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Research Article

Comparative Analysis of South Kazakhstan and the Republic of Belarus Water Resources

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Abstract

This article presents the results of a comparative analysis of the water provision, water consumption, pollution sources, major pollutants and condition of water bodies in the South Kazakhstan region and the Republic of Belarus. The difference in the ecological status of the water bodies of Southern Kazakhstan and Belarus is justified both by the weather and climate regimes of the territories and by the level of sustainable development of industry.

ABBREVIATIONS

SKR: South Kazakhstan Region; SWK: State Water Cadastre; JSC: Joint Stock Company; YPM: Yuzhpolimetall; WTP: Wastewater Treatment Plant; BOC5: Biological Oxygen Consumption; WPI: Water Pollution Index; QC: Quality Class; CWQ: Characteristics Of Water Quality; MP: Moderately Polluted; NEMS: National Environmental Monitoring System

INTRODUCTION

Water resources, as a type of natural resources, are a national treasure in all countries of the world, and issues of effective management of them are an important strategic task for any state. The intensive rates of economic development have a negative impact on the ecological state of water resources. The main sources of pollution of above ground water are flows from agro landscape, production and surface runoff from the territory of industrial enterprises and municipal wastewater from settlements. By the results of many researches in Russia where established that the average fresh water consumption is about 630 m^3 per person per year, of which 125 m^3 will be spent on public utilities and, 65 m^3 on industrial production [1]. It can be noted that the Agriculture spends about 2.5 thousand km^3 of fresh water annually (up to 70% of the world's freshwater consumption). In other countries of the post-Soviet space such an analysis was not conducted. In this regard, the study was aimed at conducting a comparative analysis of the state of water resources in the Republic of Belarus and the South Kazakhstan region of the Republic of Kazakhstan.

The territory of Kazakhstan is 13-times larger than the territory of Belarus, so it is interesting to compare the availability of water resources and their status of a separate region (South Kazakhstan region (SKR) and the Republic of Belarus.

The populations of Southern Kazakhstan and the Republic of Belarus - are comparable (8.4 and 9.5 million people respectively). The area of South Kazakhstan is about 711.5 thousand km^2, the landscapes of the region are a combination of arid, low-altitude steppes and deserts, high snow-capped mountains with well-humid foothills. The territory of the Republic of Belarus is 207.6 thousand km^2, the plain landscape prevails. The climate is moderately continental, rainy, non-hot summers, mild winters with frequent thaws, unstable weather in autumn and winter.

RESULTS AND DISCUSSION

Provision of water resources

Water sources of SKR consists 118 small rivers, 28 reservoirs and 25 lakes. The main water artery of the region is the trans-boundary river Syr Darya. The largest of its tributaries are the rivers Keles and Arys. They are formed by tributaries of the first and subsequent orders. The Syr Darya river, flowing through the territory of Kyrgyzstan, Tajikistan, Uzbekistan has been used for agriculture, industry and settlements. So, when it enters to the territory of the Republic of Kazakhstan it has already contaminated water with the organic substances, mineral salts and petroleum products. Water resources of the Republic of Belarus include river runoff and water reserves in water bodies, as well as natural and operational groundwater resources.

Forecasted operational resources of fresh groundwater are estimated at 49596 thousand m^3/day. Only about 14% of the

forecasted resources were explored. Potential opportunities for the use of groundwater are characterized by their natural resources, which amount to 43.560 thousand m^3/day or 15.9 km^3/year.

Surface waters of Belarus are represented by a significant number of above ground water bodies: more than 20 thousand rivers with a total length of about 90 thousand km, more than 10.8 thousand lakes with a water volume of about 9 km^3, and 153 reservoirs [2].

The largest of the Reservoirs is the Vileika with an area of 73.6 km^2, which is a part of the Wileyski-Minsk water system. It was created in 1968-1976 by transferring water from the Viliya river (the Neman's river basin) to the Svisloch river (Dniepr's basin) for watering the Minsk city. The capacity of the Vileyka-Minsk water system is 480 million m^3 of water per year.

In the Republic of Belarus most rivers are small rivers up to 200 km in length and small lakes with a water mirror area of less than 0.1 km^2. Water bodies of the Republic of Belarus are united in five large river basins and all of them have a clearly expressed transboundary character (Table 1).

