SATBAYEV UNIVERSITY
Engineering Journal of Satbayev University
Volume 146 (2024), Issue 1, 30-38

https://doi.org/10.51301/ejsu.2024.i1.05

Water quality of the Syrdarya River and groundwater of the Kyzylzharma field in the Kyzylorda region (Kazakhstan)

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Abstract. This research's purpose is to monitor changes in the water quality of the Syrdarya River and groundwater of the Kyzylzharma field for the sustainable supply of drinking water to the city of Kyzylorda, Kazakhstan. This article presents the results of chemical analyzes of natural waters of the Syrdarya River, taken from river water in the direction of flow, in the territory of Zhanakorgan, Kyzylorda and Kazaly. The results of the quality of groundwater used in some wells are presented in comparison with the drinking water standards in force in Kazakhstan.It should be noted that in the area of the Kyzylorda field, the mineralization of groundwater is 0.8-1.1 g/l, the sulfate content in the water of individual production wells reaches 690 mg/l, and the total hardness of groundwater is up to 14 mEq/l. The results of an assessment of possible changes in groundwater quality are presented. According to forecasts for February 16, 2038, the greatest increase in groundwater mineralization (by 0.22 g/l) will occur in wells with map numbers 131, 133, 135.

Keywords: *natural water, Syrdarya River, groundwater, Kyzylzharma field, water quality, chemical composition, change in groundwater quality.*

1. Introduction

The state of the environment and its components increasingly influences economic development, health and life expectancy. That is why protection of the environment and, especially, water bodies from pollution and depletion is one of the most important tasks in the modern world [1-2].

The chemical composition of water is of great importance, since it can influence the course of diseases, in particular those caused by excessive intake of microelements into the human body [3].

The main problem currently is the pollution of natural waters by various pollutants: pesticides and toxic chemicals, oil and petroleum products, surfactants. Increasing pollution of water bodies and drains is observed in all industrial countries [4].

Many infectious diseases of animals and humans are transmitted through water. The causative agents of these diseases are transmitted by ingesting water contaminated with human or animal feces containing pathogenic bacteria, viruses and parasites (protozoa, parasite eggs). They can survive in water for varying periods of time depending on many factors. Monitoring the safety of water sources is based on determining parameters indicating pollution caused by wastewater, animal excrement, waste storage, manure and artificial fertilizers, etc. [5-6].

Supplying the population with drinking water in sufficient quantities has important social, sanitary and hygienic significance and protects people from epidemic diseases spread through water [7].

Despite certain improvements in the provision of drinking water, today a significant part of the population of the Republic of Kazakhstan is still not fully provided with water of appropriate quality [8].

At the same time, the Republic of Kazakhstan belongs to territories with a fairly low supply of fresh surface and groundwater resources, and not all of them are suitable for use as sources of domestic drinking water supply [9].

The shortage of fresh surface water is forcing many countries to increase their use of groundwater. Groundwater as an object of law occupies a special position among all types of natural resources. On the one hand, they are contained in the subsoil and have the main characteristics of minerals, on the other hand, they are part of the general water resources of the land [10].

The anthropogenic impact on groundwater has also become especially noticeable in the current century due to the development and intensification of industry and agriculture, the growth of large cities and the expansion of urban areas. It manifests itself in the depletion of groundwater reserves and deterioration of their quality [11].

Groundwater is significantly different from other minerals. Groundwater resources, their quality, and therefore suitability for use can vary significantly over time [12]. Therefore, it is important to be able not only to assess their current state, but also to predict the future.

The purpose of this research is to monitor changes in the water quality of the Syrdarya River and groundwater of the Kyzylzharma field for the sustainable supply of drinking water to the city of Kyzylorda.

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Engineering Journal of Satbayev University. eISSN 2959-2348. Published by Satbayev University

2. Materials and methods

The Kyzylorda region is located in the lower reaches of the Syrdarya River and occupies a low-lying plain, a significant part of which is covered with massifs of aeolian sands (Fig. 1). In the north these are the Aral Karakum Desert, in the south – the Northern Kyzylkum Desert. The eastern part of the region is framed by the northwestern end of the Karatau ridge, and in the west it covers the northern and eastern coasts of the Aral Sea. The described territory is located within the inland zone of deserts and semi-deserts, which is characterized by a sharply continental climate with high amplitudes of fluctuations in annual, seasonal and daily temperatures, relatively mild winters, hot and dry summers. In winter, fairly severe frosts alternate with frequent and sometimes prolonged thaws. In winter, the air temperature is usually down to –100ºC, but minimum values can reach –370ºC. The snow cover is thin and unstable. In summer, daytime air temperatures range from +25 to +330ºC, reaching –450ºC in some years.

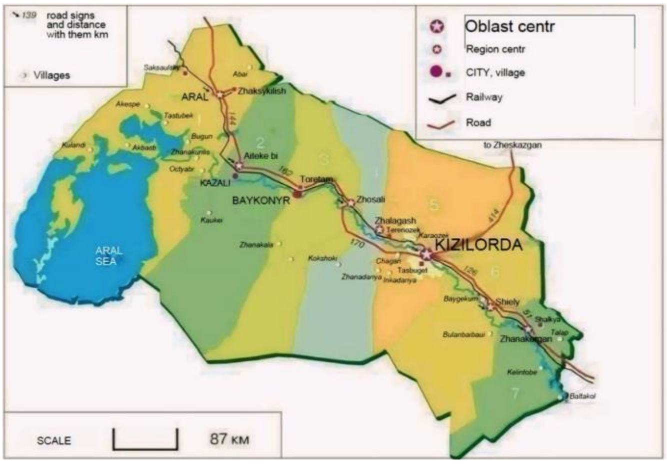

Figure 1. Map of Kyzylorda region

Atmospheric precipitation is distributed very unevenly over the seasons. The maximum amount of precipitation falls in the winter-spring period. In summer, rains occur 1-3 times a season and are short-lived. The average annual precipitation is 110-150 mm per year. Almost all settlements are concentrated along the Syrdarya River and the railway line passing through the entire territory of the region wich area is 226.02 thousand km^2 [13].

