International Journal of Academic and Applied Research (IJAAR)
ISSN: 2000-005X
Vol. 3 Issue 4, April – 2019, Pages: 43-45

Radioactivity of Mollusks and of Pisces in the Zarafshan River Basin

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Abstract: *In the present work with the help of the scintillation gamma spectrometry method the specific activity of molluscs and pisces in the Zarafshan river basin was determined.*

Keywords: algae, natural radionuclides, technogenic, migration, metabolic.

1. INTRODUCTION

In natural waters determined natural radionuclides (NRN) of uranium-238, thorium-232, Radium-226, Radon-222, polonium-210, radium-228, radium-224, uranium-234 and natural radioactive isotopes potassium-40, rubidium -87. The concentration of NRN in water varies over a very wide range and mainly depends on the species composition of the radionuclide and soil which water comes in contact with [1, p. 32-33].

In addition, nuclear and underwater tests carried out by different countries, radioactive waste disposal in rivers, accidents at the nuclear power plants have led to environmental pollution, including reservoirs with technogenic radionuclides of ^{137}Cs, ^{90}Sr, ^{144}Ce and others. Technogenic radionuclides ^{137}Cs and ^{90}Sr in water are in a highly dispersed and soluble form, which contributes to their intensive participation in the metabolic processes of biotic systems.

Radioactive substances in aqueous media, algae, aqueous sediments can be perceived by aquatic ecosystems, as well as other mineral elements, through the food chain and by way of absorption on boundary tissues.

Some algae serve as food for molluscs. Algae can accumulate natural radionuclides from both water and aqueous sediments. Radioactive elements in the body of aquatic animals accumulate in different magnitudes and this depends on the content of radionuclides in the water, in the bottom and in algae, on the properties and the external structure of the ecosystems themselves.

For example, the concentration of radium-226 and uranium in marine plankton reaches 100 pCi / kg, and the thorium content does not exceed 25 pCi / kg of fresh tissue. Intensive accumulation of radionuclides in molluscs was noted [2, p. 236 - 248].

In the present work, the specific radioactivity of natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K by the help of the scintillation gamma spectrometry in molluscs and fished out fish from the Zarafshan river basin was determined. Fish (Cyprinidae) entirely and molluscs dried, ground, weighed and packed in 1-litre Marinelli beaker. The weight of the samples was 1000-1200 grams.

The measurements of the gamma spectra of the samples were performed in Marinelli beaker geometry on γ-spectrometer with NaI(Tl) scintillation detector, Ø63 × 63 mm, an energy resolution of 10% on a gamma line ^{60}Co with an energy of E = 1332 keV. Registration and processing of the spectra were done on IBM PC with automatic writing of the spectra into the computer memory every hour which allowed to control the stability of spectrometer and correct the spectra when necessary. Measurement time was t=2 h. The identification detected in the photopeak spectra was carried out by energy, taking into account quantum yields, half-lives, and the position of photopeaks in the spectra. In all measured gamma spectra of the samples, a photopeak with an energy of 1460 keV of the natural radionuclide ^{40}K, as well as photopeaks belonging to the radionuclides of the uranium-thorium families is clearly manifested. The specific activity of radionuclides detected in the spectra was calculated by the relative method. Volumetric standard sources OMACH - ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were used for calibration of the spectrometer in registration efficiency for γ- radiation of samples and for decomposition of the spectra into components. The standard sources were Marinelli beakers with the precision 0.95.

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What stands out from the results of studies that in mollusks ^{226}Ra was <10.02, ^{232}Th was <7.99, ^{40}K was <68.28 and ^{137}Cs was <3.9; Fish: ^{226}Ra was <5.55, ^{232}Th was <2.59, ^{40}K was <59.74, ^{137}Cs was <12.22. Here the "<" sign corresponds to the sensitivity of the spectrometer for a given measurement time.

2. RESULTS AND DISCUSSION

From the data presented above it can be seen that, the radioactivity of mollusks and fish is mainly caused by the natural radioactive isotope of potassium-40 and partly by radionuclides of the uranium and thorium series, as well as by the technogenic radionuclide cesium-137. The difference in the specific activity of potassium-40 in fish and in mollusks is not significant. The accumulation of natural radionuclides ^{226}Ra, ^{232}Th, ^{40}K by mollusks exceeds than fish.

