WorkOSH
Workplace Occupational Safety and Health
An Official Newsletter of ENVIS-NIOH
Vol. 12, No. 3
Jul. - Sept.
2017
ISSN:2393-8943

AMBIENT AIR POLLUTION

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Air pollution is a complex mixture of gases and particles whose sources and composition vary over space and time. While hundreds of different chemical compounds can be measured in air, governments typically measure only a small subset of gases and particles as indicators of the different types of air pollution and major sources contributing to that pollution. $PM_{2.5}$ is the most consistent and robust predictor of mortality in studies of long-term exposure to air pollution. Ozone, a gas produced via atmospheric reactions of precursor emissions, is associated with respiratory disease independent of exposure to $PM_{2.5}$.

Numbers, Numbers Everywhere

As recognition of the world's air pollution problems has grown, estimates of the numbers of deaths and years of healthy life lost attributable to outdoor air pollution have proliferated. Most of these health burden estimates are from the World Health Organization (WHO) or from the Institute for Health Metrics and Evaluation (IHME). The WHO estimated there were 3 million deaths from $PM_{2.5}$ exposure for the year 2012, while the GBD estimate was 4.2 million for the year 2015. Other estimates exist for outdoor air pollution–related deaths in individual countries or regions, alone and at times in combination with estimates for indoor air pollution.

Fig. 1: Air Pollution due to industrial emissions (Source [2]).

India's air pollution has become a public health and economic crisis. There are increasing numbers of people who die prematurely every year with the increasing pollution levels. Deaths due to air pollution are only a fraction less than the number of deaths caused by tobacco usage. Global Burden of Disease (GBD), a comprehensive regional and global research program including 500 researchers representing over 300 institutions and 50 countries, has estimated that 3283 Indians died per day due to outdoor air pollution in India in 2015, making the potential number of deaths due to outdoor air pollution in India in 2015 to 11.98 lakh. On the economic front, loss of productivity and the forced closures of schools and industries have already started impacting our economy. The World Bank estimates that India loses around 3% of its GDP due to air pollution. This makes air pollution one of the biggest issues to fight if we are to protect peoples' lives, public health and our economy [1].

Air pollution is a complex issue, requiring an array of solutions. Many sources contribute to pollution across the country. Depending on region and climatic conditions, the contribution of particular sources will also differ. However, what is very clear is that irrespective of where you live, burning of fossil fuels (coal & oil) contributes majorly to air pollution levels across regions.

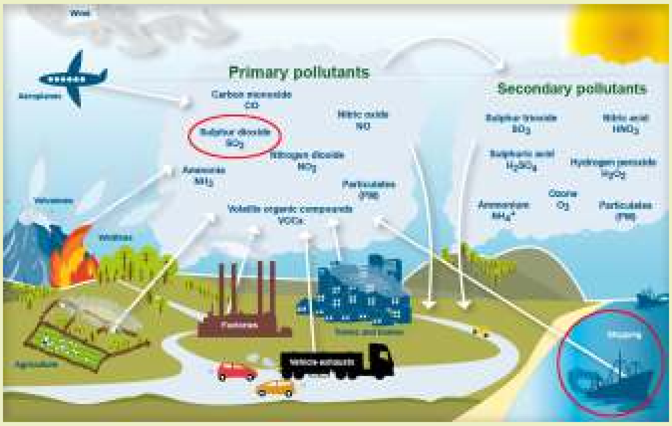

Fig. 2: Pollutants affecting the environment and health of the society (Source [3]).

The burden of increased mortality and disease from household air pollution falls most heavily on countries in Africa and in Asia where solid fuels are more extensively used. Although, still responsible for a substantial impact on global disease burden, the trends in percentage of all DALYs attributable to household air pollution are encouraging across all regions. Since 1990 there has been a 15.5% decrease globally in total deaths (a 39% decrease in death rates) and a 37% decrease in total DALYs (a 55% decrease in DALY rates) associated with household air pollution exposures.

Although household air pollution is tracked as an independent risk factor, it is also an important source of outdoor air pollution, so reducing household air pollution has added benefits for public health.

In 2015, long-term exposure to $PM_{2.5}$ contributed to 4.2 million deaths and to a loss of 103 million years of healthy life.

