Chapter 12
Physical–Chemical Properties of the Kyzyl-Suu River and Its Tributaries, Kyrgyzstan

Zheenbek E. Kulenbekov and Baktyiar D. Asanov

Abstract The article presents the results of studies of the Kyzyl-Suu River and its two tributaries, the Daara River (Daroot-Korgon village) and the Aryk-Suu River (Sary-Tash village). The study was carried out as part of the PEER NAS USAID project: "Integrated Water Resources Management of the Amu Darya and Kabul Rivers". Physical parameters of water, such as pH, temperature, electrical conductivity, resistance, etc., obtained in the field using the CyberScan Eutech PCD 650 instrument recommended by the US Environmental Protection Agency. Anions were measured in the chemical laboratory of the American University of Central Asia (AUCA). Bioindication of hydrobionts was carried out in the laboratory of ichthyology and hydrobiology of the Biological and Soil Institute of the NAS of the Kyrgyz Republic. The measurement was carried out at two points in the Kyzyl-Suu River (near the villages of Sary-Tash and Daroot-Korgon) and at two points on the Daara River (before and after the village of Daroot-Korgon), respectively, two points on the Aryk-Suu River (before and after village of Sary-Tash). Water samples were also taken. The results of the analysis for anions show that the content of chlorides, sulfates, nitrates, bicarbonates and phosphates, according to SanPin 2.1.4.559-96, GN 2.1.2.689-98, does not exceed the maximum permissible concentration (MPC) at any of the water sampling points. According to the results of bioindication, we can conclude that the water from the rivers is "clean". Abnormal values of pH, temperature, electrical conductivity, resistance, total dissolved salts, NaCl, and dissolved oxygen were not observed at the measurement points. However, it should be noted that all the measurement results have a tendency to increase after each settlement, albeit slightly, i.e., there is a certain anthropogenic impact on these rivers.

Keywords Anions · AUCA · CyberScan eutech PCD 650 · PEER NAS USAID

Z. E. Kulenbekov (✉) · B. D. Asanov
American University of Central Asia, 7/6 Aaly Tokombaev Str, Bishkek, Kyrgyzstan
e-mail: kulenbekov_z@auca.kg

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12.1 Introduction

The implementation of the PEER NAS USAID project, “Integrated Water Resources Management and Strategic Environmental Assessment of the Amu Darya and Kabul Rivers,” began in 2017 and will continue until the end of 2019. Three universities are participating in the project: Kabul University (Afghanistan); Mining and Metallurgical Institute of Tajikistan (Tajikistan); American University of Central Asia (AUCA) (Kyrgyzstan). AUCA is the regional coordinator of the project.

Measurements of physicochemical parameters and bioindication of the Kyzyl-Suu River and tributaries of the Daara and Aryk-Suu were not carried out. On the Kyzyl-Suu River, only water flow is measured. In the Kyrgyz Republic, research under the project is carried out in the Chon-Alai region, the village of Daroot-Korgon and in the Alai region, the village of Sary-Tash. These villages are located in the immediate vicinity of the Kyzyl-Suu River. The Kyzyl-Suu River is formed within the Alai Valley. The average water flow is quite high, about 65 m^3/s, and it eventually flows into the Vakhsh River outside of Kyrgyzstan’s borders. The Vakhsh River is the right tributary of the Amu Darya River.

This article presents the results of bioindication and some physicochemical analyses of the water of the Kyzyl-Suu River and its two tributaries, the Daara and Aryk-Suu Rivers.

The purpose of this article is to study the physicochemical characteristics of the Kyzyl-Suu River and its tributaries, to evaluate and analyze the main changes in the physicochemical composition of the water of rivers and its tributaries, as well as its current state. Based on the results of a literature review of this kind, an assessment and analysis of the Kyzyl-Suu River and its tributaries were not found, and therefore, this study may be the first of its kind carried out in this region of Kyrgyzstan.

12.1.1 Research Methodology and a Brief Description of the Determined Parameters

For sampling and measurement, two points were identified in the Kyzyl-Suu River, two sampling points on the Daara River and, accordingly, two points on the Aryk-Suu River, all points are shown in Fig. 12.1.

