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Analysis and Challenges of the Formative and Accumulative Process of Industrial Residues

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ABSTRACT:
The article examines the problems of waste generation and accumulation in the Republic and by regions. It also examines the dynamics of the number of stationary sources of pollution, the volume of emissions into the atmosphere, including emissions of solid waste, etc. For an accurate study, we have selected indicators from 2005 to 2022 in the Abai region. Regression coefficients and the influencing variables of the number of factors were chosen as the initial data for the regression linearity model. Identify the key issues of the Bay area from the perspective of state ecology. The vast majority of solid waste on the Abad Region's territory is industrial waste, consisting of waste from mining operations, as well as ash and slag. The annual level of waste generation from production and consumption in the region continues to be high. Based on the findings of the regression analysis, we recommend a number of measures for the industry: bringing the waste management sector into line with green principles through careful control, overspending on waste management funding, reducing emissions, reducing energy consumption in the public sector, reducing the amount of clean water used in industry, recycling high-quality waste, and disposing of solid waste properly, modernizing and constructing new landfills for solid waste. These and other gaps in environmental legislation and environmental policy documents need to be eliminated in the near future in order to achieve a significant reduction in the accumulation of production and consumption waste.

Keywords: air pollution, valuation of environmental effects, industrial residues, environment and development, Abad district, Kazakhstan

1. Introduction

In the modern world, sustainable development is becoming increasingly relevant, as it allows meeting the needs of today's generations without compromising the ability of future generations to meet their needs. Regional economic mechanisms for solving environmental and economic challenges in environmental management can include various tools and methods such as taxation, subsidies, investment in environmental projects, the development and implementation of environmental standards, regulations, and promotion of environmental entrepreneurship, and technological innovations. The implementation of these mechanisms allows for a balance to be achieved between economic development and environmental protection. For instance, the introduction of energy-efficient technologies into production enables the reduction of emissions of pollutants into the atmosphere and lower energy costs. Conversely, the development of

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eco-tourism and the preservation of natural areas contribute to the conservation of biodiversity and create new jobs. In the paper (Ohanisian et al., 2022), a decoupling analysis was conducted on the gap between the trends of economic growth in the livestock industry and anthropogenic pressure on the environment. The authors also investigated the validity of a hypothesis about the feasibility of ensuring the sustainability of foreign economic activities in agribusiness through investment in organic farming, optimized by reducing the gap between these trends. The findings of this study suggest that it is important to consider the effects of economic growth on the environment when making decisions about foreign economic investments in agriculture. By investing in organic farms that are optimized for sustainability, businesses can contribute to the preservation of natural resources and reduce their impact on the environment. It is crucial to concentrate on determining the connection between economic growth and the current (anticipated) environmental concerns given the economy's sustainable development. The decoupling effect should be included when evaluating the environmental impact of greenhouse gas emissions, according to authors Bithas and Kalimeris (2018), Abuselidze et al (2023), Azam (2016), Tsur & Zemel (2008). This link has to be evaluated, and authors like Pao and Chen (2019), Sanyé-Mengual et al. (2019), Costantini, & Monni (2008), Zhang, et al (2021) and Zhou et al (2022) concur that the decoupling index - which measures the density of economic growth and human influence on the environment - should be prioritized. Georgantzi et al (2020) have demonstrated that policy and technical advances play a significant role in the establishment of a low-carbon economy. Nonetheless, in certain instances, the findings indicate that environmental regulations could have an adverse effect on greenhouse gas (GHG) emissions, indicating a successful environmental outcome of Portuguese legislation. Regression analysis were utilized in the Carrilho-Nunes and Catalao-Lopes (2022) research to evaluate environmental taxes, such as those on energy and transportation, as the most important economic tools in Latvia's environmental policy for lowering emissions connected to transportation. The authors' estimates suggest that it may be possible to validate the quantitative aspects of biofuel production and the ecological status of the regions (Ji, et al., 2023). The fuel consumption component had the most influence on greenhouse gas emissions, according to the non-linear multifactor regression. Therefore, the study of regional economic systems related to the resolution of ecological and economic challenges in environmental management is crucial in modern society. This allows us to suggest rational approaches to regional development, taking into account both economic and environmental factors and contributes to achieving sustainable development for the country as a whole.

One of the main environmental problems in Kazakhstan is air and water pollution as a result of industrial development. The lack of modern technologies and control over emissions from poorly equipped enterprises leads to the accumulation of harmful substances in the environment and a threat to public health (Zoidze and Abuselidze, 2023). In addition, the unbalanced development of various industries, such as oil and gas and mining, has led to damage to ecosystems. The growth of environmentally related diseases is also a serious problem. Harmful emissions, such as toxic gases and heavy metals, can affect air quality in areas with high levels of industrial activity, leading to a deterioration in quality of life and an increase in illness. This includes an increase in the burden on the healthcare system, with people living or working in these areas facing an increased risk of various diseases, including cancer. To reduce the negative impact of industrial emissions on human health, it is necessary to take measures to control and reduce environmental pollution, introduce more efficient technologies and processes in industry, and maintain strict norms and standards of environmental safety. It is also important to monitor air quality and take measures to prevent and protect public health in areas with high levels of industrial activity.

The works of Kazakhstani environmental scientists are devoted to the problems of ecology. Tonkopia (2006), Upushev (2002) and Koshelev (2007). Tonkopia (2006) in his research notes, "the final results of work of enterprises should be linked to the effectiveness of environmental measures, so that every labor collective and every employee is interested in compliance with environmental legislation requirements." Supporting the opinion of scientists and ecologists, it is fair to say that every industrial enterprise should take environmental protection seriously, as ecology and its health are our shared responsibility.

Upushev (2002) revealed in his scientific works that, "Since 1990, a new environmental policy began to take shape in Kazakhstan, focusing on the development of environmental management techniques. In particular, work began on the introduction of economic mechanisms, payment for natural resources and pollution from emissions and discharges, and the role of local authorities in managing natural resources increased."

According to scientist Taigashinov et al (2014), environmental protection and the new economy require new approaches to managing the smart economy. In addition, waste recycling, environmental damage compensation costs and the production of environmentally friendly products have become mandatory requirements in today's developing economy of the country (Taigashinov, 2022).

