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The environmental state of the Akmola Region in the Republic of Kazakhstan in the 1990s

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Abstract. The article discusses the environmental issues in the Akmola region during the 1990s. It provides a description of the region's climate and addresses concerns such as air pollution from both stationary and mobile sources, the condition and use of water resources, radiation levels, and land management. The authors highlight a decline in water quality in lakes attributed to highway construction obstructing the flow of meltwater. Analysis of the data revealed that a significant environmental challenge in the region was the dusting of tailings from the hydrometallurgical plant, leading to further land degradation. In conclusion, it is emphasized that the region's environmental state was impacted by increased pollution of water and land resources due to activities in mining, processing, chemical, light, and food industries.

1 Introduction

Akmola region covered an area of 146.24 thousand square kilometres, with a population of 1,127,000 people. The climate of Akmola region is sharply continental, characterized by hot, dry summers and harsh winters. The continentality of the climate manifested itself in large annual and daily amplitudes of air temperature fluctuations. The average maximum temperature of the hottest month was +27.1°C, the average minimum air temperature in the coldest month was –14.0°C. The absolute maximum air temperature is +31.0°C, the absolute minimum is –35.0°C.

The prevailing winds were south-westerly and westerly. The average annual wind speed in the territory of Akmola region was 5.6 m/s. The average wind speed for the month of July is 4.6 m/s, for January – 5.8 m/s.

An average of 250–300 mm of precipitation fell in the region per year. The greatest amount of precipitation fell in the summer months – June-August (49%), the least amount fell in December-February; in the spring period (March-May) the amount of precipitation was 18% of the annual norm.

The unfavourable aspects of the climate of the region should include early spring drought, strong winds in spring, which often cause dust storms (soil erosion), the return of late spring and the onset of early autumn frosts. The depth of freezing of the soil reached 110 cm, in some places it reached 200 cm.

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These natural conditions prevented the rapid restoration of the natural balance after the cessation of pollution. The region is rich in mineral resources, represented by significant reserves of the following minerals: gold, uranium-containing ores, coal, building materials. There were more than 20 mining and processing enterprises in the region.

The leading industries of the region were mining, mining and processing, chemical, thermal power engineering, light and food industries [1–5].

Due to the ongoing reform of the economy and especially agriculture in the 1990s, large enterprises were constantly disintegrating, old ones were liquidated and new ones were created, farms, small settlements, state farms disappeared from the map of the region, old quarries and mines were abandoned, new ones were opened, which made it very difficult to keep records of nature users and the pollution they produced. Only thermal power plants were operating relatively stable. Machine-building and chemical enterprises were almost idle.

2 Materials and methods

This article is based on a combination of interdisciplinary methods. It incorporates materials sourced from the Ministry of Natural Resources and Environmental Protection of the Republic of Kazakhstan from the 1990s. The interdisciplinary nature of the study is evident in the use of methods from various fields such as ecology, biology, and agronomy. These combined approaches enabled an independent scientific examination of the environment in the Akmola region.

3 Results and Discussion

3.1 Atmospheric air pollution from stationary sources of emissions

The main sources of atmospheric air pollution in the region were boiler houses and thermal power plants. Due to the decline in production and even the complete shutdown of many enterprises, in the 1990s there was a decrease in emissions of harmful substances into the atmosphere from stationary sources. Thus, in 1992, the volume of emissions amounted to 237.7 thousand tons, and in 1998 – 83.65 thousand tons. The main contribution to atmospheric air pollution was made by: Stepnogorsk CHP, Hydrometallurgical Plant, Makinsky Piston Ring Plant, Kazakhaltyn JSC, Vasilkovsky GOK, Akmola CHP-1, 2, Sagzhan LLP [6]. See Table 1.

Table 1. Dynamics of emissions into the atmosphere from stationary sources in the cities of the Akmola region (thousand tons).

Years	1994	1995	1996	1997	1998
region	177.4	145.6	115.0	87.7	83.63
city of Astana	53.5	52.5	51.2	40.0	41.5
city of Kokshetau	20.4	12.9	5.97	6.59	5.55
town of Shchuchinsk	11.3	5.3	4,5	1.6	1.2
town of Stepnogorsk	47.2	33.1	29.3	21.4	19.3

Due to the lack of stationary sources, observations of atmospheric air pollution in the cities of the region were not carried out, the atmospheric pollution index was not determined in them, therefore, there is no information on the dynamics of the pollution index for cities.

