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Observing of air quality in cities of Central Kazakhstan

The problem of air quality occupies a special place among the problems of environmental protection. This is due primarily to the vital need for atmospheric air for all life on Earth, and the influence of the state of the atmosphere on global climatic processes and the biosphere as a whole due to the enormous mobility of air masses with which harmful impurities can be transported. These issues are especially relevant for the old industrial regions, where the level of anthropogenic impact has reached a critical value, one of these regions is central Kazakhstan. This article has collected data for the last 3.5 years, particalary the quantitative content of the main pollutants, from suspended particles (PM-10 and smaller) to various chemical compounds such as carbon dioxide or nitric oxide. Observation of atmospheric air by government is an integral part of the Unified State System for Monitoring the Environment and Natural Resources and is carried out in accordance with the legislation of the Republic of Kazakhstan in the field of environmental protection.

Keywords: ultrafine particles matters, maximum permissible concentration, atmospheric pollution index, standard index, highest repeatability, high pollution, extremely high pollution, solid particles, World Health Organization.

Introduction

According to the law of the Republic of Kazakhstan «On the protection of the health of the people in the Republic of Kazakhstan» in the definition of «environment» atmospheric air, drinking water and soil are noted as environmental elements that have or, under certain conditions, can have an effect (positive or negative) on the health of the population [1].

In recent decades, significant progress has been made in medical science in studying the biological role of the chemical composition of air and its possible impact on the body and public health. However, the data is often controversial. Thus, studies of air pollution on the development of various pathologies gave conflicting results [2].

The effect of polluted air on human health has long been beyond doubt [2]. But the pollution entering the atmosphere certainly gets into the water, soil, plants, meat of domestic animals. As a result, a person suffers, because along these biological chains the chemical elements of all media will still affect his health [3].

According to estimates of the World Health Organization in 2014, air pollution every year leads to premature death of about 7 million people worldwide [4]. Studies published in March 2019 showed that their number could be about 8.8 million [5].

The degree of air pollution by an impurity is estimated by comparing the concentration of impurities with MPC (in mg/m^3, μg/m^3). MPC — maximum permissible impurity concentration. To assess the level of air pollution per month, two indicators of air quality are used [6]:

- Standard Index (SI) — the largest measured in the city maximum single concentration of any pollutant, divided by MPC.
- The greatest repeatability; (NP),%, MPC excess — the highest repeatability of MPC excess by any pollutant in the air of the city.
- Atmospheric Pollution Index (IZA) is an indicator of air pollution. For its calculation, the average concentrations of various pollutants are used, divided by MPC and reduced to the harmfulness of sulfur dioxide. The degree of air pollution is characterized by four standard gradations of indicators SI, NP and IZA. If IZA, SI and NP fall into different gradations, then the degree of air pollution is estimated by IZA [7].

The aim of our study was to study the dynamics of atmospheric air pollution in industrial cities of Central Kazakhstan. We have analyzed the data for the last 3.5 years collected [8–15] at stationary posts by specialized units of the RSE «Kazhydromet».As a result of this period of time, 7004 cases of airborne diseases and 906 cases of EHP were recorded throughout Kazakhstan, of which 340 cases of airborne diseases

and 7 EHP's were registered in the cities of the Karaganda region mainly: Balkhash, Temirtau, Karaganda, however, these isolated cases cannot provide full pictures, therefore, for its compilation, data were used on the excess of MCP for specific pollutants, and standard indicators of air quality [6].

After monitoring atmospheric pollution in the city of Nur-Sultan, [8–11] collected at stationary posts by specialized units of the RSE «Kazhydromet» for 2016–2019, the data are shown in Table 1.

