The state of the environment of the West Kazakhstan region (late 1990s – early 2000s)

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Abstract. The article examines key aspects of the environmental state of the West Kazakhstan region in the late 1990s to early 2000s. It presents characteristics of the general environmental condition, atmospheric air quality, water quality, and environmental protection measures. An analysis of official data sources indicates that increased hydrocarbon production at the Karachaganak oil and gas condensate field (KOGCF) and other industrial enterprises led to a rise in gross emissions of pollutants into the atmosphere, particularly nitrogen dioxide, carbon monoxide, and hydrogen sulfide. The authors highlight a significant risk of river pollution from heavy industry waste in the region. Moreover, the analysis reveals that despite ample water and mineral resources, the West Kazakhstan region did not effectively utilize them for agricultural purposes. In conclusion, it is evident that the environmental state of the region was negatively impacted by increased pollution of atmospheric air and water resources with toxic metals resulting from industrial activities.

1 Introduction

The issues surrounding the state of the environment in the West Kazakhstan region and its impact on human health are currently pertinent and demand close attention. The West Kazakhstan region holds significant importance within modern Kazakhstan, covering a territory of 151.3 thousand square kilometers [1–6]. Its extensive span from north to south results in zonal variations across all natural components, including climate, soils, and vegetation. Situated deep within the continent and far from oceans, the region experiences aridity and a distinctly continental climate, fostering the development of dry-steppe and desert landscapes.

Annual precipitation naturally decreases from north to south, while evaporation rates exhibit an inverse trend. In some years, precipitation levels may plummet by half, although such occurrences are rare, with a likelihood of only 3–5%.

During the warm season, dry weather conditions, coupled with wind presence, give rise to dust storms. On average, the region witnesses 10–15 dust storms annually in areas with heavy mechanical soil composition, escalating to 30–45 in sandy loam and sandy soil

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regions like Zhambeyty and Karatyuby in the east. Monthly wind speeds typically range from 3.5 to 4.5 m/s in summer, 4.5 to 5.5 m/s in winter, and occasionally reach 6–7 m/s in certain areas [7].

The population of the region was recorded at 603.3 thousand people. In recent years, there has been a downward population trend attributed to declining birth rates and resettlement to neighboring regions.

The Karachaganak hydrocarbon field, a significant contributor to the regional economy, was discovered and operationalized, boasting estimated gas reserves of 1 trillion 300 billion cubic meters and liquid carbohydrate reserves of 800 million tons.

Production figures from 1999 indicate that the Karachaganak oil and gas condensate field yielded 3623.981 million cubic meters of gas and 3356.255 thousand tons of gas condensate, which increased to 4675.897 million cubic meters and 4628.636 thousand tons respectively in 2000.

The region is rich in chemical raw materials, with promising deposits including rock salt, potassium and boron-bearing salts, gypsum, calcareous rocks, and chalk. Notably, there are 9 known deposits of sand-gravel mixture with a total reserve of approximately 100 million cubic meters.

By the late 1990s, exploration efforts had unveiled the Aksuat deposit of cement raw materials, boasting a reserve of 1106482 thousand cubic meters, sufficient for constructing a cement plant with an annual capacity of 1300 thousand tons.

2 Materials and methods

The article employs interdisciplinary approaches, drawing upon materials sourced from various governmental bodies, including the Ministry of Natural Resources and Environmental Protection of the Republic of Kazakhstan, alongside other relevant departments. Interdisciplinary research is showcased through the integration of data from meteorology, ecology, and biology. This multifaceted approach enabled the authors to independently investigate the environmental conditions of the West Kazakhstan region.

3 Results and Discussion

3.1 The state of the atmospheric air

Since 1999, the regional territorial Department of Environmental Protection conducted state monitoring of atmospheric air quality, establishing monitoring stations in Uralsk, where the majority of industrial enterprises in the region were situated, and in Aksai (Burlinsky district), where intensive development of the Karachaganak oil and gas condensate field (KOGCF) took place. The latter accounted for between 84% and 92% of emissions from all stationary sources in the region over the previous five years. In other districts of the region, typically only isolated boiler houses (e.g., schools, hospitals) were operational [8].

