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Assessing Air Pollution in Dhaka: Impacts, Challenges, and Sustainable Solutions

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Abstract

Air pollution poses a critical challenge in Dhaka, Bangladesh, a city infamous for severe air quality issues driven by rapid urbanization and industrial growth. This review examines the state of air quality in Dhaka, focusing on pollutants such as particulate matter (PM10, PM2.5), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3), which frequently exceed safe levels and significantly impact public health. Dhaka's Air Quality Index (AQI) often reaches hazardous levels, resulting in increased respiratory and cardiovascular diseases. Major sources of air pollution include emissions from brick kilns and a growing fleet of motor vehicles, worsened by traffic congestion. Initiatives like the Clean Air and Sustainable Environment (CASE) project aim to enhance urban transport efficiency and promote cleaner technologies. This review highlights effective strategies for mitigating air pollution in Dhaka and emphasizes the importance of sustainable development through integrated policy interventions, technological advancements, and public engagement.

Keywords: Air pollution, Dhaka, Public health, Urbanization, Sustainable development

1. Introduction

Breathing is essential for survival, and fresh air is crucial for healthy respiration. However, polluted air, containing harmful substances, can gradually take lives. Air pollution is estimated to cause seven million deaths globally each year. The air primarily consists of Nitrogen (78.084%) and Oxygen (20.946%), with traces of Carbon Dioxide, Helium, Neon, Argon, Krypton, and Methane. Harmful compounds like ammonia, carbon monoxide, sulfur dioxide, nitrous oxides, and chlorofluorocarbons are present in small amounts but can be dangerous when elevated [1]. This pollution results from both human activities and natural processes. Bangladesh, located in South Asia and bordered by India, Myanmar, and the Bay of Bengal, has a population of about 174 million, making up 2.1% of the global population. Dhaka, the capital, is the most polluted city in the country due to its high population density and significant economic, cultural, and academic activities. Dhaka is the fourth densest city globally and ranks among the worst for air pollution. Bangladesh is the sixth highest in pollution-related premature deaths, with about 207,922 deaths annually [2] [3] [4]. A recent report from the Health Effects Institute (HEI), in collaboration with UNICEF, highlights concerning trends in air quality both in Bangladesh and globally, indicating serious health risks. Rapid urbanization, industrialization, and increased motorization contribute to Dhaka's air pollution, impacting vital organs and leading to premature deaths. Reducing pollution in major cities could save Bangladesh between $200 million and $800 million annually, representing 0.7 to 3.0% of its GDP [5].

Air Quality Index and Air Quality Monitoring System

The Air Quality Index (AQI) provides daily updates on air quality, indicating how clean or polluted the air is and predicting associated health risks. AQI values range from 0 to 500, with higher numbers signifying greater pollution and more severe health concerns: 0-50 is considered good, 51-100 moderate, 101-150 unhealthy for sensitive groups, 151-200 unhealthy, 201-300 indicating health effects for everyone, and 301-500 hazardous [6]**.** In Dhaka, while the overall AQI is low, the pollution index is high due to significant particulate matter. AQI data helps inform the public, guide emission reductions, and forecast pollution levels, and is based on pollutants like PM10, PM2.5, NO2, CO, SO2, and Ozone, monitored under National Ambient Air Quality Standards (NAAQS) in Bangladesh. Bangladesh's air quality monitoring network, with eleven Continuous Air Quality Monitoring Stations (CAMS), tracks pollution levels, identifies trends, and provides Air Quality Index (AQI) information. It informs

Table 1. Number of vehicles in Dhaka(2015-2019)

Different Registered Vehicles	2015	2016	2017	2018	2019
Private Car	18422	18010	19573	16319	15016
Pick Up	7916	8482	10300	9615	8774
Microbus	4569	5169	4927	3585	3241
Ambulance	358	287	400	456	548
Jeep	3109	4217	4712	4864	5038
Truck	4424	4553	7035	8731	6233