The scientist believes that the final results of an enterprise's work should be linked to its effectiveness in environmental protection in the regions of Kazakhstan. Environmental protection measures entail costs and significant ones at that. At the same time, these "costs", we believe, should be accounted for separately, as they may be associated with the "production of environmentally friendly products" which are attributed to the primary production, while they are auxiliary in nature as the costs for compensation for environmental damage and, consequently, harm to health. In this regard, there is a problem with the development, scientific research, and analysis of the formation and accumulation of industrial waste, as well as the accounting for environmental costs and environmental protection measures to compensate for the environmental damage caused by each company to the state.

2. Methods

The methods of regression analysis were used in this study. The direct coefficients of waste generation were calculated in the field of activity, which shows the amount of waste produced during the production of one unit of output in industry. Linear regression is a machine-learning algorithm that is primarily used for regression analysis. There are many regression models configured, and all of them are optimized versions of the two basic regression models. A matrix of paired correlation coefficients was calculated, and the conclusions of the regression analysis were drawn.

3. Results and Discussion

In 2016, at the UN headquarters in New York, Kazakhstan signed the Paris Climate Agreement, aimed at reducing greenhouse gas emissions and limiting global temperature increases to 2 degrees Celsius, while seeking funds to further limit this increase to 1.5 degrees. It unites countries in an effort to achieve a common goal in relation to combating and adapting to climate change. In accordance with the Decree of the Government of the Republic of Kazakhstan dated April 19, 2023, the country's updated national contribution to the global response to climate change should provide for accelerating and encouraging innovation, as well as creating favorable conditions for them.

The Republic of Kazakhstan has developed a National Concept and Action Program to reduce emissions of pollutants in order to solve the problem of air pollution in joint and combined ways with the EMEP (European Monitoring and Evaluation Program). The national program will allow the country to fully cooperate with the Convention on Transboundary Air Pollution (LRTAP) and its long-range dissemination (Korabayev et al., 2023; Zhumabekova, et al., 2023). This concept defines the goals, objectives, methods and directions of the development of the national program and the plan for the implementation of LRTAP and its protocols in Kazakhstan. The concept specifies the objective prerequisites, basic requirements and legal measures to fulfill the obligations under the protocols. It considers not only the technical measures in selected sectors but also the possibilities for their structural change. The National Program includes certain protocol requirements, including reporting on pollutant emissions and the possibility of implementing the best available methods (WAT - West Available Technologies). The concept, national program and implementation plan are being developed within the framework of the UNECE Project, funded by the United Nations Development Account, "Capacity Building for Air Quality Management and the Application of Clean Coal Combustion Technologies in Central Asia" (the CAPACITY Project). This project is also being implemented as part of the implementation of the regional action plan for environmental protection in Central Asia (Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, 2024).

Recognizing the severity of the situation, the European Parliament has decided to increase its climate commitments, specifically by reducing greenhouse gas emissions by 55% by 2030 compared to 1990 and achieving a net-zero emissions balance. Achieving these ambitious goals, however, is no easy task. Consequently, at the legislative level, the European Parliament (namely, through the European Climate Act) (European Climate law, 2021), has identified measures to combat climate change that should be implemented across all sectors of the economy, particularly those that contribute the most to air pollution, such as transportation.

Identifying the key problems of the regions in terms of the state of the environment, greenhouse gas emissions by selected sectors and the negative effects of climate change based on an assessment of available or provided data by local executive bodies is important and relevant. Data on the movement of hazardous waste in the Republic of Kazakhstan indicate a significant increase in the volume of waste generated at the end of 2022 compared to the previous year: an increase of 83.5%, which is significant and may indicate an increase in industrial activity or other factors contributing to an increase in waste volume. This can have serious consequences for the environment and require additional measures for the management and treatment of hazardous waste (Information review on the results of the state waste cadastre for 2018-2022).

Table 1: Movement of hazardous waste for 2018-2022 in the Republic of Kazakhstan, thousand tons

Type of operation.	2018	2019	2020	2021	2022
Availability at the beginning of the year	2 397 526,0	2 518 969,6	2 649 914,2	479 299,1	804 433,9
It was formed	149 962,4	180 506,7	137 828,0	42 090,2	46 481,2
It came from other people	11 698,7	8 700,7	16 063,9	1 006,3	1569,17
Recycled, reused, disposed of	29 993,2	36 645,3	30 711,8	4 924,0	3388,67
Defused	451,4	305,0	299,0	393,0	212,26
Buried	121 043,70	328 826,60	28 885,2	31 245,9	4310,88
Transferred to third-party organizations and enterprises	11 113,4	13 374,8	15 142,4	2 051,2	21019,28
Availability at the end of the year	2 518 080,5	2 658 156,9	2 757 951,9	480 234,6	881 415,4

**Source: Information review on the results of the State waste Cadastre for 2018-2022.*

The main "educators" of hazardous waste types today are the mining industry (Figure 1).

