Chapter 7

AIR POLLUTION: TYPES, SOURCES AND ABATEMENT

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INTRODUCTION

Air supplies us with oxygen which is essential for our bodies to function and live. Plants and animals also need air for their survival. The air which we breath is a mixture of nitrogen, oxygen, water vapor, inert gases, carbon dioxide, hydrogen, methan, nitrous oxide etc. Of these, the first four constitute altogether 99.9% of the air. The rest are found in trace amount. The gaseous composition of unpolluted air is given in Table 1. Human activities can release substances (pollutants) into the air, some of which can deteriorate the quality of air and cause problems to humans, plants, and animals. Some natural sources such as volcanic activities, dust storms, forest fire etc. also contribute to air pollution. The amounts of air pollutants vary at different locations and at different times of day, days of the week and weeks of the year depending on spacial and temporal activities of the sources. Pollution is also found inside our homes, offices, and schools due to some of our indoor activities such as smoking, cooking, heating and use of artificial building

materials. Air pollution affects human health, agricultural productivity, transport system and our cultural assets (monuments and historical buildings).

In recent years the problem of air pollution has been aggravated by a number of reasons such as the population growth, urbanization, rapid economic development, industrialization and increasing traffic and levels of energy consumption. To understand the extent of air pollution in space and time, its environmental, social and economic implications, and to decide on sensible policies to mitigate it, there is need of increasing our understanding of the problem.

Table 1: The gaseous composition of unpolluted air

The Gases	*Parts per million (vol)*
Nitrogen	756,500
Oxygen	202,900
Water	31,200
Argon	9,000
Carbon Dioxide	305
Neon	17.4
Helium	5.0
Methane	0.97–1.16
Krypton	0.97
Nitrous oxide	0.49
Hydrogen	0.49
Xenon	0.08
Organic vapours	ca.0.02

DEFINITION

One of the formal definitions of air pollution is as follows — 'The presence in the atmosphere of one or more contaminants in such quality and for such duration as is injurious, or tends to be injurious, to human health or welfare, animal or plant life.' Air pollution is caused by the discharge of harmful substances.

SOURCES OF AIR POLLUTION

Air pollutants are emitted into the atmosphere from stationary, area, and mobile sources. Stationary sources include utility, industrial, institutional and commercial facilities. Examples are thermal power plants, chemical plants, pulp and paper factories, and municipal waste incinerators etc. Area sources include many individually small activities such as petrol/diesel service stations, small paint shops, consumer solvent use, and open burning associated with agriculture and forest management activities. Mobile sources include automobile, ships and aeroplanes.

Man-made

Large-sized industries and thermal power plants, small scale industries and transport sectors are major sources of air pollution. Besides transport and industrial sectors, the domestic and commercial sectors also contribute to the overall pollution load in urban areas. Other sources of air pollution include the use of generators, waste burning, construction activities, and roadside airborne dust due to vehicular movement. The following industries are among those that emit a great deal of pollutants into the air: thermal power plants, cement, steel, refineries, petro-chemicals, and mines. Contribution of various sectors to ambient air pollution in India is given in Table 2.

Natural

Air pollution also results from a variety of natural causes, not all of which are within human control. Dust storms in desert areas and smoke from forest fires and grass fires contribute to gaseous and particulate pollution of the air. The source of pollution may be in one country but the impact of pollution may be felt elsewhere. Volcanic activity is another important natural source of air pollution. Active volcano pours great amounts of ash and toxic fumes into the atmosphere and lead to the deterioration of air quality.

Table 2: Contribution of various sectors to ambient air pollution

Sector	*1970–1971*	*1980–1981*	*1990–1991*	*2000–2001*
Industrial	56%	41%	29%	20%
Transport	23%	42%	63%	72%
Domestic	21%	18%	7%	8%

Source: MoEF 1997

TYPES OF AIR POLLUTION

Air pollutants can be considered in following two major categories: The particulate matter and gaseous.

Suspended particulate matter (SPM)

One type of air pollution is the release of particles into the air from burning fuel for energy. SPM consists of solids in the air in the form of smoke, dust, and vapour that can remain suspended for extended periods and is also the main source of haze which reduces visibility. Airborne particulate matter is a very diverse material in terms of its physical and chemical properties and there are many sources which contribute to atmospheric concentrations. The finer of these airborne particles, when breathed in can lodge in our lungs and cause lung damage and respiratory problems.

