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Environmental Assessment of the Impact of Atmospheric Air Pollution with Hydrogen Sulfide on the Health of the Population of Atyrau, Republic of Kazakhstan

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ABSTRACT

This article analyzes the morbidity of newly identified patients in Atyrau, the Republic of Kazakhstan, also calculates the correlation between the content of hydrogen sulfide in the air and mortality from diseases for a year by decade from July 2021 to June 2022. According to the analysis of morbidity over ten years, it was determined that the maximum number was detected for respiratory diseases, in second place diseases of the circulatory systems, the number of which exceeds 16,000 and 2,000 patients per 100,000 people, respectively. The calculation of the correlation dependence showed a direct positive relationship between the content of hydrogen sulfide in the air and the mortality of people from diseases of the respiratory and circulatory systems (the correlation coefficient of which is 0.99 and 0.5 respectively), and there is a negative dependence on the mortality of neoplasm diseases (the correlation coefficient is (-0.09)). This study has limitations on data, since the incidence data were given only for decades, whereas the correlation dependence would be more accurate with more data. In the future, it's planned to continue this study and include calculations of the relationship between the number of patients and the content of hydrogen sulfide for each month.

1. INTRODUCTION

Atyrau is located in the Western part of the Republic of Kazakhstan and the region has unique minerals, mainly hydrocarbons. Atyrau region is one of the most environmentally unfavorable regions of the country. The main environmental problem of the region is the low quality of atmospheric air in Atyrau. The main sources of pollution in Atyrau are oil refining and transportation facilities: Atyrau Oil Refinery, Tengizchevroil, "Atyrau Oil Company", "Embamunaigas", "Intergas-Central Asia". In addition, the city has two storage ponds of industrial discharges located on both sides of the city (the north-western side is the storage pond "Square" and the eastern side is the "Rotten Beam") [1]. All urban discharges into the storage tank are carried out practically without purification, as a result, the main source of hydrogen sulfide is formed – a storage tank of 1000 hectares, in which the processes of decay of organic substances – sewage, including petroleum products, are taking place [2].

With the growth of oil production in the Atyrau region, emissions of harmful substances into the atmosphere are increasing and the number of sick people is growing. The study of the dynamics of the morbidity of the population in Atyrau and Atyrau region in 2021 and 2022 shows that diseases of the respiratory organs, hematopoietic organs, digestive organs, etc., prevail.

The studied territory is the city of Atyrau, where observations were made on the intake of hydrogen sulfide into the air environment. Observations of the state of atmospheric air in the territory of Atyrau are carried out at 15 observation posts, including 2 manual sampling posts and 3 automatic stations [3].

Atyrau region occupies a special place among the regions and zones of ecological disaster in Kazakhstan. The ecological situation here is formed under the influence of natural and anthropogenic factors, the most important of which are the rapid development of the oil and gas complex. A large number of the population of Atyrau region comes into contact with oil and its processed products, as well as with other toxic and carcinogenic chemicals that are released into the environment and have a harmful effect on both workers and the population who do not have professional contacts with oil [4]. In Atyrau region, during the operation of oil fields, solid particles, sulfur dioxide, carbon monoxide, nitrogen oxides and hydrocarbons are released into the atmosphere [5]. The ecological situation in Atyrau has sharply worsened due to the pollution of the city's air basin with hydrogen sulfide [6]. Against the background of demographic problems, the negative impact of oil and petroleum products on the human body can increase many times.

Hydrogen sulfide is a harmful gas that is present in natural sources such as petroleum, natural gas, and volcanic and sulfur

spring emissions [7]. The release of H2S into the surroundings is also a result of different industrial procedures, such as drilling and refining operations in the petroleum and natural gas industry [8]. Exposure of humans to H2S and its toxic effects becomes more severe with increased concentration and duration of exposure, and primarily affects the respiratory, cardiovascular, and nervous systems [9]. Short-term exposure to high concentrations of H_2S can be fatal, while prolonged exposure to even low levels of H_2S in the environment can cause health problems in humans [10]. Therefore, an in-depth comprehensive scientific study of the health status of the population of the region is necessary.