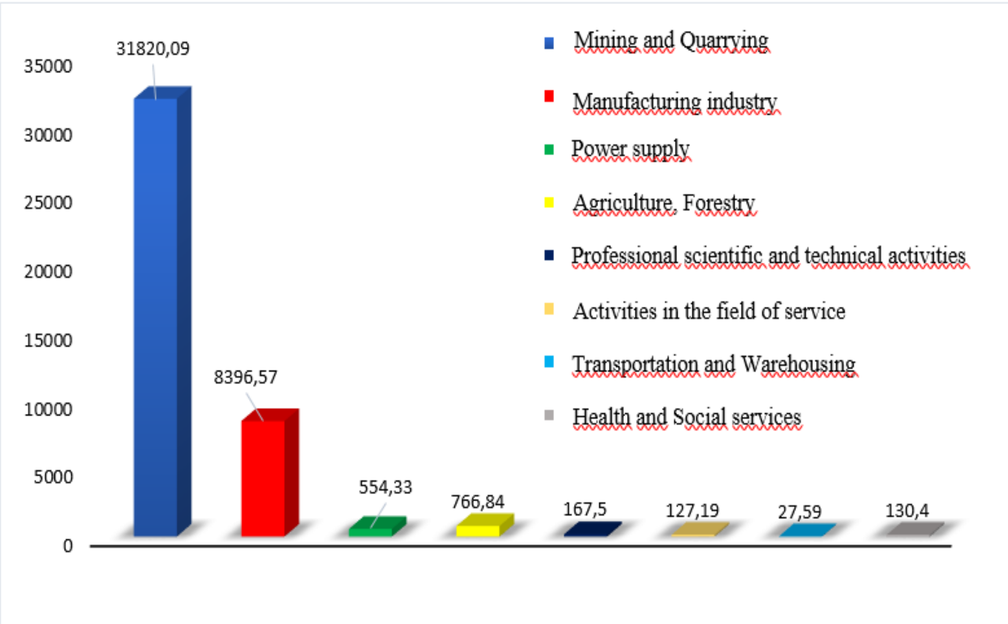

Figure 1: The main "educators" of hazardous waste types for 2021 in the Republic of Kazakhstan (thousand tons).
** Source: Information review on the results of the state waste cadastre for 2018-2022.*

The increase in waste generation in this industry in 2022 amounted to 24.7% compared to 2021. The total volume of waste generated in 2022 amounted to 31,820.09 thousand tons, while in 2021 the volume was 25,501.2 thousand tons.

We looked at the dynamics of the quantity of pollutants released into the atmosphere by stationary sources, including solid and liquid and gaseous substance emissions, as well as the number of stationary sources of pollution as indicators of the Republic of Kazakhstan's environmental protection.

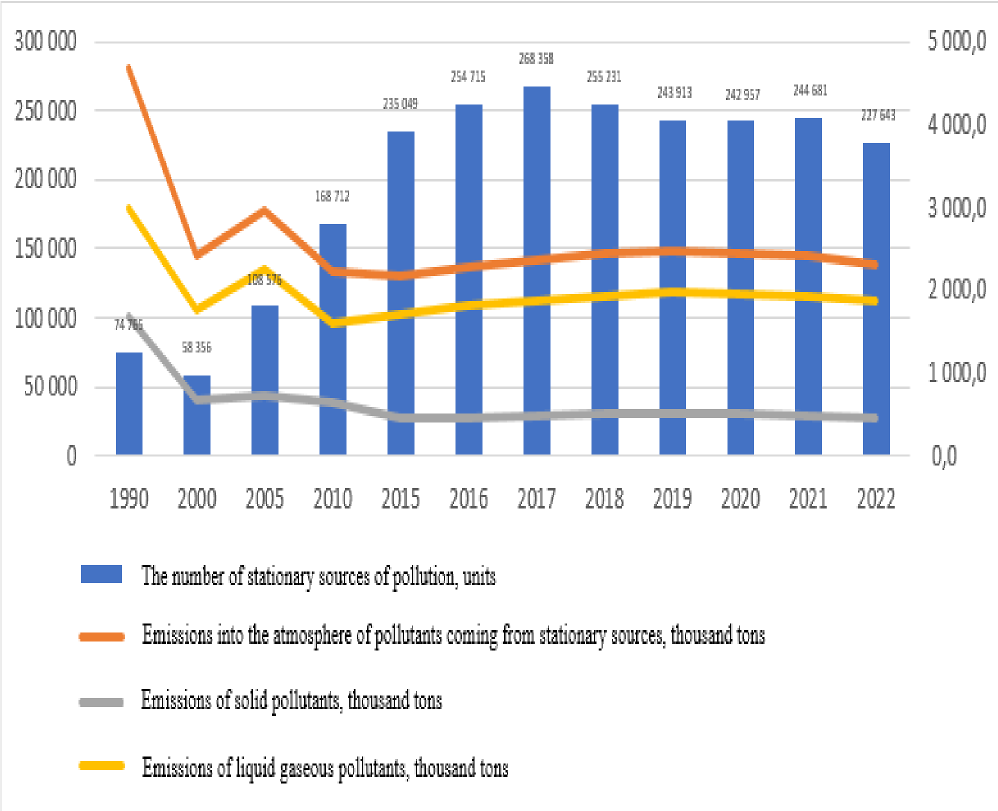

Figure 2: Dynamics of environmental protection indicators.
**Source: Statistical collection, (2024).*

The study of the dynamics of environmental protection indicators of the Republic of Kazakhstan for 1990-2021 shows that the volume of pollutants departing from all stationary sources of pollution decreased by half, starting from 2010 to 2021, the volume of emissions increased from 2,226 thousand tons to 2,314 thousand tons, or by 41%. Including emissions of solid pollutants decreased by 639.3 to 446.3 thousand tons or by 30%, emissions of liquid and gaseous pollutants increased by 1587.2 to 1868.5 thousand tons or 17% (Statistical collection, 2024).

Table 2: The volume of pollutants released into the atmosphere, their purification and disposal, thousand tons

Name	2017	2018	2019	2020	2021
The volume of pollutants coming from all stationary sources of pollution	30 564,5	34 819,1	36 250,9	35 445,9	34 293,5
Thrown away without cleaning, everything	1 606,1	1 615,8	1 678,2	1 587,7	1 629,1
of these, from organized sources of emissions	1 305,7	1 332,6	1 397,3	1 308,8	1 352,6
It was received at the treatment facilities	28 958,3	33 203,3	34 572,7	33 858,2	32 664,4
Of these, everything was captured and neutralized	28 206,7	32 372,4	33 767,8	33 004,8	31 886,0
some of them have been disposed of	4 899,6	8 000,7	9 484,0	8 186,8	7 998,2
Caught, in % of the amount of pollutants	92,3	93,0	93,2	93,1	93,0
Emissions into the atmosphere of pollutants coming from stationary sources, per capita, kg	127,7	130,7	133,9	134,1	130,1

*Note: Pollutant emissions into the environment from stationary sources were 117.9 kg per person in 2022. *Source: Statistical collection, (2024).*

The dynamics of the volume of pollutants released into the atmosphere, their purification and disposal shows that 92-93% of the total volume of pollutants coming from all stationary sources of pollution was captured, 25% of them were disposed of. Emissions of pollutants from stationary sources into the atmosphere per capita 136.4 kg in 2010 to 117.9 kg in 2022, that is, decreased by 86%.

