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Mini Review

Eco Hydrological Mechanism of Unusual Phytoplankton Distribution

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Mini Review

The study object is the ecosystem of the Novosibirsk reservoir - the largest water body in Western Siberia, constructed on the Ob River in 1959. The Novosibirsk reservoir is the main source of water supply for the city of Novosibirsk - the administrative center of the Siberian Federal District, which occupies more than 25% of the RF territory. Therefore, being unsufficiently studied, water quality formation in this reservoir is of particular importance. One paradox of phytoplankton distribution within the Novosibirsk reservoir may be explained through modeling of its aquatic ecosystem. In most summer period (June, July, September), phytoplankton biomass in the surface water layer is much higher than at depth because of worse penetration of solar radiation here. In this connection, hydro biologists call the surface water layer photosynthetic or photic one distinguished by more intensive productive processes than at depth. However, in August, invert correlation is observed in the near-dam layer of the Novosibirsk reservoir. For instance, phytoplankton biomass at depth is several times greater than in the surface layer. The observation data on vertical distribution of phytoplankton biomass in 1981 [1] are presented in (Figure 1).

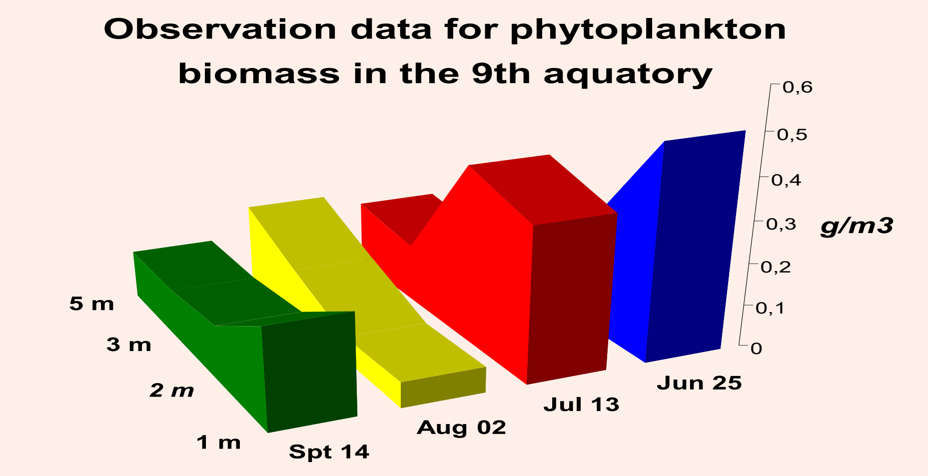

Figure 1: Vertical distribution of phytoplankton biomass near dam of the Novosibirsk reservoir (observations of 1981 year).

To understand the reasons of this paradox, it was necessary to analysis the mechanism of water quality formation. A model of phytoplankton growth in the box approximation is used for simulation of environmental processes. The solving a 3D hydro-ice-thermal problem had described variability of a spatial-temporal pattern of water flows and its temperatures for the 1981-year conditions. The choice of the option of intra-annual distribution of components in the input section follows from the actual content of mineral forms N (NH_4, NO_2, NO_3), P, O_2, chlorophyll "a", phytoplankton, organic and suspended substances with account of regional empirical ratios. Transformation and dynamics of nine Ci variables are simulated to reproduce the processes of biogeochemical transformation of nitrogen and phosphorus compounds as well as oxygen regime in the surface and intermediate boxes. These variables relate to a water column, where ZO - zooplankton biomass, F-phytoplankton biomass, N-NH_4, N-NO_2, N-NO_3 - mineral forms of N, D - suspended substances, C - dissolved organic substances, I -mineral P and O_2-oxygen. A special block of the model is designed to adequately account for processes in bottom sediments.

Equations of the "Biogen" model [2] for description of the i^{th} component transformation in the j^{th} box are as follows:

$$\frac{d(C_j^i.w_j}{dt} = W_j.R_i^j + \sum_k Q_{kj}.C_i^k - \sum_q Q_{jq}.C_i^j + J_i^j.\Omega_j + G_i^j L_j$$

τπi = Z_O, F, NH_4, NO_2, NO_3, D, C, I, O_2,
C_j^i - Concentration of the i^{th} component in the j^{th} box,
W_j - Volume of the j-th box,
t - Time,
R_i^j -rate of biochemical transformation of the i^{th} component in the j^{th} box,
Q_{kj} -Water discharged from the k^{th} box to the j^{th} box,
J_i^j - The mass flow of the i^{th} component through the interfacial surface into the j^{th} box,
Ωj -Area of the interfacial surface of the j^{th} box,
Gij - lateral load of the i^{th} component in the j^{th} box,
Lj - length of the j^{th} box.