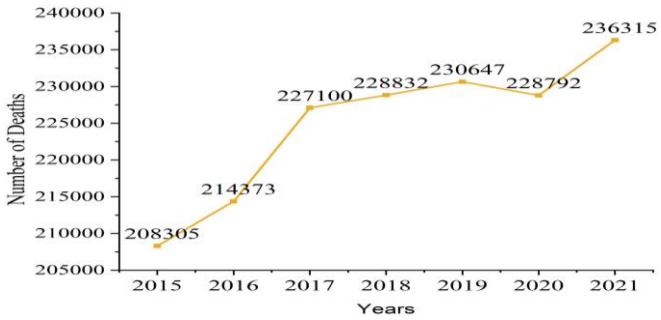


Fig. 1. Number of deaths from air pollution

the public and authorities about air quality in major cities, helps identify pollution sources, assess public exposure, and supports air quality management and planning. The data also aids in developing and validating pollution control strategies [7].

State of Global Air and CASE Project

The "State of Global Air 2019" report identifies air pollution as the third leading cause of death in Bangladesh, responsible for 14% of deaths in 2017. Household and outdoor air pollution are significant risk factors, with 72% of households using solid fuel, worsening the situation. Key health impacts include respiratory and heart diseases, stroke, lung cancer, diabetes, and pneumonia [8]. The Clean Air and Sustainable Environment Project (CASE), funded by the World Bank, ran from October 2009 to June 2019. It aimed to monitor air quality through 11 Continuous Air Quality Monitoring Stations in eight cities, including Dhaka. The project focused on emissions from brick kilns and traffic, tracking pollutants like carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, PM10, and PM2.5 to guide pollution control efforts and assess air quality standards [9] [10].

2. Reasons behind Air Pollution

In Bangladesh, air pollution is primarily driven by automobiles, industrial emissions, poor civic practices, and insufficient government services, with major pollutants including sulfur dioxide, nitrogen dioxide, and particulate matter. Human activities significantly contribute to pollution compared to natural sources. Indoor air pollution, caused by burning fossil fuels and biomass, results in about 3.8 million premature deaths globally each year, with around 70,345 deaths in Bangladesh in 2017 alone. Additionally, outdoor pollution from power generation, industry, and vehicles raises PM10 levels, leading to respiratory and lung diseases [11] [12]**.**

Brick Making Kilns

Brick kilns are a major source of air pollution in Bangladesh, with over 7,900 kilns nationwide and about 1,000 in Dhaka alone [10]. Most kilns use outdated, energy-intensive methods that rely on coal and wood, emitting significant amounts of black smoke, particulate matter, carbon oxides, sulfur oxides, and volatile organic compounds. From 2000 to 2018, coal consumption surged from 3.84 TWh to 24.79 TWh, worsening greenhouse gas emissions and air pollution [13]. In 2019, 91% of bricks were made using highly polluting traditional technologies. Although the use of fixed chimney kilns decreased from 75% in 2006 to 28% in 2018, and the use of modern technologies has increased, emission reductions remain insufficient for public health and environmental standards. The government has taken steps to address this issue, including banning traditional kilns and demolishing polluting kilns in 2019, but transitioning to energy-efficient kilns is costly and slow. The brick industry, contributing 1% to GDP and employing about 1 million people, continues to pose significant environmental and health challenges due to its high greenhouse gas emissions and soil depletion [14]. In 2010,

the Bangladesh government mandated the closure of traditional fixed chimney kilns by 2012, later extended to 2014. By November 2019, following a High Court order, 122 polluting kilns around Dhaka were demolished and fined Tk. 4.13 crore. Traditional brick production uses 100 million tonnes of topsoil annually, producing 20 million tonnes of CO_2. Although the 2019 amendment to the Brick Production and Brick Kiln Building (Control) Act 2013 promotes energy-efficient kilns, their adoption is slow due to high costs and lack of motivation among operators. This slow transition contributes to air pollution, topsoil depletion, and environmental harm, with brick production expected to increase by 5% each year [15] [10]. In Bangladesh, industries and vehicular emissions are major sources of air pollution. Industrial processes release harmful gases like carbon monoxide and nitrous oxide, with severe pollution in urban areas like Dhaka and Chittagong. The leather industry in Hazaribagh, Dhaka, is notably polluted. Transportation in Dhaka is a major contributor, with around 37,000 new cars added yearly, causing significant traffic congestion and increased fossil fuel consumption, further worsening air quality [16].