1. Kyzyl-Suu 1—located on the Kyzyl-Suu River, after the settlement of Sary-Tash;
   - 1.1 Aryk-Suu 1—located on the Aryk-Suu River, to the village of Sary-Tash;
   - 1.2 Aryk-Suu 2—located on the Aryk-Suu River, after the settlement of Sary-Tash;
2. Kyzyl-Suu 2—located on the Kyzyl-Suu River, after the village of Daroot-Korgon;
   - 2.1 Daara 1—located on the Daara River, to the village of Daroot-Korgon;

Fig. 12.1 Measurement and sampling points

2.2 Daara 2—is located on the Daara River, after the village of Daroot-Korgon.

Using the modern instrument, CyberScan Eutech PCD 650, data on pH, electrical conductivity, resistance, dissolved salts, oxygen, and water temperature was obtained at the sampling site. The CyberScan Eutech PCD 650 is very user-friendly and has a wide measuring range [1].

The pH value characterizes the acid-base balance in water and it is one of the most important indicators of water quality. The development of aquatic organisms, the formation of various elements and much more depends on pH. Generally, the pH values of natural water bodies range from 6.3 to 8.5. The pH value is affected by the state of carbonate equilibrium, the intensity of photosynthesis, and the decomposition of certain substances, as well as the content of humic substances [2].

Electrical conductivity is the quantitative characteristic measuring water's ability to conduct electric current. In most cases, the electrical conductivity of land surface water is an approximate measurement of the concentration of inorganic electrolytes in water, namely, cations and anions. The conductivity of surface water of the land depends mainly on the water's mineralization and usually ranges from 50 to 10,000 μS/cm [3]. Naturally, water temperature and dissolved oxygen are of great importance for aquatic organisms. Water temperature is indicated in degrees Celsius (°C), and dissolved oxygen in percent (%) and milligram per liter (mg/L).

Sampling for the analysis was carried out according to the rules of sampling, storage, and transportation of samples was conducted in accordance with GOST R

51592, GOST 17.1.5.05, GOST 24902, ISO 5667. Water samples were analyzed for chlorides, sulfates, nitrates, etc., at the AUCA chemical laboratory. All parameters selected for analysis are arguably the most important indicators of water quality. Chlorides and sulfates in drinking water do not have a toxic effect on humans, but they worsen the taste of water, the taste of sulfates and chlorides arises at a concentration of 250–400 mg/L. The increased nitrate content in water can serve as an indicator for the pollution of a reservoir as a result of the spread of fecal or chemical pollution (agricultural or industrial). The high nitrate content in water stimulates the mass development of aquatic vegetation. Drinking water and foods containing an increased amount of nitrates can cause various diseases in humans [4].

In addition to chemical assessment, biological methods for determining quality play an important role in determining water quality. Assessing the quality of the habitat and its individual characteristics according to the state of biota in natural conditions is called bioindication. Bioindicators are defined as species or groups of species or communities by presence, degree of development, and changes in morphological, structural, functional, and genetic characteristics. These aforementioned bioindicators help to judge the quality of water and the state of an ecosystem [5].

The selection of hydrobionts was carried out according to the directions of ISO 7828. Biondication was carried out in the laboratory of ichthyology and hydrobiology at the Biological Soil Institute in the NAS of the Kyrgyz Republic.

12.2 Results

To clarify, all data obtained in the field are averaged and shown in Table 12.1. As shown here by the results of measurements, no anomalous phenomena were revealed in the sampled river waters. In all sampled rivers, the average water temperature rises downstream. This rise in temperature can be explained by the change in altitude changing air temperatures. According to temperature data from the sampled rivers, there is no reason to discuss temperature pollution.

In accordance with the requirements for the composition and properties of water and water within recreation, as well as for other water bodies, the pH should not go beyond the range of values 6.5–8.5 [6]. As shown, the results are not outside of the normal range of pH values. Water at pH 6.5–7.5 is neutral and is explained by the presence of $Ca(HCO_3)_2$, $Mg(HCO_3)_2$ in them.

The electrical conductivity of natural water depends mainly on the concentration of dissolved mineral salts and temperature. Natural waters are mainly solutions of mixtures of strong electrolytes. The mineral part of the water is made up of Na + , K + , Ca_2 + , Cl−, SO_4^{2-}, HCO_3− ions [7]. As can be seen from Fig. 12.2, the electrical conductivity of downstream increases, which indicates an increase in the salinity of water.