Of the nine large rivers in the country (with a length of over 500 km), eight are transboundary. The watershed of the Baltic and the Black Sea's passes through the territory of the Republic of Belarus, about 45% of the country's catchment area falls on the Baltic Sea, which is cross-border for Belarus and the European Union countries (Poland, Lithuania, Latvia), and 55% of the catchment area for the Black Sea are cross-border for Belarus with Russia and Ukraine. The average annual water resources of the Republic of Belarus is 57.9 km^3, with most of the river flow (about 60%) being formed on the territory of the republic, the flow of water from neighboring countries is just over 40% [2]. Data on the distribution of runoff within the major river basins of Belarus are shown in Table 2.

The average annual outflow from the country is distributed as follows: 31.3 km^3 (54%) to Ukraine, 14.5 km^3 (25%) to Latvia, 9.83 km^3 (17%) to Lithuania, 0.87 km^3 (1.5%) to Russia and 2.5% (1.44 km^3) to the Republic of Poland. The largest rivers of Belarus - the Dnieper and Pripyat, providing 1/3 of the total river flow, are cross-border with Russia and Ukraine. Both these countries are actively moving towards harmonizing their approaches in the field of water management with international approaches, in particular with Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 laying down a framework for Community action in the field of water policy (Water framework directive) [3].

Water consumption

The development of agrolandscapes has significantly increased the level of anthropogenic impact on river basins of the South Kazakhstan region. According to the total volume of annual water consumption of SKO (3096 million m^3) among the regions of the republic shares first place with the Kyzylorda region (8230 million m^3). At the same time, 97% is accounted for agriculture, 1% of housing and communal enterprises and 2% of fish farms. The annual volume of water abstraction is 2793 million m^3, despite the fact that the useful volume of reservoirs does not exceed 784 million m^3. Consequently, the coefficient of water stress is 0.66. In addition, SKR spends 790 thousand m^3/day of groundwater, which is 18% of approved reserves [4]. In the long-term planning of water use, serious miscalculations were made to resolve the process of water return, which led to a sharp decrease in the water content of many small rivers in the region, and surface runoff from agricultural landscapes caused surface contamination of various chemical compounds.

Table 1: Transboundary river basins of the Republic of Belarus.

River Basin	Flowing country
Western Dvina	Russia, Belarus, Latvia
Dniepr	Ukraine, Belarus
Pripyat	Russia, Belarus, Ukraine
Western Bug	Ukraine, Belarus, Poland
Neman	Belarus, Lithuania, Russia

Table 2: River runoff in major river basins of Belarus [2].

Basins of rivers	Rivers runoff, km^3/year				
	Local		Mutual		
	Average many-annual	Annual delivery, 95%	Average many-annual	Annual delivery 95%	Year 2015
Western Dvina	6.8	4.3	13.9	8.6	7.4
Neman (including Vilia r.)	8.9	7.0	9.0	7.1	4.3
Western Bug (including Narev)	1.4	0.8	3.1	1.7	0.70*
Dniepr (without Pripyat)	11.3	7.6	18.9	12.6	9.2
Pripyat	11.3	7.6	18.9	12.8	9.2
Total:	34.0	22.8	57.9	37.2	29.8

Note: *- rivers runoff, formed on the territory of the Republic of Belarus

In the Republic of Belarus, the organization of a system for accounting, planning and managing water resources on the basis of a combination of administrative and basin management principles has existed for a long time. So, within the framework of the State Water Cadastre (SWK), information on the quantity and quality of water resources, as well as on their use, has been made since 1991 and up to now both in administrative-territorial units (regions, districts, cities of regional subordination and Minsk), and on the river basins. Analysis of water use according to SWK for a ten-year period indicates a stable trend of decreasing the volume of groundwater extracted and seized surface water (Figure 1).

Sources of pollution

The territories of industrial zones and large settlements are the main sources of pollution of reservoirs with ions of heavy metals, oil products and other minerals that enter the aquatic environment in the form of volley emissions together with surface runoff formed during the melting of snow and torrential rains. In such cases, the greatest stress is experienced by water bodies located in industrial zones. For example, long-term analyzes of the South Kazakhstan Hydrometeorology