Throughout the mid-1990s, a consistent trend emerged, showcasing a decline in the proportion of emissions from enterprises in Uralsk, dropping from 53.4% to 15.1%, alongside a rise in emissions from enterprises in Aksai, increasing from 17% to 73.8%.

The primary contributors to air pollution in the region were enterprises within the oil and gas sector, with their share rising from 35% in 1996 to 77.6% in 2000. Among them, Karachaganak Petroleum Operating B.V. prominently featured, responsible for the development of the Karachaganak OGCF and accounting for 84.2% of emissions within the oil and gas sector.

In 2001, atmospheric air pollution levels in Uralsk decreased from 1.4 to 1.2 according to the atmospheric pollution index compared to 2000. The escalation in hydrocarbon production at KOGCF coincided with a surge in gross emissions of pollutants into the atmosphere, notably nitrogen dioxide, carbon monoxide, and hydrogen sulfide.

Overall, there was a rise in emissions of sulfur dioxide and carbon monoxide in the region, accompanied by a slight decrease in nitrogen oxide emissions [9].

The observed late 1990s trend of increasing harmful substance emissions into the atmosphere correlated with changes in their chemical composition, primarily linked to the extraction and processing of hydrocarbons from the Karachaganak oil and gas condensate field. Specifically, emissions of sulfur dioxide increased by 1.6 times and carbon monoxide by 3.3 times, while nitrogen oxide emissions decreased by 1.4 times. During this period, the Karachaganak field accounted for 90.3% to 92.3% of total emissions and 87.5% to 73.0% of carbon monoxide emissions. See Table 1.

Table 1. Dynamics of gross emissions in the region for 1997–2001 (thousand tons).

Emissions from stationary sources					
	1997	**1998**	**1999**	**2000**	**2001**
by region	13.3	15.3	22.7	22.5	24.5
including the city of Uralsk	7.1	5.8	8.8	2.7	3.7
Emissions from mobile sources					
	1997	1998	1999	2000	2001
by region	41.7	46.0	47.3	45.6	47.0
including the city of Uralsk	26.5	25.3	24.2	23.2	24.0
Total					
	1997	1998	1999	2000	2001
by region	55.0	61.3	70.0	68.1	71.5
including the city of Uralsk	33.6	31.1	33.0	25.9	27.7

Since 1997, there was an increase in gross emissions by 1.3 times (from 55 thousand tons in 1997 to 71.5 thousand tons in 2001), including emissions from stationary sources by 1.7 times (from 13.3 thousand tons in 1997 to 24.5 thousand tons in 2001) and mobile sources by 1.3 times (from 41.7 thousand tons in 1997 to 47.0 thousand tons in 2001), driven by the development of the regional economy [8].

Atmospheric transport significantly contributed to atmospheric pollution in the region, with its level in the latter half of the 1990s amounting to 65–75% of gross emissions of harmful substances. In 1999, there were 53,449 vehicles in operation in the region, marking an 8.4% decrease compared to 1995 (58,368 units). See Table 2.

Table 2. Accounting of vehicles.

Indicators units.	**1995**		**1996**		**1997**		**1998**		**1999**	
	region	**city**	**region**	**city**	**region**	**city**	**region**	**city**	**region**	**city**
Total units of vehicles, thousand items	58.4	30.0	58.9	32.2	56.9	32.3	53.86	32.25	53.5	32.7
Emissions, thousand tons	49.1	30.6	43.6	27.4	41.7	26.5	46.0	25.3	47.3	24.4

At the same time, emissions decreased by only 3.7% (49.1 thousand tons in 1995 compared to 47.3 thousand tons in 1999). In 1999, compared with 1996–1998, the share of emissions from motor vehicles (in total emissions) decreased from 75.5% to 67.5%.

More than half of the emissions from motor vehicles accounted for the city of Uralsk. In 2001, about 30% of vehicles were switched to gas. Further implementation of this work, as well as strengthening control over the quality of fuels and lubricants sold, has reduced emissions from motor vehicles [10].

