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Influence of Natural, Climatic, and Industrial Factors on Air and Water Quality in The Kemerovo Region (Kuzbass, Russia)

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Abstract
Geographical and climatic features of the Kemerovo region (Kuzbass, Russia) determined the modern geological and geomorphological structure of the territory, as well as a characteristic pattern in the distribution of mineral deposits. The purpose of this work was to study the geomorphological and hydrological features of the Kemerovo region. Atmospheric circulation, relief, and vegetation are the climate's main factors. The combination of these factors forms the climatic characteristics of the region. Soils in open areas (meadows, hayfields) occupy a small area and have high economic and ecological value. Most of the forest is not affected by economic activities. The exception is disturbances in the territories affected by logging and mining enterprises, which especially affect the air and water quality in the region. All the obtained results of the assessment of the geomorphological and hydrological condition of the Kemerovo region should be used when planning further experiments on the stages of technical and biological reclamation of disturbed lands of mining enterprises to restore vegetation cover and the primary state of soils.
Keywords:
Geographical conditions, geological structure, geomorphological structure, hydrogeological structure, Kemerovo region, Kuzbass.

Introduction
Based on research results [1, 2], proper monitoring [3, 4], rehabilitation [5], prevention [6], and land management [7] soils play an important role in ensuring the sustainability of agriculture and the environment [8]. The constant use of land and its exploration and exploitation lead to its degradation [9, 10].
Land degradation is one of the most difficult problems faced by different regions, especially developing countries [11, 12].
To improve soil quality, it is necessary to monitor, restore, and prevent degradation processes [13] and manage land resources [14] (by recultivation of dumps, tillage [15], agriculture on steep slopes, and conservation of forest resources [16]).
However, we can assume that certain processes of changing territories affect the change of the climate system [17, 18]. According to Ukhurebor and Azi [19], changes in the climate system may be influenced by internal irregularities resulting from natural internal progressions within the climate system or external heterogeneities resulting from inconsistencies of natural or anthropogenic external influences.
The reclamation of explored, problematic, and exploited land plots formed as a result of most of the industrial activity [20], namely the oil and mining industry [21], begins even earlier when a well is drilled or a structure is being erected [22].
According to Halbac-Cotoara-Zamfir et al. [23], land degradation is more evident in places where previously there were situations of environmental exposure due to arid (dry) climate and unstable methods of mineral exploration and land exploitation.

The purpose of this work was to study the influence of climatic geomorphological and hydrological features, and industrial and economic activities of enterprises on air quality, pollution level, and structure and consumption of water resources in the Kemerovo region (Kuzbass, Russia).

Methods

The study was conducted in 2020-2021 in the Kemerovo region. We used three groups of methods to collect information.

1. Analysis of documents, scientific publications, and patents. We selected scientific publications and patents concerning the physical and geographical location of the Kemerovo region and methods to study it. To search for information, we used the Scopus, Web of Science, PubMed, and Elibrary databases for the period from the early 1970s (the first publication on the topic) until 01.07.2023. The focus was on articles published in scientific peer-reviewed journals with a high citation index over the past five years. We considered arguments based on the hypotheses of leading scientists about the influence of physical and geographical conditions on ecology and the minimization of human impact on the environment and formed our own opinion using the evidence of these hypotheses.
2. Monitoring atmospheric air quality. In the Kemerovo region, air quality analysis was carried out at stationary posts of the Kemerovo Center for Hydrometeorology and Environmental Monitoring and the Novokuznetsk Hydrometeorological Observatory. The state observation network included 18 stationary observation posts in the city districts of Kemerovo (8), Novokuznetsk (8), and Prokopyevsk (2).
3. Monitoring water quality. We performed biological testing of water samples of the Tom River and analysis of the structure of water use and the intensity of the use of natural water bodies.

Results and discussion

Climatic and natural features

A common feature of the climate in the Kemerovo region is its continentality. Winters are long and cold; summers are short and warm. An important climate-forming factor is atmospheric circulation, which depends on the terrain, and its remoteness from the seas and oceans and is determined over the region by Western disturbance, as well as by Asian and Arctic anticyclones [24]. The average annual temperature ranges from +0.7 to +3.3°C. The average temperature in January is -19.5°C and in July +18.5°C. The sum of active temperatures is 1,600 to 1,900°C, and the duration of the period with an active temperature (above +10°C) is 105-125 days [25]. The frost-free period is shorter and only lasts for 93 to 123 days. Annual precipitation varies in a wide range from 255 to 1,700 mm [25].

Large orographic units in the Kemerovo region play the role of barriers to air masses. This is supported by the nature of precipitation distribution [25].

