The environmental state of the Pavlodar region in the Republic of Kazakhstan (1990s)

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Abstract. The article examines the key aspects of the environmental condition of the Pavlodar region in the 1990s. It provides an analysis of the climate, the structure of industrial production, and the availability of minerals. Based on statistical materials, the state of atmospheric air characterized by the presence of harmful impurities polluting the environment has been studied. The status and usage of water resources in the region are also indicated. The authors note a real threat of pollution of the Irtysh River by heavy industry waste in the region. The analysis of the materials showed that despite having significant land resources, the Pavlodar region inefficiently used them for agriculture. In conclusion, it is stated that the environment of the region was influenced by an increase in pollution of water and land resources with toxic metals as a result of the activities of non-ferrous metallurgy and thermal power plants.

1 Introduction

It is important to emphasize that the state of the environment is complex and affects the air, water, and soil. There is no doubt that today, the main environmental problem of any city in Kazakhstan is pollution associated with industrial enterprises and the widespread use of motor vehicles in recent years [1–7].

The Pavlodar region covers an area of 127.5 thousand square kilometers, with a population of approximately 875.7 thousand people according to preliminary data from the last census. Most of the region's territory lies on the flat, slightly sloping northward Irtysh plain, which constitutes the southern edge of the West Siberian Plain. The southwestern part of the region is situated within the Kazakh Uplands.

The climate is sharply continental, featuring cold winters and hot summers. In January, the average temperature ranges from –17 to –19 degrees Celsius, while in July, it ranges from +19 to +22 degrees Celsius. The region exhibits an arid climate with uneven moisture patterns over the years. Long-term average data indicate that the north of the region receives up to 300 mm of precipitation annually, while the south receives around 200 mm, and the Bayanaul mountains receive from 300 to 500 mm.

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The flat terrain of the area contributes to the limited development of the river network. Within the region, the Irtysh River lacks any tributaries. Instead, numerous freshwater and saltwater lakes predominate.

Almost the entire region lies within a zone of dark chestnut soils, characterized by feather grass and sandy feather grass steppes. In the northern part of the region, there are massifs of chernozem low-humus saline soils, which support richly diverse red-feather grass steppes along with birch and aspen-birch forest outliers. Pine forests on sandy soils are preserved in the southeastern part of the region. Additionally, floodplain meadows and floodplain forests are found along the Irtysh River.

A significant portion of the region's land is dominated by light soils, such as sandy loam and light loamy soils. Therefore, the implementation of soil-protective crop rotations is necessary when utilizing these lands.

The main mineral resources are concentrated in the southwestern part of the region, notably in two coal basins: Ekibastuz and Maykubensky. The Ekibastuz basin alone boasts coal reserves ranging from 10 to 13 billion tons. These coals typically have a calorific value between 4000 to 6500 kcal but are characterized by a high ash content (40–60%) and sulfur content. They are primarily used as an inexpensive energy fuel. The brown coals of the Maikuben basin also serve as a low-cost energy fuel. However, they have an increased yield of volatile substances, primary resin, and sulfur, making them suitable for use in the chemical industry and public utilities [8].

The Pavlodar region is rich in deposits of various minerals, including copper ores (such as Bozshakol), gold (Maykain), polymetallic ores, and rare metals. Large deposits of brown ironstone have been discovered in the lower reaches of the Shiderty River, with layers reaching the surface. Additionally, the self-seeding salt lakes of the Irtysh region – Bolshoy and Maly Kalkaman, Koryakovka, and Bolshoy and Maly Tavolzhan – are of great importance.

The Pavlodar-Ekibastuz territorial industrial complex was established in the central part of the region, comprising several thermal power plants (which account for 60% of the installed capacity of the republic), coal mines, aluminum and ferroalloy plants, tractor factories, oil refineries, and chemical plants. However, these industrial facilities are also the main sources of environmental pollution.

The industrial production structure in the region is as follows:

- Mining industry: 22.2%.
- Manufacturing industry: 43.3%.
- Production and distribution of electricity, gas, and water: 34.5%.

As of February 1, 1999, the region had a total of 6,084 economic entities, excluding farms, categorized by ownership forms and types of enterprises. Among these, there were 5,330 small, 550 medium, and 204 large enterprises. Public enterprises numbered 1,275, while 4,795 were privately owned, including 14 foreign-owned ones [9].

