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MODERN MICROBIOLOGICAL AND ECOLOGICAL CHARACTERISTICS OF THE ASHIGBAYRAMLI RESERVOIR

Ansarova A.H.¹, Abaszade Z.A.², Guliyeva R.N.², Jafarova U.T.², Seyidbeyli M.I.², Mammadli Kh.Sh.³, Mammadova N.Ch.¹

Abstract

For the long-term and efficient use of one of Azerbaijan's major reservoirs, the quantitative assessment of microorganisms in its water and bottom sediments is of great importance. These include total microbial counts, specific physiological groups, and coliform-enterobacteria. The Ashigbayramli Reservoir was established in 1951 in the Ismayilli district of the Republic of Azerbaijan. Its primary purpose is to provide water supply to several settlements, including the districts of Goychay and Aghsu, as well as irrigation of agricultural lands. The floristic composition of dominant phytoplankton groups, their primary production, and the destruction of organic matter were studied seasonally throughout 2013. Microbiological investigations included determination of the total number of microorganisms in water and bottom sediments, as well as saprophytic and physiological groups of bacteria. A sanitary-hydrobiological assessment of water quality was conducted based on bacterial group abundance.

Keywords: Primary production, bacterioplankton, *E. coli*, coliform-enteric groups, saprophytes, physiological groups, destruction.

INTRODUCTION

In modern conditions of water resource utilization, the study of reservoirs is

essential for identifying alternative water sources, preventing anthropogenic eutrophication, and improving water-use efficiency. The main source of water supply to the Ashigbayramli Reservoir is a river. Water flow is directed through a special canal into the natural (old) channel of the Devabatan River and then into the reservoir basin via the Agrichay River—first into Ashigbayramli and subsequently through a dam-sluice system into the lower basin, the Yekakhana Reservoir. The reservoir covers an area of 0.8 km² with a

Yazışma üçün əlaqə:

Ansarova A.H.¹, Abaszade Z.A.², Guliyeva R.N.², Jafarova U.T.², Seyidbeyli M.I.², Mammadli Kh.Sh.³, Mammadova N.Ch.¹

1 Azerbaijan Medical University, Department of Medical biology and Genetics

2 Azerbaijan Medical University, Department of Normal physiology

3 Reference Clinical Laboratory, Baku, Azerbaijan

*For correspondence E-mail: abaszade.zumrud@mail.ru



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total water volume of 5 million m³. Since the feeding river also serves as a freshwater source for domestic use and flows through densely populated areas, and because the reservoir itself is exposed to various anthropogenic impacts, assessment of its sanitary-hydrobiological and ecological-microbiological condition is necessary.

MATERIALS AND METHODS

To determine the annual dynamics of water microbiota and bottom sediment vegetation, studies were conducted seasonally during 2013.

Four sampling stations covering the entire reservoir area were established. Sampling was performed according to planned routes and fixed observation sites.

Water samples for microbiological analysis were collected using Sorokin's method, and hydrobiological-hydrochemical samples were obtained using a Knudsen bathometer. Bottom sediments were collected using a tube corer.

Major biogenic elements, certain heavy metals, and other pollutants were measured using a Palintest THM Digital device, while dissolved oxygen was determined with a Milwaukee MW 600 instrument. Primary phytoplankton production and organic matter destruction

were calculated using the G.G. Vinberg method.

Microbiological analyses and culturing procedures were carried out according to the methodological guidelines of V.I. Romanenko, S.I. Kuznetsov, A.G. Rodina, and S.N. Vinogradsky. Oil hydrocarbon- and phenol-degrading bacteria were determined by the Voroshilova-Dianova method.

During the study period, 1,897 water and bottom sediment samples were collected, and 5,310 microbiological analyses were performed. All numerical results were statistically processed.

RESULTS

The Ashigbayramli Reservoir is shallow, with a maximum depth not exceeding 2.5m near the dam area. Due to its canal-type characteristics, thermal stratification does not form, and the reservoir rarely freezes. Water transparency is relatively high (0.8–1.2 m). Erosion processes are weak because the shores consist mainly of rocky and gravel substrates. The central and dam-adjacent areas contain silty-sandy sediments. Under moderate climatic conditions and sufficient nutrient availability (mineral nitrogen 1.3 mg/L and phosphates 0.09 mg/L), phytoplankton and phytobenthos develop from early spring.