In natural water, the value of the redox potential ranges from minus 400 to plus 700 mV. Redox potential is determined by the totality of the oxidation and reduction

Table 12.1 Average values for sampling points measured with the CyberScan Eutech PCD 650

Parameters	Kyzyl-Suu 1 (Sary-Tash)	Kyzyl-Suu 2 (Daraot-Korgon)	Aryk-Suu 1	Aryk-Suu 2	Daara 1	Daara 2
pH	7.20	7.63	7.15	7.67	7.18	7.22
Temperature (°C)	10.90	11.27	6.20	6.53	9.23	12.57
* RP, mV	−10,45	−37,17	−8,80	−39,80	−8,13	−12,77
Conductivity (µS)	680,10	945.83	317,93	429,35	390,43	386,30
**TDS (mg/L)	372,32	472,91	400,37	412,70	374,17	370,47
NaCL (mg/L)	352,83	410,93	373,90	395,85	352,00	353,67
***DO (%)	70,37	74,03	69,53	77,05	68,40	72,33
***DO (mg/L)	5,44	5,68	5,53	5,66	5,37	5,51

* RP—redox potential
** TDS—Total Dissolved Solids
*** DO—Dissolved Oxygen

processes occurring in it. Under equilibrium conditions, the redox potential characterizes the medium immediately relative to all elements with variable valency. The study of redox potential makes it possible to identify natural environments where the existence of chemical elements with variable valency in a certain form is possible, as well as to highlight the conditions under which metal migration is possible [8]. According to the types of geochemical conditions in natural waters, the RP value is characterized by values <0 refers to the reductive type. The water at all measurement points has been designated as the reducing type, since it has negative values.

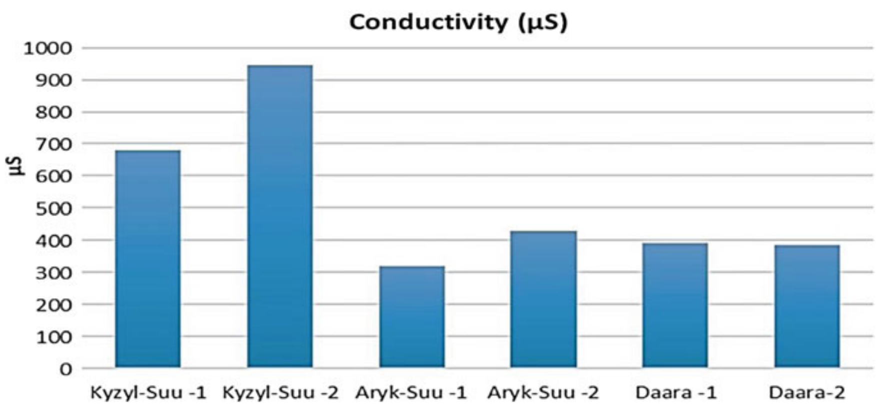

Fig. 12.2 Electrical Conductivity of rivers

Table 12.2 The results of chemical analyzes of water

Parameters, mg/L	Kyzyl-Suu 1	Kyzyl-Suu 2	Aryk-Suu 1	Aryk-Suu 2	Daara 1	Daara 2	MPC, mg/L
Chlorides (Cl^-)	133,13	266,25	80	53,25	44,38	85,2	350
Sulphates (SO_4^{2-})	<100	<100	<100	<100	<100	<100	500
Nitrates (NO_3^-)	1	1	1	1	1	3	45
Ammonium (NH_4^+)	0,7	1	0,2	0,5	1,5	1,5	2,5
Hydrocarbonates (HCO_3^-)	244	366	183	213,5	152,5	152,5	1000
Orthophosphates (PO_4^{3-})	0,2	0,2	0,2	0,2	0,2	0,5	3,5

The average values of chlorides, sulfates, nitrates, and ammonium are listed in Table 12.2. According to these parameters, we can confidently say that at no point the MPC exceeded. The value of chlorides almost doubles in the Daara River, after the village of Daraot-Korgon. We observe the same trend downstream in the Kyzyl-Suu River. But in the Aryk-Suu River, a decrease in chlorides is observed downstream.