SPM is typically classified according to the particle size. The particle size can vary from approximately 0.005 microns to 100 microns in diameter. All ambient SPM irrespective of size is referred to as suspended particulate matter (SPM) or total suspended particles (TSP) when a gravimetric procedure has been used for measuring mass. Of these, particulate matter (PM) less than 10 microns in diameter is referred to as PM10, and PM less than 2.5 microns is referred to as PM2.5. The term *fine* PM has also come to be associated with PM2.5, *ultra fine* with PM less than 0.1 microns in diameter (PM0.1), and *coarse* with PM in the size range between 2.5 and 10 microns. All PM less than 10 microns in size can be inhaled in our lungs through respiration, hence they are also referred to as respirable suspended particulate matter (RSPM). Of late, the focus of PM measurement in ambient air has shifted from

measuring TSP to mass-based measurement of PM10.The smallest particles have the greatest potential to impact human health because of their ability to be inhaled deeply into the lungs.

Airborne particles may be measured in several different ways. Generally they are now measured by a method that determines the mass of that fraction which is considered most likely to be deposited in the lung. The most commonly used is PM10 measurement that relies on the use of a size-selective sampler which collects smaller particles preferentially. An older method of measuring particulate matter is the "Black Smoke" method in which the concentration of fine particles being estimated by measuring the blackness of the stain produced when sucked through filter paper. Black Smoke measurements do not provide a reliable quantification of the mass concentration of particles in the atmosphere but rather reflect the contribution of combustion sources, most particularly diesel vehicles. There is no direct comparison with PM10 measurements, which have tended to supplant Black Smoke as the standard measure of particulate pollution.

SOME EXAMPLES OF PARTICULATE POLLUTANTS

Silica

Silica (silicon dioxide, SiO_2) and silicates constitute the major portion of all rocks and their products, such as soils, sands, and clays. Silica occurs in either its free form or a combined state called silicate. Free silica may be in crystalline form such as quartz, granite, flint and diatomite, or in non-crystalline form. Breathing of tiny particles of free silica causes *Silicosis*, a disease of respiratory system.

Asbestos

Asbestos is an incombustible chemical-resistant, fibrous material used for fireproofing materials as well as insulation, building materials, brake linings, etc. Asbestos fibers in the ambient air pose a risk to human health in the form of cancer and other diseases.

Lead

Automobiles running on petrol mixed with lead are the main sources of lead in air. Once released lead can be transported through the air and reach to human, plants, animals. Lead is present in diesel, lead batteries, paints, hair dye products, etc and contributes to particulate pollution. Lead can cause nervous system damage, digestive problems, anemia and, in some cases cause cancer. The young and the elderly people are most susceptible to the harmful effects of lead.

Mercury

Reactive, inorganic mercury is emitted to the atmosphere from various sources and then deposited on the earth's surface. Some of the deposited mercury ends up in wetlands, lakes, and streams where bacteria convert it into methylmercury, a toxic form that builds up (bioaccumulates) in the tissues of animals at each link in the food chain. In some cases, mercury accumulates in fish to levels that would be toxic if eaten by humans over a prolonged period of time or by the wildlife that prey upon those fish.

Gaseous

Another type of pollution is the release of noxious gases, such as sulfur oxides (SOx), carbon monoxide (CO), nitrogen oxides (NOx), and chemical vapors etc. These can take part in further chemical reactions once they are in the atmosphere, forming smog, acid rain and various secondary pollutants such as ozone, peroxyacyl nitrate (PAN) aldehydes and ketones. Some examples of gaseous pollutants are given below:

Sulphur dioxide (SO_2)

Sulphur dioxide is a gas produced from burning coal, mainly in thermal power plants. Some industrial processes, such as phosphate industry, production of paper and smelting of

metals produce sulphur dioxide. SO_2 is a major contributor to smog and acid rain. It is an acid gas and can affect human health and vegetation.

