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THE IMPORTANCE OF RELIEF OF MOUNTAINOUS LANDSCAPES IN THE PROCESS OF RADIONUCLIDE CONTAMINATION OF PHYTOCENOSIS

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Abstract. *The increased radiation threats in the world require a more detailed study, taking into account the specificity of the landscapes during the remote migration of radionuclides. From this point of view, two large groups can be distinguished: mountainous and plain landscapes. If the horizontal spread of radionuclide contamination as a result of atmospheric transport and landscape sorption processes are the leading factors in the conditions of plain landscapes, the vertical migration factor is added to these processes for mountainous regions. In addition, the vertical zoning of mountainous regions determines not only landscape features but also temperature regime, precipitation intensity and form, degree of insolation, and stepwise changes in phytocenoses. It is natural that, in the conditions of such a variety of factors, the study of the distribution of radionuclide-contaminated spots requires individual approaches to adequately carry out ecological monitoring of high mountain areas. For this purpose, an analysis was carried out and a list of the factors influencing the migration of radionuclides in the ecosystems of the steep slopes, depending on the landscape features of the mountainous regions, was made.*
Key words*: radionuclides, phytocenoses, vertical zonation*

In this modern era of increasing nuclear energy use and an acceleration in the construction of nuclear power stations, researchers of ecological security in their respective regions need to implement new scientific approaches [1]. The introduction of nuclear technologies is naturally accompanied by the dispersion of a certain amount of artificial radioactive elements into the environment, and in some cases - as a result of human technogenic activity - changes in the rates of migration of dangerous radionuclides [2]. Artificial radionuclides entering the biosphere actively participate in the migration processes of chemical substances occurring in nature. The interest in studying the regularities of radionuclide migration in ecosystems is primarily due to the fact that radionuclides are a source of ionizing radiation, they represent a definite threat to the environment as a whole and, therefore, to human health. In this aspect, the study of possible radionuclide pollution particularity, concerning radioecological safety - taking into account the specificity of the landscapes of different countries - is appropriate both at the transnational and national levels [3].

Unlike other countries in the region, Georgia is not among those currently utilizing nuclear energy, however, if we take into account its geolocation, hazards to radio-ecological safety are increasing every year. The man-made disasters at the Chernobyl and Fukushima nuclear power plants have shown us that the migration of radionuclides produced as a result of an accident can spread over long distances. The current situation in our neighboring countries further aggravates the above-mentioned situation, which is manifested in the fact that: the period of operation of the Armenian nuclear plant has been extended; in Russia, on the territory adjacent to the country's borders, an additional two new power units are already operating at the Rostov nuclear power plant; according to the Russian project, the construction and commissioning of four power units in Turkey have also begun. The number of high-risk factors also includes radiation hazards

caused by damage to such facilities as a result of military conflicts in the territory of countries with nuclear energy - the example of Ukraine [4]. If we take into account the fact that the construction of nuclear facilities is entering a new stage worldwide, and at the same time, a politically unstable situation is being created, the danger of increasing nuclear security risks for Georgia becomes clear. Artificial radionuclides, as sources of ionizing radiation, often do not cause noticeable changes directly at their site of entry into the environment, however, as a result of radioecological processes, they migrate and accumulate in separate rings of ecosystems (radioecological concentration). In this regard, the ecosystems of mountainous regions are of particular interest where, alongside generally accepted forms of radionuclide migration, migration processes determined by the specificity of mountain landscapes can be observed. Based on the above-stated factors, the study of the particularity of radiation pollution in the ecosystems of the mountainous regions of Georgia is an important scientific and practical task.

The issue of radionuclides spreading on soil and vegetation appears to be such an urgent ecological problem that it requires the development of effective nature-protection measures in order to reduce ecological risks for the population. The traditional content of the research conducted in this regard includes the study of the content of radioisotopes in the soil-vegetation cover to determine particularly dangerous landscapes from a radioecological point of view. The distribution of radionuclides in the territory of Georgia is mainly carried out by atmospheric means. The atmospheric source of their introduction to the soil-vegetation cover is often the initial link of migration, which, in turn, directly creates a prerequisite for the pollution of territories and water ecosystems. The migration of radionuclides deposited from the atmosphere into the soil-vegetation cover and their participation in the biogeochemical cycle of substance circulation depends on specific landscape conditions. As is known, in the complex chain of biogeocenosis systems, the soil is an important link in which toxic components scattered on land are included (encompassed). The high absorption capacity of the soil to radionuclides leads to the accumulation of these toxic substances in the upper horizons of the soil.

