Air Pollution: Health hazards and policies

Air pollution is a major environmental issue facing the world. The health effects of air quality came under public and scientific scrutiny as early as the 1930s following several incidents of mortality due to air pollution. These included an episode in Meuse Valley, Belgium in December 1930; Donora, Pennsylvania in 1948 and the infamous 'London fog' of December 1952 that took a toll of about 4000 lives. Several epidemiological studies have demonstrated a clear link between respiratory diseases and the levels of particulate air pollution. The more recent studies have been directed at quantifying the health effects and identifying the specific harmful components of air.

The common air pollutants are suspended particulate matter (SPM) or particulate matter (PM), sulphur dioxide (SO$_2$), nitrogen dioxide (NO$_2$), carbon monoxide (CO), ozone, lead and polyaromatic hydrocarbons. Of these, SPM has been most consistently linked with adverse health effects and mortality. The PM size has been utilized by various enforcement agencies to characterize and monitor ambient air quality. Particle size is expressed as its aerodynamic diameter (the diameter of a unit density particle that has the same settling velocity as the particle of interest). When inhaled, particles greater than $5 \mu m$ get deposited in the upper respiratory tract and those smaller than $5 \mu m$ get deposited in the smaller airways and are potentially more harmful. The concentration of particles less than $10 \mu m$ (PM$_{10}$) in ambient air is the standard used by most pollution control and monitoring organizations.

Increasing awareness and scientific evidence of the harmful effects of air pollution prompted many countries to establish air quality standards and agencies to monitor and enforce these standards. The Clean Air Act was passed in the USA in 1970 under which the Environmental Protection Agency (EPA) specified the National Ambient Air Quality Standards (NAAQS). The current air quality standards, as established by the EPA in 1971 and modified in 1987, specify the maximal allowable levels on an annual basis and in a 24-hour period for PM. The maximal allowed 24-hour concentration of PM$_{10}$ is $150 \mu g/m^3$ and the maximal allowed annual mean is $50 \mu g/m^3$.

In India, the National Ambient Air Quality Monitoring Programme (NAAQMP) was initiated in 1984 and by 1995, it had a network comprising about 290 stations covering 90 cities with the Central Pollution Control Board (CPCB; www.envfor.nic.in/cpcb) overseeing the operations. The NAAQMP specifies the range of acceptable levels for pollutants (SO$_2$, NO$_2$, and SPM) and is similar in scope to the EPA. To quote just one example, the annual average for 'respirable particulate matter' (size less than $10 \mu m$; PM$_{10}$) ranges from 50–120 $\mu g/m^3$ and the 24-hour average from 75–150 $\mu g/m^3$.

Over the past few years, several studies have looked at the health effects of inhalable PM. They have used different end-points such as mortality, hospital admissions for respiratory illnesses, emergency department visits for respiratory symptoms, lung functions (FEV$_1$, FEV$_{0.75}$, peak expiratory air flow), asthma attacks and bronchodilator use to quantify the effects of air pollution. The alarming results from mortality studies have aroused public concern about the deleterious effects of air pollution and promoted a search for means of tighter control.

In the prospective cohort study also known as the 'Six Cities Study', Dockery et al. followed up 8111 adults for 14–16 years in six eastern US cities. They found that mortality was strongly associated with fine, inhalable particles and was 26% higher in the most polluted city than in the least polluted, even after controlling for individual risk factors such as age, sex and cigarette smoking. Another study using the American Cancer Society (ACS) database of more than 550,000 volunteers in 151 cities over 8 years found a 17% difference in death rates between the most and least polluted cities.

The evidence is further strengthened by the time-series studies that reported day-to-day variations in death rates which correlated with the pollution levels on the preceding days. Dockery and Pope did a meta-analysis of the time-series studies and...
reported a coherent and consistent effect of PM10 level on various parameters. The daily all-cause mortality rose by almost 1% (weighted mean) with each 10 µg/m3 increase in PM10 concentration. Stronger associations were found with cardiovascular disease (1.4% per 10 µg/m3 rise in PM10) and respiratory disease (3.4% per 10 µg/m3 rise in PM10). Hospital admissions due to respiratory causes and emergency room visits increased by 0.8% and 1%, respectively, per 10 µg/m3 increase in PM10 levels. Asthma attacks and bronchodilator use increased by approximately 3% in the various studies included in the analysis. No acute effects were detected with respect to cancer and other non-pulmonary and non-cardiovascular causes of mortality. This study also revealed that the association between daily mortality and particulate air pollution was independent of SO2 concentration.

