

# Nalanda Open University

Course Name: M.A. / M.Sc. Environmental Science

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## **E-CONTENT – Evs (18)**

for

M.A. / M.Sc. Environmental Science,

Part-I, Examination - 2020

**Short description of the suggested Topics**

**Theory Paper**

**Paper-VIII**

**(ENVIRONMENTAL POLLUTION & CONTROL)**

### **1. Definition of pollutants and Pollution. Brief description of main sources of air pollution.**

#### **Introduction: Definition and Elaboration of the term Pollutant and Pollution**

##### **POLLUTANT**

A solid, liquid or gaseous substance present in the biosphere in such concentrations that may be or tend to be injurious to living and non-living components of the environment is termed as environmental pollutant.

##### **Classification of pollutants**

Different types of pollutants and the basis of their classification are as described below:

##### **(i) Biodegradable and non-biodegradable pollutants**

On the basis of whether a particular pollutant can be degraded into simpler, non toxic substances by the action of microorganisms or not, pollutants have been classified into Biodegradable pollutants and non-biodegradable pollutants.

##### **(ii) Primary and secondary Pollutants**

###### **Primary Pollutants:**

The pollutants such as carbon dioxide, hydrocarbons, oxides of sulphur and Nitrogen etc which enter the environment directly from various sources (natural or anthropogenic) are termed as Primary Pollutants.

###### **Secondary Pollutants:**

The pollutants which are formed by chemical interactions between primary pollutants themselves or between primary pollutants and atmospheric gases are termed as Secondary Pollutants.

##### **(iii) Point source and Non Point source Pollutants**

Based on whether the source of pollutant (especially water pollutant) is identified or not, they are categorized into Point source pollutants and Non Point source Pollutants. Source of Point source pollutants can be readily identified whereas those of Non Point Pollutants cannot be readily identified.

#### (iv) **Gaseous, Liquid and Solid Pollutants**

On the basis of their physical state, pollutants are classified as solid, liquid and gaseous Pollutants.

NOTE: For a question on classification of Pollutants the above mentioned points (i), (ii), (iii) & (iv) should be elaborated further with suitable examples.

#### **POLLUTION:**

Any desirable change in the physical, chemical or biological segments of our environment caused by excessive accumulation of pollutants that is harmful to humans, other biological species and/or abiotic components of the environment is termed as environmental pollution.

Pollution may be of Air, water and soil. Excessive loud sound and sources emitting harmful radiation are also injurious to humans, other life forms and/or physical environment of the environment. They are termed as noise pollution and Radiation Pollution respectively. Thus the types of Pollution may be categorized as follows:

- Air Pollution
- Water Pollution
- Soil Pollution
- Noise Pollution
- Radiation Pollution, and
- Thermal Pollution

Pollution may be caused by natural processes as well as human activities (anthropogenic sources). Natural sources include volcanic eruptions, forest fires, dust storms, landslides, floods etc. Man made pollution is the outcome of greed for short-term economic gains achieved at the cost of long term ecological benefits. Fast growth in world population, large scale industrialization, expanding urbanization, increasing mining activities and agricultural practices leading to unprecedented deforestation and automobile transportation are the major causes of anthropogenic pollution. The harm inflicted by natural causes is insignificant as compared to man-made causes as they do not stay long in the biosphere and are mostly localised.

**NOTE:** Elaborate description of pollution should be given only when asked to answer so, otherwise give the definition only if it is asked to define Pollution.

#### **Brief description of main sources of Air Pollution:**

The sources of air pollution are many which can be both natural as well as man-made (i.e. Anthropogenic)

**NATURAL SOURCES:** Natural Pollutants of air may be biotic or abiotic. Biotic air pollutants include pollen from seed-bearing plants, spore from fungi, micro-organisms and ferns. Abiotic pollutants include suspended particulate matter (SPM) and gases emanating from decaying plants, animals or inorganic substances.

But the major sources of air pollution are anthropogenic generated by various human activities in the present age of science, technology and industrialization.

### **MAN-MADE SOURCES:**

Smoke and gases present in automobile exhausts and from chimneys and furnaces of factories, thermal power plants and brick kilns, on burning of garbage and gases and toxic suspended particulate matter from agricultural activities, industries and mining activities are the common pollutants generated by human activities.

The five major air pollutants from various natural and man-made sources include the gases- carbon monoxide, carbon dioxide, oxides of sulphur, oxides of nitrogen and hydrocarbons which together with suspended particulate matter contribute to more than 90 percent of the global air pollution.

