

BULLETIN OF NATIONAL ACADEMY OF SCIENCES  
OF THE REPUBLIC OF KAZAKHSTAN

ISSN 1991-3494

Volume 4, Number 374 (2018), 6 – 12

UDC 543.311

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### ANALYSIS OF WATER QUALITY IN THE COASTAL ZONE OF THE ISSYK-KUL LAKE BEFORE AND AFTER THE TOURIST SEASON

**Abstract.** Water quality is a characteristic of the composition and properties of water, determining its suitability for specific types of water use. Natural and anthropogenic factors affect the water quality. Anthropogenic impact, solid domestic waste and wastewater have a negative impact on water quality and the state of the lake. Recently, the increase in the number of tourists affects the water quality and condition of the Issyk-Kul lake. However, according to the results of analyzes, the water of the Issyk-Kul basin is not exposed to significant pollution. The quality of the surface waters of the lake is satisfactory, but the concentrations of some parameters such as nitrites and ammonium nitrogen ( $\text{NH}_4^+$  and  $\text{NH}_2$ ) are relatively high in Balykchy Bay, and the content of the remaining parameters does not exceed the MPC. The volume of water in the lake is huge, so while the lake is completely coping with the dissolution of harmful substances to a safe level for organisms.

**Key words:** Issyk-Kul lake, water quality, petroleumproducts, tourist season.

**Introduction.** Water is chemically pure only in exceptional cases. Naturally, it always contains some dissolved and suspended matter. The range of chemical compounds in water is very diverse, since there is a change in the content of basic ions, dissolved gases, biogenic and organic substances, and trace elements [1]. A water body is characterized by a certain natural composition and water properties, and the consumer forms its own requirements for the composition and properties of the water consumed. Based on the data on the composition and properties of water, as well as customer requirements, water quality indicators (criteria) are formed. Quality is a characteristic of the composition and properties of water, determining its suitability for specific types of water use. Each type of water body has characteristic properties: salinity, alkalinity, hardness, acidity, corrosive properties. Factors affecting the state of the water body can have both a natural nature and anthropogenic, caused by human economic activity. By regulating the factors affecting the state of the water body, it is possible to regulate the quality of its water. These factors affect the quality of water, which depends on both mineralization and dissolved and suspended matter [2]. Currently, the water system is facing a serious threat due to pollution, which is a serious problem in a global context [3]. In this regard, particular interest is represented by detailed studies of the microelement composition of the coastal waters, bays and caves of Lake Issyk-Kul, which differ in their mineralization,

depending on the degree of dilution with river water. This is very important, since the accumulation of toxic heavy metals can lead to unpredictable catastrophic effects on the fauna of the lake and the ecosystem as a whole. Currently, the growing attractiveness of the resort area of the Lake Issyk-Kul for tourists creates conditions for the socio-economic development of the region, but on the other hand is a huge danger to the lake due to the ingress of insufficiently treated sewage into it and the impact of a number of other negative factors with anthropogenic activity [4]. In addition, the development of agriculture where fertilizers and grazing are used also increase the concentration of nutrients in the lake water [5-6].

The main purpose of the study is to analyze the influence of the tourist season on the hydrochemical appearance and water quality of the coastal zones of the Issyk-Kullake.

