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Modeling of highly brines transport in large water bodies

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The paper deals with the numerical modeling of a dilution and transport of highly brines in large water bodies taking into account the density stratification effects. This problem has an exceptional importance for the guarantee of ecological security of the Kama Reservoir in the conditions of extending exploitation of Verhnekamsk deposit of potassium and magnesium salts - one of the largest in the world. The output of million of tones of the potassium fertilizer is accompanied by the producing of the same quantity of highly brines demanding utilization. With the existing technologies the desalination of such quantity of brines is extremely energy-capacious and almost inapplicable. That is why main way for the brine utilization is the release into the surface water bodies or underground water-bearing horizons. Since the uncertainty level in the parameter setting for underground water-bearing horizons is higher than that for the surface water bodies, under the same or close conditions the release into the surface water bodies is considerably less dangerous. The main water body able to assimilate such huge amount of the removed brines is the upper part of the Kama Reservoir located within the Solikamsk-Berezniki industrial centre. The wastewater arriving from this centre make a decisive contribution to the formation of hydrochemical regime of Kama river. We suggested two-dimensional imitational hydrodynamical model allowing to determine the possible pollution zones depending on the flow rate and concentration of pollutant, flow rate and water level in the Kama river and wind characteristics in the zone of pollutant discharge. This model allows not only to calculate the distribution of pollution zones for various pollutant sources but also to estimate the consequences of emergencies. The Kama river near the Solikamsk-Berezniki industrial centre has complex morphometry. For the complete and efficient accounting for the morphometry peculiarities the non-linear orthogonal mesh was implemented. For the problem under consideration, taking into account the suppression of vertical turbulent mixing in the conditions of the considerable density gradients is principally important: because of the suppression of vertical turbulent pulsations the 'heavy' brines can propagate to the large distances near the bottom just slightly reducing their concentration. That is why the simulation in the framework of two-dimensional approach, using the 'shallow water' equations, is insufficiently correct for the description of highly brines transport and, generally, three-dimensional approach is required. The three dimensional modeling was carried out using k-epsilon model for turbulence, in the framework of steady and unsteady approaches. The computational domain was constructed taking into account the morphometry of water body and the configuration of the pollutant discharge. The spatial discretization was made using the finite volume method. The calculations were carried out in two steps. In the first step, the hydrodynamical fields were calculated and in the second step - the distribution of the pollutant concentration. Numerical results were compared with the data from industrial monitoring and large-scale space snapshots done on the specific dates. Due to essential difference in optical densities of the released effluents and water in the reservoir, the comparison of the computed and observed pollution zone distribution turned out to be possible. The motion of the pollutant spot in the case of break of hydro-technical construction near the mine was also analyzed.