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Self-oscillations in large storages of highly mineralized brines

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One of the stages of the production process at large enrichment plants is settling of aqueous solutions in large technological storages. The present work is devoted to the modeling of hydrodynamic regimes of large storage of highly mineralized brines. The density of brines in these objects depends not only on the content of dissolved macrocomponents, but also on the concentration of fine particulate matter. This leads to the need to consider the dynamics of the suspended sediment under significant density stratification, which greatly complicates the problem. Because of that it is important to develop hydrodynamical models of these objects. A peculiarity of these systems is the possibility of self-oscillatory regimes the mechanism of which is as follows. In warm sunny days, with high solar insolation, the heating of the sediments and bottom water takes place. The bottom water warming and the decrease of its density give rise to flow. The slurry particles composing the sediments are involved in the flow. The heated particles entrained by the flow transfer the heat to the surrounding liquid and increase the absorption of the solar radiation in the volume, which leads to equalization of temperature and convective flow damping. After the particle settling on the bottom the process is repeated. We study the stability of equilibrium of the horizontal liquid layer containing heavy insoluble particles in the presence of evaporation from the free surface and solar radiation absorption by insoluble particles. The time-dependent solution of heat transfer problem is obtained and used for estimate of time of instability onset. It is found that for the layer of saturated brines of potassium chloride of the thickness about 10 m the time for instability onset is about one hour. By using analytical estimates based on the empirical model of turbulence by Prandtl we confirmed the time for the onset of instability and obtained the estimates for the period of self-oscillations. Numerical simulation of the dynamics of suspended sediment in the storage is performed within the framework of two-dimensional unsteady approach taking into account the temperature jumps due to the water evaporation from the free surface and the radiation heating of the sediments. The dynamics of sediment in a rectangular cavity of the length 500 m and depth 10 m is considered. Initially, the water is assumed to be motionless and nonuniformly heated. The calculations show that in the first stage of the process the flows arise near the boundaries of the heated areas. Next, the large-scale vortices with the characteristic size equal to the depth of the storage are formed. The sediment located at the bottom sets into motion and only some portion of sediment located near the bottom remains motionless. Throughout several hours the mass fraction of the suspended particles in water increases, then the flow decays and the sedimentation of particles is observed.

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