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Air Pollution as an Indicator for Tracking Progress of Health and Environmental benefits

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Message

Environmental pollution is now considered as a global phenomenon which affects living beings for its severe long term consequences. Over past decades pollution was identified that altered the composition of air, water and soil environment. The sources of pollution include extraterrestrial, agricultural, industrial, biogenic, unnatural and anthropogenic.

Now there is an increasing trend in environmental pollution. Ambient air quality trends in the major cities indicate higher levels of Suspended Particulate matter beyond CPCB prescribed standards or limits. Natural and human induced factors accelerate Climate Change erratically.

The commitment for monitoring and abatement of pollution for pre-deterioration of the environment is started through a comprehensive approach. There is a burning need to prevent pollution at sources, encourage, develop and apply the best available practicable technical solutions, augmented control arrangement and prime focus for protection of heavily polluted eco-system by involving public.

In this context, publication of ENVIS Newsletter, Issue No.-56 by the State ENVIS HUB, Centre for Environmental Studies, Forest and Environmental Department, Government of Odisha is a commendable effort which solicit readers to make the best use of it.

(Suresh Chandra Mahapatra)

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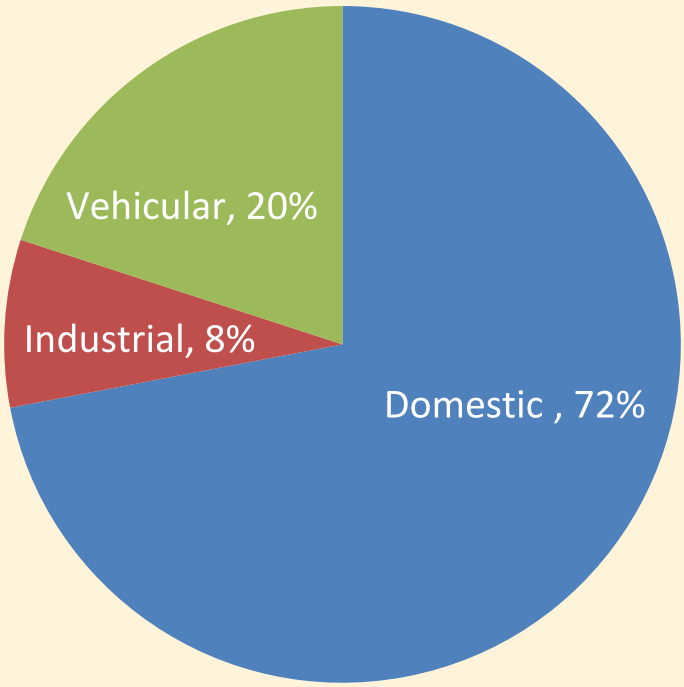
From the Coordinator's Desk...

Air Pollution serves as an important indicator for monitoring progress towards achieving sustainable, educative, healthy and desirable future. The greatest single environmental risk for health, climate, sustainable development is air pollution. Improvement in air quality is direct indication of achievements in the policies and interventions implemented for sustainable energy (i.e., energy access, energy efficiency), sustainable consumption, urban development, climate and infrastructure. Exposure to air pollution is the major cause of global mortality and mobility by assessing data on air pollution levels, their spatial and temporal trends as an essential and pragmatic indicator of health impacts of sustainable development.

Compilation and analysis of data with special emphasis on health related aspects address the health impacts of air pollution. Air Pollution is the single largest environmental health risk causing more preventable disease and death than any other environmental pollution e.g., water and chemical contamination. Air Pollution exposure is a shared link affecting population in both developed and developing countries alike. More than million death occurs in each year which includes Tuberculosis, Malaria, HIV/AIDS & others alike combined with risk factor for non communicable diseases like heart disease, chronic obstrctuctive pulmonary disease (COPD) lung cancer, respiratory infections like childhood pneumonia etc. Thus, considering the universality and close association to sustainability, ambient or outdoor air pollution exposure is a well suited and measured indicator to monitor health benefits for a sustainable future with less pollution. The proposed global relevant target on health and air pollution aims that by 2030, there will be substantial reduction in no. of deaths and illness from hazardous chemicals, air, water and soil pollution arise from contamination. In many rural areas brick killers, household fuel combustion, crop burning and other forms of inefficient energy combustion create substantial levels of health damaging air pollution. Levels of ambient air pollution can vary from day to day changes in local weather conditions, geography, economic input such as industry etc. The size or population of urban and rural areas along with their respective air pollution levels vary significantly within a country. There are significant no. of scientific studies showing kerosene to substantially put the health & safety of household members at risk i.e. relative risk of T.B. is found to be 09 times higher among households using kerosene for lighting compared to households using electricity. The normative guidance of WHO strongly recommends that all major household energy end users. (e.g. Cooking space heating and lighting) use efficient fuel & technology combination to ensure health & environmental benefits. The utility of fuel limit indicator is to monitor the impact of sustainable development as the emission i.e. level of pollution is directly linked to how well the device or technology be used.

