlős village c) Results of samples from Bakonya village.

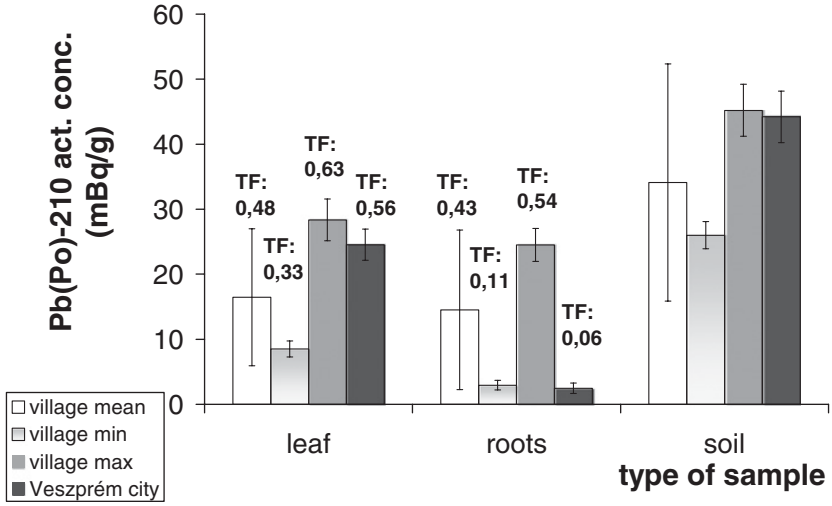

Figure 3. The mean measured values in the case of villages compared with results origin from another region of Hungary, Veszprém city.

On the other hand, it can be stated that close relationship can be found between the Pb(Po) concentration of tobacco and soil samples, so the tobacco can be recommended as a monitoring indicator for remediation.

However, it is essential to define the accumulation route for the determination of the anomalies. This is an important future task to get to be carried out.

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