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Article

Sustainable Development in Kyrgyzstan: Air Quality in Bishkek and Health of its Residents

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Abstract: This research analyses the correlation between the average annual concentration of nitrogen dioxide (NO_2) in the atmosphere and the incidence of bronchial asthma among the population of Bishkek. The analysis is based on data from relevant sources, including official statistics from the National Statistical Committee of the Kyrgyz Republic for 2014–2023. The authors put forward a hypothesis about the existence of a positive relationship between the variables, which justifies the use of a one-tailed Student's t-test with a significance level of $\alpha = 0.10$. Such approach is conditioned by the complex etiology of bronchial asthma and the influence of multiple external factors. The research confirm the existence of a link between air pollution from emissions of internal combustion engine vehicles and the increase of bronchial asthma incidence. Authors note that there is a need to expand the sample and include additional factors in subsequent studies. The data obtained within this research can be used in the development of effective environmental and preventive measures aimed at improving air quality and reducing the incidence of respiratory diseases in Bishkek city.

Keywords: Air Pollution, Public Health, Air Quality Index, Bishkek, Nitrogen Dioxide (NO_2), PM2.5, Respiratory Health, Sustainable Development, Traffic Emissions, WHO

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1. Introduction

The problem of air pollution is getting worse year by year due to urbanization and other relevant reasons. According to the World Health Organization (WHO), about 90% of people worldwide breathe polluted air. Every year, pollution of the ambient (atmospheric) air and indoor air claims 7 million lives [1]. In this regard, sustainable development of countries, especially developing ones such as Kyrgyzstan, is of great importance. Air quality in the country's capital has deteriorated significantly during the past decade.

The issue of worsening air quality in Bishkek has been actively discussed in political circles and the scientific community since 2017, when air quality sensors were first used in the city. Some analysts note: “Every year, with the onset of cold weather, rhetoric about poor air quality in Bishkek resumes. It is during this period that the thermal power plant begins to operate, and coal is burned in households and boiler rooms. These factors are considered the main causes of smog, as they are absent during the warm season.” [2]. However, the problem of polluted air is present all year round, although it is slightly mitigated in the summer. In Kyrgyzstan, including in Bishkek and its suburbs, solid fuel is used year-round for cooking, heating baths (saunas), burning garbage, etc. In summer, the air is polluted by agriculture, construction, transport, and tourism.

Bishkek is characterized by the largest share of all types of vehicles and heavy traffic based on internal combustion engines in the whole country. Many of these vehicles are outdated and cause significant air pollution. According to the emissions inventory (Chapter 8), motor vehicles are the most significant source of nitrogen oxides (NOX) and a significant source of fine particulate matter (PM2.5) emissions in Bishkek. Vehicle emissions also enter the air at ground level, which partly explains their significant impact on air quality [3]. Air pollution has a negative impact on the health of drivers, passengers, pedestrians, and residents of areas with heavy traffic. Over the past ten years, the number of people suffering from respiratory diseases in Kyrgyzstan has increased by 20% [4]. In fact, the current situation in Bishkek poses a serious obstacle to achieving Sustainable Development Goals: Goal 3 - Ensure healthy lives and promote well-being for all at all ages, and Goal 11 - Make cities and human settlements inclusive, safe, resilient, and sustainable [5].

Air pollution levels in Bishkek remain high despite numerous public discussions and the creation of working groups to combat the smog. Over the last 10 years, many scientific studies have been devoted to this problem by international organizations as well as foreign and domestic experts. Nevertheless, questions that require a further research and scientific analysis remain open. Systematic analysis and the development of effective tools for regulating environmental risks are necessary. In this regard, the relevance of this research topic is indisputable.

The purpose of this article is to study the impact of air pollution from vehicle emissions on the health of residents in Bishkek using the example of nitrogen dioxide and the incidence of bronchial asthma, and to develop practical recommendations for tackling the given issue. This study also aims to quantitatively confirm the hypothesis of a statistically significant direct correlation between the average annual concentration of nitrogen dioxide (NO_2) and the incidence of bronchial asthma among the city's population during the selected period that authors reviewed.

2. Materials and Methods

The study used scientific observation, quantitative analysis, and correlation statistics to comprehensively assess the impact of motor vehicles traffic on air quality and public health in Bishkek.

