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Review Article

Air Pollution and Health Hazards: A Narrative Review from the Bangladesh Perspective

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Abstract:

Air pollution poses a severe health hazard in Bangladesh, contributing to approximately 173,500 deaths in 2019. This review examines the pervasive impact of PM2.5 and PM10 pollutants emanating from sources like brick kilns, vehicles, and biomass burning, surpassing safe thresholds. These pollutants are linked to widespread respiratory diseases, cardiovascular complications, and elevated mortality rates among the population. Despite regulatory efforts, persistent challenges underscore the urgent need for cleaner technologies, sustainable urban planning, and heightened public awareness campaigns. Effective global and national strategies are crucial to mitigate these health risks and foster sustainable development in Bangladesh and globally.

Key words: Air pollution, Industrialization, Human and environmental health.

Introduction:

Since the Industrial revolution, the world has experienced a rapid transformation in lifestyle. Mankind enjoys a more mechanized and modernized living standard due to industrial, agricultural, technological, and transport innovations. However, these advancements come with a heavy cost to the environment. Rapid industrialization and deforestation have led to numerous atmospheric, climatic, and biophysical changes. Among them, air pollution is one of the most significant challenges to our health and environment that we have to encounter now a day.

What is air pollution and pollutant?

Air pollutants are a heterogeneous group of substances that alter the natural chemical composition of air, impacting human health and the environment. Air pollution exists when levels of atmosphere gasses, solids, or liquids are high enough to harm humans, other organisms, or materials[1].

The air may become polluted by natural causes like volcanoes, which release dust, ash, sulfur, and other gases, or by the forest fires that are occasionally caused by lightning. However, today, human activities are responsible for most air pollution. These air pollutants are divided into two groups. Primary air pollutants are harmful chemicals released directly into the atmosphere from a source, such as carbon oxides (CO & CO2), nitrogen oxides, sulfur oxides, volatile organic compounds (mainly hydrocarbons), suspended particulate matter, and heavy metals. Secondary air pollutants are produced by chemical reactions involving primary pollutants, such as sulfuric acid, nitric acid, mist, Smog, and ozone.

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How air pollution is quantified?

Air quality monitors are equipped with various sensors to detect specific pollutants. Some of these sensors use lasers to measure the density of particles in a cubic meter of air, while others use satellite imaging to assess the energy reflected or emitted by the Earth. Key pollutants that affect human and environmental health include PM2.5, PM10, and gases like ground-level ozone, nitrogen dioxide, and sulfur dioxide. The Air Quality Index (AQI), which ranges from zero to 500, increases with higher pollutant densities. An AQI of 50 or below is considered safe, whereas readings over 100 are unhealthy. According to UNEP partner IQAir, only 38 out of 117 countries and regions had average AQI readings in the healthy range in 2021[2].

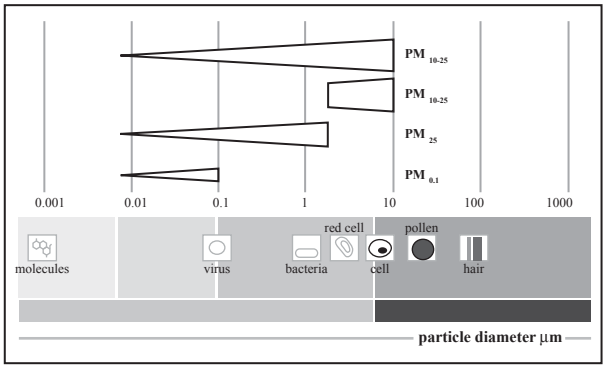

Figure 1: Aerosol sampling metrics based on PM10 and PM2.5, including ultrafine and coarse fractions[3].

PM sampling is based on PM10 and PM2.5 metrics, where PM10 is defined as particulate matter with a mean aerodynamic diameter equal to or less than 10 µm, while PM2.5 covers particulate matter with a mean aerodynamic diameter equal to or less than 2.5 µm. Both standards exclude particles above the specified size from being retained, while PM2.5 is included in PM10. The diagram depicts the particle size range covered by these PM references. Aerodynamic diameter does not necessarily coincide with the geometrical diameter of aerosol particles. However, it defines a virtual diameter of particles with their density and shape, having a terminal velocity equivalent to that of a spherical particle of unitary diameter and density[4].