(Prof. Dr. Ashutosh Debata)
Director, CES-cum-ENVIS Coordinator

Contribution of various sectors to ambient air quality



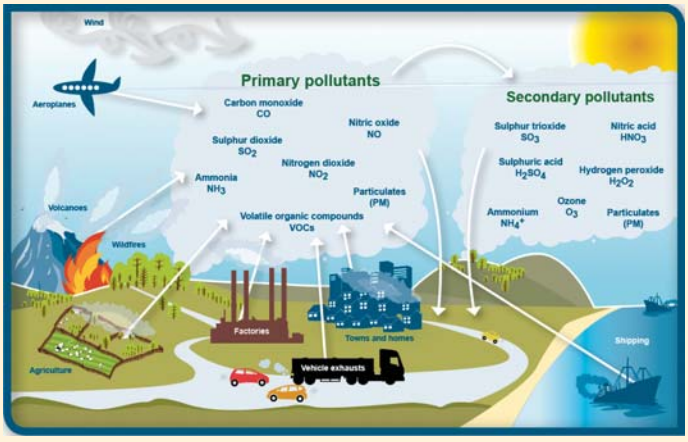
Composition and chemistry of earth atmosphere

The Earth's atmosphere is 99.9% nitrogen, oxygen and argon, of the remaining 0.1%, roughly half (0.04%) is accounted for by the three transition gases CO_2, Ne and He. The remaining minute fraction of the atmosphere (0.66%) is composed of a complex mixture of hundreds of trace gases, the most abundant being methane at 1.7 ppm. Many gases at the parts per trillion levels (10^{-2}v/v) are entirely man-made but may still have significant effect on the environment. Some trace gases control or affect the Earth's climate and stability. Substantial effects of human activities on the global cycles of trace gases have arisen only during the last century.

From the earth surface atmosphere to the outer periphery of the planet, there were several layers of gaseous clouds which are variously designated as Troposphere, Mesosphere and Thermosphere. There were various types of natural processes like volcanic, earthquake, decomposition and climatic transformations that led to the changes in global atmospheric in addition to man-made activities like industrialization, urbanization and modernization of agricultural activities.

Air Pollutants

Air pollutants which discharge from different sources may thereafter persist in atmosphere-transformed, deposited or degraded. There were various kinds of estimates of pollutants liberated by different activities of both developed and developing countries. The total emission load of traditional primary pollutants (i.e., $SO_{X,}$ particulated, $NO_{X,}$ CO, HC_S etc.) types of industries are considered to be the major air pollutant generating industries of which thermal power plants, steel industries, petroleum refineries, metal smelters are the major polluting industries.



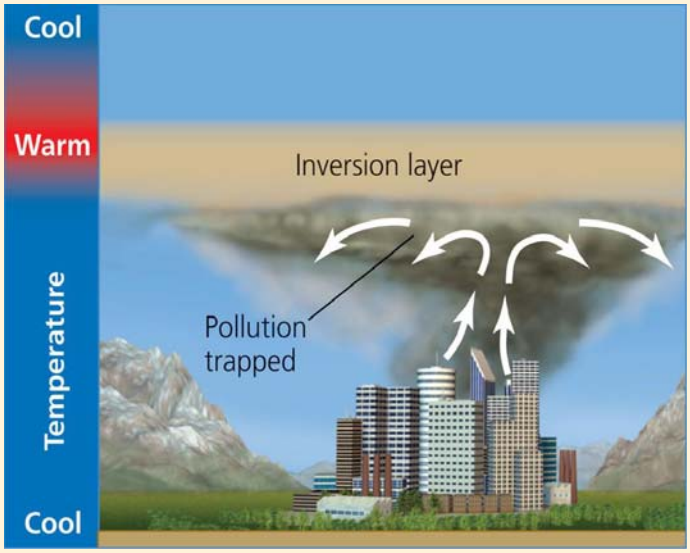
Smog Formation

The most serious air pollution episodes are the classical smog so closely associated with London. Episodes all occurred in cold winter months in areas where coal was a major fuel for both industries and heating. They are all

