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URBANIZATION PROCESSES AND ECOLOGICAL BURDEN: EPIDEMIOLOGICAL ASSESSMENT OF AIR, WATER, AND SOIL POLLUTION

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Abstract
This article provides a comprehensive analysis of the ecological burden caused by urbanization, particularly the epidemiological impact of air, water, and soil pollution. The pace of urbanization is associated with population concentration in cities, increased industrial activity, and higher transportation density, all of which contribute to environmental pollution. Based on scientific research and statistical data, the article evaluates air degradation, changes in the quality of water resources, and the rising concentration of heavy metals in urban soils. Findings emphasize the negative ecological consequences of urbanization and highlight the urgent need for sustainable urban planning policies.

Keywords: Urbanization, ecological burden, air pollution, water quality, soil pollution, epidemiological assessment.

Introduction

In the 21st century, urbanization has dramatically reshaped the global demographic landscape. According to data from the United Nations, while in the 1950s only around 30% of the world’s population lived in cities, today this figure is approximately 55–57%, and it is projected to reach 68% by 2050. Such large-scale demographic shifts turn cities into economic, social, and cultural centers, yet simultaneously place an unprecedented ecological burden on them. Industrialization, increased traffic flows, intensified construction activities, and lifestyle-driven consumption patterns have deepened environmental degradation in urban settings — particularly affecting air, water, and soil — and these processes have created significant epidemiological health risks.

The ecological burden created by urbanization is a multifactorial and complex system. The primary anthropogenic sources affecting atmospheric air quality include motor vehicles, heat and energy-producing facilities, the construction industry, and domestic waste incineration — all of which increase concentrations of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and fine particulate matter ($PM_{2.5}$ and PM_{10}). Contemporary multi-city studies show that increases in urban surface area and industrial share significantly elevate $PM_{2.5}$ levels; every 1 μg/m³ increase in $PM_{2.5}$ may result in approximately 2.5 additional respiratory disease cases per 1,000 residents.

European-country–based analyses further demonstrate that exposure to particulate matter and NO_2 is associated with tens of thousands of annual deaths and the emergence of chronic diseases, including asthma, cardiovascular disorders, and type 2

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diabetes. These findings confirm that air pollution driven by urbanization is not merely an environmental issue, but a significant public-health concern.

Water resources are also experiencing profound transformations due to urbanization. Expansion of urban territory, increased impervious surface coverage (asphalt, concrete), and insufficient modernization of sewerage infrastructure lead to the transport of contaminants — heavy metals, food industry and household chemical waste, nitrates, phosphates, and organic substances — into rivers and reservoirs via rainfall and wastewater. A global review of 625 studies demonstrated that in the past 20 years, increasing proportions of newly built urban areas correlate with consistent deterioration of water-quality indicators (nitrates, phosphates, chemical oxygen demand, dissolved oxygen), and the emergence of "black and foul-smelling" water zones has become a major barrier to cities' sanitary and economic development. Use of such water bodies for drinking, irrigation, or recreation can increase risks of intestinal infectious diseases, parasitic infections, allergic reactions, and even oncological diseases.

Studies analyzing the connection between urban growth and water resources emphasize that in developing countries, unplanned urban expansion and chaotic placement of industrial zones are accelerating degradation of aquatic systems.

Soil ecosystems are also being significantly damaged as a "silent witness" of the urban ecological burden. Heavy metals — lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), as well as zinc (Zn) and copper (Cu) — accumulate in urban areas due to vehicle emissions, industrial discharge, construction activities, and domestic waste. A systematic review covering 174 cities worldwide on heavy-metal contamination in urban soils and road dust (2010–2022) showed that concentrations exceed ecological safety standards in many metropolitan regions, and in some cases re-enter the human body through the food chain. A study published in 2025 further emphasized that heavy-metal contamination of urban soils is a global environmental and public-health issue, highlighting their high toxicity, persistence, and ability to enter the food chain — all of which increase their epidemiological importance.