The contribution of the main enterprises to the pollution of the air basin of the Akmola region in 1998:

- Akmola CHP-1 – 9.3 thousand tons.
- Akmola CHP-2 – 27.9 thousand tons.
- Stepnogorsk CHP – 16.78 thousand tons.
- Hydrometallurgical plant – 0.7 thousand tons.
- Makinsky Piston Ring Plant – 0.3 thousand tons.
- Kazakhaltyn JSC – 0.55 thousand tons.
- Vasilkovsky GOK – 0.57 thousand tons.

Due to the fact that many enterprises were not operating at full capacity or were idle at all, exceeding the maximum permissible concentration in the cities of the region was not observed for any of the ingredients. In 1998, due to lack of funds, air protection measures were not carried out in the region. The enterprises primarily allocated funds for the maintenance and repair of ash-collecting and cleaning equipment, including both current and capital repairs. It should be noted that there were no large emissions of pollutants into the atmosphere in 1998 in the region.

3.2 Air pollution from mobile sources

One of the main sources of atmospheric air pollution in the region was automobile transport, as automobile enterprises in their activities committed violations of environmental legislation, environmental norms and standards. Production control over environmental protection had been weakened. At enterprises, especially in the districts, there were very few controls (gas analysers, smoke meters), the available control devices did not pass timely state inspection by the State Standard bodies, some of them were defective, car service companies often did not perform their functions. As a result, from 20 to 40% of the car fleet was operated in excess of the standards of toxicity and smokiness. See Table 2.

Table 2. Dynamics of pollutants emissions from mobile sources (thousand tons).

Years	1992	1993	1994	1995	1996	1997	1998
Region	200.1	166.1	120.8	74.7	68.4	67.8	69.
city of Astana	43.3	32.8	30.7	25.0	21.0	20.0	27.0
city of Kokshetau	23.4	18.3	13.7	10.6	10.1	10.1	10.1
town of Shchuchinsk	19.2	16.8	11.3	6.9	6.0	5.7	5.7
town of Stepnogorsk	26.3	20.5	13.5	7.2	6.8	6.8	6.8
town of Akkol	12.2	10.2	7.3	4.5	4.5	4.5	4.5
town of Makinsk	12.7	10.8	9.1	2.1	2.0	2.0	2.0
town of Atbasar	11.9	10.5	8.8	4.0	4.0	4.0	4.0
town of Yerementau	11.0	9.8	6.8	2.7	2.5	2.5	2.5
town of Yesil	–	–	–	–	–	–	2.0
town of Derzhavinsk	–	–	–	–	–	–	2.0
other districts	40.1	36.4	19.6	11.7	11.5	12.1	3.2

3.3 The state of water resources

Within the Akmola region, the largest rivers are the Ishim River, the Koluton River, the Zhabai River, the Selety River, the Nura River, the Chaglinka River and the Kylshakty

River. The total catchment area of these rivers was about 120 thousand square kilometres. All the rivers of the region are of the plain type, the peculiarity of the water regime of which is a pronounced spring flood and drying up in summer [7]. In this regard, the main replenishment of water reserves occurred during the flood period in storage tanks – reservoirs, if any.

It should be noted that there were no organized discharges of contaminated wastewater into surface water bodies in the region (except for the discharge of stormwater from Astana into the Ishim River), and only rural settlements were located along the river banks. The water pollution index in rivers varied mainly from year to year depending on annual water levels, and by season depending on the dilution from spring floods and releases from reservoirs. See Table 3.

Table 3. Dynamics of the index of water pollution of the Ishim and Nura rivers.

Name of the river	Years					
	1990	1991	1992	1993	1994	1995
Ishim river	0.86	0.9	1.0	0.84	0.9	0.8
Nura river	1.81	1.29	1.33	1.5	1.41	1.41

After 1995, the water pollution index was not determined.

Lake Altaysor is located 11 km northeast of Bogembai village. The catchment area is 1,310 square kilometres. The composition of the water is chloride with a predominance of sodium ions. Water is very tough. It is not used for domestic water supply purposes. The average area of the lake is 2 sq. km. The inflow is 5.47 million cubic meters/year; the evaporation rate is 5.47 million meters /year (drying up). The pollution index is polluted, class 4.

