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Determination of Radionuclide Activity of U-238 in Wheat using Gamma Spectrometric Method

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Abstract: Migration and accumulation of contaminants in soil is complex and involves different processes such as leaching, capillary movement, sorption, nutrient resuspension in roots and into the atmosphere. Speciation of radionuclides in ecosystems depends on the source and layoffs, the distance from the source, dispersion processes and deposition conditions. Resuspension of radionuclides from the soil surface to the outer portions of the plants occurs due to the action of rain and wind. Significant variations in contamination can be expected depending on the type of plant, plant growth conditions and methods of its preparation before consumption. In this study we determined the activity of radionuclides U-238 in the aerial part of wheat that was sown on a sample of soil from Hadzic, and as an added contaminant different uranyl acetate concentrations were used. Gamma spectrometric measurements were carried out in a vertical coaxial HPGe detector. It is concluded that, regardless of the concentration of the contaminant, if the plant has a sufficient amount of essential elements, in this case potassium, it will not take an element that is harmful to its development, such as the uranium-238, which belongs to the toxic and unnecessary elements in plant nutrition.

INTRODUCTION

Due to differences in physico-chemical properties of the radionuclides and soil matrix in which the radionuclides are present, the different chemical forms of radionuclides present in the soil will be available for different plants. The process of migration of radionuclides in the soil-plant system and the behavior of radionuclides in soil and plants, and some certainly affect the capability of the plant. In order to quantify the transport process of radionuclides from soil to plants term plant / soil concentration ratio has been introduced often referred to as transfer factor (TF) (Mortverdt, 1994) The transfer factor (TF) is defined as a factor used to evaluate the transport of radionuclides and other elements of interest through the food chain. Shepard *et al*., defined it as a factor that describes the amount of an element which is expected to be from the substrate to enter the plant in terms of balance. Knowledge of transfer factors can theoretically allow the calculation of radionuclide activity in the plant and animal products on the basis of the measured activity in the soil, and the study of transfer still in the early radioecology been a frequent topic of research (Ng YC *et.al.*, 1982).

Contamination of plants is carried out in two ways:
- depostion of radionuclides on a plant surface (surface, foliar contamination); and
- radionuclide transfer from soil to plants via the root system.

Bettencourt *et al*.,(1988) have found that various factors such as soil characteristics, climate, plants and their parts, the physical and chemical form of radionuclides and the effect of competing organisms (organisms that compete with plants for food) may affect the value of transfer factors.

Understanding the behavior of uranium, thorium and artificially produced transuranic elements in the food chain

is important because of its long half-life, the fact that alpha emitters as well as their presence in the environment (Zovko, Pujić, 2003) . One of the very important questions is whether the uranium, if present in the soil in high concentrations of natural representation, can incorporate into biomass and above-ground part of the plant.

The task of this work was to investigate the possibility of transfer of uranium contamination on the surface of the plant from the part of the soil, which leads to the development of the primary plant species, and where there is the possibility of soil erosion, dependence on the type of soil.

For this purpose, wheat was selected and the transfer of uranium from the soil in wheat during the early stages of vegetative growth has been monitored. Reason to use this plant is its distribution in the dietary habits of the population in this region and beyond. Monitoring was carried out at an early stage of the vegetative period for practical reasons, and the scientific assumption that if uranium reached the overground part of the plant, there is a likelihood that they will be placed in the final stage of growth, that is, the fruit of the plant.(Radović-Rajević, 2011).

EXPERIMENTAL

In the experiment we used vegetable crops wheat seeds such as „Winter wheat" variety "Renaissance", the category C-1. General features of these seeds are that they have a good resistance to winter, it is very drought tolerant and resistant to powdery mildew, number of 1.000 grains weight s 40-45kg, very good milling and baking properties etc. This type of wheat has a very high yield at favorable conditions, but also in the conditions of stress caused by the drough .This put it in the group of plant varieties that can be grown in very heterogeneous agroecological regions.

The samples were taken from the soil from Hadzic area. Four wheat samples were weighed out .Additionaly, sample of the soil were packed in containers for three different uranyl acetate concentrations and one for zero concentration of UAc. The sown seeds were abundantly watered to maximum swelling, before the appearance of the first sprouts on grains. This was followed by a period of drying out of the soil in the pots, so the soil could accept a solution of the contaminant and not leak out of the pot. After that, three different concentrations of the solution of uranyl acetate were prepared: 0.03 g/cm^3, 1.00 g/cm^3 and 2.00 g/cm^3.