**Study area.** The Issyk-Kul is a drainless lake in the Northern Tien Shan, and it is located in the north-eastern part of Kyrgyzstan [7], and is one of the largest mountain lakes in the world. It is located at an altitude of 1608 m in the intermountain Issyk-Kul basin between the Kungei Ala-Too Ridge in the north and the Terskey Ala-Too Ridge in the south (figure 1). Issyk-Kul Lake of tectonic origin, was formed due to faults, faults and deflections of the earth's surface; the vast part of it sank and filled with water, while the neighboring sections rose to 3000-3500 m above the lake level. The basin of the Issyk-Kul Lake stretched 252 km long in the latitudinal direction, and 22080 km<sup>2</sup> in the meridional zone at 146 km. Of these, the lake accounts for 6,247 km<sup>2</sup>, in the foothill plain, which is a zone of river flow diversion of 3,092 km<sup>2</sup>, the remaining part of the basin (12741 km<sup>2</sup>) is occupied by mountain areas, which are a zone of river flow formation. The Issyk-Kul Lake has the following characteristics: length is 178 km, width is 60.1 km, length of the coastline is 668 km, average depth is 278.4 m, depth maximum is 668 m, area is 6247 km<sup>2</sup>, and water volume is 1738 km<sup>3</sup> [8]. The Issyk-Kul lake refers to brackish lakes. In the chemical composition of its water, sulfates predominate over chlorides, which is a particular feature of the continental origin of the salt composition of this lake, fed by high-mountain rivers [9]. The climate of the Issyk-Kul Lake basin is moderately warm, favorable for crops and horticulture [10].

