International Journal of Research in Engineering, Science and Management
Volume 4, Issue 7, July 2021
https://www.ijresm.com | ISSN (Online): 2581-5792

Environmental Overview of Air Quality Index (AQI) in Bangladesh: Characteristics and Challenges in Present Era

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***Abstract*: While Bangladesh is moving forward in a fast pace on many fronts, it is seriously lagging in some very important issues. As of writing this, according to the CASE project of Department of Environment, the AQI of Dhaka is 408, which is extremely unhealthy as par AQI category. According to the World Air Quality Report 2020, air quality of Bangladesh is the worst in the world and Dhaka ranks second among the most air polluted cities. Not only Bangladesh, the whole world is suffering from the effects of air pollution, climate change being the most important of all. About 92% of the world's population breathes air which is toxic to them. About 93% of the children also breathe toxic air. The world is putting their best minds and resources in understanding and solving the air pollution problem, so should we, as we have a long way to go than the others. It was a systemic review study regarding environmental overview of Air Quality Index (AQI) in Bangladesh. We gather different types of articles and newsletters related to Air Quality Index (AQI) using different search portal. After proper review suitable articles and newsletters which were related to this study were taken for this systemic review purpose. People couldn't see their feet while walking, the air smelled like rotten eggs. This was one of the major air pollution disasters in the human history which claimed the lives of 4000 people in the immediate aftermath. This review presents a clear scenario of air pollution condition in and around Dhaka, Bangladesh from past to present. To this point, some important air pollution epidemiology study should be conducted in Bangladesh to investigate the effects of air pollution on human health by our Govt. to revise the air quality standards to maximize their public health benefits. It's high time to take immediate actions and programs in our country for controlling air pollution.**

***Keywords*: Integrated effects of air pollution, Health, Environment.**

1. Introduction

In 2021, 50th anniversary of independence of Bangladesh, the country is on its way to become a developing nation from the Least Developed Country (LDC). While Bangladesh is moving forward in a fast pace on many fronts, it is seriously lagging in some very important issues. As of writing this, according to the CASE project of Department of Environment, the AQI of Dhaka is 408, which is extremely unhealthy as par AQI category [1]. According to the World Air Quality Report 2020, air quality of Bangladesh is the worst in the world and Dhaka ranks second among the most air polluted cities [2]. Not only Bangladesh, the whole world is suffering from the effects of air pollution, climate change being the most important of all. About 92% of the world's population breathes air which is toxic to them [3]. About 93% of the children also breathe toxic air [4]. The world is putting their best minds and resources in understanding and solving the air pollution problem, so should we, as we have a long way to go than the others.

2. Materials and Methodology

It was a systemic review study regarding environmental overview of Air Quality Index (AQI) in Bangladesh. We gather different types of articles and newsletters related to Air Quality Index (AQI) using different search portal. After proper review suitable articles and newsletters which were related to this study were taken for this systemic review purpose.

3. Air Quality Index (AQI)

An Air Quality Index (AQI) is a communication vehicle to quickly and effectively describe ambient air quality relative to the relevant national air quality standard. To report daily air quality, the AQI act as an index. It is a comprehensive index that covers an integrate pollutants simultaneously and can reflect the comprehensive status of ambient air quality [5]. It is used to describe at present how polluted the air is or how polluted it is forecast to become. Moreover, AQI focuses on effects of air pollution on health which may develop within a few hours or days after breathing of polluted air. Thus, understanding the air quality index is important because it

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would keep people informed about how to protect health from air pollution. As the AQI increases, an increasingly large percentage of the population is likely to experience severe adverse health effects. Different countries have their own air quality indices, corresponding to different national air quality standards. According to Department of Environment Government of Bangladesh 2012, in Bangladesh, the AQI is based on five criteria pollutants. They are: Particulate Matter (PM10 and PM2.5), CO, NO, SO2, Ozone (O3). AQI value runs from 0 to 500 level. The higher level of AQI value indicates the greater level of air pollution which have significant health concern. AQI value of 50 0r below, represents healthy or good air quality but AQI value over 300 represents hazardous air quality. There are six different categories of AQI. Each category corresponds to a different level of health concern. Each category also has specific color. These colors make it easily understandable to people to determine whether air quality is reaching unhealthy levels in respective communities [4]-[6].

