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STUDY OF AIR POLLUTION AND RESPIRATORY HEALTH EFFECTS ON HUMAN AND PLANT SPECIES

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ABSTRACT

The subject has long been a matter of concern since the industrialization of the country brought in its pollution hazards. Environmental chemicals pose a potential threat to health, because a large number of people get exposed to chemicals that linger in the environment. The present exposure to the environmental chemicals is more likely to produce toxicity that adult exposure. For radiation, methyl mercury, lead etc. the child is at greater risk then the adult. Subtle functional deviations in the off-springs of exposed mothers may be one of the most sensitive indications of potential harm from environmental chemicals. The consequences of prenatal environmental exposures may not be evident till the advanced age. Air pollution has come to stay in metropolitan and industrial towns. Both environmental monitoring and health monitoring of the exposed population has to be done regularly, so that the pollution could be controlled and man of today and tomorrow could live a healthier and happier life.

1.0 Introduction

Air pollution is a product of the activities of man. As man started manufacturing chemicals and metals, generating electrical power, developing faster means of transportation, crowding in overpopulated cities, problem of air pollution become inevitable. The air environment began to lose its earlier purity due to the concentration of smoke and other pollutants.

The air near the ground is heated by solar radiation and rises up. While rising, it cools off until it reaches a point where its temperature is similar to that of the air directly above it. The air with its load of pollutants can go no higher than this may lead to temperature inversion. The fall out and ambient and ground level concentrations of pollutants are usually determined by direction and speed of the prevailing wind and vertical and horizontal thermal profiles of the area. Field studies reveal that pollutants generated at urban-industrial locations may traverse 50-100 km distances or more from the point of origin, and these may spread out in a much larger area, sometimes covering vast tracts and at times trespassing all geographical boundaries, be it local, national or international. So, the air pollutants do not remain confined or limited in the vicinity of industrial establishments or emission sources, but depending on the topography and meteorology of the area, these may spread into far off places of the natural landscape, affecting growth development and productivity of plants and animals present there.

2.0 Effects on Human Health

The air pollutants contaminate air, water and soil, corrode materials, dirty buildings and clothing, harm plants and wild life and affect human health. The correlation between growth transitions of green plants, which grow outdoors and are continuously exposed to pollutants, and pollutant concentrations have helped decipher pollution zones.

2.1 Deaths

There is an association between sulphur oxide/particulate air pollution and deaths, in air pollution episodes. Such episodes have occurred in Belgium (1930), in Pennsylvania (1948), in London (1952, 1962) and in New York (1953). Excess deaths have been reported among persons suffering from heart and lung diseases. Deaths were due to bronchitis, pneumonia, and other lung and heart diseases. Photochemical oxidants are highly toxic and at low concentrations, a respiratory tract irritant. Deaths exclusively due to photochemical oxidants are not yet recorded. No single pollutant however could be considered responsible for the excess of deaths. Investigators in various countries have reported association between residence in heavily polluted areas and deaths from all causes combined and from bronchitis and other respiratory causes.

2.2 Chronic Lung Diseases

Chronic obstructive lung diseases like chronic bronchitis, emphysema, etc. are reported to be caused by air pollution exposure. Many studies of chronic lung disease and air pollution conducted through the world have indicated a relationship between the prevalence of chronic respiratory systems and the sulphur oxides particulates complex. Chronic lung disease appears to develop in response to cumulative results that smoking intensity, recurrent lung diseases in childhood and exposure to dusts. Studies have shown that most of the excess deaths and illnesses occurred in persons who had chronic lung illness before the air pollution episode. Frequently low temperatures exerts a greater effect than does air pollution and the similar temporal pattern of air pollution and cold temperature in the past may have accounted for some of the observed air pollution/disease aggravation relationships.

2.3 Gases

Soluble gases will be absorbed by the air passages, where they may be buffered, detoxified by biochemical reactions, diffused into systematic circulation or exert a pathologic effect. Less soluble gases such as ozone and nitrous oxide pass more deeply into the respiratory tract.

2.4 Lung functions

Lung function tests are considered to be very sensitive indicators of lung disfunction. These tests are of increasing importance in studying workers or population exposed to dust, fumes, gases, and vapours. The two most important tests which could be carried out in the general population are (a) Vital capacity, and (b) Forced expiratory volume. If we have with us the normal values of healthy persons of different age groups, decrease in these values in the exposed persons is a sensitive indicator of health effect. These tests are of particular importance in children. In nearly all reported studies, children residing in more polluted areas show diminished values when compared with their counter parts living in less polluted areas. Improvement in lung function tests in children living in more polluted areas in suggesting the reversibility of air pollution effect on lung function, at least in childhood.

