LONG-TERM DYNAMICS OF TOTAL BACTERIOPLANKTON IN THE DUBOSSARY RESERVOIR OF THE REPUBLIC OF MOLDOVA

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Abstract. The results of long-term (1982-2019) studies of the quantitative development of bacterioplankton in the flow-channel Dubossary reservoir in the Republic of Moldova and analysis of the reasons for its change are shown.

Introduction

Bacteria are one of the most numerous and diverse groups of aquatic organisms that have the most active metabolism and play an important role in the biochemical processes of transformation of biogenic and other elements and organic matter in general. The results of many years of research earnestly indicate that aquatic bacteria are an indispensable and essential component of trophic chains, playing an important role in the structural organization of freshwater ecosystems. Due to their species diversity and high physiological activity, they perform the function of an ecosystem stabilizer, responding extremely quickly to the slightest changes of the environmental conditions [2].

Research on reservoirs in the temporal aspect has been going on since a long time. On the territory of the CIS (formerly the USSR), they have been held for more than 80 years, starting from the 30s of the last century. At the same time, the study of the ways and prospects of the transformations of the water bodies undergoing permanent changes under anthropogenic impact still remain actual.

The initial research on the microbiological status of the flow-channel Dubossary reservoir was started in 1957, 3 years later, after its filling. However, the research has not yet been systematic, although the main indicators of the state of the aquatic bacteriocenosis, namely, the quantitative development of the general microflora, its biomass and the number of individual physiological groups have already been studied [8]. In the subsequent years, the studies were expanded by studying the production potential of the total bacterioplankton, as well as its sanitary and microbiological regime [5, 10, 13, 14, 15].

In the early 80s, the Dniester River experienced considerable environmental transformations due to construction on the territory of Ukraine of the Novo-Dnestrovsk HPP, a pumped storage reservoir (HPP 2 and the accidental discharge into the river of the concentrated effluents from the Stebnikov chemical plant (Ukraine). At the same time, the most serious transformations were related to the impact on the ecosystem of the Dubossary reservoir as a result of an uncontrolled growth of submerged aquatic vegetation. Before the regulation of the Dniester River by the dams of the aforementioned hydroelectric power plants, an increased number of microflora, especially during the flooding period, was associated with suspended particles, the amount of which was quite high. With a decrease in their number of suspended particles due to

sedimentation processes, the number of bacteria was reduced significantly. It should be noted that aggregated bacteria closely linked to these particles had much more favorable conditions for their existence, which is why their growth rate was significantly higher than that of single planktonic bacteria.

All these reasons served as the basis for carrying out detailed and systematic studies of the bacterioplankton of the Dubossary reservoir. For a comparative assessment, all the data obtained were conditionally divided into several periods characterizing the stages of the formation of the Dubossary reservoir and changes in the anthropic press: 1957-1959, 1986-1990, 1991-2005, 2006-2010, 2011-2014. All of these periods are characterized by specific conditions of hydrological, physico-chemical and hydrobiological regimes, which left a noticeable footprint on the quantitative indicators and physiological activity of bacterioplankton.

Material and methods

All the indicators described in the current article were determined by generally accepted microbiological methods [3]. Sampling was carried out in accordance with the national standard SM SR ISO 5667-6 and the Guidelines for the collection of samples of hydrochemical and hydrobiological samples [1]. In general, during the growing seasons of 1982-1919, more than 300 water samples were collected and analyzed. The total number (N_{tot}) of bacterioplankton and the amount of its saprophytic group (N_{sapr}) were determined. Inoculations were carried out on various elective media using generally accepted methods, in particular, with the SM SR EN ISO 6222: 2014 standard. The results obtained were compared with similar data obtained in previous years by other authors [8]. Certain aspects of the studies below were reflected in the studies carried out in the subsequent years [4, 5, 12, 13] and others). The data obtained were statistically processed using Exel, Statistica.

Results and discussion

The quantitative dynamics of aquatic bacteria in the Dubossary reservoir is determined by a complex of natural (morphometry, hydrology, hydrochemistry, hydrobiology) and anthropic factors (wastewater, runoff from the surrounding area). The complex dynamics of these indicators is the reason for the high interannual variability in the amount of bacterioplankton. In some years, fluctuations in the number are so great that the minimum indicators differ from the maximum up to 16 times (fig. 1).

Figure 1. Dynamics of the average growing number of bacterioplankton ($N_{tot} \times 10^6$ cells / ml) at individual stations of the reservoir in 1958-2019 years.

