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DEPENDENCIES REFLECTING QUANTITATIVE CHANGES IN PHYTO- AND ZOOPLANKTON IN THE TBILISI RESERVOIR

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Abstract. *The presented article is focused on the methodology for calculating changes in phyto- and zooplankton in the Tbilisi reservoir, which mainly determines the change in organoleptic indicators of water. Such an approach is explained by the fact that consumers have expressed complaints about the smell and taste of drinking water.*

The advantage of the methodology is especially noticeable when conducting predictive calculations, which is explained by the fact that natural hydrochemical and bacteriological analyses, as a rule, are discrete and episodic in nature, which is why statistical processing does not allow obtaining complete and reliable results.

Key words: *Reservoir, phyto- and zooplankton, Population. Concentration of Substances.*

Introduction

In aquatic systems, and in particular for the Tbilisi Reservoir, the fundamental equations of non-conservative chemical or biological impurities and organisms transport by a continuous environment are used to describe the processes of phyto- and zooplankton mass change. The formulation of mathematical biology equations from these equations is based on the generally accepted and recognized general laws of biology and biochemistry, in particular Liebig's law and the Volterra-Lotka relations; For enzymatic reactions, on Michaelis-Menten ratios; for biological populations – on Monod's dependences, etc. [1]. The work was completely carried out using the above-mentioned mathematical apparatus.

For processes reflecting the growth (decrease) of biopopulations, it is permissible to neglect the convective and diffusion terms during the transfer of impurities due to their smallness; therefore, after several transformations and assumptions, the mentioned processes are described by the equations [2]:

$$Subscript\,\frac{dc_m}{dt}=\mu_m^1 C\text{-}aC_m C_a\text{-}\gamma_m C_m^2 \tag{1}$$

$$\frac{dC_a}{dt}=\mu_a\,\frac{C_m C_a}{K_m+C_m}-\gamma_a C_a^2 \tag{2}$$

where C_m- is the concentration of microorganisms of the m-type; C_a – is the concentration of their antagonistic microorganisms; μ_m and μ_a- maximum specific rate of growth (decrease) of microorganisms; K_m- is the so-called half-sedimentation constant, equal to $0.5\mu_m$^ (Michaels-Menten or Mono's constant); a, γ- are constants with dimensions $(mg/l)^{-1}$ After several assumptions and transformations, the solution of equations (1) and (2) gives us the dependence reflecting the change in the photo and zooplankton population:

For phytoplankton:

$$C_{fp}=\frac{\eta_{zp}C_B K\,D\,\frac{h\theta\tau}{h_0\theta^*\tau_m}\left(4\text{-}\frac{h}{h_0}\right)^3(1\text{-}\frac{\tau}{\tau_m})^2\left(1\text{-}\frac{\theta}{\theta^*}\right)}{1+K_z\,\frac{\eta_{fp}K_D\,h}{27\eta_{zp}h_0}\left(4\text{-}\frac{h}{h_0}\right)^3} \tag{3}$$

For zooplankton:
where η_{zp}-Liebig coefficient; K_D – coefficient reflecting the length of the day; θ* – temperature of the proteins, equal to 42^0; h_0 – maximum transparency of the reservoir; h – transparency of the reservoir; τ_m – duration of one shift of the phyto- and zooplankton population; τ – exposure time of a given phyto- and zooplankton population; θ – temperature of the reservoir; C_B – concentration of the limited biogenic substance.

The obtained relationships determine the values of phyto- and zooplankton mass for subsequent periods, which will give us an idea of the eutrophication processes taking place in the reservoir and, accordingly, the changes in the organoleptic (taste, smell, color) characteristics of the water [3]. What is eutrophication?

The increase in the content of biogenic elements in the upper water horizons leads to an increase in the number of phytoplankton and phytoplankton-feeding zooplankton in this zone. As a result, the transparency of the water rarely decreases, the depth of sunlight penetration decreases, and this leads to the death of plants in the lower layer due to a lack of light. Dead organisms sooner or later sink to the bottom of the reservoir, where they decompose. Anaerobic decomposition of dead organisms occurs in the bottom soil deprived of oxygen, with the formation of such strong poisons as phenols and hydrogen sulfide. As a result, the eutrophication process destroys most of the species of flora and fauna of the reservoir, almost destroys the sanitary and hygienic properties of the water, to the point that it is completely unsuitable for swimming and drinking water supply. But for this, it is necessary to calculate the polluting loads on the Aragvi River basin and the Tbilisi Reservoir.

