Variations in the Hydroecological Characteristics of Water Masses in the Central Pool of the Mozhaisk Reservoir

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Abstract—Results of a special experiment conducted in the summer of 2002 in the Central pool of the Mozhaisk Reservoir are discussed. The experiment was aimed at studying short-period and small-scale variations in water temperature, electric conductivity, transparency, dissolved oxygen content, total and mineral phosphorus, phyto-, microzoo- and zooplankton. Statistical characteristics of the above-mentioned environmental parameters are presented.

The development of theoretical limnology in the last quarter of the 20th century enabled the mathematic description of not only separate internal water body processes but also of their complicated combinations, which determine annual and long-term changes in the environmental conditions of lakes and reservoirs. The limnological modeling is now applied to solving the theoretical problems of diagnosis of interactions between numerous components of aquatic ecosystems and forecasting changes in the water composition in inland water bodies due to utilization of their natural resources [2, 6, 8]. The confidence in modeling calculation results is determined by the techniques used to check the model reliability and depends on the management level of water body field investigations and the applied methods of data processing as well as on verification observations. Unfortunately, the majority of works on limnological modeling does not analyze the methodological issues of model verification.

The so-called box or reservoir models are often applied in limnological studies. The water body under investigation is divided in such models into a number of boxes (reservoirs, compartments, chambers), which are assumed to be uniform. Such boxes are characterized only by the mean values of modeled variables [1, 7]. Models of heat and mass exchange (TME) for valley-type reservoirs belong to this class. Results of express surveys of the Mozhaisk [9] and Istra [10] reservoirs, where gauging data on benchmark verticals were compared with calculations for separate blocks selected according to morphological characteristics, were used to verify the TME model. Nevertheless, it remains unclear whether the data of express survey observations on three to five stations in each water body pool are sufficiently representative for a statistically reliable evaluation of mean daily values of various characteristics for the whole water area of a stratified pool.

To enable a detailed analysis of the spatial and temporal heterogeneity of water composition characteristics within one pool in the period of their maximum variability (summer stratification), a field experiment named “MB-5 Testing Area” was planned and carried out in July 2002 on the Mozhaisk Reservoir. It consisted in an express survey of the Central Pool water area, which was regarded as the fifth (out of eight) model block (MB-5) in the TME model. The express survey was conducted on a uniform network consisting of 50 hydrological stations and also included hourly observations on one of them. At the moment of the MB-5 express survey on July 5, 2002 the pool water area was 4.92 km², its length was 4 km, the water volume was 34.4 million m³, the maximum depth over the Moscow River bed trough was 15 m, the mean riverbed width was 90 m and the mean water depth over the river edges was 10 m. The network of express survey stations consisted of 50 verticals of thermal and conductivity measuring sounding located on the average 400 m apart (Fig. 1). Among them, there were 14 stations with the depth of 10–13.5 m located along the riverbed trough, 12 shallow-water stations with the depth of <5 m while the remaining 24 stations were situated over the surface of the inundated flood plane.

The express survey was conducted with the help of two motor boats. One of them was used for thermal and conductivity (TCM) sounding at the horizons of 0.1, 0.5, 1.0 m, next at 1 m interval and finally at 0.5 m from bottom, as well as for determining water transparency by using a white disc. The second boat was used to collect water samples for the analysis of water chemistry (14 stations), and the composition of phytoplankton (nine stations), microzooplankton (infusoria), and zooplankton (eight stations). The total duration of the synchronous express survey of the testing area was 8.5 h while the spatial density of sounding was made as large as ten stations per 1 km² of water area. Measurements of T and κ were made in 1382 points within the water volume.
The observational network as dense as that, which has not been so far used in any water body, makes it possible to bring the evaluation of expectation value and variance significantly nearer to the mean values of these most important statistical parameters of the general population of hydrological characteristics, which determine the thermal conditions, salinity, and the heterogeneity of water density in the water body. Despite the lesser frequency of water sampling for chemical and hydrobiological analyses due to its higher labor intensity together with the necessity to reduce the duration of sample storing, such density of sample collection network (two stations per 1 km²), as far as we know, has not been used in limnological investigations of lakes and reservoirs.

Multiple offshore observations were conducted at a station located above the riverbed trough at a point located about 400 m from the shore in order to avoid local deformations of diurnal fluctuations of hydrological characteristics due to upwelling and downwelling in the zones of negative and positive water setup. The offshore station was located taking into account wind-induced currents estimated by using a two-dimensional hydrodynamic model of the testing area [7]. Large-scale diagrams of the vector field of these flows constructed for several wind directions show the absence of local circulation zones (where vertical components of local deformations of diurnal fluctuations of hydrology of the riverbed within the testing area). These local deformations of diurnal fluctuations of hydrography of the riverbed within the testing area). These three layers are essentially different in their hydrological characteristics and stability to the vertical mixing (Table 1). The difference between the electric conductivity values in epi- and hypolimnion (up to 17 μS/cm) is almost 30 times larger than the probable error of its measurement (0.6 μS/cm), which shows the better representativeness of this characteristic and simultaneously demonstrates the genetic difference of the upper and lower water layers as far as water salinity is concerned. Therefore it is evidently possible to consider the warmer and less mineralized water in the epilimnion as the main summer water mass (MWM) of the reservoir while the relatively cold and more saline water in the hypolimnion can be considered as the bottom summer water mass (BWM).

The metalimnion represents a quasi-horizontal frontal zone of mixing of these two water masses, which every year appear in summer in the central and near-dam areas of the Mozhaisk Reservoir [3]. The surface located in the water layer between horizons of 8 and 9 m (Table 1) (z) is the boundary, which divides the two water masses. At the same time, this surface is the thermocline with \(dT/dz = 1.6°C/m\), the chemocline with \(dκ/dz = 5\ μS/cm\) per 1 m, and the pycnocline with \(dp/dz = 0.31\ kg/m^4\), as vertical gradients of temperature, electric conductivity, salinity and consequently of water density have maximum values there. The pycnocline stability is 1.8 times larger than the average gravitation stability of the seasonal step layer, which is proportional to 0.172 kg/m³ and equal to 1.69 s⁻² (Brunt-

**Fig. 1.** Distribution of observation stations in the Central Pool of the Mozhaisk Reservoir. The shadowed circle marks the station of diurnal observations.