According to the data of the State Environmental Monitoring, there were no exceedances of the maximum permissible concentration (MPC) within the industrial enterprises of Uralsk. However, in the city of Uralsk in 1998–1999, in the areas of concentration of vehicles (market, CHP area), there were cases of exceeding the concentration of nitrogen dioxide and carbon monoxide to 3.2 MPC, dust – 3.8 MPC.

Environmental monitoring data from 2001 indicated only isolated cases of exceeding the maximum permissible concentration for nitrogen dioxide by 1.3 times. In general, its concentration ranged from 0.5–0.7 MPC.

The growth of production in the Burlinsky district and in Aksai, associated with the development of the Karachaganak hydrocarbon deposit, combined with the decline of traditional industries (mechanical engineering, instrumentation, processing of agricultural products, etc.) in Uralsk, caused a tendency to shift the vector of pollutant emissions from the regional center to the Burlinsky district [11].

The observations of the laboratory of the Research center Kazhydromet revealed a tendency to increase the concentration of pollutants (hydrogen sulfide, mercaptans, nitrogen oxides, carbon and sulfur dioxide) in the atmosphere of the settlements nearby to the KOGCF: Tungush, Berezovka, Zharsuat, Dimitrovo, Karashaganak, Zhanatalap, Karakemir, Aksai, Uspenovka, Bestau. In the settlements of Tungush and Berezovka, in 1999, there was an excess of the maximum permissible concentration for nitrogen dioxide by 1.3 times, and in subsequent years – at the level of 0.8 MPC, which was the result of a number of air protection measures. In the study of wells for productivity, the “Green Burner” method was used, which reduces emissions of solids into the atmosphere. Well annealing operations began to be carried out under weather conditions that exclude a negative impact on the villages of Tungush and Berezovka. Production monitoring was organized both at the KOGCF itself and in the adjacent territory.

The boiler room and oil heating furnaces at the Sakharny station, the Bolshoy Chagan linear production and dispatch station of the Ural Oil Pipeline Directorate of Kaztransoil JSC, and the boiler room of Nurzhanar JSC were switched to gas fuel. The switch of the Ural asphalt plant of Gordorstroy to gas had significantly improved the environmental situation in the surrounding area. Boiler rooms of 18 industrial enterprises and settlements of Zelenovsky, Kaztalovsky and Taipaksky districts of the region were also switched to gas. Dust and gas traps were installed in Zenit JSC, UPOSM JSC, Kazakhburgaz JSC, a branch of Kazakhstan Temir Zholy RSE, Ural and Aksai grain receiving enterprises.

As a result of improving the technology, emissions from the combustion of coolant and oil in the furnace of UMZ JSC were eliminated. Ventilation installations in the fire extinguisher refueling shop of the Ural Locomotive Depot were modernized. Production monitoring had been introduced in 12 large enterprises of the region, such as Karachaganak Petroleum Operating B. V., Condensate JSC, Aksaygazpromenergo JSC, Aksaygazservice JSC, UPOSM JSC, etc.

A regional program to ensure safety in motor transport, which provided for a number of measures to reduce air pollution in the settlements of the region had been developed and implemented in the region. In particular, it was planned to equip vehicles with catalysts to reduce the toxicity of engines [12].

The transfer of vehicles to gas heating contributed to the reduction of pollution in the air basin of the region. On January 1, 2000, about 30% of cars were switched to gas. For systematic work in this direction, a program was developed for the conversion of vehicles to run on liquefied and compressed gas, the first stage of which provided for the expansion of the network of enterprises installing gas equipment.

For the period from 2001–2003, the regional territorial Department of Environmental Protection developed a medium-term comprehensive program "Ecology", in which the section "Atmospheric air" included 21 major events. These measures were aimed at reducing emissions of harmful substances and dustiness of atmospheric air, monitoring the air environment of the region.

At the enterprises developing the Karachaganak KOGCF, it was planned:

- In Karachaganak Petroleum Operating B.V. – the use of desulfurized fuel gas to reduce hydrogen sulfide emissions, installation of a methanol regeneration unit, installation of an automatic control system for the presence of hydrogen sulfide in the surface air layer in the villages of Tungush, Berezovka.
- In Condensate JSC – the introduction of desulfurization of weathering gases at MTU-400, the organization of production monitoring.