What are the sources of air pollution?
Sources of outdoor air pollution

Automobiles and Industries are the main contributors to outdoor air pollution worldwide. Burning of fossil fuels in automobiles, power stations, chemical, metal and other industries cause air pollution. Lead was added to the petrol to prevent the 'knocking' of the engine. Lead is highly poisonous, and a significant accumulation of lead in the body can result in paralysis, blindness and even death. Trucks and buses run on diesel, which has high Sulphur content. The old engines emit vast quantities of suspended particulate matter, leading to heavy air pollution in many cities. All these combined can cause Smog, a type of air pollutant. The word "smog" is a combination of smoke and fog. It is a severe problem in Beijing and many other cities. In Los Angeles, exhaust fumes from cars cause Smog.

Smog first appeared in London in the 13th century. The Great Smog of London in 1952 first drew attention to the direct health hazard and air pollution when over 4000 Londoners died, and more than 12000 suffered from various illnesses, including respiratory tract diseases. Since then, it led to several changes in practice and regulation of United KIngdom, including The clean air act.

Other outdoor pollutants are building structures and mining activities leading to dust, decaying organic matter; burning wastes of all kinds, disasters like earthquakes, volcano eruptions, dust storms, leak of gases (like the Bhopal case), armed conflicts causing destruction of structures and using chemical explosives; festivals (e.g., Diwali with its crackers) etc. Polluted air may spread to places thousands of kilometers away known as trans boundary air pollution.

Sources of indoor air pollution:

Among indoor air pollutants, cigarette smoking is significant. Cigarette smoke affects both smokers and non-smokers. The common pollutants in urban interiors are cigarette smoke, gases from stoves, formaldehyde (from carpets and furniture), cleaning solvents and ozone (from photocopies), pesticides, mosquito repellents, cleaning agents, etc, used in households can cause toxic conditions. Building materials like asbestos, glass fiber, paints, glues, and varnishes are all health hazards. They can irritate the eyes and skin, respiratory ailments and cancer. Air-conditioned rooms and offices cause a broad spectrum of health complaints because the sealed space accumulates various contaminants.

In rural areas, however, indoor air pollution is caused by burning biomass fuel. Around 2.3 billion people worldwide (around a third of the global population) cook using open fires or inefficient stoves fuelled by kerosene, biomass (wood, animal dung and crop waste) and coal, which generates harmful household air pollution.

This is equivalent to smoking 100 cigarettes a day. Household air pollution was responsible for an estimated 3.2 million deaths per year in 2020, including over 237,000 deaths of children under the age of 5[5].

What are the health hazards?

Air pollution is a significant public health issue, leading to millions of premature deaths worldwide. Among all the pollutants, air pollution is the most important cause of death[6]. The World Health Organization (WHO) notes that 92% of the world's population currently breathes poor air quality[7].

Numerous studies describe that all types of air pollution, at high concentrations, can affect the airways. Nevertheless, similar effects are also observed with long-term exposure to lower pollutant concentrations. Air pollution may contribute to the development, concern, or exacerbation of some of the most common respiratory diseases, particularly bronchial asthma and chronic obstructive pulmonary disease (COPD). The most vulnerable population groups are represented by children and older adults suffering from chronic diseases. Respiratory diseases caused by pollutants are known to prevail in industrialized areas, and their severity is correlated to time of exposure to pollution and atmospheric pollutants[8].

Symptoms such as irritation of the nose and throat, along with bronchoconstriction and dyspnea, particularly in individuals with asthma, are commonly experienced after exposure to elevated levels of sulfur dioxide, nitrogen oxides, and heavy metals like arsenic, nickel, or vanadium[9]. Furthermore, air pollutants such as nitrogen oxides can increase the risk of respiratory infections[10]. Finally, chronic exposure to ozone and certain heavy metals can reduce lung function, with the latter also contributing to asthma, emphysema, and lung cancer[11].

