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Testing of models on plutonium transport in the Techa River

I. Kryshev (1), A. Kryshev (1), A. Krylov (2), A. Nosov (3)

(1) SPA "TYPHOON", Obninsk, Russia, (2) IBRAE, Moscow, Russia, (3) Atomenergoproekt, Moscow, Russia

The objective of the paper is to test models for radioactive contamination of river water and bottom sediments by ^{239,240}Pu in the Techa River (South Urals, Russia), which was contaminated mainly in 1949-1952 as a result of discharges of liquid radioactive wastes into the river. Being one of the most contaminated river in the world, the Techa can be considered as a suitable aquatic system for the radioecological assessment, dose reconstruction and risk estimation, management of protective measures and studies of processes of radionuclides migration and bioaccumulation.

Calculations of the plutonium transfer in the Techa River have been performed using different models: TRANSFER-2, CASSANDRA and GIDRO-W. The endpoints for model testing were the activity concentrations of the ^{239,240}Pu activity concentrations in water and bottom sediments at different locations downstream of the river. The model predictions were compared against the test data.

The analytical model TRANSFER-2 is based on the turbulent diffusion equation and accounts for the interaction of radioactive substances between the water mass (solution, suspended material) and bottom sediments. The analytical model is added with the assumption that the morphometric characteristics of the channel are constant over the entire river stretch under study. The total discharge of lateral tributaries is taken to be negligible as compared with the discharge of the main channel. Variations in the water discharge along the length of the river are due to changes in the flow velocity by the linear law.

The integrated information-modeling system CASSANDRA based on using geoinformation technologies is designed to predict and estimate the consequences of radioactive contamination of water bodies. The model CASSANDRA is based on the same

equations that TRANSFER-2. However, CASSANDRA allows for side tributaries, changes in the morphometric characteristics of the channel, the distribution coefficients and other parameters along the river, as well as time variations. In contrast to the analytical model, the CASSANDRA seeks a solution numerically.

The model GIDRO-W is based on the model accounting for radioactive decay, advective transport of radionuclides, dispersion, exchange between radionuclides adsorbed on suspended particles in the water column and those occurring in bottom sediments, removal of radionuclides from the river due to evaporation, filtration losses and flow of radionuclides to the river from different sources, diffusion down the profile of bottom sediments.

For the model TRANSFER-2 the error in calculation of ^{239,240}Pu in water is, on the average, 26 %, CASSANDRA 12 %, and GIDRO-W 20 %, so it practically does not exceed the measurement error. For the model TRANSFER-2 the error in calculation of ^{239,240}Pu in bottom sediments is on the average 82 %, CASSANDRA 79 %. The discrepancy with the observational data is the largest for the upper part of the river. It can be generally concluded, that the model estimates of the plutonium activity concentrations in bottom sediments in most of the points go beyond the measurement errors.

So, the models TRANSFER-2, CASSANDRA, GIDRO-W are in good agreement with the observations of the distribution of plutonium in river water, while the modelling of the plutonium distribution in bottom sediments of the Techa river requires consideration of additional processes.