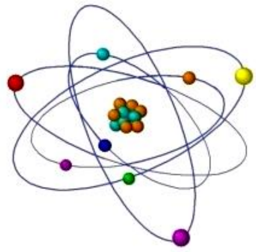
DISTRIBUTION OF RADIOCESIUM AMONG THE ORGANS OF WEEDS PLANTS



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ABSTRACT

Regularities of radionuclide accumulation and distribution in individual organs of the plant from radiocesium contaminated soil according to different vegetation periods by a widespread weed throughout Georgia -Chenopodium album L. is discussed in the paper. General localization of the radioisotope in the organs of the experimental plant was shown by radioautography method. Radioactivity characteristics of both soil and study plant organs has been determined by spectrometric analysis. It is concluded that the presented Chenopodium album L. can be used as a marker test system to study the penetration and distribution of radionuclides from the soil in the bodies of wild-growing weeds, which in turn creates a precondition for implementation of effective cleaning of contaminated areas by radionuclide and phytoremediation measures.

Key words: radionuclides**,** weeds plants, radiocesium accumulation

INTRODUCTION

As a result of the active development of nuclear energy programs there is a risk of significant amounts of radioactive decay products to be reached and locally contaminated into the Earth's surface [1,2,3]. After getting in different landscapes, radioactive isotopes are actively involved in the biological cycle of substances cycle. As numerous studies conducted in recent decades have shown, radioactive products of decay accumulate from the environment into flora and fauna, which leads to increase their quantitative rate in the biological cycle of substances cycle [4-7].

Plant foodsis a shortest way to enter decomposition products in the human body;however, no less dangerous are animals which are feeding by the plants contaminated with radionuclides. In both cases, the plant is the source of radionuclides in the human body.Long-lived radioactive nuclides are more essential from the radionuclides that pollute ecosystems [8-9]. The dimensions and degree of contamination by short-lived isotopes is limited by the duration of their existence and the relatively small area of their distribution in nature at a time when contamination by long-lived radioactive isotopes is long-lasting and can spread over a significant area under matching conditions [10]. One of the most dangerous contaminants of phytocenosis in this aspect is ^{137}Cs, which has a long half-life (more than 30 years) and the ability to incorporate significant amounts into the biological cycle of substances through the plant [11]. Due to the properties of the soil and the physic-chemical characteristics of the radionuclides themselves, radionuclides penetrate in the plant and accumulate in varying quantities; The intensity of accumulation is determined by the biological characteristics of a particular plant. It should be noted that plants can transfer relatively high doses of radioactive substances without significantly impairing their growth and development processes. In the plants, without their injury can accumulate such a large amount of radioactive isotopes that they become unusable and dangerous to humans.

A number of scientific publications have established the pattern that different radionuclides penetrate into a plant are unequally distributed and therefore the damage level of plant different parts can be substantially different. Therefore, the study of the regularities of accumulation of radionuclides absorbed by the plant, according to the individual organs of the plant, is a topical scientific-practical task.

MATERIALS AND METHODS

Widespread weed in the whole territory of Georgia- Chenopodium album L. was selected as the research object. In order to obtain a homogeneous test material, the seedlings were cultured under standard conditions and then transferred to radioactive soil. Soil contaminated with radiocesium was used as the radioactive substrate. Plants grown on contaminated soil intended for radiometry were subjected to drying and shredding on an electro-homogenizer until a powdery mass was obtained. The con-tent of radionuclides was determined by gamma spectrometry (Gamma-Beta Spectrometer "ATOMTEX МКС-AT-1315" and Gamma-Spectrometer "CANBERRA" with liquid nitrogen freeze germanium detector). For conduction radioautography under compression conditions, the dried intact plant was placed on X-ray tape. After being pressurized, the plate was exposed in the standard way and the image was transferred to negative mode by computer scanning. The accumulation coefficient in different organs of the plant was calculated in relation to the content of ^{137}Cs in the soil and in plant tissues.