Air pollution that induces lung irritation and changes in inflammatory cytokines can promote a prothrombotic state, potentially leading to coronary artery disease, angina, or even myocardial infarction[12]. Heavy metals (lead, mercury, and arsenic) and dioxins primarily affect the nervous system, causing neurotoxicity and neuropathies, with symptoms such as memory disturbances, sleep disorders, anger, fatigue, hand tremors, blurred vision, and slurred speech after exposure to arsenic, lead, and mercury[13]. These heavy metals can also cause kidney damage, beginning with initial tubular dysfunction, evidenced by increased excretion of low molecular weight proteins, and progressing to decrease glomerular filtration rate (GFR). They also increase the risk of stone formation, nephrocalcinosis, and renal cancer[14]. Maternal exposure to heavy metals, particularly lead, increases the risk of spontaneous abortion and reduces fetal growth (preterm delivery, low birth weight). Evidence suggests that parental lead exposure may also lead to congenital malformations and lesions in the developing nervous system, significantly impairing a newborn's motor and cognitive abilities[15].

What is the situation in Bangladesh?

In Bangladesh 123,000 deaths were attributable to air pollution in 2017, increasing to 173,500 in 2019[16]. The proportion of the elderly population has increased in the last decades due to increased life expectancy in Bangladesh, contributing to an additional risk factor for air pollution-related deaths. Unplanned urbanization and pollutants of mega construction works are significant contributors to air pollution in Dhaka, the largest city (IQAir, 2020a). Bangladesh has one of the highest levels of exposure to PM2.5, ranking ninth among the top ten countries with the highest level of PM2.5 in outdoor air[17].

In developing countries like Bangladesh, awareness of air pollution is almost non-existent and often ignored even when air quality becomes intolerable for most citizens. In Dhaka, the capital city and a major metropolis, primary sources of particulate matter include road dust, textile and dyeing industries, tanneries, chemical and cement factories, and brick kilns, all of which are significant contributors to pollution.

Major sources of outdoor air pollution in Bangladesh

The sources of ambient air pollution in Bangladesh include both anthropogenic and natural. Anthropogenic sources include burning fossil fuel, including coal wood, open burning of waste or agricultural residues, emission from motor vehicles, power generation and industries, biomass fuel for cooking, and trans boundary air pollution.

The Natural sources include windblown dust, sea spray, and forest fires (Natural air pollution sources). Natural sources remain localized, while anthropogenic sources are more widely distributed than natural ones[5]. For example, a 2014 report in Dhaka showed that brick kilns, surface dust, and vehicle emissions contribute about 85% of local air pollution. Other sources of air pollution include open landfills, incineration of plastic waste, and industrial processes[18]. We will discuss some of the major sources of ambient air pollution in more detail.

Brick Kilns: There are 7902 brick kilns throughout the country, with about 1000-1200 brick kilns around Dhaka. Due to rapid industrial growth and urbanization, the number of brick kilns has increased. This contributes to 58% of air pollution in Dhaka. In the kilns, coal and wood are used to burn the bricks. Approximately 2.2 million tons of coal are burned, yielding tons of PM, sulfur dioxide, carbon monoxide, volatile organic compounds, and other toxic substances such as furans and dioxin. This emission could be substantially reduced if natural gas replaced coal and wood in brick kiln industries[19,20].

Motor Vehicles: The number of motor vehicles is increasing rapidly in Bangladesh, from 1.49 million in 2010 to 4.44 million in 2020 (BRTA-Number of registered vehicles). The majorities of these vehicles are reconditioned or old and lack proper maintenance. Congested traffic, lousy parking management, contaminated fuels, overloading, and the dust generated due to friction with the roadways contribute to air pollution. About 30-50% of PM collected from different areas of Dhaka city are fine particles generated from transport-related sources, especially from diesel buses and trucks (45%) and autorickshaws (40%)[20]. Petrol-fueled light-duty vehicles (cars/ vans) and autorickshaws contribute 85% of total carbon monoxide (CO), while diesel-fueled buses and trucks contribute 84% of total Nitrogen oxides (NOx). In the late nineties, Dhaka was the most polluted city globally, with the highest levels of lead in the air (463 nanograms/m3). The government banned leaded gasoline in 1999, followed by an embargo on the two-stroke engine autorickshaws. As a result, the lead concentration in the air was reduced[19].

Power Plants: Eighty per cent (80%) of the power generation in Bangladesh is gas-based, while the remaining 20% is coal, liquid, and furnace oil-based. Combustion of coal during electrical utilities contributes about 70% of sulfur dioxide (SO2) and 30% of nitrogen oxides[21].

Infrastructure: Significant infrastructure projects, like roads, rail, bridges, and large buildings, have been undertaken. These projects have led to environmental degradation, dust production, and displacement of communities without proper safety and environmental precautions[22]. These construction projects' road and soil dust significantly contribute to air pollutants, especially PM, during the dry season[20].

