THE MATHEMATICAL MODEL OF POLLUTANT PROPAGATION IN THE NORTH TIDAL MOUTH.

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The investigation of pollutant propagation in rivers of north regions acquires particular meaning in connection with accident discharge of sewage and accident in pipelines. Such discharge of sewage took place at Novodvinskiy cellulose plant in Arkhangel'sk in winter 1995. The estimate of ecological consequences from these accidents is a serious problem. It is difficult to solve this problem without working out the corresponding mathematical models of pollutant spot propagation in the flow. The particularities of river flow in north regions make suppose that such models must take into account not only really morphology of river bed but two-dimensional character of pollutant propagation and existence of tidal wave and ice cover during long time of the year. However at present such models are absent in practice, that make difficulty to receive forecast estimates.

Description of a model.

In connection with these facts the model of pollutant propagation in tidal ice covered estuary was worked out in order to forecast the consequences of the accident discharge of sewage. The model based on enough strong hydrodynamics thesis permits us to obtain pollutant distribution at any studied reach of the river. The empirical relations containing the depth averaged longitudinal and cross-sectional components of flow velocity was used for parametrization of the momentum transfer coefficient. The values of these components was calculated from the momentum equation for vertical axis. The latter equation conform to the gradiently-viscous regime of the flow when gradient of pressure and turbulent viscosity are balanced. As the preliminary investigations have shown this regime is characteristic for this region.

After integrating of this equation along the depth taking into account the boundary conditions and some assumptions about division of the flow into two parts by the surface of zero shear stresses we obtained the expression for the velocity of one-dimensional flow. The transformed transfer equation was solved numerically by splitting method. Firstly, the cross-sectional averaged longitudinal velocity was calculated taking into account the natural situation (river flow and tidal wave). Then taking into account the depth changes over flow width we obtained the values of velocity depending on suite of calculated point in each cross-section and the time.

Results of calculations.

The comparison of calculated values of velocity, surface elevation and pollutant concentration with measurement result demonstrates satisfactory agreement. The results of hydrodynamics calculations are demonstrated on figure 1, where change of surface level deviation and flow velocity module are shown in observe station.

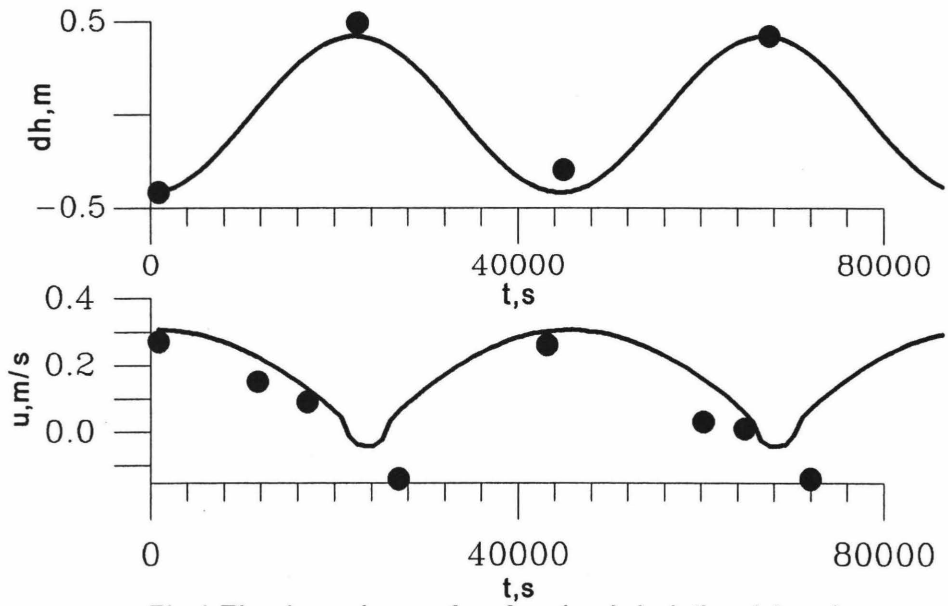

Fig.1 The dependence of surface level deviation (a) and flow velocity module (b) from the time
solid line - result of the calculation, dots - data of measurement

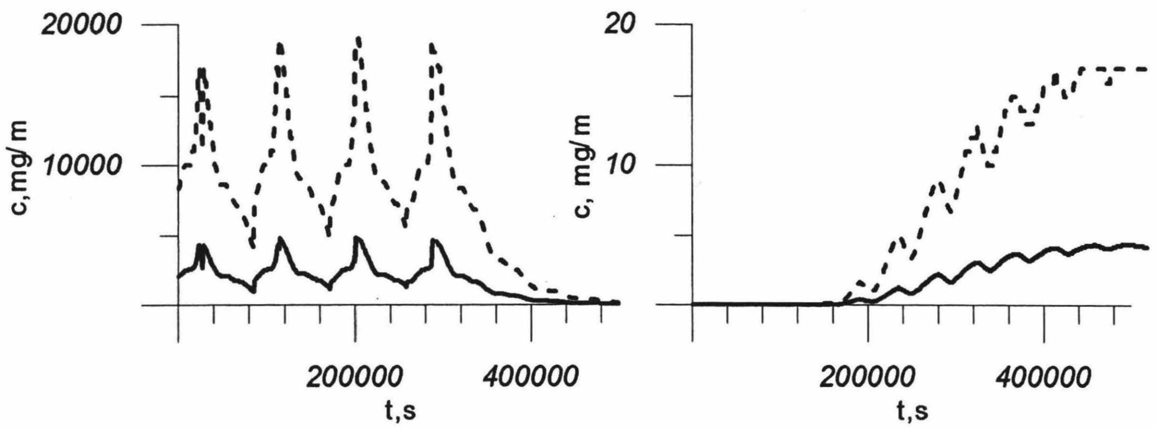

Fig.2 The dependence of the pollutant concentracion from the time
in output point (a) and in point at 15 km downstream at an oppoite bank (b)
solid line - pollutant concentration in sewage water 5 g/m
dush line - pollutant concentration in sewage water 20 g/m

These curves demonstrate the satisfactory agreement of values calculated by model and obtained by measurement. This allows us to conclude the possibility of using the above mentioned hydrodynamics relations for pollution transfer calculations. The time averaged value of pollutant concentration obtained by model calculation in observe point coincides with measurement value.

The results of the calculations show that the model sufficiently sensitive to the changes of parameter of the discharge of sewage, the duration and original pollutant concentration in output point (fig.2a) and in point situated at 15 km down stream at opposite bank (fig.2b), when the sewage was produced in 'steep' regime, i.e. during 8 hours with intervals during 16 hours for two values of pollutant concentration in sewage water $5g/m^3$ and $20g/m^3$.

Thus we can suggest for cast estimation of water quality and ecological damage from accident discharge of sewage knowing the hydrodynamics characteristics and regime of water discharge and pollutant concentration.

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