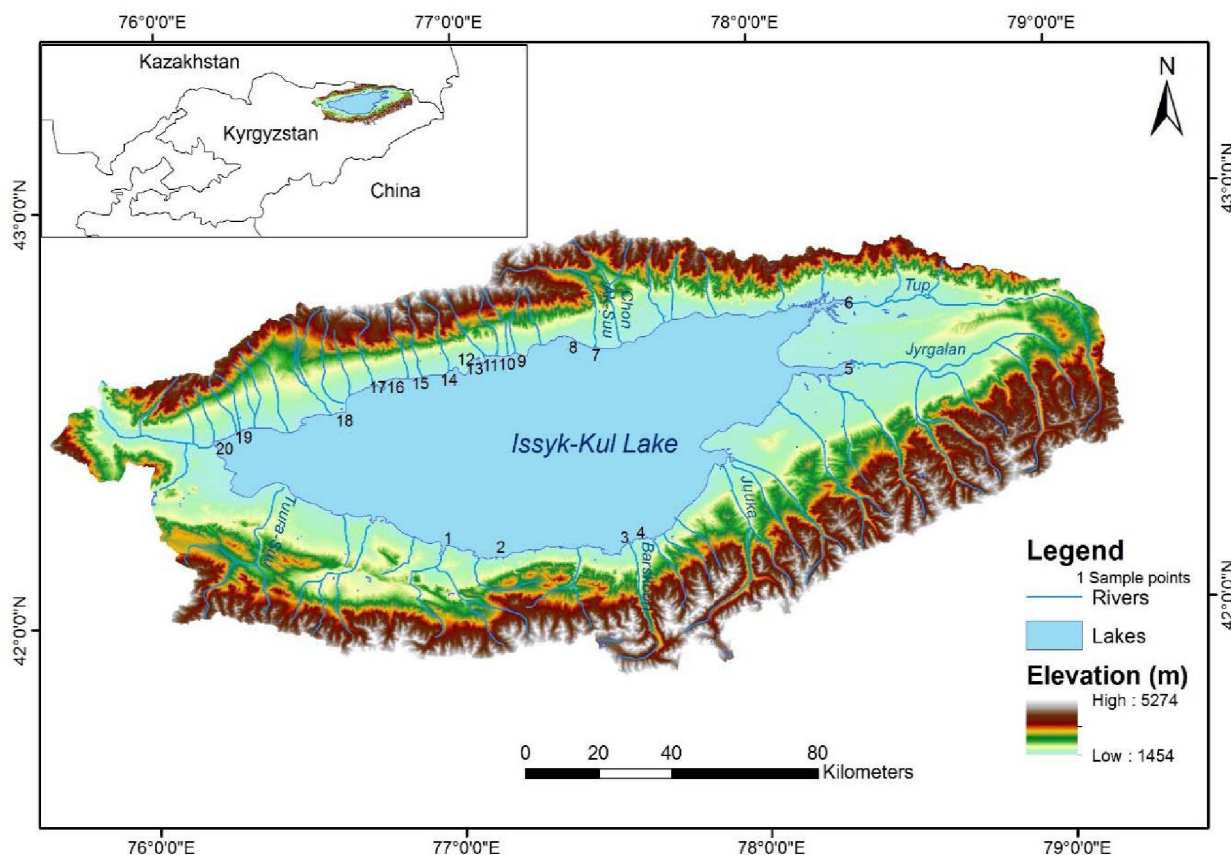


Figure 1 – Study area and sampling points

**Methods and materials.** The results of the analysis from the State Agency for Environmental Protection and Forestry under the Government of the Kyrgyz Republic (SAEPF) were used to characterize the degree of water pollution in the Issyk-Kullake. In 2016, monitoring was carried out twice a year: before and after the end of the tourist season. From 6 to 9 June and from 29 August to 1 September 2016; 20 water samples from the lake were selected (figure 1) and 20 water samples were analyzed according to the following parameters: pH, nitrogen nitrite, ammonium nitrogen, surfactants (anionic synthetic detergents), petroleum products, dissolved oxygen, heavy metals such as copper, zinc, cadmium and lead (table 1, 2).

Table 1 – Results of water analysis before tourist season (06 and 09 June 2016)

Sampling points	t, °C	pH	NH <sup>+</sup> <sub>4</sub>	NO <sup>-</sup> <sub>2</sub>	Surfactant	Oil	Cu	Zn	Cd	Pb
1	16	8.40	<0.039	<0.01	<0.015	0.04	<0.0006	<0.0005	<0.0002	<0.0002
2	16	8.36	<0.039	<0.01	<0.015	0.04	<0.0006	<0.0005	<0.0002	<0.0002
3	20	8.33	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
4	18	8.40	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002
5	18	8.18	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
6	16	8.15	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
7	17	8.37	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002
8	17	8.42	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
9	20	8.43	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002
10	19	8.43	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
11	17	8.43	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
12	17	8.41	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002
13	15	8.15	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
14	11	8.37	<0.039	<0.01	<0.015	<0.02	<0.0006	<0.0005	<0.0002	<0.0002
15	17	8.44	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
16	17	8.42	<0.039	<0.01	<0.015	0.04	<0.0006	<0.0005	<0.0002	<0.0002
17	19	8.43	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002
18	17	8.47	<0.039	<0.01	<0.015	<0.02	<0.0006	<0.0005	<0.0002	<0.0002
19	19	8.47	0.81	0.065	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
20	19	8.74	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002

Table 2 – Results of water analysis after tourist season (29 August and 1 September 2016)

Sampling points	t, °C	pH	NH <sup>+</sup> <sub>4</sub>	NO <sup>-</sup> <sub>2</sub>	Surfactant	Oil	Cu	Zn	Cd	Pb
1	20	8.27	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002
2	20	8.34	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
3	17.5	8.41	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
4	17.5	8.38	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
5	17	8.10	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
6	20.5	8.43	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
7	18	8.34	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
8	21	8.42	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
9	20.5	8.42	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
10	21	8.41	<0.039	<0.01	<0.015	0.04	<0.0006	<0.0005	<0.0002	<0.0002
11	20	8.43	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
12	21	8.53	<0.039	<0.01	<0.015	0.03	<0.0006	<0.0005	<0.0002	<0.0002
13	21	8.45	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
14	21	8.43	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
15	23	8.47	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
16	22	8.47	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
17	22	8.46	<0.039	<0.01	<0.015	<0.015	<0.0006	<0.0005	<0.0002	<0.0002
18	22	8.44	<0.039	<0.01	<0.015	<0.015	<0.0006	<0.0005	<0.0002	<0.0002
19	22	8.60	0.80	0.156	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002
20	22	8.62	<0.039	<0.01	<0.015	0.02	<0.0006	<0.0005	<0.0002	<0.0002

The analysis of water samples was carried out in accordance with modern analytical methods described in the relevant state standards.