The Ecology program included: conversion of boiler areas to gas fuel and the private sector to liquefied natural gas vehicles in Nurzhanar JSC, Alau LLP; installation and repair of ventilation systems and dust and gas traps at Zenit plant, Uralarma plant, Nurzhanar JSC plants; reconstruction of the irrigation system in order to reduction of dust in Uralsk; carrying out an inventory of greenhouse gas sources in the West Kazakhstan region with the subsequent development and implementation of a target program for energy conservation and reduction of greenhouse gases, etc. [9].

The implementation of the planned environmental measures was supposed to restrain the trend of increasing emissions of harmful substances into the atmosphere, contribute to reducing the negative man-made impact on the environment.

3.2 The state of water quality

3.2.1 The state of surface waters

The main waterways of the region are the Ural, Chagan, Derkul, and Ilek rivers. The qualitative composition of the waters of open reservoirs improved markedly in the 1990s, which was primarily due to a decrease in the anthropogenic impact of polluting objects [13].

The water pollution index for the Ural River was 0.73 in 2001, the degree of pollution of the river was classified as "clean". The average concentration of phenol was 0.002 mg/liter (2 MPC).

The Chagan River was also characterized as clean in terms of the degree of water pollution (water pollution index – 0.72). In 1999, the water in the river was cleaner in terms of biochemical oxygen consumption (BOC), petroleum products, and nitrates with a water pollution index of 0.95.

The waters of the Derkul River had an increased salt composition of natural origin. The water pollution index decreased from 1.67 in 1998 to 0.74 in 2001. Small rivers had snow supply (up to 90%). In the summer, the small rivers of the region did not have a constant flow, but were divided into separate stream pools. See Table 3.

Table 3. Dynamics of the qualitative composition of the waters of the main water bodies.

Year, river	Polluting ingredients, mg/l						Index of pollutants	Degree of contamination
	BOC	Phenols	Synthetic surfactants	petroleum products	Ammonium nitrogen	Nitrites		
MPC	**2**	**0.001**	**0.1**	**0.05**	**0.39**	**0.08**		
Ural river								
1998	2.8	0.002	0.04	0.05	0.05	0.075	0.89	clean
1999	1.9	0.004	0.01	0.012	0.05	0.051	0.94	clean
2000	2.47	0.003	0.006	0.031	0.06	0.100	0.98	clean
Chagan river								
1998	3.2	0.002	0.01	0.056	0.15	0.17	1.22	moderately polluted
1999	2.3	0.004	0.01	0.012	0.075	0.041	0.95	clean
2000	2.56	0.002	0.07	0.033	0.30	0.166	1.07	moderately clean
Derkul river								
1998	3.7	0.003	0.03	0.046	0.25	0.17	1.67	moderately polluted
1999	2.9	0.004	–	0.014	0.087	0.050	1.30	moderately polluted
2000	3.64	0.003	0.03	0.016	0.10	0.042	1.04	moderately polluted
Small rivers								
1998	2.8	0.004	0.15	0.049	0.50	0.160	1.67	moderately polluted
1999	3.9	0.004	0.01	0.053	0.075	0.056	1.30	moderately polluted
2000	3.64	0.003	0.01	0.031	0.03	0.051	1.04	moderately polluted

According to the Republican sanitary and epidemiological station, in the fourth quarter of 2000, the indicator of the quality of drinking tap water (the proportion of drinking water samples that do not meet hygienic standards for microbiological indicators) more than doubled the national average (3.2%) and amounted to 6.6%. The indicator for water from decentralized sources (wells, wells without distribution networks, springs, etc.) was 4.6% (in the republic – 7.8%).

The proportion of samples that do not meet the standards for chemical indicators for the West Kazakhstan region was 6.7% (for the republic – 10.7%), for microbiological indicators – 7.7% (for the republic – 9.4%).

3.3 The state of water protection zones

In the early 2000s, the area of water protection zones of most rivers was in a satisfactory sanitary condition. A favorable factor was an almost twofold reduction in the number of livestock, and as a result, a decrease in summer camps, bathing, etc. within water protection zones. To prevent pollution and clogging of the reservoirs of the region, measures were taken to annually remove from the water protection zones natural landfills of industrial and household garbage, warehouses of fuel and lubricants, cattle camps and livestock handling and other objects that negatively affected the quality of waters [9].

