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Satbayev University

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
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THE INFLUENCE OF ATMOSPHERIC AIR POLLUTION ON THE GEOGRAPHY OF PROFESSIONAL HEALTH

Abstract. This article examines the levels of emissions of pollutants into the atmospheric air by regions of the Republic of Kazakhstan and the results of studying the features of occupational morbidity of the population living in various geographical conditions of the Republic of Kazakhstan for the period 2011-2020. The greatest differences were noted in relation to the morbidity of Central Kazakhstan with the harmful effects of potential production factors of industrial enterprises of the Karaganda region, the article presents specially created maps of the morbidity of the population and emissions of the Karaganda region. During the study, a statistically significant positive correlation was established between the number of patients and the level of emissions of pollutants into the atmospheric air in the Akmola region ($\mathbf{r}_{xy}$=0,674; p=0, 007) and Aktobe region ($\mathbf{r}_{xy}$=0,611; p=0, 022), this confirms the negative impact of environmental factors on the health of the population living in an industrial area.

Key words: atmospheric air, pollutants, production factors, environmental factors, industrial enterprises, geography of occupational health, Central Kazakhstan.

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АТМОСФЕРАЛЫҚ АУАНЫҢ ЛАСТАНУЫНЫҢ КӘСІБИ ДЕНСАУЛЫҚ ГЕОГРАФИЯСЫНА ӘСЕРІ

Аннотация. Бұл мақалада Қазақстан Республикасының аймақтары бойынша атмосфералық ауаға ластаушы заттардың шығарындыларының деңгейлері зерттеледі және 2011-2020 жылдарға арналған Қазақстан Республикасының әртүрлі географиялық жағдайларында тұратын халықтың кәсіптік аурушаңдық сипаттамаларын зерттеу нәтижелері қарастырылады. Қарағанды облысының өнеркәсіптік кәсіпорындарының потенциалды өндірістік факторларының зиянды әсерлерімен Орталық Қазақстандағы ауру деңгейіне қатысты ең үлкен айырмашылықтар анықталды. Мақалада Қарағанды облысының аймақтары үшін арнайы жасалған аурушаңдық және шығарындылар карталары ұсынылған. Зерттеу барысында Ақмола облысында ($\mathbf{r}_{xy}$=0,674; p=0, 007) және Ақтөбе облысында ($\mathbf{r}_{xy}$=0,611; p=0, 022) науқастардың саны мен атмосфералық ауаға ластаушы заттардың шығарындыларының деңгейі арасында статистикалық маңызды оң корреляция анықталды, бұл өнеркәсіптік ауданда тұратын халықтың денсаулығына қоршаған орта факторларының теріс әсерін растайды.

Түйін сөздер: атмосфералық ауа, ластаушы заттар, өндірістік факторлар, қоршаған орта факторлары, өндірістік кәсіпорындар, еңбек гигиенасының географиясы, Орталық Қазақстан.

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ВЛИЯНИЕ ЗАГРЯЗНЕНИЯ АТМОСФЕРНОГО ВОЗДУХА НА ГЕОГРАФИЮ ПРОФЕССИОНАЛЬНОГО ЗДОРОВЬЯ

Аннотация. В этой статье исследуются уровни выбросов загрязняющих веществ в атмосферный воздух по регионам Республики Казахстан и рассмотрены результаты изучения особенностей профессиональной заболеваемости населения, проживающего в различных географических условиях РК за 2011-2020 годы. Наибольшие различия отмечены в отношении заболеваемости Центрального Казахстана с вредным воздействием потенциальных производственных факторов промышленных предприятий Карагандинской области, в статье представлены специально созданные карты заболеваемости и выбросов по регионам Карагандинской области. В ходе исследования была установлена статистически значимая положительная корреляционная связь между количеством больных и уровнем выбросов загрязняющих веществ в атмосферный воздух в Акмолинской области ($\mathbf{r}_{xy}$=0,674; p=0, 007) и Актюбинской области ($\mathbf{r}_{xy}$=0,611; p=0, 022), что подтверждает негативное воздействие экологических факторов на здоровье населения, проживающих на промышленной территории.

Ключевые слова: атмосферный воздух, загрязнители, производственные факторы, экологические факторы, промышленные предприятия, география профессионального здоровья, Центральный Казахстан.

