Model Markers of the Aquatic Mountain Ecosystem of Issyk-Kul: Assessment of the Influence of Key Qualitative Parameters

Sharshenbek Jusupkeldiev
Kyrgyz National University named after J. Balasagyn, Faculty of Physics and Electronics

Anar Zaripova
Kyrgyz National University named after J. Balasagyn, International Institute of Medicine and Science

Kalipa Salieva
Chemical Engineering, Faculty of Engineering, Kyrgyz-Turkish Manas University

Bakyt Borkoev
Chemical Engineering, Faculty of Engineering, Kyrgyz-Turkish Manas University

他

https://hdl.handle.net/2324/7395593

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 11, pp.724-728, 2025-10-30. International Exchange and Innovation Conference on Engineering & Sciences
バージョン：

Model Markers of the Aquatic Mountain Ecosystem of Issyk-Kul: Assessment of the Influence of Key Qualitative Parameters

Sharshenbek Jusupkeldiev [1], *Anar Zaripova*[2], Kalipa Salieva[3],Bakyt Borkoev [3], *Alina Kerimbaeva*[4], *Nurila Mambetjanova*[2], *and· Tyrgynbek Nyazov*[5]

[1]Kyrgyz National University named after J. Balasagyn, Faculty of Physics and Electronics, Bishkek, Kyrgyz Republic
[2]Kyrgyz National University named after J. Balasagyn, International Institute of Medicine and Science, Bishkek, Kyrgyz Republic
[3]Chemical Engineering, Faculty of Engineering, Kyrgyz-Turkish Manas University, Bishkek, Kyrgyzstan

[4] Kyrgyz State Medical Academy named after I. K. Akhunbaev, Department of Management andEconomics of Pharmacy, Medicine Technology named after E. S. Matyev, Bishkek, Kyrgyz Republic

[5]Kyrgyz National University named after J. Balasagyn, Faculty of Geography, Ecology and Tourism, Bishkek, Kyrgyz Republic

Corresponding author kalipa.salieva@manas.edu.kg

Abstract: *Climate change is one of the most significant challenges affecting the mountain ecosystem of the Issyk-Kul region, particularly Lake Issyk-Kul. The lake is a vital component of this ecosystem, requiring extensive monitoring and analysis through a broad set of environmental parameters. This study focuses on forecasting the impact of interrelated factors—such as the lake ecosystem, coastal zones, atmosphere, and water quality—on the regional climate. The primary goal is to model the aquatic mountain ecosystem of Issyk-Kul using machine learning and deep learning algorithms to assess the influence of key qualitative parameters, particularly air and water. For this purpose, specific sampling points were selected across the region. At each site, air and water samples were collected and analyzed to evaluate their quality and purity. The findings aim to support environmental monitoring and contribute to developing adaptive strategies for climate resilience in mountainous lake ecosystems.*

Key words: water resource, mountain ecosystem, air basin, climatic indicators, description models, environmental sustainability

Introduction:

Water is essential for sustaining life and maintaining the health of ecosystems worldwide. Monitoring water quality is crucial to detect contamination, manage resources sustainably, and protect both human populations and biodiversity [1,2]. Regular assessment helps identify changes caused by natural or anthropogenic factors, enabling timely interventions to prevent environmental degradation [3,4]. Effective water monitoring is therefore vital for ensuring long-term ecological balance and public health.In modern times, climate change and its consequences can be considered as one of the serious problems disturbing the main parametral indicators of the mountain ecosystem of Issyk-Kul region, in particular Lake Issyk-Kul. The main indicators are considered on the one hand - cleanliness of the air basin, and on the other hand - qualitative parameters of the water resource, directly affecting the normal life activity of the population of this region. This geographic area was not chosen at random, as it is represented by several components of this ecosystem, each contributing to the overall climate agenda of the region [5,6].