Carbon monoxide (CO)

Carbon monoxide is a colourless, odourless gas that is produced by the incomplete burning of carbon-based fuels including coal, petrol, diesel, and wood. Carbon monoxide is produced primarily by motor vehicles. Carbon monoxide reduces the capacity of the blood to carry oxygen and deliver it to the tissues. It can slow our reflexes and make us confused and sleepy. It can reduce a person's ability to think clearly, and causes visual impairment and headaches. CO can cause even death if high enough concentration is inhaled for a long time.

Nitrogen oxide (NOx)

Nitrogen dioxide is the major component of oxides of nitrogen (NOx). It is produced when fuel is burned in motor vehicles, power plants, industrial boilers, and other sources. Other significant sources of NOx are from the adipic acid production used in nylon manufacture and nitric acid production. NOx can make children susceptible to respiratory diseases in winters.

Ozone (O_3)

Ozone occur naturally in the upper layers of the atmosphere. This important gas shields the earth from the harmful ultraviolet rays of the sun. However, at the ground level, it is a pollutant with highly toxic effects. Pollutants emitted by vehicles and industries are the major source of ground-level ozone emissions. In fact, ozone is a secondary pollutant formed by photochemical reaction of primary pollutants such as NO_2 (NO_2 + UV rays $\rightleftharpoons$ NO + O; O + O_2 $\rightleftharpoons$ O_3). It makes our eyes itch, burn, and water. It lowers our resistance to colds and pneumonia. It also causes damage to vegetation.

At high concentrations, brown or white flecking often appears on leaves. At lower concentrations, plant growth may be reduced without any visible damage.

Hydrocarbons (HCs)

Hydrocarbons are compounds composed of hydrogen and carbon. These are thousands of such compounds, including methane, butane, propane etc. The most important anthropogenic source is the automobile. HCs have various direct adverse effects on plants and animals including human beings. They may be converted into harmful compounds through complex chemical reactions continuously occurring in atmosphere. Specific HCs are described in later sections of the article.

Hydrogen sulfide (HS)

Hydrogen Sulfide is a highly toxic and corrosive gas, easily identified by its characteristic rotten-egg odour. HS is produced from natural sources, such as geysers, swamps and bogs, as well as from human sources, such as petroleum processing and refining and metal smelting. The potential effects of HS include direct toxicity leading to functional disorders in animals and plants.

Radon

Radon-222 (^{222}Rn) is a naturally occurring radioactive gas which comes out of the ground. In the open air, it is dispersed but it can accumulate in buildings. The gas decays into minute solid particles which, if breathed in, can be deposited on the surface of the lungs and increases the risk of lung cancer.

OTHER GASEOUS POLLUTANTS

There are many other pollutants for which safe levels in the outdoor air have not been determined. These include Ammonia (NH_3), Hydrogen Chloride (HCl) and Hydrogen

Fluoride (HF), Persistent Organic Pollutants (POPs), Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs), Chloroflorocarbons (CFC) and the Volatile Organic Compounds (VOCs). Some of these react in atmosphere and form secondary pollutants such as ozone, metals and sulfate particles etc. Some of these affect our health; others affect our ecosystems, causing acid rain, global warming and other problems on a regional and international scale.

EFFECTS OF AIR POLLUTION

Effect on human health

Millions of people breathe air with high concentrations of pollutants. The air, in urban India is highly polluted in terms of SPM of different types. Breathing of air containing high concentration of SPM is responsible for a greater incidence of respiratory health problems. The effects are manifested in the form of sub-clinical effects, impaired pulmonary functions, use of medication, reduced physical performance, frequent medical consultations and hospital admissions with complicated morbidity and even death in the exposed population.

Respiratory infections amount for 10.9 per cent of the total burden of diseases, which may be both due to presence of communicable diseases as well as high air pollution levels (World Bank, 1993). A WHO/UNEP study (1992) compared prevalence of respiratory diseases in different areas of Mumbai, classified according to ambient average concentrations of SO_2. The study revealed a relatively higher prevalence of most respiratory diseases in polluted urban areas compared with rural control area. In Delhi, the increasing levels of air pollution are responsible for higher incidence of respiratory diseases, cancer, and heart diseases. Polluted air is responsible for over 40 per cent of the emergency hospital admissions of patients with breathing and heart problems. This was revealed in a 1999 epidemiological study by All India Institute of Medical Sciences which focused on 100,000 patients who were rushed in following aggravation of symptoms of asthma, chronic