The content of sulfates and nitrates at all points of sampling remains unchanged. An exception is the nitrate content on the Daara River, which doubles after the village of Daroot-Korgon. The ammonium content at almost all points of sampling increases downstream, although not significantly. The content of orthophosphates and bicarbonates also slightly increases downstream and does not exceed the norm at any point.

As seen in Table 12.3, the structure of zoobenthos is extremely mosaic (i.e. at various sampling stations, various species of benthic organisms are present). In total, 18 species of invertebrates were found in the Daara River. The water quality in general, according to the table, can be assessed as "pure", according to the generally accepted classifications [9].

As seen in Table 12.4, the species composition is very poor, zoobenthos is dispersed over different watercourses. It is not possible to judge the quality of water at these points, due to lack of data.

No hydrobionts were found in the water of the Kyzyl-Suu River. The poor species composition can be explained by the hydrological conditions of the Kyzyl-Suu River. Specifically, a large number of suspended particles in water, which have an "emery" effect, do not allow bottom invertebrates to catch on substrates.

12.3 Conclusion

The results of the analyses of anions show that at no water sampling point do the contents of chlorides, sulfates, nitrates, bicarbonates, and phosphates according to SanPin 2.1.4.559–96, GN 2.1.2.689–98 exceed MPC [10]. Based on the results of bioindication, we can conclude that the water in the Daara River is "clean". It was

Table 12.3 The structure of bottom invertebrates (zoobenthos) of the Daara River

Species composition	Daara 1	Daara 1 (silt)	Daara 1 (flushing from stones)	Daara 2	Daara 2 (flushing from stones)
Chironomid larvae:					
Diamesa insignipes	–	+	–	+	+
Diamesa pseudostylata	+	+	+	+	+
Orthocladius thienemanni	–	–	–	+	–
Eukiefferiella sp.	–	+	–	–	–
Thienemannimyia sp.	–	+	–	–	–
Simulid larvae:					
Metacnephia sp.	+	–	+	+	+
Simulium sp.	+	–	–	–	–
Larvae of other dipterans:					
Deuterophlebia mirabilis	+	–	–	–	–
Blepharicera asiatica	–	–	+	–	–
Athericidae basilica	+	–	–	–	–
Mayfly Larvae:					
Epeorus (Iron) из группы montanus	+	+	–	+	–
Epeorus (Ironopsis) rheophilus	–	–	–	–	+
Rhithrogena tianshanica	–	–	+	–	–
Ecdyonurus sp.	–	–	–	+	–
Baetis venustulus	+	–	–	–	–
Baetis kulindrophtalmus	+	+	–	–	–
Springtime larvae:					
Filchneria mongolica	–	–	–	–	+
Amphinemura sp.	–	–	–	+	–
Total species: 18	8	6	4	7	5

Table 12.4 The structure of bottom invertebrates (zoobenthos) of the Kyzyl-Suu and Aryk-Suu Rivers

Species composition	Aryk-Suu 1 (flushing from stones)	Aryk-Suu 1	Aryk-Suu 2 (flushing from stones)	Aryk-Suu 2
Chironomid larvae:				
Diamesa pseudostylata	–	–	–	+
Syndiamesa branickii	–	+	–	–
Eukiefferiella alpestris	–	–	+	–
Larvae of other dipterans:				
Tipula (Yamatotipula) sp.	–	–	–	+
Mayfly Larvae:				
Epeorus (Iron) из группы montanus	+	–	–	–
Baetis kulindrophtalmus	–	–	+	–
Caddis flies:				
Hydropsyche guttata	+	–	–	–
Integripalpia[a]	–	–	+	–
Total species: 8	2	1	3	2

[a] the larvae were damaged, so it was not possible to determine either the genus or species

not possible to determine the water quality in the Kyzyl-Suu River using bottom invertebrates, since no zoobenthos were found in the river. In the Aryk-Suu River, it is also not possible to judge the quality of water due to the poor species composition found there. Abnormal values of pH, temperature, electrical conductivity, resistance, total dissolved salts, NaCl, and dissolved oxygen were not observed at the measurement points. However, it is worth noting that all values, albeit not significantly, tend to increase after each settlement. From which we can conclude that there is a slight anthropogenic impact on the rivers. This is most likely due to animal husbandry, since there are no industrial emissions in the settlements near the sampled rivers. This study indicates that there is a need for annual monitoring of the water quality of the Kyzyl-Suu River and its tributaries.

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