2.5 Photochemical Oxidants

They are formed in the atmosphere from precursor pollutants with energy provided by solar radiation. The principal component of photochemical oxidant mixtures is ozone. The junction between the respiratory bronchioles and alveoli has been found to be most affected. There is an increasing frequency of eye irritation, cough, chest discomfort, breathlessness, as well as decrease in lung function values due to exposure.

2.6 Sulphur oxide/Particulate complex

These two pollutants are discussed as a single pollutant complex as their increased concentrations are usually found together in urban areas, and sulphur dioxide is transformed into a particulate aerosol. Sulphur oxide component consists of sulphuric acid, sulphites, and various metallic, and ammonium sulphates. Combustion of fossil fuel which is the principal emission source of the sulphur oxide / particulate complex yields a variety of chemical compounds including oxides of carbon, iron, aluminium, sulphur, silicon, and phosphorus as the main constituents. Increased ambient concentrations of sulphur oxides and particulates have been consistently associated and with increased deaths during episodes of air pollution, and with the aggravation of symptoms in persons with heart and lung disease, lung functional changes and chronic respiratory disease.

2.7 Synergistic action of pollutants

The ambient environment of an urban-industrial area may be contaminated with several pollutants emitted from different sources and the plants growing there would be exposed not to one but to a mixture of pollutants. The phyto-toxic action of pollutant combinations largely depend upon the concentration and ratio of each pollutant in the mixture and whether the combined pollutant stress is applied simultaneously, sequentially or intermittently.

3.0 Pollution induced habitat changes

The changes in physio-chemical properties of soil and plant can be attributed mainly to the acidity caused by SO2. It can be argued that SO2- fallout and acid precipitation may affect the plant system, directly through the leaf surface and indirectly through acidity and mineral imbalance of the soil. Under acidic conditions, the activity of soil microbes and processes of litter decomposition and mineral recycling can get awfully disturbed. The acidity causes chemical weathering of rocks in the area. It has been seen that H2SO4 reacts with rock material to form sulphates which in turn are gradually washed away, leaving the uneven surfaces exposed to further erosion. The habitat transformation consequent to SO2 pollution includes a series of changes. To start with, the trees are injured followed by shrubs and herbs. Gradually some of the plant species, especially the sensitive one, are unable to regenerate in the area and get eliminated from the landscape. Once the SO2 sink provided by the vegetation cover is substantially reduced, there is rapid increase in soil acidity which leads to cation-anion imbalance and microbial population reduction. These changes accelerate the processes of erosion making the soil infertile and hopelessly unsuitable for regeneration and growth plants.

While considering the pathways of fluoride in the environment and its long-term biological implication, one must realize that the ambient fluoride gradually settles on and accumulates in water, soil and living systems. The fluoride accumulated into the plant body enters into the food-chain through the herbivorous animals and its subsequent transfer from one animal to another continues along the prevailing food-web pattern. Fluoride is a cumulative pollutant whose concentration in the ecosystem increases with time and once introduced into the system its cycle continues in an un-ending manner. These simple but far reaching changes clearly show how the fallout of pollutants from urban-industrial areas can transform and despoil distant natural habitats.

4.0 Pollutant Uptake and Plant Response

In terrestrial of plants, the enormous surface area of expanded levels acts as a natural sink for pollutants especially the gaseous ones. A gaseous pollutant upon entering the leaves through the open stomata comes in contact with the large surface area of moist, spongy mesophyll cells, which are oxygen rich during the day time. In such a condition, the pollutant may injure the cell and eventually get changed to a less toxic state. For detection, quantification and interpretation of plant responses, symptoms of injury, such as chlorosis and necrosis, changes in growth-habitat, reductions in quality and yield, biomass accumulation and energy content of plants, changes in transpiration, photosynthesis and respiration rates, reduction in chlorophyll, amino acids, ascorbic acid, etc., are determined and correlated with pollutant to concentration and dose.