4. AQI of Dhaka

Bangladesh's capital Dhaka has ranked as the most polluted city in the world. Dhaka scored 193 in the US Air Quality Index (AQI) on April 2021. The air was classified as "unhealthy." The index was developed by the Environmental Protection Agency for reporting daily air quality of any city or country. Pakistan's Lahore and Nigeria's Port Harcourt followed Dhaka with individual scores of 171 and 162 respectively, according to data obtained from Air Visual, a mobile application that shows real-time air pollution index of any city [2]-[8]. Brick kilns, vehicles run by fuels with higher level sulphur, as well as construction works have been identified as major sources of air pollution [5], [8]. The air quality further declines during the dry months from October to April but improves in the monsoon. The situation is very serious, experts say, pointing out that five of the top 10 causes of deaths in Bangladesh are related to air pollution. The United States Environmental Protection Agency (EPA) developed the Air Quality Index to report air quality. This AQI is divided into six categories, indicating increasing levels of health concern [9]-[11]. An AQI value over 300 represents hazardous air quality and below 50 the air quality is good. The index is based on the five criteria pollutants regulated under the Clean Air Act– ground-level ozone, particulate matter, carbon monoxide, sulphur dioxide, and nitrogen dioxide. The AQI debuted in 1968, when the National Air Pollution Control Administration undertook an initiative to develop an air quality index and to apply the methodology to Metropolitan Statistical Areas [10].

5. Trend in Air Quality Index (AQI)

Seasonal variation can be seen in both PM 2.5 and PM 10 concentration in the air. According to CASE project, from November to April PM 2.5 and PM 10 concentrations in the air remain higher than the usual level of Bangladesh and from May to April it is found within the usual limit. January is also found to be the most polluted month. Trends in PM concentration in Dhaka through a year in different months is shown below by a Box-Whisker plot [13].

6. Effects of Air Pollution on Health

Among all the air pollutants, most common air pollutants are ground-level ozone and Particulates Matter (PM) which have vigorous effects on our health and environment. Air pollution is separated into two main types:

- Outdoor pollution is the ambient air pollution.
- Indoor pollution is the pollution produced by household combustion of fuels [14].

People exposed to high concentrations of air pollutants and experienced different kind of symptoms and diseases. These effects are divided into short- and long-term effects according to their duration which are affecting health [14], [15].

According to a recent epidemiological study from Harvard School of Public Health, the comparatively hugeness of the short- and long-term effects have not been completely clarified due to the different epidemiological methodologies and to the exposure errors. New models are proposed for assessing short- and long-term human exposure data more successfully [16]. In this manner, our present section reporting the more common short- and long-term health effects but also general concerns for both types of effects, because these effects are often dependent on environmental conditions, dose, and individual susceptibility [16], [17]. Short-term effects are temporary and cause discomfort, such as irritation of the eyes, throat, nose, skin, wheezing, coughing and chest tightness, and breathing difficulties, sometimes being so serious like asthma, pneumonia, bronchitis, and worsening of existing lung and increased risk of heart attack. Short-term exposure to air pollution can also cause headaches, nausea, and dizziness. These problems can be aggravated by extended long-term exposure to the pollutants, which is harmful to the respiratory systems, neurological, reproductive systems and causes cancer and even deaths [18].

The long-term effects are chronic, continue for years or the whole life and can even lead to death. On the other hand, in the long-term effects, cancer may occur because of the toxicity of air pollutants [19].

A. Effects on Respiratory system

As we know, respiratory disorders mostly occur with the inhalation of air pollutants. These pollutants will enter through the airways and will damage the target cells. Among all the air pollutants, Particulate Matter (PMs), dust, benzene, and O3 cause serious damage to the respiratory system [20]. These pollutants aggravate existing respiratory disease such as asthma[21]. Chronic obstructive pulmonary disease (COPD) may also be initiated by air pollutants. Long-term effects which are induced from traffic, industrial air pollution, and combustion of fuels are the major factors for COPD risk [20]-[22].

B. Effects on Cardiovascular System

Multiple cardiovascular effects have been observed after exposure to air pollutants[23]. Changes occurred in blood cells after long-term exposure may affect usual cardiac functions. Coronary arteriosclerosis, hypertension, stroke, myocardial

infracts, and heart insufficiency, ventricle hypertrophy was reported as cardiac effects following long-term exposure to traffic emission, brick fields, hazardous industries etc. [24].

