Advanced Studies in Biology, Vol. 15, 2023, no. 1, 107 - 117
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/asb.2023.91660

Destruction of Total Organic Matter and the Primary Product of Phytoplankton in the Main Reservoirs of Azerbaijan

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Abstract

The role of phytoplankton in regulating the flow of physico-chemical processes in ecosystems, including hydrobionts, which participates in the formation of biological products, the circulation of substances in the life of reservoirs, the creation of their energy source, is very large. Regardless of the purpose of use, quantitative and qualitative study of phytoplankton is always the main issue in the study of newly created reservoirs. This is considered natural and legal. Because phytoplankton ecosystems are very sensitive to abiotic factors and anthropogenic influences to many physical, chemical and biological factors present in the environment. Therefore, phytoplankton is considered the basis of trophic relationships in the hydroecosystem.

Keywords: hydroecosystem, trophogenic layer, toxic substances, hypoxia, anaerobiosis.

Introduction

In the sanitary and hygienic and ecological assessment of reservoirs, as well as in solving issues of large-scale water use, phytoplankton is used as an ecological and biological indicator. So, polluted river waters contribute to the vegetation of phytoplankton to the level of flowering in reservoirs, the waters are enriched with easily digestible organic substances, as a result of which the generation of bacterioplankton accelerates, oxygen consumption in the waters increases, hypoxia occurs, anaerobiosis occurs. In addition, due to the elimination of 100,000 tons of phytoplankton mass completed by vegetation, the waters are enriched with phytoncides and become unusable, acquire a dangerous quality. In a word, the study of phytoplankton makes it possible to determine the suitability of reservoirs for all purposes, their current sanitary-hydrobiological, ecological, epidemiological state and the fate of their future state. We consider it acceptable to start with the Mingechaur reservoir, based on the results obtained on the issues indicated in this section.

Materials and methods

Samples of water and soil were selected in compliance with asepsis by Yu.I.Sorokin bottle bathometer, GOIN-a small tube. The total number of microorganisms was determined by the method of A.S.Razumov, saprophytic, coliform and physiological groups of bacteria were taken into account by sowing on elective media, the compositions of which are indicated in the laboratory manuals of V.I.Romanenko, S.I.Kuznetsov and A.G.Rodina. The amount of destruction of organic matter, as one of the reliable indicators of the degree of self-purification, is taken into account, according to G.G.Vinberg. To establish the quantitative and qualitative composition of the organic matter present in the water, the depth of its decay and the degree of saprobity of the water in the Araz River, calculations of the ratio of the number of saprophytic bacteria with a total number of direct counts were applied.

Results and their discussion

The Mingechaur reservoir, which is considered the "patriarch" of reservoirs used in Azerbaijan, is one of the most thoroughly researched and controlled reservoirs among existing artificial reservoirs.The Mingechaur reservoir was created in 1953 at the intersection of the Bozdag ridge on the border of the Middle Kur and Lower Kur rivers with a dam fence. The depth of the Mingechaur reservoir, considered at that time the deepest reservoir in Europe, is 75 meters, an area of 600-(625) square kilometers, a length of 75 kilometers, a capacity of 16 cubic kilometers, a maximum width of 20 kilometers in river valleys, and an average width of 9 kilometers. Due to the commissioning of the Shamkir and Yenikend reservoirs in the Kura River, the amount of solid waste carried into the Mingechaur reservoir decreased by 3 times (8.7 million/ton) . For this reason, the transparency of water in the area, which is considered the widest river valley of the Mingechaur reservoir, has more than doubled.

It also created a favorable opportunity for biogenic elements brought by river waters to be used by phytoplankton and higher aquatic plants and their development. It is necessary to know that the Mingechaur reservoir, which differs in all parameters from reservoirs created on the territory of the country, is one of the most thoroughly and comprehensively studied reservoirs not only in Azerbaijan, but also in the former USSR. The Mingechaur reservoir contains the largest volume of water resources in Azerbaijan, and in this regard, this invaluable reservoir has been studied for monitoring purposes since its inception [5,6].

