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LOW CONTENT OF RADIONUCLIDES IN NATURAL ENVIRONMENT AND PRODUCTION AS A RATIONALE FOR DEVELOPMENT OF RECREATIONAL POTENTIAL OF NORTHERN BUKOVINA

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Abstract: *Investigation on food products contamination by Cesium-137 and Strontium-90, detection of content of natural radionuclides (Radium-226, Thorium-232, Potassium-40) in raw materials and finished products of building industry, monitoring of some radionuclides content in soils of mountainous area of Northern Bukovina was carried out. All the results were analyzed and discussed in view of the life safety position. Data on radionuclides content in surrounding natural environment as well as in building and food industry production confirm Northern Bukovina territory's attractiveness and safety for recreation areas development.*

Keywords: *Radionuclides, safety, Northern Bukovina, recreation.*

1. Introduction

Increase of the recreational potential is an actual development strategy of Chernivtsi region (Northern Bukovina). The air and water quality, presence of great quantity of mineral water sources with widely known useful properties are topical criteria of attractiveness of the region for tourists. In parallel, we have to keep in mind the existence of some areas with higher radionuclides pollution level in Bukovina that is controlled by the authorities of Committee on Hydrometeorology of the Ukraine [1-4].

Current level of territory pollution by different agents is relevant and needs to be taken into consideration when developing and implementing programs and strategy for improvement of regional perspectives in recreational tourism. It is well known that the technogenic disaster at the Chernobyl atomic electric station in 1986 was a reason for several "spot places" polluted by radionuclides on the territory of Bukovina [2]. The presence of the above mentioned polluted areas on the map of the region is the reason of necessity for permanent radiological monitoring of radionuclides spreading and transformation

in natural environment. In parallel, raw materials for industrial sections and manufacturing companies located in the Northern Bukovina should be checked for radiation activity level as well. Significance of food and building industry for tourism is determined by the fact that their production manufactured with the use of local raw materials should be essential when establishing and building recreational areas. Hence, reliable information on radiological control results and presence of both artificial and natural radionuclides in the environment of Chernivtsi region, especially in places meant for future location of recreational areas should be especially assessed. Such data should be taken into consideration when implementing safety improvement and health restoring strategy in the region as well [5, 6].

2. Materials and methods

Contamination level of food products by Cesium-137 and Strontium-90, detection of content of natural radionuclides (Radium-226, Thorium-232, Potassium-40) in raw materials and finished products of building industry, monitoring of content of natural radionuclides in mountainous area soils of some districts of Northern Bukovina were the aim of the present investigation. All the mentioned data are important to estimate attractiveness of Northern Bukovina region in view of investments into recreational areas, resorts and tourism, considering life safety aspect.

Radiation control of environment was performed by means of estimation of natural radionuclides effective specific activity according to the actual legislation [7].

The total specific activity AΣ was defined by AΣ = ARa + 1,31ATh + 0,085AK ratio, which takes into account specific activity of Radium-226 ARa, Thorium-232 ATh and Potassium-40 AK. Radiation doses were standardized as well.

Soil samples were collected according to standard operative procedures of testing methods [8] in three mountainous districts of Chernivtsi region closely to transport communication areas. Points of samples collection were located at the suburbs or beyond settlements in order to avoid misinterpretation caused by human activities' influence. The irradiation dose was measured in sample collection points as well.

Samples of food products and raw materials used for their manufacturing were obtained from enterprises and companies acting on the territory of Northern Bukovina. By analogy, samples of building materials were got from enterprises producing building materials. All data on collected samples were stored in special databases according to local regulations of standard-technical documents management.

The detection of content of Cesium-137, Radium-226, Thorium-232 and Potassium-40 was done by gamma-sprectrophotometric analytic method employing scintillating detector and multichannel FMF-04A analyzer of spectrum with a modernized software [9,10]. Sample volume was equal to 1 liter, different concentration methods were used in case of necessity. The determination of Strontium-90 was conducted using method of radiochemical analysis according to standard technique [8]. Measurements of intensity of β-irradiation were done using UMP-1500 equipment. The irradiation dose was established by using dosimeter DRG-01T as an average value for a set including 8 measurements.