### **Air Pollutants from vehicles:**

Fossil fuel operated vehicles are a major source of air pollution. The single most important contributory factor responsible for the deterioration of air quality in the cities all over the world (particularly of developing countries like ours) is the exponential increase in fossil fuel (petrol & diesel) operated vehicles. The principal pollutants emitted by vehicles include carbon monoxide and carbon dioxide, oxides of nitrogen and unburnt hydrocarbons and suspended particulate matter. Moreover, depending upon the sulphur content in the fossil fuel, the exhausts from automobiles also contain varying amount of sulphur dioxide. Moreover, a huge amount of dust is blown by running vehicles. Heavy duty diesel fuelled vehicles including three and two wheelers are the major source of carbon monoxide and hydrocarbon emissions.

Fossil fuel operated vehicles also emit polynuclear aromatic hydrocarbons (PAHs) which in higher concentrations have carcinogenic effect. Moreover, unburnt hydrocarbons and nitrogen oxides, both of which are present in the emissions of internal combustion engines play important role in the formation of secondary air pollutants such as ozone and Peroxy Acetyl Nitrate (PAN).

### **Air Pollutants from Industries**

Industries such as metallurgical industries, cement plants, chemical industries, sugar and cotton mills, paper and pulp mills, petroleum refineries, coal based thermal power plants and synthetic rubber manufacturing plants are the major contributory sources of air pollutants- smoke, suspended particulate matter and toxic gases such as oxides of nitrogen, sulphur and carbon. According to one estimate, industries contribute to about one-fifth of the total air pollution.

Air pollution is also due to leakage of toxic gases from industrial plants such as ammonia from urea plants and highly toxic chemicals, such as methyl isocyanate from Union carbide's pesticide plant at Bhopal in 1984.

### **Air pollutants from burning of garbage:**

Garbage is the name given to organic component of the domestic (i.e. municipal) and commercial waste which constitutes about 70 to 80 percent of these wastes. An unscientific yet convenient method of disposal of garbage

including garden litters, forest debris, crop residues, bush, weeds and other vegetable waste is to burn them to ashes in open air. Open burning of garbage is an important source of air pollution as it produces gases like carbon dioxide, oxides of nitrogen, oxides of sulphur and suspended particulate matter in the form of smoke, soot and ash.

### **Air Pollutants from brick kilns**

In conventional brick kilns, wood and/or coal are burnt to manufacture bricks. As bricks are an important building material, huge number of brick kilns can be found in the vicinity of towns and cities. Due to burning of carbon based fuels (wood and coal) in these kilns in huge quantity, enough of air polluting gases-carbon monoxide, carbon dioxide, oxides of nitrogen and of sulphur and particulate matter in the form of smoke and dust are produced and poured into the nearby atmosphere.

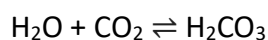
## **2. Explanatory notes on Acid-Rain, Smog, Suspended Particulate Matter and Ozone hole.**

### **[I] Explanatory note on Acid-Rain**

Acid rain or acid precipitation means the rain water having excessive acids present in it. In a broader sense, acid rain refers to a number of ways in which different acids from the atmosphere fall and deposited on the earth. It may either be wet or dry. Wet acid rain refers to acidic water which the earth receives through rainfall, snow, dew, frost and mist. Dry acid rain (commonly called dry deposition) includes acidic gases and acidic solid particles containing sulphates and nitrates present in air, which settles on the earth's surface. However, the wet acid rain is much more common and will be described here. The term acid rain was coined by Robert Angus in 1872.

### **PH of Acid Rain**

Normal rain water is slightly acidic in nature due to dissolution of atmospheric carbon dioxide in it forming carbonic acid, which is a very weak acid.



(Carbonic Acid)

PH value of normal rain water lies between 5.6 and 6.5. However, acid rain having excessive acid present in it has PH value less than 5.6 and could be as low as 4 or even below. In a few cases, PH value as low as 2.4 has also been reported.

### **Sources and chemistry of Acid Rain:**

The sources of acid rain are both natural as well as man-made (i.e. anthropogenic).

#### **Natural Sources:**

There have always been some acids in rain water due to dissolution of atmospheric carbon dioxide and from acidic substances from volcanoes, swamps and planktons in oceans.