The main pollutants of atmospheric air are manufacturing enterprises, their share in total emissions is 30% in the Republic as a whole, enterprises producing and distributing electricity, gas and water - 40%, mining enterprises -14.8%, other enterprises – 15.2%.

Table 3: Sources of emissions of pollutants into the atmosphere by enterprises with established MPI standards, thousand tons

Name	2017	2018	2019	2020	2021
The number of stationary sources of pollution, units	268 358	255 231	243 913	242 957	244 681
Emissions of pollutants into the atmosphere, total	2 356,80	2 446,34	2 482,62	2 440,70	2 404,27
Agriculture, forestry and fisheries	38,03	36,86	31,16	30,66	30,26
Industry, including:	1 982,91	2 076,91	2 130,77	2 112,78	2 074,66
Mining and quarrying	378,13	362,79	352,68	343,82	356,62
Manufacturing industry	685,36	714,71	778,47	778,71	725,20
Supply of electricity, gas, steam, hot water and air conditioning	862,86	941,00	957,90	944,49	945,25
Water supply; waste collection, treatment and disposal, pollution control activities	56,57	58,41	41,72	45,77	47,59

**Source: Statistical collection, (2024).*

To analyze the current state of waste management in the regions and take measures to develop infrastructure, an annual information review is conducted based on the results of maintaining the state waste cadastre.

The State policy of the Republic of Kazakhstan in the field of waste management is defined in the Concept for the Transition of the Republic of Kazakhstan to a "green" economy (Decree of the President of the Republic of Kazakhstan dated May 30, 2013 No. 577 "On the Concept for the transition of the Republic of Kazakhstan to a "green economy" (as amended on 09/10/2019) and is aimed at the introduction of separate waste collection, development waste recycling sectors with the production of products from secondary raw materials with the attraction of investments, including through public-private partnerships (Decree of the President of the Republic of Kazakhstan, 2013).

According to this Concept, by 2030 the share of waste recycling should be increased to 40%, by 2050 – to 50%. There are three types of landfills registered in the state waste cadastre in Kazakhstan: a hazardous waste landfill, a non-hazardous waste landfill, and a solid waste landfill. In accordance with Article 349 of the EC of the Republic of Kazakhstan, waste landfills are divided into classes: Class 1 – landfill of hazardous waste; Class 2 – landfill of non–hazardous waste; Class 3 - landfill of solid household waste.

Table 4: Number of landfills registered in the state waste cadastre for 2021

Region	Landfill of hazardous waste, unit	Landfill of non-hazardous waste, unit	Landfill of solid household waste, unit
The Republic of Kazakhstan	149	382	2384
Akmola region	13	41	90
Aktobe region	20	15	93
Almaty region	1	8	101
Atyrau region	17	5	79
East Kazakhstan region	3	16	87
Zhambyl region	3	36	174
West Kazakhstan region	3	8	176
Karaganda region	6	58	118
Kostanay region	2	27	283
Kyzylorda region	14	18	153
Mangystau region	34	10	18
Pavlodar region	10	32	213
North Kazakhstan region		32	325
Turkestan region	11	56	201
Abai Region	6	20	59
The area of Zhetisu	1	3	182
Ulytau region	3	7	29
Almaty		2	
Astana		3	1
Shymkent	2	1	2

**Source: Information review on the results of the State Waste Cadastre 2021.*

In total, 2,915 landfills of waste have been registered in the Republic of Kazakhstan, of which:
- landfills of hazardous waste – 149 units;
- landfills of non–hazardous waste - 382 units;
- landfills of solid waste – 2,384 units.

From 43.5 billion tenge in 2005 to 284.8 billion tenge in 2022, the Republic of Kazakhstan's current environmental protection expenditures have climbed dramatically. The regions with the highest environmental protection costs in 2022 were Atyrau, Aktobe, Karaganda, and Pavlodar.

Table 5: The volume of current environmental protection costs, thousand tenge

	2005	2010	2015	2020	2021	2022
The Republic of Kazakhstan	43 558 238	99 652 579	174 650 049	210 397 122	245 790 216	284 853 377
Abai	-	-	-	-	-	4 569 245
Akmola	324 102	549 875	1 200 707	3 261 696	4 791 410	4 783 079
Aktobe	4 741 222	10 075 432	18 308 916	26 847 144	32 455 655	40 651 798
Almaty	306 337	1 370 814	2 431 904	1 786 108	2 304 693	1 965 645
Atyrau	5 631 372	23 756 114	40 254 371	39 940 657	52 132 403	56 508 271
West Kazakhstan	359 935	551 627	3 793 821	13 685 551	9 038 468	8 434 895
Zhambylskaya	683 473	816 227	3 245 330	4 591 362	5 765 390	7 328 188
Zhetisu	-	-	-	-	-	973 288
Karaganda	5 363 154	12 847 914	23 881 108	28 503 150	36 770 655	32 904 100
Kostanay	4 089 098	8 892 823	5 171 019	10 423 346	13 722 916	18 068 017
Kyzylorda	856 103	3 074 167	2 904 693	2 863 434	3 300 927	3 827 088
Mangystau	10 894 270	13 362 578	29 093 197	9 632 475	7 823 690	7 783 851
South Kazakhstan	862 983	1 618 764	4 988 206	-	-	-
Pavlodar	4 938 780	12 250 778	16 696 011	25 259 670	30 579 926	30 291 043
North Kazakhstan	179 980	397 164	1 864 711	3 102 405	4 919 885	4 419 072
Turkestan	-	-	-	1 294 883	1 472 529	1 649 601
Ulytau	-	-	-	-	-	12 860 844
East Kazakhstan	3 493 977	7 547 966	15 838 119	25 635 452	28 812 255	29 156 691
Astana	85 608	267 160	1 584 670	1 032 748	955 667	6 057 361
Almaty	747 846	2 273 175	3 393 266	4 984 200	6 003 805	7 326 231
Shymkent	-	-	-	7 552 841	4 939 942	5 295 069

**Source: Department of Production and Environment Statistics, (2022).*

The Republic of Kazakhstan's investment and environmental protection cost trends for the years 2010–2022 are clearly depicted in Figure 2. The value of investments in the environmental protection system decreased from 2019 to 2022 and amounted to 160 billion tenge. The total cost of environmental protection has increased over the past 12 years and amounted to 444.51 billion tenge in 2022.