AMBIENT AIR POLLUTION

Industries, households, Cars and Trucks emit complex mixtures of air pollutants, many of which are harmful to health. All of these pollutants, fine particulate matter has the greatest effect on human health. Most fine particulate matter comes from fuel combustion, both from mobile sources such as vehicles and from stationary sources such as power plants, industry, households or biomass burning.

Fine particulate matter is associated with a broad spectrum of acute and chronic illness, such as lung cancer, Chronic Obstructive Pulmonary Disease (COPD) and cardiovascular diseases. Worldwide, it is estimated to cause about 25% of lung cancer deaths, 8% of COPD deaths, and about 15% of ischaemic heart disease and stroke. Particulate matter pollution is an environmental health problem that affects people worldwide, but low- and middle-income countries disproportionately experience this burden [1].

Traffic-Related Pollution

Motor vehicles pollute the air through tailpipe exhaust emissions and fuel evaporation, contributing to carbon monoxide, **$PM_{2.5}$**, nitrogen oxides, hydrocarbons, other hazardous air pollutants (HAPs), and ozone formation. Motor vehicles represent the principal source of air pollution in many communities, and concentrations of traffic pollutants are greater near major roads. Recently, investigators have found increased adverse health effects among those living near busy roads. Studies examining associations between adverse respiratory tract health and traffic have been reviewed. Increased respiratory tract complications in children (eg, wheezing, chronic productive cough, and asthma hospitalizations) have been associated with residence near areas of high traffic density (particularly truck traffic). Other investigators have linked various childhood cancers to proximity to traffic.

Diesel exhaust, a major source of fine particulate in urban areas, is carcinogenic. Numerous studies have found an association between occupational exposure to diesel exhaust and lung cancer. Based on extensive toxicologic and epidemiologic evidence, national and international health authorities, including the EPA and the International Agency for Research on Cancer, have concluded that there is considerable evidence of an association between exposure to diesel exhaust and an increased risk of lung cancer. Additionally, fine particles in diesel exhaust may enhance allergic and inflammatory responses to antigen challenge and may facilitate development of new allergies. Thus, diesel exhaust exposure may worsen symptoms in those with allergic rhinitis or asthma [4].

Particulate Matter (PM)

PM affects more people than any other pollutant. The major components of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. The most health-damaging particles are those with a diameter of 10 microns or less, (≤ Pm_{10}), which can penetrate and lodge deep inside the lungs. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer.

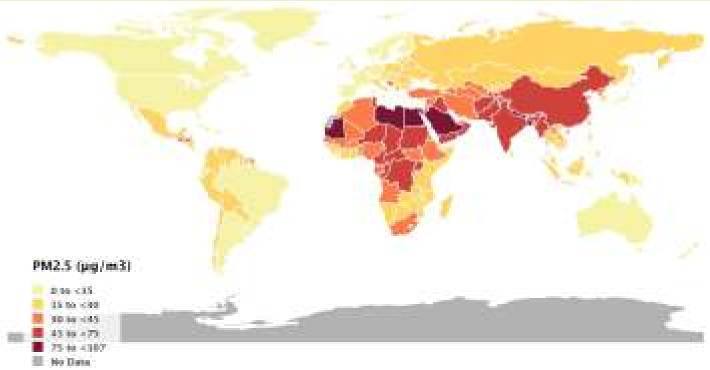

Fig no.3: Average Annual Population – Weighted $PM_{2.5}$ Concentrations in 2015 [1]

Air quality measurements are typically reported in terms of daily or annual mean concentrations of PM_{10} particles per cubic meter of air volume (m^3). Routine air quality measurements typically describe such PM concentrations in terms of micrograms per cubic meter ($\mu g/m^3$). When sufficiently sensitive measurement tools are available, concentrations of fine particles (**$PM_{2.5}$** or smaller), are also reported.

HEALTH EFFECTS

There is a close, quantitative relationship between exposure to high concentrations of small particulates (PM_{10} and $PM_{2.5}$) and increased mortality or morbidity, both daily and over time. Conversely, when concentrations of small and fine particulates are reduced, related mortality will also go down – presuming other factors remain the same. This allows policymakers to project the population health improvements that could be expected if particulate air pollution is reduced [5].

The mechanism for particulate matter–associated cardiac effects may be related to disturbances in the cardiac autonomic nervous system, cardiac arrhythmias, or increased blood concentrations of markers of cardiovascular risk (eg, fibrinogen).

