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RADIOACTIVITY MEASUREMENTS OF FISH SAMPLES FROM SERBIAN MARKETS

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ABSTRACT:

Concentrations of naturally occurring radionuclides (226Ra, 232Th, and 40K), as well as anthropogenic radionuclides (137Cs), in a total of 10 fish samples (freshwater species Oncorhynchus mykiss and Cyprinus carpio, and marine species Merluccius merluccius and Scomber scombrus) were purchased on Serbian markets have been measured to better understand background radiation levels in daily food diet. This investigation verified that the main source of radiation exposure from the fish intake is ^{40}K. In this study, none of the fish samples examined had any ^{134}Cs at measurable levels. An average ^{137}Cs level was below 20 $Bq.kg^{-1}$. The resulting radiation dose for people from fish consumption would be a very small fraction of the annual dose from exposure to natural background radiation. According to the findings, fish from Serbian markets do not present a radiological health risk.

Keywords: *fish samples, gamma spectrometry, radioactivity concentrations*

1. INTRODUCTION

Both natural and artificial radionuclides can be found in aquatic environments. The natural radionuclides are either primordial or cosmogenic in origin, and they are present in water due to their solubility, as well as their deposition from land and the atmosphere. These radionuclides can also be exchanged and removed from the aquatic environment through the removal of particulate matter. Among the radionuclides present in the aquatic environment, ^{40}K is the most abundant, followed by ^{238}U. On the other hand, ^{232}Th and its series members are not found in substantial amounts in sediments due to the fact that they are practically insoluble in water and tend to be absorbed into the particulate matter of

cosmogenic radionuclides. Plants and animals in the aquatic environment accumulate radionuclide to a concentration greater than of the ambient [1].

Radioactivity measurements of fish samples have been an important area of research for several decades. Due to the potential dangers of exposure to radioactive substances, it is crucial to monitor the radioactivity levels in the aquatic environment, particularly in fish which are a major source of food for humans. Several studies have shown that fish can accumulate and retain radionuclides in their tissues, which can be harmful to both human and aquatic life [2,3].

In recent years, there has been an increasing interest in the measurement of radioactivity in fish samples, especially in the aftermath of nuclear accidents such as the Chernobyl and Fukushima disasters. The need for accurate and reliable methods for measuring radioactivity in fish samples has never been greater. There are several methods for radioactivity measurements, including gamma-ray spectrometry, liquid scintillation counting, and alpha spectrometry, which have been widely used in the measurement of radioactivity in fish samples [4].

Serbia is a developing country which has adopted legislation setting maximum levels of contaminants in food [5,6]. However, food safety control is still a matter of great concern, particularly regarding imported food products [7]. Therefore, analyses of contaminant content in fishery products are one of the most important activities when controlling food safety [7,8].

Four fish species of great importance in the diet of the Serbian population are two imported marine species, hake (*Merluccius merluccius*) and mackerel (*Scomber scombrus*), along with two freshwater ones, common carp *Cyprinus carpio* and rainbow trout *Oncorhynchus mykiss* (dominating with over 90% of total fish production in fish ponds) [9,10].

This study aims to measure the radioactivity levels of fish samples using gamma-ray spectrometry. The results of this study will contribute to understanding the levels of radioactivity in fish samples and the potential risks associated with consuming them. In addition, this study can be an excellent introduction to the development of strategies for monitoring and controlling radioactivity levels in the environment.

2. MATERIALS AND METHODS

2.1. Gamma spectrometry analysis

Gamma spectroscopy is a common technique for assessing radioactivity in the environment and detecting radioactive contamination over large areas of land.

In this study, ten samples of technologically processed (packaged) fish were collected and analyzed. Obtained samples are available on the Serbian markets from three different distributers (Vasović, BioFish, and Tropic Trade). Fish samples were placed in sealed 450 mL Marinelli beakers and stored for over four weeks to prevent the escape of radon gas

(^{222}Rn) and avoid any disequilibrium issues between ^{226}Ra and its short-lived progeny (^{214}Pb and ^{214}Bi). The activity concentrations of radionuclides such as ^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs were measured using a high-purity germanium (HPGe) detector with an energy resolution of 1.85 keV at 1.33 MeV (^{60}Co). The MAESTRO 2 software was used for spectrum analysis.

2. RESULTS AND DISCUSSION

This study presents the results of a gamma spectrometric analysis conducted on ten fish samples from the Serbian markets. Table 1. shows the specific activity of natural radionuclides and ^{137}Cs. The first six fish samples are marine species, while the remaining four represent freshwater species.