3. Results and discussion

Investigation data on radionuclides content in soils of different districts in the Northern Bukovina are provided in table 1.

The average values of specific activity for two measurements are presented there. The provided values for the content of natural radionuclides in soils prove that it is the same for all mountain districts of Chernivtsi region. Such similarity exists probably due to the affinity of rock mediums and similar type of climatic and hydrologic conditions for geological material destruction within Bukovinian Carpathians. The absolute values of specific activity of investigated radionuclides in crystalline rocks from Bukovina were lower as compared with the activity values of samples obtained from the northern regions of the Ukraine (Zhytomyr region) [11].

The specific activity values similar in magnitude caused also insignificant fluctuations of radiation doses in places of soils sampling. Furthermore, the radiation dose value of tested soils was close to the generally accepted normal range for natural background - 14 μR/hour. The specific activity of Cesium-137 A_{Cs} varied within 18-33 Bq / kg for different sampling points within a specific district (Table 1). Such values of A_{Cs} pointed on low level of contamination of the territory. A conclusion about radiological safety of soils in highland districts of Northern Bukovina may be drawn on the basis of detection results of radionuclide content in soils and rocks. Soils radiational safety is a factor which stands for the region's attractiveness in view of establishing and developing recreation areas and resorts.

Table 1

Average values of radionuclides specific activity A (Bq/kg) in soils of settlements and radiation doses D (μR/hour)

No	Settlement	A_{Cs-137}	A_{Ra-226}	A_{Th-232}	A_{K-40}	A_{Σ}	D_{Σ}
1	Vyzhnytsia	18.7	16.1	29.9	381	87.6	15
2	Putyla	24.6	14.9	31.3	462	95.2	16
3	Seliatyn	19.5	15.6	23.6	390	79.7	17
4	Dolishniy Shepit	21.2	17.4	33.2	435	97.9	15
5	Beregomet	23.3	19.8	42.1	418	110.5	14
6	Krasloil'sk	33.2	25.4	32.1	372	99.1	16
7	Quarry run stone	< 3	39.6	68.3	748	192.6	–

The content of natural radionuclides in raw materials for building industry production was taken into consideration. Values of specific activity of some natural radionuclides in different types of raw materials extracted in the Chernivtsi region are shown in table 2.

On the contrary to quarry run stone (table 1), crushed stone (table 2) is obtained from local rocks. Lower normal range of total specific activity is of 370 Bq/kg for building materials.

Table 2

Specific activity A (Bq/kg) of natural radionuclides in building materials

No	Material	A_{K-40}	A_{Ra-226}	A_{Th-232}	A_{Σ}
1	Clay	440	12	52,5	118
2	Sand	348	38	9	62
3	Gravel	81	17	5	31
4	Slag	370	92	40	176
5	Brick	351	36	53	135
6	Wood	8	3	–	–
7	Adobe	2200	60	262	590
8	Crushed stone	495	67	85	220

According to our results, all the investigated samples of raw materials except adobe had specific activity value even below the lower limit of normal range. Hence, raw materials and manufactured products of building companies of the Chernivtsi region are safe and they may be used without limitations for building of recreational areas and resorts where investigations had been made.

It should be noticed that wood as a building material does not require increased attention from the point of view of radiological control as far as measurements of its content in radionuclides demonstrate that results comply with the level of sensitivity of the devices used (table 2). Such fact is confirmed by a number of observations regarding the transfer of radionuclides by root system of herbal plants and trees [4]. Additional risk of accumulation of radionuclides by tree leaves should be considered as minimal due to significant precipitation and seasonal change of crown.

Therefore, radionuclides contamination of food produced and soil in the Northern Bukovina from life safety aspects was taken into consideration.

Table 3 displays the results of measurements of Cesium-137 and Strontium-90 content in different food products. We paid greater attention to the previously mentioned radionuclides as far as their presence in food should be standardized [7].