**Man-made sources:**

The occurrence of acid rain has increased in frequency and intensity after the Industrial revolution. In fact, it is a product of aggressive industrialization in the developed countries in the beginning and now in developing countries as well. As fossil fuels contain some sulphur, it burns to produce sulphur dioxide. When coal, petrol or natural gas is burnt in power plants, factories and automobiles sulphur dioxide and nitrogen oxides are produced. Oxides of nitrogen originate mainly from atmospheric nitrogen which combines with oxygen at high temperature in internal combustion engines to produce nitrogen oxide. A large part of the oxides of nitrogen and sulphur entering the atmosphere react with water and other chemicals in the air to form sulphuric acid and nitric acid along with some other harmful pollutants like sulphates and nitrates. Acid rain contains a mixture of a number of acids, main acids being sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) and nitric acid (HNO<sub>3</sub>) with little of Hydrochloric acid (HCl). The detailed mechanism of their formation is highly complicated.

**Effects of Acid rain:**

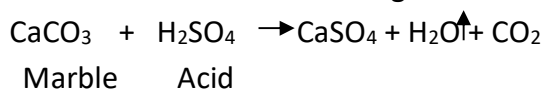
Acid rain exerts short term as well as long term effects on the organisms and materials which come into contact with it. Acid rain (both dry deposition as well as wet deposition in large quantities) have detrimental effect on wildlife, forests, soil, fresh water and buildings.

**Impact on agriculture (soil, crops and trees):**

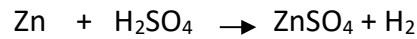
- Acid rain makes soil sour. It is not suitable for cultivation of most of the crops and for growth of trees.
- Acid rain removes nutrients of soil (such as calcium, magnesium, iron, potassium etc) through dissolution which are leached away from soil. Deficiency of these soil nutrients badly affects the growth of plants and crops sown in it.
- High acid concentration in soil damages and kills soil micronutrients including nitrogen fixing bacteria. This has detrimental effect on fertility of the soil.
- The ill effects of acid rain on trees and forest are devastating. It dissolves and washes away the nutrients and minerals in the soil of forest ecosystem and thus retards the growth of trees.
- It is not just trees that are affected; there is damage of other forest vegetation too.

**Impact on buildings and monuments**

Acid rain and dry acid precipitation causes extensive damage to buildings, monuments and sculptures made of marble, limestone, mortar or metals. The acid corrodes the materials through the following chemical reactions:



Or, Limestone



(A metal) Acid

The buildings, monuments and metal sculptures become pitted and weakened mechanically as  $\text{CaSO}_4$ ,  $\text{ZnSO}_4$  etc, being soluble in water are leached out of rainwater.

### **Impact on aquatic environment**

Aquatic environment is highly sensitive to even moderate increase in acidity. Acid rain increases the acidity of lakes, dams, rivers and streams and causes death of numerous kinds of plants and animals in aquatic ecosystems. Most planktons, molluscs and young fishes cannot tolerate acidic water having PH below 5.

In addition, fishes and other aquatic life forms in acid lakes also succumb to concentrations of such metals as Lead, Zinc, Manganese, Aluminium, Mercury etc. which are leached from the surrounding rocks by the acids.

It may be concluded that acid rain does not help aquatic ecosystem in any way.

### **Impact on Human Health:**

Acid rain affects the health of human being in more ways than one. It can harm human health through the atmosphere or through the soil in which food is grown and eaten from. Acid rain causes toxic metals such as Aluminium, Zinc, Iron, Manganese etc. to reach into underground drinking water sources or may enter into crops and animals that humans consume. These toxic metal contaminated foods may cause nervous and brain damage to children which becomes fatal in many cases.

**NOTE:** Answer may be shortened/modified as per the demand of the question asked to answer.

### **[II] Explanatory note on SMOG**

Photochemical Smog is a classical example of secondary air pollutant. The term 'SMOG' is derived from a combination of smoke and fog (SMOKE + FOG → SMOG). Smog formation often occurs in traffic-congested big cities. It reduces atmospheric visibility and affects plants as well as animal life.

Broadly two types of Smog have been recognised. They are:

- Classical (Sulphurous) smog or London Smog, and
- Photochemical Smog or Los Angeles Smog.

Classical smog consists of carbon-based soot and sulphur dioxide. Classical Smog is also called reducing Smog as it acts as a reducing agent due to presence of sulphur dioxide and carbon (soot) particles present in it.