Interestingly, Pope observed a decrease in hospital admissions of children for respiratory diseases in Utah Valley by almost 50% during the winters of 1986–87 when a local steel mill was shut down. During the shut-down, the PM10 concentrations were much lower compared to the previous year when the mill was functioning. Increased rates of hospitalization for respiratory illnesses have been also correlated with levels of sulphates and ozone. Some studies have found an association between ozone levels and risk of death. A more recent study by Samet et al. assessed the effect of levels of five major pollutants (PM10, SO2, NO2, ozone and CO) on daily mortality in twenty of the largest cities in USA. They concluded that PM10 levels were strongly associated with death rates from all causes and from cardiovascular and respiratory illnesses. These effects were observed with PM10 levels that were well below the EPA standard in all the twenty cities.

Responding to the epidemiological and circumstantial evidence from studies demonstrating an association between PM (well below the maximal allowed norm) and mortality, the EPA in 1997 proposed continuing the PM10 standard. In addition, it also proposed that a new PM2.5 standard be used to further attenuate the effects of fine PM on health. Some scientists argued that although there was enough evidence to suggest that finer particles adversely affect human health, it was not adequate to specify the size of the particle. Industry and business groups charged that the implementation of the new guidelines would cost billions of dollars to modify vehicles and power plants for relatively minimal health benefits. This issue is before the US Supreme Court and promises to be a showdown between environment and industry advocates.

The situation in India is similar but on a very different scale. There is a relative paucity of data from India but some of the studies that have been published clearly implicate PM and other air pollutants as adversely affecting health. Awasthi et al. monitored respiratory symptoms in a cohort of 664 pre-school children in Lucknow every fortnight for a period of one year. They concluded that the SPM, SO2 and NO2 levels were associated with an increased incidence and duration of respiratory symptoms. A recent study from Calcutta by Lahiri et al. compared the respiratory symptoms complex, sputum cytology and presence of micronucleus in buccal epithelium in children from Calcutta with those from a rural area in the same state. They found that urban children had a higher prevalence of the respiratory symptoms complex and also had significantly increased numbers of neutrophils, eosinophils and iron-laden alveolar macrophages in the sputum. According to the 1998 NAAQMP data, the PM10 levels in the residential areas of Delhi are critical (>210 µg/m3). However, in a recent press report, the CPCB claimed a reduction in the PM10 levels in Delhi this year compared to past years. It is estimated that about 3000 metric tonnes of air pollutants are emitted every day in Delhi. The predominant source of this is emissions from vehicles (67%), coal-based thermal power plants (13%), industrial units (12%) and domestic (8%). It is projected that Delhi may have 6 million vehicles by 2011. Currently, two-wheelers account for about two-thirds of the total vehicular population. This is an important factor in considering any strategy to reduce pollution since the inherent drawbacks in 2-stroke engines allow them to emit about 20%–40% of the fuel unburnt or partially burnt. In
addition, it is an inescapable fact that petrol is widely believed to be adulterated with kerosene, which results in emissions of thick black smoke that citizens of Delhi are well aware of. The presence of old vehicles, overloaded buses, diesel trucks and the growing numbers of three-wheelers on the streets only compounds the problem. The recent pronouncements by the Supreme Court of India ordering the relocation of polluting industrial units in residential areas of Delhi has attracted both enthusiasm and opprobrium by concerned citizens. Some human rights advocates are disturbed by the prospect of displaced, unemployed industrial workers in the face of continuing vehicular pollution (the overwhelming source of air pollution) in Delhi.19

The contrasts in the scale of air pollution between the developed world (with USA as an example) and the developing world such as India are striking. In the face of declining concentrations of PM10 in the USA, the EPA has promulgated more stringent guidelines of PM2.5 with a hope to further tighten the control of air pollution. In sharp contrast, the levels of PM10 and the morbidity and mortality in India are already at alarming levels and are rising further with unsafe, polluting vehicles contributing the most to the worsening situation.

It is becoming increasingly apparent that the health hazards of air pollution and the means to control it are at the core of concerns of diverse groups in our society. Industry and business groups are eager to challenge the newer regulations even as environmental researchers and health policy advocates want to strengthen them based on the data available. Though the remedies for reducing air pollution are beyond the scope of this discussion, a point in passing is the recent experience in Sao Paulo, Brazil (one of the most polluted cities in the world). A 6-year programme designed to reduce exhaust emissions and traffic restrictions has produced promising results. Cars are banned from the streets one day per week depending on the last digits of license plates. If everyone respects the ban, at least 20% of the vehicles are off the roads every day from May–September (when the ban is in effect). News reports from Sao Paulo suggest declining levels of particulate air pollution compared to the preceding years.

While the science to support reducing the concentrations of PM is clearly established, it will take increased public awareness and political will to clear the air. The decisions of both the Supreme Courts of USA and India will be received and scrutinized carefully by the advocates of public health and industry alike.

REFERENCES


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—Editor