2 Materials and methods

This article is based on interdisciplinary methods. The article uses materials from the Ministry of Natural Resources and Environmental Protection of the Republic of Kazakhstan. The interdisciplinarity of the research has manifested itself in a variety of methods of such sciences as ecology, biology, and agronomy. Together, they made it possible to conduct an independent scientific research of the environment of the Pavlodar region.

3 Results and Discussion

3.1 The state of the atmospheric air

In 1998, the Regional Centre for Hydrometeorology conducted 17,272 observations of atmospheric air quality. Among these observations, 217 cases (1.3%) reported exceeding the maximum permissible concentration (MPC) for various pollutants, including dust (4.6 MPC March-May, July-August), carbon monoxide (2.8 MPC May), nitrogen dioxide, phenol (3.4 MPC March-May), hydrogen chloride (3.8 MPC April), and hydrogen sulphide (1.1 MPC March).

Analysis of the observation results indicated that the level of atmospheric air pollution with harmful impurities in the cities of Pavlodar and Ekibastuz was below the national average compared to other cities in the Republic of Kazakhstan. Additionally, the average annual concentrations of all detected impurities were within acceptable limits.

In 1998, there were 5,070 stationary sources in the region, with 4,233 of them emitting pollutants into the atmosphere in an organized manner.

Emissions from stationary sources in 1998 decreased by 13% compared to 1997, totaling 446.3 thousand tons, which accounted for 18.5% of the total emissions from all enterprises in the republic. The main pollutants emitted into the air basin of the Pavlodar region by these enterprises are as follows (measured in thousand tons per year):

- Pavlodar CHP-1 – 61.5.
- Pavlodar CHP-2 – 17.1.
- Pavlodar CHP-3 – 34.7.
- JSC “Aluminium of Kazakhstan” – 17.9.
- Pavlodar Oil Refinery JSC – 8.1.
- JSC “Khimprom” – 0.01.
- Ekibastuz state district power plant-1 – 42.5.
- Ekibastuz state district power plant-2 – 68.3.
- Ekibastuz CHP – 13.1.
- Aksu Ferroalloy Plant – 27.6.
- Aksu state district power plant – 132.2.
- Severny open-pit mine – 4.0.
- Vostochny open-pit mine – 3.5.
- Bogatyr open-pit mine – 3.8.

In emissions of pollutants from stationary sources, the main share was liquid and gaseous ones – 54% [10].

3.2 Atmospheric pollution by emissions from mobile sources

In the Pavlodar region, emissions of pollutants from motor vehicles (excluding individual ones) in 1998 amounted to 20.14 thousand tons or 60% of 1997 emissions (33.469 thousand tons). Carbon monoxide and nitrogen oxides accounted for the predominant share of vehicle emissions. The composition of pollutant emissions from mobile sources in 1998: carbon monoxide – 63%, nitrogen oxides – 16%, carbons – 12%, other – 9%.

Dynamics of changes in atmospheric air pollution

In 1998, there was a steady trend of reducing emissions of pollutants associated with a decline in production. So, compared to last year, they decreased by 13%. Comparative data on atmospheric emissions for previous years are shown in Table 1.

Table 1. The dynamics of emissions from stationary sources in the Pavlodar region.

Name of substances	Emissions (thousand tons)					
Total, including	1993	1994	1995	1996	1997	1998
solid	915.0	739.5	661.6	643.9	514.0	446.3
Liquid and gaseous	512.0	437.3	344.4	359.9	287.2	242.5

In 1998, the regional Department of Environmental Protection conducted 479 inspections of enterprises and organizations on the implementation of the Law of the Republic of Kazakhstan "On the Protection of Atmospheric Air".

As a result of the inspections, 1,127 prescriptions were issued. According to the facts of violations of norms and rules for the protection of atmospheric air, 161 fines in the amount of 118,283 thousand tenge were filed, 128 fines in the amount of 78,045 tenge and 14 lawsuits in the total amount of 98,064 tenge were collected, 16 fines in the amount of 188,403 tenge.

The results of the inspections showed that the enterprises of the region carried out certain work on the implementation of air protection measures. As part of the financial agreement reached in 11998 between JSC Aluminium Kazakhstan, Aksu state district power plant, Aksu Ferroalloy Plant and the akimat of the region represented by the regional environmental protection department, these enterprises spent 480.149 million tenge on environmental protection measures. It should be noted that the implementation of air protection measures, nevertheless, in most cases boils down to maintaining in good technical condition the dust and gas cleaning plants in operation and carrying out repair and restoration work. At the same time, a number of large environmental protection measures were not carried out by enterprises due to lack of financial resources.