characterized by high levels of sulphur dioxide and smoke particulate which built up under stagnant weather conditions lasting three days or more. Mortality and illness were significantly increased and, in the worst case in terms of the number of affected, still there is more complex smog termed 'photochemical smog'. Smog is further favoured by stable meteorological conditions, when the urban emissions are held in the urban airshed by inversion acting rather like a lid over a reaction vessel, maximizing contact and reactions whilst preventing dispersion.

Thermal Inversion

During the day, the sun warms the air near the earth's surface. Normally, this heated air expands and rises, carrying low-lying pollutants higher into the troposphere. Colder, denser air from surrounding high-pressure areas, then sinks into the low-pressure areas created when the hot air rises. This conditional mixing of the air helps keep pollutants from reaching dangerous concentrations near the ground.



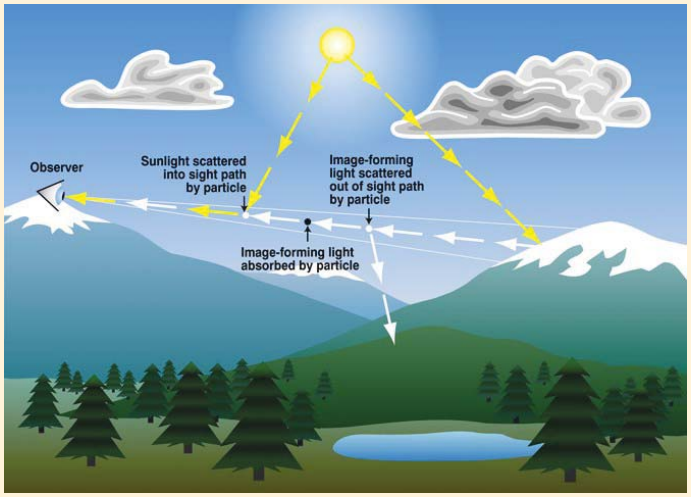
Sometimes, however, a layer of dense, cool air beneath can be trapped a layer of less dense, warm air in an urban basin or valley, causing a phenomenon known as a temperature inversion, or a thermal inversion. In fact, a lid of warm air covers the region and prevents ascending air currents (that would disperse and dilute pollutants) from developing one. Although these inversions usually last for only a few hours, sometimes-when a high-pressure air mass stalls over an area, they last for several days allowing air pollutants at ground level to build and dust domes that build up over urban areas.

Thermal inversions trap pollutants in a pool of cool air that cannot rise to carry the pollutants away. Because of its topography, Los Angeles has frequent thermal inversions, many of them prolonged during the summer months.

Effects of Air Pollution

The gaseous and particulate materials added to the atmosphere by the activities of man are considered to be pollutant when their concentrations are sufficient to produce harmful effects. The majority of man-made emissions to the atmosphere also have natural sources and in many cases these are larger than the pollutant ones.

After formation, pollutants are emitted to the atmosphere and dispersed. Once mixed the air, some air pollutants-such as the inert fluorinated hydrocarbons used in sprays-persist unaltered and become mixed throughout the atmosphere where they potentially have a global influence. More reactive pollutants have a shorter lifetime in the atmosphere and are removed either



by conversion to normal atmospheric constituents or by deposition on the surface of the earth. In the process they may react with other atmospheric constituents to form secondary pollutants, which are also removed by the same process. Both the primary pollutants and the secondary pollutants can cause alteration to the chemical composition of soils and waters, and direct damage to biological systems and property.

(a) Effects on Vegetation:

Air pollution can affect plants to varying degrees. At the lowest levels, i.e., below the 'threshold', there is no effect, such as visible damage, cumulative chronic effects, genetic effects or even gradual changes in the composition of the plant community. However, even at this level, air pollutants can be stored in the plants and introduced into the food chain affecting animals which eat plants.