The coastal zone of Lake Issyk-Kul is the first part of the ecosystem, including settlements and associated agricultural land. Lake Issyk-Kul - should be considered as the second key component of the ecosystem, which is described, analyzed and monitored using a wide range of parameters. Among these issues should be included: the study of forecasting of the main mutual influencing factors of the lake ecosystem, its coastal zone, atmosphere and water quality, the impact of all these indicators on the climate of the region as a whole. The third important component of the ecosystem is the state of the surface layer, which feeds the entire region with water, directly related to the atmospheric layer, as their interaction is considered as a contact ecosystem of the studied region. Recent studies have demonstrated that mountain lake ecosystems such as Issyk-Kul are highly sensitive to climate fluctuations, which impact both hydrological cycles and biodiversity, thereby necessitating continuous and comprehensive monitoring approaches. [7,8]

The study of these interactions is the main objective of regional policy, expressed in ensuring accelerated socio-economic development of regions to improve the welfare and quality of life of the population through focused support for the development of mountain eco-territories consisting of development centers and the corresponding towns and villages [5-9].

It should be noted that the results obtained were subsequently used as data—quality metrics input for the dataset. The data were decomposed by characteristics and applied in machine learning and deep learning methods and algorithms to study the quality and quantity of surface water, particularly in the summertime. This involved the development of various forecasting and analytical methods for assessing the surface water quality of the coastal zone of Lake Issyk-Kul. This line of research is highly relevant, as it enables the use of artificial intelligence to analyze, monitor, and forecast a wide range of issues related to water quality and the development of forecasting models.

This may involve a step in which characteristics representing a set of variable parameters are collected and subsequently used as base parameters for the algorithms. Analyzing these data and their interrelationships allows for the construction of neural networks—using machine learning and deep learning algorithms—for analyzing and identifying, for example, clean versus polluted water, using selected test images of the water surface.

Another advantage of such a neural model is that the reflectivity of the water surface can be directly used as an input parameter, without the need for additional feature engineering or parameter tuning. Advances in machine learning techniques have significantly improved the accuracy and efficiency of environmental data analysis, enabling real-time predictions and better management of aquatic resources under changing climatic conditions [10-11]

Since the algorithms analyze a wide range of parametric metrics, we considered the possibility of determining qualitative characteristics of water samples collected from various sources, such as the presence of pathogens. These cannot be directly measured using classical methods because they are not optically active, but they can be indirectly estimated using other measurable data—such as the dissolved oxygen (DO) content in selected water bodies. It should be noted that DO is one of the key characteristics that define the quality of surface water, as it reflects the condition of the aquatic ecosystem and its capacity to support the normal life activity of aquatic organisms [12-14].

In this regard, ensuring the viability of mountain eco-territories involves addressing a set of issues related to the study, assessment, and monitoring of both the air basin and the quality of consumed water. These include concerns such as irrational use, uneven distribution, and potential pollution (chemical and biological). Sources of such contamination may include domestic, industrial, and agricultural activities, along with inadequate control over the purity and quality of water resources. Accordingly, the primary goal of this study is to build a model of the aquatic mountain ecosystem of the Issyk-Kul region to comprehensively assess the impact of key qualitative parameters (air and water) using machine learning and deep learning methods and algorithms. To this end, specific sampling points were selected for collecting air and water samples, which were subsequently analyzed for purity and quality.

Objects and Methods of Research

Gas analyzers were used for the study of the air and water basins. Among them was the gas analyzer for air quality (X tester-BR-smart 128s, PM1.0, PM2.5), which enables measurements of dust levels and particles (TVOC), as well as formaldehyde detection. This device, equipped with a laser sensor, allows measurement of microparticles in the air with an accuracy of 0.25 µg/m³.

The main components of greenhouse gases (CO2 and CH4) were identified using specialized instruments: for CO2, the smart HAL-HCO201 with an integrated non-dispersive infrared (NDIR) sensor, sampling pump, and microprocessor; and for CH4, the methane gas alarm detector DZ-1-CH4.

Subjects of the Study: Water resources of the Issyk-Kul region (including rivers, the lake, sewage, groundwater, etc.) were studied to assess and predict the impacts of climate change using artificial intelligence models.

Purpose of the Work: To assess the impact of climate change on the water resources of the Issyk-Kul region using artificial intelligence models.

In the course of the research work conducted for the project, the following scientific activities were carried out:

Collection of data for water quality testing in the Issyk-Kul region, including organoleptic indicators (color, taste, odor, turbidity, etc.);

Collection of data on water hardness, cation content, dissolved oxygen (DO), heavy metal pollution, pH, and water temperature;

Periodic monitoring and analysis of water samples from the Issyk-Kul region.