The first stage of the study involved an empirical assessment of traffic intensity and traffic flow structure using scientific observation methods. It was conducted on July 19, 2025 (Saturday, a non-working day) between 3:30 p.m. and 4:00 p.m. on a intensely busy section of Muromskaya street (between Kuyukova and Manasa streets) of Bishkek. The choice of date and time interval for observation was motivated by the need to record the level of traffic activity under moderate load. It is important to note that on working days, traffic intensity on this section is significantly higher. The observation site was chosen due to the unsatisfactory condition of the road surface, which leads to a reduction in traffic speed, an increase in the time vehicles spend on this section, and, as a result, to increased exhaust emissions. The purpose of the observation was to determine the number of passing vehicles, with a focus on gasoline and diesel-powered vehicles, including old passenger cars, minibuses, construction equipment, and large-sized vehicles. The specified categories of motor vehicles are considered to be the main sources of atmospheric pollution in slow-moving traffic conditions. The data obtained formed the basis for subsequent analysis aimed at assessing the impact of emissions on air quality. The issues identified in the study area are also characteristic of other areas of the city, which underscores the relevance of further research in the context of sustainable urban development.

The second stage of the study involved operational monitoring of atmospheric air quality, with a focus on the content of fine particulate matter PM2.5, one of the most dangerous pollutants. Monitoring was carried out during the summer, on working days and weekends: July 12, 2025 (Saturday) and July 15, 2025 (Tuesday). The summer season was deliberately chosen because at this time the impact of other sources of pollution, such as the burning of solid fuels for heating, is minimized. Two indicators were used for the analysis: the Air Quality Index (AQI^+) and the concentration of PM2.5 particles, the data for which is displayed in real time on the IQAir AirVisual platform.

Data sources:

• IQAir, Air quality Real-time ranking of the most polluted major cities [6]

• IQAir, Air quality in Bishkek [7]

The data obtained were compared with the recommended limit set by the World Health Organization (WHO): 5 μg/m^3 on average per year. The next stage of the study was aimed at identifying a statistically significant correlation between the level of atmospheric pollution with nitrogen dioxide (NO2) and the number of registered cases of bronchial asthma per 100,000 inhabitants of the city of Bishkek. To achieve the established goal, the authors used the quantitative analysis method. Empirical data was obtained from an official source—the archive of publications of the National Statistical Committee of the Kyrgyz Republic, namely from the statistical compendium "The Environment in the Kyrgyz Republic" for 2015–2024 [8].

The analysis covered a ten-year observation period (n = 10). The following variables were used: independent variable (X) - average annual concentration of nitrogen dioxide (NO2), μg/m^3; dependent variable (Y) - number of registered cases of bronchial asthma per 100,000 inhabitants. Whereas use of Pearson's correlation coefficient (r) allowed to determine the strength and direction of the relationship between the variables. The choice of correlation analysis was conditioned by the aggregated nature of the available data, which represent average annual pollution levels and summary statistics on morbidity by city. The lack of individual data (e.g., on age, gender, socioeconomic status, presence of allergic diseases, and other potential factors) limits the possibility of constructing multivariate models, such as multiple regression.

Apart from this, the insufficient completeness and regularity of data on other pollutants such as PM2.5, PM10, CO, and SO2 impedes exhaustive consideration of their impact within a single comprehensive model without the risk of methodological errors. These limitations led to the choice of a simplified approach using paired correlation analysis, which is justified at the initial research stage and allows to identify the main directions of the relationship. The results of the analysis can serve as a basis for further, more comprehensive studies with an expanded database and the application of multifactorial methods. Since the research hypothesis assumed a direct positive relationship between the increase in nitrogen dioxide (NO2) concentration and the increase in the number of cases of bronchial asthma, a one-tailed t-test was applied at a significance level of α = 0.10, which corresponds to a 90% confidence interval. The choice of a less stringent significance level was conditioned by the specifics of the problem under consideration. In conditions of multifactorial exposure to pollutants, even moderate correlations can have important practical significance for health care, social and public policies.

Nitrogen dioxide was chosen as the key independent variable (x) for the following reasons:

• NO_2 is a marker of urban vehicle pollution and generally correlates well with other exhaust components, including particulate matter (PM2.5 and PM10), carbon oxides, and sulfur oxides.

• Even short-term exposure to NO_2 can cause acute respiratory symptoms, especially in sensitive populations. Long-term exposure is associated with reduced lung function and an increased risk of chronic diseases.