The temperature distribution is also determined by the characteristics of the underlying surface. On the high watersheds of the Kuznetsk Alatau and Gornaya Shoriya, the average annual temperature is 2.9-3.3°C, and the duration of the frost-free period is reduced to 93 days, during which low temperatures prevail [26]. The consequence of this is the spread of permafrost and seasonally frozen soils here, the leading role of physical weathering and cryogenesis.

The Kemerovo region is characterized by a variety of natural conditions. The relief, properties of soil-forming deposits, geography, and specificity of mineral deposits are primarily explained by the features of the geological development of the region. Most of the Kemerovo region is part of the Altay and Sayans Faulting region, and the northeastern outskirts are part of the West Siberian Platform. There are two major stages in the geological history of the region (oceanic and continental) [27].

The ore deposits in the Kemerovo region are confined to the mountainous regions of Kuznetsk Alatau, Salair, and Gornaya Shoriya. Combustible minerals, first of all, the coals of the Kuznetsk basin, are confined to the area of the intermountain trough in the central part of the region, where the most favorable conditions for sedimentation have developed. Non-metallic minerals tend to occur in alimentation zones. The geomorphological conditions of the Kemerovo region are very diverse.

Hydrogeological structure

The hydrographic network in the Kemerovo region belongs to the Upper Ob basin and is represented by a dense network of small and medium-sized rivers, lakes, reservoirs, and swamps. 32,109 rivers with a total length of 245,152 km flow through the Kemerovo region.

The largest one is the basin of the Tom River and its tributaries. It occupies the central and southern parts of the region. The Tom River and its largest tributaries (Belsu, Usa, Mras-Su, Tutuyas, Kondoma, Upper, Middle, and Lower Tersi, Taidon) originate in the mountains of Kuznetsk Alatau and Gornaya Shoriya. The Inya River basin is located in the west of the region. The Inya River is the second most significant river of the region, originating on the southern slope of the Taradanovsky ridge; its tributaries are the Urop, Blizhniy Mencherep, Dalniy Mencherep, Meret, Bachat, Ur, Kasma, and Tarsma. The rivers of the northern and northeastern parts of the Kemerovo Region belong to the Chulym River basin. The largest are the Yaya River with tributaries Barzas, Alchedat, and Kitat, and the Kiya River with tributaries Chedat, Chebula, and Tyazhin. They originate in the mountains of the Kuznetsk Alatau. The Chumysh River basin occupies an insignificant part, in the south-west of the region. The Chumysh River is formed as a result of the confluence of the Tom-Chumysh and Kara-Chumysh rivers originating on the southwestern slope of the Salair Ridge [28].

In the Kemerovo region, there are 850 lakes with a total area of 101 km^2, most of which are the old riverbeds of the rivers Inya, Yaya, and Kiya in their lower reaches. Of the existing reservoirs in the region, the largest are Kara-Chumyshskoye, Belovskoye, Dudetskoye, and Zhuravlevskoye, which are used for household drinking and technical water supply, fish farming, and recreation. The largest and most significant structure within the Sayano-Tuva hydrogeological folded region is the Kuznetsk intermountain artesian basin, which coincides geographically with the Kuznetsk Basin [29].

State of atmospheric air

According to 2021 observations, the level of atmospheric air pollution in the Kemerovo and Novokuznetsk city districts was estimated based on the content of benz(a)pyrene, and in the Prokopiev city district based on the content of suspended substances (Fig. 1).

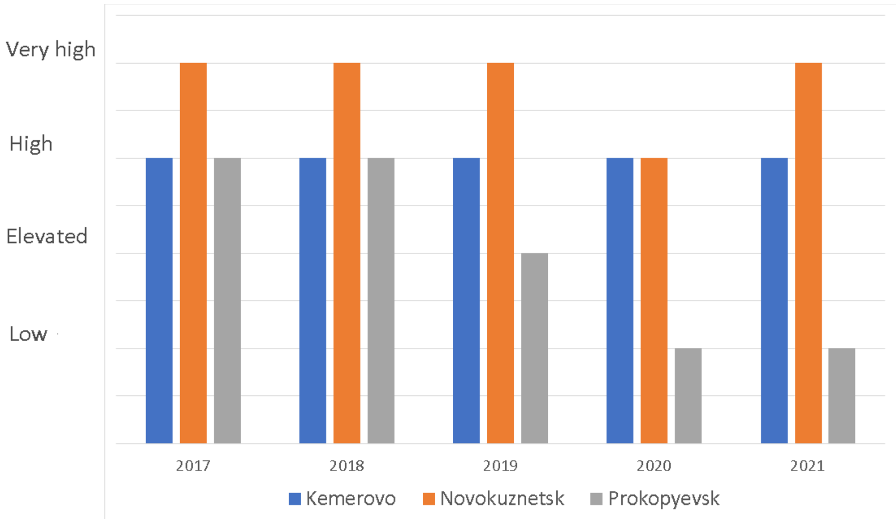

Fig. 1. The level of air pollution in the urban districts of the Kemerovo region

Compared to 2020, the level of pollution in the Kemerovo and Prokopyevsk urban districts had not changed, whereas in the Novokuznetsk urban district, it had increased to a very high level.