Table 1

Indices of atmospheric air of the city of Nur-Sultan

				Main	Number of cases of exceeding the MPC>1							
	IZA	SI	HR	pollution	PM<2.5	PM-2.5	PM-10	SO_2	NO_2	NO	HF	CO
2016	7	8	52 %	NO_2	997	35	1048	1323	626	3	78	48
2017	6	9	27 %	NO_2	548	251	143	50	738		54	102
2018	7	17	0 %	NO_2 PM<2.5 PM-2.5	1228	923	397	378	627	56	26	289
2019	1	1	0 %	HF	350	2276	710		291	302	70	277

As can be seen from Table 1, the main sources of pollution of the city of Nur-Sultan are suspended UDM especially PM-2.5, as well as nitrogen dioxide. The main sources of anthropogenic formations of these contaminants are smoke and soot generated mainly during the combustion of solid and liquid hydrocarbons (For example: heating houses, generating electricity, working engines of cars, ships and aircraft). As you know, the NO_2 air pollutant acts in several interconnected ways [7]:

– If the concentration level of 200 μg/m^3 is briefly exceeded, 3 nitrogen dioxide is a toxic gas that causes severe airway inflammation [5].
– NO_2 is the main source of nitrate aerosols that form one of the main fractions of PM2.5, and ozone in the presence of ultraviolet light.

Epidemiological studies have shown that symptoms of bronchitis in children with asthma are exacerbated by prolonged exposure to NO_2 [3]. Decreased lung function is also associated with NO_2 exposure at current levels recorded (or observed) in many cities.

In contrast to the capital, the cities of the Karaganda region are formed by large enterprises of heavy industry, for example, the Balkhash «Non-Ferrous Metals Processing Plant» or «Zhezkazgantsvetmet», and given the growing amount of motor transport combined with the continued use of thermal power plants, the anthropogenic impact in this region is much more pronounced, this is reflected in the annual report since in the cities of this region a greater number of pollutants (phenol, ammonia, hydrogen sulfide) are recorded, and the number of UDM is many times greater.

After monitoring the atmospheric air pollution in the city of Karaganda [12–15], collected at stationary posts by specialized units of the RSE «Kazhydromet» for 2016–2019, the data are shown in Table 2.

Table 2

Indices of atmospheric air of the city of Karaganda

	IZA	SI	HR	Main	Number of cases of exceeding the MPC>1									
				pollution	PM<2.5	PM-2.5	PM-10	SO_2	CO	NO_2	O_3	H_2S	Phenol	NH_3
2016	8	21	17 %	PM-2.5	10	5313	2149		1778	151	266	30	93	2
2017	8	16		PM-2.5	16	7378	3105		642	444	9	29	96	
2018	10	21	31 %	PM-2.5 Methane CO	90	9928	5333	7	4179	11		316	61	3
2019	9	20		PM-2.5	34	3697	1766		186	12	969	99	1	

As can be seen from the statistics presented in table 2, the main type of pollutant is UDM, in particular RM-2.5, and carbon monoxide. PM concentration is a frequently used indirect indicator of air pollution. They have a negative effect on more people [4] than any other air pollutant. The main components of PM are sulfates, nitrates, ammonia, sodium chloride, soot, mineral dust and water. They consist of a complex mixture of solid and liquid organic and inorganic substances present in suspension in the air. Particles with a diameter of less than 10 microns (≤ PM10) are able to penetrate deep into the lungs and precipitate in them.

Particles with a diameter of less than 2.5 microns (≤ PM2.5) have even more devastating health effects. They can cross the airborne barrier and enter the circulatory system. Chronic exposure to particulate matter aggravates the risk of developing cardiovascular, respiratory, and oncological diseases.

After monitoring the air pollution in the city of Balkhash [16–19], collected at stationary posts by specialized units of the RSE «Kazhydromet» for 2016–2019, the data are shown in Table 3.

Table 3

Indices of atmospheric air of the city of Balkhash

	IZA	SI	HR	Main pollutin	Number of cases of exceeding the MPC>1							
					PM<2.5	PM-2.5	PM-10	SO_2	CO	NO_2	O_3	H_2S
2016	7	24	3 %	SO_2	47	372	146	558	5	13		227
2017	6	20		SO_2, H_2S	73			428	45	35		554
2018	7	23		SO_2, H_2S	69			480	89	3	1	564
2019		8	2 %	SO_2	8	40	10	120	2		8	57

Based on the data presented in Table 3, it is clearly seen that hydrogen sulfide and sulfur dioxide are the main pollutants in the city of Balkhash and the adjacent territories, the average annual concentration of these substances for 3.5 years was SO_2 — 30 μg/m^3, and for H_2S — 1 μg/m^3. However, it is worth noting that the number of cases exceeding the maximum permissible concentrations of 5 and 10 times for the studied period of time was 115 times for SO_2 (MCP > 5), and for 80 H_2S, (MCP > 5) — 30 cases, (MCP > 10) — 30 cases [12–15]. The above values indicate that on the territory of the city of Balkhash there is a constant local source of emissions of pollutants, and quite strong.