Introduction. Sustainable development can be defined as development of society, in which human living conditions improve, and the impact on the environment remains within the economic capacity of the biosphere, so that the natural basis of the functioning of humanity is not destroyed. It is assumed that with sustainable development, satisfaction of needs is carried out without prejudice to future generations, environmental protection becomes an integral component of the development process (Snakin V.V., 2018; Tishkov A.A. et al., 2012). The UN Summit adopted 17 goals for the transformation of our world, 193 countries of the world are directing efforts to eliminate poverty, increase economic growth, address a number of issues in the field of education, health, social protection, employment, as well as the fight against climate change and environmental protection (Sachs, J. Et al., 2020). Currently, climate change has become one of the global problems around the world, resulting in increased emissions of greenhouse gases such as carbon dioxide, nitrogen oxide, methane and other air pollutants, as well as water scarcity, loss of biodiversity and natural disasters, all this requires effective tools for landscape research, search for new models of analysis and forecasting in geographical ecology, these issues were discussed within the framework of the draft resolution of the 66th session of the UN General Assembly and the United Nations Conference on Sustainable Development in 2012. Although natural cycles and fluctuations have caused changes in the Earth's climate several times over the past 800,000 years, our current era of global warming is directly related to human activity, in particular, with our burning of fossil fuels such as coal, oil, gasoline, natural gas, which leads to a greenhouse effect. In the US, the largest source of greenhouse gases is transportation (29%), followed by electricity generation (28%) and industrial activity (22%) (Chris Lafakis et al., 2019; Berrang-Ford L et al., 2021). At the same time, the content of fine particulate matter and other pollutants in the atmospheric air are the leading environmental risk factors for the Global Burden of Disease (Veronica A Southerland et al., 2022; Murray CJL et al., 2020). Epidemiological cohort studies reveal a link between long-term exposure to air pollution and mortality rates (Beelen R et al., 2014; Carey IM et al., 2013; Cesaroni G et al., 2013; Di Q et al., 2017; Fischer PH et al., 2015; Hanigan IC et al., 2019; Pappin AJ et al., 2019; Raaschou-Nielsen O et al., 2020).

Materials and methods. The work is based on the materials of medical statistics of the Republic of Kazakhstan on demography and morbidity of the adult population, Statistical collections of the Ministry of Health of the Republic of Kazakhstan "The health of the population of the Republic of Kazakhstan and the activities of healthcare organizations", Institute of Public and Occupational Health of the NP JSC "Medical University of Karaganda", National Reports of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan "On the state of the Environment and on the use of Natural Resources of the Republic of Kazakhstan", official data of the Bureau of National Statistics, RSE "Information and Analytical Center for Environmental Protection", as well as information from local executive bodies, public associations, non-governmental and international organizations.

These materials contain information for the period from 2011 to 2020 on the state of health and the quality of the environment, the state of natural resources and protected natural areas, as well as trends in their changes. Here represented the most acute environmental problems, measures of state regulation of nature management, their effectiveness, that allow us to trace the consequences of the influence of anthropogenic factors on the state of ecosystems. Atmospheric air indicators are formed in accordance with the "Methodology for the formation of environmental statistics indicators", approved by the Order of the Acting Chairman of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan dated December 25, 2015 No. 223.

There was applied a method of mapping using GIS technologies, with the help of which were created special maps in the geoinformation program ArcGIS. Maps are the main way of research in geographical science, represent a critical context, serve for the analysis and monitoring of objects, processes and phenomena.

To identify statistical differences and determine the degree of interrelationships between the relative movements of the two variables in groups, the correlation coefficient (r) was calculated, the reliability of differences among unrelated samples was evaluated by the t-criterion (Student). The results were processed using an application software package Statistica 5.5.

The dependence of the pollution level on the selected period was studied using the Kendall Tay-b correlation coefficient ($\mathbf{r}_{xy}$), the values of $p < 0.05$ were statistically significant.

Study design: we conducted a retrospective cohort study to understand the prevalence of professional morbidity, its causes and prognoses. The aim is to assess the impact of emissions of pollutants into the atmospheric air on the health of the working population.

Results and discussion. Emissions of pollutants have an impact on the quality of atmospheric air, while increased air pollution negatively affects human health and the sustainability of ecosystems. A significant part of the population lives in the zone of direct influence of harmful production factors, the main of which are emissions of pollutants into the atmospheric air. During the study period from 2010 to 2020, emissions of pollutants into the atmospheric air from stationary sources amounted to: 2,226.5 thousand tons in 2010, 2,346.2 thousand tons in 2011, 2,384.3 thousand tons in 2012, 2,282.7 thousand tons in 2013, 2,256.7 thousand tons in 2014, 2,179.7 thousand tons in 2015, 2,271.6 thousand tons in 2016, 2,357.8 thousand tons in 2017, 2,446,7 thousand tons in 2018, 2,483,1 thousand tons in 2019, 2,441 thousand tons in 2020.

