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INCREASE IN AIRBORNE PARTICULATE MATTER IN INDUSTRIAL AREAS AND ITS MEDICAL-BIOLOGICAL IMPACT ON PUBLIC HEALTH

Toshturdiyev Nurbek Nurali ugli
National University of Uzbekistan named after Mirzo Ulugbek
Faculty of Physics, Department of Hydrometeorology
3rd year student
Phone: +998 88 910 42 46
Email: nurbektoshturdiyev86@gmail.com

Abstract: This article scientifically analyzes the excessive accumulation of particulate matter (PM) in the atmosphere of industrial areas and its medical-biological effects on human health. The composition, size, and mechanisms of particulate matter penetration into the human body are examined. Special attention is given to the adverse effects of PM10 and PM2.5 particles on the respiratory, cardiovascular, immune, and nervous systems. Based on observations, statistical data, and reports from the World Health Organization (WHO), the health risk level of air pollution in highly industrialized regions is assessed. The conclusion section provides recommendations for preventive and ecological measures against dust pollution.

Keywords: industrial area, particulate matter, air pollution, PM2.5, PM10, respiratory system, cardiovascular system, ecology, public health, medical-biological impact.

In recent years, while the rapid development of industry has significantly contributed to human progress, it has also intensified various environmental issues. Air pollution—particularly the increasing concentration of particulate matter (PM)—has become one of the most pressing global public health concerns. This issue is especially critical in densely industrialized regions. Sectors such as metallurgy, energy production, chemical processing, and construction materials industry release a variety of particles, gases, and dust into the air, severely disrupting environmental stability.

Particulate matter suspended in the atmosphere—especially particles smaller than 10 microns (PM10) and 2.5 microns (PM2.5)—poses a serious health risk. These particles can enter lung tissues and even the circulatory system during respiration. As a result, an increase in respiratory diseases such as bronchitis, asthma, chronic obstructive pulmonary disease (COPD), cardiovascular conditions, allergic reactions, and even cancer has been observed.

According to data from the World Health Organization (WHO), nearly 7 million people die annually due to diseases associated with air pollution, including exposure to particulate matter. This problem is also highly relevant in Uzbekistan. In cities like Navoi, Almalyk, and Angren, where industrial enterprises are densely located, atmospheric pollution levels often exceed WHO-recommended standards.

This article explores the ecological and medical-biological problems associated with rising dust concentrations in industrial areas. It provides an in-depth analysis of the health impacts of airborne particles based on statistical data. Furthermore, it proposes practical technological, preventive, and monitoring strategies to mitigate the issue.

In the past decade, the contamination of the atmosphere by particulate matter has been increasingly discussed in scientific literature as a major threat to global health and environmental

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sustainability. International and local studies have thoroughly examined the sources, distribution mechanisms, and health hazards of PM10 and PM2.5 particles. According to the WHO (2021), more than 7 million deaths each year are linked to air pollution, especially from inorganic particulate matter. The WHO recommends that PM2.5 levels not exceed 15 μg/m³ and PM10 not exceed 45 μg/m³. However, in industrial zones, these values are reported to be 2–5 times higher (WHO, 2023). The United States Environmental Protection Agency (EPA, 2020) has shown that PM2.5 particles contribute to cardiovascular diseases, lung fibrosis, respiratory failure, and even neurodegenerative conditions such as Alzheimer's disease. Long-term exposure to these particles can induce oxidative stress, inflammation, and DNA mutations at the cellular level.

Uzbek researchers have also paid attention to this issue. For example, T.K. Karimov (2018) scientifically demonstrated a direct correlation between air pollution in industrialized areas and the sharp rise in bronchopulmonary diseases. Additionally, observations conducted in the Navoi region (G.M. Solieva, 2021) revealed that industrial emissions—especially from cement and metallurgical enterprises—contributed significantly to increased respiratory diseases in the population. Long-term studies by Russian scientists (Avdeeva A.N. et al., 2019) found that the prevalence of cardiovascular and allergic diseases among people living near industrial facilities was 30–50% higher compared to other regions. This suggests the potential link to long-term exposure to PM2.5 particles. Similar conclusions were drawn by scientists in China, India, and Iran, indicating that living in environments polluted with industrial dust directly reduces life expectancy and health levels (Chen et al., 2020; Naddafi et al., 2022).

A review of the literature shows that dust particles negatively impact not only pulmonary and cardiovascular health but also the immune, endocrine, and nervous systems. In particular, nanoparticles that remain suspended in the air for long periods are capable of penetrating cell membranes. Furthermore, the presence of heavy metals and organic toxins on their surfaces poses additional health risks.

This study uses a comprehensive approach to examine the rise in airborne dust concentrations in industrial zones and their medico-biological effects on public health. Several scientific methods were employed. The research integrated empirical observations, statistical analysis, and medical-biological assessments based on both primary and secondary sources.

