ENVIRONMENTAL DEGRADATION DUE TO THE ACCUMULATION OF PARTICULATES

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ABSTRACT

The global air pollution is mainly due to five primary air pollutants namely carbon monoxide (CO), oxides of nitrogen (NOX), hydrocarbon (HC), oxides of sulfur (SOX) and particulates (Part.). Out of all the primary pollutants, particulates are the most dangerous ones because of their high toxicity and comparatively longer lifetime in the environment. These may be associated with either some inorganic molecules or some organic molecules. These have differential mechanism of interaction with environment depending upon their chemical nature. On their interaction, these cause extensive damage to both living and nonliving systems of the environment. The extent and type of damage depends upon chemical composition and physical state of particulates. It is seen that the particulate induced damage is maximum when these are corrosive or these carry toxic substances along with them. In this paper, an attempt is made to discuss different sources of particulate emission, their chemical nature, their mechanism of interaction, their detrimental effects and some remedial measures to control the level of particulate in the environment.

Key Words: Particulate, Environment, Degradation, Pollutant, Air pollution, Toxicity

INTRODUCTION

Particulates are the small solid particles and liquid droplets present in the atmosphere in fairly large number varying from several hundred per cm³ in pure air to 10⁵ per cm³ in polluted air. The dimension of these particles range from 0.0002 µ to 500 µ with mean lifetime varying from few seconds to few months. The particulate mass level ranges from 10 µg/m³ in clean air to 60-2000 µg/m³ in the polluted air. Particulates with size less than 1 µ cause a number of important effects like electrical phenomena (cloud and fog formation), maintaining heat balance, formation of water droplets and ice crystals and a number of chemical reactions (photochemical oxidation, neutralization, catalysis, etc.) However when the particle size exceeds 1 µ, these particulates have large surface area, which are good sites for sorption of various inorganic and organic pollutants. Accumulation of particulates causes serious environmental hazards to both life and property of human beings. In this paper an attempt is made to discuss different sources of particulates, their formation, their nature, their detrimental effects and some remedial measures to control the level of particulate in environment.

Sources

There are numerous natural and anthropogenic processes injecting particulates into environment.
Natural Sources
Some natural sources are:

i. Volcanic eruption.
ii. Forest fire.
iii. Blowing of dust and soil by wind.
v. Bacterial decomposition
vi. Spraying of salts and other solid particles by seas and oceans etc.

Anthropogenic sources:
Some anthropogenic sources are:
(a) Fly ash from power plants and melters
(b) Mining activity i.e. during crushing and grinding of the ore, a lot of particulates are released to the environment.
(c) Incomplete Combustion process
   i. Combustion of coal.
   ii. Combustion of fossil fuel.
   iii. Wood
   iv. Natural gases.
   v. Combustion of agricultural wastes.
(d) Industrial Process: Industries mainly petroleum refineries, sugar & chemical factories, Steel plants etc are the main sources of emission.
e) Emission from jets and aircrafts etc.

Nature of the Particulates
The particulates matters are of two types:

A. Inorganic particulate matter:
   i. Metal Oxides: Metal oxides comprise a major class of inorganic particles in the atmosphere. The formation of few particulate oxides are given below:
      \[ 3\text{FeS}_2 + 8\text{O}_2 \rightarrow \text{Fe}_3\text{O}_4 + 6\text{SO}_2 \]
      \[ 4 \text{V} + 5 \text{O}_2 \rightarrow 2\text{V}_2\text{O}_5 \]
      \[ \text{Ca CO}_3 \rightarrow \text{CaO} + \text{CO}_2 \]
      Particulate
   ii. Metal halide: When Pb \((\text{C}_2\text{H}_5)_4\) in leaded gasoline is subjected to oxidation in presence of dichloromethane and dibromoethane, it gives PbX, which are volatile in nature. These lead halides condense in the atmosphere to give particles.

   \[
   \text{Pb}\left(\text{C}_2\text{H}_5\right)_4 + \text{O}_2 + \text{C}_2\text{H}_4\text{Cl}_2 + \text{C}_2\text{H}_4\text{Br}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{PbCl}_2 + \text{PbBr}_2 + \text{PbBrCl}
   \]
   The above principle is the basis of Pb-pollution in the atmosphere.
   iii. Acids: In presence of acidic gases like \(\text{SO}_2\), \(\text{SO}_3\), \(\text{NO}_2\) etc, acid droplets are formed as follows:
      \[ 2\text{SO}_2 + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SO}_4 \]
      \[ \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \]
      \[ 4\text{NO}_2 + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{HNO}_3 \]
      \[ \text{Cl}_2 + \text{H}_2 \rightarrow 2\text{HCl} \]
      \[ \text{N}_2\text{O}_5 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3 \]
      \[ \text{N}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_2 \]
      Droplet
   In presence of basic pollutants like \(\text{NH}_3\) or \(\text{CaO}\), acid droplets undergo neutralization to give salts.
      \[ \text{H}_2\text{SO}_4 + 2\text{NH}_3 \rightarrow (\text{NH}_4)_2\text{SO}_4 \]
      \[ \text{H}_2\text{SO}_4 + \text{CaO} \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} \]
      Droplet