The main volumes of pollutants show significant differences between the regions of the Republic of Kazakhstan, while over the 10-year observed period, consistently higher levels were formed in the territories of the Karaganda region, the indicator of emissions into the atmosphere amounted to: 661.2 thousand tons in 2010, 691.3 thousand tons in 2011, 641.4 thousand tons in 2012, 572.6 thousand tons in 2013, 603.6 thousand tons in 2014, 596.4 thousand tons in 2015, 593.0 thousand tons in 2016, 598.7 thousand tons in 2017, 587.5 thousand tons in in 2018, 641.3 thousand tons in 2019, 627.7 thousand tons in 2020 (Figure 1-2, Table 1). Also, the highest indicators were noted in the Pavlodar region, East Kazakhstan region, Aktobe region, Atyrau region, due to the large concentration of industrial enterprises in these areas.

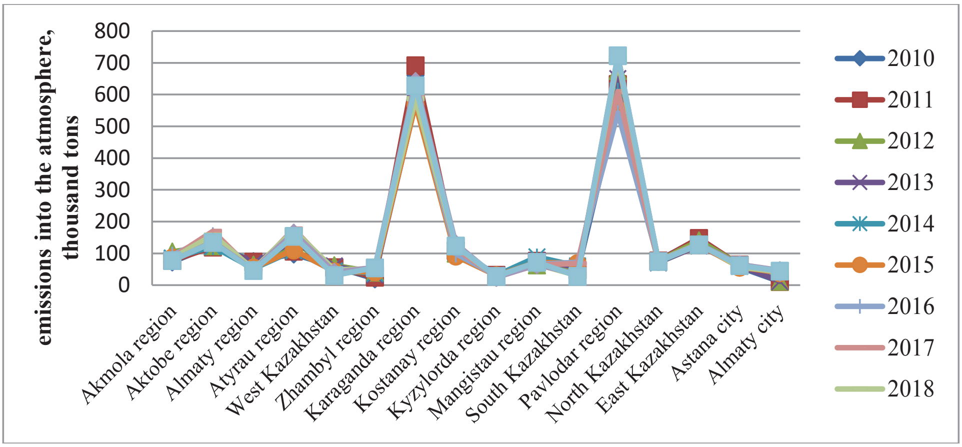

Figure 1 - Emissions of pollutants into the atmospheric air from stationary sources by regions for 2010-2020, thousand tons

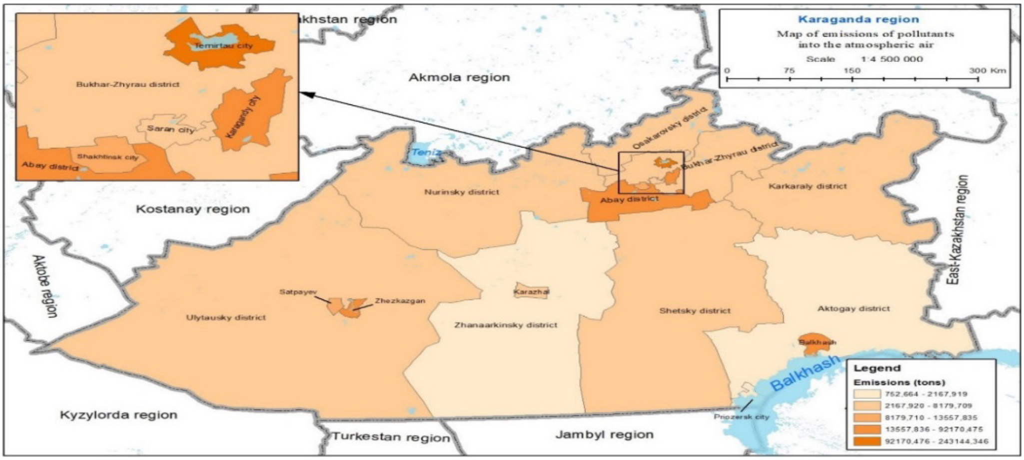

Figure 2 - Map of emissions of pollutants into the atmospheric air, Karaganda region