Thus, the choice of NO2 as the main variable of the study and the use of a one-tailed t-test are justified both from the point of view of theoretical hypothesis and in the context of an interdisciplinary (socio-ecological) approach to population health analysis.

Cohen's scale was used to interpret the strength of the correlation [9]:

• 0.10 - 0.29 - weak correlation,

• 0.30 - 0.49 - moderate,

• ≥ 0.50 – strong [10].

To test the statistical significance of the obtained coefficient, a one-tailed Student's t-test was applied, calculated manually using the classical formula:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

where:

r- Pearson's correlation coefficient,

n - sample size,

df = n−2 - number of degrees of freedom.

Pearson's correlation coefficient and the calculated t-value were calculated manually and additionally verified using Excel, which confirmed its correctness.

Such approach is acceptable when the number of variables is limited, and due to aggregated nature of initial data. In the future, with an expanded data set, it will be possible to apply more complex methods of multidimensional analysis using specialized statistical packages such as R or SPSS. Thus, the given research uses a comprehensive methodology that included field observation, monitoring of environmental factors, and quantitative statistical analysis that allows us to identify and quantitatively confirm the relationship between transport-related air pollution and the incidences of bronchial asthma in Bishkek.

3. Results

According to official data, 1,972 people died in Kyrgyzstan from respiratory diseases in 2023, out of which 1,130 were men and 842 women [11]. Generally, men tend to spend more time outdoors and make the majority of motor vehicle drivers exposing them to harmful chemicals contained in exhaust fumes. These circumstances point to the need for comprehensive measures aimed at improving air quality and sustainable development in the country.

The social goal of country's sustainable development is social well-being that can be achieved by improving the quality of life of the population. Social well-being implies, first and foremost, the individual health [12]. The health of the population depends on providing people with the essentials, the most important of which is clean air, access to which is significantly limited in the country's capital, especially in winter.

The incidence of respiratory diseases, particularly bronchial asthma, is higher in Bishkek than in any other cities in Kyrgyzstan. The deterioration of air quality on the streets and indoors undoubtedly has a negative impact on public health. Chemicals released into the air along with vehicle exhaust contribute to many diseases, including respiratory diseases. There are studies that prove a clear link between specific air pollutants and respiratory diseases, such as bronchial asthma. Some studies have addressed associations between traffic-related air pollution and respiratory disease in young children.

Traffic-related pollution was associated with respiratory infections and some measures of asthma and allergy during the first 4 years of life. Studies have demonstrated an increase in the incidence of bronchial asthma with increasing concentrations of NO2, dust, and soot [13]. At the same time, there are researchers who believe that there is no direct link between the increase in cases of bronchial asthma and air pollution. The main factor provoking bronchial asthma is allergens [14].

Decreasing quality of air in Bishkek poses a growing threat to the health of city residents, consequently the choice of this subject is not accidental and is based on the objective state of affairs when issue of improving air quality has become of high relevance, sparking heated discussions among experts, the city administration, and the government in recent years [15]. Throughout the year, the air contains significant amounts of carbon oxides (CO, CO2), nitrogen dioxide (NO2), and other harmful substances, and the concentration of PM2.5 at certain times of the day, even in summer, significantly exceeds the standards recommended by the WHO. Nitrogen dioxide is present in large quantities in vehicle exhaust gases. This violates people's right to breathe clean air.

Article 4 of the Kyrgyz Republic's law “On Atmospheric Air” clearly states that citizens have the right to atmospheric air that is favorable for life and health, to receive reliable and timely information about the state of atmospheric air and measures taken to protect it, and to compensation for damage in the event of harm to their health and property caused by emissions of pollutants…[16]. The right of the population to compensation for damaged health caused by emissions of pollutants into the atmosphere is also not protected. To date, there has been no case of compensation for damage caused to human health by emissions of pollutants into the atmospheric air by any legal entity, individual, or the state.

Air pollution in Bishkek is the result of a variety of factors, including the behavior and choices of the city's residents. In many ways, outdated cars remain the main source of emissions. It is estimated that about 80% of vehicles in the capital are operated without catalytic converters—devices designed to filter exhaust gases from soot and other harmful impurities. Catalytic converters are often dismantled by owners and resold, while government agencies do not systematically monitor their presence [17]. Considering that the number of vehicles is almost twice the design capacity of the city's road infrastructure, the harm to human health is significantly increased. As of June 1, 2024, some 416,837 cars were registered in Bishkek officially. Taking into account cars entering Bishkek from other regions, the total number of cars in the capital exceeds 600,000, while the capacity of the capital's roads is about 350,000 cars [18].