Thus, the environmental burden caused by urbanization is not limited to a single component — such as atmospheric air — but simultaneously intensifies across three interconnected media: air, water, and soil. Although many studies focus on each component separately, an integrated understanding of ecological burden requires a comprehensive epidemiological assessment of pollution indicators in connection with urbanization rates across all three sectors. Such an approach would allow for a more accurate modeling of the real exposure profiles of city populations, multi-channel exposure pathways (inhalation, ingestion, dermal contact), and long-term health outcomes. Moreover, identifying the relationship between urbanization and ecological burden provides a scientific foundation for sustainable city planning, development of green infrastructure (urban forests and green zones), implementation of clean technologies, and optimization of ecological-monitoring systems. These needs

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determine the relevance of this study and justify the necessity of complex epidemiological evaluation of air, water, and soil pollution amid urbanization.

Research Objective

This article aims to: Assess the epidemiological effects of urbanization on air, water, and soil pollution; Identify potential health-impact pathways associated with each environmental factor; Develop recommendations to strengthen sustainability principles within urban-planning practices.

Materials and Methods

A secondary-data literature-analysis method was applied. Publications relating to urbanization and environmental pollution, including scientific articles, monitoring reports, and statistical datasets, were collected and analyzed. Chronological and comparative-classification methods were used to assess epidemiological evidence. ResearchGate, MDPI, PubMed, and other scholarly databases served as the primary data sources.

Results

Findings reveal that urbanization processes influence air, water, and soil pollution — and demonstrate their epidemiological implications for human health. Key results across the three main environmental components are summarized below.

Air Pollution and Epidemiological Impact. Urban-related air pollution significantly increases concentrations of $PM_{2.5}$, NO_2, and O_3. Studies indicate that $PM_{2.5}$ levels in cities commonly exceed national and global standards. For example, environmental monitoring conducted in Bantul (Indonesia) in 2025 recorded $PM_{2.5}$ concentrations ranging from 50.7 to 61.9 $\mu g/m^3$ — markedly above the 35 $\mu g/m^3$ national limit. Epidemiological analysis confirmed health risk levels with RQ > 1, indicating a measurable and harmful impact on population health. Additionally, associations were found between urban $PM_{2.5}$ exposure and symptoms such as coughing, headaches, breathing difficulties, and ocular irritation — further confirming the epidemiological burden of polluted urban air.

Another analysis conducted in Chengdu (China) assessed $PM_{2.5}$ and O_3 exposure-related health risks between 2015 and 2021. Results indicated that over the seven-year period, non-accidental deaths attributable to $PM_{2.5}$ reached 9,386 (CI 6,542–11,726), while those attributable to O_3 totaled 8,506 (CI 4,817–11,882). These findings demonstrate that the degree of pollution associated with urbanization is directly and significantly linked to epidemiological risk.

At the same time, the most comprehensive global assessment of pollution-related health impacts — reported by The Lancet Commission — states that in 2015 nearly 9 million premature deaths were linked to pollution, the majority of which were attributed to outdoor air pollution in urban areas. This underscores the seriousness of the epidemiological perspective.

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Water Pollution and Epidemiological Analysis. Water pollution caused by urbanization primarily results from municipal wastewater, runoff from uncovered surfaces (gasoline, motor oils, heavy metals, pesticides), and other contaminants entering aquatic systems. Urban surface runoff introduces high concentrations of nitrates, phosphates, and organic compounds into water bodies, accelerating eutrophication processes.

Epidemiologically, this type of pollution worsens drinking-water quality and increases the risk of waterborne diseases — including diarrheal infections, parasitic diseases — as well as long-term risks of cancer and endocrine disruption. National and international monitoring programs have consistently reported a direct relationship between urbanization intensity and declining water-quality indices. Global analyses further show that areas with a high rate of urban expansion statistically exhibit lower water-quality measures, which in turn significantly influence epidemiological outcomes.

Soil Pollution and Health Risk. Heavy-metal contamination of urban soils is one of the most serious urbanization-related environmental issues. As urbanization expands, heavy metals — including lead (Pb), zinc (Zn), cadmium (Cd), copper (Cu), and other toxic elements — infiltrate soil through transport emissions, industrial activities, and surface runoff. High concentrations of such metals in soil not only damage soil micro-organisms and ecosystems, but also pose the risk of re-entering the human body through the food chain.

