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Reducing the Depth Migration of Radionuclides by Incorporation Organic and Inorganic Components into the Soil

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A B S T R A C T

Purification of soils contaminated with radionuclides represents actual scientific-practical task. Depending on the volume, transportation-storage of such contaminated soils is associated with some difficulties. In this regard, phytoremediation methodology using is a relatively more appropriate. The main purpose of our research was to create a layer on remediation tank, which would facilitate the implementation of the phytoremediation method and at the same time prevented the migration of radionuclides into the lower layers of the soil. Modeling of radioisotope migration was performed by using the column method. The object of the study was soil contaminated by ^{137}Cs, while, various options containing organic and inorganic components were used as migration restricting factors. Maximum indicator of depth migration reduction was obtained by using astatine and manure mixture. The proposed method of using organic and inorganic components mixture to reduce depth migration of radionuclides into the soil is appropriate not only for our marker ^{137}Cs, also in the condition of other radioisotopes contamination..

Keywords: Radionuclides, Migration, Phytoremediation, Sorption, Radioisotopes, Nuclear Energy.

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Introduction

Georgia's orography and it's interaction with airThe rapid development of nuclear energy, the widespread use of radionuclides and ionizing radiation in various fields of human activity have determined the fact that radioactive substances have become one of the permanent constituents of the contaminated biosphere, ionizing radiation is discussed as ecological factor of environment. Global radioactive emission represents one of the way occurring radionuclides on the surface on the earth [1-3]. As a result of accident at Chernobyl and later, at Fukushima nuclear power stations has been accumulated the largest factual material about the intensity of Global occurrence of radioactive products from atmosphere to the soil, plant, food, human and animal body [4-7]. At the same time, problems of local type pollution emerged; Namely, in connection with the reorganization of scientific institutions, several specialized research laboratories have ceased to function in Georgia. Therefore, some problem is the radiological monitoring of the adjacent areas to the laboratories and the issue of radioactive materials utilization [8,9]. In this regard, it's particularly important to develop a methodology of the soils purification contaminated by radionuclides, because the mass of contaminated soils due to their volume does not allow for the storage of such soils [10]. One of the effective methods is performing remedial work by using plant objects [11-13]. During planning phytoremediation methodology it's necessary to take into consideration the forms of radionuclides present in the study area. Specifically, analysis of the content of water soluble, exchangeable and non-exchangeable forms of radionuclides in the soil.

Water soluble forms of radionuclides, characterized by high rates of depth migration, they pose a significant ecological threat in terms of environmental pollution. Considering the fact that radionuclides can be introduced from the deeper layers of soil into the root system of perennials, or their spread through the groundwater into the environment, then it becomes clear how big are the environmental risks of water soluble forms of radionuclides existence in the soil [14,15]. Therefore, it's a certain scientific-practical task, apply such a methodology against depth migration of radionuclides which on the one hand will prevent the movement of radionuclides into the deeper layers of the soil and, on the other hand, allow the arrangement of tanks intended for phytoremediation.

Research Object and Methods

The object of the study was one of the most widespread soil types - brown soil in Georgia [16,17]. The soil was contaminated with the remains of closed radioisotope laboratory of the former Institute of Radiology and Ecology. Modeling of radioisotope migration was performed using the column method. Vertical columns of 50 cm were presented with combinations of different options: In the upper layers of the columns, contaminated soil was placed in equal amount. Intermediate fractions contained various types of organic and inorganic components. Ascanite was used as an inorganic component, mixing with the soil in different proportions, and the organic component was manure powder. The experiment also involved simultaneously the complex drug containing the both component-inorganic and organic. Universal humic-organic fertilizer "Agrovita", which contains: 1.5% humate, 3% nitrogen, 2.3% phosphorus and 1.6% potassium. The lower layer of the columns was provided with basic, clean soil. Fraction of acid-washed sand was used for the separation of boundaries between layers. The content of radionuclides in each fraction of column was determined by gamma spectrometry (Gamma-Beta Spectrometer "ATOMTEX MKC-AT-1315" and Gamma-Spectrometer "CANBERRA" with liquid nitrogen freeze germanium detector).

Results and discussion

The nature, velocity and diraction of migration of radionuclides distribution in the soil profile in different biogeocenosis are largely determined by their attachment or connecting strength to the soil [18]. Nowadays, studies on the attachment and connection of radionuclides to soil mainly represents laboratory researches for the study of radionuclide sorption (absorption) and desorption under static and dynamic conditions [19]. At the same time, in many cases, the study material is a mass, formed by the mixing of soils and various components over many years, the cleaning is a major problem due to its volume. Our study soil has been formed for 20 years as a result of complex creation processes of soil components and radionuclides. The characteristic radioactivity of the mentioned soil was 12230Bq/kg. Columns fractional compositions conventionally are reflected in the picture (Fig. 1). A-fraction contained contaminated soil which was washed periodically by the addition of water (for 3 months). Water was also added in equal amounts to each column. C-fraction contained a different ratio of basic soil and study organic and inorganic components. B-fraction in each column was also represented by the same amount of base soil. After the experiment, radioactivity of B-fraction was determined. Fig.1 reflects the results. In order to optimize the level of contamination, different amounts of contaminated soil to be included in the column was used - with the maximum rate 783.9 Bq/kg of radioactivity of column's B fraction of (Fig. 1-1), but minimum - 482.2 Bq/kg (Figure 1-2).