American researchers Kai Zhang and Stuart Batterman see a particular danger in the number of motor vehicles exceeding the capacity of the city's road infrastructure. They investigate the magnitude of air pollution impacts and health risks to on- and near-road populations that might occur due to recurring congestion, such as Monday through Friday rush hour traffic. Recurring congestion can result in repeated and chronic exposures, and an increase in long term health risks. Highlight of their research: The results of their study showed that, predicted total health risks increased with increased traffic volume. At the same traffic volume, traffic during the morning rush hour increased risks by 20 to 40% compared to afternoon rush hour, mainly due to the poorer dispersion conditions [19]. Studies have shown that during morning and evening rush hours in Bishkek, when dispersion is weak and traffic intensity is high, air quality is much worse than during daytime rush hours, see Table 1.

Table 1. Air Quality Index (AQI^{+}USA) and PM2.5 air pollution in Bishkek

Indicators	**15.07.2025 г. (Tuesday – working day), daytime**								
	Morning rush hours			**Mid-day rush hours**			**Evening rush hours**		
	8:00	9:00	10:00	13.00	14.00	15.00	17.00	18.00	19.00

Air Quality Index +	60	50	58	39	39	36	53	60	62
Average index of quality		56			38			58,3	
Air pollution PM2.5, μg/m³	14	9	13	7	7	6.5	10	14	15
Average air pollution PM2.5, μg/m³		12			6,8			13	
Weather conditions: Temperature, º C.	29	31	31	34	36,	34	30	29	31,
Wind movement, km/h	6.8	7.5	10.7	10.5	12.4 ,	19.3 ,	13.2	10.7	4.4
Air humidity, %	22	20	20	14	14	18	19	24	25

Table 1 show that even during the summer evening rush hour, the average air quality index in Bishkek is 58.3, with PM2.5 pollution levels reaching 13 μg/m³, which is 2.6 times higher than the recommended daily average set by the WHO (5 μg/m³).

According to WHO recommendations, when this indicator is exceeded by more than 1.8 times, sensitive groups of the population including children, the elderly, and people with chronic respiratory diseases are advised to limit outdoor physical activity, wear protective masks, and close windows to minimize contact with polluted air. However, in practice, during the summer Bishkek residents go out en masse for evening walks without any protective equipment.

At the same time, residents often keep their windows closed during the day but open them in the morning and evening when pollution levels remain high. Such behavior clearly indicates that the awareness among the population about the actual condition of the air in the city and in their neighborhoods is extremely low. Even on weekend evenings, PM2.5 concentration significantly exceeds recommendations of World Health Organization, posing a health risk to vulnerable groups, see Figure 1.

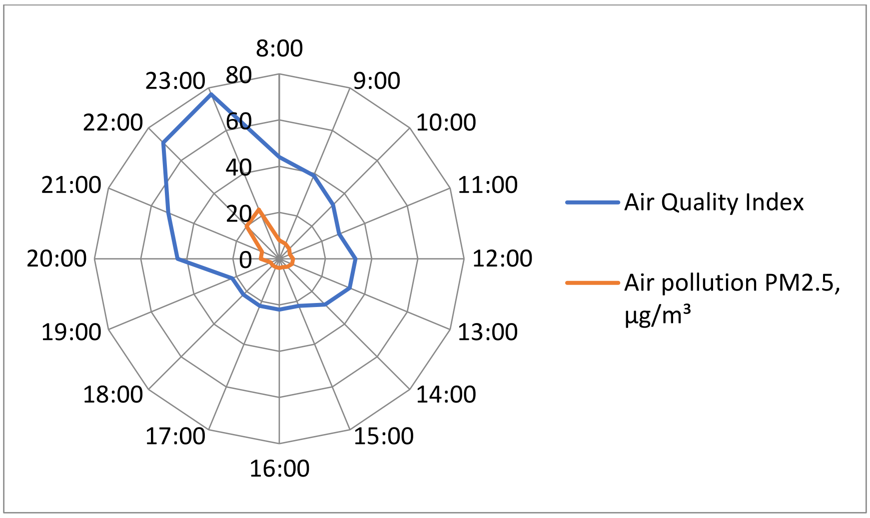

Figure 1. Air Quality Index (AQI⁺USA) and PM2.5 air pollution in Bishkek
Source: IQAir (July 1, 2025). Monitoring was conducted in live time

