MODERN STATE AND CHANGES OF RUSSIAN LARGE BOREAL LAKES UNDER CLIMATE AND ANTHROPOGENIC IMPACTS

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The Russian Federation has over 2.7 million lakes of various origins. An overwhelming majority of lakes in Russia are freshwater lakes, but there are several brackish, saline and bitter-saline lakes in the south of its European territory and also in southern Siberia. The largest lake's regions situated in the Northwestern European part and Caspian, West-Siberian, North-Siberian, Transbaikalian, Amur and Kamchatka areas. Considerable attention to ensuring to eutrophication, water pollution and invasions of Lakes Ladoga and Onego – Great Lakes of Europe. The importance of these lakes is obvious for the development of economy in particular for drinking purposes, recreation, water transport, energy and bio-resources. The impacts of pulp-and-paper industry, metallurgy, mining, and wastes discharge of cities and towns located on the shores of the lakes and in the catchment areas, require scientifically substantiated recommendations for rational use and protection of the water and biological resources.

Were applied set of 3-D numerical models developed by Sankt-Petersburg Institute of Economy and Mathematics of RAS (Astrachantcev, Rukhovets et al, 2003; Ladoga and Onego, 2010). By using of this set of the models were described lake's hydrodynamics and lake ecosystem functioning with phytoplankton succession in the eutrophication process based on the phosphorus and nitrogen cycles. In this model, the ecosystem's state at any given moment is specified by 3-dimensional fields of concentration in water of dissolved mineral phosphorus, nine complexes of phytoplankton, zooplankton; detrial phosphorus, dissolved organic matter, and dissolved oxygen. The model reproduces the transfer of substances by currents; turbulent diffusion and sedimentation; transformation of organic components (phyto- and zooplankton, detritus, and DOP), as well as dissolved mineral P and O_2.

It was apply innovative mathematical models. These are expert systems which based on the methods of artificial intellect for the estimation trophic status of the lakes. The

application of expert system proved for studying ecosystems of numerous lakes which any or minimum experimental data available (Menshutkin et al, 2014).

Special attention will be addresses to the contemporary state of the lakes of Russia especially largest lakes of Europe (lake Ladoga & Lake Onego) and their watershed under anthropogenic and climate changes, with special emphasis placed on feedforward and feedback interactions between aquatic ecosystems, watershed hydrology and economy of the region. To investigate the responsiveness of both environments to the respective counter impacts, as well as regional and global climate change, data analysis of multi-year field observations, numerical modeling are exploited.

The anthropogenic load of phosphorus (P) on Lake Ladoga, the origin of the lake eutrophication, has increased since the early 1960s. Until the mid-1980s, the average phosphorus concentration, P_{tot}, reached 28 μg P/L, changing the lake status from oligotrophic to mesotrophic (LADOGA, 2013). The economical collapse in Russia in the 1990s led to a certain decrease of the phosphorus load (from 6100 t P/yr in 1984–1995 to 4000 t P/yr in 1996–2003). The anthropogenic load on Lake Onega in 1970–1986 resulted in the evolution of the lake trophic status from oligotrophic to mesotrophic in semi-closed bays. In the last 15 years, the lake as a whole has retained its oligotrophic status. Currently, P_{tot} in the lake is 8–10 μg P/L. Lake Onega is now at the stage of ecosystem destabilization and in the initial phase of eutrophication. Note that the phosphorus load on Lake Onego changed from 1003 t P/yr in 1992–1997 to 786 t P/yr in 2001–2002.

A recent increase of economic activity in the region has determined a higher load on Lakes Ladoga and Onego that, in turn, initiated the observed deterioration of the water quality. It becomes important to define limits of the anthropogenic load on the lakes to preserve their oligotrophic status. The forecast of maximum permissible load is complicated by effects of regional climate warming, which should be taken into consideration as well. During the last 15 years, a climate warming was observed in the Ladoga and Onego catchment area (LAKES LADOGA AND ONEGO, 2010). The linear trends in annual air temperature over the watershed of Great European Lakes are characterized by positive values 0.6 °C/50 yr; a strong increase of air temperature is observed in spring (about 3.5°C/50 yr). The number of ice-free days has increased from 217 to 225. The main objective of our study is to evaluate how the ecosystems of the study lakes may respond to possible changes in the regional climate and economy and to assess whether they may lead to the negative tendencies.

The effect of possible changes in the regional climate on the ecosystems of Ladoga and Onego is rather small. The nutrient load on the lakes remains the main factor that strongly affects their ecosystems. The climate variations may only strengthen or weaken this effect to a small extent.

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