Table1 Floristic composition of phytoplankton in Ashigbayramli reservoir

№ p/p		Branches Taxa	Taxa		
			Spring	Summer	Autumn
1		Cyanophuta	13	6	17
2		Euglenophuta	1	2	1
3		Dinophuta	3	4	2
4		Bacillarophuta	8	12	4
5		Chlorophuta	5	10	8
6		Chrysophuta	1	2	2

As can be seen from Table 1, a total of 101 species of phytoplankton are recorded in the reservoir, among which blue-green and green diatom taxa are almost identical and predominate. Based on the fact that representatives of green and blue-green species predominate in phytoplankton throughout the year, it can be assumed that with increasing anthropogenic pressure on the ecosystem, bloom and death events and water poisoning with phytoncides and other metabolic products are possible. During the development of phytoplankton, the temperature factor determines its qualitative composition. Thus, when the water temperature is up to

10-12°C, taxa of the diatom division predominate in the algal flora, and as the water warms, an increase in green and blue-green vegetation is observed. In addition, samples were collected from surface water layers to determine the amount of primary photosynthetic production of phytoplankton and its dominant divisions (qualitative composition). Due to the non-freezing of the reservoir and the sufficient number of bright sunny days even in winter, phytoplankton photosynthesis and the destruction of organic matter in the water are observed here in all seasons of the year (Table 2).

Table 2 Primary phytoplankton production and destruction (organic matter) (mg O₂/l. day)

Location	Winter		Spring		Summer		Autumn	
	II ¹	D	II	D	II	D	II	D
1	0,1	0,3	0,6	2,1	1,30	3,0	0,3	2,4
2	0,2	0,4	0,9	2,4	1,70	2,8	0,8	2,3
3	0,3	0,8	1,3	2,6	2,10	3,3	1,4	2,9
4	0,4	0,9	2,0	3,2	3,20	3,8	2,3	3,0
Medium	0,25	0,60	1,2	2,50	2,10	3,10	1,20	2,2

PP – Primary production;

D – Decomposition of organic matter

As can be seen, the minimum of phytoplankton production is observed in winter and the maximum in summer. The characteristic indicators of organic matter destruction, the average seasonal destruction data are almost 2 times higher than the initial production. The increase in the average annual destruction value compared to the photosynthetic production of phytoplankton is apparently due to the

introduction of allochthonous organic matter with river waters, the main source of which is considered to be wastewater from settlements located in the catchment area. It should be noted that saprophytic (heterotrophic) bacteria react very sharply to the presence of easily mineralized organic matter. The results of our study are presented in Table 3.

Table 3 Total number of microorganisms (million/ml) in water and silt-soil (billion/g) in Ashigbayramli reservoir by season, amount of saprophytic bacteria in water (thousand/ml) and aerobic and anaerobic cellulose-decomposing, free nitrogen-fixing, denitrifying and sulfating bacteria in water and silt-soil.

Type of analysis	Station	Winter		Spring		Summer		Autumn	
		In the water	In the mud	In the water	In the mud	In the water	In the mud	In the water	In the mud
Total microbial count	1	1,4	0,6	2,4	1,6	3,6	1,8	2,1	1,9
	2	0,6	1,3	3,2	2,1	2,1	2,7	1,9	2,1
	3	0,8	1,3	1,6	3,0	2,9	3,3	2,0	2,6
	4	0,9	1,4	2,0	3,4	3,2	3,4	4,6	3,0
Saprophytic bacteria	1	1,0	0,9	3,0	2,2	4,2	2,7	3,7	1,7
	2	1,2	1,2	5,0	2,6	3,2	3,2	2,2	2,4
	3	1,3	1,4	3,2	3,2	2,9	3,3	2,3	2,6
	4	0,9	1,5	10,1	3,6	3,6	4,6	1,8	3,0
Cell-absorbing aerobes	1	10	100	1000	100	100	100	1000	10
		10	100	100	100	100	100	1000	10
	2	10	10	1000	1000	100	1000	1000	100
		10	100	100	1000	100	1000	1000	1000
	3	10	10	1000	1000	100	1000	100	100
		10	100	100	1000	100	1000	100	100
	4	10	10	1000	1000	100	1000	100	100
		10	100	100	1000	100	1000	100	1000
Nitrogen-fixing (aerobes)	1	0,0	3,0	16,0	10	270	0	250	123,0
	2	0,0	7,0	67,0	10,0	294	10,0	270	118,0
	3	0,0	5,0	44,0	10,0	110,0	10,0	190	110,0
	4	0,0	8,0	33,0	0,0	40,0	10,0	110	104,0
Sulphating	1	0,0	0,0	0,0	0,0	10,0	66,0	10,0	60,0
	2	0,0	0,0	5,0	11,0	10,0	106,0	100	116,0
	3	0,0	16,0	3,0	34,0	100	260,0	100	26,0
	4	0,0	24,0	7,0	46,0	100	320,0	100	67,0
Denitrifier	1	0,0	0,0	10,0	100	100	1000	1000	100
	2	0,0	0,0	10,0	100	100	1000	100	1000
	3	0,0	10,0	100	1000	100	1000	100	1000
	4	0,0	10,0	100	1000	100	1000	100	1000