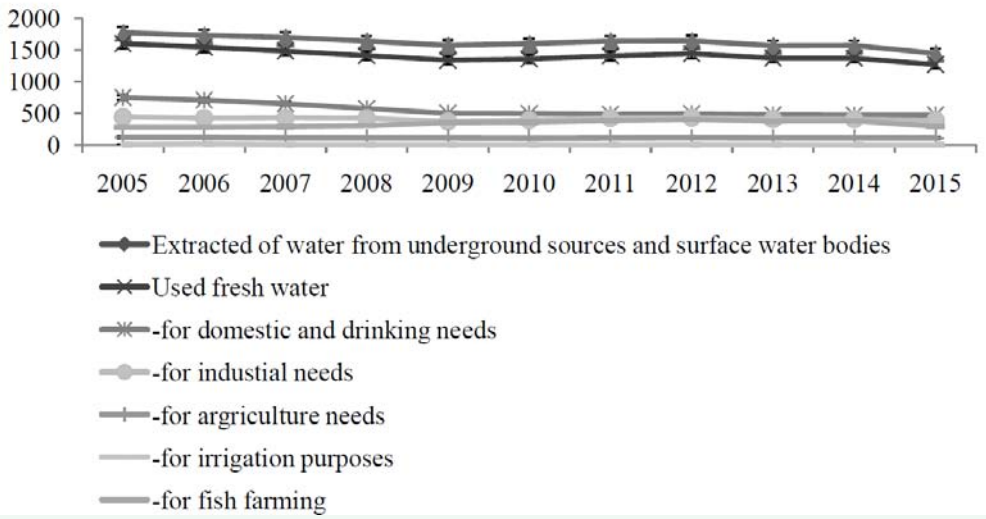

Figure 1 The dynamic the main indexes of water use of Republic of Belarus.

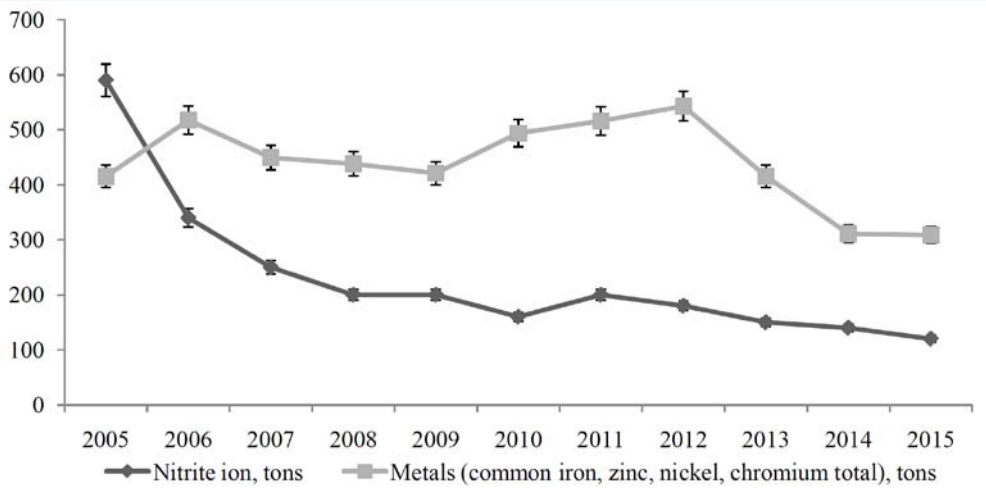

Figure 2 Supply of two main priority pollutants to the water bodies of the Republic of Belarus.

Center have established a seasonal nature of the increase in the concentration of heavy metals in the Badam River's water, which is associated with the arrival of surface sewage and the steady hydraulic communication of the river with contaminated groundwater from the territory of JSC Yuzhpolimetall (YPM) [5]. In the spring periods of the year, the content of copper, zinc and lead in the waters of the Badam River exceeds the Maximum permissible concentration (MPC) by 2.4±0.12 times. A similar situation is typical for many tributaries of the Arys river, the waters of which are taken by the main water artery of the region - the river Syr Darya. The growth of the technogenic burden on the main tributaries of this river led to an increase in the level of total mineralization of its waters - 0.8 ± 0.03 mg/dm^3.

