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The Air Quality : A Global Challenge -2

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Editorial

*ENVIS-IITM centre deals with the very important and sensitive component of the environment **"The Air we breathe"** and related challenges. In our last series of newsletters under the heading "Air Pollution Chemistry" we have taken a brief knowledge of Earth system, interdependence of different components of environment, the atmosphere, air pollution, criteria air pollutants etc. now it's a time to go deep in to the subject "Acid Rain and Atmospheric Pollution" and know much more about how the air quality has changed over the period of time resulting in to the very complex local, regional and global problems like urban heat Iceland, visibility reduction, smog formation, acid rain, global warming, climate change etc…We are very happy to introduce you with our new series of ENVIS newsletters **"The Air Quality: A Global Challenge"** which will give you detailed information of various striking problems in the field of Air Pollution and different scientific pathways involved. At the end of this series you will come to know what causes the smog, what is acid, how it damage our ecosystem, Is climate is changing with unsustainable rate, what is global warming so on and so forth… This will help you to take definite measures to improve air quality at your level.*

Present issue gives you the information about acid deposition and its impact on vegetation, material, forest and surface water. We hope our attempt to convey complicated scientific information in simple language will help to create awareness amongst the common public which is the first step towards safeguarding our environment

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ACID DEPOSITION

Dry Deposition

The direct deposition of gases or particles onto a surface is known as dry deposition. Measurement of dry deposition is rarely done. The standard procedure is to model dry deposition based on measurements of gas concentration and an estimate of surface resistance which is expressed as deposition velocity. This resistance depends on factors such as vegetation height, the affinity of particular pollutant for an individual type of surface and wind speed. In general, dry deposition is important close to sources of pollutants, while wet deposition is more important in remote from sources.

The current understanding of dry deposition processes in the UK and the way that this has been implemented to provide estimates of dry deposition fluxes is described in NEGTAP (2001).

Ammonia is dry deposited very efficiently and it is believed that around 40-50 % of deposition of reduced N in UK comes by this route. **SO2** is quite readily dry deposited, with the rate of deposition to vegetation being determined by whether or not the stomata are open. And by surface wetness, deposition is more efficient on wet surface than dry.

NO2 is not ready dry deposited and it is estimated that this pathway contributes only 25% of Oxidized N deposition to the UK. Nitric acid gas is however readily deposited.

Cloud to water interception or occult deposition

The direct deposition of water droplet from cloud is called cloud to water interception or occult deposition. This process becomes important in the areas where cloud surface regularly blanket the surface, usually on hill tops. The concentration of pollutants in hill cloud have been found to be significantly high than those in rain. The deposition of cloud droplet will be enhanced in forested upland areas because of their surface roughness, so inputs of acidity to forested areas regularly under cloud may be particularly important.

Wet Deposition

Wet deposition occurs due to the removal of pollutants from within clouds or beneath clouds as precipitation falls. It is dominated by the removal of acidic aerosols species and so occurs largely

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remote from sources, once the chemistry of air has had time to evolve. Wet deposition is usually predominate rural and upland areas. The amount of wet deposition is calculated by measuring the concentrations of the pollutants in rain (SO4, NO3, NH4) and then multiplying this by the amount of rainfall at a site. Where rainfall is known to contain ions derived from sea spray, the measured concentrations are correlated for this so that the data reflect non-sea salt sulphate. This correlation does not need to be applied for nitrate or ammonia.

Acid Deposition Units

Kg S or N ha^{-1} yr^{-1}, mg S or Nm^{-2} yr^{-2} or in equivalents of H^{+} e.g. ha^{-1} yr^{-1}. Equivalents are useful units for making comparison between pollutants and for comparing critical load.

Damage thresholds- Critical loads and critical levels

While evidence of long term increase in the acid loading of the atmosphere and of ecosystem change or damage accumulated from individual sites, it was realized that having clear cut defined pollution threshold for species or ecosystems would be a useful tool. The term threshold was subsequently replaced by the terms critical loads for deposition and critical level for gas concentrations. A critical load is now been defined as a quantitative estimate of exposure to one or more pollutants bellow which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.

Effect of acid deposition on Ecosystem

Damage to vegetation

Direct damage to plants arises namely through dry deposition of the gaseous pollutants and acid rain acts indirectly. The acid precipitation may increase the acidification of the soil. This can lead to changes in soil biota and mobilisation of heavy metals. Agriculture can increase the acidity considerably by the use of nitrogenous fertilisers. Acid mist cause damage to forests through attack on tree leaves, but the mechanism of damage is not clearly understood.

Effect on surface waters

Changes in pH of water bodies due to acid rain is largely neutralized by the soil and lakes that surround them, which act as buffers and prevent large changes in pH.

However, some soils are poor sinks to the acid deposition and very low pH has been observed for some lakes in Scandinavia. The most serious concern that arises from decreasing pH of water is the damage to all forms of aquatic life especially fish. Most of the acid deposition and very low pH is due to atmospheric pollution from power plants. Aluminium ion is often considered to be the direct cause of the toxicity of acidic waters to fish. The toxicity of aluminium is dependent on Ph. Both the aluminium and the hydrogen ion affect the gill. Aluminium precipitates on the gill filament thus causing clogging by mucus. Low ph damages fish eggs. At ph 4.1 newly fertilized salmon eggs die within two days. The result is that numerous lakes in Scandinavia and North America, where the rain is acidic, have very depleted fish population.

Effect on forests

Air pollutants and acids generated by industrial activities are now entering forests at an unprecedented scale and rate, greatly adding to these stresses carried over from the last, Many forests in Europe and North America now receive an much as 30 times more acidity than they would if rain and snow were falling through a pure atmosphere.