Chart 1 demonstrates a gradual decline in air quality in the evening during the summer period from 8:00 p.m. to 11:00 p.m. The average air quality index at this time is 61, and the average concentration of PM2.5 is approximately 15 μg/m³, which is three times higher than the WHO recommended daily average standard of PM2.5. Since the location of motor vehicle emissions and human respiratory belt height is the same, the human respiratory system becomes the most direct target of such pollutants. [20].

Consequently, even on weekends, between 8:00 p.m. and 11:00 p.m., residents of Bishkek should wear masks when walking outside and close their windows depending on the area where they live. The risks at the intersections of the busiest streets in Bishkek are particularly alarming. A group of Kyrgyz researchers, together with the youth environmental movement Move Green, monitored the nitrogen dioxide content in the air at the five busiest intersections in Bishkek and tried to determine whether air quality depends on the number of different types of vehicles and their speed. The outcome of the monitoring of three busiest intersections are presented in Table 2.

Table 2. Nitrogen dioxide concentration in the air at intersections in Bishkek

Names of intersecting streets	Concentration of nitrogen dioxide (NO2)	Description of the intersection and daily situation at the intersection
Aul / Elebesova (former Sovetskaya)	100 μg/m3 in 2019 and 90 μg/m3 in 2020. The limit was exceeded by more than two times	Elebesova str. is one of the three main avenues in the city. It connects the southern and northern parts of Bishkek. In the north, it connects the capital with residential areas around the largest clothing market in Central Asia - "Dordoi" which is located 800 meters from the intersection. A large number of vehicles, including trucks, enter the market area every day. Every morning and evening, market workers who live in the center and southern districts of the city pass through the intersection. A traffic jam about five kilometers long forms from the intersection to Zhibek Zholu Str.
Zhibek Zholu / Ibraimova	100 μg/m3 in 2019 and 70 μg/m3 in 2020 Exceeding the norm by two times	Zhibek Zholu is another main street in Bishkek connecting its eastern and western parts. It passes through city's largest food and clothing markets, Oshskiy and Alamedinskiy, as well as western and eastern bus stations. This street connects also the capital with its suburbs. It has a varied layout, mainly consisting of a six-lane street with a strip of greenery separating the directions of traffic. The intersection ranks first in terms of the total amount of vehicles flow, including freight and passenger transport.
Manas / Moskovsaya	80 μg/m3 in 2019 and 60 μg/m3 in 2020 Exceeds the norm almost two times	Manas is one of the capital's three main six-lane avenues. It connects the city center with the southern neighborhoods. Moskovskaya is a three-lane street with one-way traffic. From east to west, there is a dedicated lane for public transport. During rush hour, the Manas-Moskovskaya intersection is congested with traffic as are these two streets individually. This intersection ranks first in terms of number of buses, second in terms of the total number of vehicles and minibuses, and third in terms of the number of freight vehicles.

Table is compiled by authors. Source: Valentina kyzy R., Nogoibaeva A. (2022)

Consequently, the large number of motor vehicles, slow driving, and idling cars increase emissions of pollutants into the air, including nitrogen dioxide. The situation is exacerbated by the fact that the substances emitted by cars are mainly distributed at the level of human breathing.

Due to the dense development of residential areas, ventilation of this zone is difficult, so emissions are not dispersed by the wind [21]. It should be noted that construction of high-rise buildings has been thriving in the city over the past ten years. Experts fear that the deteriorating environmental situation in recent years is dictated by human factors. So called corridor of the natural flow of the winds coming from outside of the city, known as the "wind of rose" was disrupted, hence the level of airflow in the streets has decreased resulting the dust and car exhaust gases being constantly accumulated stagnating the air quality even further [22].