bronchitis and heart ailments. According to another study conducted in 10 schools of Delhi in 1996 by Vallabh Bhai Patel Chest Institute, the cumulative prevalence of asthma in children was 15.3 per cent (GHK International Ltd., 2000). Brandon et al. (1995) estimated the total magnitude of economic costs associated with environmental degradation in India. Using the 1991–1992 air pollution data for particulates, SO_2, NOx, and lead from 36 cities, health impacts were estimated in terms of reductions in morbidity and mortality if pollutant levels in these cities were reduced to the WHO annual average standard. The total health costs due to air pollution were estimated to be US $ 517–2102 million.

Ecological effects

Acid deposition

Acid rain, which may damage lakes and streams, occurs when emissions of certain air pollutants react in the atmosphere to form acidic compounds that are then deposited on the earth's surface. The main precursors of acid deposition are emissions of SO_2 and NOx. This deposition consists of both wet processes (polluted rainfall) and dry processes (interception of gases and particles at the surface) and can occur hundreds of kilometers away from the source of the emissions.

Greenhouse effect

The is a natural phenomenon that occurs when certain gases in the atmosphere, especially water vapor, carbon dioxide and methane, cause the Earth's surface to heat up more than it otherwise would, thereby maintaining a global average temperature warm enough to support a rich variety of life. Global warming occurs when the amounts of carbon dioxide and other such gases in the atmosphere increase beyond natural levels, thereby intensifying the greenhouse effect manifested by various environmental problems. CO_2, CH_4,

N_2O, and CFCs are some important greenhouse gases responsible for global warming.

Carbon dioxide is the principle greenhouse gas emitted as a result of various human activities such as the burning of biomass, coal, oil, and natural gases. CO_2 concentrations in the atmosphere are increasing at approximately 0.5 per cent per annum. The global man-made emissions of CO_2 are currently estimated to range between 5.7 and 6.9 billion tonnes carbon per annum (not including a further 1.5 billion tonnes from land use change). Average global surface temperatures have increased by 0.6°C ± 0.2°C over the 20th century. Current climate models predict that global temperatures will rise by a further 1.4°C to 5.8°C by the end of the 21st century. However, research suggest that if the effects of climate change on the carbon cycle are included then there could be an additional 2°C warming over land by 2100. Global mean sea levels are also predicted to rise by 9 cm to 88 cm by 2100.

Studies suggest that observed changes in regional climate over the past 50 years have already affected biological and hydrological systems in many parts of the world, e.g., species distributions and the timing of reproduction or migration events. There are also preliminary indications that some social and economic systems have been affected by recent increases in floods and droughts. Some of the most substantial effects of climate change could include: increased threats to human health, particularly in lower income populations; increased extinction risk for some vulnerable species; decreased agricultural yield in many tropical and subtropical regions; heightened water shortages in many water-scarce areas of the world; further risk of storm and flooding damage in populations that inhabit small islands and low-lying coastal areas.

Stratospheric ozone depletion

Ozone is continually created and destroyed in the stratosphere by a cycle of chemical reactions. Depletion of the ozone layer

is caused when halogenated compounds are broken down in the stratosphere by sunlight to release chlorine and bromine atoms which then catalyse the reactions that destroy ozone. This process is enhanced by the presence of polar stratospheric clouds (PSCs), which form at very low temperatures in the stratosphere and enable normally inert compounds to take part in reactions that produce ozone destroying free radicals such as chlorine atoms. In polar regions, ozone depletion is particularly rapid during the winter and spring but slows when the atmosphere warms up sufficiently to prevent the formation of PSCs. As the rate of ozone destruction slows down the reactions that form ozone, and the influx of ozone-rich air from other latitudes help to replenish the ozone lost during the previous months. There is now unequivocal evidence that stratospheric ozone depletion is being caused by anthropogenic emissions of chlorine and bromine-containing substances such as CFCs and halons, emitted as a result of their use as spray can propellants, refrigerants, foam-blowing agents and in fire extinguishers. Emissions of methyl chloroform, carbon tetrachloride and methyl bromide also contribute to the depletion of ozone.