Samples were spiked with contaminants in small portions, making sure that all contaminant remains in the container with soil. In this way, the simulated contamination on the surface layer and maximum availability enabled contaminant to enter the root system of plants. To monitor the transfer of uranium from the soil in biomass it was necessary to monitor its presence in the soil, root system, and in the aerial part of the plant, but only after it is established radioactive equilibrium (six half-lives).

For this purpose, the separation was carried out above ground portion of the plant root system by cutting it to a height of 1 cm from the surface of the soil, to obtain a pure sample from the aboveground part of the plant. All four samples were dried at room temperature to a stage when the plant breaks down to hey and process of annealing can be performed.

Given that the experimental conditions did not allow a large yield of plant material above ground part of the plant, preparation phase annealing was not performed, because in this case the mass of the sample for measurement was extremely small. Prepared samples are weighted and packed in plastic boxes, and then the measurements were performed.

Gamma spectrometric measurements were performed on a vertical coaxial HPGe detector POP-TOP p-type, manufacturer "ORTEC" model "GEM 30P4" with relative efficiency of 30% and a resolution of 1.85 keV-MeV and at 1.33. Activity of this radionuclide (^{238}U) was measured from its gamma gamma lines and lines of his descendants. The specific activities of ^{238}U was calculated from ^{234}Th to 63 keV energy and the energy ^{234}Pa 1001 keV's.

RESULTS AND DISCUSSION

Since the task was to determine whether there is a transfer of uranium from the soil in the overground part of the plant, the experimental setup used was for areal soil specific chemical composition (Table 1).

Table 1: The chemical composition of the used sample soil.

Parameters	Sample
pH (H_2O)	7.46
pH (1 M KCl)	7.21
$CaCO_3$ (%)	2.04
K_2O (mg/100 g soil)	56.78
Cu (mg/kg)	42.0
Fe (%)	3.38
Ca (%)	0.25
Mg (%)	0.69

It was expected that such a chemical composition will have a quite an impact on the yield of plant species. And will transfer uranium from the soil in biomass. Which according to the classification of plant nutrient belongs to the group of toxic elements? Given the laboratory setting conditions of the experiment, eliminating the sensitivity of plant species to agroecological heterogeneity. We used the highly resistant wheat variety, which is easily adaptable and dry and moist soils and diversity of the chemical composition of the soil. The growth of plants was monitored during 26 days and then samples were prepared for measurement. The experiment was performed three times measuring of the height of the plant above the ground and data are presented in tabular and graphical form.

Table 2: Results of radionuclide activity in the overground part wheat.

C(UAc) (g/ml) in the soil	A (Bq/kg) U-238	A (Bq/kg) U-235	A (Bq/kg) K-40
0.00	1.20	< 29	1819.98
0.03	20.10	< 22	1822.00
1.00	80.60 +/- 54.3	8.24 +/- 5.51	1881.35
2.00	152.58+/- 58.05	13.87 +/-11.40	1665.02

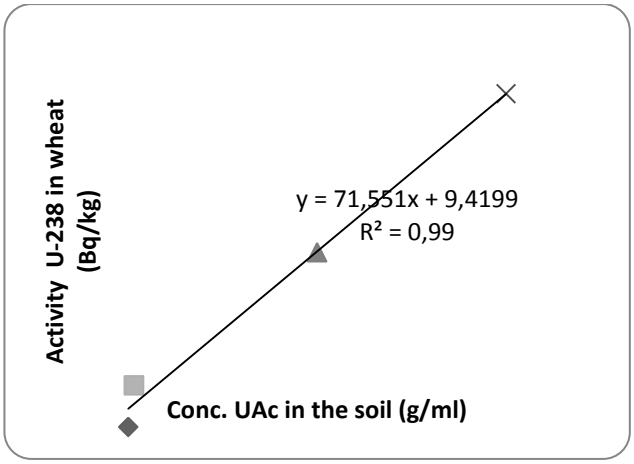

Diagram 1: Distribution of U-238 in the overground part wheat.