Construction equipment, mainly large diesel-powered vehicles, plays a significant role in the city's motor vehicle traffic. These vehicles have a significant negative impact on air quality and are often the cause of traffic accidents and congestion, which further exacerbates the environmental situation. Our observations on a section of Muromskaya str., (between Kuyukova and Manasa streets) revealed a high proportion of motor vehicles contributing to air pollution (a detailed description of the observation method is provided in the "Methodology" section). During 30 minute observation, 208 vehicles passed through this section, including: 3 large city buses running on liquefied gas; 144 passenger cars, of which 72 were technically worn-out vehicles of outdated models, mainly running on gasoline; 7 technically worn-out PAZ passenger buses running on diesel; mainly diesel-powered 37 minibuses for passengers and cargo, and 17 units of diesel-powered construction equipment. Given that gasoline and diesel fuel are the main sources of air pollution, it can be concluded that there is a high level of anthropogenic impact on the atmosphere in this area.

It is also worth noting that the poor quality of the road surface in this area leads to a reduction in traffic speed, which contributes to an increase in the time that harmful substances are emitted into the air. Similar situation is at outskirts of Bishkek where a high concentration of outdated and environmentally unfriendly motor vehicles flow constantly. Exhaust gases of motor vehicles heavily pollute the air with harmful chemicals with nitrogen oxides (NOx) and sulfur oxides (SOx) are being the main composition if it keep posing a huge health hazard. NOx in motor vehicle exhaust is mainly nitric oxide (NO) and nitrogen dioxide (NO2). NOx is mainly from the by-products of fuel combustion [23].

All these substances affect human health in different ways. Their concentration is influenced by many different factors, including weather conditions, season, and the geographical location of the city. The combined influence of anthropogenic and natural factors leads to an increase in the concentration of tiny particles and harmful chemicals in the air.

4. Discussion

It To analyze the correlation between the average concentration of nitrogen dioxide (X) and the number of recorded cases of bronchial asthma per 100,000 inhabitants of Bishkek (Y), we use the data presented in Table 3.

Table 3. Data for analysis

Variables	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Average concentration of nitrogen dioxide, μg/m³	40	50	50	60	60	70	60	80	50	60

Registered patients with bronchial asthma per 100,000 inhabitants, persons.	290	295	312	336	342	341	305	314	327	329

Source: (National Statistical Committee of Kyrgyz Republic. Environment in Kyrgyz Republic, 2015-2024)

The average values of the variables $\bar{X}$ and $\bar{Y}$:

$\bar{X}$=58;

$\bar{Y}$= 319,

Creating the table for calculation of Pearson's correlation coefficient (table 4).

Table 4. Calculation table

X	Y	$X-\bar{X}$	$Y-\bar{Y}$	$(X-\bar{X})(Y-\bar{Y})$	$(X-\bar{X})^2$	$(Y-\bar{Y})^2$
40	290	-18	-29,1	523,8	324	846,81
50	295	-8	-24,1	192,8	64	580,81
50	312	-8	-7,1	56,8	64	50,41
60	336	2	16,9	33,8	4	285,61
60	342	2	22,9	45,8	4	524,41
70	341	12	21,9	262,8	144	479,61
60	305	2	-14,1	-28,2	4	198,81
80	314	22	-5,1	-112,2	484	26,01
50	327	-8	7,9	-63,2	64	62,41
60	329	2	9,9	19,8	4	98,01
				932	1160	3152,9

Following formula is used to calculate Pearson's correlation coefficient (r):

$$r = \frac{\Sigma\,(Xi - \bar{X})(Yi - \bar{Y})}{\sqrt{\Sigma\,(Xi - \bar{X})^2 * \Sigma\,(Yi - \bar{Y})^2}}$$

where:

Xi and Yi – variable values of X and Y,

$\bar{X}$ and $\bar{Y}$ - mean values of variables X and Y respectively

Calculation of Pearson's correlation coefficient (r):

$$r = 932 / \sqrt{(1160*3152{,}9)} = 0.487$$

Pearson correlation coefficient was r = 0.487. According to Cohen's scale [24], this indicator corresponds to a moderate positive correlation. We shall test the statistical significance of the calculated correlation coefficient using the one-tailed Student's t-test (the formula is shown in the Methodology section):

$$t = 0{,}487*\sqrt{[(10-2)]} / \sqrt{[1-(0{,}487)^2]} = 1{,}578$$

The calculated value of the criterion was t = 1.578, which exceeds the critical value t crit = 1.397 at a significance level of α = 0.10 (90% confidence interval). This allows us to conclude that there is a statistically significant positive correlation between the variables under the study. The analysis revealed a moderate positive correlation between the average annual concentration of nitrogen dioxide and the incidence of bronchial asthma in the city of Bishkek for the period 2014–2023. This relationship was statistically significant at a significance level of α = 0.10. The results confirm the hypothesis about the impact of air pollution on public health.