The southern, southeastern and eastern industrial zones, as well as industrial areas located at some distance to the northwest and northeast of the city of Atyrau, are subject to the most intense negative impact. At the same time, the highest level of pollution is formed in the immediate vicinity of enterprises, as a rule, emissions from which are relatively small and have relatively small (low) sources of pollution. The area of distribution of pollutants around such industrial facilities is small, and as they move away from them, the concentrations of harmful substances in the surface layer of atmospheric air decrease [11].

In 2021, 238 cases of high and 4 cases of extremely high atmospheric air pollution with hydrogen sulfide were recorded. This is more than it was in 2020 - 161 and 2. Of these, 46% are accounted for by the Bolashak integrated oil and gas treatment plant and other NCOC facilities in the Makat district. 38% falls on the evaporation fields "Rotten beam", where the waste of the city and the AOR is dumped [12].

With the growth of oil production in the Atyrau region, emissions of harmful substances into the atmosphere are increasing and the number of sick people is growing. The study of the dynamics of morbidity of the population in Atyrau and Atyrau region in 2021 and 2022 shows that diseases of the respiratory organs, hematopoietic organs, digestive organs, etc., prevail [13].

In this paper, for the first time, an analysis of the relationship between the number of sick residents of Atyrau and the content of hydrogen sulfide in the air was carried out, which was based on the calculation of the correlation between these data. The increase in the incidence of the population was not previously associated with an increase in air pollution with hydrogen sulfide. This analysis will allow medical professionals to understand the reasons for the increase in the incidence of respiratory and circulatory systems and, accordingly, to draw up the correct protocol for the treatment of these diseases.

2. MATERIAL AND METHODS

2.1 Study area

The studies were conducted for the period from July 2021 to June 2022 according to 15 points of observation of the state of atmospheric air in the city of Atyrau and statistical data on morbidity, first identified in medical oranizations and on the number of people who died from various types of diseases in the city of Atyrau. Data on the content of hydrogen sulfide in the air of Atyrau were taken from observation points, which are recorded in the AirKz application, the Kazhydromet website (www.kazhydromet.kz), as well as on the basis of previous studies by the authors [3, 6, 12]. Data on the morbidity of the population of Atyrau for the periods from 2020 to 2022 were also studied, data from the website of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (www.stat.gov.kz) were taken from them [14].

2.2 Methods

In this paper, calculations of the correlation dependence of the effects of pollutants present in the air on the health of the population are carried out.

The correlation is the dependence of body weight on height: each value of height (X) corresponds to a set of values of mass (Y), and, despite the general trend that is true for the average of them: a larger value of height corresponds to a larger value of body weight, in some observations a subject with a larger height may have a smaller mass. The correlation will be the dependence of morbidity on the effects of external factors, such as dustiness, radiation levels, solar activity, etc. There is a correlation between the dose of ionizing radiation and the number of mutations, between the pigment of human hair and eye color, between indicators of the standard of living of the population and the percentage of mortality [15].

It is correlation dependencies that are most often found in nature due to the mutual influence and close interweaving of a huge variety of very different factors that determine the values of the studied indicators.

The correlation dependence can be described using an equation of the form:

$$r = \frac{\overline{\overline{x \cdot y}} - x \cdot y}{S_x \cdot S_y} \quad (1)$$

where, $S_x = \sqrt{x^2} - x^2$ and $S_y = \sqrt{y^2} - y^2$

Basic properties of the sample correlation coefficient (Figure 1):

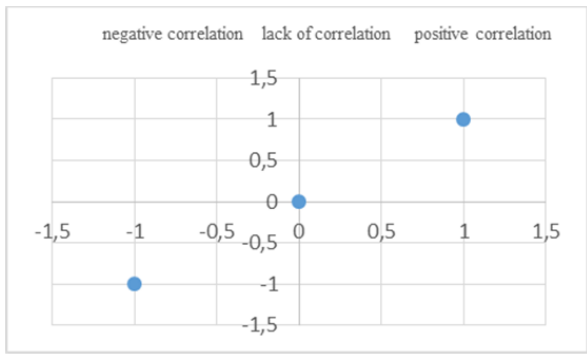

Figure 1. Basic properties of the sample correlation coefficient

1. The correlation coefficient of two quantities that are not connected by a linear correlation is zero.

2. The correlation coefficient of two quantities related by linear correlation is equal to 1 in the case of increasing dependence and -1 in the case of decreasing dependence.

