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A Systematic Approach to Assessing the Radiation Safety of Drinking Water in the Republic of Uzbekistan

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Abstract The article is devoted to a comprehensive assessment of the radiation safety of drinking water. To study this problem, the results of radiometric, spectrometric analysis were used to determine the radiation contamination of drinking water with natural and artificial radionuclides. The studies were carried out on the basis of the Scientific Research Radiological Laboratory of the Tashkent Institute for Advanced Medical Studies. Based on the results of the studies, dose loads on people living in the studied regions and radiation risks associated with drinking water consumption were calculated.

Keywords Drinking water, Alpha-beta total activity, Natural and artificial radionuclides, Spectrometric and radiometric analysis, Average annual effective dose

1. Introduction

Safe and clean water is one of the main elements of the life support of the population and a paramount factor in people's health. The level of sanitary and epidemiological well-being and social stability of a society depend on water quality. Almost twenty percent of the world's population lives in areas where there is not enough drinking water. It is known that a quarter of the world's population lives in countries with poorly developed or lacking infrastructure, which provides for the collection of water from water sources and its water treatment.

The radionuclide composition of natural waters varies over a wide range depending on the type of water, climatic conditions, and the composition of the host rocks [5]. Surface, groundwater and groundwater significantly differ in their physicochemical characteristics, including radionuclide composition.

The content of natural radionuclides in the waters is determined by the form of their presence in the rocks and the composition of the latter, the nature of the exchange of water, the duration of contact of the water with the rocks and other factors. As a result of this, differences in radionuclide concentrations in groundwater can be several orders of magnitude [7,8,9].

According to the geological classification, groundwater is divided into radium, radon, radon-radium and 3 categories of groundwater enriched with uranium. For all types of groundwater (except waters associated with an increased uranium content in rocks), the radioactive equilibrium is shifted toward radium isotopes [6].

The problem of standardizing the quality and safety of drinking water is complex, and when solving it, all the basic characteristics that determine its harmlessness to the human body should be taken into account, if possible.

2. The Aim of the Study

Assessment of the quality of natural water in terms of radiation safety, calculation of internal doses and risks from drinking water from various sources of water supply in the pilot regions.

3. Materials and Research Methods

The objects of study are underground and surface water sources of pilot regions.

According to the Sanitary Norms and Rules № 0193-06 “Radiation Safety Standards (RSS-2006) and the Basic Sanitary Rules for Radiation Safety (BSRORS-2006)” [1] in radiation monitoring of water, the following shall be determined with priority:

- the total activity of alpha and beta emitting radionuclides Aα, Aβ (preliminary assessment of the suitability of water);
- activity ^{210}Po, ^{210}Pb, ^{226}Ra, ^{228}Ra, ^{238}U, ^{234}U (comparison with individual values of specific weight of water and calculation of the total effective dose due to water consumption).

And at the last stage, in some cases, the need arose for

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additional determinations of the activity of ^{228}Th, ^{230}Th, ^{232}Th, ^{90}Sr, ^{137}Cs, ^{239,240,238}Pu, ^{241}Am, ^{40}K.

The total alpha and beta activity of drinking water was measured on a UMF-2000 alpha-beta radiometer according to the Methodological Instructions of the Ministry of Health of the Republic of Uzbekistan № 012-3 / 345 of 05/10/2019. "Measurement technique for the total volume (specific) activity of alpha-emitting and beta-emitting radionuclides in drinking water, source water and natural waters" [3]. Water research on the radionuclide composition was carried out on a Radek beta gamma spectrometer according to the Methodological Instructions of the Ministry of Health of the Republic of Uzbekistan № 012-3 / 349 dated 06/10/2019. "Methodology for measuring the specific activity of natural radionuclides, cesium-137, strontium-90 in environmental objects environment" [4]. The selection and preparation of water samples was carried out in accordance with the Methodological Recommendations of the Ministry of Health of the Republic of Uzbekistan № 012-3 / 335 of 09/26/2018, "The selection and preparation of water samples for determining radiological parameters in water" [2].