Our research in other reservoirs is a repeat of the research conducted in the Mingechaur reservoir.Because the same methodological apparatus and methods were used in all periods and reservoirs, and general information about the primary phytoplankton product is also explained when interpreting the results obtained at the Mingechaur reservoir. First of all, it should be noted that the amount of the primary product formed due to photosynthesis, including the growth of phytobacterioplankton in the Mingechaur reservoir has changed many times over the past 60 years. So, until the 80s of the last century, the reservoir belonged to the mesotrophic type, but in later periods it was proved that it is eutrophic, due to prolonged anthropogenic influence. However, after the creation of the Shamkir [14] and Yenikend reservoirs in 1982 and 2000, the transparency of water in the wide water area of the Kura, Gabyrra and Ganykh rivers increased 5 times as a result of the influx of clear water without solid impurities in the Mingechaur reservoir. This, in turn, created the basis for the mass development of phytoplankton in relatively deep-water areas, and higher aquatic plants in shallow waters. The water transparency in this water area reached up to 2.4 meters in 2015 compared to 0.5 meters in 1962, which led to a multiple increase in primary production (Table 3.1).

Table 3.1

Table of changes in water transparency (m), the average annual primary product of phytoplankton and the amount of destructive organic substances (mgS/l) in the Mingechaur reservoir in 1962-2015.

Point-station	1962			1984			2015		
	transparency (m)	primary product	destruction	transparency (m)	primary product	destruction	transparency (m)	primary product	destructio n
1	0,4	0,36	1,80	1,4	2,8	3,40	2,70	9,60	6,70
2	0,5	0,39	1,60	2,0	2,30	2,60	2,40	10,20	6,30
3	0,5	0,40	1,70	1,3	2,60	3,00	1,80	8,70	5,80
Average	0,5	0,38	1,70	1,60	2,60	3,00	2,40	9,3	6,2

It is characteristic that the increase in transparency in the ecosystem of the Mingechaur reservoir created the basis for the participation of phytoplankton in photosynthesis, in deeper layers of the reservoir. Therefore, in the current period, the eutropho-trophic layer in the reservoir has deepened. Thus, it is known that during the formation of the eutrophication process in the Mingechaur reservoir [7], along with the intensive development of phytoplankton, the area of their assimilation and physiological activity expanded and deepened. In the Mingechaur reservoir, the continuation of the eutrophication process over the past 50 years in the direction of increase from year to year is more clearly noticeable in the summer seasons (Table 3.2)

Table 3.2. Comparison of the primary phytoplankton product Mingechaur reservoir in 1962, 1984 and 2015 (summer mgS/l)

Station	1962	1984	2015
1	0,34	1,80	9,60
3	0,40	2,20	10,20
5	0,80	2,60	8,70
7	0,90	1,90	9,10
8	1,00	2,10	11,00
9	1,10	4,30	12,40
10	1,30	5,10	11,60
11	1,50	5,80	12,10
12	1,60	7,80	13,70
13	1,40	8,10	14,30
Average	1,00	4,20	11,20

Table 3.2 shows that the primary phytoplankton product in the Mingechaur reservoir has increased 11 times over the past 53 years. Interestingly, the dynamics of the initial primary product of reproduction by seasons of the year remained, as in previous years, productivity over the entire area of the reservoir sharply decreased on the right bank. This is due to increased erosion along the coast. In other words, due to the collapse of the flood of the southeastern Bozdag, the transparency of the water decreases to a depth of 10 meters, the afotosynthetic activity of phytoplankton in turbid water sharply decreases. If the mass development of phytoplankton was noted in the areas adjacent to the Khanabad region of the reservoir until the 80s, then after the creation of the Shamkir reservoir, the primary product is formed in similar quantities over the entire area of the reservoir, with the exception of shallow muddy water up to 5 meters outside [10].

According to the seasons of the year, the formation of the primary product-the harvest – continues intensively in spring, summer and autumn, with the exception of the winter period (Table 3.3).