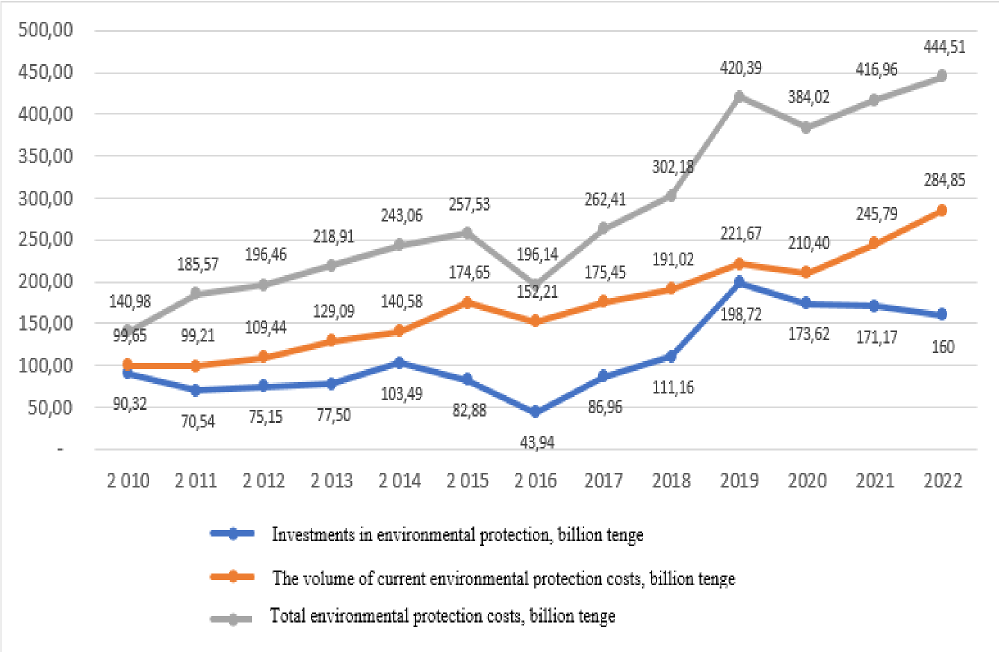

Figure 3: Dynamics of indicators of investments and costs for environmental protection of Kazakhstan for 2010-2022.
**Source: Department of Production and Environment Statistics, (2022).*

In 2021, observations of the state of atmospheric air in the territory of the Abai region were carried out at 30 observation posts, including 2 manual sampling posts and 5 automatic stations (Table 6).

Table 6: Atmospheric air quality in the Abai region

Locality	Number of observation posts		Indicators		
	Manual	Automatic	Atmospheric Pollution Index (API)	Standard Index (SI)	The Greatest Repeatability, % (GR)
Semey	2	4	2 (low level)	6 (high level)	7 (increased level)
Ayagoz	-	1	-	4 (increased level)	15 (increased level)

**Source: Kazhydromet, (2024).*

The key environmental issues in the Abai region are the lack of technologies for recycling and recycling of solid household waste, an increase in the number of illegal landfills in cities and towns, and a high level of atmospheric air pollution due to an increase in the number of vehicles.

Table 7: Dynamics of the volume of pollutants released into the atmosphere, their purification and disposal in the Abai region

Years	The number of sources of pollutant emissions, units	Emissions of solid pollutants, thousand tons	Emissions of liquid and gaseous pollutants, thousand tons	Emissions of air pollutants coming from stationary sources, thousand tons	Emissions of air pollutants from stationary sources per capita, kg	Pollutants were caught and neutralized, thousand tons	Disposed of pollutants, thousand tons
2005	6612	25,64	32,50	58,1	774,00	212,84	168,30
2006	7057	21,49	25,70	47,2	644,21	180,43	134,54
2007	6888	22,69	31,36	54,1	753,78	200,58	151,65
2008	6722	21,36	26,60	48,0	595,12	200,81	140,14
2009	6572	21,67	27,32	49,0	602,07	198,11	133,41
2010	6308	21,44	27,46	48,9	626,11	182,70	115,18
2011	6682	21,42	28,43	49,8	629,32	183,88	121,26
2012	6538	17,50	27,00	44,5	565,89	177,44	142,54
2013	7014	15,20	24,40	39,6	450,68	215,20	179,92
2014	7448	15,10	25,10	40,2	534,27	197,10	159,32
2015	7536	13,60	26,40	40,0	512,03	177,90	140,44
2016	8126	14,50	28,00	42,5	535,25	170,00	106,37
2017	9476	15,00	27,10	42,1	569,81	197,50	3,76
2018	8340	15,40	26,90	42,3	581,94	192,30	14,20
2019	8870	15,10	25,60	40,9	570,55	172,10	9,60
2020	9124	16,00	25,40	41,4	562,42	150,00	11,00
2021	9227	15,90	26,20	42,1	556,71	151,90	14,60
2022	8081	14,03	24,97	39,0	288,45	144,60	18,57

**Source: Statistical Collection. Environmental Statistics (2024).*

During the period 2019-2022, a total of 163.4 thousand tons of pollutants were released into the atmospheric air by stationary sources of pollution in the Abai region. On average, annual emissions remain at the level of 45 thousand tons.