The features of hydrochemical and hydro biological regimes of the Novosibirsk reservoir were studied by simulating biogeochemical cycles of biogenic element transformation. Concurrent solution (in 30 boxes) of zero-dimensional problems with a specified heat, water and mass transfer allowed us to obtain a spatially inhomogeneous dynamics of aquatic ecosystem components of the Novosibirsk reservoir. The mechanism of the effect lies in the control role of thermal stratification of the dam water area in summer (Figure 2). This figure presents the calculated average water temperatures in three boxes of near-dam aquatory, i.e. surface, middle and bottom ones. A steady difference in temperatures of two (surface and intermediate) layers is clearly visible until almost the end of June. In hydrology, the "locking" effect of this phenomenon, or the so-called "thermocline", is well known. It is a sharp decrease in water exchange between water column layers at the temperature boundary. In this situation, rapidly developing (in June) phytoplankton quickly eats up the supply of nutrients in the surface layer. At the same time, mass transfer with an intermediate layer saturated with bio gens is locked by a thermocline that results in ceasing further growth of phytoplankton biomass. During this period, most algae in the surface layer dies-off (Figure 3) of the Novosibirsk reservoir.

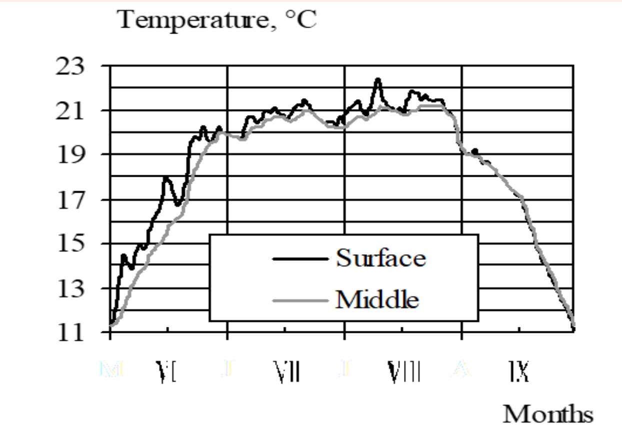

Figure 2: Annual variability of temperature in the near-dam aquatory of the Novosibirsk reservoir in 1981 year.

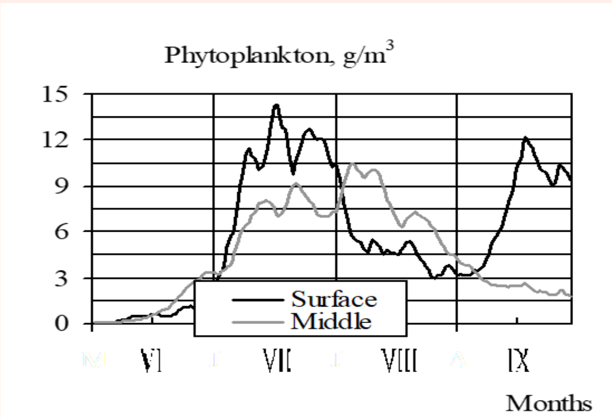

Figure 3: Annual variability of phytoplankton content in the near-dam aquatory in 1981 year.

As evident from (Figure 2), daily temperature fluctuations happen from the second half of June. Often night temperatures in the surface and intermediate layers hardly differ. Water exchange between the layers resumes for short hours thus providing individual algae entry to the intermediate layer, rich in nutrients and intensive phytoplankton growth. The latter may be greater than in the surface layer due to downward water exchange. (Figure 3) explains the presence of excessive phytoplankton biomass in the water column compared to the surface layer. Thus, concurrent simulation of hydrothermal phenomena and biogeochemical cycles of transformation of nitrogen and phosphorus compounds allowed us to explain one unusual spatial phytoplankton distribution in the Novosibirsk reservoir during the study period. This result was obtained due to simulation of major mechanisms of intra-aquatic processes affecting the hydrobiont state of the reservoir ecosystem. The developed model ensuring the detailed analysis able to reveal non-trivial features of ecological processes expands forecasting ecosystem responses to changes induced by varying external impacts. To reduce the negative consequences of eutrophication, one can select a suitable mode for the hydro-energy station's operation. Polluted water outflow from some water areas through the directed use of natural phenomena energy is possible.

Acknowledgement

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References

1. Podlipskii Yu I, Chaikovskaya TS (1985) (Eds.), Comprehensive Studies of the Novosibirskoye Reservoir. Moscow: Gidrometeoizdat Ppp. 134.
2. Tskhai AA, Ageikov VYu (2021) Disturbance of sustainability of the reservoir ecosystem: a model approach for assessing and forecasting the long-term process of eutrophication. Journal of Sustainable Development of Energy. Water and Environment Systems. 9(1): 1080327.