Table 3: The mass of absorbed radionuclides in the overground part wheat.

C(UAc) (g/ml) in the soil	0.00	0.03	1.00	2.00
NUCLIDE	**U-238**	**U-238**	**U-238**	**U-238**
Mass (µg) in the overground part wheat	1.05	2.8	6.53	12.35

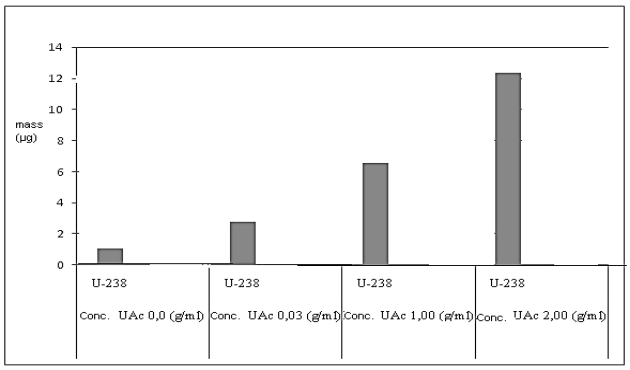

Diagram 2: Graphical representation of radionuclide mass depends on the concentration of the contaminant.

The results of measurements of activity of nuclides in the soil from the site Hadzici (Tables 2 and Diagram 1). The uranium activity in the soil increased proportionally increasing the concentration of the contaminant, and potassium content remained constant.

Aboveground part of plants were characterized by a sudden increase in the content of potassium, slightly below 2000 Bq/kg, and a sudden drop in uranium content. Therefore, plants have had quite enough source of potassium, which is incorporated in the overhead part of the plant, while in the same part of the plant. The uranium content is very low.

From obtained values for nuclides activity and using data on the specific activity (As) U-238 (1g U-238 = 12 350 Bq) we obtained results presented in Table 3 that shows a mass in micrograms absorbed radionuclides U-238 in surface parts of plants developed during the experiment.

The resulting values are shown in the diagram 2, from which it is evident that the amount of absorbed U-238 is measured in micrograms.

CONCLUSIONS

Following the development of the above-ground plant species in the course of 25 days, and measuring the height of plants on day 12, 19 and 25 from the time of seeding, it can be concluded that regardless of the concentration of the contaminant, the development of plant species flowed freely, and is directly proportionate to the amount of potassium- 40, present in the soil in which the plants are sown. Looking at the distribution of uranium-238 and potassium-40 in the system soil - plant, we concluded that regardless of the concentration of the contaminant, if the plant has a sufficient amount of essential elements, in this case potassium, it will not take an element that is harmful to its development, as it is uranium-238, which belongs to the unnecessary and toxic elements in food plants. But in all the works, and so in this experiment can be performed that every living organism, including the plant in the process of self-preservation, perform the selection of micro and macro elements from the soil, and takes the most necessary elements for optimal development.

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Summary/Sažetak

Migracija i akumulacija kontaminanata u tlu je kompleksna i uključuje različite procese kao što su ispiranje, kapilarno kretanje, sorpciju, unošenje korjenom i resuspenziju u atmosferu. Specijacija radionuklida u ekosistemima zavisi od izvora i načina otpuštanja, udaljenosti od izvora, disperzionim procesima i uslovima depozicije. Resuspenzija radionuklida s površine tla na vanjske dijelove biljaka dešava se usljed djelovanja kiše i vjetra. Značajne varijacije u kontaminaciji mogu se očekivati u zavisnosti od vrste biljke, uvjeta rasta biljke i načina njene pripreme prije konzumiranja. U ovom radu određivana je aktivnost radionuklida U-238 u nadzemnom dijelu pšenice koja je zasijana na uzorku zemlje iz Hadžića, a kao kontaminant je adiran uranil-acetat različite koncentracije. Gamaspektrometrijsko mjerenje vršeno je na vertikalnom koaksijalnom HPGe detektoru. Zaključeno je, da se bez obzira na koncentraciju kontaminanta, ukoliko biljka ima dovoljnu količinu esencijalnog elementa, u ovom slučaju kalija, ona neće uzimati element koji šteti njenom razvoju, kao što je to uranij-238 koji spada u toksične i nepotrebne elemente u ishrani biljke.