From an epidemiological standpoint, contaminated soil increases risks of dermal exposure, oral ingestion of toxic substances, and long-term risks of oncological and neurological disorders. Studies assessing soil pollution associated with urbanization show that concentrations of heavy metals in soils near industrial and transportation zones are significantly above normative standards, increasing ecological burden and epidemiological threats.

Epidemiological Correlations. When air, water, and soil-pollution patterns associated with urbanization are collectively analyzed, several key epidemiological relationships become evident:

Air pollution and disease burden: $PM_{2.5}$ and O_3 levels significantly increase epidemiological risk, raising mortality and morbidity linked to cardiovascular, respiratory, and oncological diseases. Water quality and infectious disease: Chemical contaminants from urban wastewater elevate risks of intestinal and parasitic infections, with water-quality indices consistently lower in urban regions. Soil contamination and long-term health: Heavy-metal soil contamination poses chronic epidemiological threats, particularly among children and adults exposed via food-chain re-entry or physical contact.

Discussion

This section interprets the epidemiological consequences of air, water, and soil pollution driven by urbanization and compares the findings with global scientific literature to clarify their broader significance.

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Air Pollution and Human Health. The results demonstrated that urbanization increases concentrations of atmospheric pollutants — particularly $PM_{2.5}$ and NO_2 — which substantially elevate risks of respiratory diseases, cardiovascular disorders, and chronic pulmonary illness. These findings are consistent with global literature: air pollution contributes to more than 4.2 million premature deaths worldwide each year, mainly through cardiovascular and pulmonary mechanisms. This confirms that urban atmospheric pollution is a major public-health hazard.

Furthermore, scientific literature shows a complex linkage between urban air quality and human health — including interactions involving the urban heat-island effect, transportation emissions, and city design. Urban transport systems, large-volume traffic, and inadequate ecological infrastructure elevate PM concentrations; in particular, under high-temperature conditions, both $PM_{2.5}$ and O_3 levels rise, intensifying respiratory-disease risk.

These insights align strongly with the epidemiological risks identified in the results: urban air pollution directly increases morbidity and mortality, and therefore air-quality indicators must be a central consideration in urban-planning strategies.

Integration of water pollution and health risks. The results showed that pollutants originating from wastewater and urban runoff led to a measurable decline in water-quality indices. Consequently, drinking-water quality deteriorates, and the risk of waterborne diseases — including enteric infections and parasitic illnesses — increases.

Extensive research has examined the mechanisms of urban runoff pollution. For example, rapid flow from urban shelters transports salinity, organic matter, and heavy metals into water bodies, disrupting aquatic ecosystems and compromising water resources used by humans. Deteriorating water quality promotes the proliferation of biological contaminants, causes oxygen depletion, and accelerates eutrophication — affecting not only aquatic life but also human health.

From an epidemiological standpoint, declining water quality increases the risk of waterborne diseases among infants and children — such as diarrhea, parasitic infections, and other gastroenterological problems. This reveals a critical link between rapid urbanization and insufficient sanitation infrastructure.

Soil pollution and long-term health risks. The results indicated heavy-metal contamination in urban soils. Such findings are globally consistent: soil pollution — especially the accumulation of heavy metals and toxic chemical compounds — poses a serious health threat, as contaminants can return to the human body through the food chain. The biological basis of the relationship between soil quality and human health has been widely studied, with evidence linking contaminated soil to increased risks of osteoporosis, cardiovascular disorders, neurological diseases, and cancer.

Soil pollution is responsible not only for crop contamination but also for wash-off into waterways, creating a coupled-stressor effect — linking soil and water contamination. This integrated mechanism demonstrates more accurately how air, water, and soil collectively impact population health.

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Formation of epidemiological risk. When assessing the health burden caused by air, water, and soil contamination associated with urbanization, it is essential to consider their combined effects. Air pollution continuously contributes to respiratory and cardiovascular illnesses; declining water quality increases gastroenterological and intestinal infectious diseases; and soil pollution leads to long-term toxic exposures — particularly due to heavy-metal bioaccumulation. These findings demonstrate that epidemiological impacts occur through multiple pathways and therefore must be evaluated within the broader context of an integrated ecological burden.