The main substances polluting the atmospheric air in the Republic of Kazakhstan were: sulfur dioxide amounted to 723.6 thousand tons in 2010, 774.2 thousand tons in 2011, 769.6 thousand tons in 2012, 729.2 thousand tons in 2013, 729.1 thousand tons in 2014, 710.6 thousand tons in 2015, 767.5 thousand tons in 2016, 786.4 thousand tons in 2017, 838.314 thousand tons in 2018, 885.7 thousand tons in 2019, 868.1 thousand tons in 2020; carbon monoxide 401.1 thousand tons in 2010, 445.1 thousand tons in 2011, 446.2 thousand tons in 2012, 457.8 thousand tons in 2013, 478.8 thousand tons in 2014, 451.2 thousand tons in 2015, 473.0 thousand tons in 2016, 491.9 thousand tons in 2017, 476.869 thousand tons tons in 2018, 487.9 thousand tons in 2019, 486.5 thousand tons in 2020; nitrogen oxide 215.6 thousand tons in 2010, 232.7 thousand tons in 2011, 249.4 thousand tons in 2012, 250.2 thousand tons in 2013, 256.5 thousand tons in 2014, 243.4 thousand tons in 2015, 246.6 thousand tons in 2016, 264.7 thousand tons in 2017, 272.164 thousand tons tons in 2018, 313.9 thousand tons in 2019, 311.4 thousand tons in 2020 and others (Table 2).

According to the Bureau of National Statistics of the Republic of Kazakhstan, about 103 ingredients were found contained in the emissions of stationary and mobile sources of pollution, including 37 I-II hazard classes. In 2020, the republic's air basin received such specific pollutants as toluene in the amount of 2,150.7 tons, copper 424.9 tons, lead and its compounds 369.6 tons, benz(a) pyrene 50.3 tons, naphthalene 50.1 tons, arsenic 27.3 tons, dichloethane 0.9 tons, cadmium 0.8 tons, mercury 0.18 tons and others.

The largest amount of ingredients is contained in the emissions of industrial enterprises located on the territory of Central Kazakhstan, especially in such an industrially developed regional center as the Karaganda region.

There was carried out the assessment of occupational morbidity indicators of the population of the Republic of Kazakhstan for the 10-year observed period from 2011 to 2020, the level of professional morbidity was: in 2011 - 3439, in 2012 - 3435, in 2013 - 3460, in 2014 - 3430, in 2015 - 3254, in 2016 – 3291, in 2017 - 3671, in 2018 - 3659, in 2019 - 2871, in 2020 – 2156 (Figure 3, Table 3).

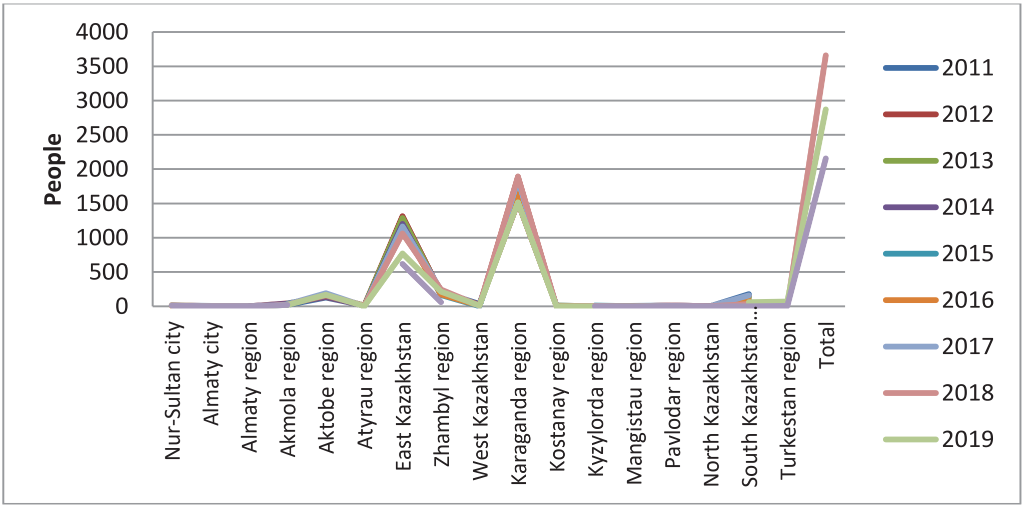

Figure 3 - Geography of professional morbidity in the Republic of Kazakhstan

These indicators are much higher among the population living in Central Kazakhstan, especially in the Karaganda region (44.9%): in 2011 – 1596 people, in 2012 - 1512, in 2013 - 1611, in 2014 – 1712, in 2015 - 1600, in 2016 - 1678, in 2017 - 1843, in 2018 - 1896, in 2019 - 1518, in 2020 – 1427 (Figure 4).

