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THE CONCENTRATIONS OF RADIOISOTOPES IN SELECTED FISHES AND ZOOPLANKTON BIOMASS OF DZIERŻNO DUŻE DAM-RESERVOIR (UPPER SILESIA, POLAND)

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ZAWARTOŚĆ RADIOIZOTOPÓW W WYBRANYCH GATUNKACH RYB I ZOOPLANKTONIE ZE ZBIORNIKA ZAPOROWEGO DZIERŻNO DUŻE (WOJEWÓDZTWO ŚLĄSKIE)

Określono koncentracje radioizotopów w tkance mięśniowej lina (*Tinca tinca*), karpia (*Cyprinus carpio*) oraz szczupaka (*Esox lucius*) pochodzących z zanieczyszczonego zbiornika Dzierżno Duże (woj. śląskie). Stwierdzono, że zawartość radioizotopu potasu ^{40}K mieści się w obserwowanych dla żywych organizmów granicach. Zawartość radioizotopów szeregu uranowego ^{238}U i torowego ^{232}Th są niewielkie w porównaniu z zawartością radioizotopów w osadach dennych, w badanym zbiorniku. Stanowią one około 0,1% tych wielkości. Stężenia izotopów promieniotwórczych szeregu uranowego ^{238}U i torowego ^{232}Th w tkance mięśniowej ryb są niewielkie. W próbkach rozwielitek nie stwierdzono obecności cezu ^{137}Cs. Najwyższą zawartość cezu ^{137}Cs stwierdzono w tkance mięśniowej szczupaka.

Summary

Concentration of radioisotopes in biological material of fishes tench (*Tinca tinca*, carp (*Cyrpinus carpio),* pike (*Esox lucius*) from the Dzierżno Duże dam-reservoir were determined. The concentrations of potassium isotope ^{40}K are with normal limits for living organisms. The concentrations of radioisotopes from uranium-radium (^{238}U) progeny are about 0.1% in comparison to the concentrations of bottom sediments of this lake. The highest concentrations of cesium ^{137}Cs were determined in the muscles of pike (*Esox lucius*). Isotope cesium (^{137}Cs) was not found in the *Copepoda* biomass. The concentrations of radioisotopes from uranium-radium and thorium progeny are not hazardous.

INTRODUCTION

Anthropogenic reservoirs in the Upper Silesian Industrial Region area and its vicinity are under exceptionally strong and negative pressure of industry [4, 5]. Biological balance in these reservoirs results from morphology and morphometry of the reservoir, hydrochemical content of feed water and also kind and load of pollutants inserted into the reservoir [4, 7]. The above processes have an impact on ichtiofauna which forms spontaneously in these reservoirs by natural succession determined among other things by the geochemical character of the basin. In some cases this is a result of fishery and fishing economy which consists in stocking waters with different fishes [3].

The dam-reservoir Dzierżno Duże fed with water from the river Kłodnica plays a role of a river purification plant and considering that the river is highly polluted with municipal and industrial wastes, for many years it has been considered to have a high level of pollution [4, 6].

As in the lake ecosystem fish constitute the final link of the food chain, it has been assumed that the concentrations of radioactive isotopes as well as heavy metals in fish organisms will reflect the process of their accumulation from the bio-accessible resources [3, 18]. Also, it has been assumed that the results of the research on the presence of radioisotopes in fish which have lived for many years in a polluted environment, will give some important information on the blending of these pollutants in chosen elements of the analyzed water ecosystem [2, 8, 9].

In order to check opinions on the given research subject, and also in order to observe the most important facts, as to the functioning and efficiency of the lake ecosystem, an attempt has been made to determine the concentration of radioisotopes in sòme fishes which live in this reservoir.

RESEARCH METHODOLOGY

The subject of the research was muscle tissues of three species of fish i.e. tench (*Tinca tinca*), carp (*Cyprinus carpio*) and pike (*Esox lucius*). Taken samples were dried in temperature of 105±1°C, and next, after being minced, were placed in standard containers of Marinelli type. The measurements were done also for zooplankton from *Copepoda* group.

The natural radioactivity was determined by means of gamma-ray spectrometer with a CANBERA semiconducting detector HPGe, with high energy resolving power (2 keV) and high efficiency (in the order of 30%). The numerical analysis of gamma-ray radiation spectrum was carried out with IAEA software, GANNAS program. The identification of gamma-ray radioactivity quantum was done in energy range from 100 keV to 3 MeV. The concentration of radioisotopes was calculated with the comparative method with the soil radioactive standard of the Atomic Agency in Vienna (type 375 SOIL (IAEA).

RESULTS

As a result of measurements and numerical analysis in analyzed samples of sediments, there were identified radioisotopes which belong to uranium progeny ^{238}U: ^{214}Bi, ^{234}Pb, ^{226}Ra, thorium progeny ^{232}Th: ^{228}Ac, ^{210}Pb, ^{208}Tl, radioactive isotope ^{40}K of natural potassium and artificial radioisotope of cesium ^{137}Cs. Activities of individual radioisotopes belonging to radioactive progeny ^{238}U and ^{232}Th are presented in Table 1.