The entry of air pollutants to plants may take place directly by gaseous diffusion or from the contaminated soil, acidic air pollutant in particular. The direct entry of gaseous air pollutants like SO_x, NO_x, CO_2 etc. may take place directly by stomata of the foliages. Solid particulates are however adsorbed on the surface. In general, pollutants cause injury at lethal concentration on sensitive plants while tolerant plant species are capable of sinking the pollutants to a considerable extent without any injury.

Thus, various air pollutants have different types of injuries on exposed sensitive plants. Suspended particulates after deposition on foliages cause a number of damages to leaf functions, viz.,

(a) Changes in the sun's energy falling on the leaf surface affecting energy exchange due to dust layer;

(b) Decreases chlorophyll content;

(c) Interruption in gaseous exchange due to clogging of stomata by dust particulates;

Dust deposition causes changes in the soil properties that support the plant growth.

Effect of air pollutants on plants

Pollutants	Symptoms
a)Major Pollutants:	
a)Sulphur dioxide	Interveinal bleaching and marginal bleaching,chlorosis, discolouration(red/brown)
b) Oxides of nitrogen	Chlorosis and marginal bleaching
c) Ozone	Bronzing, Chlorosis, coloured fleck
d) Fluorides	Chlorosis, particularly along the leaf margin, marginal necrosis from leaf tips to leaf bass

b)Minor Pollutants:

a) Ammonia	Leaves turn dull green and the brown or black glating or silvering on the underside of leaves.
b) Ethylene & propylene	Leaf curling.
c) Particulates (with toxic metals)	Chlorosis followed by reddening & yellowing, necrosis, bleaching of leaf margin.

The oxides of sulphur, nitrogen and carbon are absorbed by the plants through gaseous exchange and then either assimilate in such a manner so that there is no detrimental injury to the plant parts or it causes appreciable injury to various plants organs. In general, sensitive plant forms could be used for biomonitoring air pollutants. Several species of lichens and angiospermic plants are often used for biomonitoring of these pollutants.

(b)Effects on Animals :

The indirect effect of air pollutants has been observed for a considerable time. It tends to occur near smelters treating non-ferrous ores and near factories, such as phospha-te fertilizer works, brick kilns and aluminium smelters, where fluorides are emitted and are concent-rated in the grasses in surrounding fields. Identically, lead compounds

from automobile exhausts are Deposited near to roads, although the concentrations found in vegetation are much smaller than those near smelters and have so far been measured as below the accepted threshold for toxicity to animals. But with time such metals accumulate in animal bodies through food chain and finally pose danger to animal health. The signs of heavy metal poisoning are diarrhea, anemia and stiffness. Fluorosis is a more widespread problem, which affects ruminants, particularly dairy cows.

(c)Effect on Man:

Air pollutant along with breathing air enters the nose, where fine hair filter out most particles greater than about 10 micrometers diameter. The air is then warmed and humidified, and is then passed through the windpipe into the bronchial tubes which subdivide the air stream and pass it

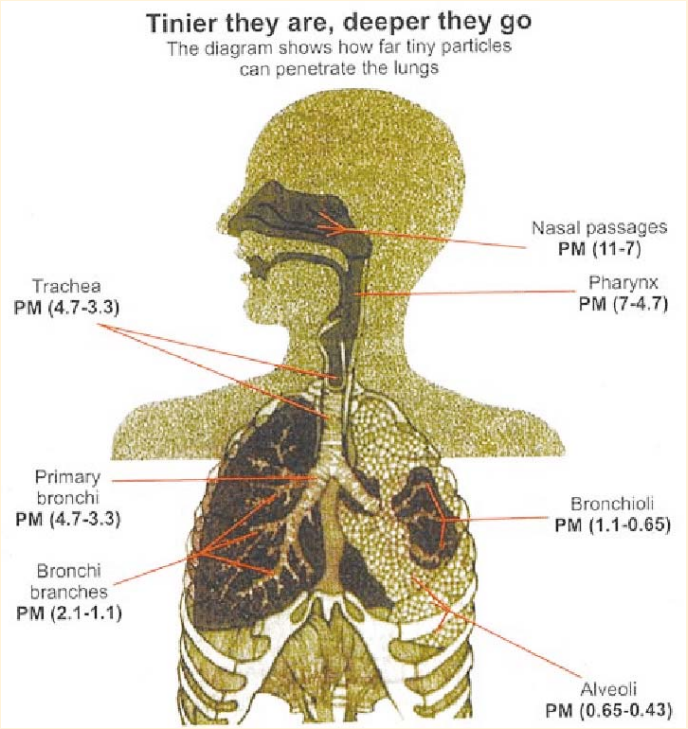
into the lungs where there are multiplicities of air sacs. From air sac through capillary diffusion gaseous pollutants enter into blood streams and particulates deposit in the alveolar sacs. The dangers of some small particles such as silica and asbestos, which are common in mines, quarries and some industrial plants are well-known over the years.