Table 3.3. Average daily quantity of primary product-harvest – phytoplankton in the Mingechaur reservoir by seasons of the year (mgS/l, 2015)

Station	Winter	Spring	Summer	Autumn
1	3,10±0,12	3,20±0,15	9,6±0,46	6,60±0,8
3	3,40±0,14	9,00±0,35	10,20±0,48	3,10±0,12
5	4,00±0,18	7,00±0,32	8,70±0,47	5,70±0,24
6	3,70±0,16	5,60±0,26	7,10±0,34	5,00±0,22
7	3,10±0,13	7,00±0,32	9,10±0,44	6,20±0,28
8	4,20±0,19	3,30±0,16	11,00±0,52	7,40±0,32
9	3,10±0,14	7,40±0,36	10,40±0,50	8,30±0,38
10	3,00±0,12	8,10±0,40	11,60±0,54	8,60±0,42
11	4,40±0,20	10,30±0,44	12,10±0,56	9,10±0,44
12	5,20±0,21	11,20±0,52	13,40±0,58	10,00±0,48
13	4,60±0,20	10,30±0,51	14,30±0,62	11,30±0,50
14	5,20±0,24	10,80±0,52	13,40±0,60	11,40±0,52
Average	0,34	7,43	10,8	8,50

Table 3.3 shows that the difference between the average daily value of the primary product-harvest – phytoplankton in the spring, summer and autumn seasons is 25-30 percent. And in previous periods, the peak period of phytoplankton vegetation was observed in the second period of spring. It is characteristic that in the water area of the Mingechaur reservoir named "lake" by river valleys, although the transparency of the water is low, clearly the increase in the rise of the primary crop product is determined due to the fact that the biogenic elements brought by the spring water leash create the basis for the mass development of phytoplankton in the upper part of the reservoir. In modern times, there have been significant changes in the physico-chemical properties of the waters of the Mingechaur reservoir. For the same reason, the intensity in the process of forming the biological productivity of the Mingechaur reservoir differs. I wonder what with.Rzayeva and Mammad Salmanov, who studied phytoplankton and its primary production and microbiological regime in the Mingechaur reservoir, attributed the Mingechaur reservoir to a mesotrophic reservoir. But in the 80s it became clear that the Mingechaur reservoir is a typical eutrophic reservoir of trophic type. It should be noted that in the last 25-30 years reservoirs have been created in the course of the three main rivers – Kur, Araz, Gabyrra, flowing into the Mingechaur reservoir, and unlike previous years, biogenic solid sediments are not discharged directly into the basin. However, the average annual amount of primary organic matter synthesized by phytoplankton in the Mingechaur reservoir is higher than the indicators defined in the eutrophic type and anthropogenic eutrophication continues without weakening. In order to clearly understand how high the total product-harvest – of phytoplankton in the Mingechaur reservoir is, the average annual indicators in Table 3.4 are compared with the results of other eutrophic and mesotrophic reservoirs. Table 3.4 shows that the primary product -phytoplankton yield in the Mingechaur reservoir is 1.3-2 times higher than in other eutrophic reservoirs.

Table 3.4. Comparison of the average annual amount of primary product-harvest phytoplankton and degraded organic matter in the Mingechaur reservoir (gS/m2), with indicators determined by other mesotrophic and eutrophic lakes and reservoirs

Name and type of reservoir	Primary product	Destruction	Author
Eutrophus: Aggel	200	180	(77)
Garagel	210	176	(78)
Kuibyshev reservoir	370	522	(190)
Volgograd reservoir	260	310	(174)
Kremenchug reservoir	348	460	(85)
Zaporozhye reservoir	360	440	(85)
Mingechaur reservoir	460	740	(68)
Mesotrof: Deep Lake	112	93	(173)
Lake Baikal	110	86	(174)
Kolomenskoye Lake	103	87	(77)
Rybinsk reservoir	80	120	(224)
Gorky reservoir	127	130	(171)
Kiev reservoir	110	98	(85)