During 1998, inspections of 40 motor transport enterprises were carried out jointly with the traffic police. 920 vehicles were subjected to instrumental measurements, of which 150 exceeded the standards of toxicity and smokiness of exhaust gases, 33 were stopped to eliminate the causes of exceeding the emission standards. The total amount of fines for violations amounted to 81,540 tenge.

3.3 Status and use of water resources

The main sources of water supply in the Pavlodar region are the Irtysh River, the Irtysh-Karaganda canal, small rivers and underground springs.

The Irtysh River is a reservoir of fishery importance of the highest category. According to the pollution index, the section of the Irtysh River within the Pavlodar region belongs to the category of moderately polluted water bodies of class III. At the entrance to the region, the concentration of zinc was 5–6 MPC and concentration of copper was 3–3.5 MPC, which was a consequence of pollution of the river by discharges from enterprises of the East Kazakhstan region.

Within the Pavlodar region, the increase in river pollution was lower than the discharge of Pavlodar urban wastewater treatment plants, mainly it was the discharge of "warm waters" from the AOOT "EEC" of Aksu – thermal pollution.

Water protection zones had been established at almost all water intakes of the Irtysh River and the Irtysh-Karaganda canal, ensuring the protection of waters from pollution and clogging. There were no water protection zones on the small rivers of the region due to the lack of funds for design work [11].

There was a real threat of contamination of the Irtysh River by mercury from JSC Khimchrome. According to hydrogeological studies, the groundwater under the building of the electrolysis workshop was contaminated with mercury.

In the region, 2,904 surface and groundwater water consumers were covered by state accounting. Water intake in 1998 amounted to 2,540 million cubic meters, including:

- Municipal and household needs – 73.0 million cubic meters.
- Industry – 1109.3 million cubic meters.
- Agriculture – 910.6 million cubic meters.
- Fisheries – 1.1 million cubic meters.
- Losses on the Irtysh-Karaganda canal – 112.5 million cubic meters.
- Transferred to other regions – 333.0 million cubic meters.

The dynamics of the use of water resources for industrial, municipal, and agricultural needs are presented in Table 2.

Table 2. Dynamics of water resources use.

Year	1992	1993	1994	1995	1996	1997	1998
General water intake (million cubic meters)	3660.6	3387.9	3484.0	3694.5	2567.8	2756.0	2539.5

Water intake from surface sources (the Irtysh River) in 1998 amounted to 2518.4 million cubic meters, i.e. 99.2% of the total water consumption of the region. See Table 3.

Table 3. Water intake from surface sources.

Year	1992	1993	1994	1995	1996	1997	1998
Water intake from surface sources (million cubic meters)	3579.6	3322.4	3426.8	3644.7	2523.0	2717.6	2518.4

3.4 Wastewater discharges

The main discharge of wastewater from wastewater treatment plants was carried out into the Irtysh River (93%) [12]. Of all the enterprises in the region, the largest volume of waste water into the Irtysh River was at the open joint-stock company "EEC" (Aksu River). There were 54 wastewater treatment plants in the region, 32 of which were functioning, including one inefficiently. 22 sewage treatment plants did not work in 1998. See Table 4.

Table 4. The volume of wastewater disposal in the region by year (million cubic meters).

Dumping sites	1992	1993	1994	1995	1996	1997	1998
General water disposal	1972.3	1945.7	1771.6	1849.3	1308.8	1134.9	1069
Including the Irtysh River	1872.8	1843.7	1672.4	1754.7	1223.2	1051.4	993.0
Including the warm waters of the open joint-stock company "EEC". town of Aksu	1797.1	1767.5	1606.3	1689.8	1175.0	1005.7	947.2
In the storage tanks, on the filtering fields	99.5	102.0	100.0	94.6	85.6	83.5	76.0

The volume of water used in recycling and re-supply decreased, which was explained by the general decline in production.

3.5 Production and consumption waste and its impact on the environment

There were 36 waste storage facilities in the Pavlodar region, of which only 3 could be classified as meeting the necessary requirements. The largest ones were located in the city of Pavlodar.