The city of Kyzylorda is the administrative center of the Kyzylorda region. The official population of the city for 2022 was 277.678 people [14].

The provision of drinking water in the city of Kyzylorda is carried out by the State Municipal Enterprise under the right of economic management «Kyzylorda su zhuyesi». On average, the city consumes water 200.000.0 m³/day. Currently, water supply to the city of Kyzylorda is carried out from two sources: - from a surface source - the Syrdarya River; - from underground sources – wells of the Kyzylzharma and Kyzylorda fields.

At the site of water intake facilities for treatment from an open source (Syr Darya River) for drinking water supply, the following complex of water treatment facilities operates:

1. Understream water intake.
2. Pumping station of the 1st lift, design capacity – 46.0 thousand m^3/day.
3. Two filtration stations with a total capacity of 56.5 thousand m^3/day.
4. Chlorination shop. Automatic vacuum chlorinator AHB-1000 – 1 piece, designed for dosing chlorine gas and chlorinating drinking water.
5. Coagulant reagent workshop, automatic dosing unit for preparing coagulant solution ALEBRO Mixlain 7100 with a total capacity of 2000 l/hour.
6. Clean water tanks – 5 pcs. with a total volume of 18800 m^3.
7. Pumping station of the 2nd lift with a design capacity of 65.23 thousand m^3/day.

Groundwater collection from Quaternary alluvial deposits is carried out from 20 wells linearly located along the river bed at a distance of 100 m. The depth of the wells is 60-65 m, the distance between them is 237 m. The number of wells is 113 pieces.

We have carried out research work to study the quality of water from surface and underground (Kyzylzharma field) water supply sources for the city of Kyzylorda. To study the quality of water in the Syrdarya River, samples were taken from river water in the direction of flow, that is, in the territory of Zhanakorgan, Kyzylorda and Kazaly. Water sampling was carried out in 2021-2022 in accordance with [15]. The layout of observation sites for sampling is shown in Figure 2.

Figure 2. Layout of observation positions

In order to determine the chemical composition of groundwater, water samples were taken from wells 1-ts, 2r, 4r and 1721. The observation method during the pumping process is generally accepted [16]. At the end of pumping, water samples were taken for the necessary types of analysis. The layout of the wells in which sampling was carried out is shown in Figure 3.

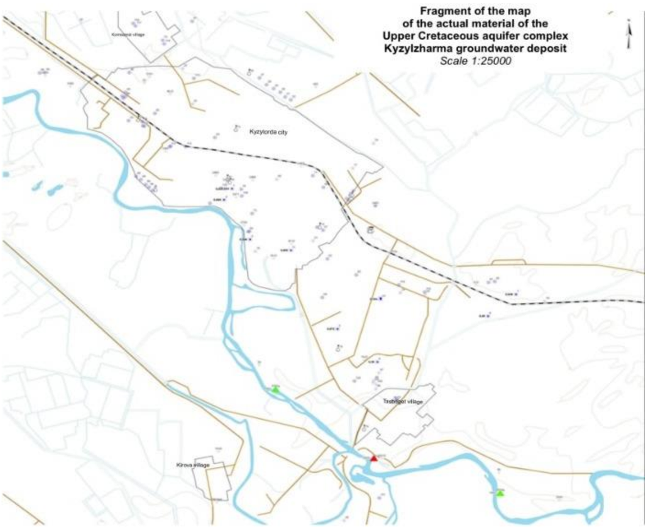

Figure 3. Layout of wells in which sampling was carried out

Laboratory analyzes of samples from the Syrdarya River and groundwater were carried out using photometric, flame-atomic absorption, spectrometric measurement methods using a spectrometer, photocalorimeter and oil product analyzer with a fluorimeter, in a certified laboratory of the «Institute of Hydrogeology and Geoecology named after U. Ahmedsafina».

3. Results and discussion

3.1. Characteristics of water quality of the Syrdarya River

The Syrdarya River is formed far beyond the borders of Kazakhstan at the confluence of the Kara Darya and Naryn rivers. The total length of the river is 2660 km, the basin area is 462 thousand km^2. The banks of the Syrdarya are low, composed of loess-like loams and sands. The river often washes them out and moves its bed across the plain, forming branches and channels. The average slope of the river bed is 0.002-0.003. The river's feeding is mixed. It receives the greatest amount of water in May-July. The river flow by season is distributed as follows: in spring – 41% of the annual norm, in summer – 26%, in autumn – 18% and in winter – 15%. The bed of the Syrdarya River is characterized by a large number of meanders and oxbow lakes. The natural banks of the river are steep, but not high, no more than 0.7 m above the water's edge in spring and no more than 3-4 m in low water. To protect the coastal area from flooding by flood waters, numerous dams were built along the banks of the river.

The river flow usually does not exceed 700 m^3/s, and in the summer it decreases (in the area of Kyzylorda) to 100 m3/s or less. The width of the Syrdarya River is 140-600 m with a depth of 2.1-5.0 m. The river flow speed is 0.8-1.7 m/s. The river freezes in December and is cleared of ice in February-March. The results of chemical analyzes of natural waters of the Syrdarya River taken from river water in the direction of flow in the territory of Zhanakorgan, Kyzylorda and Kazaly are shown in Table 1.

