

ENVIRONMENTAL CHEMISTRY

It deals with the study of the origin, transport reactions, effects and fates of chemical species in the environment.

1. ENVIRONMENTAL POLLUTION

It is the effect of undesirable change in our surroundings that have harmful effects on plants animals and human beings.

A substance that causes pollution is known as pollutant. It can be solid or liquid or gaseous substances present in greater concentration than in natural abundance and are produced due to human activities or due to natural happenings.

Types of pollutants

2 types

1) Primary and secondary pollutants

Primary pollutants

Those which after this formation enter the environment and remain as such.

eg : NO, NO₂, SO₂

Secondary pollutants

The harmful material which are formed by chemical reactions between primary pollutants in the atmosphere.

eg : 1) Hydrocarbon + oxide of nitrogen $\xrightarrow{h\nu}$ ozone

2) NO₂ (NO + oxygen)

3) Acid rain

2) Biochemical and non-biodegradable pollutants

A) Biodegradable

eg : Cow dung

B) Non Biodegradable

eg : DDT, Hg

Atmospheric pollution

Regions of the atmosphere; It has 4 regions

Region	Altitude	Temperature range	Species present or gases present
1) Troposphere	0 - 11 km	decreases from 15 to -56°C	N_2 , O_2 , CO_2 , H_2O , vapour
2) Stratosphere	11 - 50 km	Increase from -56°C to -2°C	N_2 , O_2 , O_3
3) Mesosphere	50 - 85 km	decreases from -2 to -92°C	N_2 , O_2 , NO^+ , O_2^+
4) Thermosphere	85 - 500 km	increases from -92°C to 1200°C	O_2^+ , O^+ , NO^+ , e^-

Types of pollution

Depending on the part of the environment polluted

- 1) Air pollution
- 2) Water pollution
- 3) Soil pollution

1) Air pollution

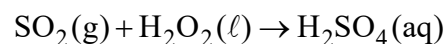
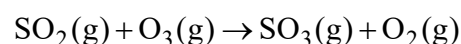
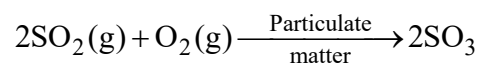
Gaseous air pollutants

a) Oxides of sulphur

Sulphur(from fossil fuel) \longrightarrow Oxides of sulphur(SO_2 , SO_3)

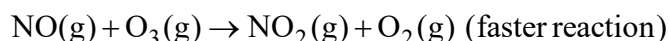
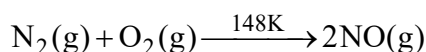
Toxic effect

- 1) At low concentration of SO_2 causes respiratory diseases.
eg : Asthma, bronchitis, emphysema
- 2) It causes protection to the eyes resulting in tears and redness
- 3) High concentration of SO_2 is responsible for stiffness of flower buds

**b) Oxides of nitrogen**

- $\rightarrow \text{N}_2$ and O_2 at high altitudes when lightning strikes, combine to form oxides of nitrogen
- $\rightarrow \text{NO}_2$ is then oxidised to NO_3^- which is washed into soil where it serve as a fertilizes.

→ In an automobile engine when fossil fuel (hydrocarbons) is burnt, N_2 and O_2 combine to give significant quantities of Nitric oxide (NO) and NO_2



Toxic effect

- (1) The irritant red haze in the traffic and congested places is due to oxides of nitrogen
- (2) Higher concentration of NO_2 damages the leaves of plants and retard the rate of photosynthesis
- (3) It is toxic to living tissues
- (4) NO_2 is also harmful to various textile fibres and metals

3) Hydrocarbons

They are formed by incomplete combustion of fuel used in automobiles

Toxic effect :

- (1) They are carcinogenic
- (2) In plants they cause ageing, break down of tissues and shedding of leaves, flowers, and twigs

4) Oxides of carbon

1. Carbon monoxide

Source of CO

- 1) Incomplete combustion of carbon, coal, fire, wood, petrol etc
- 2) Automobile exhaust

Toxic effect

It is poisonous. It binds to haemoglobin to form carboxy haemoglobin which is about 300 times more stable than the oxygen-haemoglobin. It reduces the oxygen carrying capacity of blood. It causes headache, weak eye sight, nervousness and cardiovascular disorder.