Groundwater was the most important, and in some areas of the region, the only source of domestic drinking water supply. Of the 23 explored deposits, Uralskoye and Serebryakovskoye, used for water supply in Uralsk and a number of other settlements, were the most affected by man-made impacts.

The main sources of groundwater pollution were enterprises of mechanical engineering, light and food industries, livestock farms and agricultural fields, sedimentation tanks, waste and material storages. Thus, pollution of underground drinking waters of the Serebryakovskoe and Uralskoe deposits was associated with the constant discharge of wastewater from poultry farms, urban storage facilities and settlements into sanitary protection zones. Within the sanitary protection zone of the Uralskoe groundwater deposit, there was a dump of household waste from the village of Daryinskoye, filtration fields and a litter storage of Bird JSC, storage of livestock waste from the settlements of Zhelayevo, Volodarka, Sholpan. As a result, the presence of phenols – 1.2–4.5 MPC, manganese – 5–12 MPC, nitrates – up to 4.5 MPC was detected and mineralization reached 1.2–1.5 g/l in the groundwater of the deposit.

To reduce the anthropogenic impact on the field, Scientific production association Kazakhzhobalau JSC developed a project for the construction of sewage treatment plants and filtration fields of JSC Ptitsa, and JSC Institute Uralskvodproekt developed a project for the construction of a solid waste landfill for the village of Daryinskoye, the implementation of which was held back due to lack of financial resources.

The main sources of pollution of the Serebryakovskoe groundwater deposit were the sewage storage and litter storage facility of Akkainat JSC, the manure storage facility of Balagan and Bolshoy Chagan settlements, and the discharge of water from the storage facilities of Uralsk. Nitrogen compounds, phenols, and manganese exceeding MPC by 1.5–4.0 times were observed in groundwater.

At the same time, a sharp decrease in state budget financing led to a significant reduction in the volume of routine observations of the state of groundwater conducted by Zhaiykhydrogeology JSC at large water intakes in the region, and since 1998 these works have practically been stopped, which prevented the study of changes in the qualitative composition of groundwater.

3.4 Wastewater discharge

Wastewater had not been discharged into surface water sources in the region since 1968 [14]. All wastewater from Uralsk city and Aksai town was diverted to storage facilities after the treatment facilities. In 1996 wastewater discharge was 20.48 million cubic meters, then in 2000 it was 11.94 million cubic meters, i.e. it decreased by 42%. See Table 4.

Table 4. Dynamics of wastewater discharge (million cubic meters). Wastewater discharge in the region.

Districts	**Enterprises-pollutants**	**Years**				
		1996	**1997**	**1998**	**1999**	**2000**
	On the filtration fields (thousand cubic meters)					
Dzhangalinsky	CJSC “Intergaz-Central Asia” Kisyk-Kamys	66.6	52.5	45.5	25.2	21.2
Zelenovsky	Enterprises developing gas fields	17.0	16.0	14.0	12.0	27.0
	In storage units (million cubic meters)					
the city of Uralsk	Public Utility Companies	18.0	14.2	12.3	10.7	10.7
the town of Aksai	Public Utility Companies	2.0	1.9	1.6	1.2	1.2
	Into water bodies (million cubic meters)					
the city of Uralsk	ZHTE JSC, Regional Management Vodokanal, Plant Metalist JSC	–	–	–	–	1.2
		Discharge of conditionally clean waters into the Soldier’s village of the Ural river				
Total in region		20.4	16.3	15.1	13.0	11.97

3.5 Characteristics of sewage treatment plants

There were 54 treatment facilities registered with the regional environmental protection department, with a design capacity of 91.608 thousand cubic meters/day, of which 21 treatment facilities with discharge into urban sewers (21.144 thousand cubic meters/day)

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and 33 treatment facilities with discharge into storage tanks, filtration fields and terrain (70.494 thousand cubic meters/day).

The actual load amounted to 11,377 thousand cubic meters/year, while 34 wastewater treatment plants were in working condition: 15 with discharge into urban sewers, 19 with discharge into storage tanks, filtration fields and terrain [9].