Table 1. The radioisotopes content of biological samples on Dzierżno Duże dam-reservoir

Isotope	Gamma energy [keV]	Copepoda (*Daphnia sp.*)	Tench (*Tinca tinca*)	Carp (*Cyprinus carpio*)	Pike (*Esox lucius*)	Ash sample
		Activity [Bq/kg] dry mass				
^{40}K	1460.7	190.3	185.5	204.3	372.4	681.3
^{208}Tl A	2614	18.5				2.3
^{208}Tl B	582.9	7.7			0.6	3.0
^{228}Ac	911.2	16.8	0.5		0.8	3.0
^{212}Pb	238.6	11.9		0.5		3.3
progeny ^{232}Th		13.7	0.5	0.5	0.7	2.9
^{214}Bi	609.3	12.9			0.6	1.9
^{214}Pb A	352.2	23.1	1.8	1.7	2.7	4.4
^{214}Pb B	295.2	17.6				3.6
^{226}Ra	186.1	13.0				3.1
progeny $^{238}U-^{226}Ra$		16.6	1.8	1.7	1.3	3.3
^{137}Cs	661.7	0.0	0.5	0.9	3.8	3.2

SUMMARY

As a result of biocumulation process pollutants accumulate in tissues of fish, including radioisotopes of which concentration reflects the condition of environment of the given ecosystem [10, 12].

The fact that ^{137}Cs does not occur in environment in a natural way, is an indicator which enables to monitor the impact of anthropopressure on the quality of the environment. The source of this radioisotope was explosions of nuclear charges in the atmosphere and nuclear reactor failures. After the nuclear power plant accident in Chernobyl, a particularly distinct increase in cesium concentration in soils, plants and animal organisms was observed [1, 7, 10–13, 14–16].

According to the information given by National Atomic Energy Agency (PAA) in Poland, in 1995 the concentration of cesium isotopes ^{137}Cs in meat of fresh-water fish was on average 2.8 Bq/kg in comparison with the values 0.6 Bq/kg from the period preceding the accidents in Chernobyl [15]. In 1994 the cesium ^{137}Cs concentration was on average 2.3 Bq/kg. The strontium ^{90}Sr concentration was below 0.1 Bq/kg [15]. In the analyzed material, there was an increased value, similar to that given by PAA, observed in case of ^{137}Cs, in muscles of pike (*Esox lucius*), where it was 3.8 Bq/kg. It can be explained by predatory life of this fish, which enables bigger species accumulation of ^{137}Cs in its tissues.

In years 1990–1995 there was research on radioactivity of the sea fish. Similar research was also conducted earlier since 1982 [1, 13, 17].

The highest concentration of ^{137}Cs was observed in flounder meat – 26.4 Bq/kg of fresh mass, the lowest concentration for flounder was 6.7 Bq/kg of fresh mass. The average concentration of cesium ^{137}Cs in 1990–1995 in three species of fish i.e. flounder, herring and cod was adequately: 11.9 – 3.0; 11.0 – 1.9 and 12.2 – 2.0 Bq/kg of fresh mass [17].

It has been observed that in biomass of daphnia (*Copepoda*) the concentrations of natural radioisotopes – ^{40}K, ^{238}U – ^{226}Ra progeny, and ^{232}Th progeny – are comparable with their concentrations in bottom sediments. It is puzzling that there occurs repeatedly higher concentration in biomass of zooplankton than in the tissues of examined fish. Surprising is also lack of cesium ^{137}Cs in biomass of daphnia, below 0.02 Bq/kg of detection threshold. This result can point to the lack of this radioisotope in water, or to its inaccessibility in the food chain at the stage of plankton organisms. Due to the unique results further research in that field is expected.

CONCLUSIONS

1. Concentrations of radioactive isotopes of uranium ^{238}U – ^{226}Ra and thorium ^{232}Th progeny in analyzed samples are not high and constitute about 0.1% in comparison with sediments in the examined reservoir.
2. The highest concentration of cesium ^{137}Cs for tissues of the examined fish was observed in muscle tissues of pike. It was repeatedly (4–8 times) higher than in the tissues of the rest of the fishes.
3. In the zooplankton biomass there occur concentrations of natural isotopes – ^{40}K, of ^{238}U – ^{226}Ra and ^{232}Th progeny, repeatedly higher than in tissues of the examined fishes, comparable to their concentrations in the bottom sediments.
4. The lack of cesium ^{137}Cs in the biomass of daphnia can point to the presence of factors in the examined reservoir, which limit transfer of this radioisotope from water to this group of zooplankton organisms.
5. Considering the role of anthropogenic water reservoirs in this region of Poland, it is purposeful to continue research.

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