In the growth of pollution of surface water sources, the volume of municipal wastewater plays an important role. During the last 40-50 years, municipal sewage was discharged both into the system of special treatment facilities and into natural reservoirs. Analysis of the level of water consumption and discharge of sewage over the past 30 years has shown that on average, 4.78 million m^3 of sewage was discharged into natural water bodies per year, which was 34.5% of the total volume of water disposal in the region. At that time, 43 wastewater treatment plants were functioning in the region. Only for 24 of them the values of the maximum permissible discharge were developed, and out of 30 purified waters were released into natural reservoirs. In the growth of pollution of surface water sources, the volume of municipal wastewater plays an important role. The largest wastewater treatment plant (WTP) with a capacity of 97 thousand cubic meters per day was built in Shymkent, which received mixed wastewater from communal and industrial enterprises. Wastewater after treatment was discharged into the Burzhar water storage and used for irrigation of adjoining agrolandscapes. However, the actual load WTP was more than 100 thousand m3 / day, which is associated with an increase in the number of enterprises that do not have a water

recycling system and discharge sewage into the city sewer. So, during the last 30 years, drainage into the city sewerage of oil-containing sewage from the territory of 11 enterprises of the city continued. There have also been violations of regulations for the discharge of sewage from many public utility facilities. The increased load often led to a decrease in the operating efficiency of the WTP, which contributed to the receipt of under-treated wastewater in the accumulator. The results of chemical analyzes of sewage Burzhar water storage have repeatedly established the facts of exceeding the values of MPC and temporarily permitted discharge for such indicators as ammonium nitrogen, nitrates, nitrites, oil products, heavy metals, and suspended substances.

Modern conditions for the development of the ecological situation in the territory of South Kazakhstan are associated with intensive rates of economic development and urbanization processes. According to the Department of Statistics of the SKR, 253 production facilities, 75 gas stations, 112 service stations, 3 large heat and power centers operate in Shymkent alone, and the number of road transport exceeded 200 thousand units. The activities of these facilities currently contribute to a significant increase in the technogenic burden on the land and water ecosystems of the region, in the form of expanding areas of oil contaminated areas, the concentration of heavy metals in the soil and the degree of contamination of surface water sources.

For the period of 2001-2016, the share of irrigated land in the region is 442.3 thousand km^2, in 2018 it increases by another 13.8 thousand km^2. In addition to the main agrolandscapes, the water resources of surface sources are used for the needs of the private sector - 850 rural settlements of the region. In connection with this, the flow of surface runoff entering the reservoirs from the surrounding agrolandscapes has increased, and as a result, the tendency of the hydrochemical characteristics of the aquatic environment of surface water sources to deteriorate.

In the Republic of Belarus, according to the number of discharged wastewaters, the distribution is as follows: housing and communal services - more than 50%, agriculture - 17%, industrial production - 15%, pond fisheries - 15%, energy - 3%. An analysis of the dynamics of the arrival of pollutants into water bodies indicates that, relative to 2005, the majority of pollutants have a steady tendency to reduce their inflow into water bodies (Figure 2).

Primary pollutants

According to the long-term data of the South Kazakhstan Hydrometeorology Center, the main pollutants of the Syr Darya river basin are magnesium, copper, sulfate, nitrite and petroleum products, whose average annual concentrations exceed the norm from 1.4 to 5.8 MPC [6]. The water pollution index ranges from 0.28 to 2.74, which correspond to the third class of purity - moderately polluted. On the section of the river near the village of Kokbulak, the maximum values of water pollution exceed the maximum permissible concentration for sulfates- 12.9 times, for nitrites- 9.3 times, for copper- 15 times, for magnesium- 3.6 times. The maximum level of water pollution occurs in the spring period of the year, which is due to the amount of precipitation and volley doses of pollutants falling into rivers with sewage. The quality of the waters of its main tributaries flowing through the industrial zones of the South Kazakhstan region exerts a significant influence on the seasonal dynamics of the contamination of the Syr Darya waters.

The Arys river is one of the major tributaries of the Syr Darya, originating in the southern slopes of the mountain system of the Western Tien Shan, in the Aksu-Jabagly Reserve area of the Tyulkubas District. Up to the mouth, the river receives water from 85 tributaries of the first and second orders. Before the settlement of Mashat-Sairam district, the river belongs to the second class - pure water quality characteristics. The pollution of the waters of the river occurs after receiving water from the tributaries of Badam and Mashat. The Mashat river, which until 1998 belonged to the number of clean rivers in the region, is currently contaminated with organic substances, which is associated with the expansion of organized and spontaneous places of rest for townspeople. The main pollutants are food waste and municipal wastewater. At the mouth of the river, the content of sulphates, nitrates and nitrites exceeds the MPC by 3.4-4.2-times. Their maximum values in the summer months reach 5.7 - 7.3 MPC and the dynamics of biochemical processes associated with the decomposition of organic impurities increases, the value of biological oxygen consumption (BOC_5) is 7.8 - 9.5 mg O_2/L. The Badam river makes a tangible contribution to the pollution of the waters of the Arys river, which is associated with the reception of waters from heavily polluted tributaries such as Lengersay, Togus and Koshkar-Ata. The Lengersay and Togus rivers, flowing through Lenger and other settlements of the Tolebi district, take household and industrial wastewater. At the mouth of the river, the hydrochemical indicators of water correspond to the fifth class of purity - dirty, which significantly affects the degree of pollution of the river Badam. So, after receiving the waters of the Lengersay river, near the village of Togus, the waters of the river Badam corresponds to the third class of purity - moderately polluted. Mineral pollution of the Badam river occurs in the territory of Shymkent, where through the surface sewage and groundwater the river is contaminated with copper, zinc and lead ions, which is established by chemical analyzes of water before and after the territory of JSC YPM.

