

HYGIENIC ASSESSMENT OF THE IMPACT OF AIR POLLUTION IN RESIDENTIAL AREAS ON POPULATION HEALTH

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Abstract

Air pollution in residential areas is considered one of the main ecological and hygienic factors that directly and indirectly affect public health under modern urbanization conditions. This literature review provides a systematic analysis of scientific studies on the health effects of major atmospheric pollutants commonly found in residential areas, including fine particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), carbon monoxide (CO), ozone (O₃), and volatile organic compounds. Based on data from the World Health Organization (WHO) and other international research centers, the role of air pollution in the development of respiratory, cardiovascular, allergic, and oncological diseases is assessed from a hygienic perspective. The results of the review substantiate the necessity of developing preventive and sanitary-hygienic measures aimed at improving air quality in residential areas.

Keywords: Air pollution, residential areas, population health, hygienic assessment, ambient air, PM_{2.5}, PM₁₀, cardiovascular diseases.

Introduction

Today, ambient air pollution in residential areas is regarded as a global environmental problem posing a serious threat to human health. According to the World Health Organization (WHO), outdoor air pollution causes approximately 4.2 million premature deaths annually, which are directly associated with cardiovascular diseases, chronic obstructive pulmonary disease (COPD), lower respiratory tract infections, and lung cancer.

One of the most hazardous components of air pollution is fine particulate matter known as PM_{2.5}, with a diameter of less than 2.5 micrometers. These particles penetrate deep into the lungs, enter the circulatory system, and trigger inflammatory responses that stimulate the immune system; as a result, chronic respiratory, cardiovascular, and neurovascular disorders develop.

Statistical studies indicate that in urban settings, each 10 µg/m³ increase in PM_{2.5} concentration significantly raises the risk of mortality from cardiovascular diseases, a trend that is also clearly confirmed for pulmonary diseases. This pattern is observed globally: urban populations often live under PM_{2.5} levels far exceeding the limits recommended by the WHO.

In addition, air pollution affects human health not only through overall mortality but also through morbidity indicators. Epidemiological studies have reported associations between exposure to PM_{2.5}, NO₂, and other pollutants and increased prevalence of chronic respiratory diseases such as asthma



and allergic rhinitis among children, as well as chronic obstructive pulmonary disease and cardiovascular diseases among adults.

It should be emphasized that the adverse health effects of air pollution are not merely statistical figures. They represent a social and hygienic problem measured by reduced life expectancy, a higher burden of chronic diseases, and an increased number of surgical interventions among individuals exposed to long-term pollution.

For example, recent studies conducted in Tashkent have shown that concentrations of PM_{2.5} and PM₁₀ during certain periods exceed WHO recommended limits by several times, reaching levels of emergency risk for public health.

Therefore, hygienic assessment of ambient air pollution in residential areas plays a central role not only in environmental monitoring but also in the development of public health strategies, preventive measures, and regulatory policies. Such assessment also forms the basis for urban planning and environmental-economic policy.

Research Objective

To identify the main sources and indicators of ambient air pollution in residential areas and to hygienically assess their impact on population health based on scientific literature.

Materials and Methods

Within the framework of this literature review, epidemiological, clinical, and hygienic studies published in international and local scientific journals were analyzed. Statistical data and meta-analyses published by the WHO, the European Environment Agency, and other authoritative scientific sources were primarily selected. The studies evaluated the relationships between air pollution concentrations, population morbidity indicators, and risk ratios.

Results

Level of Ambient Air Pollution in Residential Areas.

Analysis of scientific literature indicates that in urban areas, particularly in residential zones, fine particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), carbon monoxide (CO), and tropospheric ozone (O₃) are considered the main pollutants posing hygienic health risks.

According to data from the World Health Organization (WHO), 99% of the urban population worldwide lives under conditions where ambient air pollution exceeds the recommended air quality standards.