Table 1. Results of chemical analyzes of natural waters of the Syrdarya River

No.	Name of chemical indicators	Water quality information		
		Zhana-korgan	Ky-zylorda	Kazaly
1	Temperature at the time of sampling, °C	3-27		
2	pH value	7.20	7.15	7.21
3	Odor at 20°C and 60°C, points no more	1	1	1
4	EMF turbidity mg/l	33.8	38.4	39.1
5	Ammonium salt NH_4 mg/l	0.001	0.44	0.47
7	Nitrates NO_2 mg/l	0.035	0.021	0.14
8	Nitrates NO_3 mg/l	9.4	10.8	11.2
9	Chlorides Cl mg/l	102.8	182.4	137.9
10	Iron Fe mg/l	0.87	1.36	1.37
11	Total hardness mEq/l	7.8	9.0	9.1
12	Sulfates SO_4 mg/l	384.7	458.16	460.4
13	General mineralization, mg/l	1679.6	1715.0	1684.8
14	Aluminum Al mg/l	0.11	0.2	0.18
15	Oxidability mg O/l	2.16	2.1	2.21
17	Fluorides F mg/l	0.39	0.41	0.38
18	Manganese Mn mg/l	0.021	0.018	0.022
19	Copper Cu mg/l	0.0012	0.0010	0.001
20	Biological oxygen demand (BOD_5) mg O_2/l	1.92	1.9	1.97
21	Suspended substances, mg/l	109.8	84.3	85.9
25	Total α – radioactivity, Bq/l	0.09	0.09	0.07
26	Total β – radioactivity Bq/l	0.09	0.1	0.1
27	Coli - index	599.0	604.0	603.0
28	TMC (total microbial count)	45.0	45.0	46.0

The results of chemical analyzes showed that there is no significant increase in pollution in the city of Kyzylorda. The main pollution is transboundary and is formed outside the territory of the Kyzylorda region.

At the same time, in certain seasons of the year, water mineralization increases to 1.5-1.84 g/dm^3, the sulfate content increases to 748 mg/dm^3, and the total water hardness increases to 14 mg/dm^3, this makes it completely unsuitable for household and drinking purposes without purification.

3.2. Characteristics of groundwater quality

Fresh groundwater from the Upper Turonian aquifer at the Kyzylzharma field will be used for centralized domestic and drinking water supply. Therefore, their quality must be assessed in accordance with the standards of modern requirements for the quality of water used for centralized domestic and drinking water supply, i.e. in accordance with standards [17]. The quality of groundwater used in some wells in comparison with drinking water standards in force in Kazakhstan is shown in Table 2.

In the area of the Kyzylzharma field, the mineralization of groundwater in the alluvial aquifer complex is 0.8-1.1 g/l, the sulfate content in the water of individual production wells reaches 690 mg/l, and the total hardness of groundwater is up to 14 mEq/l.

It should be noted that fresh and very slightly brackish groundwater with mineralization up to 1.0-1.4 g/l in the alluvial quaternary aquifer complex is distributed within a relatively narrow riverbed strip of the Syrdarya River valley.

Groundwater of Quaternary alluvial deposits has a close relationship with the surface water of the Syrdarya River, the waters of which in recent years have been subject to significant technogenic impact and have sharply deteriorated their quality. In this regard, negative changes are noted in the chemical composition of groundwater in alluvial deposits (increased mineralization, increase in sulfate content, increase in total hardness, etc.) It is not possible to predict further changes in the quality of both groundwater and surface waters, due to the transboundary nature of the river flow Syrdarya and the inability to foresee the impact of human economic activity on the ecosystem of the Syrdarya River.

In addition, when assessing operational reserves, the problem of predicting possible changes in the quality of groundwater by the end of the design life of water intakes was solved. This particular task was carried out using mathematical modeling. The forecast for groundwater quality during further operation of the water intake is given below in Table 3.

3.3. Assessment of possible changes in groundwater quality

The deterioration of the quality of groundwater in the exploited Upper Turonian aquifer of the Kyzylzharma field is possible mainly due to the flow of brackish groundwater from the Maastrichtian, Coniacian-Campanian and Upper Albian-Cenomanian horizons. In order to predict changes in the quality of groundwater in the Kyzylzharma field, the problem of transfer of components dissolved in it by the flow of groundwater was solved using the created model.

Table 2. Quality of groundwater used in comparison with drinking water standards

No.	Water quality indicators or names of certain components	National Standard for Drinking Water	Quality indicators or component content			
			Observation points			
			Well 1-C	Well 2P	Well 4P	Well 1721
1	Smell, points at 20^0C	up to 2	0	0	0	0
4	Color, degrees	up to 20	0	0	0	0
5	Turbidity, NTU	up to 1.5	1	0.6	0.5	0.5
6	pH value	6-9	8.37	7.05	7.65	8.27
7	Permanganate oxidability O_2, mg/l	2-5	1.28	0.84	1.16	0.72
8	Ammonia nitrogen (by nitrogen), mg/l	up to 2.0	0.5	1.0	<0.1	<0.1
9	Nitrates NO_2 mg/l	up to 3.3	<0.01	<0.01	<0.01	1.2
10	Nitrates NO_3 mg/l	up to 45.0	0.2	<0.2	3.5	1.3
11	Total hardness mEq/l	up to 7.0	0.7	1.3	1.3	0.6
12	Dry residue, mg/l	up to 1000 (1500)	1003	1320	1068	1012
13	Chlorides, mg/l	up to 350	170.2	258.8	212.7	191.5
14	Sulfates, mg/l	up to 500	341.2	477	349	332.2
15	Iron (Fe^{+2}, Fe^{+3}), mg/l	up to 0.3 (up to 1.0)	<0.1	<0.1	<0.1	<0.1
16	Copper, mg/l	up to 1.0	0.05	0.04	0.06	0.05
17	Zinc, mg/l	up to 5.0	0.05	0.05	0.048	0.05
18	Molybdenum, mg/l	up to 0.25	0.0025	0.002	0.0021	0.0025
19	Arsenic, mg/l	up to 0.05	0.001	0.004	0.0038	0.005
20	Lead, mg/l	up to 0.03	0.04			0.002
21	Fluorine, mg/l	up to 1.2	0.55	0.5	0.55	0.55
22	Aluminum, mg/l	up to 0.5	0.5			0.04
23	Mercury, mg/l	up to 0.0005	0.0002			0.0002
24	Polyphosphates, mg/l	up to 3.5				
25	Beryllium, mg/l	up to 0.0002	0.00005			0.00005
26	Selenium, mg/l	up to 0.01	0.0001			0.0001
27	Manganese, mg/l	up to 0.1 (up to 0.5)	0.05			0.05
28	Nickel, mg/l	up to 0.1	0.001			0.005
29	Cobalt, mg/l	up to 0.1				
30	Chromium, (Cr+6), mg/l	up to 0.05	0.01			0.025
31	Bor, mg/l	up to 0.5	0.25	0.45	0.45	0.4
32	Barium, mg/l	up to 0.1	-			0.004
33	Cadmium, mg/l	up to 0.001	0.0007			0.001
34	Cyanide (CN), mg/l	up to 0.035	0.005			0.005
35	Petroleum products, in total, mg/l	up to 0.1	0.05			0.05
36	Surfactants, mg/d m^3	до 0.5	0.05			0.05
37	Phenolic index, mg/l	up to 0.25	0.001			0.0005
41	Total α – radioactivity, Bq/l	up to 0.1	0.018			0.046
42	Total β – radioactivity Bq/l	up to 1.0	0.09			0.18