One of the main reasons for the widespread concern about depletion of the stratospheric ozone layer is the anticipated increase in the amounts of ultraviolet radiation received at the surface of the Earth and the consequent effects on human health and on the environment. Increased exposure to UV radiation will increase the likelihood of deleterious effects on biological systems. In humans these effects include sunburn, skin cancers, damage to the eye and affects on the immune system; similar effects may be expected for land and aquatic animals. Increased UV radiation might also modify the development of flora and fauna, interactions between species and affect biodiversity through the selection of UV resistant aquatic and terrestrial species. International agreement to limit the production and consumption of ozone depleting substances was reached in 1987 through the Montreal Protocol on Substances that Deplete the Ozone Layer.

ABATEMENT AND CONTROL OF AIR POLLUTION IN INDIA

Abatement and Control of Air pollution in India is a challenging issue. The government has taken a number of measures such as legislation, emission standards for industries, guidelines for siting of industries, environmental audit, Environmental Impact Assessment (EIA), vehicular pollution control measures, pollution prevention technologies, action plans for problem areas, development of environmental standards, and promotion of environmental awareness. However, despite all these measures, air pollution still remains one of the major environmental problems. At the same time, there have been success stories as well, such as the reduction of ambient lead levels (due to introduction of unleaded petrol) and comparatively lower SO_2 levels (due to progressive reduction of sulphur content in fuel). Introduction of Compressed Natural Gas (CNG) vehicles in Delhi and phasing out of old vehicles from roads are some recent steps taken to control air pollution.

Legislation

The government has formulated a number of legislative measures, policies and programmes for protecting the environment. Some of these related to air pollution are the Air (Prevention and control of pollution) Act, 1981 and the Environment (Protection) Act, 1986. India has also adopted the Male declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia in April 1998. Ambient air quality standards have been laid down for industrial, residential, rural and sensitive areas with respect to pollutants such as SO_2, NOx, SPM, RSPM and Pb.

Guidelines for siting of industries

Guidelines for siting industries are prescribed so that the possible adverse effects on the environment and quality of

Table 3: Six major air pollutants, their sources, health effects and control measures

Pollutant	*Symbol*	*Major Man-made Sources*	*Human Health and Welfare Effects*	*Control Methods*
PARTICULATE MATTER				
Airborne solid or liquid particles, smaller than 10 microns in diameter smaller than 2.5 microns	PM_{10} $PM_{2.5}$	Power plant boilers, steel mills, chemical plants, unpaved roads and parking lots, wood-burning stoves and fireplaces. Automobiles and other.	Aggravates respiratory effects like asthma and emphysema. May cause lung and heart problems. May carry toxic materials deep into the respiratory system. Impairs visibility.	Pollution control equipment and reduction of fuel combustion. or
SULFUR DIOXIDE				
A colorless non-flammable gas.	SO_2	Power plant boilers, sulfuric acid plants, petroleum refineries, smelters, paper mills, and fuel combustion in diesel engines	Respiratory irritant. Aggravates lung and heart problems. In presence of moisture and oxygen, sulfur dioxide converts to sulfuric acid which can damage marble, iron, steel, and damage crops and natural vegetation. Impairs visibility. Precursor to acid rain.	Use of low sulfur fuel, energy conservation (reduces power plant emissions), and pollution control equipment.
CARBON MONOXIDE				
An odorless and colorless gas.	CO	Incomplete combustion of carbon-based fuels in motor vehicle and industrial boilers.	Reduces the ability of blood to deliver oxygen to vital tissues, affecting the cardiovascular and nervous system. Impairs vision, causes dizziness, and can lead to unconsciousness or death.	Transportation planning, vehicle emissions testing, efficient combustion techniques, and energy conservation.