**Results and discussion.** The pH values of all collected surface water samples show that they are in the allowable concentration. The water in the lake has an alkaline reaction, the pH of the water is between 8.10-8.74 in 2016 (tables 1, 2). The total alkalinity is mainly due to the content of  $\text{HCO}_3^-$  and partially  $\text{CO}_3^{2-}$  ions. The concentration of other ions affecting the alkalinity of water ( $\text{H}_2\text{BO}_3$ ,  $\text{HPO}_4^{2-}$ ,  $\text{H}_2\text{PO}_4^-$ ,  $\text{HSiO}_3$ ) is very small [11]. The concentration of ions of  $\text{HCO}_3^-$  and  $\text{CO}_3^{2-}$  ions depends on the mineralization of water and  $\text{CO}_2$ . The surface water temperature in the study area ranges from 17.0 to 20.0 °C in June and 17.5 to 23 °C in August.

The content of ammonium nitrogen in the water of reservoirs is subject to seasonal fluctuations: in spring it decreases, in summer it increases due to the intensification of bacterial decomposition of organic substances [4]. According to the results of the chemical analysis of water collected in the bay of the Balykchi shipyard, an exceedance of the maximum permissible concentration (MPC) for nitrogen ammonium was 2.1 times, nitrite nitrogen 2.7 times (figure 2a, b). If the pollution does not go beyond these areas, then it can be considered that self-cleaning ability will maintain an equilibrium state in these areas of the reservoir [ ] (Karmanchuk, 2002). It can be seen from the table that the concentrations of all elements other than  $\text{NH}_4^+$  and  $\text{NO}_2^-$  do not change significantly in the waters of the coastal zone.

In the Soviet period, the plant "Selkhozkhimiya" operated, where mineral fertilizers were stored for the Issyk-Kul and Naryn oblasts, and, accordingly, the soil was contaminated with various chemicals.

The chemicals is washed out by rain and partially falls into the lake. Storm runoff in urban areas contains various pollutants from residential and industrial areas [13, 14] flows into the lake and reduces water quality [15]. In addition, excessive use of fertilizers, manure and pesticides can be harmful, although they are used for better production and protection of crops [16, 17].