Atansor Lake is located in the south-eastern part of the region. The catchment area is 1,160 square kilometres, including the area of the main tributary of the Atan River – 961 square kilometres. The bottom of the middle part is silted up, the silt thickness is 0.3–0.5 m. The composition of the water is chloride with a predominance of sodium ions (42% equivalent to CI). Hardness is 100–120 eq (very hard) in summer and winter, mineralization is up to 20 g/kg (0.02 mg/l). The area of the lake mirror is on average 20 sq. km. The pollution index is moderately polluted, class 3.

Lake Zhukey is located south-east of Shchuchinsk. The total catchment area is 160 square kilometres. The average estimated area of the lake is 15 square kilometres. Bicarbonate chloride-magnesium-sodium water. Mineralization is 2.3–2.5 g/kg. Hardness is 14–17 mg/eq, pollution index – contaminated, Class 4.

Lake Zerenda. The catchment area is 97.7 square kilometres. Water mineralization is 600–1000 mlg/l, hardness is 4–6 ml/g eq (moderately hard). The chemical composition is bicarbonate with a predominance of sodium ions. The pollution index is moderately polluted, class 3.

Lake Kopa. The total catchment area is 3,860 square kilometres. Most of it is accounted for by the tributaries of the Chaglinka River and the Kylshykty River. Its own part of the catchment area is 80 square kilometres. Mineralization is 300–700 mg/l, hardness is 3–7 mg/eq (very hard). The water is bicarbonate chloride-sodium in composition. The average area of the lake's water mirror is 13 square kilometres. The average volume of water is 19.6 million cubic meters. The lake is silted up, the average capacity of bottom silts is 2 m. The pollution index is moderately polluted, class 3.

Lake Kotyrkol. The total catchment area is 29.9 square kilometres. The average area of the water mirror is 4.5 square kilometres. The water is sodium bicarbonate in composition. Hardness – 3.8 mg/eq (moderately hard). The pollution index is very dirty, class 6.

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Chebachye Lake. The total catchment area is 150 square kilometres. The average area of the water mirror is 22 square kilometres. The volume of the lake is 240 million cubic meters. Mineralization is 400–600 mg/l, hardness is 3–5 mg/eq (moderately hard). The chemical composition is bicarbonate with a predominance of sodium and a significant content of magnesium ions. The pollution index is moderately polluted, class 3.

Maloe Chebachye Lake. The total catchment area is 139 square kilometres. The volume of the lake mirror is 21 sq. km. The average volume of water is 131 million cubic meters. Water mineralization is 2.3–2.7 g/kg, hardness is 15–25 mg/eq/l (very hard). The chemical composition is sodium chloride with a significant magnesium content. The pollution index is dirty, class 5.

Lake Shchuchye. The total catchment area is 64.4 square kilometres. The mirror area is 18 square kilometres, the volume of water is 255 million cubic meters. Water mineralization is 250 mg/l, hardness is 2.0–2.5 mg/eq (soft). The chemical composition of the water is bicarbonate-calcium. The pollution index is moderately polluted, class 3.

Borovoe Lake. The total catchment area is 164 km. The average area of the water mirror is 10 sq. km. The average volume of water is 29 million cubic meters. Mineralization is 100–150 mg/l, hardness 1.0–1.2 mg/eq (very soft). The chemical composition of the water is bicarbonate-calcium. The pollution index is moderately polluted, class 3.

Zhukey Lake. The total catchment area is 160 square kilometres. The area of the water mirror is 19 square kilometres, the average volume is 91 million cubic meters. Mineralization 2.3–2.5 g/kg, hardness 14–17mg/eq (very hard). The chemical composition is bicarbonate-chloride-magnesium-sodium. The pollution index is polluted, class 4.

Lake Maybalyk. The total catchment area is 5.8 square kilometres. The area of the lake mirror is 1 sq. km. The volume of water is 2.0 million cubic meters. The lake's water is salty. The pollution index is very dirty, class 6 [8].