3. The absolute value of the correlation coefficient of two values connected by a linear correlation relationship satisfies the inequality $r \leq 1$. At the same time, the correlation coefficient is positive if the correlation dependence is increasing, and negative if the correlation dependence is decreasing.

4. The closer r is to unity, the closer the correlation between the values Y, X.

By its nature, the correlation can be direct and inverse, and by strength – strong, medium, weak. In addition, there may be no connection or it may be complete (functional).

A feature of the regulation of atmospheric air quality is the dependence of the impact of pollutants present in the air on the health of the population not only on the value of their concentrations, but also on the duration of the time interval during which a person breathes this air.

SI is the standard index, the highest measured single impurity concentration divided by MPC. It is determined from the observation data at the post for one impurity, or at all posts of the territory under consideration for all impurities for a month or a year. Characterizes the degree of short-term contamination.

GR – the greatest repeatability (in percent) of exceeding the maximum one-time MPC according to observations of one impurity at all posts of the territory for a month or a year.

In accordance with the existing assessment methods, four levels of atmospheric pollution are distinguished:

1. Low at ISA from 0 to 4, SI<1, GR < 10%;
2. Increased at ISA from 5 to 6, SI<5, GR from 10 to 20%;
3. High ISA from 7 to 13, SI from 5 to 10, GR from 20 to 50%;
4. Very high with an ISA equal to or greater than 14, SI>10, GR>50%.

3. RESULTS AND DISCUSSION

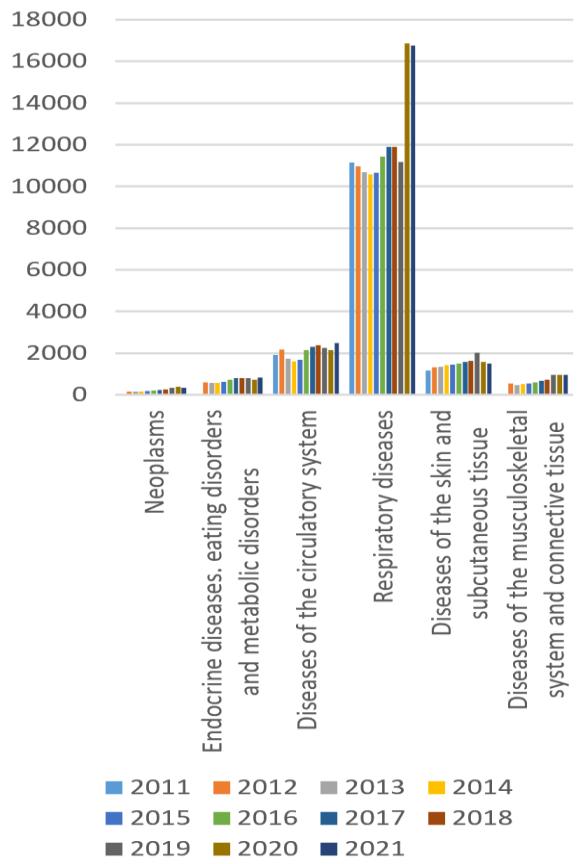

Figure 2. The dynamics of morbidity of the population (the number of diseases registered for the first time in life, per 100,000 people of the corresponding population

Data obtained from the website https://new.stat.gov.kz/ru/

We conducted the research for the period from July 2021 to June 2022 according to 15 points of observation of the state of atmospheric air in the city of Atyrau and statistical data on morbidity, first identified in medical organizations and on the number of people who died from various types of diseases in the city of Atyrau.

Figure 2 shows the dynamics of the number of diseases detected for the first time, in which there is a gradual increase in the population of the Atyrau region for the period 2011-2021 (per 100,000 people of the corresponding population).

