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Radiochemoecological Monitoring of the Salt Lakes of the Crimea

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1 Introduction

The salt lakes of the Crimea contain the practically inexhaustible sources of salts of sodium, magnesium, bromine and other chemical elements (Ponizovskii, 1965), being the potential powerful raw materials base for the large-scale chemical industry of Russian Federation. In 1986, as a result of the Chernobyl NPP accident, the Crimean region was exposed to a primary radioactive contamination by means transport of air masses from the accident area (Livingston et al., 1986). In post-accident period the radioecological situation in the Crimea was determined by the secondary radionuclides contamination, primarily ^{90}Sr, with river flow, mainly the Dnieper, and by a chronic contamination, mainly due to the water consumption of the North-Crimean Canal (NCC) (Kulebakina, 1996; Polikarpov et al., 2008). The mercury holds one of the first places among the most dangerous chemical pollutants of marine ecosystems, which is due to the stability of its compounds to the changing of a saline environment, as well as accumulation of Hg in sediments and aquatic organisms (Kostova et al., 2001). The despite the growth of anthropogenic impact and climate change in the region, the last 23 years the researches of the environmental salt lakes of the Crimea were held occasionally (Sivash region ..., 2007; Diyakov et al., 2013).

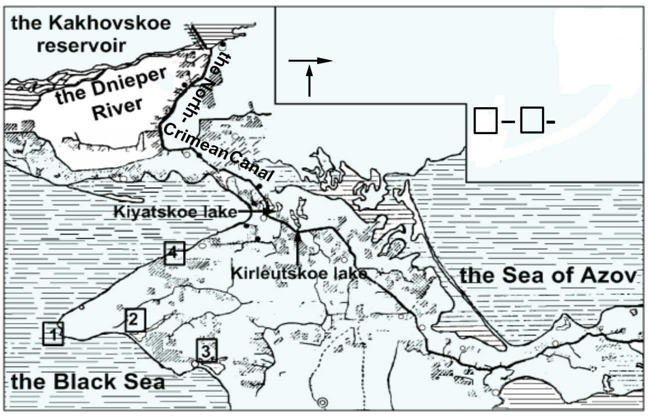

Fig. 1. Sampling stations in the Crimea region (2012–2013)

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The estimation of the radiochemoecological state of salt lakes Kiyatskoe and Kirleutskoe (Fig. 1), relating to the Perekopskaya group of the salt lakes of the Crimea, was fulfilled. The levels of radioactive (^{90}Sr) and chemical (Hg) contamination of components of the aquatic ecosystems were determined and analyzed for the study objects.

2 Results and Discussion

The concentration of ^{90}Sr in the Black Sea water along the North-Western part of the Crimean peninsula on stations 2-4 of sampling (Fig. 1) did not exceed pre-accident levels (Table 1). This is because the biogeochemical and hydrological processes in the Black Sea ecosystems reduce on 106-127 years the time of presence of the postaccident ^{90}Sr in the marine environment (Mirzoyeva et al., 2013).

It was obtained (Table 1), that in seawater near Cape Tarkhankut and in water of the salt lake Kiyatskoe the ^{90}Sr concentration in 1.7 and 23 times higher, respectively, than the content of this radionuclide, which is defined in the reservoirs of the Crimea before the Chernobyl NPP accident. Slight excess of radionuclide concentrations in sea water near Cape Tarkhankut was defined by the chronic secondary entrance of ^{90}Sr with waters of the Dnieper River through the NCC (Gulin et al., 2013; Mirzoyeva et al., 2013) physical decay of the radionuclide and the biogeochemical processes occurring in the environment. Increased concentration of post-accident ^{90}Sr in water of Kiyatskoe lake due to the peculiarities of hydrological, hydrochemical characteristics of this water reservoir, significant anthropogenic pressure on the investigated ecosystem. Kiyatskoe lake concerning its hydrological regime belongs to the drainless reservoirs. Ingress of water

Table 1 Range of pollutants concentrations in the salt lakes and check stations of sampling (the Crimean region).