Calculation of pollutant loads

To successfully address this problem, first of all, material was found that provides the characteristics of polluting objects: areas of pastures, hayfields, agricultural fields, and types of crops, the amount of fertilizers applied, livestock and poultry indicators, capacity of enterprises, data on auto farms and other mechanisms in the region, etc. In the process of finding data, a number of violations were identified, including encroachment and unauthorized activities within sanitary protection zones, as a result of which agricultural, household, and industrial runoff enter the water systems. The facts of grazing and watering a large number of livestock in prohibited areas, cases of placement and construction of houses or other objects in the prohibited zone, the absence of a sewage network, malfunctions of the Zhinvali-Tbilisi collector, etc. Based on the obtained data and the above calculation assumptions, the amounts of pollutants entering the Tbilisi Reservoir caused by the main polluting ingredients were determined for various areas of the Aragvi River drainage system, Zhinvali and Tbilisi reservoirs.

Table # 1

№	Indicators	Zhinvali Reservoir	Aragvi River Bulachauri	Aragvi River Natakhtari	Sioni Reservoir
1	Weighted average	1956	796	2921	990
2	Dry residue	1065	1083	1634	547
3	Organic matters	214974	19336	17976	107490
4	Nitrogen total	47024	30486	32792	23360
5	Phosphates	5820	937	1107	2910
6	Potassium	15820	8582	9236	77,25
7	Chlorides	140	39,7	57,7	69,1
8	Oxygen Biochemical demand (BOD)	90254	4950	3651	45127
9	Oxygen chemical demand	261064	19652	25287	130532
10	Surface-active substances	83,4	43,4	58,7	41,9
11	Iron common	7,7	3,6	5,9	3,9
12	Polutant particle number * 10^9	2,35	0,19	0,29	1,18

Note: Tbilisi seawater pollution is mainly formed at the expense of flows from the Zhinvali and Sioni reservoirs. Since the catchment area of the Tbilisi Sea is small, it is clear that the values of polluting loads coming from the environment are not large, although the additional flow of pollution with biogenic elements has a considerable impact on the development of phyto- and zooplankton and macrophytic algae.

From the analysis of the results of the calculations given in the table, it follows that the water of the Aragvi, Zhinvali, and Tbilisi reservoirs is satisfactory in terms of chemical pollutants. In particular, from an ecological point of view, they belong to the class of clean and slightly polluted waters, and are also suitable for water supply to the population.

Above the Zhinvali Reservoir, the pollution from industrial facilities on the Aragvi River, and especially the Pshavi' Aragvi River, is insignificant, which is completely understandable, since industry is practically not developed in these areas.

Pollution caused by agriculture (mainly total nitrogen, phosphates, potassium) in the lower part of the Aragvi River basin is twice as high as the same type of pollution in the Pshavi Aragvi and Aragvi River basins up to the Zhinvali Reservoir, which is explained by the small number of agricultural areas in the upper part of the Aragvi River. We also note that pollution caused by pesticides and toxic chemicals in the lower part of the Aragvi River is practically not observed in the Aragvi river system, which is explained by the episodic and very insignificant introduction of this type of pollutants into the territory of agricultural lands.

Pollution with nitrogen and phosphorus compounds should be distinguished separately, due to their importance. In this case, the following circumstance should be emphasized: although the polluting loads on water systems have decreased to some extent, due to the regulation of the water system and the continuous flow of biogenic elements over the years, favorable conditions have been created for the development of phyto- and zooplankton and macrophytic algae Charophyta, which developed in infiltration basins. Thus, the initial phase of eutrophication of the system has taken place. We note that eutrophication processes have begun for a long time, and there is a tendency for their development, moreover, under certain conditions, its revolutionary development is possible, which can cause irreparable damage to water intake and recreational facilities and the system as a whole.

Main conclusions

The main goal of the study was to improve the water quality of the Tbilisi Sea, primarily according to organoleptic (smell, taste, color) indicators, while maintaining the performance of the headwaters at the appropriate level. The data of hydrobiological observations obtained in various services are not only inadequate, but even the existing individual observations are too superficial and unprofessional in nature; they are practically useless, and it has become necessary to conduct full-fledged observations.

In addition, we believe that, based on the existing data and forecast calculations, the issues of the stability of the system of differential equations describing the water system under study should be investigated in order to prevent deviations greater than those envisaged during the evolutionary development of the system.

Based on numerous studies conducted abroad, measures and recommendations have been developed that will slow down and, with due effort, prevent the processes of eutrophication of the reservoir.

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