RESULTS AND DISCUSSION

The penetration of radionuclides from the soil into the plant is the first step in their transition from abiotic components of ecosystems to biotic components in the food chain. Once they are getting into the plant from the soil, the radioactive substances, due to their chemical properties, are distributed to the plant organs. To study the localization parameters of the model weed plant Chenopodium album L. in the organs, we conducted a study by radioautographic method (pic 1). As can be seen from the picture, all parts of the plant grown on radiocesium contaminated soil showed local darkening of the photographic material, indicating the general localization of the radioisotope in the plant parts.

The young organs of the plant are known to contain significantly more potassium than the long-lived organs: it is more abundant in the organs and tissues where the processes of metabolism and cell division take place intensively [14].Due to the above, active transport of radiocesium is carried out through potassium channels and it is natural that similar processes are observed with respect to the movement and localization of this radionuclide [15]. It is natural that this parameter should vary according to the vegetation of the plant. To study the dynamics of radiocesium content in growth and development processes, we analyzed the above ground parts of the plant during the 8 months of vegetation. From Figure 2 can be seen that radiocesium is accumulated most actively in plant tissues during the early stages of vegetation (310Bq/kg).

It is at this time in the development of the plant is observed active growth and accumulation of vegetative mass. In the following period (June-September) the intensity falls relatively (302-298Bq/kg), and at the end of the vegetation period it reaches the minimum value (279Bq/kg). Overall, the results obtained are consistent with a general understanding of the mechanism of radiocesium penetration by potassium channels in the plant tissues. Active growth - Maximum number of ^{137}Cs in the proliferative activity zone, further stabilization of the growth reaction and finally, cessation of growth processes and enhancement of radioisotope basipetal conduction [16]. For a detailed study of the final volume of radio cesium penetrated into the plant organs, we conducted a radioactivity study of individual parts of the plant. As can be seen from Figure 3, the highest radioactivity was observed in the lateral roots, the lowest rate was observed in the main trunk tissues. The picture of radiocesium accumulation according to *Chenopodium album L* organsis as follows: lateral roots> main root> leaves> secondary trunks> main trunk.

Fig. 1 Radioautography of the seedling of *Chenopodium album L* cultured on radiocesium contaminated soil (*negative image*)

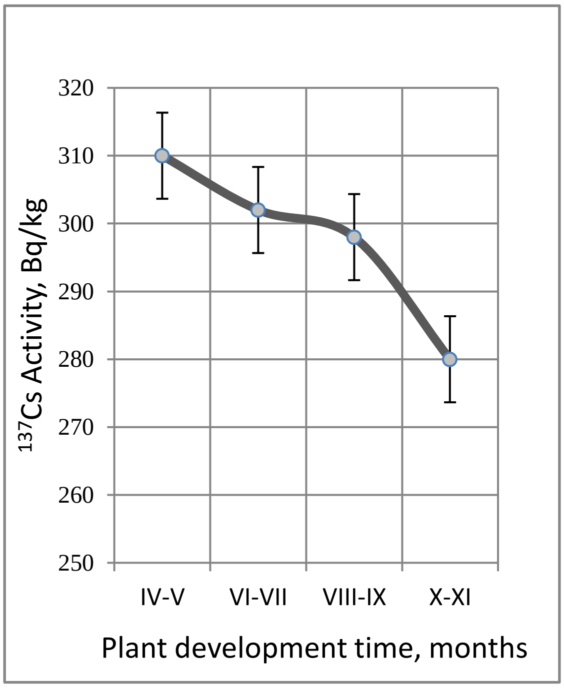

Fig.2 Dynamics of radiocesium content in the above ground parts of the plant in their vegetation process

One of the main determining factors of the overall distribution of radionuclides in plants is the characteristic of quantity and condition of radionuclides in the soil. In order to calculate the coefficient of accumulation of radionuclides in the organs of the test plant, in addition to the indices of radioactivity of the tissues, it is necessary to determine the characteristic of the radioactivity of the soil. Spectrometric analysis showed that the soil used in the experiments contained 12,230 kBq/kg ^{137}Cs.Another important radiation parameter is the form of radionuclide in the soil and its availability to the plant. The radiocesium gets into the bonded state fairly quickly when it gets into the soil. Over time, ^{137}Cs are absorbed by soil minerals, where they take up potassium in crystalline structures and become inaccessible for plants. It’s accepted this phenomenon to be called "radionuclide aging". It’s believed that showed period lasts 1-4 years, although in the paper [17] this period is estimated at 5-10 years.