Time points (8:00, and 12:00–17:00) and specific geographic locations were selected for real-time air and water analyses, which covered the route from Balykchy to Oruktu. This route included two towns and more than 20 aiyls (villages). It was selected due to its high traffic activity and the presence of many private homes that rely on coal for heating. In parallel, water samples were collected in May from relevant territorial points in the Issyk-Kul region.

These samples were subsequently analyzed for nitrogen content, cations, heavy metal pollution, pH, and turbidity.

Results and Discussion

Air basin measurements were conducted in the coastal zone of Lake Issyk-Kul and along the main route from Sary-Kamysh to Orto-Örüktü, including Cholpon-Ata and the settlements in between (see Fig. 2).

Fig.2. Geographical location of the main measurement points : Issyk-Kul oblast, Latitude: 42°26′1″ Longitude: 77°15′46″; Area: 6236 km².

Since the objects of the study were water samples from various sources (collected during spring sampling), each analytical mode included sample preparation tailored to the experimental conditions. A preliminary series of analyses focusing on the organoleptic indicators of these samples was conducted. To this end, an initial evaluation was carried out both in field expedition settings and laboratory conditions by determining key organoleptic parameters: color, odor, odor variation with temperature change, and taste.

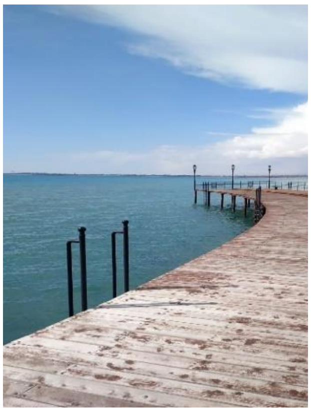
It is well known that organoleptic indicators are used to characterize the quality of water intended for consumption, as they rely on human sensory perception—sight, taste, touch, and smell. Thus, organoleptic assessment of water quality is considered a rigorous, essential, and foundational procedure that forms part of the sanitary and chemical control of water resources. Such assessments often utilize standardized test scales and reference tables, which ensure systematic and accurate evaluation.

Real-time studies conducted in May 2025 along the selected section of the route yielded data on the content of CO_2 and CH_4 in air samples. These studies revealed that elevated CO_2 levels were primarily due to anthropogenic impacts, particularly the increased motor traffic on the route caused by the seasonal rise in the number of holidaymakers (see Table 1).

Table 1. Average Gas Concentrations in the Selected Area of the Issyk-Kul Basin (May 2025; Sampling by Location and Time)

№	Towns and villages	Distance, km	CO_2	CH_4	Sensors for measurement	
					PM2.5	PM10
1	Bishkek	1	364-460	0.02	22-27	26-31
2	Balykchy	164	343-364	0.02	8-12	11-15
3	Tamchy	220	321-346	0.02	6-9	8-14
4	Chon-Sary-Oi	235	426-471	0.02	5-7	7-11
5	Cholpon-Ata	255	460-475	0.02	13-23	12-26
6	Temir	280	382-397	0.02	14-21	11-23
7	Ananyevo	300	325-370	0.04	18-23	14-21
8	Өгүктү	340	300-356	0.03	9-13	12-15

Since the main indicators of our study were air cleanliness near the coastal zone of Lake Issyk-Kuy, we conducted additional analyses of lake water, according to the selected time and place of monitoring (fig. 3.).




a B


c D

Fig. 3.Inspection and study of the water surface and coastal zone of Lake Issyk-Kul at different geographical points

Thus, the determination of pH in selected water samples not only reflects the acid-base equilibrium of the water but is also regarded as one of the most critical indicators influencing the overall quality of the water resource intended for consumption. In general, pH significantly impacts the biological activity of aquatic organisms, the chemical forms of elements present in the water, and their migration patterns. The pH value is influenced by several key factors: the concentration of carbonate compounds, the intensity of photosynthetic processes and the associated decomposition of organic matter, and the distribution of humic substances. Typically, the pH of surface waters ranges between 6.3 and 8.5 (see Table 2).