In humid air, water condenses on carbon particles and forms irritating Smog. The earliest recorded major disaster due to classical (Sulphurous) Smog formation occurred in London in December 1952, hence the name London Smog. The disaster affected nearly half the population of

the London city and resulted in the death of over 4000 people mostly due to aggravated respiratory problem.

Photochemical Smog or Los Angeles Smog formation involves unburnt gaseous hydrocarbons and nitrogen oxides, both of which are present in the emissions of internal combustion engines (Particularly motor vehicles). Those chemicals play an important role in the formation of ozone (O<sub>3</sub>) and PAN (Peroxy Acetyl Nitrate). The Smog itself consists of nitrogen oxide, ozone and PAN. Photochemical smog is also known as 'Oxidising Smog', because it has a high concentration of oxidising agents. Ozone is a common oxidising agent found in photochemical Smog. Los Angeles in California, USA first experienced a serious form of secondary air pollution due to photochemical Smog formation in 1943, hence the name Los Angeles Smog.

#### **Effect of Smog Formation:**

Smog formation produces a haze in the atmosphere, thereby reducing visibility, leading to increased number of accidents. Smog causes a toxic effect on humans, animals, plants and the physical environment. It causes acute eye irritation and aggravates lung related diseases in human beings. It adversely affects plants growth and can corrode marble statues and monuments. PAN in Smog reduces photosynthetic efficiency of plants.

#### **[III] Explanatory note on Suspended Particulate Matter (SPM)**

Suspended Particulate Matter (SPM) is among the five major air pollutants (other four being Carbon monoxide, oxides of sulphur, oxides of Nitrogen and Hydrocarbons) which contribute to more than 90% of the global air pollution. They are microscopic particles of solid or liquid matter suspended in the air. Of the Suspended Particulate Matter (SPM) those which are designated as PM<sub>10</sub> are inhalable coarse particles with a diameter of 10 micrometer or less. Extremely fine particles designated as PM<sub>2.5</sub> has a diameter of 2.5 micrometer or less.

Sources of SPM can be natural as well as anthropogenic. Natural sources include particulate matter originating from volcanoes, dust storms, forest and grassland fires, living vegetation etc. Anthropogenic sources include such human activities as a burning of fossil fuels in vehicles, stubble burning, road dust and wet cooling towers in cooling system. Suspended Particulate Matter in the form of smoke, soot, dust including metal dust and vapour are produced by asbestos and fibre factories, pesticide industries, wooden furniture industry, power plants, steel plants, mining, cement plants etc.

#### **Health effects of Particulate Matter**

SPM is a major air pollutant which affects both the lung and heart of human beings. Numerous scientific studies have linked SPM exposure to a variety of problems including

- Premature death in people with heart and lung disease
- None fatal heart attacks
- Irregular heart beats
- Aggravated asthma
- Decreased lung function

- Increased respiratory systems, such as irritation of the air ways, coughing or difficulty in breathing

In fact, SPM is the most wide spread pollutant affecting more people globally than any other pollutant of air, water or soil.

#### **[IV] Explanatory note on Ozone hole**

Ozone is a triatomic form of oxygen ( $O_3$ ) which occurs naturally throughout the earth's atmosphere. Its maximum concentration (around 10 ppm) is in the stratosphere at an altitude of 15-50 Km above the earth's surface. The presence of ozone layer in the stratosphere, which forms a well marked ozone layer, is of vital importance to humans and other life forms on the earth. It serves as a protective shield (umbrella) for life on the earth by absorbing most of the harmful short wave (high energy) ultraviolet (UV) radiation of the Sun and thereby protects life on the earth from severe radiation damage.

In the Stratosphere, thickness of the ozone layer above 200 DU (Dobson Unit) is considered normal. If the thickness fall below 200DU, it is termed as Ozone layer depletion or more popularly as 'Ozone hole'. Thus, the term ozone hole refers to thinning of the vertical column of the stratospheric ozone below 200DU label. The term ozone hole is a partial misnomer. Rather than being a literal hole through the ozone layer, the ozone hole is a large area of the stratosphere having extremely low concentration of ozone.