OZONE				
(Smog) A colorless or bluish gas.	O_3	Formed from emissions of volatile organic compounds (VOC) and nitrogen oxides in the presence of sunlight. Fuel combustion in motor vehicles, gasoline storage and transport, solvents, paints and landfills.	Irritates mucous membranes, aggravates lung and heart problems. Damages rubber, some textiles and dyes. Damages plants. Reduces crop yield.	Use of low-VOC solvents, evaporative controls, vehicle emissions testing, pollution control equipment.
NITROGEN DIOXIDE				
A reddish-brown gas.	NO_2	Fuel combustion in motor vehicles and industrial sources.	Respiratory irritant. Aggravates lung and heart problems. Precursor to ozone and acid rain. Causes brown discoloration of atmosphere.	Exhaust gas recirculation in cars, reduction of combustion temperatures in industrial sources, energy conservation and pollution control equipment.
LEAD				
A toxic heavy metal.	Pb	Smelters, lead-acid battery manufacturing, electric arc furnaces, incineration of garbage containing lead products, and use of leaded gasoline.	Toxic to the nervous system, organs, and most levels of body function.	Phase-out of leaded gasoline, and use of pollution control equipment in industrial plants.

life can be minimized. Some natural life-sustaining systems and specific land-uses are more sensitive, and thus the minimum distance for siting a given industry has been prescribed in such cases.

Environmental impact assessment

Environmental Impact Assessment (EIA) is mandatory for 29 specific activities/projects and also for some of the activities to be taken up in identified areas such as the coastal zone. The procedure for examining the impact of different activities includes the preparation of an EIA report, holding a public hearing and examination by a duly constituted expert committee (MoEF 1999). MoEF has also taken up carrying capacity based regional planning studies in certain selected areas of the country including the National Capital Region (NCR).

Emission standards for industries

The CPCB has laid down the maximum permissible limits for different pollutants for many categories of industries that contribute to air pollution. The standards have been notified by MoEF under the Environment (Protection) Act 1986. National Ambient Air quality Standards are given is Table 4.

Environmental audit

Submission of an environmental statement by polluting units to the concerned State Pollution Control Boards has been made mandatory under the Environment (Protection) Act, 1986.

Zoning atlas for siting of industries

In order to delineate the areas that are suitable for industrial siting, a district-wise zoning atlas project has been taken up by the CPCB that zones and classifies the environment in a district. The industrial zones are identified based on the sensitivity and pollution-receiving potential of the district.

Table 4: National Ambient Air quality Standards (NAAQS)

Pollutants	*Time Weighted Average*	*Concentration of Ambient Air*			
		Industrial Area	*Residential Rural and*	*Sensitive area other area*	*Method of Measurement*
Sulphur Dioxide (SO_2)	Annual Average 24 hours	80μg/m³ 120μg/m³	60μg/m³ 80μg/m³	15μg/m³ 30μg/m³	Improved west and Gacke Method Ultraviolet fluorescence
Oxides of Nitrogen (NO_2)	Annual Average 24 hours	80μg/m³ 120μg/m³	60μg/m³ 80μg/m³	15μg/m³ 30μg/m³	Jacab Hochheister modified (Na-Arsentire method Gas Phase Chemilumine Scene
Suspended Particulate Matter (SPM)	Annual Average 24 hours	360μg/m³ 500μg/m³	140μg/m³ 200μg/m³	70μg/m³ 100μg/m³	High Volume sampling (average flow rate not less than 1.1 m³/ minute)
Respirable Particulate Matter (size Less than 10μm) RPM	Annual Average 24 hours	120μg/m³ 150μg/m³	60μg/m³ 100μg/m³	50μg/m³ 75μg/m³	Respirable particulate matter sampler
Lead as Pb	Annual Average 24 hours	1.0μg/m³ 1.5μg/m³	0.75μg/m³ 1.0μg/m³	0.50μg/m³ 0.75μg/m³	AAS method after sampling using EPM 2000 or equivalent filter paper
Carbon Monoxide (CO)	8 hours 1 hour	5.0μg/m³ 10.0μg/m³	2.0μg/m³ 4.0μg/m³	1.0μg/m³ 2.0μg/m³	Non disbersive infrared spectroscopy

Annual Average: Annual Arithmetic Mean of minimum 104 measurements in a year taken twice a week 24-hourly at uniform interval.
24 Hours Average: 24-hourly/8-hourly values should be met 98% of the time in a year. However 2% of the time, it may exceed but not two consecutive days.

DEVELOPMENT OF POLLUTION PREVENTION TECHNOLOGIES

Industries are encouraged to use cleaner and low waste or no waste technologies to reduce waste generation and the emission of pollutants (CPCB, 2000). There is an opportunity

for the demonstration and replication of cleaner technologies in clusters of small-scale industries.