Daily changes in mortality rates and numbers of people hospitalized are linked to changes in particulate air pollution. These studies and others have estimated that for every 10 $\mu g/m^3$ increase in PM_{10}, there is an increase in the daily mortality rate between 0.5% and 1.6%. Effects were seen even in cities with mean annual PM_{10} concentrations between 25 and 35 $\mu g/m^3$. These recent studies suggest that even the current federal standards for $PM_{2.5}$ (24-hour standard = 65 $\mu g/m^3$; annual standard = 15 $\mu g/m^3$) and PM_{10} (24-hour standard = 150 $\mu g/m^3$; annual standard = 50 $\mu g/m^3$) should be lowered to protect public health. [4]

OZONE

Ozone Ambient ozone is formed by the action of sunlight on nitrogen oxides and reactive hydro-carbons, both of which are emitted by motor vehicles and industrial sources.

Ozone is a powerful oxidant and respiratory tract irritant in adults and children, causing shortness of breath, chest pain when inhaling deeply, wheezing and cough. Children have decreases in lung function, increased respiratory tract symptoms, and asthma exacerbations on days with higher levels of ambient ozone. Increases in ambient ozone have been associated with respiratory or asthma hospitalizations, emergency department visits for asthma, and school absences for respiratory tract illness.

In healthy adults, ozone causes airway inflammation and hyper reactivity, decrements in pulmonary function, and increased respiratory tract symptoms. Although most of the controlled studies of ozone exposure have been performed with adults, it is

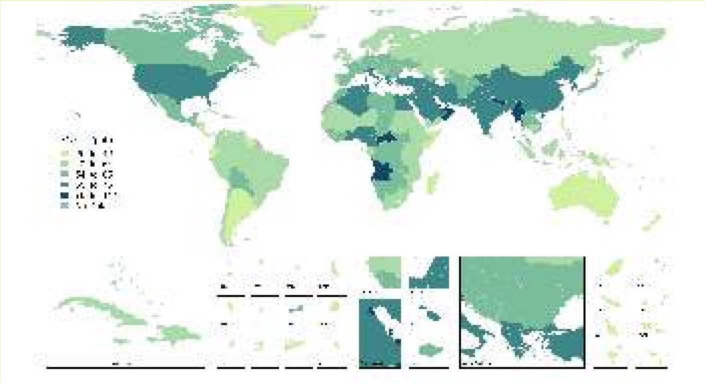

Fig. 4: Average Seasonal Population-Weighted Ozone Concentrations in 2015 [1].

reasonable to believe that the results of these findings could be extended to children [4].

Excessive ozone in the air can have a marked effect on human health. It can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases [6].

Recent studies of hospitalizations for respiratory tract illness in young children and emergency department visits for asthma suggest that the effects of ozone may occur at ambient concentrations below 0.09 ppm [7] [8].

In addition to studies on short-term effects, 2 recent studies of college freshmen suggested that increasing cumulative childhood exposure to ozone may affect lung function when exposed children reach young adulthood, particularly in measures of flow in small airways. Early childhood exposures may, therefore, be particularly important [9].

NITROGEN DIOXIDE

Nitrogen dioxide is a gaseous pollutant produced by high-temperature combustion. The main outdoor sources of nitrogen dioxide include diesel and gasoline-powered engines and power plants. Levels of nitrogen dioxide around have actually increased in the past 20 years because of an increase in nitrogen oxide emissions from diesel vehicles. This increase is of concern, because nitrogen oxide emissions contribute to ground-level ozone (smog) and other environmental problems such as acid rain.

The current WHO guideline value of 40 $\mu g/m^3$ (annual mean) was set to protect the public from the health effects of gaseous.

As an air pollutant, NO_2 has several correlated activities.

- At short-term concentrations exceeding 200 $\mu g/m^3$, it is a toxic gas, which causes significant inflammation of the airways.
- NO_2 is the main source of nitrate aerosols, which form an important fraction of $PM_{2.5}$ and, in the presence of ultraviolet light, of ozone.

The major sources of anthropogenic emissions of NO_2 are combustion processes (heating, power generation, and engines in vehicles and ships).

Epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO_2 [5].