This pattern is associated with the peculiarities of anthropogenic influence on the modern geoecological state of the environment of the industrial regional center, especially in the cities of Karaganda, Temirtau, Satpayev, Balkhash and others, where the main mining and metallurgical centers of the republic are located. The large enterprises of JSC ArcelorMittalTemirtau have 15,242 employees in production, among them 2,631 women. At the same time, 13,143 work in harmful conditions, 1,601 of which are women. The number of employees with suspected professional diseases is 64, the number of employees with professional diseases is 259, the company operates 19 health centers.

Figure 4 - Distribution map of patients with professional pathology, Karaganda region

G. Satpayev Kazakhmys Corporation LLP has 10150 employees in production, among them 1679 women. At the same time, 8514 people work in harmful conditions, 1237 of which are women. The number of employees with suspected professional diseases is 497, the number of employees with professional diseases is 53, 15 health centers are functioning at the enterprise. Zhezkazgan Kazakhmys Corporation LLP has 9155 employees in production, among them 1806 women. At the same time, 7574 people work in harmful conditions, 1727 of which are women. The number of employees with suspected professional diseases is 328, the number of employees with professional diseases is 46, there are 8 health centers in the enterprise. Balkhash Kazakhmys Corporation LLP has 8664 employees in production, among them 2350 women. At the same time, 8210 people work in harmful conditions, 2092 of which are women. The number of employees with suspected professional diseases is 4, the number of employees with professional diseases is 35, 11 health centers are functioning at the enterprise.

High rates of professional morbidity in the East Kazakhstan region (33.4%) were also revealed: in 2011 – 1211 people, in 2012 - 1316, in 2013 - 1289, in 2014 - 1202, in 2015 - 1164, in 2016 - 1116, in 2017 - 1163, in 2018 - 1061, in 2019 - 772, in 2020 – 619. The basic branch of the economy in the East Kazakhstan region is non-ferrous metallurgy, the production of polymetallic ores that contain zinc, lead, copper, precious metals, which puts a strain on the health of the working population.

The structure of nosologies is dominated by radiculopathy (1766 people - 46.2%), pneumoconiosis (684 people - 17.9%), bilateral sensorineural hearing loss (344 people – 9.0%), deforming osteoarthritis (300 people - 7.8%), vibration disease (245 people - 6.4%) and others (Figure 5).

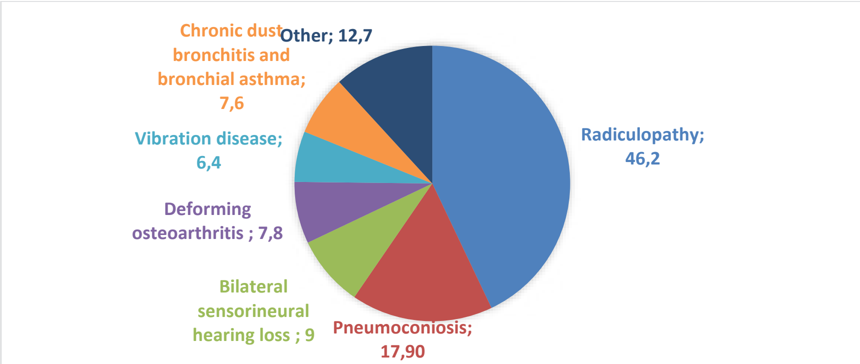

Figure 5 – The structure of nosologies

The lowest indicators were noted in the Southern territories (Almaty region (0.03%), Almaty (0.05%), Kyzylorda region 0.06%)) and Northern territories (North Kazakhstan region (0.08%), Kostanay region (0.12%)).

Next, we conducted a statistical analysis of the data obtained, as a result of which the following was revealed.

