



## Effect of flooding waves on a removal of pollutants from underwater quarries

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A characteristic feature of the effects of large-scale sandy gravel extraction from water bodies is the formation of a considerable underwater quarries, that strongly changes the hydrodynamical regimes of these water bodies. Traditionally, to estimate the consequences of the formation of the quarries researchers focus on lowering of the water level at limiting hydrological regimes which have fundamental importance for ensuring the sustainability of the different water intakes. Additionally, the changes in the velocity regimes of water body are estimated from the viewpoint of minimizing the possible erosion processes.

There is the Verkhnekamskoye potassium and magnesium salts deposit (the largest in Russia and the second in the world) on Kama river (Kama Reservoir) within Berezniki-Solikamsk-industrial unit. For this deposit the consideration of the formation of quarries is much more complicated because of the presence of significant natural and technogenic output of brines into the Kama reservoir. In this case it is necessary to analyze the problem of estimating the accumulation of the brines in these underwater quarries and to calculate the intensity of the removal of pollutants at their washing due to the changes in the hydrological regime of the water body. The problem of changing the hydrodynamic regime, first of all the lowering of the water level and the calculation of the flow velocity can be solved very successfully in two-and even in one-dimensional approach and the problem of washing the underwater quarries is essentially three-dimensional. In this paper we simulate the removal of contaminants from the underwater quarry. The problem is solved in the framework of unsteady approach. The calculations show that in the flow near the bottom of quarry the vortex is formed whose direction is such that the front edge of the quarry is eroded. The computations and field observations show that, the upper, rather thin ( $<1$  m) water layer in the quarry is washed during the flood wave passing quickly enough (for 600-1000 sek) and the follow-up process is carried out much slower. This is due to the fact that in this later stage the limiting process is vertical transport of pollutants in the conditions of considerable density stratification.

A similar problem, very important for the sustainability of water supply of Kirov city, arises when the flooding occurs during the passage of contaminated water bodies by flood waters. Taken out of these water bodies the contaminant substances can create an unacceptably high level of pollution of the water entering the main drinking water intake of Kirov city. In this case, a very important problem is the forecasting the level of pollution of water, depending on the value of water flow in the Vyatka river and the duration of its standing.

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