According to the Yearbook of the State of Atmospheric Pollution in Cities in the Territory of Russia for 2021 [29], prepared by the Main Geophysical Observatory named after A.I. Voeykov (Rosgidromet), the air quality in the Kemerovo region in 2021 was as follows (Table 1).

Table 1. Characteristics of air pollution in the Kemerovo region for 2021

Index	City		
	Kemerovo	Novokuznetsk	Prokopievsk
Substances for which SI**>10	Benz(a)pyrene	Benz(a)pyrene	-
NP***, % (>20) and substance	-	-	-
Substances for which qav>1 MPC	Benz(a)pyrene, formaldehyde	Benz(a)pyrene, hydrogen fluoride, suspended solids, formaldehyde	Benz(a)pyrene, hydrogen fluoride, suspended solids, formaldehyde
Emissions of pollutants into the atmosphere from industrial enterprises, thousand tons, 2021*			
solids	8.7	24.4	3.2
SO_2	14.0	40.3	1.6
NO_2	12.8	14.5	1.8

CO	7.2	178.9	7.9
Population, thousand	555.25	544.6	187.9
Number of stations	8	8	2

*: in Kemerovo, Novokuznetsk, Prokopyevsk municipal districts

SI** (the highest average monthly concentration divided by the maximum permissible concentration (MPC)) more than 10 benz(a)pyrene was observed in Kemerovo (12.7 MPC) and Novokuznetsk (42.4 MPC)

NP*** (the highest frequency of exceeding the MPC) is below 20%

The average annual concentrations of benz(a)pyrene and formaldehyde exceeded 1 MPC in Kemerovo and Novokuznetsk, and the suspended solid concentrations exceeded 1 MPC in Novokuznetsk and Prokopyevsk. The average annual concentrations of hydrogen fluoride in Novokuznetsk and carbon monoxide in Prokopyevsk also exceeded 1 MPC.

The total volume of pollutant emissions (including emissions from railway transport) into the atmospheric air in 2021 amounted to 1,667.8 thousand t, having decreased by 0.7% since 2020. Emissions from road transport amounted to 64.0 thousand t, decreased by 3.8% compared to the level of 2020 and by 68.8% compared to the level of 2012. Emissions from stationary sources amounted to 1,603.2 thousand t, which decreased by 0.5% compared to 2020 but increased by 17.8% compared to 2012 (Fig. 2) [26].

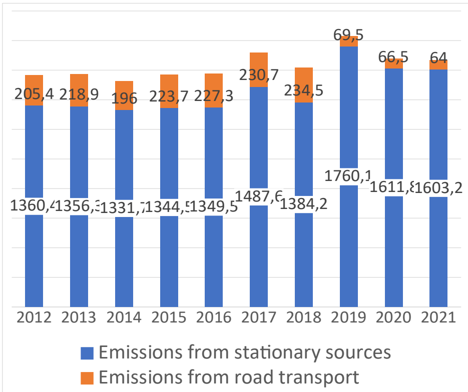

Fig. 2. Dynamics of pollutant emissions into the atmospheric air

Emissions from the local treatment facilities (LTF) decreased to the greatest extent (by 13.7 thousand tons), sulfur dioxide emissions (by 7.8 thousand tons) and nitrogen oxides (by 0.5 thousand tons) also decreased, but at the same time, emissions of solids (by 0.8 thousand tons) and carbon monoxide (by 1.7 thousand tons) increased. Compared to the 2012 level, the volume of solid emissions had decreased by 8.9%, sulfur dioxide by 10.8%, but at the same time, the volume of carbon monoxide emissions increased by 1.0%, nitrogen oxides by 27.8%, and emissions from LTF by 104.7% (Table 2) [26].