As can be seen from the bar chart, for all newly identified types of diseases in the Atyrau region, there has been an increase of 100,000 cases over ten years. Among all types of newly identified diseases, the largest number is characteristic of respiratory diseases (from 11156.2 in 2011 to 16751.5 in 2021), diseases of the circulatory system are in second place (from 1907.1 in 2011 to 2491.7 in 2021), diseases of the skin and subcutaneous tissue are in third place (from 1175.2 in 2011 up to 1495.0 in 2021), the following are endocrine diseases. eating disorders and metabolic disorders (from 579.4 in 2011 to 833.6 in 2021) and diseases of the musculoskeletal system and connective tissue (from 491.1 in 2011 to 955.4 in 2021), neoplasms are in last place (from 189.8 in 2011 to 337.4 in 2021). In terms of the incidence of malignant neoplasms from 2011 to 2016, the increase was insignificant from 189.8 to 198.2 people, with decreases in 2012 and 2013 (149.5 and 145.9 people), in 2017 and 2018 there was an increase of 28 percent compared to 2011 to 244-266.9 people, and since 2019 the incidence of oncological diseases exceeds three hundred people (328.4-378.5 people). Diseases of the musculoskeletal system and connective tissue in the population of the Atyrau region have almost doubled compared to 2011 and 2019-2021 (from 491.1 to 955.4-969.8 people per 100,000 population. In the period from 2011 to 2015, there was a stable fluctuation, when the incidence of the musculoskeletal system was detected in 491.1-546.2 people, then there was a slight increase in 2016-2018 at the level of 605.7-723.2 people. The incidence of endocrine diseases. eating disorders and metabolic disorders for four years from 2011 to 2014 were at the same level of 575.6-597.3 people per 100,000 population, in 2015 it slightly increased to 617 people, then since 2016 there has been a significant increase to 718.1- 833.6. For diseases of the skin and subcutaneous tissue for ten years, there has been a fluctuation in newly identified patients from 1175.2 to 2018.8 people, the minimum number in 2011 and the maximum in 2019. For diseases of the circulatory systems, you can also see fluctuations in the number of newly diagnosed sick people from 1610.1 in 2014 and 2491.7 in 2021, after 2016, these figures exceed two thousand people per 100,000 population. The incidence of respiratory diseases was stable from 2011 to 2019, amounting to 11156.2 people in 2011 and 11177.3 people in 2019, respectively, with minimum values in 2014 (10569.7 people) and maximum values of 11905.2 people in 2017. In the last 2 years, there has been a significant increase to 16858.6 in 2020 and 16751.5 in 2021.

Overall, this bar chart allowed us to understand that among all types of diseases first detected in the population of the Atyrau region per 100,000 population for the period from 2011 to 2021, the maximum changes are characteristic of respiratory diseases, where over the past two years their number has increased from eleven thousand people to more than sixteen thousand. There is also an increase in newly identified patients with neoplasm diseases almost twice and diseases of the circulatory systems.

The bar chart (Figure 3) shows data on eighteen types of diseases for two years 20220 and 2021, registered in medical organizations of Atyrau region. In the first place are two types of morbidity - diseases of the circulatory system and respiratory organs, the number of patients per 100,000 population of which exceeds sixteen thousand people in 2020, and in 2021 they increase to seventeen thousand people. In second place are endocrine diseases, eating and metabolic disorders and complications of pregnancy, childbirth and the postpartum period, the number of patients per 100,000 population of which there are about and more than six thousand people with small increases in 2021 to one hundred people. In third place are diseases of the eye and its appendages and diseases of the genitourinary system, the number of patients per 100,000 population of which is more than 4.5 thousand to 4.8 thousand. Diseases of the blood, hematopoietic organs and diseases of the digestive organs account for about four thousand people per 100,000 population. Diseases of the nervous system, skin and subcutaneous tissue, as well as the musculoskeletal system and connective tissue are in fifth place and account for more than two thousand patients per 100,000 population. The number of patients with infectious and parasitic diseases, diseases of the ear and mastoid process, trauma and poisoning ranges from 1.5 thousand to 2 thousand patients. More than a thousand people suffer from mental and behavioral disorders and neoplasms. Mental disorders and behavioral disorders associated with the use of surfactants and congenital anomalies (malformations), deformities and chromosomal disorders account for the smallest number of patients less than a thousand patients per 100,000 population.