B. Organic particulate matter:
   The organic particulate matter usually contain poly cyclic aromatic hydrocarbons (PAH) which are highly carcinogenic in nature. Some typical PAH are benzo (\(\alpha\)) pyrene, chrysene, benzo fluoranathene —etc. In urban areas, the level of PAH is very often found to be around 20 \(\mu\text{g/m}^3\). PAH compounds are
usually remaining absorbed (associated) with soot, which is itself a highly condensed product of PAH compounds. Each soot particle consists of several thousand interconnected crystalites, which are made up of graphitic platelets. The platelets consist of roughly 100 condensed aromatic rings. In addition to PAH, each soot particle may contain 1 to 3% of H, 5 to 10% O and traces of metals like Be, Cd, Cr, Mn, Ni, V etc.

Detrimental effects of Particulates
(a) Effects on human beings
   (i) Asbestos particles cause lungs disorder.
   (ii) Lead containing particulates affect children's brain and interfere with the development and maturation of red blood cell.
   (iii) Particulates of less than 1µ reach alveoli of lungs and damage lungs tissues.
   (iv) Soluble aerosols gets absorbed into blood from alveoli while the insoluble aerosols are carried to the lymphatic stream and get deposited in the pulmonary, lymphatic depot point or lymph glands.
   (v) Black lung disease of coal miners, pulmonary fibrosis of asbestos workers and emphysema of urban peoples are due to particulate accumulation.
   (vi) The lodged particles in the lungs (<3µ) can cause severe breathing trouble by physical blockage and irritation of lung capillaries.

(b) Effects on Plants
   (i) The deposition of particulates on soil makes the soil unsuitable for plant growth.
   (ii) Deposition of particulate on leaves prevents CO₂ absorption and hence decreases the rate of photosynthesis.
   (iii) Particulates deposited on plant leaves block the stomata of plants and thus inhibiting the rate of transpiration from the soil.
   (iv) In case of some plants, which are sensitive to traces of toxic metals, their enzyme activity is disturbed in presence of particulates containing trace elements.

(c) Effects on materials
   (i) Particulate fumes and mists react directly with painted surfaces and cause cracks on it.
   (ii) These induce corrosion of metals.
   (iii) These accumulate on the soil surface causing soil erosion.
   (iv) Particles including fumes, dust, soot, mists and aerosols can bring about severe damage to buildings, sculpture and monuments.

(d) Effect of solar radiation
   (i) Particulates reduce visibility by absorption and scattering of solar radiation.
   (ii) These disturb the delicate heat balance of the atmosphere.
   (iii) These compensate the climatic effects due to increased CO₂ concentration.
   (iv) These influences the climate through the formation of clouds, rains and snow, by acting as nuclei upon which water condensation can take place.

Control of particulate emission
The removal of particulate matter from gas streams is an essential step for air pollution control. The different techniques employed for this purpose are as follows:

1. Use of Gravity setting chamber: The effluent gases are introduced into a chamber which is large enough to permit gas velocities to decrease and dust or droplets to settle by the action of gravity. The particles with more than 50µ are removed in this technique.

2. Use of cyclone collector: The effluent gases are allowed to flow in a tight circular spiral which produces a centrifugal force on suspended particles, forcing them to move outward through
the gas stream towards the wall where these are collected.

3. **Use of Wet Scrubbers:** The effluent gases are allowed to pass through a suitable absorbent (usually a liquid) to remove solid, liquid, and gaseous contaminants. The extent of contact and interaction are further increased using spray chambers or towers where the liquid is introduced into the effluent gas stream as fine spray.

4. **Use of electrostatic precipitators:** When the particulate particles are charged, these can be precipitated by passing through electrostatic precipitator, which is oppositely charged.

5. **Use of cyclonic separators and trajectory separators.**

**CONCLUSION**

From the above discussion, it is quite clear that particulates like other primary pollutants cause serious environmental hazards both to living and nonliving systems. The extent and type of damage depends upon their chemical composition, nature, mechanism of interaction and physical states. The particulate induced degradation is maximum when these are corrosive and carry toxic substances. So in order to minimize the level of particulates in environment, these should be removed from the gas streams (source) before their discharge into air, adopting suitable technique.

**REFERENCES**