BENEFICIATED COAL

The Ministry of Environment and Forests has made it mandatory for thermal power plants located more than 1,000 km from the coal pit-head, or in urban, ecologically sensitive or critically-polluted areas, to use beneficiated/blended coal containing ash no more than 34 per cent, with effect from June 2002. The power plants using FBC (Fluidized Bed Combustion) and IGCC (Integrated Gasification Combined Cycle) combustion technologies are, however, exempted from using beneficiated coal irrespective of their locations.

EPIDEMIOLOGICAL STUDIES

MoEF has initiated the environmental epidemiological studies in seven critically polluted areas. The initial feedback from the studies indicates that the incidence of symptomatic morbidity (eye irritation, respiratory problem and skin lesion/ irritation) is high in areas of industrial activity. However, no direct correlation between morbidity and mortality rates and environmental pollution could be established.

CONTROL OF VEHICULAR POLLUTION

Due to increasing number of vehicles, contribution of air pollution by transport sector is increasing day by day. The measures taken by government to mitigate emissions from transport sector are as follows:

Stringent emission norms

Mass emission standards for new vehicles were first introduced in India in 1991. Stringent emission norms along with fuel quality specifications were laid down in 1996 and 2000. Euro I norms are applicable from 1 April 2000 and Euro II norms will be applicable all over India from 1 April 2005.

However, in the case of the National Capital Region (NCR), the norms were brought forward to 1 June 1999 and 1 April 2000 for Euro I (Bharat Stage I) and Euro II (Bharat Stage II), respectively (CPCB, 1999; SIAM, 1999).

Cleaner fuel quality

To conform to the stringent emission norms, it is imperative that both fuel specification and engine technologies go hand in hand. Fuel quality specifications have been laid down by the Bureau of Indian Standards (BIS) for petrol and diesel for the period 2000–2005 and beyond 2005 for the country. Given the increased usage of diesel in India it has become necessary to reduce the sulphur content of diesel. The directive by the Supreme Court, the Ministry of Petroleum and Natural Gas requires the supply of diesel with 0.05 per cent (500 ppm) sulphur content in the entire NCR from July 2001. In Mumbai and Calcutta, all vehicles are required to use 0.05 per cent sulphur in diesel from October 2000 and October 2002, respectively. Unleaded gasoline was introduced in April 1995 in the four metro cities of Delhi, Mumbai, Calcutta and Chennai. Leaded petrol has been phased out in the entire country since 1 February 2000. Similarly the benzene content is to be reduced and now, unleaded petrol with 1 per cent benzene and 0.05 per cent sulphur content is being supplied in the NCR. It will also be extended further to other parts of the country. The use of LPG as fuel for automobiles has also been permitted.

Inspection and maintenance (I&M)

The most important step towards emission control for the large in-use fleet of vehicles is the formulation of an inspection and maintenance system. It is possible to reduce 30–40 per cent pollution loads generated by vehicles through proper periodical inspections and maintenance of vehicles (CPCB, 2000). I&M measures for in-use vehicles are an essential complement to emission standards for new vehicles. In India, the existing mechanism of I&M is inadequate. Thus, there is a great need to establish effective periodic I&M programmes.

Other stringent measures

On 1st April 1999, the specifications for 2T oil became effective. In order to prevent the use of 2T oil in excess of the required quantity, premixed 2T oil dispensers have been installed in all gasoline stations of Delhi (CPCB, 1999). Traffic management measures such as restriction on movement of goods vehicles during peak traffic hours have been enforced. Other measures include bans on commercial vehicles more than 15 years old, phase out of high polluting vehicles, replacement of all pre-1990 autos and taxis with new vehicles using clean fuels; and the removal of eight-year old buses from the roads unless they use compressed natural gas (CNG) or other clean fuel. All buses/autos/taxis in Delhi are to switch over to CNG instead of diesel (CPCB, 1999). By the end July 2001, 1,600 buses, 25,000 autos and 10,000 cars including 1,100 taxis were operating on CNG in Delhi.

Role of the judiciary

In recent years, the judiciary has played a prominent role in environmental protection. A number of judgments relating to stringent vehicle emission norms, fuel quality, introduction of cleaner fuels, phasing-out of older vehicles, and shifting of hazardous industries have provided a great deal of momentum in the efforts to improve air quality. The Environment Pollution (Prevention & Control) Authority for the National Capital Region (EPCA) has been monitoring the implementation of action points outlined in the White paper on Pollution in Delhi with an action plan and priority measures approved by the Supreme Court of India.