The state of the environment in general, and the composition of air, water, and soil, in particular, are undoubtedly influenced by human activity, which often causes anthropogenic pollution. The activities of industrial complexes located in the territories of such cities as Karaganda, Balkhash, Zhezkazgan, Temirtau are a gross interference in the natural ecosystem, which leads to significant changes in environmental factors, and, therefore, affects the state of public health. Air intake directly into the human body is inevitable under all conditions. Therefore, the composition of atmospheric air, its purity, and the content of certain chemical elements in it are the main ones in assessing the environment.

Also, after monitoring atmospheric pollution in Zhezkazgan [20–23], collected at stationary posts by specialized units of the RSE «Kazhydromet» for 2016–2019, the data are shown in Table 4.

Table 4

Indices of atmospheric air of the city of Zhezkazgan

	IZA	SI	HR	Main pollution	Number of cases of exceeding the MPC>1									
					PM<2.5	PM-2.5	PM-10	SO_2	CO	NO_2	O_3	H_2S	Phenol	NH_3
2016	7	10	17 %	H_2S	107	21	109	45	29	7	184	693	270	
2017	8	9	31 %	H_2S	255	67	122	90	26	5		2689	505	1
2018	7	19,6		H_2S	343			58	31	21		8506	343	
2019		7,8	29 %	H_2S	230			2	6			481	167	

As can be seen from the data presented in Table 4, it is noticeable that hydrogen sulfide is the main health hazard for residents of Zhezkazgan. The excess cases (MPC > 5) amounted to 891 cases, and (MPC > 10) — 15 cases, the average annual concentration was 5.75 μg/m^3, which is approximately 3.5 times less than the permissible norm [1], but do not forget that hydrogen sulfide very toxic: acute human poisoning occurs already at concentrations of 20–30 μg/m^3, a concentration above 100 μg/m^3 is fatal, with chronic intoxication a mutagenic and teratogenic effect is observed.

It is known that Temirtau [23–27] has perhaps one of the worst environmental conditions in our Republic, this is due primarily to the presence of large coke and chemical plants and ferrous metallurgy and steel smelting, as well as the presence of a number of coal mines.

After monitoring atmospheric pollution in Temirtau, collected at stationary posts by specialized units of the RSE «Kazhydromet» for 2016–2019, the data are shown in Table 5.

Table 5

Indices of atmospheric air of the Temirtau city

	IZA	SI	HR	Main pollution	Number of cases of exceeding the MPC>1							
					PM<2.5	NO	SO_2	CO	NO_2	H_2S	Phenol	NH_3
2016	8	11	27 %	SO_2, NO_2	114	176	2060	106	2036	1557	593	26
2017	8	12		SO_2, H_2S	296	3	1604	201	561	2444	451	47
2018	8	13,5		SO_2, NO_2	169	92	1858	137	1693	1302	594	31
2019		12		SO_2, NO_2	450	67	1479	15	3749	1276	422	1

As can be seen from Table 5 in Temirtau, in contrast to the above cities, there are more stable pollutants whose emissions exceed the PCD by 5 times: SO_2 — 175 cases, NO_2 — 816 cases, H_2S — 180 cases, it is also worth considering cases of exceeding the PCD by 10 times: SO_2 — 1 case, NO_2 — 64 H_2S — 9 cases. The average annual concentrations for 3.5 years according to these pollutants were: SO_2 — 54.25 μg/m^3, NO_2 — 37.75 μg/m^3, H_2S — 22.5 μg/m^3 [12–15].