Table 2. The number of emissions in the Kemerovo region from 2012 to 2021

Emissions	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total	1,360.4	1,356.3	1,331.7	1,344.5	1,349.5	1,487.6	1,384.2	1,760.1	1,611.8	1,603.2
Solids	154.6	130.8	138.3	146.1	142.1	146.8	139.0	154.9	140.0	140.8
CO	273.0	265.1	258.8	235.5	241.5	274.7	251.1	284.1	274.1	275.8
SO_2	110.0	99.0	100.9	110.9	124.9	135.5	115.2	120.1	105.9	98.1
NO_x	69.5	55.6	63.0	68.5	74.7	78.5	73.6	93.2	89.3	88.8
LTF*	6.4	4.1	4.3	4.5	5.7	7.3	22.8	65.5	26.8	13.1

*: local treatment facilities

State of water landscapes

The Tom River and its tributaries (Usa, Mras-Su, Mundybash, Kondoma, Aba, Uskat, Chernov Naryk, Iskitimka). The Tom River and its tributaries are polluted by wastewater from mining, fuel, energy, metallurgical, coke-chemical, chemical, and woodworking industries, agro-industrial complex, and utilities.

The water quality in the area of the Teba village according to the specific value of the combinatorial water pollution index had not changed compared to 2020. The water was characterized as slightly polluted, quality class 2. The largest share in the overall assessment of the degree of water pollution belonged to total iron. The water quality in Tom upstream of Mezhdurechensk compared to 2020 had not changed. The water was characterized as slightly polluted, quality class 2. In the control area downstream of the city of Mezhdurechensk, the water quality remained unchanged. The water corresponded to Class 3 A (polluted). The largest share in the overall assessment of the degree of water pollution belonged to total iron, manganese, and volatile phenols. In the control areas upstream/downstream of the city of Mezhdurechensk, the average annual concentrations of phenols exceeded the MPC by 1.3/2 times, manganese by 1.2/1.6 times, and total iron by 1.1/1.4 times (Table 3).

Table 3. Average pollutant concentrations in the surface waters of the Kemerovo region as of 2021

Body of water, settlement, target	Soluble oxygen	Chemical oxygen demand (COD)	Biological oxygen demand (BOD)5	Ammonia nitrogen	Nitrogen nitrite	Phenol	Oil products	Zinc	Copper	Manganese	Total iron	Suspended solids
	MPC, mg/l (*mkg/l)											
	6.0 to 4.0	15.0	2.0	0.40	0.02	0.001	0.05	10.00*	1.00*	10.00*	0.10	
Tom, Teba village, water post	9.68	7.79	0.996	0.121	0.004	0.001	0.02	0.571	0.429	8.29	0.093	11.9
Tom, Mezhdurechensk, within the city	10.6	8.55	1.11	0.135	0.003	0.001	0.028	0.571	0.00	11.6	0.109	8.75
Tom River, Mezhdurechensk, 3.5 km downstream of the city	10.7	6.45	1.19	0.178	0.018	0.002	0.047	0.571	0.143	15.7	0.137	12.1
Tom River, Novokuznetsk, 1 km upstream of the city (Dragunsky water intake)	10.0	8.22	1.12	0.192	0.012	0.002	0.027	0.00	0.143	14.7	0.254	9.92
Tom River, Novokuznetsk, within the city, water post	10.6	10.9	1.15	0.159	0.015	0.002	0.027	0.00	0.143	5.29	0.184	15.3
Tom River, Novokuznetsk, 30 km downstream of the city (Slavino village)	10.9	13.2	1.25	0.655	0.041	0.001	0.037	0.00	0.143	9.00	0.260	20.9
Tom River, within the Krapivinsky village	9.42	10.2	1.79	0.099	0.014	0.000	0.134	1.43	0.571	0.0	0.283	23.3
Tom River, Kemerovo, 12 km upstream of the	9.89	9.53	1.61	0.095	0.007	0.000	0.041	1.71	0.429	0.0	0.224	7.55

city (Metalploshchadka village)											
Tom River, Kemerovo, 1 km downstream of the city (Verkhotomka village)	9.89	9.44	1.72	0.091	0.008	0.000	0.004	1.14	0.429	0.0	0.257	7.64
Tom River, Kemerovo, 20.5 km downstream of the city,(Podyakovo village)	9.59	9.20	1.74	0.094	0.008	0.000	0.04	1.43	0.857	0.0	0.223	7.71

Compared with 2020, the water quality in the Tom in the control areas upstream of/within Novokuznetsk had not changed. The water was characterized as slightly polluted, quality class 2. Volatile phenols, total iron, and manganese contribute the largest share to the overall assessment of the water pollution degree. The average annual concentrations of phenols exceeded the MPC by 2/2 times and total iron by 2.5/1.8 times in the areas upstream/downstream of Novokuznetsk. Besides, in the control area upstream of Novokuznetsk, the average annual concentration of manganese exceeded the MPC by 1.5 times (Table 3). In the control area downstream of Novokuznetsk (Slavino village), the water quality had deteriorated. The water corresponded to Class 3 B, very polluted (in 2020, the quality class was 3 A, polluted).