Table 8: Sources of emissions of pollutants into the atmosphere by enterprises with emissions of pollutants in the Abai region in 2022

	The number of stationary sources of pollutant emissions			Of these, those who carried out emissions of pollutants in the reporting period			Pollution emissions into the atmosphere during the reporting period	The structure of emissions into the atmosphere of
	total, units	of these		total, units	of these			
		organized	of them equipped with sewage		organized	one of them equipped with		

			treatment plants			sewage treatment plants		SV, in %
The Abai region	8 081	3 815	526	7 599	3 698	512	38 995,893	100,0
Semey city administration	3 879	1 922	419	3 747	1 874	412	23 619,710	60,6
Kurchatov city administration	297	146	11	294	146	11	714,460	1,8
Abai district	169	56	7	145	50	7	448,752	1,15
Aksuat district	72	36	-	50	34	-	326,098	0,84
Ayagoz district	1 075	504	33	1 046	501	33	5 325,487	13,6
Beskaragai district	364	202	7	344	194	3	593,808	1,5
Borodulikhinsky district	523	300	19	522	300	19	3 280,300	8,4
Zharminsky district	1 095	438	24	952	398	24	3 028,833	7,7
Kokpekty district	220	41	x	132	36	x	294,701	0,75
Urdzhar district	387	170	4	367	165	x	1 363,747	3,5

**Source: On the state of atmospheric air protection in the Abai region. 4 series Environmental statistics. The year 2022.*

The main share of emissions falls on Semey – 56.6%, Ayagozsky district – 11.8%, Zharminsky district – 9.5%, Borokhodulikhinsky district – 8.1%, Urdzharsky district – 4.9%, etc. Every year, large enterprises in the region emit about 28 thousand tons into the atmospheric air, of which more than 13 thousand tons in Semey. In 2019-2021, revenues for emissions, discharges and waste disposal amounted to KZT 15.3 billion.

The main emissions were carried out from the production activities of the State Enterprise "Teplokommunenergo". In 2021, the company carried out repair and restoration work of electric filters and dust cleaning facilities, developed an action plan for the repair of boilers and inspection of electric filters. According to data from open sources in Semey, CHP emissions exceeded the norms by 27 times. The Ministry of Ecology, Geology and Natural Resources conducted an unscheduled inspection at the Teplokommunenergo enterprise, the results of which showed gross violations of the operation of the CHP. In particular, the excess of emission standards for inorganic dust by 27 times was revealed at the gas flues of CHP-1. The unsatisfactory technical condition of the flues and many different violations were also revealed. Environmental protection costs in the Abai region have a positive trend: from 2020 to 2022, costs increased 2.2 times to 5.8 billion tenge (Statistical collection, 2024).

	2020	2021	2022
Environmental protection costs by region, thousand tenge	2 600 586	3 244 786	5 804 267

Let's consider the relationship between the indicators of the state of environmental protection and the number of patients diagnosed with malignant neoplasms for the first time in their lives, taken into account by oncological organizations per 100,000 people in the Abai region.

Table 9: Dynamics of indicators of the state of environmental protection and health care

	The number of patients diagnosed with malignant neoplasms for the first time in their lives, counted by oncological organizations per 100,000 people of the population	The number of sources of pollutant emissions, units	Emissions of solid pollutants per capita, kg/person	Emissions of liquid and gaseous pollutants per capita, kg/person	Emissions into the atmosphere of pollutants coming from stationary sources, thousand tons	Disposed of pollutants per capita, kg/person	Pollutants were captured and neutralized per capita, kg/person
2005	276,8	6612	39,42	49,97	58,1	258,77	327,27
2006	274,6	7057	33,15	39,63	47,2	207,51	278,28
2007	266,9	6888	35,08	48,49	54,1	234,45	310,10
2008	261,6	6722	32,98	41,06	48,0	216,38	310,04
2009	264,5	6572	33,34	42,02	49,0	205,23	304,76
2010	272,3	6308	32,95	42,21	48,9	177,01	280,78
2011	271,1	6682	32,93	43,71	49,8	186,43	282,72
2012	276,2	6538	26,91	41,51	44,5	219,16	272,82
2013	285,6	7014	23,37	37,51	39,6	276,58	330,81
2014	298,8	7448	23,20	38,56	40,2	244,77	302,81
2015	301,4	7536	20,86	40,50	40,0	215,42	272,89
2016	296,3	8126	22,29	43,05	42,5	163,55	261,38
2017	306,3	9476	23,19	41,90	42,1	5,81	305,36
2018	296,6	8340	23,91	41,77	42,3	22,05	298,58
2019	296,6	8870	23,55	39,93	40,9	14,97	268,43
2020	255,9	9124	25,09	39,83	41,4	17,25	235,23
2021	294,1	9227	25,05	41,28	42,1	23,00	239,33
2022	360,3	8081	22,96	40,86	39,0	30,39	236,64

Note: Calculated by the author on the basis of data from statistical collections. Environmental statistics.

The dynamics of indicators for the state of environmental protection and healthcare show that, over the period from 2005 to 2022, the number of malignant neoplasms diagnosed by oncology organizations per 100,000 people in the Abai region increased from 276.8 in 2005, to 360.3 in 2022. Pollutant emissions from fixed sources have declined throughout this time, although they are still rather substantial. In 2022 their value was 40.8 kg per person, which was 5% more than in 2019.

