THE DEPENDENCE OF ATMOSPHERIC AIR POLLUTION IN THE MAJOR CITIES OF THE FERGANA VALLEY ON NATURAL-GEOGRAPHICAL CONDITIONS

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Abstract: This study examines the relationship between atmospheric air pollution in the major cities of the Fergana Valley and the region's natural-geographical conditions. The research analyzes how climatic parameters, and meteorological processes influence the formation, accumulation, and dispersion of air pollutants. Particular attention is given to the valley's enclosed relief, precipitation amount, seasonal wind patterns, and their combined effects on the concentration of anthropogenic emissions. The findings highlight that the unique natural-geographical characteristics of the Fergana Valley significantly exacerbate air pollution levels, making the understanding of these factors essential for effective environmental monitoring and pollution mitigation strategies.

Keywords: Fergana Valley, atmospheric air pollution, natural-geographical conditions, climate, precipitation amount, urban environment, environmental monitoring, anthropogenic emissions, dust.

ЗАВИСИМОСТЬ ЗАГРЯЗНЕНИЯ АТМОСФЕРНОГО ВОЗДУХА КРУПНЫХ ГОРОДОВ ФЕРГАНСКОЙ ДОЛИНЫ ОТ ПРИРОДНО-ГЕОГРАФИЧЕСКИХ УСЛОВИЙ.

Аннотация. В данном исследовании рассматривается взаимосвязь между загрязнением атмосферного воздуха крупных городов Ферганской долины и природно-географическими условиями региона. В работе проанализировано влияние климатических показателей и метеорологических процессов на формирование, накопление и рассеивание загрязняющих веществ. Особое внимание уделено замкнутому рельефу долины, количеству атмосферных осадков, сезонному режиму ветров и их совокупному воздействию на концентрацию антропогенных выбросов. Результаты исследования показывают, что природно-географические особенности Ферганской долины существенно способствуют повышенному уровню загрязнения воздуха. Поэтому глубокое понимание данных факторов является важным условием для разработки эффективных стратегий экологического мониторинга и снижения загрязнения.

Ключевые слова: Ферганская долина, загрязнение атмосферного воздуха, природно-географические условия, климат, количество осадков, городская среда, экологический мониторинг, антропогенные выбросы, пыль.

Introduction. The health of urban populations and its deterioration are directly related to the processes of urbanization and the landscape-ecological conditions of the environment. Urbanization exerts a significant impact on environmental components, particularly within cities and their surrounding areas. The expansion of urban territories and the growth of population primarily lead to the violation of ecological and hygienic standards. From the perspective of ecological physiology and medicine, the concentration of a large portion of the population in small areas creates a range of ecological and social anomalous conditions.

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Main part. The study of changes in the composition of urban atmospheric air has always been relevant. In urban areas, vehicles generate noise levels of 60–80 dB, which negatively impacts the nervous and cardiovascular systems of the population. Operating a single vehicle consumes 150–200 mg of fuel, emits 120 m³ of exhaust gases per hour, and releases 1,500 kg of rubber odor annually [1].

The stabilization of landscape-hygienic conditions in large cities largely depends on the establishment of green spaces and their ratio relative to the total urban area. In several developed countries, significant attention is given to the creation of green areas. For instance, in cities such as London, Paris, and Washington, the ratio of green space coverage reaches 10:1, while in Moscow it is approximately 10:1.5.

Green spaces play a crucial role in improving the sanitary-hygienic condition of cities, purifying the air, capturing dust and toxic substances harmful to human health, and biologically cleansing the environment. According to data, one hectare of green space produces approximately 200 kg of oxygen per day. In particular, for dust capture, one hectare of land captures 32 t by elm, 36 t by pine, 56 t by oak, 59 t by beech, and 63 t by hornbeam. It is well known that in large cities, due to the adverse effects of meteorological factors on atmospheric air, natural pollution indicators reach high levels [5].

Anthropogenic sources of atmospheric pollution include industrial and thermal power enterprises, transport, residential heating systems, agriculture, and household waste. As a result of economic activities, pollutants or chemical compounds are released into the atmosphere from sectors such as energy production, transport, agriculture, and waste processing. These compounds undergo various chemical reactions, leading to secondary pollution in the atmosphere. The acceleration of urbanization processes also significantly contributes to the intensification of air pollution.