3.4 Use of water resources

In 1998, in the territory of Akmola region, taking into account three districts of the former Kokshetau region, fresh water was taken from underground and surface water sources in the amount of 122.42 million cubic meters, including 36.668 million cubic meters from surface and 85.753 million cubic meters from underground. During this year, water was used: 32.19 million cubic meters for industrial needs, 39.22 million cubic meters for household and drinking water, 42.42 million cubic meters for agriculture. Water was not used for fisheries. See Table 4.

Table 4. Dynamics of water intake in the Akmola region (million cubic meters).

Years	1993	1994	1995	1996	1997	1998
Water intake (total)	414.95	330.9	339.97	280.5	256.45	122.42
From surface sources	219.51	159.67	174.02	143.21	140.74	36.67
From underground sources	195.44	173.23	165.95	137.29	115.71	85.75

In the period from 1991 to 1998, there was a sharp decrease in water use due to a reduction in production volumes, but, nevertheless, there was no sharp decrease in water use in recycled water supply systems [9].

The use of water resources in 1998 decreased by almost 5 times compared to 1991. According to the components, there was also a decrease in water use: for industrial needs, water consumption decreased by 40% due to a decrease in production volumes; for household and drinking needs – by 58%; for agricultural needs – by 89%. See Table 5.

Table 5. Dynamics of water use in the Akmola region (million cubic meters/year).

Indicators	1993	1994	1995	1996	1997	1998
Total water used, including:	399.0	320.1	326.9	270.0	246.0	119.42
from surface sources	211.07	153.53	167.33	137.7	134.74	33.67
from underground sources	187.93	166.57	159.57	132.29	111.26	85.75
Including: for production needs	55.07	46.29	40.99	35.92	29.47	32.19
for household and drinking needs	87.11	81.35	80.8	63.7	54.87	39.22
agricultural industry. Of these:	254.3	190.4	203.1	168.3	159.6	48.01
estuary irrigation	165.8	100.13	130.51	113.76	122.11	13.08
regular irrigation	42.77	51.4	34.82	21.95	10.63	8.75
watering of pastures	37.985	32.087	32.082	27.817	22.373	22.53
agricultural water supply	–	–	–	–	–	–
fisheries	2.5	2.0	2.0	2.0	2.0	Not used

3.5 Water disposal

The main enterprises with outlets for wastewater discharge into surface water sources in the territory of the Akmola region were: sewage treatment plants of Stepnogorsk, Tselinny Mining and Chemical Combine, Progress JSC, Biomedpreparat Kazakhstan scientific and industrial complex and stormwater sewerage of Progress JSC. The effluents from the above-mentioned facilities, being treated at sewage treatment plants, were discharged into the Aksu river. The results of observations showed that below the discharge of wastewater from these enterprises, the content of ammonium salt, nitrates, and suspended solids increased in the river, but it did not exceed the norm. The qualitative composition in the river below all discharges fully met the requirements for sanitary reservoirs [10].

Basically, in the territory of the region, pollution of surface and underground water sources occurred due to the discharge of insufficiently treated and untreated wastewater into storage tanks, filtration fields, etc. Of the 42 wastewater treatment plants with a design capacity of 102.4 million cubic meters/year, more than half were not working or were not working effectively. Due to the lack of financial resources and poor training of maintenance personnel, the technical condition of wastewater treatment plants deteriorated annually, which had an extremely negative impact on the quality of wastewater treatment.

3.6 Radiation situation

There were enterprises using and processing radioactive substances on the territory of the Akmola region [11].

District enterprise “Ore Management No. 3” was located in the Enbekshelder district of the Akmola region. Uranium ore mining operations were discontinued in 1992. The total area of disturbed land was 77 hectares. The area occupied by dumps was 28.3 hectares, including ore – 166 thousand cubic meters (10.9%) off–balance sheet – 531 thousand cubic meters (34.9%), rock – 825 thousand cubic meters (54.2%), the remaining 20 hectares are occupied by surface structures of mine No. 8. 10 million cubic meters of mine and treated economic and faecal waters were discharged into the storage lake “Koksor”. The quantity and volume of radioactive emissions were unknown, and departmental control was not provided.

Characteristics of the types of radioactive substances. The sources of radioactive contamination were: natural uranium, radium, thorium and potassium-40. The measurement of the specific total activity showed – on the dump of off–balance sheet ore, covering an area of 9.88 hectares from 3,875 Bq/kg to 25,000 Bq / kg; ore warehouse with an area of 3.08 hectares – the average specific total activity of 270,000 Bq / kg. At the place of discharge of mine waters into the lake, the storage tank "Koksor" up to 270,000 Bq/kg was located.

