Data Analytics for Urban Pollution and Respiratory Health

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Abstract

Strolling across Dhaka streets in the winter seasons, one gets the impression of walking in a heavy gray curtain. The haze is low, and it smokes through traffic-crowded intersections, and it burns the throat. With the country slowly entering early 2026, both the existing empirical evidence and the intuitive judgments by the residents of the nation attest to the same fact: the quality of air in the capital is an acute public health crisis. What was previously defined anecdotally, i.e.

itchy eyes, coughing continuously, crowds in emergency rooms, is now something that can be applied statistically. Researchers are revealing a direct, numeric relationship between the amount of particulate matter citizens breathe in and the number of hospital bed they fill by combining data of the environmental sensors with data of hospital admissions. It is not an environmental issue but environmental justice where the least lucky and those most vulnerable in Bangladesh are the most exposed to unhealthy air.

Air pollution and respiratory illness are no longer a matter of speculation. In time-series Poisson regression models, longitudinal studies at major institutions, such as Dhaka Medical College Hospital, have used the study design to analyse the daily variations in the levels of pollution and hospital admissions. The results are stark. The statistics of the years 2020-2024 show that a 10-unit change of the daily Air Quality Index (AQI) is associated with the growth of the total respiratory admissions by 3.8 percent. This apparently minor change translates to dozens of other emergency visits in the city during high-pollution days. The burden on the healthcare facilities is huge when combined over the course of the weeks of continuous exposure.

Of the pollutants, PM2.5 (fine particulate matter) turns out to be the deadliest cause of respiratory pathology. These are the particles that are less than 2.5 microns in diameter and when inhaled, they deepen into the alveoli and in some cases they are absorbed into the bloodstream. Statistical modeling suggests that an increase in PM 2.5 level by 10 microgram per cubic meter is linked to a 5.2 percent increase in daily hospital admissions due to asthma, pneumonia, chronic obstructive pulmonary disease (COPD) and

associated diseases. The risk is heightened during the dry winter months between December and February when PM 2.5 concentration in Dhaka has been recorded to be 171 micrograms per cubic meter- almost 18 times higher than the safe concentration recommended by the World Health Organization. This seasonal peak is exactly in time with high emergency room visits due to respiratory distress creating an annual and predictable alarming trend.

The Geographic Information Systems (GIS) mapping has also helped to shed more light on the spatial aspects of this crisis. The pollution is not evenly spread in Dhaka. The levels of particulate are always higher in industrial areas and in the neighborhoods with high traffic, i.e., Tejgaon, Mirpur, and Jatrabari. These hotspots are in accordance with the areas of concentration of the brick kilns, building-sites, and road-systems that are crowded. Almost 98 percent of people residing in large road areas are highly exposed and the likelihood of respiratory illness has been estimated to be seven times greater in the high pollution areas than in the less congested and greener residential areas. These results highlight the fact that the quality of air is as much air planning or zoning policy as it is meteorology.

Dhaka air pollution is a trend of a larger pattern of socioeconomic inequality. Although all residents breathe the same skyline, exposure levels and thereof and hardiness vary strongly in relation to income groups. The poor households are overly concentrated along the industrial plants, informal-waste-burning sources and highways. Poor social amenities and lack of access to green spaces increase the exposure to indoor pollution. It has been found out that in these high exposure areas, the inhabitants have a probability that is 9.5 times higher to experience chronic coughing and wheezing than those residing in relatively clean areas. To a large number of families, the cost of relocation is prohibitive leaving them languishing in areas that progressively worsen the health conditions.

Clinical outcomes are not the only economic impact. In Bangladesh, the number of lost workdays due to Air pollution is approximated to be 263 million every year, which is approximately 4.4 percent of the national GDP. To the daily wage earner breath disease is not only a health problem but also a survival problem to the family. One sick day can translate to buying food and not eating. Children with recurring respiratory infections are absent in school and it exacerbates educational inequalities that reflect environmental inequalities. Therefore, contaminated air acts as an invisible poverty multiplier, which strengthens disadvantaged cycles.