Epidemiologic studies have reported relationships between increased ambient nitrogen dioxide and risks of respiratory tract symptoms and asthma exacerbations [10]. As noted previously, children with asthma living in communities with increased levels of air pollution (especially nitrogen dioxide, acid vapor, and particulates) were more likely to have bronchitis symptoms. The same mix of air pollutants was also associated with deficits in lung growth (as measured by lung function tests) [11]. These effects were increased in children who spent more time outdoors.

The epidemiologic studies of health effects associated with nitrogen dioxide should be interpreted with caution. Increased levels of ambient nitrogen dioxide may be a marker for exposure to traffic emissions or other combustion-related pollution. An independent role of nitrogen dioxide cannot be clearly established because of the high covariation between ambient nitrogen dioxide and other pollutants. None the less, these studies illustrate that adverse respiratory tract effects are seen in urban areas where traffic is a dominant source of air pollution [4].

SULFUR DIOXIDE (So_2)

SO_2 is a colorless gas with a sharp odour. It is produced from the burning of fossil fuels (coal and oil) and the smelting of mineral ores that contain sulfur. The main anthropogenic source of SO_2 is the burning of sulfur-containing fossil fuels for domestic heating, power generation and motor vehicles.

A SO_2 concentration of 500 $\mu g/m^3$ should not be exceeded over average periods of 10 minutes duration. Studies indicate that a proportion of people with asthma experience changes in pulmonary function and respiratory symptoms after periods of exposure to SO_2 as short as 10 minutes.

The (2005) revision of the 24-hour guideline for SO_2 concentrations from 125 to 20 $\mu g/m^3$ was based on the following considerations.

- Health effects are now known to be associated with much lower levels of SO_2 than previously believed.
- A greater degree of protection is needed.
- Although the causality of the effects of low concentrations of SO_2 is still uncertain, reducing SO_2 concentrations is likely to decrease exposure to co-pollutants.

SO_2 can affect the respiratory system and the functions of the lungs, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract. Hospital admissions for cardiac disease and mortality increase on days with higher SO_2 levels. When SO_2 combines with water, it forms sulfuric acid; this is the main component of acid rain that is a cause of deforestation [5].

OTHER AIR POLLUTANTS

Airborne levels of lead, sulfur dioxide, and carbon monoxide have decreased dramatically because of the implementation of control measures. However, levels of these pollutants may still be high near major sources. For example, high lead levels may be found near metals-processing industries, high sulfur dioxide levels may occur near large industrial facilities (especially coal-fired power plants), and high levels of carbon monoxide may occur in areas with heavy traffic congestion.

In addition to criteria air pollutants, there are numerous other air pollutants produced by motor vehicles, industrial facilities, residential wood combustion, agricultural burning, and other sources that are hazardous to children. More than 50000 chemicals are used commercially, and many are released into the air. For most of these chemicals, data on toxicity are sparse [12]. Some pollutants remain airborne or react in the atmosphere to produce other harmful substances. Other air pollutants deposit into and contaminate land and water. Some toxic air pollutants such as lead, mercury, and dioxins degrade slowly or not at all. These pollutants may bioaccumulate in animals at the top of the food chain, including humans. Children can be exposed to toxic air pollutants through contaminated air, water, soil, and food. One example of a persistent pollutant emitted into ambient air that leads to exposure through another route is mercury, a developmental neurotoxicant [13]. Industrial emissions, especially from coal-fired power plants, are the leading source of environmental mercury. Although the levels of airborne mercury may not be hazardous, mercury deposits into soil and surface waters and ultimately accumulates in fish [4].

AIR POLLUTION AND THE REGULATORY PROCEDURES

NATIONAL AMBIENT AIR QUALITY STANDARDS

S.NO	POLLUTANT	TIME WEIGHTED AVERAGE	CONCENTRATION IN AMBIENT AIR		WHO Guidelines
			INDUSTRIAL,RESIDENTIAL,RURAL & OTHER AREA	ECOLOGICALLY SENSITIVE AREA (NOTIFIED BY CENTRAL GOVERNMENT)	
1.	Sulphur Dioxide (SO_2) μg/m^3	Annual *	50	20	20 μg/m3 24-hour mean 500 μg/m3 10-minute mean
		24 hours **	80	80	
2.	Nitrogen Dioxide (NO_2) μg/m^3	Annual*	40	30	40 μg/m^3 annual mean 200 μg/m^3 1-hour mean
		24 hours **	80	80	
3.	Particular Matter (size less than 10 μm) or PM_{10} μg/m^3	Annual*	60	60	20 μg/m3 annual mean 50 μg/m3 24-hour mean
		24 hours **	100	100	
4.	Particular Matter (size less than 2.5 μm) or $PM_{2.5}$ μg/m^3	Annual*	40	40	10 μg/m3 annual mean 25 μg/m3 24-hour mean
		24 hours **	60	60	
5.	Ozone(o_3) μg/m^3	8 hours **	100	100	100 μg/m3 8-hour mean
		1 hours **	180	180	