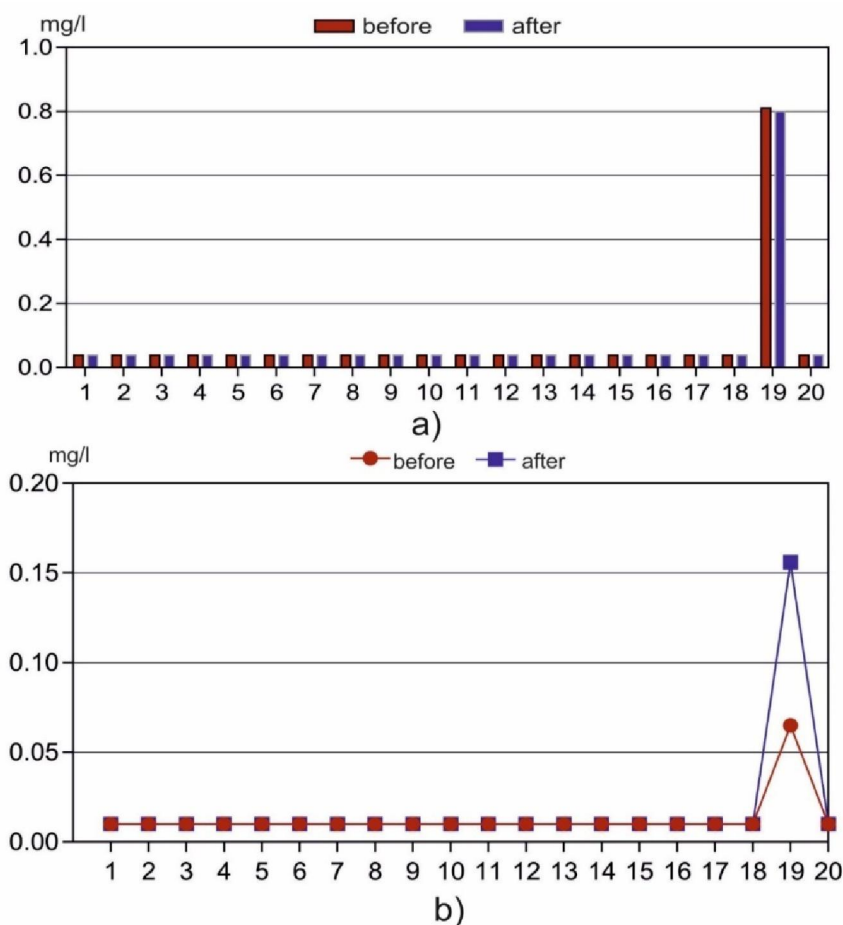


Figure 2 –The content of before and after the season: a) Ammonium nitrogen, b) Nitrite nitrogen



The content of oil/petroleum products in the water did not exceed the maximum permissible concentration limit and varied within the range of 0.02-0.04 mg/l. The most polluted by oil products is the coastal zone of the lake, within which the average content varied from 0.00 to 0.69 mg/l for the period 1975-1982. In the period 1985-1992 and 2000 (figure 3), the content of oil products in the lake's water decreased as a result of the introduction of the K-2 wastewater treatment plants for boarding houses and resorts, thanks to the creation of sanitary protection zones and the prohibition of transportation of petroleum products by water transport [12]. According to [4] in 2016 in the area of the shipyard in Balykchy, there was an excess of 0.07 mg/l for petroleum products.

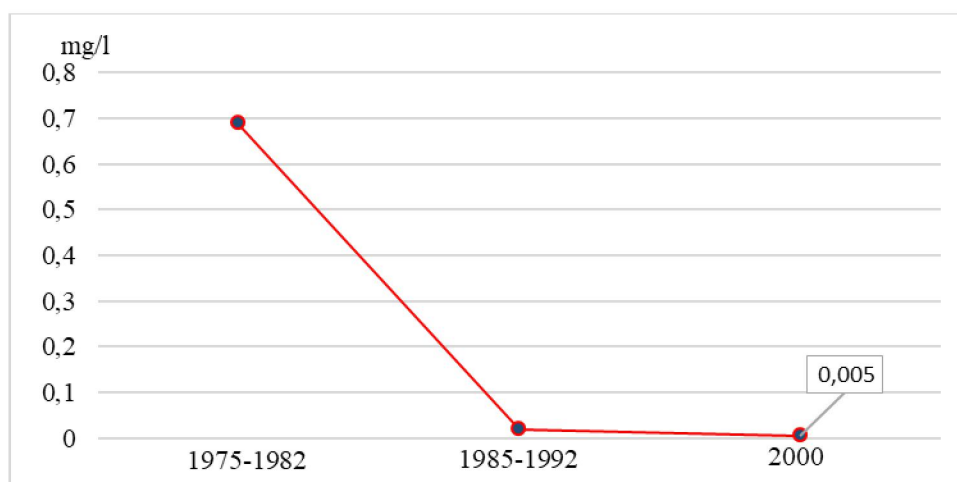


Figure 3 – The contents of petroleum products

The presence of dissolved oxygen in water is important for aquatic organisms. Its concentration depends on both physical (water-air exchange and turbulence), and on chemical (photosynthesis and oxidation) factors. The solubility of oxygen in the lake water depends on temperature, atmospheric pressure and has a seasonal regime [12]. The dissolved oxygen of the coastal zones according to the data obtained in 2016 is from 7 to 10 mg/l (figure 4). The presence of oxygen in almost all the coastal zones indicates the presence of a lake water flow, through which water exchange between the coast and the lake takes place. In addition, it is quite possible to wedge cold spring waters in this area, as there are numerous outcrops along the lake's coastal strip, as well as the presence of aquatic flora (thick algae).