A preliminary assessment of the quality of drinking water in terms of radiation safety was given by the specific total alpha and beta activity [10]. But even with the values of the specific total alpha and beta activity below 0.2 and 2 Bq / l, respectively, we measured the specific activities of the main dose-generating radionuclides to determine dose loads and assess the possible risk to the health of people in the pilot regions of the republic.

4. Results of Research

In 147 water samples taken in 2019 from underground and surface sources of drinking water supply of two pilot regions of the republic, the average alpha activity of water for the study period averaged from 0.06 to 0.12 Bq / kg, the total beta activity water ranged from 0.2 to 0.79 Bq / kg, which does not exceed standard values according to the Sanitary Norms and Rules № 0193-06 "Radiation Safety Standards (RSS-2006-2006) and the basic sanitary rules for ensuring radiation safety (BSRORS -2006) [1].

The average specific activities of the main dose-generating natural and technogenic radionuclides of drinking water of the pilot regions of the Republic of Uzbekistan are presented in table.

Table 1

№	Region	Specific activities, Bq / kg							∑ (Ai / ILi)
		^{226}Ra	^{232}Th	^{238}U	^{40}K	^{137}Cs	^{90}Sr	^{222}Rn	
1	Pilot region №1	0,33	0,12	0,22	16,6	0,07	0,03	5,0	0,47
2	Pilot region №2	0,37	0,15	0,20	27,5	0,14	0,08	4,7	0,55

As a result of the studies, it was found that the total activity of radionuclides in the water of drinking water sources of the pilot regions is determined mainly by radium isotopes.

Based on the data obtained and considering that the year is 365 days and the average human consumption of drinking water per day is 2.2 liters, the individual annual effective doses (μSv / year) were calculated:

Pilot region No. 1: ^{226}Ra -74.2; ^{232}Th - 35.1; ^{238}U - 7.5; ^{137}Cs-0.77; ^{90}Sr -0.48. Pilot region No. 2: ^{226}Ra -87.7; ^{232}Th –27.7; ^{238}U - 7.2; ^{137}Cs-1.5; ^{90}Sr -1.2.

The estimated average annual effective dose (AAED) due to the consumption of drinking water was:

Pilot region № 1– 0.11 mSv;

Pilot region № 2 - 0.12, 12 mSv.

In pilot region No. 1, the risk factor for the occurrence of malignant neoplasms (malignant neoplasms) due to drinking water consumption was 2.7 E-5, and the risk of malignant neoplasms was 35 cases for the subsequent years of life of the entire population of the region. In the pilot region No. 2, the risk factor for occurrence was 2.9 E-5, the risk of neoplasms was 90 cases for subsequent years of life of the entire population of the region.

In order to improve the sequence of operations for radiation monitoring of drinking water, an algorithm has been developed for radiation monitoring and ensuring the radiation safety of drinking water in the Republic of Uzbekistan, for which a patent was received from the Intellectual Property Agency of the Republic of Uzbekistan (Certificate on the official registration of the program for electronic computers № DGU 05498, 06.07 .2018, Tashkent). This algorithm made it possible to improve the monitoring of the radiation safety of drinking water and to optimize the protective measures of water sources with a high content of radionuclides.

5. Conclusions

As a result of the studies, the following conclusions were made:

1. The values of the specific total alpha and beta activity in drinking water do not exceed the standard values according to SanPiN No. 0193-06 "Radiation Safety Standards (NRB-2006) and the basic sanitary rules for ensuring radiation safety (BSRORS -2006)" (0.2 Bq / kg and 2.0 Bq / kg, respectively).
2. The total activity of radionuclides in the water of drinking water sources in the pilot regions is mainly determined by radium isotopes.
3. The value of ∑ (Ai / ILi) does not exceed 1 for 100% of the studied water samples taken from surface and

underground water sources. Measures to reduce the radioactivity of water in these regions are not mandatory.

4. The average annual effective dose (AAED) of internal exposure of the population due to the constant consumption of drinking water from the surveyed sources in the pilot regions is 0.11-0.12 mSv / year.
5. The lifetime risk coefficient for residents of the pilot region № 1 due to the consumption of drinking water was 2.7E-5, for residents of the pilot region № 2 - 2.9E-5.

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