The species composition of the phytoplankton of the Mingechaur reservoir has been studied twice sinceRzayeva in the 1950s and A.Manafova in the 1980s. A total of 250 species of phytoplankton have been recorded. It turned out that blue-green diatoms and green algae species that grow massively in the Mingechaur reservoir all year round and are leaders in the formation of primary products belong to the species belonging to the department of green algae. In our studies, the work on the classification of phytoplankton was not considered, however, in the case of mass growth of phytoplankton, sometimes growing at the flowering stage, samples were taken and analyzed, according to our research, taxa belonging to diatoms dominate in the spring – autumn seasons and in low-water reservoirs. Usually winter diatomaceous vit-plankton is 71-80 percent, among them Cyclotella, Kuetzingiana, Cyclotella meneghiniana, Melosira granulata, Cymbella, etc. they are distinguished by the number and quantity of biomass. Although there are species from all departments in the summer season, green and blue-green algae predominate during this period. Among them there is no aphanizomenon of water thread, oocysts, chlorella, Scenedezma, pediastrum.In autumn, the second place after diatoms belongs to the species of green algae. It was found that the negative effect of solar radiation on the physiological activity of phytoplankton in the water column to a depth of 0-0.5 meters. The maximum synthesis of primary organic matter was recorded at a depth of 3-8 meters in the conditions of the Mingechaur reservoir [6,7,8].

During periods of temperature surges, mainly in hot months, at depths where warm water meets relatively cool water in the upper layers, the abundance and biomass of phytoplankton increases many times. It became clear that due to the temperature difference, phytoplankton, which makes up the majority in quantity at a depth of 18-22 meters, cannot synthesize organic matter like phytoplankton on the upper layers. The reason is that transparency decreases in deep layers. Above, we noted the positive role of increasing transparency in the basin by increasing the primary phytoplankton product in the Mingechaur reservoir over the past 25-30 years.

After the creation of the Shamkir reservoir [14], the volume of solid sediments carried into the Mingechaur reservoir decreased by 3 times; and the vegetation of primary and higher aquatic plants increased. In addition, the collapse of the shores of the reservoir of an abrasive nature, an erosion spill caused an increase in its total area due to an increase in the volume of bottom sediments in the basin itself. According to S.M.Khalilov's research, in 1953-2013, the coastline shifted by an average of 150-300 meters, and the reservoir area increased by 4.2 percent (more than 25 km2). This means that favorable conditions have been created for increasing the primary phytoplankton product in the Mingechaur reservoir [16], both in depth and in the horizontal direction. It should be noted that although more than 60 years have passed since its creation, the processes of productivity and destruction in the Mingechaur reservoir have not fully formed. The main reason for this is the presence of a source of anthropogenic factors that have a negative impact on the Kura River and the Mingechaur reservoir.

A comparison of long-term studies and our observations shows that there have always been biogenic elements that have a direct positive effect on the intensive development of phyto-bacterioplankton in the Mingechaur reservoir. Although the channel enriched with allochthonous substances enters directly into the Mingechaur reservoir of anthropogenic eutrophication, the abundant supply of organic substances of allochthonous origin enhances the processes of dissimilation, which in turn accelerates the regeneration of biogenic elements. In other words, an increase in the amount of organic substances in allochthonous and autochthonous, actively participating in the processes of biodegradation of microbes, causes their mass generation [4]. Interestingly, a large biomass of phytoplankton is mineralized by the microbiota, and if the energy needs of phytoplankton are fully met, the biomass of microbes is formed in the same medium for the second time. Thus, it is quite obvious that intensive vegetation of phyto-bacterioplankton in the Mingechaur reservoir continues en masse throughout the year and with the elimination of thousands of tons of organic substances, biogenic elements and other hydrochemical ingredients are reused by phyto-bacterioplankton. It should be noted that after the creation of new reservoirs on the Kura, nitrate and phosphate salts of biogenic elements in the water are not fully used even in those months when the mass growth of phytoplankton in the Mingechaur reservoir continues. However, it is known from numerous studies that nitrate-phosphate salts are completely absorbed in reservoirs during the mass vegetation period of phytoplankton. In the Mingechaur reservoir in the summer months of 1958-1960, the absence of determination of nitrate, nitrite and mineral phosphorus salts in the water was also noted by M.M. Huseynov and Mammad Salmanov. At the same time, it became clear that the initial – primary product created by phyto-bacterioplankton and higher aquatic plants multiplied many times. Therefore, it can be assumed that the processes of assimilation and regeneration of biogenic elements necessary for the continuous vegetation of phytoplankton in the Mingechaur reservoir are regulated by the ecosystem itself. However, the complete stabilization of assimilation and dissimilation processes in the Mingechaur reservoir is controversial from an ecological point of view. In other words, the sanitary and hydrobiological condition, the level of saprobity and trophic direction is unstable and depends on the overall quality of the water coming from the upstream. It is difficult to imagine without the anthropogenic impact of the Mingechaur reservoir. Because the discharge of wastewater into the Mingechaur reservoir with the Gabyrry and Ganykh rivers continues. Therefore, there is no doubt that organic substances of allochthonous origin and polyutants of various compositions enter the Mingechaur reservoir.