A- Contaminated soil fraction; B- Base (clean) soil fraction; Base soil and study components used in the C-model. Dotted lines indicate the radioactivity of B-fraction contaminated by the migration of ^{137}Cs: 1-Double count of contaminated soil; 2 - Standard amount of contaminated soil; 3- Mixture of sand and ascanite; 4- Basic soil treated with "Agrovita" drug; 5- Manure powder; 6-Mixture of basic soil and manure powder; 7-Base soil mixture with ascanite and manure powder.

Since, experiment involved the introduction of the study components into the C-fraction, due to the volume of the column; minimal amount of contaminated soil was introduced in each column. – It's activity was 482.2 Bq/kg, so the second option

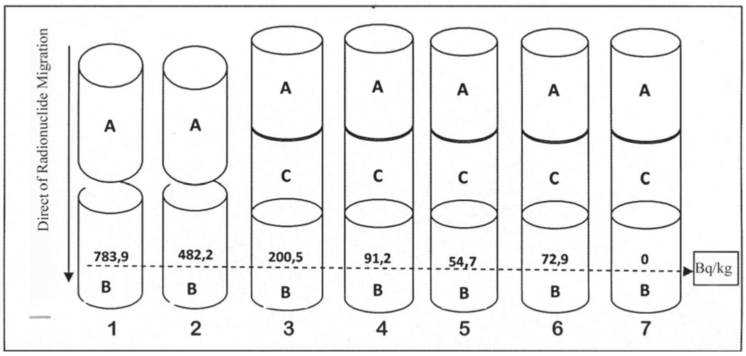

Fig. 1. *General Scheme of Radionuclide Migration Modeling*

(without C-fraction) was considered as a control option, where the standard amount of contaminated soil was included, as in other options used in the experiment. The C-fraction of 3th column contained a mixture of sand and ascanite (5: 1), whose radioactivity of the B-fraction amounted to 200.5 Bq/kg. The C-fraction of 4th column consisted a basic soil treated with "Agrovita" drug. The radioactivity of the B-fraction of the mentioned column was 91.2 Bq/kg. The C-fraction of 5th column was represented by a manure powder whose B-fraction radioactivity was 54.7 Bq /kg. In the C-fraction of 6th column, the base soil was introduced together with the manure powder (1: 1 ratio). The radioactivity of the B-fraction last one was 72.9 Bq/kg. As for 7th column, it's C-fraction contained a mixture of ascanite and manure powder, but no radioactivity was observed for the B-fraction of this column. It is clear that only water soluble forms of radionuclides are subject to depth migration from contaminated soil. Therefore, the presence of water-soluble forms of radionuclides is important during radiation contamination of soil-vegetation cover, on which depends the soil components connection strength of radionuclides to the soil components and there transport above ground parts of the plant. Radioactive decay products in form of anions, which are poorly connected with the soil, moving fairly fast in the soil profile. The quantitative characteristics of different forms of radionuclides (water soluble, exchangeable and non-exchangeable) are determined by their chemical properties — the heterogeneous nature of complex compounds formation with soil components. Figure 2 shows that the zones saturated with the test components used in our experiment are characterized by different radio capacity.

Figure 2 shows the influence of C-fraction's (Fig. 1) different content on the migration intensity (expressed in %) of radionuclides. The migration intensity of the control option radionuclides is assumed to be 100% (Fig. 2-1). In the second option (Figure 2-2) radioactivity of B-fraction amounted to 41.6% compared to the control; the same indicator was 18.9% in option treated by "Agrovita" (Fig. 2-3), and in the 4th and 5th option respectively 11.3 and 15.1% (Fig. 2-4.5). The maximum rate of sorption processes was obtained when using a mixture of ascanite and manure powder (Figure 2-6). Radioactivity feature of B-fraction was not observed in mentioned option.

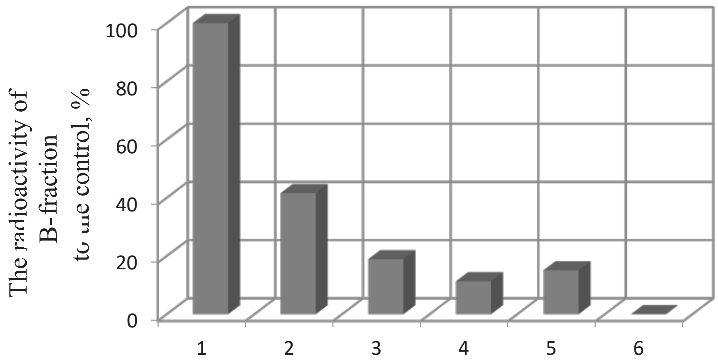

Fig. 2. *Influence of various organic and inorganic compounds On the intensity of radionuclide migration*

1 - Standard amount of contaminated soil; 2- Mixture of basic soil and ascanite; 3- Basic soil treated with "Agrovita" drug; 4- Manure powder; 5- Mixture of base soil and manure powder; 6- Base soil mixture with ascanite and manure powder.

Conclusion

The obtained results allow to establish the complex mechanism of radionuclides interaction with soil components. The results of the present study show the similarity of the final effects, despite the fact that experimental options are based on different mechanisms of the interaction of soil components with radionuclides. All options used in the experiment are characterized by relatively high rate of sorption, but maximum rate of deep migration reduction is obtained by using a mixture of ascanite and manure. In the last option, radioactivity of B -fraction reaches to the background level. Each component of the ascanite-manure option is characterized by quantitative constraints, namely, high concentrations of ascanite impede the flow of water into the column, and the use of pure manure is not conducive for plant cultivation intended for phytoremediation. Therefore, the proposed approach for the use of a mixture of organic and inorganic components for the depth migration reduction of radionuclides into the soil is appropriate not only for marker ^{137}Cs used by us, but also in condition of other radioisotope contamination.

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