The mathematical model of the transfer of components dissolved in them by groundwater flow is generally described by the equation:

$$\frac{\partial(\theta C^k)}{\partial t} = \frac{\partial}{\partial x_i}\left(\theta D_{ij}\frac{\partial C^k}{\partial x_j}\right) - \frac{\partial}{\partial x_i}\left(\theta v_i C^k\right) + q_s C_s^k \qquad (1)$$

C^k – the concentration of the dissolved *k*-th component (ML^{-3});

θ – porosity of the filtration medium, dimensionless value;

t – time;

x_i – coordinate corresponding to the *i*-th Cartesian coordinate axis, (L);

D_{ij} – hydrodynamic dispersion coefficient tensor (L^2T^{-1});

v_i – filtration speed (LT^{-1}) wich is defined as Darcy flow through the relation $v_i = q_i / \theta$;

q_s – volumetric flux per unit volume of the aquifer, representing a source (positive) or sink (negative) (T^{-1});

C_s^k – concentration of the dissolved *k*-th component in the source or sink (ML^{-3}).

To solve this equation, the MT3D module of the GMS modeling system was used. The mathematical model simulated the convective transport of components dissolved in groundwater. It was believed that the mineralization of groundwater in the Maastricht aquifer is 4 g/l and does not change in the process of solving the forecast problem. The initial values of groundwater mineralization of the Coniac-Campanian, Upper Turonian aquifers and the Upper Albian-Cenomanian aquifer complex for solving the forecast problem were set on the basis of the corresponding maps constructed as of October 1, 2010.

The map of the predicted mineralization of groundwater in the Upper Turonian aquifer (as of February 16, 2038) is shown in the Figure 4.

The map of changes in the mineralization of groundwater in the Upper Turonian aquifer from October 1, 2010 to February 16, 2038 is shown in Figure 5.

Table 3 shows the results of calculating the predicted mineralization in water intake wells of the Upper Turonian aquifer as of 02/16/2038.

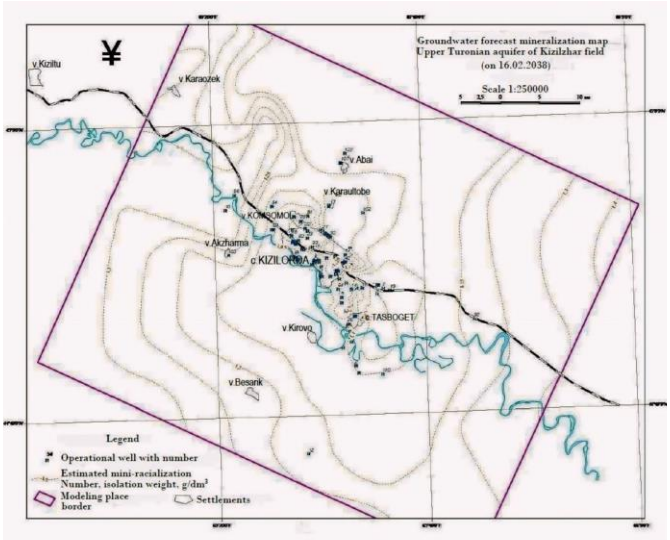

Figure 4. Map of predicted groundwater mineralization of the Upper Turonian aquifer (as of 02/16/2038)

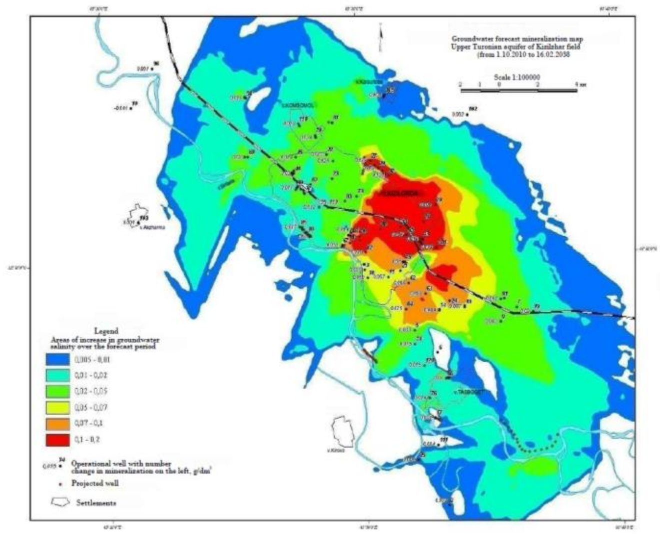

Figure 5. Map of changes in the mineralization of groundwater in the Upper Turonian aquifer from 10/1/2010 to 02/16/2038

Table 3. Predicted values of groundwater mineralization for production wells of the Upper Turonian aquifer as of February 16, 2038 (based on modeling results)

