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Air Pollution and Health Hazards

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Abstract

Air pollution is one of the most significant environmental health risks globally. Both outdoor (ambient) and indoor air pollution contribute substantially to morbidity and mortality, particularly in developing countries. According to the World Health Organization (WHO), air pollution caused approximately 7 million premature deaths annually by 2012–2014 (4). Major pollutants include particulate matter (PM2.5 and PM10), nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3), and volatile organic compounds (VOCs). Exposure to these pollutants has been linked to respiratory diseases, cardiovascular disorders, cancer, neurological effects, and adverse pregnancy outcomes. This review paper summarizes the sources, mechanisms, epidemiology, and public health impacts of air pollution. The paper also discusses preventive strategies and policy interventions necessary to reduce health hazards associated with air pollution.

Keywords: Air pollution, PM2.5, respiratory diseases, cardiovascular disease, environmental health, public health policy

1. Introduction

Air pollution refers to the contamination of indoor or outdoor air by chemical, physical, or biological agents that modify the natural characteristics of the atmosphere. Industrialization, urbanization, transportation, fossil fuel combustion, and biomass burning are major contributors.

The World Health Organization reported that over 90% of the global population lives in areas where air quality exceeds guideline limits (5). Rapid economic development, particularly in low and middle-income countries such as India and China, has intensified exposure levels.

Air pollution is classified into:

- Outdoor (ambient) air pollution
- Indoor (household) air pollution

Both forms significantly impact human health.

2. Major Air Pollutants

2.1 Particulate Matter (PM)

Particulate matter is categorized by size:

- PM10 (≤10 μm)
- PM2.5 (≤2.5 μm)

Fine particles (PM2.5) penetrate deep into the lungs and enter the bloodstream. The International Agency for Research on Cancer classified outdoor air pollution and particulate matter as Group 1 carcinogens in 2013 (2).

2.2 Nitrogen Oxides (NOx)

Produced mainly by vehicles and power plants, NOx contributes to respiratory irritation and the formation of secondary pollutants like ozone.

2.3 Sulfur Dioxide (SO2)

Generated by burning sulfur-containing fossil fuels. It causes broncho constriction and aggravates asthma.

2.4 Ozone (O3)

Ground-level ozone forms through chemical reactions between NOx and VOCs in sunlight. It is a strong respiratory irritant.

2.5 Carbon Monoxide (CO)

CO reduces oxygen delivery to tissues by binding with hemoglobin, leading to hypoxia.

2.6 Volatile Organic Compounds (VOCs)

These include benzene and formaldehyde, which are toxic and carcinogenic.

3. Sources of Air Pollution

3.1 Anthropogenic Sources

- Vehicle emissions
- Coal-based power plants

- Industrial processes
- Construction activities
- Biomass burning

3.2 Natural Sources

- Forest fires
- Volcanic eruptions
- Dust storms

In India, vehicular emissions and biomass burning remain primary contributors.

4. Mechanisms of Health Effects

Air pollutants cause damage through:

- Oxidative stress
- Inflammation
- Endothelial dysfunction
- DNA damage
- Immune system modulation

Fine particles trigger systemic inflammation, leading to cardiovascular complications.

5. Respiratory Health Effects

5.1 Asthma

Exposure to PM2.5 and ozone increases asthma attacks and hospital admissions.

5.2 Chronic Obstructive Pulmonary Disease (COPD)

Long-term exposure worsens COPD symptoms and progression.

5.3 Lung Cancer

The International Agency for Research on Cancer concluded that outdoor air pollution causes lung cancer.

6. Cardiovascular Health Effects (01)

- Air pollution increases:
- Hypertension
- Ischemic heart disease
- Stroke
- Heart failure

A major epidemiological study (03) showed long-term PM exposure increases cardiovascular mortality.

7. Vulnerable Populations

- Children
- Elderly
- Pregnant women
- Low socioeconomic groups

Children are particularly vulnerable due to developing lungs and higher breathing rates.

8. Indoor Air Pollution

Indoor pollution is mainly caused by:

- Biomass fuels (wood, dung, coal)
- Poor ventilation
- Tobacco smoke

In developing countries, women and children face high exposure.

9. Global Burden of Disease

According to the Global Burden of Disease (GBD) Study 2012, 2013 (2,6,7):

- Air pollution ranked among the top risk factors for death globally.
- Major contributors: stroke, ischemic heart disease, lung cancer, COPD.
- The World Health Organization estimated millions of deaths annually linked to air pollution.

10. Air Pollution in India

India has some of the world's highest PM2.5 levels. Major cities such as Delhi frequently exceed safe limits.

Government initiatives include:

- National Air Quality Monitoring Programme (NAMP)
- National Clean Air Programme (NCAP)

11. Prevention and Control Measures

11.1 Policy Measures

- Stricter emission standards
- Renewable energy promotion
- Public transport enhancement

11.2 Individual Measures

- Use of masks
- Avoid outdoor activities during high pollution
- Improved ventilation indoors

11.3 Technological Solutions

- Air purifiers
- Cleaner fuels (LPG instead of biomass)

12. Conclusion

Air pollution remains a major global public health crisis. Evidence up to 2016 confirms its strong association with respiratory, cardiovascular, and oncological diseases. Multi sectoral approaches combining policy regulation, technological innovation, and community awareness are essential to mitigate health hazards. Strengthening monitoring systems and promoting sustainable development are critical for future health protection.

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