C. Effects on Psychological System

Psychological complications, autism, delayed development, retinopathy, fetal growth, and low birth weight seem to be related to long-term air pollution [23], [24]. The etiologic agent of the neurodegenerative diseases (Alzheimer's and Parkinson's) is unknown yet, although it is guessed that profuse exposure to air pollution may be one of the factors. Specifically, pesticides and metals are mentioned as etiological factors, alone with diet [25].

D. Dermatological Effects

We all know, skin is our protector against ultraviolet radiation (UVR) and other pollutants, as it is the most exterior part of our body. PAHs, VOCs, oxides, and PM which are traffic-related pollutants, may cause pigmentations on our skin. Air pollutants absorbed by the human skin may cause acne, atopic dermatitis, eczema, psoriasis, urticarial, and skin aging that are usually caused by exposure to oxides and photochemical smoke. Exposure to PM and cigarette smoking act as skin- aging agents and may cause spots and wrinkles [26].

E. Carcinogenic Effects

When air pollutants penetrate through the skin or are inhaled through respiratory system, it damages several organs because some of these pollutants are mutagenic and carcinogenic, they affect the liver, lung and skin. These pollutants cause several types of cancers like lung cancer, hepatic carcinoma, pancreatic cancer, breast cancer and so on [27].. Air pollutants also affect the neurological systems in both adults and children like headache, dizziness, less concentration, anxiety, and sleeplessness etc. [26], [27].

7. Environmental Impacts of Air Pollution

At a country level, the new report says weighted by population, Bangladesh emerges as the most polluted country in the world. Gurgaon, a suburb of the Indian capital New Delhi, is the world's most polluted city. According to the report, air pollution will cause around seven million premature deaths globally next year and have a major economic impact. Bangladesh, one of the most densely- populated countries in the world, has been struggling with air pollution for long. Dhaka, the country's capital, often finds its place among the most polluted cities in global indices. Brick kilns and vehicles run on fuel with higher level of sulfur have been identified as the major sources of air pollution in the country [28]. The AQI, an index for reporting daily air quality, tells people how clean or polluted the air of a certain city is, and what associated health effects might be a concern for them. There is no denying that air pollution has reached menacing proportions in the city which has become virtually unlivable. Urban air in the city is thick with fumes; water either in the rivers, ponds or tube-wells, is polluted, and the land is poisoned. Unchecked dumping of waste, a lot of it toxic, noxious emissions from vehicles and the pesticides used in farmlands are the main causes. Although the city did fare well in terms of reducing pollution, the situation is still alarming, posing serious health hazards for city dwellers [20]. [27]. Things get worse in dry season as air, thick with particulates, becomes a prevalent cause of chest and respiratory diseases. According to the Department of Environment (DoE), the density of airborne particulate matter (PM) has reached 247 micrograms per cubic meter (mcm) in Dhaka which is nearly five times the acceptable level of 50 PM per mcm set by the National Ambient Air Quality Standard (NAAQS) of Bangladesh [26]. Airborne particulates are considered more harmful when they are 10 micrometers or smaller in diameter and in Dhaka the density of PM which is 2.5 micrometers or smaller has been found to be 9.0 times higher than the NAAQS recommendation. Ambient air in the city becomes extremely polluted between October and March every year when rain is scarce and when thousands of brick kilns become operational, burning used automobile and rickshaw tyres, low grade coal and in many cases fuel-wood. World Health Organization (WHO) air quality guidelines however recommend a maximum acceptable PM level of 20mcm compared to Bangladesh standard of 50. Cities with 70 mcm are considered highly polluted. Airborne lead is the worst of the harmful PMs. Although there is no definite study, doctors suggest exposure to such a volume of air pollution may cause premature deaths and also various diseases including pulmonary, respiratory and neurological illnesses. Air pollution has also an adverse effect on all other life forms including plants [25]. Cost of maintaining building structures in the urban areas also rises significantly due to such air pollution. The number of patients with different chest and respiratory diseases in the hospitals and clinics is on the rise. If this trend of air pollution continues, those living in Dhaka city, will become exposed to ailments stated above and also other complications. The mental faculty of children will be adversely affected by lead pollution, which can also affect the central nervous system and cause renal damage and hypertension. In addition to brick kilns, old buses, fleets of trucks and thousands of other poorly serviced vehicles contribute highly to the pollution. Moreover, dust from roads and construction sites and toxic fumes from industrial sites turn the air quality scenario even worse. Industrial wastes are responsible for 60 per cent of the surface water pollution in and around Dhaka city while domestic wastes contribute to rest of the pollution. At present, underground water is extracted exploring 300 meters deep. More than 0.35 million motor vehicles ply the roads in Dhaka. Diesel-run vehicles account for more than 80 per cent of the air pollution as most of them fail to comply with the emission standard [20]-[22]. According to WHO guidelines, blood lead level above 10 microgram per deciliter is considered as lead poisoning. A recent survey found lead concentration in urban children to be 5.8 to 21.6 microgram per deciliter and urban slum children's lead level ranged from 9.6 to 38.9 microgram per deciliter, three times more than the acceptable level. Sadly, enough, laws exist to book a polluter, but law enforcers shy away from using the laws in most cases because of an unholy alliance with the vehicle drivers. In most cases, polluting vehicles drive away emitting noxious fumes in the presence of the law enforcement personnel