Name	No. on the map	Row number, column number of the model block	Forecast water turnover Q,	Water conductivity km, m^2/day	Water well filter radius	Mineralization C, g/dm^3	Change in mineralization over the forecast period	Sulfate concentration, g/dm^3
Water intake		(I, J)	$м^3$/day		r, м		ΔC,	
Wells							g/dm^3	
LLP "Hotel Kyzylorda", well No. 0760	1	-58.62	43.3	350.00	0.10	1.212	0.1116	0.369
JV "Kazgermunai", well No. 0339	2	-93.99	950.4	164.24	0.10	1.094	0.0087	0.333
JSC "Torgai Petroleum", well No. 226-D	3	-63.67	46.6	278.95	0.10	1.154	0.0545	0.351
JSC "PetroKazakhstan Kumkol Resources", well No. 1, water intake	4	-59.62	79.15	350.00	0.10	1.191	0.0906	0.362
JSC "PetroKazakhstan Kumkol Resources", well No. 2, water intake	5	-69.8	79.15	228.72	0.10	1.204	0.0334	0.366
JSC "Ai-Dan Munai", well No. 19-D	6	-71.85	280	210.55	0.10	1.191	-0.0087	0.363
LLP JV "Kuat Amlon Munai", Belkul station, well No. U-300/55	7	-56.95	46.6	149.77	0.10	1.054	0.0349	0.321
JSC "Ai-Dan Munai", well No. 0759	8	-58.62	20	350.00	0.10	1.212	0.1116	0.369
CJSC "KumkolTrans-Service", well No. 1	9	-60.93	46.6	157.92	0.10	1.049	0.0433	0.319
State Municipal Enterprise "Regional Medical Center", well No. 2,225-D	10	-54.22	150	160.00	0.10	1.299	-0.0011	0.395
State Municipal Enterprise "Regional Medical Center" skv No. 2,225-D	11	-62.71	605.5	252.03	0.10	1.178	0.0568	0.358
LLP "Shopan-Ata", well No. 96-D	12	-116.96	50	159.23	0.10	1.179	0.0001	0.359
Plot" well No. 2	13	-63.82	164.4	234.39	0.10	1.172	0.0638	0.357
Plot" well No. 4	14	-63.82	164.4	234.39	0.10	1.172	0.0638	0.357
Aeroportovskaya	110	-92.1	500	149.75	0.10	1.261	0.0006	0.384
LLP "KUAT", Akmechet Microdistrict, well No. 1721	15	-55.55	45	350.00	0.10	1.071	0.0124	0.326
Individual Enterprise "Murzagalieva", well No. 1-V	16	-57.63	50	350.00	0.10	1.193	0.0927	0.363
LLP "Nurai", well No. 271-D	17	-49.73	49.9	102.72	0.10	1.231	0.1310	0.375
Syrdaroil (Nik Oil Company)	18	-61.86	50	193.07	0.10	1.077	0.0671	0.328
Belkul station (JSC "Vagonservis")	19	-56.98	46	148.91	0.10	1.050	0.0204	0.320
Individual (Abenova Orazgul)	20	-94.1	47	148.48	0.10	1.264	0.0006	0.385
Aray microdistrict, Bereke str., 3, apt. 18	21	-60.73	48	250.00	0.10	1.215	0.0629	0.370
"NeftTechService", Hong Bon Do str., 26	22	-45.53	49.9	224.36	0.10	1.025	0.0246	0.312
"Trans Service", Hong Bon Do str., 40	23	-49.55	49.3	287.85	0.10	1.026	0.0260	0.312
LLP "SPF Montazhspetsstroy"	24	-62.84	149	220.40	0.10	1.113	0.0714	0.339
"Koksu" peasant farm	25	-89.9	72.8	161.42	0.10	1.107	0.0093	0.337
Kyzylzharma village, well No. 1	26	-43.59	437.3	103.08	0.10	1.165	0.0978	0.355
Kyzylzharma village, well No. 2	27	-43.6	437.3	98.49	0.10	1.206	0.1267	0.367
Kyzylzharma village, well No. 3	28	-43.61	437.3	95.14	0.10	1.219	0.1561	0.371
Kyzylzharma village, well No. 4	29	-43.62	437.3	92.29	0.10	1.229	0.1712	0.374
Kyzylzharma village, well No. 5	30	-43.62	437.3	92.29	0.10	1.229	0.1712	0.374
Kyzylzharma village, well No. 6	31	-44.63	437.3	90.82	0.10	1.133	0.1327	0.345
Kyzylzharma village, well No. 7	32	-44.64	437.3	87.71	0.10	1.154	0.1314	0.351
Kyzylorda Energy Center, well No.1	33	-54.5	437.3	350.00	0.10	1.048	0.0173	0.319
Kyzylorda Energy Center, well No.2	34	-54.51	437.3	350.00	0.10	1.050	0.0164	0.320
Kyzylorda Energy Center, well No.3	35	-54.51	437.3	350.00	0.10	1.050	0.0164	0.320
Kyzylorda Energy Center, well No.4	36	-54.52	437.3	350.00	0.10	1.054	0.0178	0.321
Kyzylorda Energy Center, well No.5	37	-54.52	437.3	350.00	0.10	1.054	0.0178	0.321
Munayshi street, well №	40	-53.75	437.3	109.16	0.10	1.333	0.2114	0.406