The largest share in the overall assessment of the degree of water pollution in the control area downstream of Novokuznetsk (Slavino village) belonged to volatile phenols, nitrite nitrogen, ammonium nitrogen, and total iron. In this control area, the average annual concentrations exceeded the MPC with the following values: volatile phenols by 1.4 times; nitrite nitrogen by 2.1 times; ammonium nitrogen by 1.6 times; and total iron by 2.6 times. In single samples in the control area Novokuznetsk (Slavino village), the following maximum concentrations were recorded: organic compounds according to the COD index: 2 MPC; ammonium nitrogen: 3.9 MPC; nitrite nitrogen: 6.3 MPC; phenols: 4 MPC; total iron: 6.7 MPC.

The quality of water in the control area of the Krapivinsky village had not changed in comparison with 2020. The water was characterized as slightly polluted, quality class 2. The largest share in the overall assessment of the degree of water pollution belonged to petroleum products and total iron. The average annual concentrations exceeded the MPC with the following values: petroleum products by 2.7 times; total iron by 2.8 times. The water quality of the Tom River in the control areas upstream of the city of Kemerovo and downstream (Verkhotomka village) had slightly deteriorated. The water was characterized as slightly polluted, which corresponds to quality class 2 (in 2020, the water was conditionally clean, quality class 1). In the control area downstream of the city of Kemerovo (Podyakovo village), the water quality had not changed. The water was characterized as slightly polluted, quality class 2.

In the Kemerovo region, the average annual concentration of total iron exceeded the MPC by 2.2-2.6 times (Table 3). In single samples, the maximum concentration of total iron in the control areas of the city of Kemerovo was 7.4-7.8 MPC (Table 3).

In the Polomoshnoe village, the water quality in the control area had not changed compared to the previous year. The water belonged to Class 2, slightly polluted. The largest share in the overall assessment of the degree of water pollution belonged to petroleum products and total iron. The following average annual concentrations exceeded the MPC: petroleum products by 1.8 times; total iron by 2.4 times. In the Tom River in the control area upstream of Novokuznetsk, 12 cases of thermal pollution were registered during the year. The temperature of the river water rose to +30°C - +9°C during the winter and to +28.4°C on July 12 and August 3.

In 2021, biological testing of water samples of the Tom River was carried out, taken in two sites in Kemerovo (Metallploschadka village, Podyakovo village). 22 water samples were examined, and no acute toxicity was detected.

In the controlled section of the Tom River in 2021, the control area downstream of Novokuznetsk (Slavino village) remained the most polluted one. The oxygen regime of the river throughout the year was satisfactory. Tom's tributaries have a significant impact on the quality of its water. In 2021, the water quality in the Uskat River improved compared to the previous year. While in 2020 the water was characterized as dirty (water quality class 4 B), in 2021 it was characterized as very polluted (water quality class 3 B).

Nitrite nitrogen and total iron made up the largest share of the overall assessment of the degree of water pollution. In Uskat, the average annual concentrations of nitrite nitrogen exceeded the MPC by 2.3 times, and the total iron concentration exceeded the MPC by 1.5 times (Table 3). In the Aba downstream of the city of Prokopyevsk/within the city of Novokuznetsk, the water was characterized as dirty, water quality class 4 A. The water quality in the control areas had deteriorated. In Aba, nitrite nitrogen, ammonium nitrogen, manganese, total iron, volatile phenols, and petroleum products made up the largest share of the overall assessment of the degree of water pollution. The following average annual concentrations in Aba exceeded the MPC: nitrite nitrogen by 3.1-5.1 times; manganese by 6.7-7 times; total iron by 2.1-3.9 times; phenols by 2 times; petroleum products by 1.1-1.9 times. In Aba, on February 9 and March 9, cases of thermal water pollution up to +5 or +6°C, respectively, were registered.

Water quality in Kondoma (the city of Tashtagol, in the city of Novokuznetsk) had not changed. The water was characterized as polluted, quality class 3 A. In Kondoma (upstream/downstream of the city of Osinniki), the water quality improved slightly in 2021, and the water was characterized as polluted, quality class 3 A. In Kondoma, manganese and total iron made up the largest share of the overall assessment of the degree of water pollution. The average annual concentrations in Kondoma were the following: manganese 1.5-2.5 MPC; total iron 3.5-4.3 MPC. In addition, in the control areas of Tashtagol, the average annual concentrations of nitrite nitrogen exceeded the MPC by 1.7 times, and in the control area downstream of Osinniki, the average annual concentration of volatile phenols exceeded the MPC by 2 times.