Table 1 - Emissions of air pollutants from stationary sources

Administrative area	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Tpr., %, basic	Average Tpr%	r_{xy}	p
Republic of Kazakhstan	2226,5	2346,2	2384,3	2282,7	2256,7	2179,7	2271,6	2357,8	2446,7	2483,1	2441	9,6%	0,9%	0,418	0,073
Akmola region	72,9	77,8	105,7	83,8	84,6	85,6	94,5	86,9	84,5	76,7	77,3	6,0%	0,6%	0,018	0,938
Aktobe region	125,3	119,7	123,9	125,4	121,8	134,2	155,6	169,5	158,1	136,6	135,1	7,8%	0,8%	0,527	0,024
Almaty region	74,7	73,4	64,2	68,4	51,6	55	50,3	43,4	50,2	48,1	46,3	-38,0%	-4,7%	-0,818	0,000
Atyrau region	97,8	107,3	133,1	138,4	109,1	110,6	167,1	177	172,3	164,5	154	57,5%	4,6%	0,564	0,016
West Kazakhstan	58,1	56	62,1	60,4	44,7	42,4	42,5	41,5	48,2	41,2	30,8	-47,0%	-6,1%	-0,673	0,004
Zhambyl region	19,3	25	40,7	33,6	38,2	41,9	52,4	51,9	52,1	55,8	55	185,0%	11,0%	0,818	0,000
Karaganda region	661,2	691,3	641,4	572,6	603,6	569,3	593	598,7	587,5	641,3	627,7	-5,1%	-0,5%	-0,236	0,312
Kostanay region	114,5	109,4	100,6	115,4	103,8	91,6	98,7	114,8	124	130,5	123,4	7,8%	0,8%	0,309	0,186
Kyzylorda region	29	31,9	31,1	31,3	30,8	30,1	30,1	27,5	26	24,4	28,3	-2,4%	-0,2%	-0,624	0,008
Mangistau region	68,6	75,8	64,2	77,5	88,3	72,5	65,8	62,6	65,5	64,5	72,5	5,7%	0,6%	-0,220	0,349
South Kazakhstan	40,7	47,1	48,6	56,3	59,9	68,9	72	68,2	30,1	33,5	28,2	-30,7%	-3,6%	-0,018	0,938
Pavlodar region	572,5	632,2	676	650,4	610,2	552,9	542,7	609,8	709,3	721,5	723	26,3%	2,4%	0,309	0,186
North Kazakhstan	77,8	77	75,7	71,4	71,9	74,8	77,7	76,4	75,5	74,7	75,2	-3,3%	-0,3%	-0,236	0,312
East Kazakhstan	147	147,2	140	124,9	129,6	127,1	128,7	129,3	130,7	128,8	127,2	-13,5%	-1,4%	-0,345	0,139
Nur-Sultan city	56,1	63,5	64,9	60,5	65,1	56,3	61,7	59,2	56,4	65,1	62,4	11,2%	1,1%	0,110	0,639
Almaty city	11	11,6	12,1	12,4	43,5	39,1	38,8	41,2	43	46,1	44,5	304,5%	15,0%	0,782	0,001

On average, the amount of pollutants during the study period grew at a rate of 0.9% per year from the initial level of the period (the Average Tpr indicator % is the average growth rate), in general, it has increased by 9.6% over 10 years (basic Tpr indicator % is the basic growth rate).

Emission levels have significantly increased in Aktobe, Atyrau, Zhambyl regions and in Almaty city, Almaty region, West Kazakhstan and Kyzylorda regions, the level of emissions has significantly decreased.