Shifting of industries from residential areas

Necessary steps have been taken to shift and relocate industries located in residential area to assigned industrial areas in order to reduce pollution and its impact on human population in urban areas.

MONITORING OF AIR QUALITY

Air quality monitoring involves estimation of concentration levels of Suspended particulate matter (SPM), Respirable suspended particulate matter (RSPM), Sulphur dioxide (SO_2), oxides of Nitrogen (NOx) and Carbon monoxide (CO) in the study area. The mineralogical composition of respirable dust is also required to be analysed.

Method of sampling and monitoring

Respirable dust high volume sampler is the instrument used for the monitoring of Air quality parameters. This instrument (design based on NEERI, Nagpur, Technology) separates SPM and respirable fraction (i.e. particle size less than 10 microns) of respirable suspended particulate matter (RSPM) and thus helps in estimation of both SPM and RSPM concentrations. This instrument has provision for incorporation of gaseous sampling unit for simultaneously monitoring gaseous pollutants like SO_2 and NOx present in Ambient Air. The gaseous sampling module has impingers for absorption of gaseous pollutants into suitable absorbing solutions. Pollutant concentrations are subsequently estimated by standard methods of Analysis.

The sampling duration and frequency of Air quality monitoring have been clearly specified by MoEF in the questionnaire issued for environmental appraisal of mining projects under Environment impact Assessment Notification issued in 1994. The Air quality monitoring is carried out in all the seasons in a year except monsoon. Three eight hourly samples are collected in continuous 24 hours period for two days in a week for the all the seasons (except monsoon). Whereas SPM, RSPM, SO_2 and NOx are measured as 8 hourly concentrations, CO concentration is measured by collecting 3 grab samples a day (each of 5 minutes duration).

Method of analysis

The air quality parameters are analysed as per IS-5182 — Method of measurement of pollution: SPM — Gravimetric

Analysis; SO_2 — Modified West & Gaeke Method; NOx — Jacobs & Hochheiser Method; CO — Indicator Tube Method.

STATUTORY BODIES

Central pollution control board (CPCB)

The Central Pollution Control Board (CPCB), a statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests under provisions of the Environment (Protection) Act, 1986.

Principal functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981 include (i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) to improve the quality of air and to prevent, control or abate air pollution in the country. The CPCB coordinates with State Pollution Control Boards (SPCB) functioning in different states of the country.

National ambient air quality monitoring (NAAQM) programme

Air Quality Monitoring is an important part of the air quality management. The National Ambient Air Quality Monitoring (NAAQM) Programme has been established with objectives to determine the present air quality status and trends and to control and regulate pollution from industries and other source to meet the air quality standards. It also provides background air quality data needed for industrial siting and town planning. This nation wide programme aws initiated in 1984.

Besides, CPCB has automobile monitoring stations at various strategic locations to monitor RSPM, CO, O_3, SO_2, NO_2

and SPM, regularly. In addition, NEERI monitors special parameters, like Ammonia (NH_3), Hydrogen Sulphide (H_2S) and Polyaromatic Hydrocarbons (PAH). Based on Annual Mean Concentration (microgram per cubic meter of ambient air) of SO_2, NO_2 and SPM and the Notified Ambient Air Quality Standards, the Ambient Air Quality Status is described in terms of Low (L), Moderate (M), High (H) and Critical (C) for Industrial (I), Residential and mixed use areas of cities/towns in different states/UTs. The meteorological parameters, like wind speed & direction, temperature and humidity are also collected.

SOURCES OF AIR POLLUTION DATA

As described in earlier sections, the primary data on different parameters of air quality are generated by CPCB, SPCB and NEERI. In addition, data on air pollution are also generated by various Government and Non-Government agencies, Academic & Research organizations for specific requirements. The data generated by these agencies can be accessed from their annual reports, published and unpublished documents-Theses, Journals, News Letters and Magazines. Some data can also be accessed from the websites through internet. Industries also generate air pollution data which can be accessed from their technical reports.

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