The specific gamma activity of radium-226 in water is 4.4 Bq / kg. Like other radioactive elements, radium, found in igneous rocks, when eroded in a significant amount, pass into natural solutions and is transferred to the lake, seas, rivers, and oceans, where it partially remains dissolved in water, partly together with silt and other sediments are precipitated on the bottom of reservoirs [4, p. 45 - 53].

However, thorium compounds are practically insoluble. Thorium migrates mainly in water flows in a suspended and colloidal state [4, p. 45 - 53]. Thorium is characterized by weak migration with the formation of chemical compounds. In addition, the radionuclide content in river-waters is significantly influenced by the characteristics of the channel, the flow rate, temperature, chemical composition and degree of water salinity. For different rivers, these features are not identical. There is a high content of radionuclides ^{226}Ra, ^{232}Th, and ^{40}K in aqueous sediments in relation to their content in reservoirs. Apparently, this phenomenon is explained by the fact that in an aqueous medium, potassium due to adsorption, is predominantly retained on particles of sediments. The minerals of thorium in natural waters dissolve much less than the minerals of uranium. Therefore, thorium is contained in waters hundreds of times less than uranium. Consequently, the thorium content in the aqueous sediments should be just over. Thorium goes into aqueous sediments not from solutions, but through the weathering of the igneous rocks in which it was originally present.

The increased accumulation of natural radionuclides by mollusks that settle on the bottom of reservoirs is apparently due to the accumulation of radionuclides. The accumulation of radionuclides in fish is caused both from water and from aquatic animals, which are eaten by fish as food.

As can be seen from the table, there is a significant difference in the specific activity of technogenic radionuclide ^{137}Cs in fish and mollusks. The specific activity of ^{137}Cs in fish is 3 times higher than in mollusks. Apparently, this can be explained as follows. Technogenic radionuclide ^{137}Cs and ^{90}Sr formed after nuclear explosions in water are highly dispersed and soluble, which contributes to their intensive participation in the metabolic processes of biotic systems. A significant part of the explosion products is in water in a soluble state, which is why it can remain in the upper layers of water for a long time [3, p. 18 - 21]. It has been established that aquatic animals have a pronounced ability to selectively accumulate in their tissues individual radionuclides, which is due to their functional properties. For example, the concentration ratio of ^{90}Sr with brown algae ranges from 20 to 40. Strontium green algae practically do not accumulate. Marine phytoplankton intensively concentrates ^{60}Co and ^{65}Zn. However, ^{137}Cs is hardly perceived by them.

Invertebrate animals have the ability to assimilate radioactive substances from water during its filtration. Accumulation of invertebrate radioisotopes also occurs when eating contaminated food, the accumulation coefficient of ^{137}Cs in the tissues of bivalve mollusks is 20-50. ^{137}Cs is deposited mainly in the muscles of the mollusks.

The penetration of radioactive substances into the body of fish occurs through the gills, skin, as well as the digestive tract when eating contaminated feed and swallowing water. On integumentary tissues there is a deposition of radionuclides without their pronounced separation. A number of authors carried out radiochemical analyzes of fish tissues and showed that ^{137}Cs mainly accumulates in muscles and in some parenchymal organs. It has been established that the level of contamination of the internal tissues of fish with radionuclides is lower than the specific activity of water. And only the gills, fins and head accumulated ^{137}Cs and ^{90}Sr in quantities several times higher than the specific activity of water [3, p. 18 - 21]. Intensively accumulated by internal and integumentary tissues.

3. CONCLUSION

And so, one can understand the difference in specific activity of ^{137}Cs in mollusks and fish, if we consider that aquatic organisms have the ability to selectively accumulate in their tissues individual radionuclides, which is due to their functional properties. In addition, the intensity of accumulation of radionuclides on the surface tissues of aquatic animals depends largely on their area. Adsorption is especially effective in forms that have a large body surface. Fish have a relatively larger area than mollusks. And so in our experiments the radioactivity of fish is measured entirely, including the gill, fin, and head. The source of radioactive contamination of water cannot be persistent and quickly destroyed, which in turn reduces the risk of radioactive contamination of fish and other aquatic organisms.

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