According to the data published annually by the specialized units of the RSE «Kazhydromet» [6, 10] on environmental monitoring, all the cities studied in the period from 2016 to 2019 had a high level of pollution. Such a level of air pollution in settlements is caused by such pollutants as: nitrogen dioxide, carbon monoxide, sulfur dioxide, formaldehyde, hydrogen sulfide, suspended solids, phenol, ammonia is caused by:

- The load of roads by urban transport — the multicomponent exhaust emissions of gasoline and diesel fuel of vehicles is one of the main sources of air pollution of settlements with nitrogen dioxide, carbon monoxide, organic substances, etc., and high congestion of roads even in cities with good ventilation leads to accumulation harmful impurities in the atmosphere.
- The dispersion of emissions from industrial enterprises — the result of production processes during the combustion of industrial products is the entire list of harmful substances that cause high levels of air pollution. Their dispersal in the air basin over the territory of settlements significantly affects the air quality of cities, suburbs and villages.
- Low ventilation of the atmospheric space of settlements — airborne pollutants accumulate in the surface layer of the atmosphere, and their concentration remains at a very high level.

In this article, we would like to emphasize that the untimely transition of energy and heavy industry enterprises to more environmentally friendly raw materials and methods of processing them, as well as the technological backwardness of the Kazakhstan car fleet and the low level of «awareness» by the population of their own impact on the environment, can comprehensively irreparably worsen the ecological situation in our country and neighboring regions.

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Орталық Қазақстан қалаларындағы атмосфералық ауа сапасының мониторингі

Қоршаған ортаны қорғау мәселесі арасында ауа сапасының орыны ерекше. Бұл ең алдымен, жер бетіндегі барлық тіршілік иелері үшін атмосфералық ауаның өмірлік қажеттілігі және зиянды қоспалар тасымалдайтын ауа массаларының орасан қозғалғыштығына және ғаламдық климаттық процестердің ауаға ықпалы мен биосфераға байланысты. Бұл мәселелер антропогендік әсер ету деңгейі сыни дәрежеге жеткен ескі өнеркәсіптік өңірлер үшін ерекше өзекті болып саналады, осындай өңірлердің бірі Орталық Қазақстан болып табылады. Мақалада соңғы 3,5 жылдағы деректер, атап айтқанда, көмірқышқыл газы немесе азот оксиді сияқты өлшенген бөлшектерден (ТЧ-10 және одан да көп ұсақ) әртүрлі химиялық қосылыстарға дейінгі негізгі ластаушы заттардың сандық құрамы жинақталған. Атмосфералық ауаның жай-күйін бақылау мемлекеттік органдардың қоршаған орта мен табиғи ресурстар жай-күйі мониторингі бірыңғай мемлекеттік жүйенің ажырамас бөлігі болып табылады және Қазақстан Республикасының Қоршаған ортаны қорғау саласындағы заңнамасына сәйкес жүзеге асырылады.

Кілт сөздер: ультрадисперсты бөлшектер, поллютант, шекті рұқсат етілген концентрация, атмосфера ластануының индексі, стандартты индекс, жоғары қайталанушылық, жоғары ластану, экстремальды жоғары ластану, қатты бөлшектер, ДДСҰ.

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Мониторинг качества атмосферного воздуха городов Центрального Казахстана

Проблема качества атмосферного воздуха занимает особое место среди проблем охраны окружающей природной среды. Это обусловлено, прежде всего, жизненной необходимостью атмосферного воздуха для всего живого на Земле и влиянием состояния атмосферы на глобальные климатические процессы и биосферу в целом за счет огромной подвижности воздушных масс, с которыми могут переноситься вредные примеси. Особенно актуальны эти вопросы для старопромышленных регионов, где уровень антропогенного воздействия достиг критической величины, одним из таких регионов является Центральный Казахстан. В статье собраны данные за последние 4 года, а именно: количественное содержание основных загрязнителей (от взвешанных частиц [PM-10 и более мелкие] до различных химических соединений, таких как диоксид углерода или оксид азота). Степень загрязнения атмосферного воздуха примесями оценивалась при сравнении концентрации примесей с ПДК (в мг/м^3, мкг/м^3). Регион Центрального Казахстана был выбран не случайно, так как его каждый крупный город представлен одним или несколькими предприятиями тяжёлой промышленности.

Ключевые слова: ультрадисперсные частицы, поллютант, предельно допустимая концентрация, индекс загрязнения атмосферы, стандартный индекс, наибольшая повторяемость, высокое загрязнение, экстремально высокое загрязнение, твёрдые частицы, ВОЗ.

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