Conclusion

This study focused on examining how urbanization shapes ecological burden — particularly air, water, and soil pollution — and how these environmental factors contribute to epidemiological risks in the population. An integrated interpretation of the findings shows that rapid urban expansion and increased industrial-transport pressure are driving progressive degradation of ecological systems — resulting in serious, visible health consequences.

1. Urbanization's impact on atmospheric pollutants was clearly and statistically demonstrated: elevated $PM_{2.5}$ and NO_2 levels increase risks of cardiovascular and respiratory disease, as well as premature mortality. These results align with international epidemiological evidence, confirming that urban air is a major public-health hazard.
2. Water resources have become the weakest link in urban expansion: chemical and biological contaminants from wastewater have reduced water-quality indices, raised risks of intestinal infectious diseases, and placed severe pressure on sanitation systems. This indicates that infrastructure development is lagging behind the pace of urban growth.
3. Soil contamination — particularly the accumulation of heavy metals (Pb, Cd, Hg and others) — constitutes a "silent source" of long-term ecological and health risk. Bioaccumulation routes through the food chain threaten the health of future generations and highlight the need for monitoring and remediation programs.

Urbanization must therefore be viewed not only as a driver of economic and social development, but also as a source of ecological burden and multi-channel health risk. Integrating sustainable ecological strategies into city-planning — including green-infrastructure expansion, ecological monitoring, and public-health–aligned policies — is essential for ensuring future urban well-being. Managing urban growth is ultimately a matter of protecting both cities and population health.

References

1. Abidin, A. U., & Rekso, N. A. (2025). Environmental health risks and impacts of PM2.5 exposure: A health risk assessment in Bantul Regency, Indonesia. Environmental Health and Preventive Medicine, 30, Article S2214750025000678.

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2. Adewumi, A. J., & Ogundele, O. D. (2024). Hidden hazards in urban soils: A meta-analysis review of global heavy metal contamination (2010-2022), sources and its Ecological and health consequences. Sustainable Environment, 10(1). https://doi.org/10.1080/27658511.2023.2293239
3. Axmadaliyeva, N. O., Bozorova, M. Y., Nigmatullayeva, D. J., & Jalolov, N. N. (2023). GIPERTONIYA KASALLIGI SABABLARI VA DAVOLASH USULLARI. Евразийский журнал медицинских и естественных наук, 3(6 Part 2), 130-133.
4. Diao B, Ding L, Zhang Q, Na J, Cheng J. Impact of Urbanization on $PM_{2.5}$-Related Health and Economic Loss in China 338 Cities. Int J Environ Res Public Health. 2020 Feb 5;17(3):990. doi: 10.3390/ijerph17030990. PMID: 32033295; PMCID: PMC7037730.
5. European Commission. (2025, January 15). Urbanization drives water quality decline over the last 20 years. Smart Water Magazine.
6. Fuller, R., & Landrigan, P. J. (2022). Pollution and health: A progress update. The Lancet Planetary Health, 6(6), e535–e547. https://doi.org/10.1016/S2542-5196(22)00090-0
7. Ikramova, N. A., Jalolov, N. N., Mirsagatova, M. R., Kasimova, K. T., Sadirova, M. K., & Sultonov, E. Y. (2025, April). AMBIENT TEMPERATURE AND THE RISK OF THERMOREGULATORY DISORDERS AMONG TRAFFIC POLICE OFFICERS: AN EPIDEMIOLOGICAL ANALYSIS. International Conference on Advance Research in Humanities, Applied Sciences and Education.
8. Jalolov, N. N., Umedova, M. E., & Ikramova, N. A. (2025, April). Occupational risk factors for workers operating in hot climates: the case of traffic police officers. International Conference on Advance Research in Humanities, Applied Sciences and Education.
9. Khilola, T. K. (2024). Assessment of environmental conditions in tashkent and relationship with the population suffering from cardiovascular diseases.
10. Lou, X., & Zhou, Y. (2025). Can the Effectiveness of Urban Water Pollution Control Contribute to the Overall Development of the City? Evidence from 268 Cities in China. Water, 17(17), 2502. https://doi.org/10.3390/w17172502
11. Mandard, S. (2025, January 30). Air pollution's economic and health costs in France. Le Monde.
12. Münzel T, Hahad O, Daiber A, Landrigan PJ. Soil and water pollution and human health: what should cardiologists worry about? Cardiovasc Res. 2023 Mar 31;119(2):440-449. doi: 10.1093/cvr/cvac082. PMID: 35772469; PMCID: PMC10064841.
13. Piracha, A., & Chaudhary, M. T. (2022). Urban Air Pollution, Urban Heat Island and Human Health: A Review of the Literature. Sustainability, 14(15), 9234. https://doi.org/10.3390/su14159234
14. Rahimov, B. B., Salomova, F. I., Jalolov, N. N., Sultonov, E. Y., Qobiljonova Sh, R., & Obloqulov, A. G. (2023). O 'ZBEKISTON RESPUBLIKASI NAVOIY SHAHRI HAVO SIFATINI BAHOLASH: MUAMMOLAR VA YECHIM YOLLARI.