Needles and leaves yellow and drop prematurely from branches, tree crows progressively become thin, and ultimately die. Even trees that show no visible sign of damage may be declaring in growth and productivity. Moreover, the tendency of the acid rain to leach nutrients from sensitive soils may undermine the health and productivity of forests long into the future. Taken together these direct and indirect effects threaten not only future wood supplies but the integrity of whole ecosystems on which society depends.

The role of acid rain and other forms of air pollution is under intensive investigation. In spite of the dimensions of the forest damage, however, a firm link has not been established. One can get some idea of the difficulties by contrasting the forest decline with clear-cut cases of forest poisoning by air pollutants. Smelters and chemical plants that emit sulphur dioxide, oxides of nitrogen or fluoride compound are often girdled by dead timber. In such cases there is a clear correlation between tree damage, a specific pollution sources and a threshold concentration of the pollutant. The forests that are now dying, in contrast, are far from any sources and are exposed to pollutants in concentrations well below the levels previously reported to injure trees.

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Many stresses, both biotic and abiotic, combine to affect the vigour of a forest. The tree's genetic endowment or age can be source of stress, a stand may be genetically weak or senescent. Other stress may take such forms as disease, insects, parasitic fungi, a shortage of light, water or essential nutrients and sporadic injury from events such as floods high winds and ice storms. Stresses easily withstood in isolation can combine with debilitating or fatal effects. A fatal sequence of stress may begin with a predisposing stress such as shortage of nutrients. The tree may then be seriously weakened by an inciting stress, such as a severe winter. It is then defenceless against, a final contributing stress, the actual cause of death such as disease or insect attack.

Effect on Material

Most of the corrosion of the city buildings and monuments is apparently the result of the dry deposition of SO_2 and sulphate particles, and is mainly due to high and localized urban concentrations of pollutant. Decay tends to happen in bursts rather than steadily or continuously. When sulphur pollutants fall on the surface of sandstone or limestone, for instance, they can react with the calcium carbonate in the stone to form gypsum, which sticks to the stone like icing on cake. This cause flaking that can then wash away by rainwater, exposing more stone to corrosion. Gypsum and soot particles combine to form ugly black crusts on the shelters surfaces of building. Acid attack can also lead to stone decay through the creation of salts, which can crystallize, expand and or contract, bringing on fatigue or disintegration. Salt weathering may in fact be the most important agent in decay.

Rate of Corrosion

The rate of corrosion depends on two main factors:

1. The relative reactivity of the material to acidity
2. Meteorological conditions and the physical force of the delivery of pollutants.

Stone and masonry that contain calcium carbonate or calcium sulphate are particular susceptible. The pigments in paint can make paintwork susceptible, and humidity encourages metal corrosion.

Also temperature, wind speed, and the intensity of, duration and amount of rainfall are all important factors. Physical location is also important – the level of pollutants may be higher at street level than on the tenth floor.

Effect on Taj Mahal

In India, there is concern for the Taj Mahal. Emissions from oil refinery built during 1970s upwind from the monument may be threatening its marble and sandstone surface.

Stone is not the only material prone to damage, carbon steel, galvanized steel, copper, nickel, zinc, lead and cast iron can all be corroded to varying degrees.

Table-1 Acid damage to material

Material	effect	Principle pollutant	Other factors
Metals	Corrosion, tarnishing	SO_2 acid gases	Moisture, air particles, salt
Building Stones	Surface erosion, soiling, black crust formation	Same as metals	Mechanical erosion, salt, particles, CO_2, temperature, vibration, micro-organisms
Ceramic & Glass	Surface erosion, surface crust formation	Acid gases, especially those containing fluoride	Moisture
Paint	Surface erosion, discoloration, soiling	SO_2 hydrogen sulphate,	Moisture, O_3, sunlight, particles, mechanical erosion, micro-organisms
Paper	Embrittlement, discoloration	SO_2	Moisture, physical wear, acid used in manufacture
Photographic material	Small blemishes	Same as paper	Moisture, particles
Textile	Soiling and reduced tensile strength	SO_2, NO_2	Moisture, particles, light, physical wear, washing
Leather	Weakening, powdered surface	SO_2	Physical wear, residual acids used in manufacture
Rubber	Cracking	SO_2	O_3, sunlight, physical wear

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Acid Rain: Regional Scale problem

Air Pollution modelling studies and the analysis of back trajectories of polluted air masses, carried out under OECD study of the long range transport of air pollutants, has established that the significant element of acid deposition was transboundry air pollution problem. It was shown that air masses reaching Scandinavia started out about two days earlier over central Europe and UK were SO2 emissions were very high.

Acid Rain is a result of long range transport and policy initiatives to reduce emissions and ecosystem damage have had to be implemented at the transnational level.

DO YOU KNOW?

- Europe: Late 1950s : Concern about widespread ecosystem damage as a result of acid deposition came to light, in relation to freshwater in southern Sweden
- West Germany: In 1970s : Acid Rain is identified as a possible cause of forest damage
- The idea of threshold was developed in Scandinavia and Canada in the 1970s and defined at the Stockholm environment conference in 1982.
- Researchers at the US National Acid Precipitation Assessment Program have found that chemical degradation removes 10-17 micrometers of stone per year, more than mechanical erosion.
- In Katowise region of Poland, acid pollution has been blamed for corroding railway lines to such an extent that, in places, trains in 1981 were only allowed to travel 40kmh.
- Reading staken in central Stockholm reveals that the rate of corrosion of zinc increased by 150 % between 1938 and 1958.

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