Biochemical Action

The fine particles present in the ambient air reach the pulmonary region of the lungs and remain there for long periods of time and behave as cumulative posions. The submicron particles enter deeper into lungs and are deposited on alveolar walls where the metals could be transferred to blood plasma across the cell membrane (Fig.1). The residual particles being silica (40-73%) cause the disease Silicosis. All the heavy metals (Ni, Cd, Sb, As, Cr, Pb etc) generally found in fly ash are toxic in nature.

In general, air pollutants mostly enter through the respiratory passages and thereby cause mostly various types of health disorders. Limits are set as to the maximum concentrations to which healthy persons are permitted to be exposed for periods of up to 8 hours per day. These are called Threshold Limit values.

Penetration of tiny particles into lungs



Health effects and air quality guidelines for major air pollutants

Sulphur	Exacerbations of respiratory illness from exposures. Increased prevalence of respiratory symptoms, including chronic bronchitis from long-term exposures
Suspended particulate matter Black smoke Total suspended particulates	Same as for SO_2 Combined exposure to SO_2 and SPM[b] may have pulmonary effects
Lead	Blood enzyme changes. Anemia. Hyperactivity and neuro-behavioral effects
Nitrogen dioxide 1 hour 24hours	Effects on lung function in asthmatics from short-term exposures
Carbon monoxide 15minutes	Reduced oxygen-carrying capacity of blood

It was interesting to note the fact that low level exposure of air pollutants like NO_x and SO_2 on long term basis has significant health disorders. There are also possibilities of air pollution induced carcinogenesis in urban environment as urban air pollutants contain a number of carcinogenic elements. Extracts of atmospheric particulates showed the existence of polyaromatic hydrocarbons which are known to be potent carcinogen.

(d)Effects on Materials :

Air pollutants have a deleterious effect on materials; stone, paintwork, stained glass, fibre material and others. The soiling effect of particulate is obvious in industrial cities where building of light-coloured stones and bricks soon take on the characteristic black colour. The erosion of the stonework on buildings of great historic and architectural value is very serious indeed, other results of air pollution are the faster deterioration of clothing, curtains and wood, the corrosion of metals and the soiling and subsequent cracking of paintwork.

(e)Global Climate Changes :

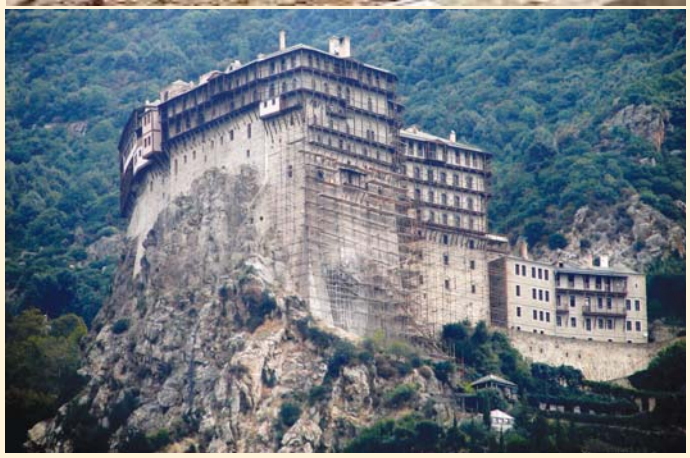
Air pollutants cause a considerable change in global climate and associated processes, viz., greenhouse effects, ozones depletion, acid precipitations and El Nino effects.

Monuments' damage by air pollutants

The pollutants of the atmosphere, viz., CO_2, SO_2 and NO_2 often produce acid after dissolution with atmospheric moisture. As such, they produce bulk of carbonic acid and traces of sulphuric and nitric acid. Such acidic water may cause gradual corrosion of materials by which monuments were made of.