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15. Saucier D, Registe PPW, Bélanger M, O'Connell C. Urbanization, air pollution, and water pollution: Identification of potential environmental risk factors associated with amyotrophic lateral sclerosis using systematic reviews. Front Neurol. 2023 Mar 8;14:1108383. doi: 10.3389/fneur.2023.1108383. PMID: 36970522; PMCID: PMC10030603.
16. Tu, J., Zhang, F., Huang, F. et al. Effects of urbanization on soil heavy metal accumulation and improvement using Glomalin-related soil protein. Sci Rep 15, 22000 (2025). https://doi.org/10.1038/s41598-025-05456-5
17. Wang XY, Liu EF, Yang XM, Wang BL, Lin JK, Yan MX, Bi SJ. [Critical Review on Heavy Metal Contamination in Urban Soil and Surface Dust]. Huan Jing Ke Xue. 2024 May 8;45(5):2926-2938. Chinese. doi: 10.13227/j.hjkx.202306138. PMID: 38629554.
18. Zhan, C., Xie, M., Lu, H., Liu, B., Wu, Z., Wang, T., Zhuang, B., Li, M., and Li, S.: Impacts of urbanization on air quality and the related health risks in a city with complex terrain, Atmos. Chem. Phys., 23, 771–788, https://doi.org/10.5194/acp-23-771-2023, 2023.
19. Ахмадалиева, Н. О., Нигматуллаева, Д. Ж., Ёкубов, М. С., & Хакимова, Д. С. (2018). Исследование показателей терморегуляции у рабочих в условиях нагревающего микроклимата. In INTERNATIONAL INNOVATION RESEARCH (pp. 223-225).
20. Самигова, Н. Р., Шеркузиева, Г. Ф., Мусаев, Э. В., Рустамова, М. К. К., & Хаджаева, У. А. К. (2019). Особенности условий труда медицинских работников санитарно-гигиенических лабораторий. Academy, (2 (41)), 97-98.
21. Нигматуллаева, Д. Ж. (2018). Исследование функционального состояния зрительного и слухового анализаторов у работников умственного труда. In advanced science (pp. 218-220).
22. Ниязова, О. А., Хусниддинова, М. С., Махкамова, Д. М., & Нигматуллаева, Д. Ж. (2025, March). МИКРОКЛИМАТ КЛАССНЫХ ПОМЕЩЕНИЙ ОБЩЕОБРАЗОВАТЕЛЬНОЙ ШКОЛЫ И ЗДОРОВЬЕ УЧАЩИХСЯ. International Conference on Advance Research in Humanities, Applied Sciences and Education.
23. Рахимов, Б. Б., Саломова, Ф. И., Жалолов, Н. Н., Султонов, Э. Ю., & Облакулов, А. Г. (2023). Оценка качества атмосферного воздуха в городе навои, республика Узбекистан: проблемы и решения. In Сборник трудов по материалам Международной научно-практической конференции.