Munayshi street, well №2	41	-53.74	437.3	108.74	0.10	1.317	0.2174	0.401
Munayshi street, well №3	42	-52.75	437.3	107.92	0.10	1.326	0.2019	0.404
Munayshi street, well №4	43	-52.74	437.3	107.16	0.10	1.271	0.1705	0.387
Titova auyl, well №1	44	-51.48	437.3	321.36	0.10	1.040	0.0341	0.317
Titova auyl, well №2	45	-48.48	437.3	273.47	0.10	1.035	0.0259	0.315
Titova auyl, well №3	46	-52.48	437.3	336.56	0.10	1.043	0.0371	0.317
Titova auyl, well №4	47	-52.49	437.3	348.05	0.10	1.029	0.0295	0.313
Titova auyl, well №5	48	-52.49	437.3	348.05	0.10	1.029	0.0295	0.313
Tasboget auyl, well No. 1	49	-74.89	437.3	198.25	0.10	1.106	0.0082	0.337
Tasboget auyl, well No. 2	50	-74.89	437.3	198.25	0.10	1.106	0.0082	0.337
Tasboget auyl, well No. 3	51	-74.89	437.3	198.25	0.10	1.106	0.0082	0.337
Kyzylorda, Biological wastewater treatment station (BWTP) well No. 1	52	-42.35	437.3	193.48	0.10	1.118	0.0183	0.340
Kyzylorda, Biological wastewater treatment station (BWTP) well No. 2	53	-42.35	437.3	193.48	0.10	1.118	0.0183	0.340
Kyzylorda, Biological wastewater treatment station (BWTP) well No. 3	54	-42.35	437.3	193.48	0.10	1.118	0.0183	0.340
Zhakhaeva street, Kyzylorda, well No. 1	55	-62.66	437.3	292.55	0.10	1.156	0.0562	0.352
Zhakhaeva street, Kyzylorda, well No. 2	56	-62.66	437.3	292.55	0.10	1.156	0.0562	0.352
Shugyla microdistrict, well No. 1	57	-58.74	437.3	214.71	0.10	1.236	0.0539	0.376
Shugyla microdistrict, well No. 2	58	-58.73	437.3	219.62	0.10	1.252	0.0701	0.381
Kyzylorda City park, well No. **1**	59	-57.62	437.3	350.00	0.10	1.194	0.0935	0.363
Kyzylorda City park, well No. 2	60	-57.62	437.3	350.00	0.10	1.194	0.0935	0.363
Kyzylorda City park, well No. 3	61	-57.62	437.3	350.00	0.10	1.194	0.0935	0.363
Kosherbaeva street, Kyzylorda, well No. 1	62	-61.76	437.3	250.00	0.10	1.188	0.0878	0.362
Kosherbaeva street, Kyzylorda, well No. 2	63	-62.79	437.3	245.60	0.10	1.187	0.0875	0.361
Astana	64	-66.77	437.3	250.00	0.10	1.175	0.0753	0.358
Kyzylorda Sity Polise Department	65	-53.71	437.3	109.07	0.10	1.248	0.1467	0.380
Shukurova street, well No. 1	66	-74.88	437.3	200.31	0.10	1.143	0.0201	0.348
Kyzylorda Old market	67	-60.61	437.3	350.00	0.10	1.151	0.0511	0.350
Kyzylorda TB dispensary, well No. 1	68	-53.39	437.3	227.39	0.10	1.120	0.0213	0.341
Kyzylorda TB dispensary, well No. 2	69	-53.39	437.3	227.39	0.10	1.120	0.0213	0.341
Komsomol district, Kyzylorda, well No. 1	70	-43.49	437.3	212.74	0.10	1.049	0.0333	0.319
Agroprom district, Kyzylorda,	71	-52.7	437.3	107.52	0.10	1.230	0.1302	0.374
Baiseitova st., well No. 2	72	-60.65	437.3	350.00	0.10	1.193	0.0926	0.363
30 years of victory	73	-50.6	437.3	205.48	0.10	1.044	0.0440	0.318
Nurdaulet	74	-71.81	437.3	215.92	0.10	1.215	0.0153	0.370
Kyzylorda Nursing home, well No. 2	75	-58.73	437.3	219.62	0.10	1.252	0.0701	0.381
Tasboget area – 2, well No. 2	76	-79.87	437.3	186.65	0.10	1.169	0.0142	0.356
Water intake 1C	77	-82.89	437.3	171.15	0.10	1.123	0.0069	0.342
Residence, Citizens Service Centre (CSC)	78	-64.68	437.3	265.27	0.10	1.152	0.0519	0.351
Zhanaauyl	79	-45.74	437.3	95.74	0.10	1.202	0.1024	0.366
Shapagat (new)	80	-54.66	437.3	193.04	0.10	1.196	0.1014	0.364
Seksenbaeva street, well No.1	81	-39.51	437.3	197.05	0.10	1.052	0.0440	0.320
Gagarina village, 5th clinic	82	-52.52	437.3	350.00	0.10	1.018	0.0184	0.310
Kultekenova street, Kyzylorda	83	-52.59	437.3	262.11	0.10	1.038	0.0347	0.316
Seksenbaeva street, Kyzylorda, well No. 2	125	-40.51	964.9	203.94	0.10	1.045	0.0447	0.318
Chizha San Tina street, Kyzylorda, well No. 1	126	-44.59	964.9	105.03	0.10	1.099	0.0864	0.335
Chizha San Tina street, Kyzylorda, well No. 2	127	-44.59	964.9	105.03	0.10	1.099	0.0864	0.335
Chizha San Tina street, Kyzylorda, well No. 3	128	-45.59	964.9	107.95	0.10	1.043	0.0433	0.318
Chizha San Tina street, Kyzylorda, well No. 4	129	-45.6	964.9	102.33	0.10	1.062	0.0623	0.323
Chizha San Tina street, Kyzylorda, well No. 5	130	-46.6	964.9	106.00	0.10	1.054	0.0544	0.321
Munayshi, well No. 4	131	-53.74	964.9	108.74	0.10	1.317	0.2174	0.401
Munayshi, well No. 1	132	-52.74	964.9	107.16	0.10	1.271	0.1705	0.387
Munayshi, well No. 5	133	-53.74	964.9	108.74	0.10	1.317	0.2174	0.401
Munayshi, well No. 2	134	-52.74	964.9	107.16	0.10	1.271	0.1705	0.387
Munayshi, well No. 3	135	-53.74	964.9	108.74	0.10	1.317	0.2174	0.401
Kyzylorda Sity Polise Department, well No. 1	136	-53.71	964.9	109.07	0.10	1.248	0.1467	0.380
Kyzylorda Sity Polise Department, well No. 2	137	-53.71	964.9	109.07	0.10	1.248	0.1467	0.380
Kyzylorda City park, well No. 1 повторение	138	-57.62	964.9	350.00	0.10	1.194	0.0935	0.363
Kyzylorda City park, well No. 2	139	-57.62	964.9	350.00	0.10	1.194	0.0935	0.363
Kyzylorda City park, well No. 3	140	-57.62	964.9	350.00	0.10	1.194	0.0935	0.363
Kyzylorda City park, well No. 4	141	-57.62	964.9	350.00	0.10	1.194	0.0935	0.363
Kyzylorda Old market, well No. 1	142	-61.61	964.9	350.00	0.10	1.150	0.0504	0.350
Kyzylorda Old market, well No. 2	143	-60.61	964.9	350.00	0.10	1.151	0.0511	0.350
Kyzylorda Old market, well No. 3	144	-60.62	964.9	350.00	0.10	1.190	0.0904	0.362
"Arai 2" area, well No. 1	149	-76.73	964.9	158.14	0.10	1.100	0.0005	0.335
"Arai 2" area, well No. 2	150	-76.73	964.9	158.14	0.10	1.100	0.0005	0.335
"Arai 2" area, well No. 3	151	-76.73	964.9	158.14	0.10	1.100	0.0005	0.335
"Arai 2" area, well No. 4	152	-76.73	964.9	158.14	0.10	1.100	0.0005	0.335
"Arai 2" area, well No. 5	153	-77.74	964.9	156.93	0.10	1.099	-0.0009	0.335
"Arai 2" area, well No. 6	154	-77.74	964.9	156.93	0.10	1.099	-0.0009	0.335
"Arai 2" area, well No. 7	155	-77.75	964.9	158.45	0.10	1.106	0.0064	0.337
"Arai 2" area, well No. 8	156	-77.75	964.9	158.45	0.10	1.106	0.0064	0.337
"Arai 2" area, well No. 9	157	-77.75	964.9	158.45	0.10	1.106	0.0064	0.337
"Arai 2" area, well No. 10	158	-77.76	964.9	159.95	0.10	1.144	0.0435	0.348
"Arai 2" area, well No. 11	159	-77.76	964.9	159.95	0.10	1.144	0.0435	0.348
Water intake, well No. 1	160	-82.89	964.9	171.15	0.10	1.123	0.0069	0.342