It is characteristic that microbiological studies and determination of the primary phytoplankton product were carried out for the first time in the Mingechaur reservoir. Also, studies to determine the amount of organized mineralized organic matter assimilated by hydrobionts and the balance of organic substances were conducted for the first time in the Mingechaur reservoir. Since the creation of the Mingechaur reservoir, the same studies have been conducted 3 times, with a consistent comparison of the results. Based on the comparison of the results, it is possible to determine changes in the sanitary and hydrobiological state, ecological property, assimilation and dissimilation processes, the causes of changes in the ecological system. Until now, since the creation of the Mingechaur reservoir, the amount of primary organic matter, synthesized phytoplankton has been increasing [8].

It is characteristic that this growth from 1960-1984 (in 24 years) is twice as much as from 1984 to 2015 (in 30 years). This is explained by the fact that before the construction of the Shamkir reservoir [14], foreign substances brought by the Kura River directly flowed into the Mingechaur reservoir.

According to the results of seasonal studies in the Mingechaur reservoir in 2015, the calculation of the primary phytoplankton product is given in Table 3.5. Thus, it is known that in the current period in the Mingechaur reservoir, on average, more than 400,000 tons of primary organic matter are created by phytoplankton per year.

Table 3.5. Calculation of the primary phytoplankton product Mingechaur reservoir in 2015

Indicator	Winter	Spring	Summer	Autumn
Average daily product with/l	1,30	2,40	2,40	1,60
G S/m2	117	220	216	144
Throughout the reservoir thousand tons / s	70,2	133	133	87

Quantitative indicators of primary organic matter produced by phytoplankton of hydrobionts living in the basin are more convenient and convincing for visualizing changes occurring in the Mingechaur reservoir. It is proved that phyto-bacterioplankton are the most sensitive to anthropogenic impact on the reservoir. A comparison of the ecosystem assessed as an adequate response to anthropogenic impact over the last period in the Mingechaur reservoir is given in Table 3.6.

Table 3.6. Comparison of changes in the primary product synthesized by phytoplankton of the Mingechaur reservoir by year and season

Indicators	Seasons											
	Winter			Spring			Summer			Autumn		
	1[1]	2[2]	3[3]	1	2	3	1	2	3	1	2	3
Average daily product mg/l	0,26	0,50	1,30	0,60	1,20	2,40	0,90	1,30	2,40	0,33	0,70	1,60
G C/m2	23,0	46,0	117,0	54,0	108,0	216,0	81,0	120,0	216,0	30,0	63,0	144,0
Through out the reservoir Thousand tons/ s	13,3	27,0	70,0	32,0	64,0	129,0	48,6	71,0	129	180	38,0	86,0

Note; 1 – 1962; 2 – 1984 The total average annual product during the year. 3 – 2015

In 1962 – 111,000 tons or 185 G/m2

In 1984 – 201,000 tons or 335 G/m2

In 2015 – 423,000 tons or 690 G/m2

For more than 50 years (1962-2015), the primary production of phytoplankton in the Mingechaur reservoir has increased by 6.2 times.

Conclusion

Special attention is paid to the relationship of the primary organic matter of reservoirs with the issues of productivity of the living world, including ichthyofauna in the aquatic ecosystem. From the point of view of limnology, an abundant fish product is formed in natural eutrophic reservoirs. However, water blooming is considered undesirable in reservoirs intended for drinking needs. To get out of the situation, they even take measures to combat the growth of phytoplankton blooms in reservoirs. The flow formed in the Mingechaur reservoir, the change in the level regime, solar radiation, temperature regime and the active activity of the microbiota protects the Mingechaur reservoir from anaerobiosis, from phytoncites and other bio-microbiological metabolites.With the study of the destruction of organic substances, first of all, it is possible to clarify the degree of self-purification in the ecosystem, the direction of the formation of biological productivity, the possibility of using water [15].

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Received: May 31, 2023; June 25, 2023