

THE IMPACT OF AIR POLLUTION ON OUR HEALTH

Yuldosheva Kamola Urol qizi

First-year student, Group 101

*Faculty of Biotechnology Engineering and Pharmacy, Samarqand
State Medical University*

Asatillayev Rustamjon Bakhtiyarovich

Samarqand State Medical University, Stajior-assistant

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ABSTRACT:

This research article provides an in-depth examination of the escalating crisis of atmospheric air pollution and its multifaceted consequences on human physiology. As urbanization and industrialization reach unprecedented levels, the quality of the air we breathe has deteriorated, leading to what many experts call a ‘public health emergency.’ This paper specially analyzes the biochemical pathways through which pollutants such as fine particulate matter (PM_{2.5}), nitrogen oxides (NO) and sulfur dioxide (SO₂) induce systemic inflammation and oxidative stress. By synthesizing current epidemiological data, the article highlights the causal links between long-term exposure and chronic conditions, including cardiovascular diseases, respiratory failure, and emerging neurological impairments. The abstract concludes that without immediate transition to green energy and rigorous environmental policy enforcement, the global burden of disease related to air quality will continue to rise, disproportionately affecting vulnerable populations.

Introduction: The air is an invisible infrastructure of life, yet it has become a carrier for toxic substances. In the 21st century, air pollution is identified by the World Health Organization as the single largest environmental risk to health. While infectious diseases dominated the 20th century health discourse, non-communicable diseases driven by environmental factors—specifically air toxicity—are the primary challenge of the modern era. Understanding the enemy requires a breakdown of its chemical and physical components: Particulate matter is a complex mixture of extremely small particles and liquid droplets. PM10: Inhalable particles, with diameters that are generally 10 micrometers and smaller. PM2.5: Fine inhaled particles, with diameters that are 2.5 micrometers and smaller. These are the most lethal as they can settle deep into the lungs and cross the blood-air barrier. Gaseous Pollutants Nitrogen Dioxide: A foul-smelling gas from vehicle exhaust that causes airway inflammation. Particles smaller than 0.1 microns that can translocate directly into the cell mitochondria and the central nervous system.

Beyond solids, gaseous pollutants play a critical role: Carbon monoxide: Competes with oxygen for hemoglobin binding, causing tissue hypoxia. Unlike the protective ozone layer, surface ozone is a potent respiratory irritant formed via photochemical reactions.

When pollutants are inhaled, they trigger an immediate immune response. Alveolar macrophages attempt to ingest particles, leading to the release of pro-inflammatory cytokines. This chronic low-grade inflammation results in: Remodeling of airway tissues. Increased mucus hypersecretion. Irreversible decline in Forced Expiratory Volume.

Perhaps the most significant discovery in modern toxicology is that air pollution is a cardiovascular poison. PM2.5 enters the bloodstream and causes Endothelial Dysfunction: The lining of blood vessels loses its elasticity. Systemic Oxidative Stress: Leading to the oxidation of LDL cholesterol, a key step in plaque formation. Autonomic Disruption: Altering heart rate variability and increasing the risk of sudden cardiac arrest.

Recent evidence suggests that the brain is a major target of air pollution. Pollutants can reach the brain through two pathways: Systemic via the bloodstream after crossing the blood-brain barrier.

Olfactory directly from the nose via the olfactory nerve. This has been linked to increased beta amyloid plaques, similar to those found in Alzheimer's patients.

The health impact of air pollution is inextricably linked to poverty. Pollution-related illnesses lead to millions of lost workdays and decreased cognitive performance in students. The World Bank estimates that the global cost of health damages caused by air pollution is approximately \$8.1 trillion annually, or 6.1% of global GDP. Low and middle income

countries suffer the highest exposure levels due to reliance on solid fuels for cooking and lax industrial regulations. To bend the curve of pollution related mortality, a systemic shift is required. Reducing waste and industrial emissions through advanced filtration and carbon capture. Designing cities to reduce the need for motorized transport. Expanding AQI sensor network to provide citizens with actionable data to protect their health.

The evidence is irrefutable air pollution is a multi systemic toxin that affects every organ in the human body. The transition to clean energy is not just an ecological necessity but a fundamental public health imperative. Our ability to clean the atmosphere will determine the health trajectory of future generations.

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