A major environmental problem was created by the ash dumps of Pavlodar CHP-2 and CHP-3, into which the ash and slag waste of the stations was discharged. Filtration of process waters from the ash dump bowl led to flooding of the adjacent territory. In addition, dusting of the ash dump led to atmospheric air pollution (from 10 to 200 MPC for dust).

As of May 1, 1999, the actual volume of filling ash dumps was 3.638 million cubic meters for CHP-2, 2.24 million cubic meters for design, 7.577 million cubic meters for CHP–3, and 6.316 million cubic meters for design.

The landfill of industrial waste (LLP "Polygon") was intended for the storage of waste of hazard class 3, 4. The landfill was located in the southern industrial area of the city, 10 km from the residential area. Its area was 18.7 hectares. The capacity of the facility was 6 million tons. The sanitary protection zone was 1000 meters.

The municipal solid waste dump of Avtobaza Spetsmashin LLP was located in the north-eastern part of the city at a distance of 1.2 km from populated areas. The area of the facility was 50 hectares. Sanitary protection zone was 1000 m. The waste was stored in the form of a bulk hill with subsequent levelling and compaction [11].

As a result of the constant increase in the volume of accumulated industrial and solid household waste, the migration of pollutants, due to the unsettled places of storage and burial of production and consumption waste in the natural environment, negative, including irreversible processes occurred. At the same time, the situation was aggravated by the fact that their physico-chemical properties changed during the storage of such waste. Thus, according to the Pavlodar Hydrometeorology Centre and the regional sanitary and Epidemiological station, soil and groundwater pollution in some areas of the city of Pavlodar exceeded the normalized values on mercury, arsenic, fluorine, etc. See Table 5.

Table 5. Dynamics of accumulation of household waste.

Dumping sites	1992	1993	1994	1995	1996	1997	1998
Household waste, thousand cubic meters	9440.4	10140.4	10740.8	11290.4	11555.3	11882.1	12150.5

The accumulation of overburden in the region in 1998 amounted to 41 million cubic meters, whereas in 1993 it amounted to 62 million cubic meters.

3.6 Radiation situation

As of January 1, 1999, 3,732 ampule sources of ionizing radiation (ASII) were concentrated in the region, including Cs-137 – 913 units, Co-60 – 48 units, 2,748 alpha sources (Pu-239), 7 neutron sources (Pu-Be), 3 sources of beta radiation (Pm-147), 2 ampule sources with Ni-63, 11 sources with Ra-226, of which 2 are open (radium radon generators).

2037 ASII with expired service life and not used in production were subject to burial. Among them are 5 powerful gamma installations of the Pavlodar Research Institute of Agriculture of the Academy of Sciences of the Republic of Kazakhstan with 226 ampule sources having a total activity of 27,820 Curies as of September 1, 1999. To transfer them to burial, about 9 million tenge was required at the existing rates of the Institute of Atomic Energy of the National Nuclear Centre.

Liquid radioactive waste formed as a result of the failure of radium generators is solidified by introducing gypsum into a solution and enclosed in containers. The issue of disposal of such waste was not resolved in the republic at that time.

The dynamics of the burial of ampule sources of ionizing radiation in pieces by enterprises of the region is shown in Table 6.

Table 6. Dynamics of burial of ampule sources of ionizing radiation.

Years	1991	1992	1993	1994	1995	1996	1997	1998
Ampule sources of ionizing radiation	10	1	0	0	262	0	432	34

Burial had been carried out within the republic since the second half of 1995 in connection with the introduction of the Baikal bench complex at the National Nuclear Centre.

3.7 Land resources

Pavlodar region has significant land resources suitable for agricultural production. However, the degree of suitability of land for agriculture varied by districts, and in general it was low in the region. Thus, the share of arable land and deposits, certainly suitable for the cultivation of cereals and other food and fodder crops, was only 27 percent. The remaining lands are mainly soiling of light mechanical composition, potentially erosive and dangerous, saline, brackish and crushed [10].

The average quality score of arable lands in the region was 18. The share of highly productive pasture lands was only 4%. The region was rich in floodplain hayfields, but half of them were waterlogged and swampy areas, where the harvesting process was complicated and the feed quality was relatively low.