The river Koshkar-Ata originates from large underground sources in the center of Shymkent and, flowing through densely populated areas, flows 12 km into the river Badam. Sources of pollution of the river's waters are unorganized dumping of domestic and technical waste, food waste and municipal wastewater from the private sector. For 12 km of the road, the pollution of the river waters increases many times. The qualitative characteristics of the waters in the mouth of the river correspond to the sixth class of purity - very dirty. The composition of pollutants is dominated by suspended substances - 47.8 mg/L, nitrates - 35.8 mg/L, nitrites - 0.4 mg/L, magnesium ions - 26.4 mg/L, copper - 4.5 mg/L, zinc - 5.3 mg/L, lead - 0.05 ml, oil products - 0.4 mg/L, BOC_5 - 16.8 mg O_2/L. For these reasons, the waters of the Badam river in the mouth correspond to the fourth class of purity and largely pollute the basin of the river Arys. The main sources of water pollution in the river Keles are the wastewater of adjoining agrolandscapes. Currently in the river Keles discharges sewage from seven collectors from irrigated land. The main pollutants are sulfates, nitrites, copper and magnesium. The maximum sulfate content exceeds the norm

Table 3: Quality classes of the studied reservoirs of the SKR (in terms of WPI (Water pollution index) indicators).

N	Name of the pond	Water pollution index (WRI)	QC	CWQ
1	Zhabaglysu Kaskacu Kelte Mashat	0,25±0,01 0,26±0,02 0,24±0,01	1 1 1	Very clean Very clean Very clean
2	Baldybrek Bogen Balabogen Boralday Sayramsu Res.“Maydantal” Res.“Usynbulak” Res.“Kanshagay” Res. “Badam” Res.“Akylbeksay” Res.“Togys”	0,50±0,02 1,00±0,02 0,70±0,03 0,90±0,03 0,90±0,03 0,95±0,03 0,70±0,02 0,93±0,03 0,71±0,03 0,98±0,03 0,97±0,03	2 2 2 2 2 2 2 2 2 2 2	clean clean clean clean clean clean clean clean clean clean clean
3	Syr Darya r. Arys r. Lengersay r. Togus r. Res.“Shardara” Bogen r. Mashat r. Res. “Bogen”	1,78±0,31 2,10±0,10 2,19±0,21 2,24±0,11 2,37±0,31 2,21±0,21 2,40±0,11 2,41±0,31	3 3 3 3 3 3 3 3	MP MP MP MP MP MP MP MP
4	Badam r.	3,80±0,14	4	Contaminated
5	Koshkar Ata r.	5,01±0,14	5	Dirty
Reservoirs for technically polluted waters				
6	Pond accumulator “Akdala”	8,9±0,9	6	very dirty
7	Pond accumulator “Buzhar”	12,6±0,61	7	Excessively dirty.

Note: QC-Quality class, CWQ- Characteristics of water quality, Res. – Reservoir, MP -Moderately polluted

Table 4: Hydrochemical status of aquatic ecosystems in 2014 (in% of the total number of controlled sections of watercourses and the total number of reservoirs of this river basin) [2].

Pool rivers	Excellent status	Good status	Satisfactory status	Bad status	Very bad status
Water sources					
Dnepr r.	21,2	69,7	9,1	0	0
West Bug r.	0	40,0	60,0	0	0
West Dvina r.	72,7	27,3	0	0	0
Neman	46,2	51,3	2,6	0	0
Pripyat r.	37,9	58,6	3,4	0	0
Reservoirs in the pool					
Dnepr r.	50,0	50,0	0	0	0
West Bug r.	0	100,0	0	0	0
West Dvina r.	67,6	29,4	2,9	0	0
Neman	33,3	66,7	0	0	0
Pripyat r.	20,0	80,0	0	0	0

Abbreviations: QC-Quality class; CWQ- Characteristics of water quality; Res. – Reservoir; MP -Moderately polluted; r.-river.

by 8.7-times, nitrite 1.5-times, copper 6-times and magnesium 2.8-times. By the degree of pollution of the river Keles belongs to the sixth class of purity - very dirty.