Table 2.Data of water resource sampling points

№	Sampling points	Description of the sampling location	Absolute height of the point, m
1	J-1	Zhyrgalan River, near Zhyrgalan	1617

		resort	
2	T-2	Tyup River, at the junction with the main road	1611
3	O-3	Ortho-Oruku, under the bridge, at the junction with the motorway	1668
4	G-4	Chon-Ak-Suu River, at the intersection with the motorway	1744

The analyses carried out on these rivers: Zhyrgalan (J-1), Tyup (T-2), Ortho-Oryuktyu (O-3) and Chon-Aksuu (G-4) using the CyberScan Eutech PCD 650 instrument showed the following parameter values (Table 2):

Table 3.Parametric data on water samples from rivers in Issyk-Kul oblast

Parameter	J-1	T-2	O-3	G-4
pH	↑ 7.60 → 8.45	↑ 8.01 → 8.40	= 9.00	↑ 8.10 → 8.35
Temperature (t°C)	↓ 17.00 → 10.35	↓ 21.20 → 11.25	= 13.15	↓ 12.91 → 9.42
ОВП (mV)	= 8.63	= 7.23	= -1.95	= -4.83
Conductivity (µS)	↓ 182.30 → 162.30	↓ 175.96 → 155.96	↓ 123.13 → 103.13	↓ 134.65 → 104.65
TDS (ppm)	↓ 175.35 → 155.35	↓ 165.61 → 148.56	↓ 141.45 → 121.43	↓ 147.82 → 127.33
NaCl (ppm)	↓ 166.20 → 136.30	↓ 152.75 → 132.24	↓ 135.05 → 110.65	↓ 124.78 → 109.60
Resistivity (kΩ)	↑ 3.05 → 3.78	↑ 2.85 → 3.13	↑ 3.39 → 3.65	↑ 3.31 → 3.52
DO (mg/L)	↑ 7.61 → 8.09	↑ 6.14 → 9.75	= 9.01	↑ 8.90 → 9.40
Мутность (FTU)	↓ 81.00 → 37.41	↑ 37.75 → 61.00	= 12.94	↓ 54.90 → 10.53

Additionally, lake water samples were chemically analysed for the presence of metal ions in selected samples, salinity, hardness, pH (table 4.-5.).

Table 4.Main parameters of investigated water samples

№	Samples	Stiffness values, ^{0}S	pH	t°C
1.	S - I	8.65	6.85	13.2
2.	S - II	8.75	6.75	14.3
3.	S – III	9.50	6.50	14.3
4.	S – IV	10.55	6.55	14.4
5.	S – V	9.85	6.85	15.1
6.	S – VI	9.45	6.80	14.2
7.	S – VII	10.10	6.90	14.3
8.	S – VIII	9.85	6.85	14.4
9.	S – IX	10.25	6.55	15.1
10.	S – X	10. 05	6.50	14.3
11.	S – XI	10.75	6.75	14.2
12.	S – XII	10.15	7.15	14.3
13.	S – XIII	9.25	6.95	14.5
14.	S - XIV	9.95	6.95	14.4
15.	S - XV	9.90	6.90	13.2

Table 4.Values of the content of major ions contained in the analysed water samples

№	Samples	Ca^{2+}, mg/dm^3	Mg^{2+}, mg/dm^3	Cl^-,	SO_4^{2-}, mg/dm^3	CO_3^{2-}, mg/dm^3	Fe^{2+}/ Fe^{3+}, mg/dm^3
1.	S - I	22	2.75	2.2	11	75	0.155
2.	S - II	25	2.56	2.5	12	79	0.125
3.	S – III	25	2.55	2.5	12	79	0.145
4.	S – IV	24	2.48	2.4	12	73	0.176
5.	S – V	27	2.71	2.7	12	65	0.175
6.	S – VI	26	2.62	2.6	12	60	0.180
7.	S – VII	28	2.80	2.8	12	65	0.165
8.	S – VIII	28	2.84	2.8	12	70	0.160
9.	S – IX	26	2.66	2.6	12	75	0.164
10.	S – X	25	2.54	2.5	11	78	0.184
11.	S – XI	27	2.73	2.7	11	77	0.155
12.	S – XII	28	2.81	2.8	12	75	0.125
13.	S – XIII	29	2.90	2.9	11	72	0.145
14.	S - XIV	26	2.63	2.6	11	88	0.176
15.	S - XV	25	2.56	2.2	11	70	0.155

It should be noted that the chemical analysis of the selected samples revealed average values for the investigated parameters, representing the most characteristic indicators for such sites. The results obtained from the spring (May) sampling were used to enhance the array of model markers and input them into the Big Data system. Water resource sites are studied periodically, and each sampling point is subsequently incorporated into a comprehensive model series. Synchronizing the data by time and location enables the construction of predictive models using machine learning and deep learning algorithms to analyze and evaluate the resulting data.