Urban air quality monitoring programs typically focus on five major pollutants: particulate matter (suspended solids), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and nitrogen oxide (NO). Depending on the composition of industrial emissions and the characteristics of nearby cities and adjoining areas, additional substances—such as ammonia, phenol, formaldehyde, ozone, chlorine, solid fluorides, hydrogen fluoride, and heavy metals—may also be included in the monitoring framework.

Air Pollution Trends from Stationary and Mobile Sources in Uzbekistan: The table below summarizes the long-term (10-year) and medium-term (3-year) trends in emissions from stationary and mobile sources, as well as the behavior of specific pollutants in Uzbekistan.
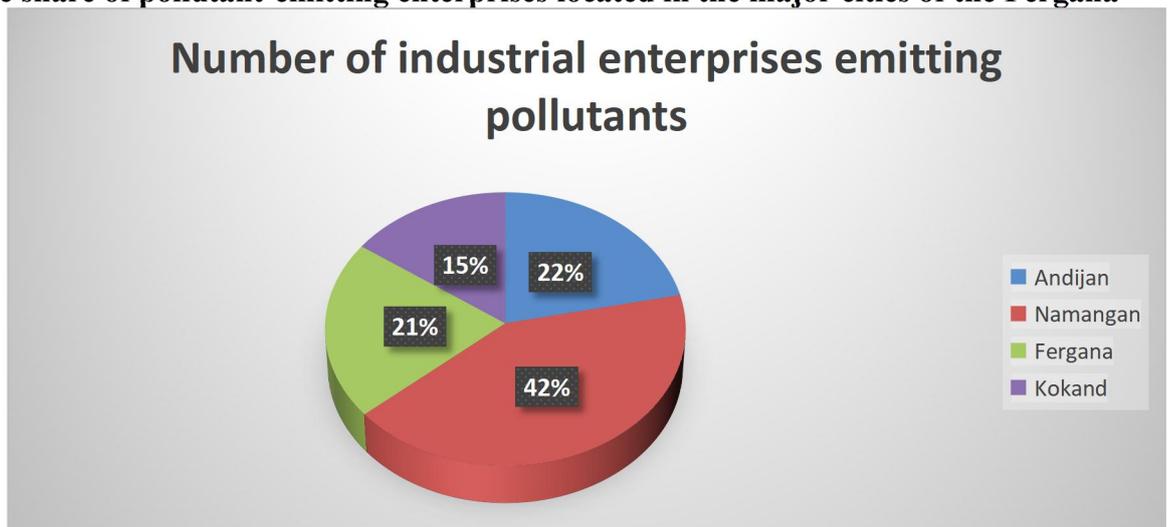
Indicator	Long-term (10 years)	Medium-term (3 years)	Details
Pollution from stationary sources	○ Negative	Stable	Stationary sources increased during the first half of the period (2012–2022), but have recently stabilized.
Pollution from mobile sources	○ Negative	○ Negative	The largest contributors are vehicles, particularly in Tashkent city (88% of all mobile emissions) and in Tashkent, Fergana, and Samarkand regions.
Solid substances	○ Negative	○ Negative	Industrial emissions (e.g., cement production) remain high, negatively affecting environmental and human health.

Indicator	Long-term (10 years)	Medium-term (3 years)	Details
Sulfur dioxide (SO₂)	○ Negative	○ Positive	Industrial emissions (energy sector) are still high but show improvement in recent years.
Carbon monoxide (CO)	○ Negative	○ Positive	Significant reduction has been achieved in recent years.
Nitrogen oxides (NOx)	○ Negative	○ Negative	Increases are associated with industrial and agricultural activities.
Hydrocarbons	○ Negative	○ Positive	Significant reduction has been observed over the last few years.

Over the long term, both stationary and mobile sources contribute significantly to atmospheric pollution in Uzbekistan. Mobile sources, especially vehicles in major urban centers, dominate emissions in densely populated regions such as Tashkent, Fergana, and Samarkand. Recent years show some improvements for pollutants like CO, SO₂, and hydrocarbons, whereas solid substances and NOx remain critical concerns due to ongoing industrial and agricultural activities. Dust particles in the atmosphere have an adverse effect on the human body. The impact of dust depends on the biological activity, chemical composition, and physical properties of the particles. For example, continuous inhalation of dust containing lead (Pb), arsenic, manganese (Mn), cadmium (Cd), and fluoride (F) aerosols can lead to chronic diseases. Specifically, it may cause conditions such as anemia, fluorosis, polyarthritis, and polyneuritis. Exposure to fluoride (F) compounds can result in nosebleeds, rhinitis, and persistent coughing. Nitrogen oxides can lead to lung diseases, lowered blood pressure, dizziness, fainting, and vomiting. Lead (Pb) dust affects the nervous system, may cause inflammation of the brain, impair liver and kidney function, and delay physical development in children.[4]

Figure 1

**The share of pollutant-emitting enterprises located in the major cities of the Fergana**

Number of industrial enterprises emitting pollutants

- Andijan 22%
- Namangan 42%
- Fergana 21%
- Kokand 15%

Valley.