Thus, the soil used in our study, which was characterized by a 20-year period of radionuclide contamination, was difficult to assimilate in terms of radionuclide penetration into the plant. The rates of radionuclide accumulation coefficients in different organs of Chenopodium album L are shown in Figure 4. From the data, at the end of the vegetation, the main content of radioisotope is accumulated in the root system (61%), and in the above ground parts - only 39%. Active accumulation of radioisotope from underground parts is characterized by lateral roots (33%), and from above ground parts- leaves (21%).

It is noteworthy that the parameters analyzed in the paper (accumulation coefficients, distributionaccording to the organs, specific tissue activity) are mainly related to the form of the presence of radionuclides in the soil. In this regard, in the weed plant Chenopodium album L, which we used as amarker, was detected the active transport and accumulation of radionuclides from soils that have beensubjected to radionuclide fixation with soil elements for many years. On the other hand, the accumulation of radionuclides in the soil, which is characteristic of weeds, can be used to effectively clean radionuclide-contaminated areas and carry out phytoremediation measures.

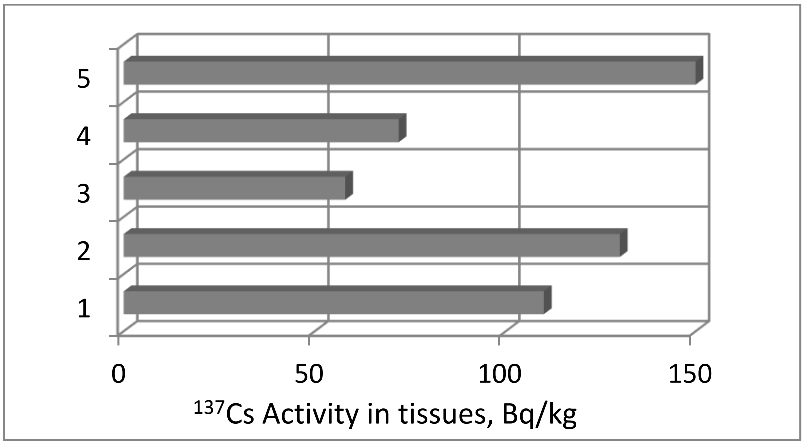

Fig.3 Distribution of radionuclides in plant organs

1-main root; 2-lateral roots; 3-main trunk; 4-secondary trunk; 5-leaves

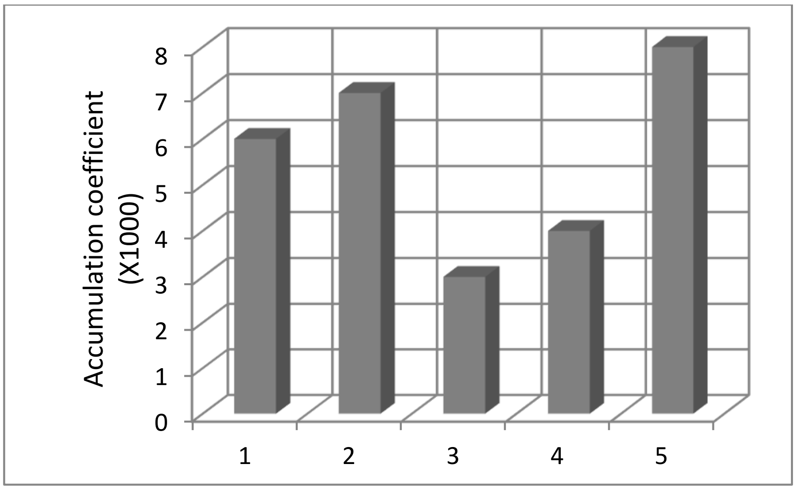

Fig.4 Radiocesium accumulation coefficients in the tissues of contaminated soil grown *Chenopodium album L*

1-main root; 2-lateral roots; 3-main trunk; 4-secondary trunk; 5-leaves

CONCLUSIONS

The obtained experimental results allow to conclude that the common species of Chenopodium album L. presented in the paper can be used as a marker test system to study the penetration and distribution of radionuclides from the soil in the bodies of wild-growing weeds. Maximum and minimum levels of radionuclides were observedaccording to the developmental stages of weeds.Since the assimilation of radionuclides by the root system may play a key role in the transmission oflong-time important information for determining the levels of radiation contamination of wild andnon-lived radionuclides into the food chain, the data obtainedcoagricultural phytocenosis.

