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Spatial structure of floodplain soil radionuclide contamination of the Enisey River near the Krasnoyarsk Mining and Chemical Combine

V.G Linnik (1), J.E. Brown (2), V.N. Potapov (3), and V.V. Surkov (4)

(1) Vernadsky Institute of Geochemistry and Analytical Chemistry, Kosygin Street 19, 117975 Moscow, Russia, linnik@geokhi.ru, (2) Norwegian Radiation Protection Authority, Grini Naeringspark 13, P.O. Box 55, N-1332 Østerås, Norway, Justin.Brown@nrpa.no, (3) Technopark, RRC "Kurchatov Institute", 1 Kurchatov Square, 123182 Moscow, Russia, potapov_v@mail.ru, (4) Moscow State University, Geographical Department, 119992, GSP-2, Russia

Enisey River floodplain soils were contaminated by technogenic radionuclides arising from operations at the Krasnoyarsk Mining Chemical Combine (KMCC) from 1958 to 1992. The radioecological situtation of the Enisey flood plain landscapes has been formed by the interaction of two factors: (i) characteristics of radionuclide discharges to the aquatic environment, (ii) hydrological regime of the Enisey River. The radionuclide discharge determined the potential extent of contamination, while the river hydrology was responsible for its transport over considerable distances. The erection of the dam of the Krasnoyarsk power station in 1970 changed the hydrological regime of the Enisey River. The water discharge and suspended sediments became uniform in all seasons and extreme floods, extending over high floodplain areas, ceased.

The distribution of radioactive contamination within floodplain soils downstream from the KMCC was studied with the objectives of mapping contamination levels and analyzing the spatial structure of radionuclide distributions arising from floodplain formation.

Based on a digital elevation model of floodplain landscapes at a strip of KMCC-Strelka the flooded area of the Enisey River was determined. In 1960 to 1970, deposition of contaminated sediments occurred at heights less than 6 m over an area of 99,2 km2, in 1970-1992 the flooded area with a height less than 3,5 m was of 38,2 km2.

Since radiocaesium in the Enisey River primarily occurs in a well fixed sediment-associated form it is possible to use the analysis of landscape structure within the floodplain to detect lithologo–geomorphological zones corresponding to a varying degree of 137Cs contamination.

Radionuclide contamination was measured using in situ gamma spectrometry and soil sampling undertaken at control points. Maximum 137Cs contamination densities (700 kBq m−2) were found on low- and middle-level floodplains of Beriozovy Island (16 km from the KMCC). The contamination density of 60 and 152,154Eu (up to 190 kBq m−2) are also maximal at the level of a low floodplain folded by silts, by peats and light loams. Maximum 137Cs and total 60Co, 152Eu and 154Eu contamination densities on Cheriomukhov Island (250 km from the KMCC) were 390 and 50 kBq m−2, respectively.

The analysis of 137Cs distributions in Beriozovy Island showed that in 2000 the maximal inventory of the radionuclide (59,7%) was over a low floodplain at a height of 1-2 m. The maximal radionuclide deposition was observed in places of sedimentation of silt or sandy-silt fractions while pebbles represent transit zones of radionuclides.

According to results of GIS modelling on the site "Kazachiy" (at a distance of 180 km), the total flooded area was 15,56 2, 137Cs inventory was 1075 GBq. This corresponds to 5,5% of 137Cs total discharge for the period of 1976-2000. For the total area from KMCC to Strelka (250 km from KMCC) an estimation of 137Cs deposit was obtained that is equal to 30,5% of the total 137Cs discharge for the period of 1976-2000.