Water intake, well No. 2	161	-82.9	964.9	168.30	0.10	1.103	0.0013	0.336
Water intake, well No. 3	162	-82.9	964.9	168.30	0.10	1.103	0.0013	0.336
Water intake, well No. 4	163	-82.9	964.9	168.30	0.10	1.103	0.0013	0.336
Water intake, well No. 5	164	-82.91	964.9	165.51	0.10	1.098	0.0076	0.334
"Steppe 2" area, well No.1	165	-77.1	964.9	160.00	0.10	1.283	0.0005	0.391
"Steppe 2" area, well No.2	166	-77.1	964.9	160.00	0.10	1.283	0.0005	0.391
"Steppe 2" area, well No.3	167	-78.1	964.9	160.00	0.10	1.281	0.0005	0.390
"Steppe 2" area, well No.4	168	-78.1	964.9	160.00	0.10	1.281	0.0005	0.390
"Steppe 2" area, well No.5	169	-78.1	964.9	160.00	0.10	1.281	0.0005	0.390
"Steppe 2" area, well No.6	170	-79.1	964.9	160.00	0.10	1.279	0.0005	0.389
"Steppe 2" area, well No.7	171	-79.1	964.9	160.00	0.10	1.279	0.0005	0.389
"Steppe 2" area, well No.8	172	-80.1	964.9	160.00	0.10	1.277	0.0005	0.389
"Steppe 2" area, well No.9	173	-80.1	964.9	160.00	0.10	1.277	0.0005	0.389
"Steppe 2" area, well No.10	174	-80.1	964.9	160.00	0.10	1.277	0.0005	0.389
"Steppe 2" area, well No.11	175	-80.1	964.9	160.00	0.10	1.277	0.0005	0.389
"Steppe 2" area, well No.12	176	-79.1	964.9	160.00	0.10	1.279	0.0005	0.389
"Steppe 2" area, well No.13	177	-79.1	964.9	160.00	0.10	1.279	0.0005	0.389
"Steppe 2" area, well No.14	178	-78.1	964.9	160.00	0.10	1.281	0.0005	0.390
"Steppe 2" area, well No.15	179	-77.11	964.9	160.00	0.10	1.274	0.0006	0.388
"Steppe 2" area, well No.16	180	-76.11	964.9	160.00	0.10	1.276	0.0006	0.388
"Steppe 2" area, well No.17	181	-75.11	964.9	160.00	0.10	1.278	0.0006	0.389
"Merey" microdistrict, well No.1	145	-60.54	964.9	350.00	0.10	1.116	0.0161	0.340
"Merey" microdistrict, well No.2	146	-61.54	964.9	350.00	0.10	1.114	0.0144	0.339
"Merey" microdistrict, well No.3	147	-61.55	964.9	350.00	0.10	1.119	0.0188	0.341
"Merey" microdistrict, well No.4	148	-61.55	964.9	350.00	0.10	1.119	0.0188	0.341

The highest mineralization of groundwater will be in well No. 40. It will reach 1.33 g/l by the end of the forecast period. The greatest increase in groundwater mineralization (by 0.22 g/l) will occur in wells with map numbers 131, 133, 135. In these wells, the maximum depth of the dynamic level is also predicted (129.81 m) at the end of the forecast period.