(1) In pregnant woman increased CO level induces premature birth, spontaneous abortions and deformed babies.

(2) CO_2

Sources :

- 1) Respiration
- 2) Burning of fossil fuels for energy
- 3) decomposition of limestone during the manufacture of cement
- 4) Volcanic eruptions

It causes global warming

Global warming and green house effect

75 % of solar energy reaching the earth is absorbed by the earth surface and in then , this increases the temperature of the earth. The remaining of the heat radiates back to the atmosphere, some of the heat is trapped by gases such as CO₂, methane, O₃, chlorofluorocarbon (CFCs) and water vapour in the atmosphere. Thus they increases the temperature of the atmosphere. This causes global warming.

Just as the glass in a green house holds the suns warmth inside, atmosphere traps the sun heat near the earth's surface and keep it warm. This is called natural green house effect because it maintains the temperature and makes the earth perfect for life.

CO₂ is the major contributor of global warming in addition to CO₂ other green house gases are CH₄, water vapour, nitrons oxides, CFCs and ozone

Sources

1) CH₄

- a. CH₄ is liberated naturally when vegetation is burnt digested or rotted in absence of oxygen
- b. It is released in paddy fields, coal mines, from rotting garbages dumps and by fossil fuels

2) CFCs

CFCs are non made industrial chemical used in air conditioning etc. It is also responsible for depletion of the ozone layer.

3) N₂O

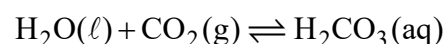
N₂O produced due to the use of chemical fertilizers, and the burning of fossil fuels

Harmful effects of Global warming

It increases the incidence of infections diseases like dengue, malaria, yellow fever, sleeping sickness etc.

Acid Rain

The pH of rain water is 5.6 due the presence of H⁺ ions formed by the reaction of rain water with CO₂ present in the atmosphere.



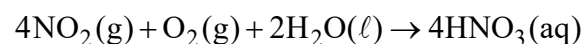
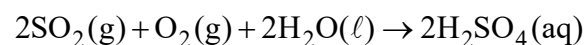
When the natural rain falls through polluted air it comes in contact with chemicals such as oxides of sulphur oxides of nitrogen, mist of HCl and phosphoric acid. There substances dissolves in falling rain making it more acidic

→ pH of acid rain ranging between 5.6 and 3.5

→ when pH of rain water drops below 5.6 it is called acid rain

→ Tag Trapezium is an action plan to save tag material form acid rain

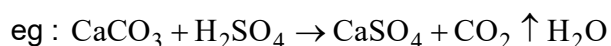
Chemistry of acid rain



Besides these ammonium salt are also formed and can be observed as an atmospheric haze (aerosol of fine particles)

Harmful effect of acid rain

- 1) It is harmful for agriculture, plants trees also affects plants and animal. Life in aquatic ecosystem.
- 2) It causes respiratory ailments in human beings and animals
- 3) It corrodes water pipes resulting in the dissociation of heavy metals. such as iron and Cu into drinking water
- 4) Building materials such as stone marble, are corroded and weakened on reaction with acid rain



Particulate pollutants

Particulates refers to minute solid particles or liquid droplets in air. These are found in vehicle emissions, smoke particles from fire dust particles, and ash from industries. Particulates in the atmosphere may be viable or non-viable.

Viable particulates

Minute living organisms that are dispersed in the atmosphere

eg : bacteria, fungi, algae etc

Non - viable particulates

It is classified as follows

- a) Smoke particulates : They consist of solid or mixture of solid and liquid particles formed during combustion of organic matter.

eg : Cigarette smoke, smoke from burning of fossil fuel, garbage and dry leaves, oil smoke etc.

- b) Dust

It consist of fine solid particles, over $1\mu\text{m}$ diameter.

eg : saw dust from wood works, pulverized coal, cement and fly ash from factories

- c) Mists

They are produced by particles of spray liquids and by condensation of vapour in air

eg : H_2SO_4

- d) Fumes

They are produced by the condensation of vapours during sublimation, distillation, boiling etc.

Toxic effect

- 1) Particulate pollution bigger than 5 microns are supposed to lodge in the nasal passage
- 2) Particulate pollutants of about 1 micron enter into lungs easily
- 3) Lead petrol is the primary source of air lead emission it interfere with blood cells.