Vehicles and Traffic Jam

As of September 2016, Greater Dhaka had around one million registered motor vehicles, with an additional 400,000 unregistered ones on the roads [17]. Traffic jams in Dhaka are worsened by poor management, high population density, and low public awareness. Many old, poorly maintained vehicles contribute to severe pollution, emitting black carbon, carbon monoxide, nitrogen oxides, and sulfur oxides. Studies show that residents in high-traffic areas face more respiratory problems, including higher bronchitis rates and slower pulmonary development in children.

Dust Pollution and Particulate Matter

Air pollution in Dhaka, primarily from particulate matter (PM), poses severe health risks. PM10 and PM2.5, with the latter being more harmful, are emitted by sources like brick kilns (83 tons/year), steel mills (17 tons/year), cement factories (130 tons/year), and ceramic factories (20 tons/year). Dust pollution, exacerbated by unplanned construction, open transport of materials, and poor waste management, significantly worsens air quality. Brick kilns alone contribute to 58% of Dhaka's air pollution, leading to serious health impacts, including 46,000 deaths annually in Bangladesh. The WHO has classified PM2.5 as a "Group 1 carcinogen," highlighting the urgent need to address these pollution sources [10] [18]**.** Bangladesh, particularly Dhaka, faces severe challenges with rapid population growth, now nearing 10 million, contributing to extreme density. Between 2008 and 2018, the population rose from 143.8 million to 163.65 million, straining resources. High density, compounded by illiteracy and cultural norms, is among the highest globally. Deforestation worsens air quality by reducing CO2-absorbing trees, while burning fossil fuels and wood releases harmful gases. Agriculture, through pesticides and fertilizers, increases ammonia and methane emissions, which worsen air quality and global warming. Waste management issues, including open burning, release harmful chemicals, worsening pollution. Air pollution is a major health risk, causing 21% of deaths in Bangladesh and contributing to chronic conditions globally. Improved waste management and composting can help reduce some of these impacts [19] [20]**.** Coarse and fine particulate matter harms children's cognitive function by altering brain structure and is linked to health issues like skin cancer from radon, secondhand smoke, vision problems, and COPD. In Bangladesh, air pollution is a leading cause of death, contributing to lung cancer (13%), lower respiratory infections (7%), COPD (7%), ischemic heart disease (6%), and stroke (5%). Poor air quality can damage organs, causing congenital disabilities. Around 2.5 million global deaths annually are attributed to air pollution. Vulnerable groups—children, the elderly, pregnant women, and those with heart or respiratory conditions—should avoid polluted air. Air pollution is also linked to atherosclerosis, cognitive decline, and brain changes similar to Alzheimer's disease [21]. Air pollution harms ecosystems, causes acid rain, and drives global warming. Toxic pollutants disrupt habitats, contaminate water, and degrade soil, reducing crop yields. Acid rain harms soil, water, and buildings. Greenhouse gases like CO2 and methane raise temperatures, melt glaciers, and increase sea levels. CFCs deplete the ozone layer, allowing more UV radiation. Black carbon accelerates warming and glacier melt.

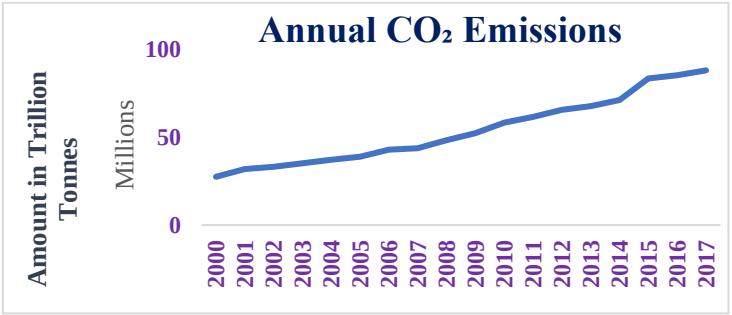


Fig. 2. Carbon Dioxide emission in Bangladesh, measured in terawatt-hour (TWh) equivalents [19]

