RADIOECOLOGICAL STUDY OF FRESH WATER ECOSYSTEMS INFLUENCED BY THE OPERATION OF NUCLEAR CYCLE FACILITIES IN THE URALS

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Nuclear cycle facilities have been functioning in the Urals for over four decades which resulted in significant impacts on the environment.

The researchers of the Department of Continental Radioecology of the Institute for Plant and Animal Ecology (IPAE) has for long years conducted radioecological studies of the river Techa and water basins in the East-Urals Radiation Trace (EURT) area, and in the vicinity of the Beloyarsk APS.

The present paper only contains integral indices, such as inventory of the radionuclides contained in the ecosystems studied.

Radioecological conditions in the Urals region were to a significant extent a result of operation of the Mayak Industrial Association (MIA) and a major accident that occurred at the plant. It was in the South Urals that the USSR's first reactor (1948) and first radiochemical plant (1949) were started. Their task was to make the first Soviet atomic bomb.

Releases of radioactive wastes from the radiochemical plant into the river Techa were going on from 1949 through 1956. Seventy-six million cu m of effluents with total beta-activity of 2.8 million Ci were disposed into the river in the period indicated. About 95% of total activity entered the river from March 1950 through November 1951. During that period the average daily discharge of activity constituted 4.3 thousand Ci and the radionuclide composition of sewage waters: 0.8% of Sr-89, 11.6% of Sr-90, 26.8% of rare element radionuclides, 13.6% of Zr-90 + Nb-95, 25.9% of Ru-106. Radioactive releases into the river system were sharply decreased during the next 5 years and made up 9.5 thousand Ci/yr in 1952 and from 0.5 to 2 thousand Ci annually in the period of 1953-1965 (1).

Currently, 0.7×10^{14} Bq of Sr-90 and 1.3×10^{14} Bq of Cs-137 are contained in the river Techa according to measurement data, the bulk of the activity being deposited in the bottom sediments of the river. The Techa floodplains contain 1.3×10^{14} Bq of Sr-90 and 1.7×10^{14} Bq of Cs-137 (Table 1).

Inventory of Sr-90 and Cs-137 in the Techa River and its Floodplains

Components	Sr-90	Cs-137
The river	0.7×10^{14}	1.3×10^{14}
Floodplains	1.3×10^{14}	1.7×10^{14}
Total inventory (river+floodplain)	2.0×10^{14}	3.0×10^{14}

According to the calculations made by the researchers of Department of Continental Radioecology, IPAE, and the National Laboratory, RISO (Denmark), under the supervision of Dr. A. Aarkrog and on the basis of our own results and literature data, approximately 1×10^{15} Bq of radioactive releases (Sr-90 + Cs-137) were migrating from the river Techa into the river-system Iset-Tobol-Irtysh-Ob over 4 decades (2).

The explosion of a tank of volume 300 m^3 which contained 70-80 tons of high-level waste (mostly in the form of nitrate-acetate compounds) occurred on September 1957 on Mayak's production site

About 2 million Ci (out of 20 million Ci of radioactive substances from the tank) were released into the air to the height of up to 1 km which led to the formation of a plume. The deposition of radioactive substances from the plume led to the contamination of an area of 23 thou km^2 in Chelyabinsk, Sverdlovsk and Tyumen Regions. The contaminated area was designated by the term East-Urals Radiation Trace (EURT). The dispersed radioactive substance consisted mainly of short-lived radionuclides. However, it was the long-lived Sr-90 in the mixtures (2.7% of total activity) released that presented the main long-term hazard.

Radioecological monitoring of three lakes (Tygish, Bolshoi Sungul and Chervyanoye) was being carried out by our laboratory for several years in the EURT area, close to the boundary between Sverdlovsk and Chelyabinsk Regions. The results of this work was summarized in an inventory drawn for Sr-90 contents in lakes.

Maximum Sr-90 contents were found to be contained in the Tygish Lake: 374 GBq; while the contents for the Sungul and Chervyanoye were 240 and 167 GBq, respectively (Table). The data used in calculations were only those that were included in our monograph [3].

Table 2

Distribution of Sr-90 in the main components of some lakes on the EURT in Sverdlovsk Region (1992)

Lake	Sr-90 contents, GBq		
	In water	In bottom sediment	Total for the lake
Tygish	35.1	338.8	373.9
B. Sungul	21.8	218.3	240.1
Chervyanoye	15.2	151.7	166.9

Beloyarsky APS named after Kurchatov, the first electric station in the USSR was put on line in 1964. At present one of the blocks FN-600 is functioning on fast neutrons generating 600 Megawatts of power. Two other blocks, one for 100 and the other for 200 megawatts, were shut down.

The scientists of the Department for Continental Radioecology, IPAE, assessed the contents of the principal artificial radionuclides, Co-60, Sr-90, Cs-137, released by the APS into the Beloayrsk Water Reservoir [4].

The cooling pond of the APS contains 244 GBq of Co-60, 144 GBq of Sr-90 and 668 GBq of Cs-137. The concentration of these radionuclides in the bottom sediments constitutes 90%. From 2 to 8% of the total radionuclides indicated above are registered in water and less than 0.01% in plants (Table 3).

Table 3

Distribution of radionuclides among components of the Beloyarsky Water Reservoir

Components	Co-60		Sr-90		Cs-137	
	MBq	%	MBq	%	MBq	%
Water	6600	2.7	9900	8.0	12000	1.8
Sediments	238000	97.3	114000	92.0	656000	98.2
Aquatic plants	26	0.01	12	0.01	15	0.002

It should be mentioned in conclusion that the impacts of the radioactive contamination in the Urals resulting from the operation of a nuclear facility had a regional and local aspects. Thus, the discharges of radionuclides into the Techal led to the pollution of the entire Ob-Irtysh basin.

The accident of 1957 at Mayak IA resulted in the scatter of radioactive matter over the area of 23,000 km^2 . Although the radioecological conditions in the area around Beloyarsky APS are much safer, there is a local pollution of the Beloyarsk Reservoir. Taking into account the unique character of the environmental situation observed in a number of water reservoirs, it would be necessary to conduct further in-depth investigations.

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