REFERENCES

1. Brett L. Rosenberg, Joseph E. Ball, Georg Steinhauser. Radionuclide pollution inside the Fukushima Daiichi exclusion zone, part 1: Depth profiles of radiocesium and strontium-90 in soil. Applied Geochemistry. 2017. Volume 85, Part B, 2017. Pages 201-208.
2. Anne Mathieu, Mizuo Kajino, Damien Didier. Fukushima Daiichi–derived radionuclides in the amosphere, transport and deposition in Japan: A review Applied Geochemistry. January 2018. Volume 1 (2018) Pages 122-139.
3. Alexey Shcheglov, Ol'ga Tsvetnova, Alexey Klyashtorin. Biogeochemical cycles of Chernobyl radionuclides in the contaminated forest ecosystems. Long-term dynamics of the migration processes. Journal of Geochemical Exploration. 2014, Volume 144, Part B, Pages 260-266.
4. M. Gómez-Ros,G. Pröhl, M. Lis. Uncertainties of internal dose assessment for animals and plants due to non-homogeneously distributed radionuclides. Journal of Environmental Radioactivity. 2008,Volume 99, Issue 9.Pages 1449-1455.
5. Geras'kin, T. Evseeva, A. Oudalova. Effects of long-term chronic exposure to radionuclides in plant populations. Journal of Environmental Radioactivity. 2013, Volume 121, Pages 22-32.
6. Tzvetana Nonova, Zornitza Tosheva. Cesium and strontium in Black Sea macroalgae. Journal of Environmental Radioactivity. 2014,Volume 129, Pages 48-56.
7. N. Pozolotina, I. V. Molchanova, E. V. Antonova. Radionuclides in terrestrial ecosystems of the zone of Kyshtym accident in the Urals. Journal of Environmental Radioactivity, 2010, Volume 101, Issue 6, Pages 438-442.
8. Anna Burger, Irene Lichtscheidl. Stable and radioactive cesium: A review about distribution in the environment, uptake and translocation in plants, plant reactions and plants' potential for bioremediation Science of The Total Environment, 2017,Volume 618, 2018, Pages 1459-1485.
9. George Shaw. Radionuclides in forest ecosystems Radioactivity in the Environment. 2007, Volume 10,Pages 127-155.
10. Laila Omar-Nazir, Xiaopei Shi, Carmel Mothersill. Long-term effects of ionizing radiation after the Chernobyl accident: Possible contribution of historic dose. Environmental Research, 2018, Volume 165 2018, Pages 55-62.
11. Toshihiro Yoshihara, Hideyuki Matsumura, Fumiyuki Goto. Changes in radiocesium contamination from Fukushima in foliar parts of 10 common tree species in Japan between 2011 and 2013, Journal of Environmental Radioactivity. 2014,Volume 138, Pages 220-226.
12. M. Dugger. The Botanical Review. 1957.Vol.23, pages 351–387.
13. Nagata. Techniques of radioautography for medical and biological research. Braz J Med Biol Res, February 1998, Volume 31(2) 185-195.
14. Wang, Wei-Hua Wu. Regulation of potassium transport and signaling in plantsCurrent Opinion in Plant Biology, 2017. Volume 39, Pages 123-128
15. M. Anjos, B. Mosquera, H. Mercier. Caesium, potassium and ammonium distributions in different organs of tropical plants. Environmental and Experimental Botany 2009. Volume 65, Issue 1, Pages 111-118.
16. Моисеев И.Т., Агапкина Г.И., Рерих Л.А Изучение поведения ^{137}Cs в почве и его поступления в сельскохозяйственные культуры в зависимости от различных факторов. Агрохимия, 1994. N 2. с.103-117.
17. Суркова Л.В., Погодин Р.И. Состояние и формы нахождения цезия-137 в почвах различных зон аварийного выброса ЧАЭС. Агрохимия, 1991. N4. с.84-86.