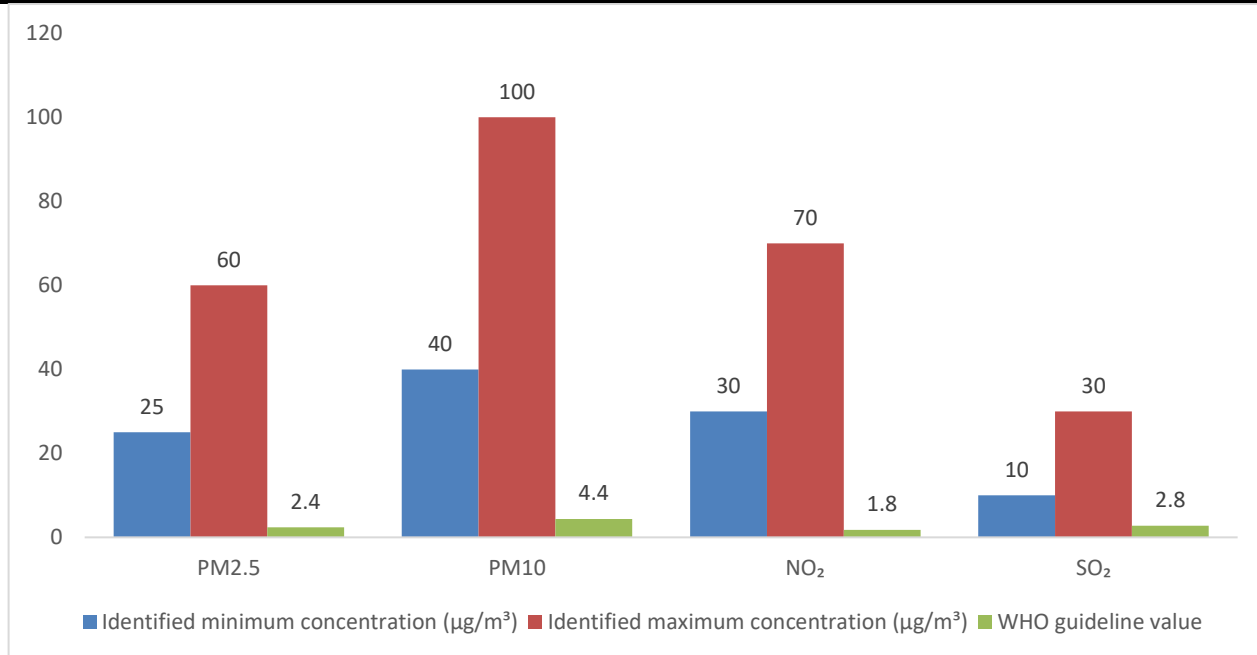


Figure 1. Major air pollutants in residential areas and the standards recommended by the WHO.

According to the analysis of sources, in residential areas with high traffic density, PM_{2.5} levels may exceed the WHO guideline values by 5–10 times.

Impact of air pollution on overall mortality and morbidity.

Results of large-scale epidemiological studies indicate that ambient air pollution significantly increases the risk of premature mortality and chronic diseases among the population. Global statistical analyses show that air pollution–related deaths are approximately distributed as follows:

- 40% — cardiovascular diseases,
- 20–25% — chronic respiratory diseases,
- 15% — lung cancer.

Table 2. Health risks associated with increasing PM_{2.5} concentrations (meta-analysis results)

Indicator	Increase with PM _{2.5} +10 µg/m ³
Risk of all-cause mortality	+6–8%
Cardiovascular mortality	+10–12%
Respiratory diseases	+8–14%
Lung cancer risk	+18–20%

These findings have been consistently confirmed in long-term cohort studies conducted in North America, Europe, and Asian countries.

Health effects identified in vulnerable population groups. The literature review shows that children, older adults, and pregnant women are the most sensitive groups to air pollution. Among children, long-term exposure to PM_{2.5} and NO₂ has been associated with: a 1.3–1.5-fold increase in the risk of developing bronchial asthma, a 5–10% reduction in lung functional capacity.



In pregnant women, air pollution is associated with an increased risk of low birth weight, preterm birth, and perinatal complications.