Primarily, limestone blocks (chalk to marble) of the monuments are affected. Rainfall containing carbonic acid slowly attacks limestone to give a solution of calcium bicarbonate, which then transforms to calcium carbonate.

Slates containing carbonates and the calcareons sandstones, often used as roofing materials, are attacked by pollutants, and atmospheres. Damage usually occurs mainly on the undersides, especially between the laps where water is held for some time as a thin film. Recent debate regarding the damage of internationally reputed monuments like Taj Mahal of Agra (India) and Victoria Memorial of Kolkata (India) are considered to be very significant in this regard.



There are a number of chemical/gas exposures encountered in indoor environment as occupational exposure. These exposures on long term basis have serious health hazards.

For a long time such exposures were ignored by mankind. But such indoor exposures are much more significant health hazards than outdoor air pollutant exposures. Thus there is an extreme necessity for protection of occupational exposure to diverse gases/chemicals in respective work places.

On the whole the over harmful effects of air pollutants on plants, animals and ecosystems has manifold short-term and long-term consequences.

Air pollution problems in urban environment are a global problem over several decades. Since 1975, systematic monitoring of primary air pollutants ($NO_{X,}$ $SO_{X,}$ SPM, CO, HC & Pb) was attempted. According to WHO guidelines of air pollutant level, many cities already cross the tolerance limit of human exposure of individual pollutants. The major causatives of such urban pollution are due to automobile exhaust and anthropogenic activities. Thus there is need for careful pollution control measures in major megacities of the world not only for local environmental protection but also for regulation of greenhouse gas emission.

A summary of air pollution effects

Pollutants	Major Sources	Human Health	Vegetation	Materials	Aesthetics/ Nuisances	Comments
Carbon Monoxide(CO)	Transportation, industrial processes	Reacts with hemoglobin reducing mental attentiveness, physical exertion, and exacerbating cardiovascular disease symptoms	None	None	None	Past knowledge was based on study of high exposure for short periods with healthy, young individuals. New data show possible health effects for susceptible persons at CO levels in the blood found in urban populations
Nitrogen oxides(NO_2)	Transportation space heating/ cooling, power generation	Reduction in growth of plants with broad leaves (e.g. beans, tomatoes)	Reduction in growth of plants with broad leaves (e.g. beans, tomatoes None	Accelerated deterioration of dyes and paints	Creation of a brownish colouring in urban air	Conclusions are based on limited exposure of healthy adults to low doses, extensive animal studies, and only limited data relevant to ambient conditions
Hydrocarbons (HC)	Transportation & industrial processess	See photo-oxidants		None	None	Indirectly polluting through the production of photochemical oxidants upon reaction with NO and NO2 in the presence of sunlight

Pollutants	Major Sources	Human Health	Vegetation	Materials	Aesthetics/ Nuisances	Comments
Photo-oxidants (O3)	See nitrogen oxide and hydrocarbons	Interfere with respiratory functions & cause eye irritations	Severe reduction in growth and eventual death of leafy vegetables, field and forge crops, shrubs, fruit and forest trees caused by ozone and PAN	Ozone causes the cracking of rubber and the accelerated Deterioration of nylon, rayon dyes and paints	Ozone has a distinct- Although not terribly offensive- odour	Ozone (O3) is the most common type and the key indicator for photo-oxidants. Health effects are based on limited and inadequate data. Ozone, peroxyacetylnitrite (PAN), etc. are formed by atmospheric reactions
Sulphur oxides (SOx)	Power generation, space heating/ cooling, industrial processes	Little effect in the pure gas form; similar effects as particulates when combined with then	Reduction in growth of plants with broad leaves	Corrosion of iron, metals, accelerated deterioration of building stone, cotton, paper, leather, paints and other finishes	Scattering of sunlight to produce haze, production of unpleasant odours	Sulphur dioxide is readily converted to SO3 and then to sulphuric acid (a particulate). Determining which effects are due solely to SO2 is difficult in acid rain research
Particulates	Power generation, space heating/ cooling, industrial processes, soil erosion	Interference with respiratory functions, possible contribution to lung cancer	Reduction in plant growth by physical blockage of light when deposited on leaf surface	Soiling of fabrics and buildings and corrosion of metals when combined with SO2	Creation of smoke plumes, scattering of sunlight to produce haze and colourful sunsets, and formation of hydroscopic nuclei to produce fog	The effects of particulates are difficult to separate from those of sulphur dioxide
Heavy metals, radioactive agents, carbon dioxide, others	Power generation, industrial processes space heating	Specific to each pollutant	Fluoride causes long-term damage to selected field crops(and animals)	Tarnishing of metals by hydrogen sulphide	Hydrogen Sulphide produces extremely unpleasant odours	Pollution from these agents can be intense at the sources, but tends not to be widespread. However, Carbon dioxide is the main cause of global 'greenhouse effect' and chlorofluorocarbons affect the ozone layer