The virgin land mining and chemical plant was located in the area of Stepnogorsk, Akmola region. The total area of the industrial site was 6,500 hectares. The company was engaged in the enrichment of uranium ores at a hydrometallurgical plant, made heap leaching of uranium from off-balance ores at two heap leaching facilities. The production waste was the tailings of uranium ore enrichment, the solid phase of which was discharged into the tailings dump. The volumes of tailings accumulation by year amounted to 389423 tons in 1993, 149675 tons in 1994, 363285 tons in 1995, 181027 tons in 1996, 70870 tons in 1997, and 127177 tons in 1998.

Emissions of radon-222 and daughter decay products amounted to: according to the tailings dump: in 1996 – 0.945 Ci, in 1997 – 0.698 Ci, in 1998 – 1.682 Ci.

3.7 The structure of the land fund

The land fund of the Akmola region consisted of the following structure. See Table 6.

Table 6. The structure of the land fund (thousand hectares).

Total land	**14650.2**
Agricultural purposes	12022.5
Settlements	1311.6
Forest Fund	525.2
Specially protected natural areas	322.1
Lands of industry, transport, communications	117.9
Water Fund	12.6
Reserve Lands	338.3

Analysis of materials from a large-scale soil survey conducted in individual farms and districts during survey tours from 1965 to 1990, and later, indicated significant changes in the physicochemical properties of soils. Notably, there was a marked alteration in the humus content, which serves as a key indicator of soil fertility. On the lands of the Shchuchinsk district (Zlatopolsky, Urumnaisky) its content decreased by 23–28%. Of course, the materials of a large-scale soil survey required serious generalization and specific conclusions. Nevertheless, it can be concluded that the natural fertility of the region's soils is decreasing.

The soil survey showed that the bonitet in the most common ordinary, carbonate, medium-thick, low-humus, light clay chernozems was: in 1990 – 60.4 points, in 1995 – 58.0 points.

For southern, carbonate, medium-thick, low–humus, light clay chernozems, it was: in 1990 – 50.3 points, in 1995 – 45.2 points. These data indicated a sharp decrease in the fertility of the land. The materials of the soil survey showed structural changes in the composition of the soil cover. These include the appearance of eroded lands to varying degrees in Shchuchinsk and Zerendinsk districts. Water erosion here had the character of linear erosion. In recent years, arable land has decreased due to the transformation of low-productive lands (solonetz, saline, gravel) into pasture lands, therefore, the impact of wind erosion on arable land has sharply decreased [12]. See Table 7.

Table 7. Dynamics of disturbed, depleted and reclaimed lands of the Akmola region (thousand hectares).

Years	**1994**	**1995**	**1996**	**1997**	**1998**
The area of disturbed land	12.4	12.4	12.4	13.7	15.5
The area depleted land	6.2	6.2	6.2	6.9	9.1
The area of reclaimed land	89.0	46.0	109.0	109.0	171.0

4 Conclusion

During the study, the authors concluded that there was a deterioration in the water quality of the lakes. The main reason identified was the reduction of the catchment area due to the construction of highways, which blocked the access of meltwater. The decrease in the volume of water in the lakes was also attributed to water abstraction for management needs. Improper reclamation work at the RU-3 uranium mining complex in Zaozerny settlement and RU-4 in Krasnogorsk settlement, where wind and water erosion of off-balance sheet ore dumps occurred, exacerbated the situation. Due to insufficient funding, no reclamation work was carried out. Another significant environmental issue arose from dusting at the tailings dam of the hydrometallurgical combine. Dusting resulted from reduced uranium ore processing, leading to incomplete humidification of the tailings dump. Pollution was observed in a northeasterly direction, extending up to 13 km from the dump. Further land degradation ensued due to reduced acreage, with significant areas left unsown and overrun with weeds. Efforts to improve soil fertility ceased, despite the accumulation of hundreds of thousands of tons of manure in the region, which remained unutilized and contributed to land and environmental pollution. Consequently, by the 1990s, a complex set of environmental problems had accumulated in the Akmola region, demanding a concerted effort from both state and industrial organizations for resolution.

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