The current study examined the relationship between the average annual concentration of nitrogen dioxide (NO2) in the atmospheric air of Bishkek (variable X) and the incidence of bronchial asthma per 100,000 inhabitants (variable Y). Based on theoretical assumptions and data from previous studies, a clear hypothesis was put forward: an increase of bronchial asthma incidences is associated with an increase of NO2 concentration. In this respect, the one-tailed Student's t-test was used to test statistical significance, since the effect was assumed to be in only one direction (an increase in NO2 concentration leads to an increase in the incidence rate). The significance level α = 0.10 was chosen for the following reasons. Firstly, the incidence rate of bronchial asthma may also be influenced by other pollutants contained in exhaust gases such as particulate matter, carbon monoxide, and volatile organic compounds, as well as by important factors such as genetic predisposition, exposure to allergens, living conditions, and lifestyle. These additional variables introduce a high level of variability into the data, which may reduce the likelihood of detecting the real effect. Increasing the significance level to 0.10 reduces the risk of a type II error or failure to detect a real relationship, which is considered acceptable at the stage of initial identification of possible patterns and formation of scientific hypotheses.

At the same time, in future studies, it would be advisable to significantly increase the sample size and apply a two-tailed t-test with a more stringent significance level (α = 0.05), as well as take into account additional variables, including environmental (other pollutants), climatic, and socioeconomic factors. This will allow for a more accurate assessment of the impact of nitrogen dioxide and other factors on the health of the population of Bishkek.

The aim of the current study was to quantitatively confirm the existence of a statistically significant positive correlation between the average annual concentration of nitrogen dioxide and the incidence of bronchial asthma. To solve this task, Pearson's correlation coefficient was used, followed by a test of statistical significance. Given the stated objective, the use of correlation analysis appears to be sufficient, since the task of constructing a predictive model or assessing the impact of additional factors was not set within the framework of this study.

5. Conclusion

Based on the study, the following conclusions were drawn and corresponding recommendations were made:

Conclusion 1: A moderate positive correlation was established between the average annual concentration of nitrogen dioxide (NO2) and the number of registered bronchial asthma patients in the city of Bishkek.

Recommendation: Include NO2 as one of the environmental risk indicators when planning urban sanitation policy and public health priorities.

Conclusion 2: The hypothesis of a direct (positive) impact of nitrogen dioxide air pollution on the increase of bronchial asthma incidence has been preliminarily confirmed in the case of Bishkek.

Recommendation: Promote interdisciplinary research in the fields of sustainable development, urban planning, environmental safety, transport sustainability, and environmental medicine, with a focus on the impact of transport pollutants in large cities.

Conclusion 3: Urban air is polluted not only by nitrogen dioxide (NO2), but also by other harmful substances associated with motor vehicles and construction equipment, including carbon monoxide (CO), hydrocarbons, soot, and sulfur compounds.

Recommendation: Develop and implement a comprehensive program to reduce emissions from transport and construction equipment, with a focus on the phased replacement of outdated vehicle fleets, the expansion of green areas, and the transition to environmentally friendly fuels.

Conclusion 4: The current load on Bishkek's ecological infrastructure exceeds its capacity, especially during periods of smog.

Recommendation: Tighten requirements for the technical condition of motor vehicles, develop low-emission public transport, and introduce live- time or instant environmental monitoring systems.

Conclusion 5: One of the significant factors contributing to air pollution in Bishkek is the heavy traffic of heavy diesel vehicles, both in winter, when meteorological conditions contribute to the accumulation of pollutants and the formation of smog, and in summer, when construction work in the city intensifies.

Recommendation: Restrict heavy diesel traffic in the central part of the city throughout the year in order to reduce the concentration of harmful emissions and reduce the risk to public health, Support the introduction of Low Emission Zones, especially near children's institutions, hospitals, and residential areas, Increase urban greening, including planting trees along roads and near residential areas, to reduce pollutant concentrations and improve the microclimate.

Conclusion 6: The population of Bishkek is poorly informed about the actual state of atmospheric air and the associated health risks.

Recommendation: Develop environmental education and public awareness programs, especially for vulnerable groups (children, the elderly, people with chronic respiratory diseases), with a focus on the harmful effects of transport emissions.

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