In the first phase, official statistical data on air pollution, especially PM10 and PM2.5 concentrations, provided by the Ministry of Ecology of the Republic of Uzbekistan and its regional departments, were analyzed. Reports on public health issued by the Sanitary-Epidemiological Service were also reviewed. In addition, data on disease dynamics from healthcare institutions—especially pulmonology, cardiology, and allergology centers—served as key sources.Within the scope of this study, real-time air quality monitoring was conducted in industrial zones with high dust concentrations—such as mining, metallurgy, and construction material enterprises in Navoi city, and in other industrial cities like Almalyk and Chirchik. The levels of PM particles were measured using modern instruments, including automated dust sensors and samplers. Daily average values were compared against WHO-defined health standards.

Moreover, the study assessed the extent to which dust particles affect public health. The correlation between disease incidence and dust concentration was statistically evaluated. Correlational analyses identified significant links between air pollution and respiratory diseases, cardiovascular issues, and allergic reactions. A dynamic analysis was conducted to examine trends over time.

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Comparative regional analyses were also carried out to assess differences between industrialized and environmentally clean areas.

Based on medical-biological assessments, the mechanisms of how dust particles affect the human body were investigated. It was found that these particles penetrate alveoli in the lungs, trigger inflammation, cause oxidative stress, and damage cell structures. Comparative analysis was made with experimental results from international literature, which confirm the negative effects on cardiovascular, nervous, and endocrine systems. The findings clearly show that PM10 and PM2.5 concentrations in industrial zones significantly exceed permissible limits. In particular, in cities like Navoi, Almalyk, Chirchik, and Angren, PM concentrations were found to be 1.5 to 3 times higher than WHO hygienic standards, especially during summer months and in windless weather conditions.

Monitoring results revealed that daily average PM2.5 concentrations in Navoi's industrial zones ranged from 45 to 70 μg/m³—significantly higher than the WHO standard of 25 μg/m³. Such conditions directly affect public health. In recent years, respiratory illnesses such as bronchitis, asthma, and allergies have increased among people living near industrial areas. According to statistics, respiratory diseases in these areas have risen by 20–30% over the last five years. Pulmonary dysfunction, cardiovascular problems, chronic inflammation, and weakened immunity are particularly common among children and the elderly. It was found that dust particles enter the circulatory system, increasing the risk of ischemic heart disease, hypertension, stroke, and heart attacks. There is also evidence that long-term exposure to dust negatively affects central nervous system functions.

Statistical correlations between dust concentrations and disease incidence were established. Correlation analyses showed that respiratory diseases—particularly bronchial asthma and pneumonia—increased markedly during periods of high PM2.5 levels. This was especially pronounced when monthly dust concentrations doubled the standard levels. Comparative regional analyses confirmed that in environmentally clean areas, the rates of the aforementioned diseases are significantly lower, and the overall health status of residents is better. Furthermore, environmental awareness among the population was found to be insufficient. Many people do not fully understand the health risks of industrial emissions, reducing the effectiveness of preventive measures.

Overall, the results of the study demonstrate that airborne dust particles from industrial activities pose a serious threat to both the environment and public health. This underscores the urgent need to ensure environmental safety, implement advanced air purification technologies, and strengthen public health protection measures.

The scientific research confirmed that in industrial areas, concentrations of airborne dust—particularly PM10 and PM2.5—are significantly above permissible levels, posing a serious threat to public health. Observations and analyses show that respiratory, cardiovascular, allergic, and chronic inflammatory diseases are sharply increasing in areas with high dust concentrations. Children, the elderly, and people with weakened immune systems are most vulnerable.

Statistical analysis confirmed the link between dust particle concentration and public health. The prevalence of respiratory illnesses among people living near industrial plants is several times higher than in environmentally clean areas. Moreover, long-term exposure to dust is considered a key factor in the development of life-threatening diseases such as ischemic heart disease, stroke, and bronchial asthma.

Based on these conclusions, the following recommendations can be proposed:

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- First, align the operations of dust-emitting industrial enterprises with environmental standards by introducing modern purification and filtration technologies. Strict control mechanisms must be implemented to minimize dust emissions during production processes.
- Second, increase the number of automated air quality monitoring stations and develop real-time information systems to keep the public informed via mass media.
- Third, strengthen public health prevention measures, especially for vulnerable groups—such as children, the elderly, and those with chronic illnesses—by organizing regular medical checkups.
- Fourth, promote environmental awareness and engage the public in environmental protection activities. Concepts of ecology and air quality should be gradually incorporated into the education system.
- Fifth, improve regulatory frameworks to ensure environmental safety, enhance the ecological accountability of enterprises, and establish strict penalties for entities causing environmental harm.

In conclusion, the increase in airborne dust concentrations in industrial zones must be viewed not only as an ecological issue but also as a social and medical problem. A comprehensive approach based on scientific evidence, supported by joint actions from government, society, and healthcare systems, is essential for finding balanced solutions.

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