The product samples were provided by manufacturers in view of compliance with the hygienic standards according to the requirements of actual legislation. The normal ranges of values are provided in table 3 as well.

The average values of specific activity were determined for different quantity of samples (n). Standard deviation σ for each of the investigated radionuclides was provided on the basis of the normal probability law.

Table 3

Average specific activity A of Cesium-137 and Strontium-90 (Bq/kg), standard error of the mean σ, and acceptable levels (Bq/kg) for food products

No	Title of product / raw material	Samples quantity	A_{Cs}	σ_{Cs}	A_{Sr}	σ_{Sr}	Acceptable levels	
							A_{Cs}	A_{Sr}
1	Beef meat	13	4.77	1.38	1.96	0.82	200	20
2	Pork meat	4	< 3	–	< 1	–	200	20
3	Mutton meat	3	3.27	0.38	2.11	0.97	200	20
4	Milk	7	< 3	–	< 1	–	100	20
5	Flour	5	< 3	–	< 1	–	20	5
6	Dried fruits	6	8.83	3.28	4.83	1.27	40	20
7	Fresh mushrooms	6	8.63	3.12	13.42	4.63	500	50
8	Dried mushrooms	2	14.31	4.78	11.09	3.78	2500	250

Special attention should be given to the detection of radionuclides' presence in fish products. Such need is maintained by the fact, that major part of fish stocks is located in closed ponds with low water drainage in Kitsman' district of Bukovina (a portion of Kitsman'district area has status of radionuclide contamination of fourth grade).

Hence, a part of our research was conducted as an attempt to detect and estimate the content of some radionuclides (Cesium-137, Strontium-90, Radium-226 and Potassium-40) in fresh fish, in pond water and in benthal deposits.

All the investigated samples were obtained from Stavchany pond in the Kitsman' district.

Measurements results of radionuclides content in two types of industry fish are provided in table 4. The content of Cesium-137 and Strontium-90 in fish and fish products from Northern Bukovina was normal (135 and 35 Bq/kg correspondently). It is obvious that radionuclides content is almost the same in live fish, pond water and benthal deposits. Such balance is typical for equilibrium in fish-pond biosystems.

We observed a higher Potassium-40 content in live fish by comparing levels in water and benthal deposits. The external intake of Potassium-40 and accumulation in fish for a long time period is probably the reason for such findings. This hypothesis was revealed by the investigation on radionuclides level determined in feed put into pond to feed the fish [12, 13]. Values of specific activity of Potassium-40 in feed for fish are also provided in table 4.

Table 4

Specific activity A (Bq/kg) of radionuclides in carp and crucian fish, benthal deposits, fish feed, pond water of Stavchany village

Radionuclide	Carp	Crucian	Pond water	Benthal deposits	Feed
Cesium-137	0.3	0.5	0.7	18.5	–
Strontium-90	0.9	0.7	0.3	22.1	–
Potassium-40	239.2	196.9	1.9	342.4	822.3
Radium-226	23.4	21.3	5.2	27.4	–

4. Conclusions

A conclusion may be drawn that fresh fish meets the criteria of safety for consumption. At the same time, great attention should be paid to a fact of possible presence of nondetected radionuclide Potassium-40 in feed for fish.

The investigation results of radionuclides content in the surrounding natural environment and production of building and food industry confirm fact that the Bukovina territory is safe and attractive for investments and development of recreation areas [7, 14-16]. Thus, the possibility of unlimited use of local industry production for building is substantiated.

The results of the present investigation confirm the objectivity of advertising messages on attractivity and safety of recreation areas within Northern Bukovina.

It should be marked that our study was a pilot one, and our deductions are generalized and prefatorial, as far as samples quantity for radionuclides content detection varied from a few ones to dozens that might influence dispersion of results. Radionuclides' propagation over the territory, their content in food products and building materials should be investigated more fundamentally in case of necessity by means of collecting and analyzing unified data corresponding to control agencies of Chernivtsi region. The field research may be further continued by means of increase of both quantity of samples and points of their collection. The list of controlled isotopes in natural environment and industry products should be widened in future as well.

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