Table 2 - Emissions of the most common pollutants into the atmosphere

Pollutants	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Tpr., %, basic	Average Tpr%	r_{xy}	p
Total	Thousand tons / year	2226.5	2346.2	2384.3	2282.7	2256.7	2179.7	2271.6	2357.8	2446.7	2483.1	2441	9.6%	0.9%	0.127	0.586
Of them:																
Sulfur dioxide		723.6	774.2	769.6	729.2	729.1	710.6	767.5	786.4	838.314	885.7	868.1	20.0%	1.8%	0.418	0.073
Carbon monoxide		401.1	445.1	446.2	457.8	478.8	451.2	473	491.9	476.869	487.9	486.5	21.3%	1.9%	0.527	0.024
Nitrogen oxides		215.6	232.7	249.4	250.2	256.5	243.4	246.6	264.7	272.164	313.9	311.4	44.4%	3.7%	0.673	0.004
Hydrocarbons (without volatile organic compounds)		132.1	137.6	170.5	96.1	62	66.1	63	45.2	35.3	128.5	123.7	-6.4%	-0.7%	-0.236	0.312
Volatile organic compounds		49.7	53.4	58.1	92	114.4	105.1	100.4	87.2	91.7	158.7	146.2	194.2%	11.4%	0.527	0.024
Ammonia		-	2.2	2.2	2.0	2.2	2.3	2.5	2.6	2.5	2.5	2.2	0.0%	0.0%	0.447	0.090
VHF (solid particles). of these:		-	631.1	593.8	551.2	494.2	466.0	460.6	475.7	508.0	507.7	500.4	-20.7%	-2.5%	-0.378	0.128
Soot		-	9.6	9.0	8.6	8.9	7.3	8.0	8.7	7.6	6.9	6.6	-31.3%	-4.1%	-0.733	0.003
Coal ash with a calcium oxide content of 35-40%		-	47.7	35.3	18.6	14.4	8.6	8.6	14.2	13.5	9.0	7.1	-85.1%	-19.1%	-0.719	0.004
Lead	tons/ year	-	644.9	542.0	572.4	699.4	636.3	224.5	254.8	241.5	390.0	369.6	-42.7%	-6.0%	-0.378	0.128
Cadmium		-		1.2	1.3	1.2	1.2	1.3	6.5	0.9	0.8	0.8	-50.0%	-4.9%	-0.236	0.360
Mercury		-	0.3	0.2	0.2	0.2	0.2	0.5	0.3	0.2	0.2	0.2	-40.0%	-5.5%	-0.155	0.575
Copper		-	310.4	248.8	165.9	162.6	254.5	217.7	32.9	32.3	366.2	424.9	36.9%	3.6%	-0.022	0.929
Arsenic		-	160.8	101.3	121.8	87.7	40.5	13.4	7.9	41.6	13.8	27.3	-83.0%	-17.9%	-0.600	0.016
Toluene		-	1334.2	1688.8	1761.4	2075.9	2174.1	1941.7	2354.9	2339.6	2178.5	2150.7	61.2%	5.4%	0.600	0.016
Benz(a)pyrene		-	12.7	17.1	35.2	23.2	49.6	22.8	24.7	27.9	57.8	50.3	296.1%	16.5%	0.600	0.016
Naphthalene		-	68.7	69.1	51.6	54.9	54.5	56.2	58.7	61.2	61.0	50.1	-27.1%	-3.4%	-0.111	0.655
Dichloroethane		-	510.2	201.1	0.0	0.1	1.2	1.2	1.1	1.1	3.3	0.9	-99.8%	-50.6%	-0.205	0.417
Acetone		-	156.3	204.6	248.5	686.8	331.7	301.3	-	-	-	-	92.8%	14.0%	0.600	0.091

On average, the amount of pollutants during the study period grew at a rate of 0.9% per year from the initial level of the period (the Average Tpr indicator. % is the average growth rate), in general, it has increased by 9.6% over 10 years (basic Tpr indicator % is the basic growth rate). Statistically significant increases occurred in the levels of pollution of carbon monoxide, nitrogen oxides, volatile organic compounds, toluene, benz(a)pyrene. Levels of pollution with soot, coal ash with a calcium oxide content of 35-40% and arsenic, on the contrary, significantly decreased.

The dependence of the pollution level on the given period was studied using the Kendall Tay-b correlation coefficient ($\mathbf{r}_{xy}$), the values of $p < 0.05$ were statistically significant.

Table 3 - Report by regions for 2011-2020. Professional morbidity

Regions of the Republic of Kazakhstan	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	r_{xy}	p
Nur-Sultan city	10	10	12	11	10	9	17	19	15	10	-0,409	0,241
Almaty city	2	1	2	-	1	2	5	2	1	2	0,176	0,650
Almaty region	2	1	-	2	-	-	-	1	1	3	-0,112	0,832
Almola region	21	41	22	39	38	28	31	26	21	19	0,674	0,007
Aktobe region	129	139	165	143	160	158	189	163	168		0,611	0,022
Atyrau region	13	11	11	9	10	10	4	7	4	-	-0,493	0,072
East Kazakhstan	1211	1316	1289	1202	1164	1116	1163	1061	772	619	0,200	0,421
Zhambyl region	215	198	188	177	165	172	238	244	215	60	-0,090	0,719
West Kazakhstan	35	25	6	19	3	11	9	10	10		0,310	0,249
Karaganda region	1596	1512	1611	1712	1600	1678	1843	1896	1518	1427	-0,289	0,245
Kostanay region	10	5	10	6	-	4	1	2	1	-	-0,148	0,615
Kyzylorda region	1	1	1	-	10	1	-	5	1	2	-0,318	0,312
Mangistau region	8	4	4	2	2	4	-	2	2	1	0,000	1,000
Pavlodar region	10	10	8	12	8	9	7	10	9	6	-0,094	0,714
North Kazakhstan	3	4	4	4	3	2	3	3	-	1	-0,417	0,145
South Kazakhstan (Shymkent city from 2018)	176	151	127	92	80	87	161	36	62	1	0,111	0,655
Turkestan region								13	71	5		
Total	3439	3435	3460	3430	3254	3291	3671	3659	2871	2156	0,067	0,788

The results obtained allow us to establish that a statistically significant positive correlation was found between the number of patients and the level of emissions in the Akmola and Aktobe regions (Kendall's Tay-b (**r_{xy}**), $p<0.05$ values were statistically significant). (Figure 6-7).