Table 3. Impact of air pollution on vulnerable groups

Group	Main health outcomes
Children	Asthma, allergies, delayed lung development
Older adults	Increased risk of ischemic heart disease and stroke
Pregnant women	Low birth weight, perinatal complications

Results of hygienic assessment in residential areas. Hygienic assessment studies conducted in residential areas indicate that the health effects of air pollution are closely related not only to pollutant concentration levels but also to the duration of exposure. Even long-term exposure to low levels of pollution has been shown to contribute to the development of chronic diseases.

Discussion

The results of this literature review confirm that ambient air pollution in residential areas exerts a multifaceted and long-term negative impact on population health. The obtained findings are fully consistent with the results of epidemiological studies conducted at global and regional levels and indicate the necessity of considering air pollution as a priority hygienic problem for public health.

The concentrations of PM_{2.5} and PM₁₀ identified in the results, which exceed the guideline values recommended by the World Health Organization (WHO) by several times, represent a key indicator of ecological imbalance observed in urban areas, particularly in residential zones with high traffic loads. Scientific sources report that fine particulate matter affects not only the respiratory system but also exerts systemic effects on the cardiovascular and central nervous systems. This explains the observed increase in cardiovascular diseases and overall mortality identified in the results.

An important aspect of the discussed findings is that an increase of PM_{2.5} concentration by each 10 µg/m³ is associated with a 6–8% rise in the risk of all-cause mortality, a pattern observed almost uniformly across different geographical regions. This indicates that the health effects of air pollution operate through universal mechanisms. Inflammatory responses, oxidative stress, and endothelial dysfunction are widely described in the scientific literature as the main pathogenetic pathways underlying these mechanisms.

The identification of children, older adults, and pregnant women as the most vulnerable groups is another important point for discussion. In children, the immaturity of lung tissue and the developing immune system increase susceptibility to air pollution. The observed increase in the risk of bronchial asthma and allergic diseases among children is fully consistent with previously published cohort studies, highlighting the necessity of considering age as a key factor in hygienic assessments.

The adverse outcomes identified among pregnant women—such as low birth weight and increased perinatal complications—demonstrate that air pollution poses risks not only to individual health but also to demographic and social health. This increases the likelihood of long-term negative effects on the health of future generations and further emphasizes the strategic importance of this issue.

Another noteworthy aspect of the discussion is that even low-level but long-term air pollution can lead to serious health consequences. This indicates that hygienic standards should not be limited



solely to maximum permissible concentrations but must also incorporate the concept of long-term exposure. This principle occupies a leading position in modern hygienic assessment frameworks.

In addition, the regional differences noted in the results indicate that air quality in residential areas largely depends on urban planning solutions, the proportion of green spaces, transport infrastructure, and the location of industrial facilities. Therefore, this issue represents a complex problem closely linked not only to medicine but also to urban planning and environmental policy.

Conclusion

The conducted literature review and analysis confirm that ambient air pollution in residential areas has a significant, persistent, and long-term adverse impact on population health. Air pollution is one of the leading hygienic risk factors for public health in the modern urban environment.

1. The results show that concentrations of pollutants such as PM_{2.5}, PM₁₀, and nitrogen dioxide in residential areas often exceed international hygienic standards, significantly increasing the risk of cardiovascular and respiratory diseases. Long-term exposure to fine particulate matter has been scientifically proven to be directly associated with increased overall mortality and chronic morbidity.
2. The analysis of the literature indicates that the health effects of air pollution vary depending on age and physiological status. Children, older adults, and pregnant women represent the most vulnerable groups, in whom even low concentrations of pollutants combined with long-term exposure can lead to serious adverse outcomes. This substantiates the necessity of mandatory consideration of individual and demographic factors in hygienic assessments.
3. Based on the results and discussion, it is evident that air quality assessment in residential areas should not be limited to laboratory measurements alone but must be integrated with epidemiological data, exposure duration, and regional urban planning characteristics. Such an approach is essential for identifying real health risks and developing effective preventive measures.

Reducing and controlling ambient air pollution in residential areas should be a priority direction of sanitary-hygienic, environmental, and public health policy. Strengthening air quality monitoring, improving urban infrastructure, and implementing scientifically grounded preventive strategies are essential conditions for protecting population health and forming a sustainable urban environment.

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