State of water bodies

According to the results of chemical analyses of river waters forming the basin of the Arys river, it is established that only small rivers of the foothill zone belong to the “Very Clean” and “Clean” quality classes. The quality of the waters of the flat rivers corresponds to the estimates “Moderately polluted” - “Very dirty” (Table 3).

This situation exacerbates the problem of drinking water in many settlements, water supply of which is completely carried out from river basins. To date, 73% of rural residents in the SKR are fully provided with drinking water, and 93% - with a centralized water supply system. To improve the ecological situation in the region, in the framework of the state program “Development of regions up to 2020” in 2017, it is planned to build 26 facilities in the sphere of drinking water supply.

At present, according to the estimates of the Department of Natural Resources of Rational Nature Management of the SKR, the

territory of the region is conditionally divided into 3 ecological and geographical areas:

1. The territory of the ecological pre-crisis state - with an increased content of salts and radionuclides in environmental objects, primarily in groundwater;

2. Areas of powerful man-caused impact, Kentau - zones of increased soil contamination with heavy metals, Shymkent - zones affected by lead, zinc and arsenic, which include both industrial zones and adjacent agrolandscape zones;

3. Zones under moderate anthropogenic impact.

As part of the National Environmental Monitoring System (NEMS) in the Republic of Belarus, operating since 1993, an assessment of the state of surface water bodies is being carried out.

In 2015, the monitoring network for the state of surface waters of the Republic of Belarus included:

1. 109 hydrological observation points at 75 water bodies (water level and temperature, water and sediment runoff, etc.);

2. 300 observation points for hydrochemical indicators at 160 water bodies;

3. 143 hydrobiological observation points at 55 water bodies.

The transboundary monitoring network for surface water bodies includes 34 observation points: 8 - near the state border of the Republic of Belarus with the Russian Federation, 13 - with the Republic of Poland, 10 - with Ukraine, 2 - with the Republic of Lithuania and 1 - with the Republic of Latvia [2]. Taking into account the need to introduce a new approach to the system of assessing the state of surface water bodies (parts thereof) through ecological status, a system of monitoring the state of surface waters is being improved.

For methodological support of determining the ecological status of surface water bodies (parts thereof) in 2012-2014. A number of technical normative legal acts have been developed and approved that allow assessing the hydrobiological and hydrochemical status of surface water bodies [7-10]. As a result of determining the status of an ecosystem, one of five classes is assigned: I - excellent status; II - good status; III - satisfactory status; IV - poor status; V - very bad status. Information on the assigned class of ecological status (status) to surface water bodies (parts thereof) is reflected in the SWC [11]. Determination of the river ecosystem status is carried out for individual sections of the river at the observation point of the NEMS, and the ecological status of the lake ecosystem is determined for the lake as a whole. At present, within the framework of the NEMS, the hydrochemical and hydrobiological status of the sections of water bodies covered by a stationary network of observations of the state of surface waters, respectively, is determined. In 2014, according to the results of observations of the state of surface water bodies, the majority of the observed sections of watercourses and water bodies corresponded to excellent and good hydrochemical status (Table 4).

The hydrobiological status of the watercourses of the Western Dvina and Dnieper river basins was characterized as excellent for 2.6% of water bodies, good for 76.9%, satisfactory for 19.2%, poor status for 1.3%.

CONCLUSIONS

Based on the comparative analysis of the water resources of the Republic of Belarus and the South Kazakhstan region, the following conclusions were drawn:

- For the aggregate of ecological characteristics, the South Kazakhstan region is one of six ecologically unfavourable regions of Kazakhstan, and the qualitative characteristics of the region's environment correspond to the assessment of the pre-crisis state. The existing level of man-caused impact on the ecosystems of SKR is associated with the inherited background of pollution and intensive development of the economy in modern conditions.

- The ecological state of the water resources of the Republic of Belarus is characterized as stable, with a predominance of good status for most water bodies.

- The difference in the ecological status of the water bodies of Southern Kazakhstan and Belarus is justified both by the weather and climate regimes of the territories and by the level of sustainable development of industry.

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