The abundance of total bacterioplankton in the reservoir 4 years after its filling varied in different seasons of 1958-1959. from 2.5 to 7.7×10^6 cells / ml, and the average for the growing season (April-October, 270 days) was $5.0 \pm 1.9 \times 10^6$ cells / ml (fig. 2).

Figure 2. Interannual dynamics of the total number of bacterioplankton ($N_{tot} \times 10^6$ cells / ml) in different periods 1958-2019 (average for the growing season)

Despite the fact that the water entering the reservoir (St. Camenca) was characterized by a higher content of bacteria - $8.0 \pm 5.9 \times 10^6$ cells / ml, the differences ($P = 0.05$) are still insignificant. In subsequent periods, noticeable fluctuations in the number of bacterioplankton were recorded, however, in the last period (2015-2019), it significantly decreased at all the studied sections and varied in a narrow range of $1.2 - 1.6 \times 10^6$ cells / ml, amounting to, on average, $1.22 \pm 0.47 \times 10^6$ cells / ml, which indicates the transformation of the reservoir from a eutrophic to a mesotrophic reservoir. Observations of the numerical development of bacterioplankton, carried out during the recent research period (1986-2019), in all studied areas demonstrate stabilization of bacterioplankton the level of $2.6-3.3 \times 10^6$ cells / ml. (fig. 3), which clearly

confirms the uniformization of the conditions for the existence of the bacterial population. Moreover, due to a significant decrease in the speed of water flow throughout the entire section of the Dniester river, downstream of the aforementioned dams of hydropower stations, as well as the massive development of submerged aquatic vegetation, the river undergoes limnophilization and leveling of microbiological indicators, both in the section flowing into the entrance to the reservoir (St. Camenca) and in the reservoir itself.

Figure 3. Average long-term (1986-2019) number of bacterioplankton ($N_{tot} \times 10^6$ cel / ml) at the entrance to the Dubossary reservoir (St. Camenca) and in the reservoir (St. Erjova-Cocieri)

Seasonal changes in solar radiation and dynamics of water masses usually determine the existence of winter, spring-summer and autumn periods. The peculiarities of the functioning of hydroelectric power plants on the territory of Ukraine led to the fact that in the upper and even middle sections of the Dubossary reservoir in winter, the temperature practically corresponds to the spring level. As a rule, this results in significant changes in the entire hydrobiocenosis. However, for bacterioplankton, in contrast to other groups, these changes are not so pronounced. As before, the trend of an insignificant increase in the number of bacteria in the summer period persists (fig. 4).

Figure 4. Seasonal population dynamics ($N_{tot} \times 10^6$ cells / ml) at different stations Dubossary reservoir in the period 1957-2019.

However, temperature is not always the dominant factor. This impact is often indirect, through local enrichment of water with autochthonous and allochthonous organic matter [7], which leads to significant variations in the numerical indicators of bacterioplankton development. This is especially true [6, 11, 9] for such an important indicator group of bacterioplankton as saprophytic bacteria (Nsapr). The dynamics of the quantitative development of this group of bacteria, as well as the dynamics of the total bacterioplankton, is very variable not only within the same season, but also in different years (fig. 5).

Figure 5. The number of saprophytic bacteria (Nsapr, × 103 CFU / ml *) in summer 2011 and 2018 at St. Camenca and in the Dubossary reservoir. (* CFU – colonies forming units)

Similar changes are observed in the interannual aspect (fig. 6).

Figure 6. Interannual dynamics of saprophytic bacteria (Nsapr, × 103 CFU / ml) in the Dubossary reservoir (St. Erojova - St. Cocieri) in different years

The analysis of the data presented above indicates that by now the Dubossary reservoir has passed 3 stages of formation. The first stage (1958-1959) was characterized by a low abundance (fig. 7) of saprophytic microflora (average index $-0.81 \pm 0.35 \times 103 \text{ CFU / ml}$), which was most likely explained by the lack of trophic substrate for these groups of organisms.

Figure 7. Dynamics of the number of saprophytic bacteria (Nsapr. $\times 103$ CFU / ml) in the river. Dniester (St. Camenca) and Dubossary reservoir (St. Erjova- St. Cocieri) in various periods of research

The second stage (1986-2005) was accompanied by an increase in discharges of poorly treated wastewater from enterprises of various profiles that were intensively operating at that time. These wastewaters were a good nutrient medium for this group of bacteria, which also explains the increase in the number of saprophytes (average value $-4.35 \pm 1.66 \times 103$ CFU / ml). And, finally, at the last stage (2006-2019), there is (with rare exceptions) a relative stabilization of the conditions for the existence of saprophytes (the average is $-2.68 \pm 0.75 \times 103$ CFU / ml).

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