The table shows that the total number of microorganisms in water and bottom sediments varies between 0.6 million/ml and 1.4-3.4 billion/g, respectively. Such fluctuations in the number of microflora in time and space depend primarily on the ambient temperature and the availability of

energy material. In particular, saprophytic bacteria are a kind of biological indicator in this regard. The maximum number of saprophytic bacteria, noted in Tables 2 and 3, coincides with the maximum rate of primary production and destruction of organic matter. Since the water depth in

the reservoir is shallow, the mineralization of organic matter in the water column does not have time to be completely oxidized, and its relatively complex components settle to the bottom. Therefore, there is a significant difference in the qualitative composition of colonies of saprophytic bacteria grown in water and bottom sediments. It is characteristic that at one time S.I. Kuznetsov (1952; 1970) proved that in reservoirs the easily digestible components of proteinaceous organic substances are mineralized primarily by non-spore forms of saprophytic bacteria, while the heavier compounds of the substrate are absorbed by spore-forming bacteria. Based on the above, it can be noted that in the Ashigbayramli reservoir, non-spore-forming saprophytic bacteria cultures grown from water samples constitute an average of 68-76 percent, and in bottom sediments - 40-51 percent. It was also determined that the number of saprophytic bacteria in the water of the Ashigbayramli reservoir varies greatly depending on the season compared to the bottom sediments. As can be seen in Table 3, if the difference in the number of saprophytic bacteria between the minimum (winter) and maximum (summer) indicators in the water column is equal to 3, then in bottom sediments it is higher - 6-7 times. Also, there are no noticeable deviations in the distribution of the total number of microorganisms in water and silt-soil both by reservoir sections and by seasons. Therefore, it can be assumed that the Ashigbayramli reservoir has optimal conditions for self-purification processes, since homothermia and oxygen saturation are observed in the reservoir in all seasons.

DISCUSSION

It is characteristic that the widespread distribution of aerobic forms of bacteriocenosis among physiological groups of bacteria is more noticeable in the water and bottom sediments of the reservoir. As can be seen in Table 3, in all seasons of the year the number of aerobic cellulose-decomposing bacteria in the water exceeds the bottom layer by 10 times, while in the bottom sediments the difference in the number of aerobic-anaerobic bacteria is almost not noticeable. Free-living aerobic nitrogen-fixing bacteria (genus *Azotobacter*) are observed in relatively high numbers in areas where higher aquatic plants develop and in warm seasons when their maximum number exceeds 290/ml. Another free-living nitrogen-fixing genus, the anaerobic *Clostridium pasterianum*, is not widespread in the reservoir. It is not observed in most water samples, and in soils it does not exceed 110-120/g. There is a rather noticeable difference in the number and distribution of sulfate-reducing and denitrifying bacteria, which are anaerobes. As can be seen in Table 3, the main biotopes of both bacterial groups are bottom sediments, but the number of sulfate-reducers is on average 4-5 times less than that of denitrifiers. Based on the fact that for optimal development and physiological and biochemical activity of sulfatizers, there must be a sufficient amount of organic matter, mineral salts of sulfates and sulfites, and a lack of oxygen (Kuznetsov, 1959), it can be assumed that the conditions in reservoirs are not suitable for the active activity of these bacteria and there is no danger of poisoning hydrobionts with hydrogen sulfide and deterioration of the quality of the water in them. Since there are settlements, farms

and local industrial facilities in the basin of the Ashigbayramli reservoir, he is on a summer expedition to the reservoir and the river. Arpachai determined the number of coli groups, phenol and hydrocarbon

oxidizing bacteria (table 4). The presence of phenol-hydrocarbon oxidizing bacteria in the water in the amount of 1000/ml is, of course, due to technogenic factors of anthropogenic origin.

Table 4 Number of phenol, hydrocarbon, oxidizing and coliform bacteria groups in water (1 ml) of Arpachay and Ashigbayramli reservoirs (August, 2013).