Name of the object	Salinity, ‰	Concentration	
		^{90}Sr, Bq·m^{-3}	Hg (total), ng·L^{-1}
Kiyatskoe lake	78.1–82.6	350.5±15.8	19.8–363.2
Kirleutskoe lake	190.4–242.8	no sample	19.1–20.6
1 – sea near Cape Tarkhankut	17.6	24.8±2.1	4.7
2 – Donuzlav lake	16.9	11.±1.6	2.0
3 – sea near Yevpatoria city	17.5–17.7	15.5±1.6	14.0–21.2
4 – sea near Bakalskaya spit	17.3–17.9	12.5±1.7	21.5–22.4

Note: Sampling dated 10th of August 2012 and 19th of February 2013.

to Kiyatskoe lake occurs through groundwater of an artesian basin, spillway channels and drainage systems of the NCC, through which the Dnieper water gets to this lake. All of that, in turn, provide a secondary chronic entrance of dissolved ^{90}Sr from the accident region in Kiyatskoe lake. Long-term discharge of wastewater from the Crimean Soda Plant, which in its operating cycle uses water as the NCC and Siwash salt lake, also is an additional source of entrance of ^{90}Sr to Kiyatskoe lake in the period after the Chernobyl NPP accident. It was determined that the concentration of ^{90}Sr, which was reconstructed for 1986 is 730.2 Bq·m^{-3}. This corresponds to the concentration of this radionuclide (728.8 Bq·m^{-3}), which entered in dissolved form with the Dnieper waters to Kakhovske reservoir and then to the NCC in November 1986 (Mirzoyeva et al., 2013). Kiyatskoe lake belongs to the Perekopskaya group of salt lakes of the Crimean, second class. It is characterized by an increased content of dissolved NaCl (83.8 %) and $MgCl_2$ (13 %), a small content of $CaSO_4$ (1.6 %) and Ca $(HCO_3)_2$ (0.07 %) (Ponizovskii, 1965). This allows the post-accident ^{90}Sr advantageously be in ionic form in the aqueous solution of the lake. Its redistribution between the hydrobionts and bottom sediments of this lake is insignificant. So ^{90}Sr concentration in aquatic plants (the genus of *Cladophora* and *Potamogeton*) from Kiyatskoe lake was 0.30±0.04 Bq·kg^{-1} and 0.37±0.04 Bq·kg^{-1} wet weight, respectively, and in the bottom sediments – 0.45±0.22 Bq·kg^{-1} dry mass. Thus, hydrological and hydrochemical features of Kiyatskoe lake allow to use this lake as a model for aquatic ecosystems, where the main and perhaps the only factor in the elimination of the radionuclide from the environment is its radioactive decay.

Studies of the salt lakes of the North-Western part of the Crimea showed that the highest concentration of mercury was noted in water of Kiyatskoe lake (363.2 ng·L^{-1}) (Table 1). This value was in 3.5 times higher the MPC. It may be assumed, that the high content of mercury in this lake depends from anthropogenic pressure, namely, with many years of being discharged into the lake wastewater of the Crimean Soda Plant. Significant contribution to the total content of this pollutant was represented by the dissolved mercury. In the same areas of study the greatest concentrations of mercury were observed in the summer (August 2012), the lowest - in winter (February 2013).

Resume

Thus, the highest concentrations of such pollutants as ^{90}Sr and mercury were identified in Kiyatskoe salt lake of the Crimean region. This is due to the peculiarities of hydrochemical and hydrological characteristics of this water object, as well as the exploitation of the Kiyatskoe lake in a cycle of the Crimean Soda Plant. It should be noted, that anthropogenic load is a determining factor of pollutants entrance into this investigated reservoir. Hydrological and hydrochemical features of Kiyatskoe lake allow to use its as a model for other aquatic ecosystems, where the main process ensuring elimination of ^{90}Sr from the water is radioactive decay of the radionuclide.

Key words: the Crimea, salt lakes, the Black Sea, the Chernobyl NPP accident, water, sediments, hydrobionts, Hg, ^{90}Sr, ecological impact.

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