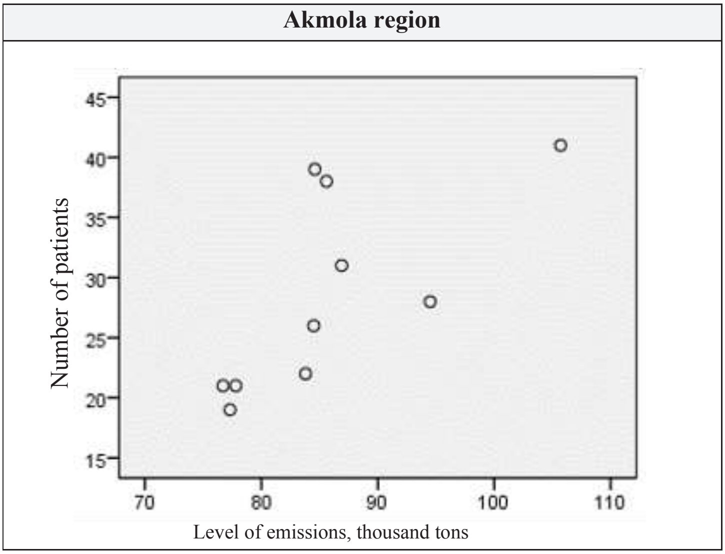

Figure 6 - Correlation between the number of patients with professional diseases and the level of emissions in the Akmola region

Aktobe region

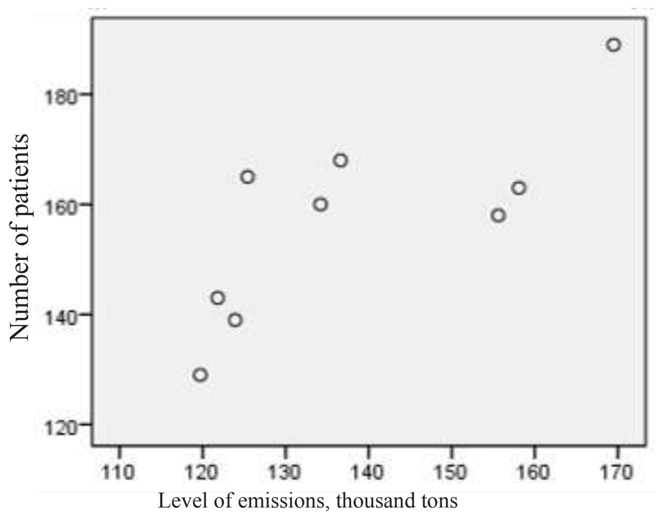

Figure 7 - Correlation between the number of patients with professional diseases and the level of emissions in the Aktobe region

Conclusion. The analysis of the data obtained allows us to conclude about the causal relationship of atmospheric air pollution with harmful substances and professional morbidity of the population of Central Kazakhstan. One of the explanations may be the influence of unfavorable factors of technogenic and, first of all, chemical factors of the habitat, since large production complexes of the coal, mining, and metallurgical industries are located on the territory of the Karaganda region. In recent years, an intensive process of technical improvement and intensification of production processes has been carried out, which radically changes not only the working conditions of employees, but also leads to the formation of an unfavorable environmental situation. At the same time, a statistically significant positive correlation between the number of patients and the level of emissions was established in Akmola region ($\mathbf{r}_{xy}$=0.674; p=0.007) and Aktobe region ($\mathbf{r}_{xy}$=0.611; p=0.022). The authors will continue to study the multifactorial impact on public health of the population.

The policy to improve the health of the population living in industrial centers with high urbanization should take into account regional differences and be aimed at the need to take measures to reduce the negative impact of the environment and the production environment on the health of the population, the use of economic mechanisms to motivate employers to ensure safe working conditions, a healthy lifestyle of employees, as well as strengthening the potential of primary medical and sanitary care of public health.

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