6.	Lead (Pb) µg/m^3	Annual*	0.50	0.50	-
		24 hours **	1.0	1.0	
7.	Carbon Monoxide(CO) mg/m^3	8 hours **	02	02	-
		1 hours **	04	04	
8.	Ammonia(NH_3) µg/m^3	Annual*	100	100	-
		24 hours **	400	400	
9.	Benzene(C_6H_6) µg/m^3	Annual*	05	05	-
		24 hours **			
10.	Benzo(a)Pyrene(BaP)- particulate phase only,ng/m^3	Annual*	01	01	-
11.	Arsenic(As), ng/m^3	Annual*	06	06	-
12.	Nickel(Ni), ng/m^3	Annual*	20	20	-

*Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

**24 hours or 08 hours or 01 hourly monitored values as applicable shall be complied with 98% of the time I a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring [6] [14].

Population exposures to toxic air contaminants may be of substantial public health concern. In contrast to criteria pollutants, monitoring of toxic air contaminants is more limited. Protecting populations from exposure to the harmful effects of air pollutants will require effective control measures. Industry (eg, coal-burning power plants, refineries, and chemical plants) and motor vehicles (both gasoline- and diesel-powered) are major sources of criteria pollutants and HAPs. Municipal and hospital waste incinerators release toxic air pollutants including mercury, lead, cadmium, and dioxin emissions. Depending on weather conditions and individual physicochemical properties, some pollutants can be carried by air currents to areas many miles from the source [5].

The air quality index (AQI) provides local information on air quality and potential health concerns at the observed (or forecasted) levels of air pollution and can be a useful tool for educating families about local air quality and health. [15] Although many states and local air districts actively forecast and disseminate health warnings, the challenge is to have people take actions to protect themselves and decrease activities that cause air pollution.

The high levels of particulate emissions from diesel-powered buses and trucks must also be addressed. More than 70% of fine particle emissions from traffic are attributable to diesel-powered buses and trucks.

Driving a private car is probably a typical citizen's most "polluting" daily activity, yet in many cases, individuals have few alternative forms of transportation. Thus, urban planning and smart growth are imperative. Urban sprawl affects land use, transportation, and social and economic development and ultimately has important implications for public health [15].

FACTS FROM WHO

- **China and India together accounted for 52% of the total global deaths attributable to $PM_{2.5}$.**
- **On a global scale, the absolute number of deaths attributable to $PM_{2.5}$ increased from 3.5 million in 1990 to 4.2 million in 2015, due both to increases in air pollution and to growth and aging in the global population.**
- **India and Bangladesh experienced some of the largest increases in $PM_{2.5}$ -attributable mortality, on the order of 50% to 60%. India now approaches China in the number of deaths attributable to $PM_{2.5}$.**
- **Globally there was a 60% increase in ozone-attributable deaths, with a striking 67% of this increase occurring in India [1].**

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EVENTS

World Ozone day celebration was conducted at ENVIS-NIOH. On this backdrop, ENVIS Resource Partner organized an awareness programme on Ozone Layer production and its associated environmental benefits on 15th September 2017 at 11:30 a.m. at the auditorium of ICMR-National Institute of Occupational Health. The programme was inaugurated by Dr. Rekha Kashyap, Scientist 'F' and ENVIS Coordinator. Dr. L.K. Sharma, Scientist 'C' and ENVIS Co-Coordinator gave an introduction about the day. In this occasion, an awareness programme including video films on Ozone Protection and a success story was displayed to around all scientific and technical staff including the research scholars of the institute.

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Published by: **ENVIS Resource Partner**
ICMR - National Institute of Occupational Health,
Meghaninagar, Ahmedabad – 380016

Background Picture Source:
Front: https://www.medicalnewsbulletin.com/exposure-ambient-air-pollution-negative-impacts-prenatal-development-april-30-2016/
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