The water quality in the Chernovoy Naryk River was characterized as very polluted, quality class 3 B. Manganese, volatile phenols, total iron, nitrite nitrogen, and petroleum products made up the largest share of the degree of water pollution. The following average annual concentrations in the Chernovoy Naryk exceeded the MPC: phenols by 2 times; nitrite nitrogen by 2.4 times; petroleum products by 1.3 times; manganese by 2.4 times; total iron by 1.6 times. A case of thermal water pollution up to +3°C was recorded in the Chernovoy Naryk River on February 17.

In 2021, the water quality in the Us upstream of the city of Mezhdurechensk had not changed (quality class 3 A, polluted water). There were also no changes in the control area downstream of the city of Mezhdurechensk where the water was slightly polluted, quality class 2. The largest share in the overall assessment of the degree of water pollution in the control areas belonged to total iron by 1.2-1.7 times, and in the control area downstream of the city of Mezhdurechensk, the average annual concentration of manganese exceeded the MPC by 2.8 times.

In Mras-Su and Mundybash, water quality had improved compared to the previous year. The water was characterized as slightly polluted, quality class 2 (in 2020 it was polluted, quality class 3 A). The largest share in the overall assessment of the degree of water pollution belonged to total iron and manganese. The average annual concentrations were: total iron from 1.9 to 2.9 MPC and manganese from 1.5 to 1.7 MPC.

In 2021, the water quality in Iskitimka had not changed compared to the previous year (quality class 3 A, polluted) Manganese made up the largest share of the overall assessment of the degree of water pollution. In Iskitimka, the following average annual concentrations exceeded the MPC: manganese by 8.8 times; nitrite nitrogen by 1.1 times; total iron by 2.2 times. The oxygen regime of the Tom tributaries remained satisfactory throughout the year.

Belovskoe reservoir, the Inya River, and its tributaries (Bolshoy Bachat, Malyi Bachat). In 2021, the water quality in the Belovsky reservoir deteriorated: in the village of Pomortsevo, the water was polluted, quality class 3 A; and at the state district power plant (SDPP) dam, the water was slightly polluted, quality class 2. In 2020, the water in the Belovsky reservoir had the following characteristics: in the village of Pomortsevo it was slightly polluted, quality class 2; at the SDPP dam it was conditionally clean, quality class 1.

The largest share in the overall assessment of the degree of water pollution in the control area of the village of Pomortsevo belonged to total iron, copper, and manganese. In this control area, the average annual concentrations of total iron exceeded the MPC by 1.4 times, manganese exceeded the MPC by 4 times, and copper exceeded the MPC by 2.8 times. In the control area at the SDPP dam, the average annual copper concentration exceeded the MPC by 2.5 times (Table 3).

In the control areas upstream/downstream of the city of Leninsk-Kuznetsky, the water was characterized as very polluted, quality class 3 B. Compared to 2020, the water quality had not changed. The largest share in the assessment of the degree of water pollution belonged to total iron compounds. The average annual concentrations of total iron equaled 1.9/2.1 MPC, and organic compounds in terms of BOD5 exceeded the MPC by 1.1 times in the control areas upstream/downstream of the city of Leninsk-Kuznetsky. In addition, in the control area downstream of the city of Leninsk-Kuznetsky, the average annual concentrations of manganese exceeded the MPC by 1.9.

The quality of water in the Inya River is influenced by its tributaries Bolshoy Bachat and Malyi Bachat. In the tributaries of the Inya, the largest share in the overall assessment of the degree of water pollution belonged to compounds of zinc, manganese, copper, and total iron. In the control area upstream of the city of Belov in 2021, the water was characterized as dirty, which corresponds to quality class 4 A (in 2020, the water was very polluted, quality class 3 B). In the control area downstream of Belov in 2021, the water quality had not changed (quality class 3 B, very polluted). In Bolshoy Bachat (in the control areas upstream of/downstream of Belov, respectively), the following average annual concentrations exceeded the MPC: zinc by 2.0/7.1 times; manganese by 3.0/6.5 times; total iron by 2.3/1.8 times, copper by 1.4/1.9 times. The average annual concentrations of organic compounds in terms of BOD5 exceeded the MPC by 1.1/1.2 times.