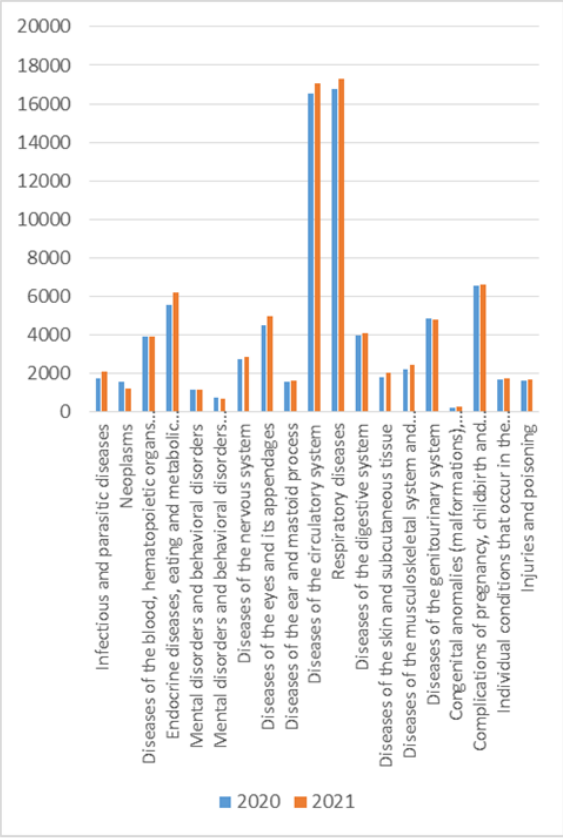

Figure 3. Dynamics of the general morbidity of the population of Atyrau region by classes of diseases, registered in medical organizations

Data obtained from the website https://new.stat.gov.kz/ru/

Overall, we see that according to the chart on the general morbidity of the population of Atyrau region by classes of diseases registered in medical organizations, the largest number per one hundred thousand of the population is characteristic of diseases of the circulatory system and respiratory organs, the number of which is 2.5 times higher than the number of diseases in second place, such as endocrine diseases, eating disorders and metabolic disorders substances and complications of pregnancy, childbirth and the postpartum period and is more than 16 thousand people. The minimum number of registered diseases are mental disorders and behavioral disorders associated with the use of surfactants and congenital anomalies (malformations), deformities and chromosomal disorders, the number of which is more than 15 times less than the diseases located in the first place.

Studies of the effects of hydrogen sulfide in low concentrations were accumulated due to observations of the population living near industrial enterprises and geothermal fields that emit hydrogen sulfide [16, 17]. These studies are aimed at various results related to the sense of smell, increased respiratory symptoms and taking anti-asthma medications. Other studies have reported neurological symptoms and headaches [18]. Thus, these data, as in the works of Ragnhildur Gudrun Finnbjornsdottir and others [19], show that the greatest exposure to hydrogen sulfide leads to an increase in respiratory diseases and heart diseases. Thus, according to their data, short-term associations between simulated average concentrations of low-transmittance H_2S and daily hospitalizations and emergency department visits at the University Hospital Landspitali (LUH) with heart disease, respiratory diseases and stroke are the main diagnoses among people living in the Reykjavik metropolitan area. However, these studies were conducted only for a short period, i.e., within a day after the increase in hydrogen sulfide content, whereas in our studies, a long-term analysis was carried out during the year. At the same time, it should be noted that in these two studies there is a direct link between the effects of hydrogen sulfide on diseases of the respiratory and cardiovascular systems.

The Figure 4 shows the dependence of the number of deaths from diseases of Atyrau neoplasms and the content of hydrogen sulfide in the air for the period from summer 2021 to summer 2022.

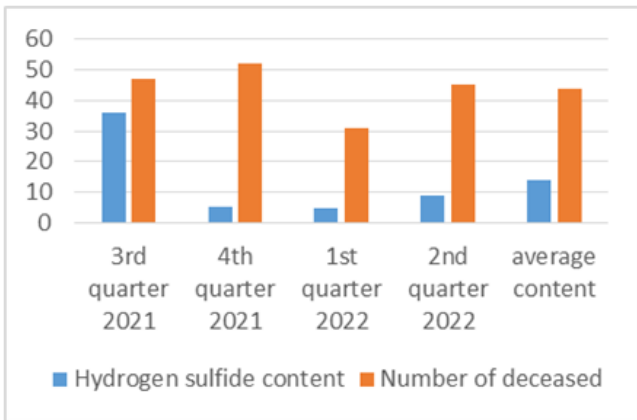

Figure 4. Dependence of the number of deaths from diseases of neoplasms of Atyrau and the content of hydrogen sulfide in the air for the period from summer 2021 to summer 2022 (data are given quarterly)

Data obtained from the websites https://new.stat.gov.kz/ru/ and https://www.kazhydromet.kz/

This bar chart compares quantity of died people from cancer and emissions of hydrogen sulfide in Atyrau city for the period from June 2021 to August 2022.