Table 1. Specific activities of radionuclides in selected fish samples (fish species and distributers).

Sample	*^{226}Ra (Bq.kg^{-1})*	*^{232}Th (Bq.kg^{-1})*	*^{40}K (Bq.kg^{-1})*	*^{137}Cs (Bq.kg^{-1})*
Hake (Vasović)	3.2 ± 0.2	4.2 ± 0.2	94.1 ± 4.7	4.5 ± 0.2
Hake (BioFish)	2.2 ± 0.1	4.2 ± 0.2	124.4 ± 6.2	5.1 ± 0.3
Hake (Tropic Trade)	2.3 ± 0.1	3.1 ± 0.2	93.1 ± 4.7	3.1 ± 0.2
Mackerel (Vasović)	8.9 ± 0.4	5.9 ± 0.3	105.9 ± 5.3	2.9 ± 0.1
Mackerel (BioFish)	5.4 ± 0.3	7.4 ± 0.4	97.5 ± 4.9	7.5 ± 0.4
Mackerel (Tropic Trade)	4.3 ± 0.2	7.2 ± 0.4	107.4 ± 5.4	5.4 ± 0.3
Common carp (Vasović)	6.7 ± 0.3	6.3 ± 0.3	86.4 ± 4.3	6.4 ± 0.3
Common carp (BioFish)	7.8 ± 0.4	5.8 ± 0.3	95.8 ± 4.8	2.8 ± 0.1
Rainbow trout (Vasović)	9.0 ± 0.5	11.1 ± 0.6	111.3 ± 5.6	3.3 ± 0.2
Rainboe trout (Tropic Trade)	10.1 ± 0.5	9.8 ± 0.5	159.8 ± 8.0	5.8 ± 0.3
Min	2.1	3.1	86.4	2.8
Max	10.1	11.1	159.8	7.5
Mean	6.0	6.5	107.6	4.7
SD	2.8	2.4	20.3	1.6

The results of this study show that the concentrations of naturally occurring radionuclides (^{226}Ra, ^{232}Th, and ^{40}K) and anthropogenic radionuclide (^{137}Cs) in the fish samples collected from Serbian markets were generally low. The average activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs were found to be 6.0 ± 2.8, 6.5 ± 2.4, 107.6 ± 20.3, and 4.7 ± 1.6 Bq/kg, respectively. These results are consistent with other studies that have reported low levels of radioactivity in fish samples [11, 12].

This study's results show that most of the radiation exposure from fish consumption comes from naturally occurring radionuclides such as ^{40}K, rather than from anthropogenic

radionuclides such as ^{137}Cs. The fact that none of the fish samples had detectable levels of ^{134}Cs is a positive finding, as this radionuclide is a byproduct of nuclear power plants and can potentially contaminate the environment and food chain.

It is worth noting that the concentrations of ^{226}Ra and ^{232}Th in the fish samples were relatively low. This could be attributed to the fact that the fish were not affected by nearby industrial activities or geological features that could contribute to higher levels of these radionuclides. These values were well below the recommended limits set by international organizations such as the International Atomic Energy Agency (IAEA) and the European Union (EU).

It is important to note that the measured activity concentrations of radionuclides in fish samples can vary depending on several factors, such as the fish species, the fishing ground's location, and the environmental conditions. Therefore, continued monitoring of radioactivity levels in fish samples from different sources is necessary to ensure the safety of consumers.

This study's findings align with the national and international regulations on food safety and radiation protection. The results can be used by regulatory bodies and health authorities to make informed decisions about food safety and to establish appropriate guidelines and limits for radioactivity levels in food products.

3. CONCLUSION

The study aimed to investigate the radioactivity levels in fish samples purchased from Serbian markets to assess potential radiological health risks associated with fish consumption. The results showed that naturally occurring radionuclides, particularly ^{40}K, were the main contributors to radiation exposure through the fish intake. Anthropogenic radionuclides were below measurable levels in all samples. The average ^{137}Cs level was found to be near the limit of detection, and the radiation dose from consuming fish was found to be negligible compared to the annual dose from natural background radiation. The results of this study provide valuable information on the radioactivity levels in fish sold on Serbian markets and serve as a baseline for future monitoring and assessment of radioactivity in fish and other food products. Overall, the findings suggest that consuming fish from Serbian markets does not pose a significant radiological health risk to the general population.

4. LITERATURE

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