The death burden is also impressive. Over 102,456 premature deaths annually have been attributed to air pollution in Bangladesh. By meeting the PM2.5 air quality standard in the country of 35 micrograms per cubic meter, it is estimated by analysts that almost 20000 deaths each year could be avoided. These numbers turn the air-quality into a measure of the quality of the environment into a variable that determines the life expectancy. They also present clean air as a policy requirement based on quantifiable human good.

Data analytics provides a way of eliminating this cycle. The changes in the air quality can be viewed as a measurable factor of inequality, which allows the policymakers to incorporate urban environmental data science into the city administration directly. Combining real-time monitoring networks with predictive modeling, zonal health alerts depending on neighborhoods can be provided. To illustrate, in the case of hazardous PM2.5 concentration being recorded around school areas in Tejgaon, the authorities can send out local alerts advising on the need to wear N95 masks, outdoor activities, or even road closures. These kinds of interventions are more effective than blanket warnings across the city that can be diluting.

Another issue in GIS mapping is the presence of an acute requirement of greening urban areas. It is analyzed that most of the learning institutions and playgrounds are located in the high-pollution zones. Development of green buffers, or perimeter of trees, vertical gardens, and vegetative barriers can help in minimizing the intrusion of particulates and offer small but significant mitigation. City designers should focus on designing micro-parks and rooftop gardens in overcrowded neighborhoods where the area of green space is scarcely available. Sections are selected based on data which makes sure that interventions are applied to communities that have the highest exposure load.

Another pillar of reform is enforcement of regulations. Air Bangladesh Air pollution control rules 2022 will offer a legislative framework in Bangladesh, but realisation must be furthered through strict data based audits. The monitoring of the continuous emissions of vehicles, construction sites, and industries should be accompanied by the use of the public dashboard to increase the transparency. Geographic areas that are classified as "Very Unhealthy" must be accompanied by a compulsory inspection and non-conformity punishment. Even the most detailed policy will be a mere symbol without enforcement.

Other than regulation, the public health systems should prepare to deal with the predictable pollution cycles. History-based pollution-health relationships can be used by hospitals to predict respiratory hospital surges on a seasonal basis. Resource planning oxygen availability, inhalers, staffing, etc. can be modified in advance in high risk months. With this, environmental analytics will be a clinical planning tool, which can fill the gap between environmental science and healthcare management.

The level of community involvement is necessary. Unless the data is transformed to accessible information, it will not be able to drive change. Sensitisation efforts on understanding the AQI readings, health hazards, and protective measures enable the citizens to limit exposure. The availability of environmental intelligence can be democratized through the mobile app that provides information about air quality on a neighborhood level. When the citizens are made aware of the health consequences of the pollution statistics, then it will have a group pressure to promote cleaner air.

Finally, it is not just the mixture of gases and particulates that dominate the air of Dhaka, but rather an opportunity and health structure determinant. The injustice on the environment is not merely the different

exposure but the different ability to react. The richer residents can either install purification devices in their homes or move to greener areas, or even get private healthcare. Such options are not available to marginalized communities. Data analytics highlights such inequities in a transparent manner, providing a guide that can be used to engage in the necessary intervention and fair reform.

With the future of Bangladesh's urbanization, the fusion of environmental data science into the planning, healthcare, and economic policy is no longer a choice. The idea of clean air should be redefined as a right and not a geographical or income privilege. The data is indisputable: by cleaning up pollution, lives will be saved, livelihoods preserved, and the gaps in the income inequalities reduced. By applying a high level of analysis, open governance, and political determination, Dhaka can shift its crisis management policies to proactive environmental management. The gray curtain that covers the city does not have to decide what to do with the city. The statistics already signal a healthier, juster future- one in which all breathing will not be risky, but possible.