On the 3rd quarter 2021, the largest hydrogen sulfide content was 35.98 mg/m^3, but the number of diseases of neoplasms were on the second place, 47 people. On the 4th quarter of 2021, the hydrogen sulfide content dropped suddenly from 35.98 mg/m^3 to the smallest level of 5.13 mg/m^3, and the number of deaths slightly increased to a maximum of 52. The hydrogen sulfide index rose steadily to 8.83 mg/m^3 by the second quarter 2022 and the number of deaths from diseases of tumors decreased too for 45. These correspond the average content for one year. However, in this year on the 4th quarter there was inverse relationship between amount of pollutant and death. Despite the smallest content of hydrogen sulfide in air was 5.13 mg/m^3, the number of diseases of people was the largest – 52. The incidence content of hydrogen sulfide for the 2nd quarter of 2022 corresponds to the average quarter for the whole year. Compared to other period the least indicators pollution and deaths were in the 1st quarter 2022 – 4.89 mg/m^3 and 31 people.

Overall, this bar chart shows an inverse relationship between hydrogen sulfide and mortality, except for the 3rd quarter of 2021.

In Figure 5, you can see the dependence of the number of deaths from diseases of the circulatory systems of Atyrau and the content of hydrogen sulfide in the air for the period from summer 2021 to summer 2022.

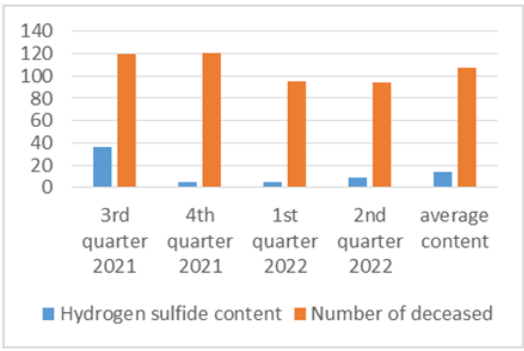

Figure 5. Dependence of the number of deaths from diseases of the circulatory systems of Atyrau and the content of hydrogen sulfide in the air for the period from summer 2021 to summer 2022 (data are given quarterly)
Data obtained from the websites https://new.stat.gov.kz/ru/ and https://www.kazhydromet.kz/

This bar chart compares the quantity of deaths from cardio-vascular system of Atyrau city and the volume of hydrogen sulfide in the air for the period from June 2021 to August 2022.

On the 3rd quarter of 2021, there was the largest amount of hydrogen sulfide, but the number of diseases of circulatory systems were on the second place 120 people. On the 4th quarter of 2021, the hydrogen sulfide content dropped suddenly from 35.98 mg/m^3 to 5.13 mg/m^3 and the quantity of deaths slightly increased to a maximum of 121. Unlike all, on the 1st quarter of 2022 the smallest indicator of hydrogen sulfide was 4.89 and the mortality fall steadily from 121 to 95. The volume of hydrogen sulfide on the 2nd quarter of 2022 was more about to 4 mg/m^3 than the 1st quarter. On the 1st and 2nd quarters of 2022, the number of diseases were almost the same 95 and 94 people. On the average content, the amount of hydrogen sulfide was approximately 13 mg/m^3 and the count of deaths was 107.

Overall, for the period from summer 2021 to summer 2022 the quantity of diseases was slight fluctuate and there had been a continual increase in the level of hydrogen sulfide, except for a sudden drop on the 4th quarter of 2021.

Figure 6 shows the dependence of the number of deaths from respiratory diseases in Atyrau and the content of hydrogen sulfide in the air for the period from the summer of 2021 to the summer of 2022.