Transboundary air pollution: Bangladesh is surrounded by three sides by India, a highly polluted country. Trans boundary pollutants typically originate in North-Western India, West Bengal, Nepal, and the neighboring areas, with pollutants travelling from 200 to 500 km across the border to Bangladesh. The trans boundary PM from India's coal burning contributes to 40% of the air pollution in Bangladesh, especially between November and January[23]. In addition, the burning of agricultural fields in India in October and November emits smoke plumes that blanket almost the whole of Indo the Gangetic Plain (IGP) from the West to the East, including Bangladesh[24], and can even be transported through Himalayan foothills[25].

Major source of indoor air pollution in Bangladesh

Biomass fuel emissions from cook stoves are responsible for 41% of household pollutants[26–28]. A 2020 study showed that 85.5% of the respondents used biomass fuel. The average cooking years of the respondents were 26.9±8.59 years, and the daily average cooking duration was 3.09 hours. The total biomass fuel consumption is 44 million tons annually[20].

Commonly used biomass fuels are wood (41%), leaves, bamboo, cow dung, straw, paddy husk, jute sticks, bagasse, and sawdust. Rural households usually use traditional stoves; one family can consume 7 to 8 kg of biomass fuel daily. However, the efficiency of traditional stoves is poor, and only about 5-15% of available fuel energy is utilized[20,29]; moreover, due to incomplete harmful pollutants such as PMs, carbon monoxide, sulfur dioxide, nitrous oxides, as well as formaldehyde and other carcinogens[27]. Culturally, a Bangladeshi woman prepares food for the family and cooks for 3-7 hours. Thus, women and young children are heavily exposed (WHO, 2006).

About 30 million households in Bangladesh use biomass fuel. This includes 90% of households in rural areas, about 24 million households[29]. After standardization of collected information, it was found that in 2019, the proportion of the population with primary reliance on clean fuels and technologies for cooking was 23%, while it was 13.6% in 2011. Similarly, the number of people primarily relying on clean fuels and technologies for cooking was 38.739 million in 2019 and 20.932 million in 2011. In Bangladesh, the number of solid fuel users decreased to 6.5 million from 2010 to 2019[20]. In addition, Bangladesh Improved Cook Stoves Program has installed 1.7 million Improved Cook Stoves since its inception in 2013, reducing greenhouse gas emissions[29]. Department of Health Survey revealed that 50% of urban households in Bangladesh use solid fuel.

Bangladesh's urban population is about 55 million, and the average household size is 5; about 5.5 million urban households use solid fuels for cooking[20].

How can we prevent it?

The prevention of air pollution is a multisectoral approach. It needs strong international policymakers' commitment, and collaboration with various countries and organizations can play a pivotal role. On the other hand, the national and social movement towards the change in adopting more environmentally friendly energy sources, strict structural and industrial regulations, constant monitoring, awareness, and health education can restrict the extent of air pollution. Personal-level adaptation of healthy lifestyles like smoking cessation and using cleaner fuels for daily use in cooking and running energy-efficient vehicles is another area to be firmly addressed.

To mitigate household air pollution and safeguard health, it is crucial to promote the adoption of clean fuels and technologies. Options include solar power, electricity, biogas, liquefied petroleum gas (LPG), natural gas, alcohol fuels, and biomass stoves that comply with the emission standards set by the WHO Guidelines.

Conclusion:

In conclusion, air pollution remains a formidable public health challenge in Bangladesh, significantly impacting the population's well-being and economic productivity. The pervasive presence of pollutants such as PM2.5 and PM10, originating from various sources, including brick kilns, vehicles, and biomass burning, continues to exceed safe limits, leading to widespread respiratory and cardiovascular ailments. Despite regulatory efforts and interventions, the burden of air pollution persists, necessitating robust measures such as adopting cleaner technologies, stringent enforcement of emission standards, and sustainable urban planning.

Concrete efforts from policymakers, industries, and communities are essential to mitigate air pollution's adverse effects. Public awareness campaigns and investments in green technologies and infrastructure will play pivotal roles in safeguarding public health and promoting sustainable development in Bangladesh. Addressing air pollution comprehensively requires both local initiatives and international cooperation to achieve cleaner air and healthier communities for current and future generations.

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