Table 1. Zonation of the territory of Georgia according to altitude

№	ზონები სიმაღლეების მიხედვით	დასავლეთ საქართველო		აღმოსავლეთ საქართველო		საქართველო მთლიანობაში	
		კმ²	%	კმ²	%	კმ²	%
1	0-200	7673,2	24,0	282,2	0,8	7955,4	11,4
2	200-400	2464,5	7,7	3405,7	9,0	5870,3	8,4
3	400-600	2104,6	6,6	4245,1	11,3	6349,7	9,2
4	**600-1000**	**4009,8**	**12,6**	**7871,3**	**21,0**	**11881,1**	**17,1**
5	**1000-1400**	**4144,7**	**13,0**	**5851,7**	**15,6**	**9996,4**	**14,5**
6	**1400-1800**	**4028,6**	**12,6**	**5708,1**	**15,2**	**9736,7**	**14,0**
7	1800-2000	3089,6	9,7	4719,6	12,6	7809,2	11,2
8	2000-2600	2434,3	7,6	2933,8	7,8	5368,1	7,7
9	2600-3000	1303,4	4,1	1737,7	4,6	3041,1	4,4
10	3000-3500	474,1	1,5	601,8	1,6	1075,9	1,5
11	3500-4000	165,5	0,5	178,4	0,5	343,9	0,5
12	4000-4500	31,6	0,1	24,8	-	56,4	0,1
13	4500-5000	5,1	-	4,7	-	9,8	-
	ჯამური ფართი	31929,0	100	37564,9	100	69493,9	100

Mountain landscapes differ from plain landscapes as a rule by great dynamism. They are characterized by intense erosive and gravitational processes, which, in the case of radiation pollution, increase the probability of radioisotope migration processes in the ecosystems of the mentioned zone. Mountainous regions react more acutely to atmospheric-climatic changes and are characterized by the diversity of ecosystems. Therefore, the creation of a global database on mountain areas is vital for the implementation of programs that lead to the security and sustainable development of mountain ecosystems. From this point of view, the territory of Georgia is a good model of mountainous ecosystems, as can be seen from Table 1, most of the territory of both eastern and western Georgia is characterized by the abundance of mountainous landscapes. In addition, as a result of the accident at the Chernobyl nuclear power plant, the mountainous regions of Georgia also fell into the zone of radionuclide contamination. Naturally, the specificity of the mentioned landscapes is determined not only by the formation of radionuclide spots caused by the relief particularity but also by the level of pollution of phytocenoses.

Keeping in mind the above-stated factors, the particularity of the distribution of radionuclides in plain and mountain ecosystems should be clearly distinguished.

To study the latter issue, it is necessary to use an indicator reflecting the state of the ecosystem, which will record the negative impact of such factors on it. Based on the determination of radiocaesium content and radiocapacity parameters, it is possible to assess the state of biotypes in ecosystems [5]. For example, the dynamics of radiocesium absorption by a plant, which presents a potassium analog, can reflect the radiation state of the plant. The main factors determining the level of accumulation of radionuclides in plants are: Physico-chemical forms of radionuclides, ways of penetration and vertical distribution of radionuclides in soil, agrochemical characteristics of soil, the particularity of plant metabolism [6], etc. Thus, by the presence of radiocesium in plant tissues, we can judge the radiation pollution of a specific area of the studied landscape. In order to determine the possible role of the topography of specific landscapes in the processes of radioisotope contamination, an important issue is the selection of the above-mentioned marker plants that grow in a specific place for a long time. For this study, a typical perennial plant pine of the study region was used. As can be seen in fig. 1, in the pine organs, with the radionuclide content criterion, a clear relationship with the relief is observed which is manifested in the fact that the minimum value of the studied criterion is recorded in the watershed zone, and the maximum value is at the lower threshold of the slope.