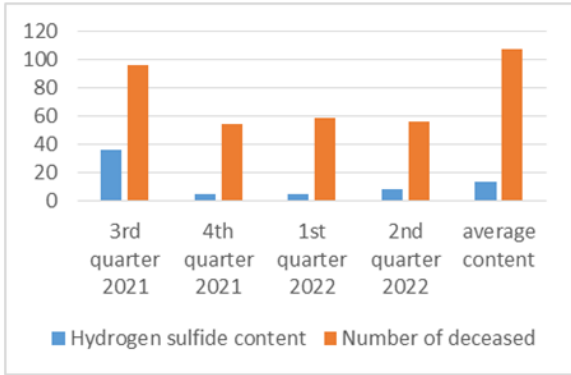

Figure 6. The dependence of the number of deaths from respiratory diseases in Atyrau and the content of hydrogen sulfide in the air for the period from the summer of 2021 to the summer of 2022 (data are given quarterly)
Data obtained from the websites https://new.stat.gov.kz/ru/ and https://www.kazhydromet.kz/

This bar chart shows the dependence between content of hydrogen sulfide in the air and the number of deaths from respiratory diseases for the period from the summer of 2021 to the summer of 2022 by given quarterly.

In 2021 on the 3rd quarter the bar chart shows the largest number of mortality from respiratory diseases than the entire period to 96 people and the hydrogen sulfide content in the 3rd quarter was significantly fewer to 35.98 mg/m^3. In the next quarter amount of hydrogen sulfide decreased dramatically to 5.13 mg/m^3 and respectively the number of deaths fell same and was 55. At next year in the first quarter, hydrogen sulfide content slightly dropped, 4.89 mg/m^3, but the number of mortalities grew suddenly by 55 people. At the second, quarter in the same year the amount of hydrogen sulfide in the air rose slightly to 8.83 mg/m^3 and deaths from respiratory diseases decreased slightly by 56 people.

Overall, the largest indicators of hydrogen sulfide were in the 3rd quarter of 2021 and the smallest in the 4th quarter in the same year. After the 3rd quarter of 2021 the number of mortality people from respiratory diseases was fluctuate. The average content of hydrogen sulfide in the air was 13.7 mg/m^3 and the number of deaths from respiratory diseases was 66.5.

Calculations were carried out to calculate (1) the correlation between the content of hydrogen sulfide in the air of Atyrau and the number of people who died from three types of diseases, primarily those types of diseases that were recorded in the maximum amount, such as diseases of the circulatory system and respiratory diseases, and for comparison, calculations were also carried out for diseases whose number does not have maximum values. The data were taken quarterly, for the 3rd and 4th quarters of 2021 and the 1st and 2nd quarters of 2022.

Calculations based on the correlation between the content of hydrogen sulfide in the air of Atyrau and the number of

people who died from neoplasms are presented according to formula 2.

$$r = \frac{\overline{\overline{x \cdot y}} - x \cdot y}{S_x \cdot S_y} = \frac{1129.81 - 13.7 \cdot 66.5}{12.96 \cdot 17.09} = \frac{1129.81 - 911.05}{221.48} = \frac{218.76}{221.48} = 0.99 \quad (2)$$

Calculations based on the correlation between the content of hydrogen sulfide in the air of Atyrau and the number of people who died from circulatory system diseases are presented according to formula 3.

$$r = \frac{\overline{\overline{x \cdot y}} - x \cdot y}{S_x \cdot S_y} = \frac{1558.2 - 13.7 \cdot 107.5}{12.96 \cdot 13.01} = \frac{1558.2 - 1472.75}{168.6} = \frac{85.45}{168.6} = 0.5 \quad (3)$$

Calculations on the correlation between the content of hydrogen sulfide in the air of Atyrau and the number of people who died from respiratory diseases are presented according to formula 4.

$$r = \frac{\overline{\overline{x \cdot y}} - x \cdot y}{S_x \cdot S_y} = \frac{626.69 - 13.7 \cdot 43.75}{12.96 \cdot (-23.04)} = \frac{626.69 - 599.375}{-298.59} = \frac{27.3}{-298.59} = -0.09 \quad (4)$$

The calculations show that the correlation between the content of hydrogen sulfide in the air of Atyrau and the number of people who died from neoplasms is (-0.09), from diseases of the circulatory systems 0.5 and from respiratory diseases 0.99.