**Conclusion.** The analyzed data show that in general the Issyk-Kul lake water is not exposed to significant pollution. Analysis of the quality of surface water in the study zone shows that the concentrations of certain parameters ( $\text{NH}_4^+$  and  $\text{NH}_2$ ) are relatively high in Balykchi Bay, the content of the remaining parameters does not exceed the MPC. The volume of water in the lake is huge, so while the lake is completely coping with the dissolution of harmful substances to a safe level for organisms. But if there is a saturation of harmful substances, then we can not clean up any forces. Therefore, it is necessary to organize constant monitoring of the Issyk-Kul lake water in order to obtain reliable information on the state of the water of pollutants in the lake water.

**Acknowledgment.** This work was supported by the National Science Foundation of China (U1603242), and the Science and Technology Services Project Fund of the Chinese Academy of Sciences (Y838031001, TSS-2015-014-FW-1-2).

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### **ТУРИСТІК МАУСЫМҒА ДЕЙІН ЖӘНЕ КЕЙІН ЫСТЫҚКӨЛ КӨЛІНІҢ ЖАҒАЛАУ АЙМАҚТАРЫНЫҢ СУЫНЫҢ СУ САПАСЫН ТАЛДАУ**

**Аннотация.** Судың сапасы дегеніміз судың құрамы мен сипаттамасы және оның су қолдану түрлеріне қарай жарамдылығын анықтайды. Табиғи және антропогендік факторлар судың сапасына әсер етеді. Антропогендік факторлар, қатты тұрмыстық қалдықтар және ағынды сулар көлдің жағдайы мен су сапасына әсер етеді. Кейінгі кезде туристер санының өсуі Ыстықкөл көлінің жағдайы мен су сапасына әсер етіп жатыр. Дегенмен, анализ нәтижелеріне сүйенсек, Ыстықкөл көлінің суы айтарлықтай ластанбаған. Көлдің жер үсті сулары қанағаттанарлық жағдайда, бірақ нитриттер және аммонийлы азот ( $\text{NH}_4^+$  и  $\text{NH}_2^-$ ) сияқты кейбір көрсеткіштер концентрациясы Балықшы шығанағында салыстырмалы түрде жоғары, ал қалған көрсеткіштер мөлшері ШРК-ден жоғары емес. Көлдегі су мөлшері ауқымды, сондықтан әзірше көл зиянды заттарды ағзаларға қауіпсіз жағдайға дейін ерітіп жібере алады.

**Түйін сөздер:** Ыстықкөл көлі, су сапасы, мұнай өнімдері, туристік маусым.

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### АНАЛИЗ КАЧЕСТВА ВОДЫ ПРИБРЕЖНОЙ ЗОНЫ ОЗЕРА ИССЫК-КУЛЬ ДО И ПОСЛЕ ТУРИСТИЧЕСКОГО СЕЗОНА

**Аннотация.** Качество воды это характеристика состава и свойств воды, определяющая пригодность ее для конкретных видов водопользования. Природные и антропогенные факторы влияют на качество воды. Антропогенное воздействие, твердые бытовые отходы и сточные воды оказывают негативное влияние на качество воды и состоянии озера. В последнее время увеличение потока туристов влияют на качество воды и состояние озера Иссык-Куль. Однако, согласно результатам анализов, вода бассейна озера Иссык-Куль не подвергается значительным загрязнениям. Качество поверхностных вод озера в удовлетворительном состоянии, однако концентрации некоторых показателей таких как нитриты и азот аммонийный ( $\text{NH}_4^+$  и  $\text{NH}_2$ ) относительно высоки в заливе Балыкчи, и содержание остальных параметров не превышает ПДК. Объем воды в озере огромны, поэтому пока озеро полностью справляется с растворением вредных веществ до безопасного для организмов уровня.

**Ключевые слова:** озеро Иссык-Куль, качество воды, нефтепродукты, туристический сезон.

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