By 2000, the facilities of such enterprises as Oral JSC, Fur Factory, Nuraly Leather Factory, Omega, and district creameries were not working. Other enterprises such as Zenit JSC, Mechanical Plant, Ayaz, Metallist, UPSM, Metalloizdeliya and others worked 2–4 days a week.

The largest sewage treatment plants in the region were:

Sewage treatment plants in Uralsk (regional management “Vodokanal”), with a capacity of 50 thousand cubic meters / day. The project was developed by Kazvodokanalproekt State design institute, put into operation in 1987. The complex of sewage treatment plants (STP), located on 5 km of the Uralsk-Saratov highway, occupied an area of 40 hectares.

The chemical composition of wastewater discharged into the natural environment according to analysis data for 2000: pH – 7.8, BOC_5 – 48 mg/l, Chemical oxygen demand (COD) – 80 mg/l, suspended solids – 61.4 mg/l, chlorides – 172.6 mg/l, ammonia – 21.8 mg/l, nitrates – 7.85 mg/l, nitrites – 0.054 mg/l, total iron – 0.19 mg/l, petroleum products – 0.041 mg/l.

In addition to mechanical cleaning, natural biological cleaning was carried out: a cascade of storage tanks and biological ponds was located 24 km southwest of Uralsk on the territory of the Zelenovsky district. The natural biological purification system consisted of storage tank No. 1, built on Bezlastichnaya arroyo (16.1 million cubic meters), storage tank No. 2 (43.5 million cubic meters) and cascades of 4 biological ponds (4.2 million cubic meters).

The sewage treatment plants of Aksai (Burlinsky district) consisted of 2 biological treatment plants: STP-7000 and STP-2500. The STP-7000 sewage treatment plants were built according to the Kazvodokanalproekt project in Almaty, and STP-2500 – according to the OKR Banske Projects project in Ostrava, Czechoslovakia.

The STP-7000 wastewater treatment plants consisted of three complexes of structures in block design, with a total capacity of 7 thousand cubic meters/ day, which included:

- Head pumping station.
- Reception chamber.
- Tangential sand traps.
- Aeration-sedimentation tank.
- Sand filters.
- Contact well for receiving and disinfecting treated wastewater.
- Pumping station of treated wastewater.
- Storage tank.
- Sand and silt platforms.

The chemical composition of wastewater discharged into the natural environment, according to analysis data for 2000: pH – 7.4, BOC_5 – 120 mg/l, COD – 200 mg/l, suspended solids – 64 mg/l, chlorides – 182.53 mg/l, ammonia – 22 mg/l, nitrates – 4.2 mg/l, nitrites – 0.020 mg/l, total chromium – 0 mg/l, total iron – 0.40 mg/l, petroleum products – 0.131 mg/l.

Sewage treatment plants STP-2500. The STP-2500 wastewater treatment plant, consisting of two purification complexes (of the Hydrovit – 1000-S type), had:

- The pumping tank in which the preliminary wastewater treatment took place.
- Aeration-sedimentation equipped with a sand trap with an air pump.
- Distribution tank.

- Blower.
- Air compressor.
- Secondary sump.
- The tank.

The chemical composition of wastewater discharged into the natural environment, according to analysis data for 2000: pH – 7.4, BOC_5 – 30 mg/l, COD – 65.0 mg/l, suspended solids – 14 mg/l, chlorides – 380.95 mg/l, ammonia – 12 mg/l, nitrates – 5.0 mg/l, nitrites – 0.295 mg/l, total chromium – 0 mg/l, total iron – 0.4 mg/l, petroleum products – 0.08 mg/l.

4 Conclusion

Based on the above, we can draw the following conclusions. One of the primary environmental challenges facing the region was the preservation of the ecosystem of the Ural River, which plays a stabilizing role in the surrounding steppe areas. Both surface and groundwater quality and conditions were deteriorating. An analysis of the environmental situation in the West Kazakhstan region and an evaluation of the pollution levels of prominent facilities indicate an escalating environmental pollution trend, despite the measures implemented by government agencies. To mitigate the adverse impact of the Karachaganak field, it was imperative to formulate a comprehensive plan of environmental protection measures.

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