SMOG

smoke + fog \rightarrow smog

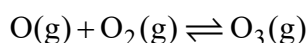
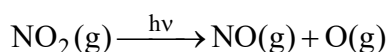
There are two types

Classical smog	photochemical smog
a) It is also known as sulphurous smog or London smog	It is known as Los Angeles smog
b) It occurs in cool and humid conditions	It occurs in warm, dry and sunny climate
c) It is a mixture of smoke, fog and SO ₂	The main components of this smog result from the action of sunlight on unsaturated hydrocarbons and nitrogen oxides produced by automobiles and factories
d) Chemically because of the presence of SO ₂ and carbon. It is a reducing mixture. Called as reducing smog	It has high concentration of oxidising agent like NO ₂ and is, therefore, called as oxidising smog

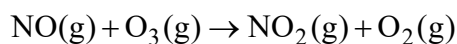
Mechanism of photochemical smog

→ Burning of fossil fuels produces hydrocarbons and nitric oxide (NO)

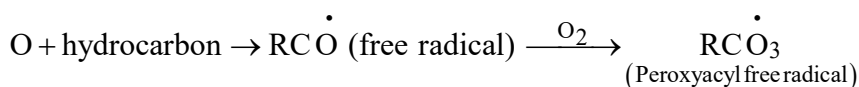
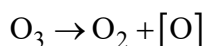
→ When concentration of these pollutants increases to sufficient high levels a chain reaction occurs from their interaction with sunlight in which NO is converted to NO₂

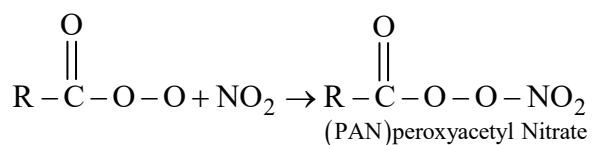


The O₃ formed rapidly reacts with NO



Like NO₂, O₃ is a toxic gas





Harmful/toxic effects of photochemical smog

- 1) Compounds of photochemical smog, NO and O₃, irritated the nose and throat and their high concentration causes headache, chest pain, dryness of throat, cough and difficulty in breathing
- 2) It causes cracking of rubber and extensive damage to plant life
- 3) It causes corrosion of metals

Control of photochemical smog

- 1) Using catalytic convertors in the automobile, which prevent the release of NO and hydrocarbons to the atmosphere.
- 2) By plantation of certain plants like pinus, juniperus pyrus and vitis which metabolise NO

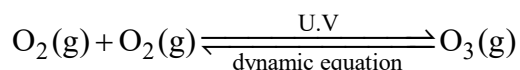
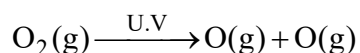
Stratospheric Pollution

Formation and Break down of ozone

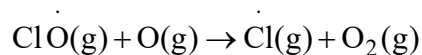
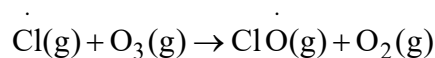
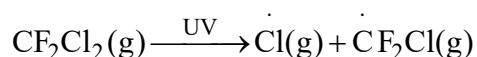
The ozone layer protect us from U.V radiations

These reaction causes skin cancer

O₃ is produced as a result of the action of U.V on dioxygen



The main reason of ozone layer depletion is due to the release of CFCs known as freons.



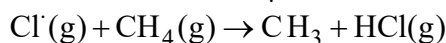
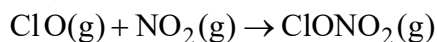
Thus chlorine radicle are continuously regenerated and causes the decomposition of ozone

Ozone hole

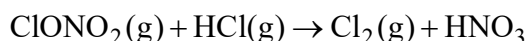
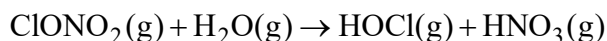
It is generally occur over the south pole.