without being held up or booked. Old and dilapidated vehicles disappear from the roads during special drives by the law enforcers only to return after the drive comes to an end [25]. In the past, attempts to prohibit plying of old vehicles in Dhaka city streets failed either for political reasons or in the face of resistance by transport owners and their employees. But if the neighboring countries can improve air quality of their cities by banning use of old vehicles and also relocating some of their polluting industries, authorities in Bangladesh can also do the same [28]. It is thus time to phase out old and black smoke emitting vehicles from city roads as our right to live in healthy environment largely depends on it. Good governance helped curb air pollution in cities like Bangkok, Kolkata, Kathmandu and Lahore while weak administration caused the increase of air pollution in Dhaka and Karachi. Indeed, Bangladesh is one of the few countries that faces extreme hazards due to environmental degradation and resource depletion. The degradation of the environment has been highlighted in various forums because of its universal potential for chaos and disorder. Environmental problems faced by Bangladesh are far too many though largely caused by factors, which are teleological because of its geographical position. The ecological hazards of pollution and resource depletion pose a potentially catastrophic threat to Bangladesh. The problem should be high on the agenda of the government as well as political parties. One hopes that the issue will get the priority it deserves. The government should, in the circumstances, take the environmental threats seriously, and create public awareness and undertake action-oriented programs [29].

8. Challenges

Every problem needs a solution. Implementing the solution itself is another challenge. Bangladesh is continuously trying to rise up to the challenges they are facing due to air pollution.

- Before 2002, there were a lot of two stroke engine driven three wheelers in Dhaka city. Two stroke engines have low fuel efficiency and produce more PM than four stroke engines of similar size. Starting from December 31, 2002, Govt. of Bangladesh banned use of two stroke engines which helped in significant reduction of PM2.2 compared to the previous year's [30].
- In 1999, National environmental council of Bangladesh banned the use of leaded gasoline. Awareness in the mass media and public support helped a lot in implementing this. The decades before that, air pollution by lead was a major concern. In 2003, use of two stroke engine driven vehicle was banned. During that period and later, policy regarding brick kiln was also being implemented. To observe the effect, from 1996-2015 data on PM2.5, PM10, Lead and Black Carbon was collected which showed the levels were quite stable despite the increasing economic and automobile activity in the following decades [31].
- On November 26, 2019, The High Court issued an order to shut down illegal brick kilns in five surroundings cities of Dhaka. Govt. of Bangladesh also decided to phase out use of bricks in all govt. projects by 2025 and start using concrete blocks. More ecofriendly green technologies for producing bricks are also being considered and changing the stack height helped brick kiln owners by more efficient burning and producing better quality bricks (Rahman, 2019). But reduction in dependency on brick for construction or rapid shutdown of illegal kilns will put many entrepreneurs and workers out of business and work. That number may well be close to one million [32].
- Govt. of Bangladesh promoted use of CNG as a fuel for vehicle which greatly reduced burning of petroleum. Burning CNG also produces less greenhouse gases and pollutants, thus greatly improving air quality [33]. CNG is cheaper than petroleum as fuel for transport - which has been an important factor for the increasing number of cars for personal use [34]. As the domestic gas reserves are depleting fast, Bangladesh will be more dependent on LNG in future which may cause change in the market price of fuel for transports [34], [35].
- Due to poor efficiency of older engines, old vehicles pollute air more. To prevent that, Govt. has banned use of buses older than 20 years and trucks older than 25 years. Although this will help in improving air quality but this ban is hard to enforce, as the transport vehicle owners and workers are yet to co-operate fully. Replacing old vehicles with new ones also need time and money which is difficult to manage within a short period. Ban on importing older vehicles was successful but the extra cost of importing comparatively newer vehicles has been passed to buyers [36].
- A bus can accommodate 36-40 people. Three private cars take up the same space as bus but can carry only 12 people. Although it is clear which transportation medium is more efficient in fuel consumption and freeing up roads to avoid traffic congestion, reality is different. The number of private cars in Bangladesh increased about 82% since 2010. Transportation system of Dhaka was designed to carry 88% of people by buses which would occupy around 5% of the road. But according to a World Bank report in 2018, private transports occupy 70% of the road space now, carrying only 5% passengers. On the other hand, buses carry only 30% passengers but occupy 5% of the space. This has created an immense pressure on the roads causing traffic jam, excess unnecessary burning fuels, air pollution and health hazards, work hour and economic loss. According to a World Bank study in 2017, average traffic speed in Dhaka has gone down to 7 km per hour which is slightly better than the walking speed. But still people are opting for private cars because of the chaotic, unreliable, inefficient public transport system, comfort and security, better status, low price of CNG comparative to petroleum oil, improvement of economic status and easy loan for buying cars [36], [37].
- Acceptable limits for exhaust emission of new vehicles sold in EU follow European emission standard. The final standard is Euro 7 which will finally phase out fossil fuel vehicles. According to vehicle emission standard 2005, Bangladesh followed Euro 2 for the light vehicles and