Using the gradation table for assessing the closeness of communication, we draw the following conclusions:

- the x and y relationship is strong, positive between the content of hydrogen sulfide in the air and the number of people who died from respiratory diseases, which is close to 1;
- the x and y relationship is average, positive between the content of hydrogen sulfide in the air and the number of people who died from diseases of the circulatory system, which is 0.5;
- the x and y relationship is weak, the negative difference between the content of hydrogen sulfide in the air and the number of people who died from diseases of neoplasms, which is close to zero and is equal to -0.09.

In general, the strongest relationship between the content of hydrogen sulfide and the number of deceased patients is observed for respiratory diseases, and the lowest relationship is characteristic of neoplasm diseases.

According to the Atyrau observation network, the level of atmospheric air pollution was assessed as elevated, it was determined by the SI value =4.4 (elevated level) for hydrogen sulfide in the third quarter of 2021 and ПК =15% (increased level) for hydrogen sulfide in the second quarter of 2022.

4. CONCLUSIONS

The research carried out in this work is aimed at studying the relationship between atmospheric pollution with hydrogen sulfide and the number of newly diagnosed patients, as well as human mortality from various types of diseases. Data on newly identified patients were taken for ten years and based on the results, the types of diseases were identified, the number of patients for which reaches the highest value. Based on these studies, a correlation analysis of the dependence of mortality on the maximum number of people who died by different types of diseases was carried out.

The research results show that in the city of Atyrau of the Republic of Kazakhstan, of all the diseases identified for the first time in the period from 2011 to 2021, the maximum number of diseases is characteristic of respiratory diseases, for which more than ten thousand sick people have been identified, while there is a tendency to increase in the last two years to sixteen thousand patients per 100,000 population. In second place are diseases of the circulatory systems, according to which the number of identified patients for ten years is in an oscillatory state with small increases in the last five years and fluctuate about two thousand patients per 100,000 people of the corresponding population.

The results on the dynamics of the total mortality of people in the city of Atyrau from various types of diseases also coincide with the number of diseases detected for the first time and show that in two years the maximum values are observed for diseases of the respiratory and circulatory systems, the number of patients for which is more than sixteen thousand people per 100,000 people of the corresponding population, with small increases in 2021, as opposed to 2020.

Based on these data, it was decided to calculate the correlation between the mortality of these two types of diseases and the content of hydrogen sulfide in the air of Atyrau according to data for the 3rd and 4th decades of 2021 and the 1st and 2nd decades of 2022. In addition, calculations were carried out for neoplasm diseases as a comparison. Calculations show that there is a positive correlation between the content of hydrogen sulfide in the atmosphere and diseases of the respiratory and circulatory systems, while this dependence is higher for data on mortality from diseases of the respiratory systems and is 0.99, that is, close to one, and for diseases of the circulatory systems it is 0.5. These results indicate that between There is a direct correlation between the content of hydrogen sulfide in the air and the number of people who died from respiratory and circulatory diseases. Calculations based on the correlation dependence of the hydrogen sulfide content in the air and mortality from neoplasm diseases do not show such a dependence, since this coefficient is equal to (-0.009), that is, a negative number and close to zero.

The results on the relationship between the content of hydrogen sulfide in the air with respiratory diseases and the cardiovascular system are confirmed by studies and studies of scientists from other countries, for example in the works of Ragnhildur Gudrun Finnbjornsdottir and others [16-19]. But, despite these results, it should be noted that this study was limited by time data, i.e., data on morbidity were obtained only for decades, and not by months. There was also no data on morbidity on the days when critical indicators of hydrogen sulfide content in the air were noted. All this may limit the generalizability of the results, therefore, in the future it is necessary to conduct research and study short-term associations between simulated average concentrations of hydrogen sulfide with periodic emissions and visits to emergency hospitals for heart diseases, respiratory diseases

and stroke as a primary diagnosis.

In general, this study shows a direct relationship between the content of hydrogen sulfide in the air of the city of Atyrau of the Republic of Kazakhstan and an increase in the number of patients, including those who died from diseases of the respiratory and circulatory systems.

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NOMENCLATURE

H_2S	hydrogen sulfide
MPC	maximum permissible concentration
AOR	Atyrau Oil Refinery
POP	Pollution Observation Point
NCOC	North Caspian Operating Company
SI	standard index
GR	greatest repeatability