The total area of the land fund of the region was 12470.5 hectares. Its structure as of January 1, 1999 was as follows:

- Agricultural land – 5146.2 thousand hectares (41.3%).
- Lands of settlements – 1264.9 thousand hectares (10.1%).
- Industrial and communication lands – 129.4 (0.2%).
- Forest fund lands – 451.3 thousand hectares (3.6%).
- Lands of the water fund – 21.8 thousand hectares (1.0%).
- The reserve land – 5,452.8 thousand hectares (43.7%).

In 1998, the region used 1373.6 thousand hectares of arable land, of which 786.5 thousand hectares for spring sowing, including 680.3 thousand hectares of grain crops. 70 thousand hectares of fallows were processed. The crops of perennial grasses amounted to 516.7 thousand hectares. As of January 1, 1999, the area of disturbed lands amounted to 21163 hectares, and 6907 hectares were depleted. The distribution of these lands for the departments was as follows: for the Ministries of Energy, Industry and Trade was 17571 hectares, for the Ministries of Agriculture was 1074, for the Ministries of Transport and Communications was 447 hectares and for other non-governmental agricultural enterprises was 1909 hectares

3.8 The state of biological resources

There were five forestry enterprises in the region, one interregional forest protection station and the regional department of forestry, fisheries and hunting [1]. As of January 1, 1999, the total area of the state forest fund was 405.5 thousand hectares, including 2.8 thousand hectares in long-term use, 254.5 thousand hectares were covered with forest. 154 species of

plants grew on the territory of the region, of which 15 were woody and shrubby and medicinal. There are 139 species of honey and other plants.

The logging fund was developed in 1998 in the amount of 5.3 thousand cubic meters. Thinning and sanitary fellings was carried out on an area of 5997.7 hectares with timber harvesting in the amount of 138.1 thousand cubic meters. The income from sales amounted to 1327.6 thousand tenge. In 1998, forest crops were planted in the forestry of the region on an area of 601 hectares, of which valuable species accounted for 88.4%. The preservation of annual crops was 41% or 247%, survival rate was 47.3%.

As a result of large forest fires in the period 1997–1998, forest crops were lost on an area of 5,326 hectares. Seedlings were introduced into the category of valuable species on an area of 936 hectares, including forest crops on an area of 653 hectares. 5553.5 thousand pieces of standard planting material were grown. 890 kg of forest seeds were harvested, including 815.5 kg of pine seeds.

The total fisheries fund of the region included the Irtysh River, 9 reservoirs located along the route of the Irtysh-Karaganda canal, with an area of 12349 hectares, backwaters, channels of the Irtysh River, steppe and floodplain reservoirs with an area of 30410 hectares.

The species composition of fish in the reservoirs of the region was represented by grass carp, Volga pikeperch, Phoxinus, common dace, ruff, crucian carp, tench, bream, lampern, burbot, nelma, perch, sturgeon, roach, peled, gudgeon, vendace, zander, carp, sterlet, silver carp and ide.

The volume of fish resources in the region was about 1,000 tons. The use of fish resources was on average 200 tons. Licenses for fishing with a fishing rod were sold in the reservoirs of the Irtysh-Karaganda canal, Karbyshevsky backwater, etc. In 1998, licenses were sold in the amount of KZT 301,314. Measures were taken to restore fish stocks in the reservoirs of the region from 1990 to 1998.

The total area of the region's hunting grounds was 10.8 million hectares. 22 assigned hunting farms were assigned to the regional society of hunters. There were 120 reproduction areas on the territory of the farms. 26 huntsmen worked in the hunting farms of the region. 8 district inspectors and 35 public ones worked in the operational department of the regional administration.

The species composition of wild animals and birds based on accounting data for 1998: squirrels – 5800 items, wolves – 265 items, geese – 22520 items, hares – 24300 items, roe deer – 1173 items, partridges – 15500 items, mooses – 135 items, foxes – 4500 items, muskrats – 1100 items, lynxes – 20 items, marmots – 70,000 items, grouses – 7350 items, ducks – 442560 items, including coots – 88100 items, ferrets – 3390 items.

4 Conclusion

Thus, it can be said that the state of the environment in the region had not undergone significant changes by 1998, except for an increase in pollution of water and land resources with toxic metals. In the region, there was a real threat of contamination of the main waterway – the Irtysh River with mercury and other hazardous waste. The analysis of air and water protection measures showed that the planned costs allowed to maintain the state of the environment to a certain extent, however, there were still quite a lot of unresolved problems with the environmental situation in the region during this period.

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