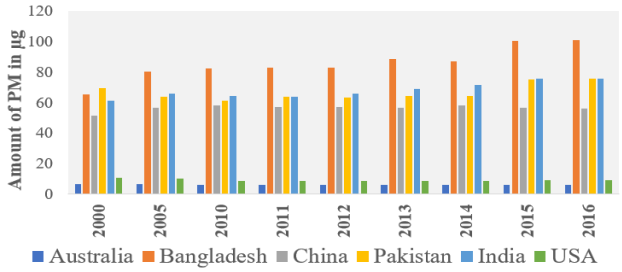


Fig. 3. Particulate Matter of different countries measured in micrograms per cubic meter (µg/m³) [18]

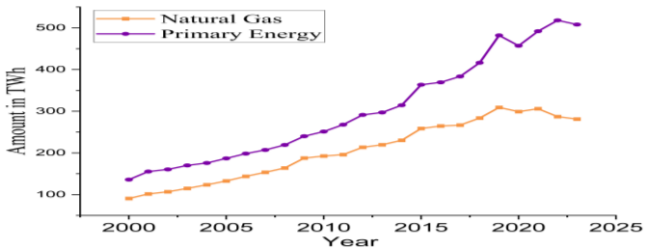


Fig. 4. Natural gas and primary energy consumption in Bangladesh [22] [23]

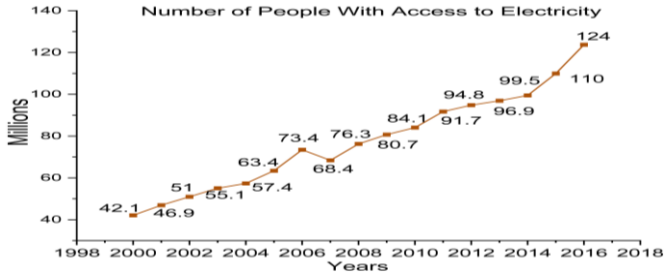


Fig. 5. Number of people with access to electricity [24]

Addressing these requires global emission reductions and environmental management [25] [22] [23]. In Dhaka, air quality significantly deteriorates during the dry season, from November to March, with particulate matter (PM10 and PM2.5) frequently exceeding national air quality standards (NAAQS). Data from Continuous Air Monitoring Stations (CAMS) reveal that these particulates surpass NAAQS for over 100 days annually, while gaseous pollutants generally remain within permissible limits. This seasonal spike in particulate pollution highlights a critical period for air quality management in the city. [18]

3. Comprehensive Strategies for Improving Air Quality in Dhaka

To effectively tackle Dhaka's severe air pollution, a holistic approach is essential. The following strategies can be implemented: **1. Cleaner Brick Kilns**: Adopt gas-fired kilns and efficient systems, supported by IDCOL and Climate and Clean Air, to replace traditional kilns with concrete blocks by 2030, reducing CO2 and PM2.5. **2.Population Management**: Raise awareness about the impact of overpopulation on air quality. Encourage population control measures and enhance living standards in less populated areas to relieve pressure on Dhaka. **3. Decentralization**: Relocate major industries and government offices from Dhaka to distribute economic opportunities more evenly and reduce emissions. **4. Vehicle Emissions Reduction**: Promote public transportation, cycling, walking, and electric vehicles to lower fuel consumption and alleviate traffic congestion. **5. Clean Energy Transition**: Invest in and expand the use of solar, wind, and geothermal energy to replace fossil fuels, thereby reducing pollution from energy production. **6. Energy Efficiency**: Encourage the adoption of energy-efficient devices and practices to lower emissions from power plants. **7. Indoor Air Quality Management**: Install effective ventilation systems and air filters in buildings and vehicles to improve indoor air quality. **8. Green Urban Infrastructure**: Develop urban green spaces, including vertical gardens and urban forests, to absorb pollutants. Establish "green belts" around industrial areas to act as buffers. **9. Smart Traffic Management**: Implement smart traffic systems using real-time data to optimize traffic flow, reduce congestion, and minimize vehicle emissions. Integrate air quality sensors into traffic infrastructure. **10. Electrification of Public Transport**: Transition public transport to electric buses and trains, supported by a robust network of electric vehicle (EV) charging stations. **11. Waste-to-Energy Initiatives**: Invest in waste-to-energy technologies