#### **Ozone Hole Studies:**

In 1974, a theory was proposed by Dr. M. Molina and Dr. S. Rowland of University of California, linking ozone depletion (Ozone hole formation) with chlorofluorocarbons (used as refrigerants, blowing plastic foams, aerosol spray etc.). Later in 1985, research group of scientists from the British Antarctic Survey (BAS) reported a large hole in the ozone layer over Antarctic (the southern hemisphere) where ozone concentration dropped by about 30percent. Subsequently a similar hole was discovered above the Arctic (the thickly populated northern hemisphere) in 1990. This phenomenon was later detected in other parts of the world as well including Australia.

#### **Causes of Ozone depletion**

Chlorofluorocarbons (CFCs) have been found to be the primary culprit causing most of ozone layer depletion. One molecule of Chlorofluorocarbon has been found to be capable of destroying as high as  $10^5$  ozone ( $O_3$ ) molecules in the stratosphere.

There is another family of organic compounds called Halons which contain bromine. Halons have been found to be 100 times more potent than CFCs in destroying ozone. Other gases which cause ozone layer destruction are Nitrogen oxides and Methane.

#### **Effects of Ozone Layer Depletion (i.e. Ozone hole formation) :**

The thinning of ozone layer results in more UV radiation reaching the earth's surface, which has serious implications for all the life on the earth's surface.



**Effect on Humans:**

In humans the increased UV radiation increases the incidence of Sun burn, cataract, ageing of the skin and the skin cancer. Increased exposure to UV radiation weakens the immune system leading to increased cases of such infectious diseases as Malaria, Measles, Chickenpox and other viral diseases.

**Effect on earth temperature:**

The thinning of ozone layer would mean more and more of UV radiation reaching the earth's surface. As a consequence, the temperature of the lower atmosphere will rise too high for biological species to survive on the earth.

**Effect on Plant and animal planktons:**

Many micro-phytoplanktons and Zooplanktons may die because of increased exposure to UV solar radiations. Photosynthesis by phytoplanktons would be greatly reduced due to reduction in phytoplanktons. A reduction in phytoplankton which forms the basis of the marine food chain would adversely affect the whole food chain and food web of marine organisms which depend on phytoplanktons.

**Effect on Crop Productivity:**

As UV radiation affects the crops and plants by reducing the leaf size and germination rate, they cause a reduced rate of photosynthesis. A thinning of ozone layer would, therefore, result in decrease in vegetation and food production, and increased rate of carbon dioxide (CO<sub>2</sub>) accumulation in the atmosphere.

As carbon dioxide is a potent green house gas, the ozone layer depletion is indirectly related with the enhanced green house effect leading to global warming.

**International efforts to curb the problem:**

Ozone layer depletion (i.e. the ozone hole) has generated worldwide concern over increased cancer risks and other negative effects. These concerns led to the adoption of the Montreal Protocol in 1987, which bans the production of CFCs, halons and other ozone depleting chemicals. The ban came into effect in 1989. As a result, ozone levels stabilized by the mid 1990s and began to recover in the 2000s, as the shifting of the jet stream in the southern hemisphere towards the south pole has stopped and might even be reversing. Recovery is projected to continue, and the ozone layer is expected to reach pre-1980 levels by around 2075. Moreover, already in 2019 NASA reported that the ozone hole was the smallest ever since it was first discovered in 1982.

The Montreal Protocol is considered the most successful International environmental agreement to Date.

**NOTE:** The study Material has been prepared with a view to answer Full Length question on Ozone Layer Depletion/Ozone hole. The prepared study matter may be shortened as per demand of the question asked to answer.

#### **4. Definition of Noise Pollution; Main sources of Noise Pollution; effects of Noise Pollution; Control and Abatement measures to reduce the menace of Noise Pollution.**

##### **Noise Pollution: An Introduction**

Any sound which is unwanted, disagreeable and unpleasant to our ears is termed as noise. Noise pollution may be defined as any undesirable sound which adversely affects the physical and mental health of its recipient.

It may, however, be noted that degree of annoyance due to loud sound may not necessarily be related to the intensity of sound alone; personal attitude and mood of the recipient are also the important influencing factors. A loudly played music may be liked by someone whereas very feeble sound may be taken as noise by an ailing person or by someone who likes loneliness and tranquillity.

Noise may be natural (such as thunder) or man-made. But the impact of natural noise is insignificant as compared to man-made noise because the rarity of its occurrence.

Noise is essentially a feature of the technology based society of modern times. Scientific and technological advancement has increased human miseries as well. Noise is one among them, which is found to have physiological and psychological effect of damaging nature on human beings. Sound is measure in a unit called decibel (dB).