According to the data from the Statistics Agency under the President of the Republic of Uzbekistan, 2024.

Analyzing the above 1-diagram, among the major cities of the Fergana Valley, considering the administrative centers and the main regional cities, Namangan and Kokand emit the least amount of pollutants. However, due to factors such as the city's location slightly away from prevailing

wind directions, the relief conditions, the urban and construction layout, and the sparse and irregular distribution of green spaces within the city, the impact of pollution remains significant. In almost all major cities of the valley, pollution levels have doubled compared to the 2014 indicators. Unfortunately, this increase corresponds with a decrease in precipitation, the growth of green areas, and the number of windy and foggy days. These changes affect the landscape-urbanistic conditions of the valley's cities (Figure 2).

Figure 2

Gaseous and liquid pollutants
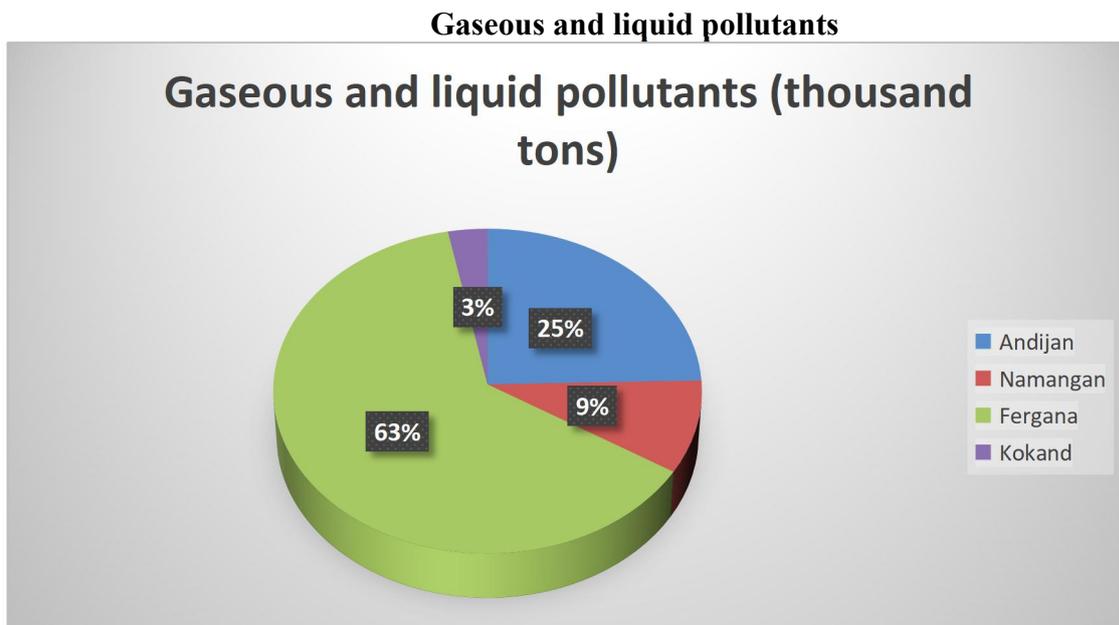
In terms of potential atmospheric pollution, the cities of Kokand and Fergana stand out. Another major factor contributing to potential pollution is the occurrence of wind and fog events. However, fog events in almost all areas of the Fergana Valley are approximately twice less frequent than the national average. For example, in Andijan city, the total duration of fog during the cold months of the year is 154 hours. In Fergana city, the average annual duration of fog is 110.1 hours. The least foggy conditions are observed in Namangan city, with a duration of 66.2 hours during the cold months.