Stations	FR ¹	C/h	Coli bacteria
Arpachay River (above the city)	10	10	32
Collector (downtown)	1000	1000	360
Estuarii (source of a reservoir)	1000	1000	123
Water reservoir 1	1000	1000	55
Water reservoir 2	100	100	34
Water reservoir 3	100	100	28
Water reservoir 4	100	100	14

1. Note: FD – phenol decomposition;

2. HOA – hydrocarbon oxidizing agent.

The results of determining the number of coli-enteric bacteria are very indicative. As can be seen from Table 4, the amount of coli group in the water above the Arpachay River settlement area is only 32/ml, and in the settlement area (collector) it increases more than 10 times. At the same time, the number of E. coli in the water along the flow path from the point of maximum pollution to the reservoir (10-11 km) decreases by 5-6 times. However, the presence of E. coli in the river itself, in the reservoir, indicates that the water is polluted with feces, the main sources of which are populated areas.

CONCLUSION

Thus, without conducting the above-mentioned studies in the context of seasons and factors, and without determining the course of substance circulation in reservoirs, it is impossible to correctly assess and predict, from a scientific and applied perspective, the sanitary-hydrobiological safety of water collected in reservoirs for use in

households, agriculture, industry, and processing farms. The primary production of phytoplankton, which is considered the basis of the balance of organic matter in reservoirs, and the amount of destroyed substrates were studied together. Biological productivity, the degree of self-purification of waters, anthropogenic eutrophication and its ecological significance were studied. It became clear that the waters in the reservoirs created in the Kura and Araz rivers, which are severely polluted in Georgia and Armenia, are polysaprobic and autoeutrophic.

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AŞIQBAYRAMLI SU ANBARININ MÜASİR MİKROBİOLOJİ VƏ EKOLOJİ XÜSUSİYYƏTLƏRİ

Ənsərova A.H.¹, Abaszadə Z.Ə.^{2*}, Quliyeva R.N.², Cəfərova Ü.T.², Seyidbəyli M.İ.², Məmmədli X.Ş.³, Məmmədova N.Ç.¹

¹Azərbaycan Tibb Universiteti, Tibbi biologiya və Genetika kafedrası

²Azərbaycan Tibb Universiteti, Normal fiziologiya kafedrası

³Referens Klinik Laboratoriya, Bakı, Azərbaycan

* Yazışma üçün E-mail: abaszade.zumrud@mail.ru

Xülasə

2013-cü ilin mövsümü üçün dominant fitoplankton qruplarının floristik tərkibi, onların ilkin istehsalı və üzvi maddələrin məhv edilməsi öyrənilmişdir. Mikrobioloji tədqiqatlar mikroorqanizmlərin ümumi sayının, saprofitlərin sayının, su və dib çöküntülərinin bakteriyalarının fizioloji qruplarının təyini

əhatə etmişdir. Suyun sanitar hidrobioloji qiymətləndirilməsi coli bakterial qruplarına əsasən aparılmışdır.

Açar sözlər: *İlkin istehsal, bakterioplankton, bağırsaq çubuqları-coli entero qrupu, saprofit, fizioloji qruplar, məhv edilməsi.*

СОВРЕМЕННЫЕ МИКРОБИОЛОГИЧЕСКИЕ И ЭКОЛОГИЧЕСКИЕ ХАРАКТЕРИСТИКИ ВОДОХРАНИЛИЩА АШИГБАЙРАМЛИ

Ансарова А.Г.¹, Абасзаде З.А.^{2*}, Кулиева Р.Н.², Джафарова У.Т.², Сейидбейли М.И.², Маммадли Х.Ш.³, Мамедова Н.Ч.¹

¹Азербайджанский Медицинский Университет, Кафедра Медицинской биологии и Генетики

²Азербайджанский Медицинский Университет, Кафедра Нормальной физиологии

³Клиническая Лаборатория Реферанс, Баку, Азербайджан

* Для корреспонденции E-mail: abaszade.zumrud@mail.ru

Резюме

Изучены по сезонам 2013 года флористический состав доминирующих групп фитопланктона, его первичная продукция и деструкция органического вещества. Микробиологические исследование охватили определение общей численности микроорганизмов, количества сапрофитных, физиологических групп бактерий воды и донных отложений. Дана санитарно-гидrobiологическая оценка воды по данным коли групп бактерий.

Ключевые слова: *Первичная продукция, бактериопланктон, кишечные палочки – коли-энтерогруппы, сапрофитные, физиологические группы, деструкция.*