In this context, samples from various water sources across the Issyk-Kul region were selected and analyzed as part of a temporal monitoring effort. The results of the May sampling for both air and water quality, corresponding to specific times and locations, were obtained as test data. These results will serve as inputs for constructing predictive models using advanced machine learning and deep learning techniques.

References

1. Mohd Aliff Mohd Anuar ; Mohd Shalahuddin Mohd Adnan ; Mohamad Hafiz Hassanet al.Morphometric Analysis of the Pahang River Basin and Its Sub Basin System at Pahang State, Peninsula Malaysia Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 10, pp. 868 - 873, 2024-10-17.

2. Meriam Makinano-Santillan ; Michelle V. Japitana ; Arnaldo C. Gagulaet al Land-cover Characterization and Water Quality Assessment of the Sambunotan Watershed, Dinagat Islands in Support of the Development of the Watershed Management Plan/ Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 10, pp. 910 - 915, 2024-10-17.

3. Lubsanova, T. M. "Soil Respiration of the Selenginsk Middle Mountains." *Proceedings of the International Scientific Conference: Spatio-Temporal Organization of Soil Cover: Theoretical and Applied Aspects*, 270–72. St. Petersburg, 2007.
4. Makarov, V. V., and M. V. Sereda. "Features of Agricultural Technology of Rice Cultivation in the Rostov Region." *Scientific Journal of KubGAU* 79 (2012).
5. Zhusupkeldiev, Sh., A. Zhumabekov, et al. "Measurements of Charges of Suspended Particles in the Issyk-Kul Basin." *Vestnik Kyrgyz National University* 4, no. 100 (2019): 167–72.
6. Zhusupkeldiev, Sh., et al. "Measurements of Charges of Suspended Particles in the Issyk-Kul Basin." *News of Osh Technological University* 1 (2018): 152–60.
7. Kerimbaeva, A. D., N. N. Mambetjanova, A. A. Zaripova, and S. P. Li. "Humic Composites – Sorbents for Analysis of River Water Quality." In *XIII International Scientific and Practical Conference*, 120. Les Ulis: MBFA, 2024.
8. AmnestyEurasia. "Что мы делаем: Изменение климата." Accessed May 31, 2025. https://eurasia.amnesty.org/chto-my-delaem/izmenenie-klimata/.
9. Mambetjanova, N. N., A. D. Kerimbaeva, O. Abyshev, A. A. Zaripova, et al. "Study and Assessment of Qualitative Indicators of Water Sources in the Issyk-Kul Mountain Ecosystem." BIO Web of Conferences 160 (2025).
10. Prana Air. "What Is Hydrogen Sulfide (H_2S)?" Accessed May 31, 2025. https://www.pranaair.com/ru/what-is-hydrogen-sulfide-h2s/.
11. Alifujiang, I., J. Abuduwaili, B. Maihemuti, M. Groll, and G. Isanova. "Changes in Intra-Annual Runoff and Its Response to Climate Variability and Anthropogenic Activities in the Issyk-Kul Lake Basin, Kyrgyzstan." 2020.
12. *Law of the Kyrgyz Republic on the Country's Adherence to the UN Ramsar Convention*, April 10, 2002, no. 54. Bishkek.
13. Sharma, Chandra, and Anil K. Shukla. "Climate Change and Its Impact on Mountain Lakes: A Review." *Environmental Monitoring and Assessment* 192, no. 3 (2020): 181.
14. Li, Xiaowei, and Ming Chen. "Applications of Machine Learning in Water Quality Monitoring and Prediction: A Review." *Environmental Science and Pollution Research* 29, no. 12 (2022): 17450–64.