4. Conclusions

The obtained analyzes indicate that the surface waters of the Syrdarya River are polluted with sulfates, magnesium, and have increased mineralization. At the same time, in certain seasons of the year, water mineralization increases to 1.5-1.84 g/l, the sulfate content increases to 748 mg/l, and the total water hardness increases to 14 mg/l. The water of the Syrdarya River is suitable for irrigation and industry, and for domestic and drinking water supply the use of deep water treatment methods is required. And also the results of chemical analyzes showed that there is no significant increase in pollution in the Kyzylorda region. The main pollution is transboundary and is formed outside the territory of the Kyzylorda region. It is not possible to predict further changes in the quality of both groundwater and surface waters, due to the transboundary nature of the flow of the Syrdarya River.

Groundwater of Quaternary alluvial deposits has a close relationship with the surface water of the Syrdarya River, the waters of which have been subject to significant technogenic impact in recent years and have sharply deteriorated their quality. In this regard, negative changes are noted in the chemical composition of groundwater in alluvial deposits (increased mineralization, increased sulfate content, increased total hardness, etc.)

The obtained analyzes indicate that very slightly brackish groundwater with mineralization up to 1.0-1.4 g/l in the alluvial quaternary aquifer complex is distributed within a relatively narrow riverbed strip of the Syrdarya River valley.

At the same time, in the area of the Kyzylzharma field, the mineralization of groundwater in the alluvial aquifer complex is 0.8-1.1 g/l, the sulfate content in the water of individual production wells reaches 690 mg/l, and the total hardness of groundwater is up to 14 mEq/l.

As well as deterioration in the quality of groundwater in the exploited Upper Turonian aquifer of the Kyzylzharma field is possible mainly due to the flow of brackish groundwater from the Maastrichtian, Coniacian-Campanian and Upper Albian-Cenomanian horizons. In order to predict changes in the quality of groundwater in the Kyzylzharma field, the problem of transfer of components dissolved in it by the flow of groundwater was solved using the created model.

The obtained analyzes for predicting changes in groundwater quality indicate that the highest mineralization of groundwater will be in well No. 40. It will reach 1.33 g/l by the end of the forecast period. The greatest increase in groundwater mineralization (by 0.22 g/l) will occur in wells with map numbers 131, 133, 135.

It should be noted that currently there is no unified groundwater monitoring system throughout the entire territory of the Kyzylzharma field. Moreover, the overwhelming majority of operating production wells are not equipped with water meters that allow reliable accounting of water intake. There are also no special observation wells-piezometers that allow long-term observations of the position of the depression surface of the operational Upper Turonian aquifer and observation wells on the above and below-lying aquifers, from which substandard groundwater may flow.

Acknowledgements

We highly appreciate the support of the Ministry of Science and Higher Education of the Republic of Kazakhstan. This research has been/was/is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR10965134 "Assessment of fresh groundwater resources as the main source and long-term reserve of sustainable drinking water supply for the population of the Republic of Kazakhstan".

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Қызылорда облысындағы (Қазақстан) Сырдария өзені мен Қызылжарма кен орнының жер асты суларының сапасы

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Аңдатпа. Бұл зерттеудің мақсаты Қызылорда қаласын (Қазақстан) ауыз сумен тұрақты қамтамасыз ету үшін Сырдария өзені суының және Қызылжарма кен орнының жерасты суларының сапасының өзгеруіне мониторинг жүргізу болып табылады. Бұл мақалада Жаңақорған, Қызылорда және Қазалы аумақтарындағы ағыс бағыты бойынша өзен суларынан алынған Сырдария өзенінің табиғи суларына химиялық талдау нәтижелері келтірілген. Қазақстанда қолданыстағы ауыз су нормативтерімен салыстырғанда кейбір ұңғымаларда пайдаланылатын жерасты суларының сапасының нәтижелері ұсынылған. Айта кету керек, Қызылорда кен орны ауданында жер асты суларының минералдануы 0.8-1.1 г/л құрайды, жекелеген өндіруші ұңғымалардың суындағы сульфаттардың мөлшері 690 мг/л жетеді, ал жер асты суларының жалпы қаттылығы-14 мг экв/л дейін. 2038 жылғы 16 ақпандағы болжам бойынша жер асты суларының минералдануының ең көп ұлғаюы (0.22 г/л-ге) карта нөмірлері 131, 133, 135 ұңғымаларда болады.

Негізгі сөздер: *табиғи су, Сырдария өзені, жер асты сулары, Қызылжарма кен орны, судың сапасы, химиялық құрамы, жер асты суларының сапасының өзгеруі.*

Качество воды реки Сырдарья и подземных вод месторождения Кызылжарма в Кызылординской области (Казахстан)

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Аннотация. Целью данного исследования является мониторинг изменений качества воды реки Сырдарья и подземных вод месторождения Кызылжарма для устойчивого снабжения питьевой водой города Кызылорда (Казахстан). В данной статье представлены результаты химических анализов природных вод реки Сырдарья, взятых из речных вод по направлению течения, на территории Жанакоргана, Кызылорды и Казалы. Представлены результаты качества используемых в некоторых скважинах подземных вод в сравнении с нормативами питьевой воды, действующими в Казахстане. Следует отметить, что в районе Кызылординского месторождения минерализация подземных вод составляет 0.8-1.1 г/л, Содержание сульфатов в воде отдельных добывающих скважин достигает 690 мг/л, а общая жесткость подземных вод – до 14 мг-экв/л. Представлены результаты оценки возможных изменений качества подземных вод. По прогнозам на 16 февраля 2038 года наибольшее увеличение минерализации подземных вод (на 0.22 г/л) произойдет в скважинах с номерами карт 131, 133, 135.

Ключевые слова: *природная вода, река Сырдарья, подземные воды, месторождение Кызылжарма, качество воды, химический состав, изменение качества подземных вод.*

Received: 02 December 2023
Accepted: 15 February 2024
Available online: 29 February 2024