In the cities of the Fergana Valley, the level of atmospheric pollution, as well as its self-purification, is directly correlated with precipitation (correlation coefficient approaches 1). Analyzing precipitation levels, it is evident that Andijan city receives higher rainfall compared to other cities. In Kokand, however, precipitation is significantly lower—approximately 87% less than in Andijan and Namangan—which implies that when pollution levels rise, the air's natural self-cleaning capacity is strained. Low precipitation contributes to an increase in secondary pollution levels in these cities. This indicates that the volatility of airborne pollutants, particularly PM-2.5, can increase by 2.5 times (see Figure 3).

Figure 3

PRECIPITATION AMOUNTS IN MAJOR CITIES OF THE FERGANA VALLEY, 2022
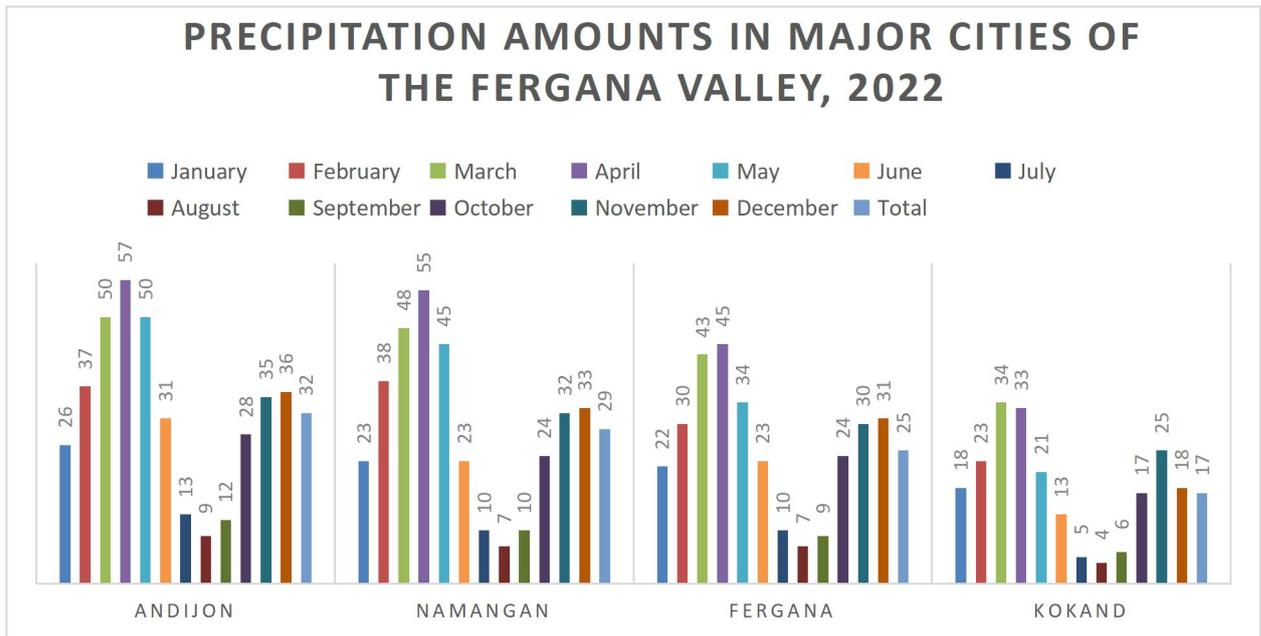
Compiled by the author based on data from the Hydrometeorology Service Agency.

As an important indicator of the sanitary-hygienic condition in the Fergana Valley, the incidence of various diseases among urban populations is also recognized as a significant criterion. In the major cities of the valley, diseases of the nervous system, respiratory organs, and digestive system are among the most common. The incidence of pneumonia, respiratory diseases, and ischemic heart disease is relatively high in Fergana and Kokand. This can be explained by the comparatively greater natural and anthropogenic air pollution in these cities. The elevated rates of respiratory diseases in the studied cities are directly associated with both natural and technogenic sources of air pollution.

Conclusion. In the air pollution of major cities in the Fergana Valley, natural factors and human-related factors are closely interlinked. The annual increase in pollution levels in valley cities, coupled with a corresponding rise in demographic pressure, necessitates an accurate assessment of the landscape-urban conditions and the development of effective solutions. Among the major cities of the valley, the levels of secondary and "effective pollution" are particularly high in Kokand and Namangan. In Namangan, this is explained by the high population density and relatively unorganized infrastructure, while in Kokand, it is attributed to the rapid growth of industrial activity and natural factors such as low rainfall and specific wind conditions. Considering the demographic, economic, and climatic changes in the Fergana Valley over at least the past 20 years, it is essential to accurately forecast the ecological situation.

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