Euro 1 for heavy vehicles, which lags far from the world standards. Currently nearly all vehicles are imported from Japan, India, China and South Korea who follow Euro 3, 4 and 5 standards. If we do not update our vehicle emission standard importers will retune the vehicle to meet our standard of Euro 2 which will not even produce any financial benefit. In 2012, Department of Environment and CASE project presented a report recommending revisions of vehicle emission standard of Bangladesh. Not only has the vehicle, the fuel we use needed an upgrade in quality too. Monitoring of vehicle emission during certification is still far away due to lack of testing facilities and poor institutional capacity [4], [5].

- Many brick kiln owners use coal as a fuel source. But coal contains sulfur and other impurities which cause harmful particle emission upon burning. Govt. policy does not allow import of coal containing more than 1% sulfur but govt. has allowed importing coal containing 3-5% sulfur as they are cheaper (bdnews24, 2010). This is a prime example of weakness in implementing policies and poor governance. Right now, govt. is planning to reduce dependency on coal and coal powered projects and focusing more on natural gas such as LNG [36]-[38].
- Not only government but also private organizations and NGOs are working together to improve our air quality. In 2019, Department of Environment drafted a bill named: Clean Air Bill 2019" with the help of the experts from BELA (Bangladesh Environmental Lawyers Association). Although it was a great step, the bill is yet to be passed [39]. Another organization named BAPA (Bangladesh Poribesh Andolon) has been in the frontline for many environmental activities since 2000.
- Govt. is also encouraging individuals to join in eco-friendly activities by declaring 10% tax reduction for having rooftop gardens and solar panels [40].

9. Conclusion

In December 1952, London was covered under the thick blanket of deadly smog for five days, made of sulfur dioxide, carbon dioxide and smoke particles – produced from the burning of cheap coal which was used to run everything from heating home to run factories; diesel fueled automobiles contributed to the smog too. People couldn't see their feet while walking, the air smelled like rotten eggs. This was one of the major air pollution disasters in the human history which claimed the lives of 4000 people in the immediate aftermath. This was not the first nor will it be the last air pollution disaster in the human history, if we do not act, and act fast. This can happen anywhere, anytime – our country is no exception too. We need to move solving the air pollution problem to the top of our priority list before it's too late. This review presents a clear scenario of air pollution condition in and around Dhaka, Bangladesh from past to present. To this point, some important air pollution epidemiology study should be conducted in Bangladesh to investigate the effects of air pollution on human health by our Govt. to revise the air quality standards to maximize their public health benefits. It's high time to take immediate actions and programs in our country for controlling air pollution.

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