In Malyi Bachat, the water quality in the control area upstream of the city of Guryevsk had deteriorated. The water was characterized as dirty, quality class 4 A (in 2020, the water was polluted, quality class 3 A). In the control area downstream of the city of Guryevsk, the water quality had not changed (quality class 4 A, dirty water). The average annual concentrations in the Malyi Bachat upstream of/downstream of Guryevsk were zinc 7.1/4.1 MPC; manganese 6.5/4.4 MPC; total iron 1.8/2.1 MPC, copper 1.9/2.1 MPC. There was an excess of MPC by 1.1 times in terms of BOD5. In addition, in the control area downstream of the city of Guryevsk, the average annual concentration of nitrite nitrogen exceeded the MPC by 1.4 times. In single samples in the Malyi Bachat River, 3 cases of high zinc pollution (HP) of the river were registered: on March 15, 21.9 MPC was registered in the control area upstream of Guryevsk, 13.6 MPC was registered downstream of Guryevsk; and on April 12, 19.4 MPC was registered in the control area upstream of Guryevsk. The oxygen regime of the Belovsky reservoir, the Inya, and its tributaries was characterized as satisfactory.

Rivers of the north of the region: Kiya, Yaya, Tyazhin, Barzas, Alchedat. In the rivers of the Chulym basin, compared with 2020, the water quality had improved in Kiya (Makaraksky village), Yaya, and Alchedat; worsened in Kiyf (city of Mariinsk) and Tyazhin; and had not changed significantly in Barzas. In 2021, the water quality in the rivers Kiya (Makaraksky village), Yaya, and Alchedat was characterized as slightly polluted, quality class 2. In Kiya (upstream/downstream of the city of Mariinsk) and Barzas, the water was characterized as polluted, quality class 3 A.

In Tyazhin, the water was characterized as very polluted, with quality class 3 B. The largest share in the overall assessment of the degree of contamination of the water of the rivers of the north of the region belonged to COD, manganese, petroleum products, and total iron. The average annual concentrations of petroleum products exceeded the MPC by 1.1-4.4 times, and total iron by 2.0-4.3 times. In addition, the following average annual concentrations exceeded the MPC: nitrite nitrogen by 3.4 times in Barzas; organic compounds in terms of COD by 1.1-3.3 times in Barzas, Tyazhin, Alchedat; manganese by 8.2 times in Tyazhin. The oxygen regime of all rivers in the north of the region during the year was satisfactory [23].

In 2021, 1,605.4 million m^3 of fresh water was taken from natural water bodies for use, which is 10.8% less than in 2020, and 29.6% less than the water intake indicator for 2012 (Table 4) [23].

Table 4. The hydrological regime of the Tom River

Year	Water intake		Fresh water use	Circulating and re-sequential water supply
	From underground sources	From surface sources		
2012	407.10	1,874.33	1,990.82	5,114.46
2013	444.86	1,616.10	1,729.79	5,043.35
2014	420.75	1,620.65	1,724.91	4,765.56
2015	407.78	1,630.41	1,735.45	4,894.92
2016	395.96	1,583.95	1,679.75	4,890.70
2017	409.22	1,579.49	1,670.66	4,895.12
2018	409.96	1,436.76	1,523.61	4,789.56
2019	410.78	1,419.33	1,513.00	4,749.12
2020	417.61	1,382.78	1,476.19	4,653.68
2021	422.23	1,183.14	1,272.62	4,436.55

The use of fresh water in 2021 amounted to 1,272.6 million m^3. Compared to the level of 2020, the use of freshwater had decreased by 13.8%, and compared to the level of 2012 it had decreased by 36.1%.

Analysis of the structure of water use shows that in 2021 the greatest changes occurred in the field of production needs: compared with the level of 2020, the use of fresh water in this area decreased by 16.0% (Table 5) [27].

Table 5. Structure of water use, million m^3

Water consumption	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Production needs	1,672.98	1,424.34	1,449.90	1,479.62	1,432.98	1,432.52	1,270.18	1,265.92	1,238.61	1,040.80
Agricultural water supply	2.76	2.61	1.44	1.99	2.02	1.86	1.90	1.93	1.25	1.22
Drinking and	248.28	232.88	210.04	196.77	192.00	183.54	188.81	173.53	173.02	169.29

household needs										
Irrigation	1.67	0.91	0.65	0.50	0.10	0.93	1.18	1.49	1.41	1.25
Other	65.13	69.04	62.87	56.56	52.67	51.81	61.54	70.13	61.91	60.06
Household water consumption per capita, m^3/year per person	91	85	77	72	71	68	71	65	66	65

The water disposal rate in 2021 amounted to 1,286.0 million m^3, which is 13.2% less than in 2020 and 32.6% less than in 2012. The discharge of polluted wastewater without treatment in 2021 amounted to 61.4 million m3, which is 9.4% less than in 2020 and 69.3% less than in 2012. The discharge of insufficiently treated polluted wastewater amounted to 163.7 million m^3, which is 15.7% less than in 2020, and 56.0% less than in 2012 [30].