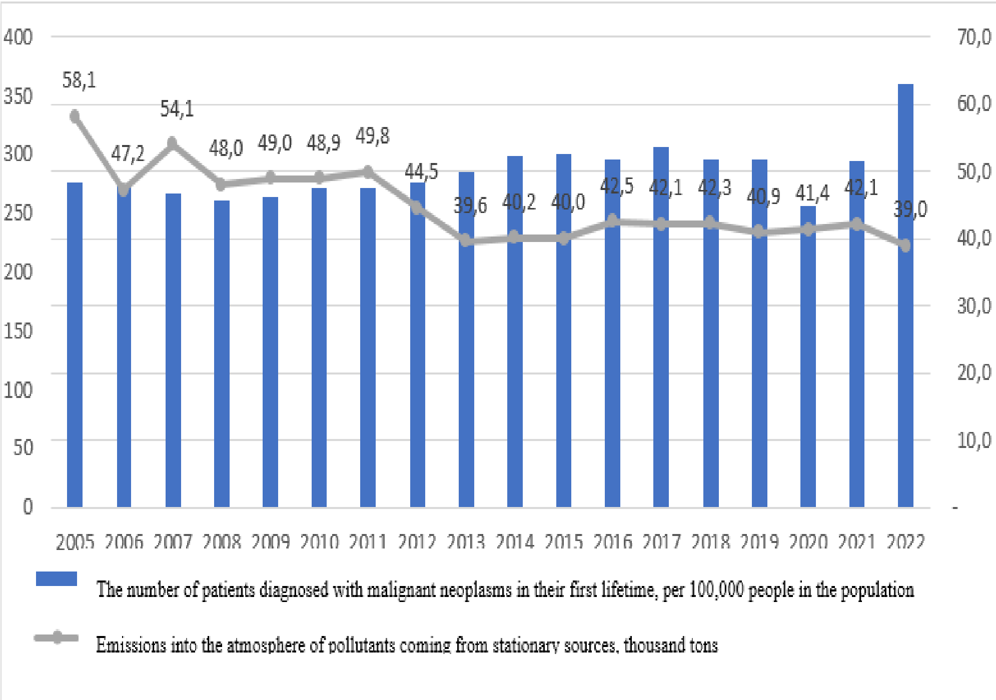

Figure 4: Dynamics of the relationship between emissions of pollutants into the atmosphere from stationary sources and the number of cancer patients in the Abai region.
**Source: Statistical collection, (2024)*

Emissions of pollutants from stationary sources into the atmosphere have changed from 58.1 thousand tons in 2005 to 39.0 thousand tons in 2022. Their value over the past 10 years has remained at the same level of 39-42 thousand tons, and the number of patients has increased significantly.

To determine the relationship between the number of patients diagnosed with malignant neoplasms for the first time in their lives per 100,000 people in the Abai region and environmental protection indicators (Table 7), it can be considered using a multifactorial correlation analysis using a Data Analysis tool in Microsoft Excel designed to perform this task. We use the data in Tables 7 and 9 as the initial data.

The linear regression model has the following form:

$$Y = a_0 + a_1 \times x_1 + a_2 \times x_2 + \ldots a_i \times x_i$$

where a is the regression coefficients, x is the influencing variables, and k is the number of factors.

In our case, the indicator is the number of patients diagnosed with malignant neoplasms per 100,000 people for the first time in their lives. Influencing factors – environmental protection indicators (Xi) (Kazhydromet, 2024):

X_1 - The number of sources of pollutant emissions, units;
X_2 - Emissions of solid pollutants, thousand tons;
X_3 - Emissions of liquid and gaseous pollutants, thousand tons;
X_4 – Emissions of air pollutants from stationary sources per capita, kg;
X_5 - Thousands of tons of pollutants were caught and neutralized;
X_6 - Disposed of pollutants, thousand tons.

The matrix of paired correlation coefficients.

To prove the absence of multicollinearity of the factors, it is necessary to calculate the pair correlation coefficient, reflecting the nature of the stochastic linear relationship between them. Table 10 corresponds to a correlation matrix of dimension 6×6, which is filled in accordance with the properties of its elements according to Tables 7, 9.

Table 10: Matrix of paired correlation coefficients

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1						
X_1	0,4188481	1					
X_2	-0,6331013	-0,6841717	1				
X_3	-0,339115	-0,3666843	0,700484	1			
X_4	-0,7342655	-0,3445121	0,7817472	0,7756351	1		
X_5	-0,3801845	-0,5262145	0,4657121	0,4023545	0,4912464	1	
X_6	-0,4187366	-0,8650131	0,5090349	0,3248702	0,3405553	0,6397931	1

Analyzing the paired correlation coefficients between factor features (rXiXj) and characterizing their closeness, it is necessary to assess their independence from each other. This is a necessary condition for regression analysis. Since there are no completely independent variables in the economy, it is important to identify the most independent variables as far as possible. Features that are closely correlated with each other are multicollinear factors. The inclusion of these multicollinear variables in the model makes it difficult to economically interpret the results of the regression model. A change in one variable will also change related variables, leading to a breakdown of the model. The multicollinearity criterion for factors is rXiXj > 0.8

Studying the values of the correlation coefficients between all indicators, we see that the values between the factors do not exceed 0.8, which confirms the absence of multicollinearity of the factors.

Conclusions of the results of regression analysis using a Data Analysis tool in Microsoft Excel:

Table 11: Regression statistics

Regression statistics	
Multiple R	0,8616189
R-square	0,7423872
The normalized R-square	0,6018711
The standard error	15,130596
Observations	18

The R-squared value, also known as the measure of precision, characterizes the accuracy of the obtained regression line. This accuracy is measured by the degree of agreement between the original data and the predicted values from the regression model. The multiple R, which is equal to the correlation coefficient between the independent variable (x) and dependent variable (y), expresses the strength of the relationship between these variables. The square root of this coefficient is the multiple R. Both values can range from 0 to 1. In our example, the R-squared score of 0.75 or 86.2% indicates that the model fits the data well. This means that the calculated parameters of the model explain 75% of the dependence between the studied parameters. That is, the variation in the effective indicator (the number of patients diagnosed with malignant neoplasms for the first time in their lives per 100,000 people in the Abai region), by 75%, depends on changes in the studied factors. The unaccounted-for factors account for 25% of these changes. The Multiple R index is 0.86, indicating a close relationship between the two indicators.

The higher the coefficient of determination, the better the model. In our case, this indicates strong relationships between variables.

Table 12: Analysis of variance

	df (number of degrees of freedom)	*SS* (sum of squares of deviation)	*MS* (variance)	*F* (Fisher's criterion)	*Significance of F (significance level)*
Regression	6	7257,1784	1209,5297	5,2832901	0,008600396
Residual	11	2518,2844	228,93494		
Total	17	9775,4628			

Table 13: The conclusions of the regression analysis

	Coefficients	*The standard error*	*t- statistics*	*P- Value*	*Lower 95%*	*Upper 95%*	*Lower 99,0%*	*Upper 99,0%*
Y- is the intersection	203,5425	118,0731	1,72386798	0,112684	-56,3347	463,4196	-56,3347	463,4196

X_1	0,002413	0,010414	0,23169809	0,821026	-0,02051	0,025335	-0,02051	0,025335
X_2	-0,68939	2,60651	-0,2644863	0,796295	-6,42628	5,047505	-6,42628	5,047505
X_3	7,463591	2,86005	2,60960137	0,024275	1,168663	13,75852	1,168663	13,75852
X_4	-0,25536	0,078922	-3,2355405	0,007937	-0,42906	-0,08165	-0,42906	-0,08165
X_5	0,157644	0,253553	0,62173776	0,546784	-0,40042	0,71571	-0,40042	0,71571
X_6	-0,06959	0,139884	-0,4974601	0,628659	-0,37747	0,238297	-0,37747	0,238297

The significance of the equation is determined by the Significance indicator F, and the significance of the coefficients of the equation by the coefficient P is the Value. The values for the selected indicators should be less than 0.05, which means that the equation as a whole is significant and its coefficients are significant, therefore, it can be used for further calculations.