to convert waste into clean energy, minimizing the need for open burning and landfill use. **12. Public Awareness Campaigns**: Launch campaigns to educate the public about the health impacts of air pollution and promote cleaner technologies and community involvement in local initiatives. **13. Urban Air Quality Monitoring**: Expand the network of air quality monitoring stations across the city to provide real-time pollution data, informing policy decisions and public awareness. **14. Incentives for Clean Technologies**: Offer financial incentives and subsidies for investments in clean technologies, including solar panels and energy-efficient appliances. **15. Enhanced Building Codes**: Update building codes to mandate energy efficiency and pollution control measures in new constructions and major renovations. **16. Green Logistics**: Promote the use of electric or hybrid vehicles for delivery services and implement congestion pricing in heavily trafficked areas to reduce vehicle numbers. **17.Community Clean-Air Initiatives**: Foster community-led projects like clean-up events and tree planting to address air pollution. A coordinated effort among government, businesses, and communities is essential to reduce pollution and improve air quality in Dhaka.

4. Discussion

The comprehensive strategies outlined for improving air quality in Dhaka are indeed a crucial step toward addressing the city's severe air pollution challenges. However, while these initiatives are well-conceived, they may not be sufficient on their own to fully mitigate air pollution in such a densely populated and rapidly urbanizing environment.

Limitations of Current Strategies

1. Implementation Challenges: Adopting cleaner kiln technologies faces hurdles like funding, technical gaps, and industry resistance. Strong government support and clear regulations are crucial for success. **2. Public Awareness and Engagement:** Public awareness campaigns need sustained community engagement, as many lack access to information or resources. Grassroots efforts are vital for driving behavioral change. **3. Infrastructure Development:** Smart traffic management and public transport electrification need significant investment, often challenged by budget limits and bureaucracy. Seamless urban integration is key to success. **4. Decentralization and Economic Impact:** Relocating industries and offices risks disrupting local economies; careful planning is crucial to mitigate short-term impacts.

Additional Initiatives for Consideration

To bolster the effectiveness of the proposed strategies, the following additional initiatives should be considered:
1. Strengthening Policy Frameworks: Establish strict air quality regulations with penalties for non-compliance to enforce cleaner technologies and ensure industry adherence to environmental standards. **2. Incentivizing Research and Development:** Encourage research into innovative air pollution control technologies and sustainable practices through funding and grants. Supporting local startups focused on environmental solutions can foster a culture of innovation. **3. Enhancing Public Transportation Infrastructure:** Invest in a reliable, affordable, and accessible public transportation network to reduce reliance on private vehicles, cutting traffic congestion and emissions. **4. Community-Based Monitoring:** Empower communities with tools for air quality monitoring to boost accountability and address local pollution issues.**5. Regional Cooperation:** Air pollution transcends city boundaries; collaboration with neighboring regions is vital to tackle cross-border pollution and shared environmental challenges. **6. Promoting Sustainable Urban Planning:** Integrate air quality into urban planning by creating mixed-use neighborhoods and expanding green spaces to cut motorized transport and enhance livability. **7. Education and Capacity Building:** Offer training for industry workers and officials on sustainable practices to strengthen air quality management and implementation.

5. Conclusion

The proposed strategies for improving Dhaka's air quality offer a promising framework, but their success requires a multi-faceted approach. Strengthening regulations, boosting public engagement, and promoting sustainable urban development are key to long-term improvements. A coordinated effort among government, businesses, and communities is essential to create a healthier environment for all residents.

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