The dynamics of indicators for wastewater disposal and discharge of polluted wastewater are shown in Fig. 3.

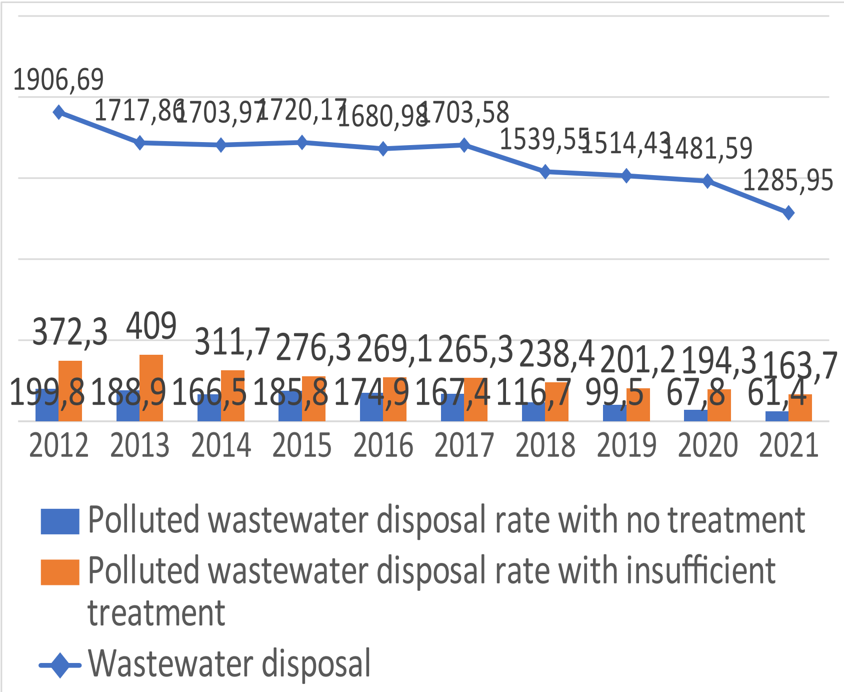

Fig. 3. Dynamics of indicators for water disposal and discharge of polluted wastewater, million m^3

Conclusion

We found that the long geological history of the region, changes in marine and terrestrial sediments, and magmatic activity determine the modern geological and geomorphological structure of the Kemerovo region, as well as the placement of minerals. The specifics of the location of large orographic units provide features of atmospheric circulation, and the distribution of hydrothermal indicators, thereby playing an important role in the formation of the structure of soil and vegetation cover and the distribution of landscapes, including man-made ones. In terms of climate, the Kemerovo region is heterogeneous. The main climate-forming factors are atmospheric circulation, relief, and vegetation. The combination of these factors forms local climatic features. In general, there is a pattern in the distribution of heat and moisture: the mountainous areas of Kuznetsk Alatau and Gornaya Shoria are provided with moisture, but thermal resources are scarce. The areas located in the rain shadow of the ridges (Salair, the northern spurs of Alatau) are deficient in moisture, but they are sufficiently heat-supplied. The most favorable conditions are in the foothills of the windward slope of the Kuznetsk Alatau, where the territories are sufficiently moistened and provided with heat.

The influence of geographical, geological, and climatic factors has shaped the economic and economic environment of the Kemerovo region. Mining, fuel and energy, metallurgical, coke-chemical, chemical, woodworking industries, agro-industrial complex, and public utilities are located in the region.

The concentration of industrial enterprises has an impact on air and water quality in the region. Structural analysis of pollutant air emissions shows that in 2021 there was a decrease in emissions from some key pollution sources compared to the level of 2020. Within the framework of the regional Clean Air project, a comprehensive action plan has been developed to reduce emissions of pollutants into the atmospheric air in Novokuznetsk for the period from 2019 to 2024. By 2024, it is planned to reduce emissions into the atmospheric air by 69.03 thousand t (20.25% to the level of 2017).

The results of the water quality analysis vary depending on the survey area. In some territories, the average annual concentrations of petroleum products, iron, nitrite nitrogen, and other chemical compounds exceed the MPC. However, there is a positive dynamic of reduction in wastewater disposal and discharge of polluted wastewater. We believe it is necessary to carry out further experimental work to improve water quality in the region.

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