The coefficient 203.5 shows what Y will be like if all the variables in the model under consideration are equal to 0.

As a result, the coupling equation has the form:

$$Y= 203{,}54 + 0{,}0024\ X_1 - 0{,}6894\ X_2 + 7{,}46\ X_3 -0{,}255\ X_4 + 0{,}157\ X_5 - 0{,}069\ X_6$$

The coefficients of the equation show the quantitative effect of each factor on the performance indicator while the others remain unchanged. Here we can give the following interpretation of the equation obtained: the increase in the number of patients, which means that the level of public health is strongly influenced by emissions of solid, liquid and gaseous pollutants. The effective indicator decreases by 0.689 with a decrease in solid pollutants; increases by 7.46 increases with an increase in emissions of liquid and gaseous pollutants; and decreases by 0.069 with a decrease in the volume of disposed pollutants.

Based on the above, it follows that without the introduction of strict norms and standards for industrial emissions, without switching to the use of modern technologies and methods of purification and emission control, it is impossible to reduce the negative impact of industrial emissions on human health. Periodic monitoring of air quality and informing the population about its condition and possible risks will make it possible to preserve the health of the population.

According to the draft development plan for the Abai region (2022), the unfavorable environmental situation in the region is aggravated by:

- the continuing trend of accumulation of orphan, industrial, toxic and household waste, as well as the lack of recycling and recycling technology;
- non-compliance with the requirements of sanitary regulations of existing solid waste disposal facilities;
- low volumes of solid waste recycling (2% of the total volume of solid waste);
- underdevelopment of separate collection of solid waste.

4. Conclusions

According to the analysis of the key problems of the regions in terms of the state of the environment, greenhouse gas emissions and the negative effects of climate change, the following conclusions can be drawn. The main environmental problems arise due to emissions of pollutants into the atmosphere and problems in the waste management sector. The main emissions of pollutants into the atmosphere occur in urban areas, which is due to the presence of industry in cities and the concentration of transport. Special attention needs to be paid to the issue of emissions into the atmosphere from the CHP plant in the city of Semey, where there is an excess of emission standards for inorganic dust by 27 times.

There are facilities in the Abai region that have the maximum amount of greenhouse gas emissions, which, as a result, are included in the National Carbon Quota Plan "Total carbon quotas for regulated areas of activity". Therefore, it is required to request information on the situation from the MEG of the Republic of Kazakhstan or the region in order to draw a conclusion about further actions in this direction.

It is necessary to bring the waste management sector in line with green principles, which, as can be seen, is not fully funded, most of the available funds go to wastewater treatment.

The implementation of the Abai region's development plan for green and low-carbon areas can be an important step towards improving the environment and reducing harmful impacts on it. The development plan of the Abai region in the direction of "Economic growth of the region" should provide for the goal of "Improving the environmental situation", which will provide for the following activities:

- the level of satisfaction of the population with the environmental quality of life from 68.2% to 80.0% in 2025;
- reduction of emissions of pollutants into the atmosphere;
- reduction of energy consumption in the public sector and housing and communal services by 6.0% to 15.0% in 2025;
- reduction of the level of regulatory and technical losses of electricity in national and regional electric networks;
- reduction of the volume of fresh water intake in industry;
- an increase in the natural population of fish resources by 1% until 2025;
- the share of recycling and recycling, including: Solid waste from 15.7% to 24.0% (of the volume of education), waste from the agro-industrial complex from 5.0% to 10.0% (compared to the previous year), hazardous medical waste (of the collected volume);
- the number of citizens covered by the environmental information campaign increased from 15.0% to 50% in 2025;
- modernization and construction of landfills in 28 rural settlements (2024-2026), elimination of unauthorized landfills. It is envisaged that the level of satisfaction of the population with the environmental quality of life will increase due to the construction of a solid waste landfill, the installation of containers for separate collection in rural settlements, the replacement of electric filters and the repair of ash collection plants of industrial enterprises of the region.

These measures that aim to improve the environmental quality of life and air conditions, reduce emissions of pollutants into the atmosphere and reduce energy consumption, electricity loss, and waste in the water and other sectors, will help to achieve the goal of improving the environment in the Abai area. The program covers a wide range of issues related to green and low carbon development, but in light of instructions from the President of Kazakhstan, there may be opportunities to add to or modify the development of the document on green and low carbon.

The carbon quota is the norm of permissible greenhouse gas emissions, which is set by the state for enterprises. This is one way to limit the negative impact of human activities on the climate. Installations of the electric power, oil and gas, mining, metallurgical and chemical industries, as well as manufacturing industries fall under carbon quotas. At the same time, a quota-based installation is recognized as an installation whose quota-based greenhouse gas emissions exceed 20 thousand tons of carbon dioxide per year.

Based on the above, as well as taking into account the demographic shift of the region in a positive direction and the development of the region as a whole, first of all, it is necessary to improve the quality of life of the population, take appropriate measures to reduce emissions of pollutants, as well as improve the ecology of the region.

Therefore, there is an urgent need to conduct research that will help develop specific measures and recommendations to implement sustainable regional development. It is crucial to take into consideration the principles of environmental responsibility and efficient use of natural resources while formulating regional development strategies. Additionally, it is worthwhile to pay attention to the development of innovative technologies that could reduce the negative environmental impact of industrial facilities. It is likewise essential to create conditions that support the growth of the market for environmental products and services, which would help reduce the industry's negative impact on the environment. Overall, the success of a region's development should be based on sustainability principles, considering environmental, economic, and social factors. Only by addressing these issues can we ensure the long-term, sustainable development of any region.

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