Polar stratospheric clouds

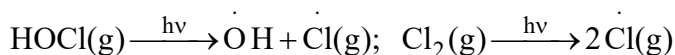
In summer season, nitrogen dioxide and CH₄ react with chlorine monoxide and chlorine atom forming chlorine sinks and thereby, preventing much ozone depletion



In winter, special type of clouds called polar stratospheric clouds are formed over Antarctica. These polar stratospheric clouds provide surface on which chlorine nitrate formed gets hydrolysed to form hypochlorous acid



In spring when sunlight returns to the Antarctica the sun's warmth breaks up the clouds and HOCl and Cl_2



The chlorine radicals thus formed initiate the chain reaction for ozone depletion

Harmful effects

- 1) U.V radiations affect plant protein which leads to harmful mutation of cells
- 2) It increases evaporation of surface water

Water pollution

Pollution of water originates from human activities

- 1) Point source pollution : Early identified source of place of pollution is called as point source
eg : Municipal and industrial discharge pipes
- 2) Non point source of pollution : where a source of pollution cannot be identified
eg : Agriculture run off, drainage

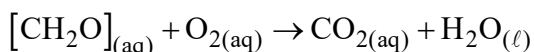
Cause of water pollution

a) Pathogens : Water pollutants which are the disease causing agents. It includes bacteria

b) Organic waste : Excessive phytoplankton growth within water is also a cause of water pollution

Importance of dissolved oxygen in water

- The fish growth is inhibited if the dissolved concentration of oxygen in water is below 6 ppm
- The lower the concentration of dissolved oxygen, the more polluted in the water sample
- The dissolved oxygen in water is consumed rapidly by microorganisms



- The amount of oxygen required by bacteria to break down the organic matter present in a certain

volume of a sample of water is called biochemical oxygen demand (BOD)

→ The amount of BOD in water = the amount of organic material present

→ Clean water would have BOD value less than 5 ppm

→ If it is more than (7 ppm water is highly polluted)

c) Chemical pollutants

1) heavy metals such as Cd, Hg, Ni that present in water damage kidneys, central nervous system, liver etc.

2) Various industrial chemicals like polychlorinated biphenyls (PCBs) which are used as cleaning solvent, detergent and fertilizers are also water pollutants

3) Fertilizers contain phosphates as additives. The addition of phosphate in water enhances algae growth

4) This process in which nutrient enriched water bodies support a dense plant population, which kills animal life by depriving it of oxygen and results in subsequent loss of biodiversity is known as eutrophication

International standards for drinking water

1) **Fluoride** : Up to 1 ppm or 1 mg/dm³, the F ions make the enamel on teeth much harder by converting hydroxyapatite $[3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{Ca}(\text{OH})_2]$. The enamel on the surface of the teeth, into much harder fluorapatite $[3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{CaF}_2]$

→ If the concentration of F^- above 2 ppm → brown mottling of teeth .

2) **Lead** : 50 ppm - It can damage kidney, liver, reproductive system.

3) **Sulphate** → Up to 500 ppm

4) **Nitrates** → up to 50 ppm - excess nitrate in water cause methemoglobinemia (blue baby syndrome)

	ppm(mg/dm ³)
Fe	0.2
Mn	0.05
Al	0.2
Cu	3
Zn	5
Cd	0.005

SOIL POLLUTION

Pesticides, herbicides, Insecticides causes soil pollution

- a) Pesticides → ex : DDT
- b) Herbicides → Sodium chlorate (NaClO_3), Sodium arsenite (Na_3AsO_3) etc
- c) Insecticides → Chlorinated hydrocarbons, DDT, BHC

Fungicides

Organic compounds of mercury have been used as fungicides

Note

Fertile soil will have a pH between 6 - 7

Waste management

- 1) Recycling
- 2) Sewage treatment - The main stages are
 - a) The removal of large solids that get into the system of filtering the waste water through screens
 - b) Settlement in tanks to allow the removal of solids that settle out (called sludge)
 - c) The degradation of the organic content by microbial oxidation
 - d) Chemical removal of phosphate, coagulation, filtration and disinfection using chlorine

The safe disposal of the sludge produced during water treatment is a problem. The sludge is dried and then may be incinerated, digested or dumped

Green chemistry

It is a way of thinking and is about utilising the existing knowledge and principles of chemistry and other services to reduce adverse impact on environment

- eg : 1) Dry cleaning of clothes - by using liquified CO_2
- 2) Bleaching of paper - use of H_2O_2 with suitable catalyst