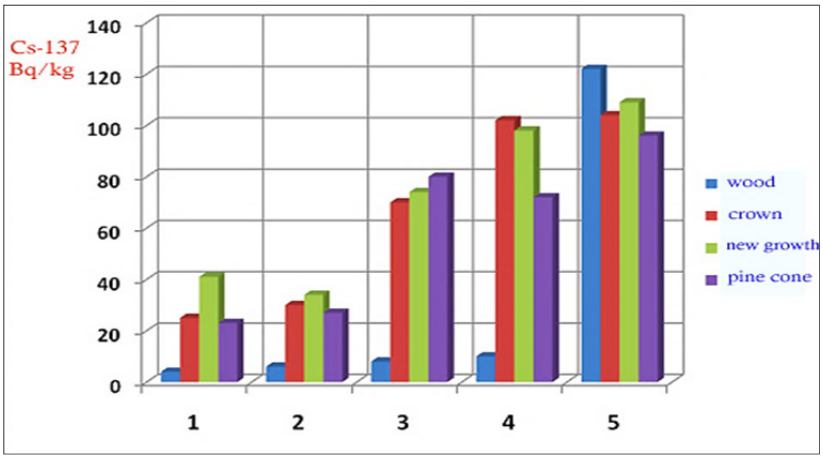

Fig. 1 Radiocesium content in pine structure in organs in relation to relief.

1-watershed; 2- upper slope; 3- terrain; 4-lower slope; 5- the lower limit of the slope

According to the mentioned experimental data, it is clear that during the destructive events characteristic of different types of mountainous terrain, a favorable situation for radiation concentration is created when soil and inert material contaminated with radionuclides accumulate in the lower part of the zone.

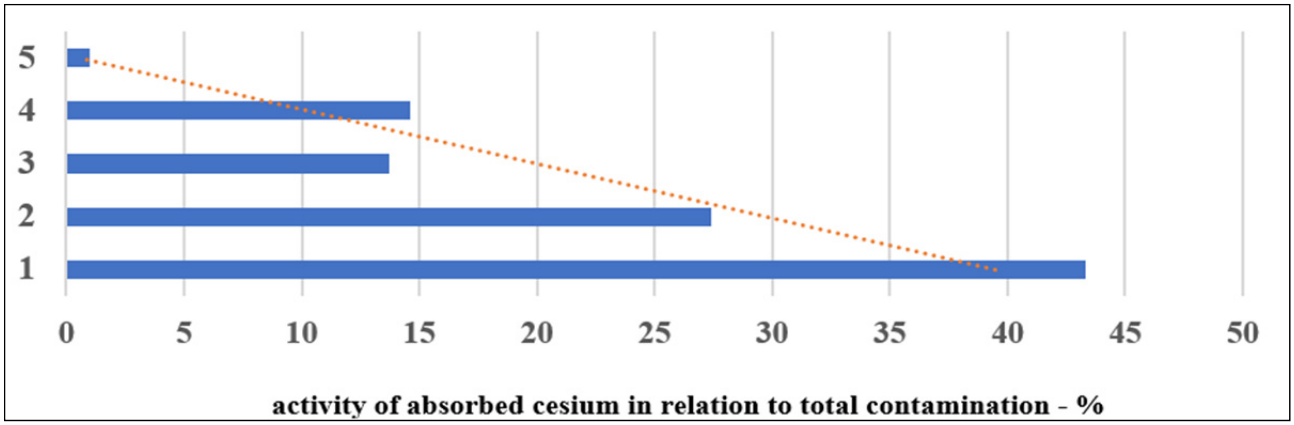

Fig. 2. 1-watershed; 2- upper slope; 3- terrain; 4-lower slope; 5- the lower limit of the slope
(the trend is displayed with a dotted line)

Thus, if we summarize the above-mentioned data, the specificity of the radiation pollution dynamics of mountainous regions is expressed not only by the different nature of the distribution of radionuclide pollution according to the mountain slopes but also by the nature of their accumulation in specific ecosystems, namely; the landscape-geochemical structures of the location affect the character of primary and secondary distribution of radioactive elements - they are transferred from the zone of primary contamination and accumulate in geochemical and landscape barriers. Naturally, the concentration of radionuclides in relatively small areas of localization creates a real picture of the formation of radionuclide contamination spots, which represent a dangerous level of radiation pollution. This model of distribution refers to the form of atmospheric migration of radionuclides. The tragic experience of past years has shown the relatively low intensity of atmospheric migration processes, in particular, during the global dispersion of radionuclides in the atmosphere 10 years after the start of the nuclear explosion the content of radionuclides in automorphic forest landscapes decreased by only 2 times, while the same characteristic in accumulation landscapes increased significantly [7].

Conclusions

1. The data obtained on the basis of the conducted analysis indicate the specific forms of radiation pollution in the mountainous regions of Georgia, which, in turn, require individual approaches when predicting possible results in the case of long-distance atmospheric transport of radionuclides.
2. By determining the parameters of radiocesium content in mountain ecosystems, it is possible to judge the radiation pollution of a specific area of the studied landscape.

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