Climate Change Combat – A Conspectus

Climate change is one of the major issues, which is currently threatening several ecosystems and affecting the livelihoods. Climate change could happen due to natural and/or anthropogenic causes. Climate change and global warming are mainly due to the emission of greenhouse gases, of which carbon dioxide is one of the predominant greenhouse gases and several initiatives have been undertaken to reduce its emission and by sequestering it in different carbon pools. Oceans and forests are considered to be important carbon reservoirs in aquitic and terrestrial ecosystems respectively. Spreading awareness and capacity-building to mitigate and slow down the consequences of climate change is the need of the hour. Also, on an individual level, appropriate eco-friendly measures ought to be taken to minimize the carbon footprints and means to combat climate change.

Air Quality Index

An air quality index (AQI) is used to communicate to the public how polluted the air currently is or how polluted it is forecast to become. There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The proposed AQI will consider eight pollutants ($PM_{10,}$ $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3,Pb) for which short-term (up to 24-hourly averaging period).

Based on the measured ambient concertrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. Awareness of daily levels of air pollution is important to the citizens, a simple yet effective communication of air quality is important. The objective of an AQI is to quickly disseminate air quality information (almost in real-time) that entails the system to account for pollutants which have short-term impacts. The proposed index has six categories with elegant colour scheme, as shown below. Good (0-50) Satifactory (51-100) moderately polluted (101-200) poor (201-300) Very Poor (301-400) Severe (>401)

Ambient Air Quality Standards in India

Ambient air quality refers to the condition or quality of air surrounding us in the outdoors. National Ambient Air Quality Standards are the standards for ambient air quality set by the Central Pollution control Board that is applicable nationwide. The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.

Urban Air Quality Management

The components of an urban air quality management system include an air quality monitoring network, emission inventories, numerical predication models, air quality standards and public information bands, and a range of cost-effective pollution control policies and measures, together with the resources and powers to impose them.

Thrust areas to control air pollution

- Source Attribution Study to be Carried out Systematically in all Non- attainment
- Cities and Other Critically Polluted Areas
- Action Plan Preparation and Implementation in Following Areas
- Reduction of Sulphur in Diesel.
- Premix 2T Oil for 2 Stroke Vehicles
- Phasing out of 2 Stroke Vehicles
- Particulate Trap in Diesel Vehicles
- More Use of Clean Transportation Vehicles
- Effective I/M Programme for inuse Vehicles
- Reduction of Particulate Emission from Coal Based Power Plants (Bag filters, ..)
- Reduction of Sulphur in Furnace Oil
- Effective Pollution Control from Stone Crusher, Lime, Kiln, Brick Kiln, Foundry, Small Boilers, Hot-Mix Plants, Secondary Lead Indistry etc.
- Relocation of polluting Industries
- Approved Fuel Usage in Major Cities
- Ban on Open Burning of Biomass
- DG sets (Both Stationery and Portable) Pollution Control
- Checking of Adulteration in Fuel
- Use of beneficiated Coal in Thermal Power Plants
- Reduction of Emission from Ash Pond
- Continuous Monitoring of PM10, $O_{3,}$ $NO_{X,}$ HC etc. in Ambient Air

Way Forward

Approach

- Need to follow an integrated approach: Source Apportionment
- Include Explosure Assessment in the process
- Strategies to be evolved on the basis of requirements
- Coordination among concerned agencies – let action taken by one agency not reversed by other
- Need to think beyond numbers-focus on reduction of toxic constituents, emission reduction strategies

Enforcement

- Regulatory reforms - involvement of local bodies, EIA-in-built preventive measures, cleaner production options
- Build reliable computer-based EI and work for reductions
- Periodical review of actions-learn from experience and take corrective steps
- Performance evaluation of model, Sensitivity analysis-for EIA
- Remote monitoring of industries
- Empower people with information

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