4.1 Individual Pollutants

Plant responses usually increase with the increase in ambient concentration of pollutant. In case of SO2, it has been observed that at higher concentrations the rate of pollutant uptake is much more than the rate of pollutant detoxification by the plant. At lower concentrations, less pollutant is absorbed per unit time which helps oxidation of the pollutant to innocuous levels with no apparent injury to the plant. The oxidation and gradual changes of SO2 into SO3 and SO4 is good example of the detoxification process. In case of the HF, the most severe injury and the highest fluoride accumulation occurs at the highest pollutant levels. The fluoride concentration in plant body may be gradually decreased during pollution free or recovery periods due to dilution of the pollutant in the gradually increasing phytomass.

4.2 Pollutant, Plant & Environment Interaction

The rate of pollutant varies from species to species, stage of plant development and ecological conditions, such as solar radiation, temperature, humidity, edaphic factors, etc. For low levels of ground temperature, wind velocity and precipitation, high level of humidity and basin topography the pollution potential is greater than those for high levels of ground temperature, wind velocity and precipitation and low levels of relative humidity and flat topography.

Besides ecological conditions, plant responses to pollutants may also depend upon its internal conditions. For example, when stomatal density is high, relative water content is high, nutrient uptake is optimum and ascorbic acid content is low, then the plant response is high. Similarly when the stomatal density is low, relative water content is low, nutrient uptake is minimum and the ascorbic acid content is high the response level is low.

4.3 Air Pollution Tolerance Level of Plants

Plants on the basis of their responses to pollutants under field and laboratory conditions have been classified into sensitive and tolerant species. The degree of sensitivity of a plant depends on its developmental stage, nutritional status and other ecological factors. The plants achieve resistance to pollutants either through stress avoidance that is by avoiding the entry of pollutants into the plant body through decreasing stomatal pore size and stomatal density and increasing circular resistance and pubescence, or through stress tolerance, this is by physiological manipulation of toxic pollutants entering into the plant body.

5.0 Bio-monitoring of Air Pollution

The living organisms can serve as excellent quantitative as well as qualitative indices of the pollution of the environment. Plants and animals are continually exposed and can act as long term monitors that integrate all environmental effects to reflect the total state of their environmental mileu. They can show the pathway and points of accumulation of pollutants in ecological systems. Their use can remove the extremely difficult task of relating physical and chemical measurements to biological effects. To test the air purity, physic-chemical and biological methods are in vogue.

In connection with bio-monitoring, one should remember that plants are more sensitive to air pollutant than animals, including man. Presently there is enough evidence to show that plants can be used in monitoring and controlling air pollution. Many plants can act as early warning sentinels for particular pollutants. By looking at certain plants, for example, it is possible not only to identify the presence of certain pollutants in a given area but also to gain information on the concentration and its variation in time. Relationships between specific pollutant concentrations and plant responses are being established in two different ways. These include investigations with test plants in the vicinity of pollution sources and analysis of specific pollutant-sensitive species exposed to given pollutant concentrations under known ecological conditions.

Laboratory studies are performed with potted or plot-grown plants enclosed in a suitable size fumigation chamber, consisting of an iron frame covered with transparent polythene sheet and supplied with the pollutant of a known concentration. The continuous supply of a specific pollutant is achieved through chemical generation. For example, SO2 is produced by reacting Na2SO3 or NaHSO3 with dilute H2SO4. The pollutant produced is allowed to mix with the volume of chamber air to obtain a desired concentration. The exposure of plants to pollutants may continue for a short or long duration, depending on the air and objectives of the experiment. The exposed plants are then analysed with respect to changes in some of the reliable morphological, physiological and biochemical parameters.

6.0 Conclusion

It is obvious that there are short-term and long-term ecological implications of fallout and drift of pollutants from urban-industrial complexes to natural habitats. The pollutants may gradually affect and alter the structure and function of an ecosystem by altering its abiotic and biotic components. Such changes in course of time affect transformation of a healthy and fully productive habitat into an unhealthy and less productive one. Therefore, there is need for a constant monitoring of pollution load in an ecosystem. For this purpose plants sensitive to air pollutants may help monitoring of air pollution, provided the pollutant concentration and plant response relationships are precisely established with the help of fumigation experiments and physic-chemical monitoring experiments. Since plants constitute a living system, it is imperative to have a proper understanding of all the ecological factors influencing the ambient pollution potential and pollution absorption pattern of plants. As a note of caution it may be added that for understanding the total impact of pollution on ecological systems, the effect of not only one specific pollutant but the action and interaction of all different pollutants should be considered. Furthermore, the total effect of a large number of minor pollutants may be as great as that of one major pollutant. Thus, the total pollution burden may be impossible to estimate except by direct observation of its overall effect on ecosystem.

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