14. ENVIRONMENTAL CHEMISTRY

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ENVIRONMENTAL POLLUTION

- **Environmental pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings.**

AIR POLLUTION

WATER POLLUTION

SOIL POLLUTION

POLLUTANT

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

ATMOSPHERIC POLLUTION

LAYERS OF ATMOSPHERE

- The lowest region of atmosphere in which the human beings along with other organisms live is called troposphere.
- Troposphere is a turbulent, dusty zone containing air, much water vapour and clouds.
- The region above the troposphere, between 10 and 50 km above sea level is called stratosphere.
- The stratosphere contains dinitrogen, dioxygen, ozone and a little water vapour.

TROPOSPHERIC POLLUTION

- The lowest region of atmosphere in which the human beings along with other organisms live is called troposphere.
- Troposphere extends up to a height of about 10 km from sea level.
- Tropospheric pollution occurs due to the presence of undesirable solid or gaseous particles in the air.
- i.e. Gaseous Air Pollutants and Particulate Air Pollutants

1. GASEOUS AIR POLLUTANTS

- These are oxides of sulphur, nitrogen and carbon, hydrogen sulphide, hydrocarbons, ozone and other oxidants.
- They cause asthma, bronchitis and can lead to acute respiratory diseases.

2. PARTICULATE AIR POLLUTANTS

- Particulates pollutants are the minute solid particles or liquid droplets in air.
- These are present in vehicle emissions, smoke particles from fires, dust particles and ash from industries.
- These are dust, moist fumes, smoke, smog etc.

VIABLE AND NON VIABLE POLLUTANTS

VIABLE POLLUTANTS

- The viable particulates are minute living organisms that are dispersed in the atmosphere.
- E.g., Bacteria, Fungi, Moulds, Algae etc.

NON-VIABLE POLLUTANTS

- Non-viable particulates may be classified according to their nature and size as follows:

- (a) Smoke particulates consist of solid or mixture of solid and liquid particles formed during combustion of organic matter.
- E.g. Cigarette smoke, smoke from burning of fossil fuel, garbage and dry leaves, oil smoke etc.
- (b) Dust is composed of fine solid particles produced during crushing, grinding and attribution of solid materials.
- E.g. Sand from sand blasting, saw dust from wood works, pulverized coal, cement and fly ash from factories, dust storms etc.

- (c) Mists are produced by particles of spray liquids and by condensation of vapours in air.
- E.g. Sulphuric Acid mist, Herbicides, Insecticides etc.
- (d) Fumes are obtained by the condensation of vapours during sublimation, distillation, boiling and several other chemical reactions.
- E.g. Organic solvents, metals and metallic oxides form fume particles.

PRIMARY AND SECONDARY POLLUTANTS OF AIR

- A primary pollutant is an air pollutant emitted directly from a source.
- Primary pollutants are those which are present in the environment as such after their formations.
- Eg:- CO, NO, and SO_2.
- A secondary pollutant is not directly emitted as such, but forms when other primary pollutants react in the atmosphere.
- Eg:- Ozone, NO_2, SO_3, Peroxy Acyl Nitrates (PAN).

HARMFUL EFFECTS OF NITROGEN AND ITS COMPOUNDS

- The irritant red haze in the traffic and congested places is due to oxides of nitrogen.
- Higher concentrations of NO_2 damage the leaves of plants and retard the rate of photosynthesis.
- Nitrogen dioxide is a lung irritant that can lead to an acute respiratory disease in children.
- It is toxic to living tissues also.
- Nitrogen dioxide is also harmful to various textile fibres and metals.

CO is more dangerous than CO_2. Why?

- Carbon monoxide when inhaled reacts with haemoglobin to form the complex carboxy haemoglobin.
- Therefore, haemoglobin cannot carry oxygen to the various parts of the body.
- On the other hand, the presence of carbon dioxide can lead only to green house effect causing global warming.

GLOBAL WARMING

- About 75% of the solar energy reaching the earth is absorbed by the earth's surface.
- It increases the temperature of earth.
- The rest of the heat radiates back to the atmosphere.
- Some of the heat is trapped by gases such as carbon dioxide, methane, ozone, CFC and water vapour in the atmosphere.
- Thus the atmosphere is heated up.
- This is called global warming.

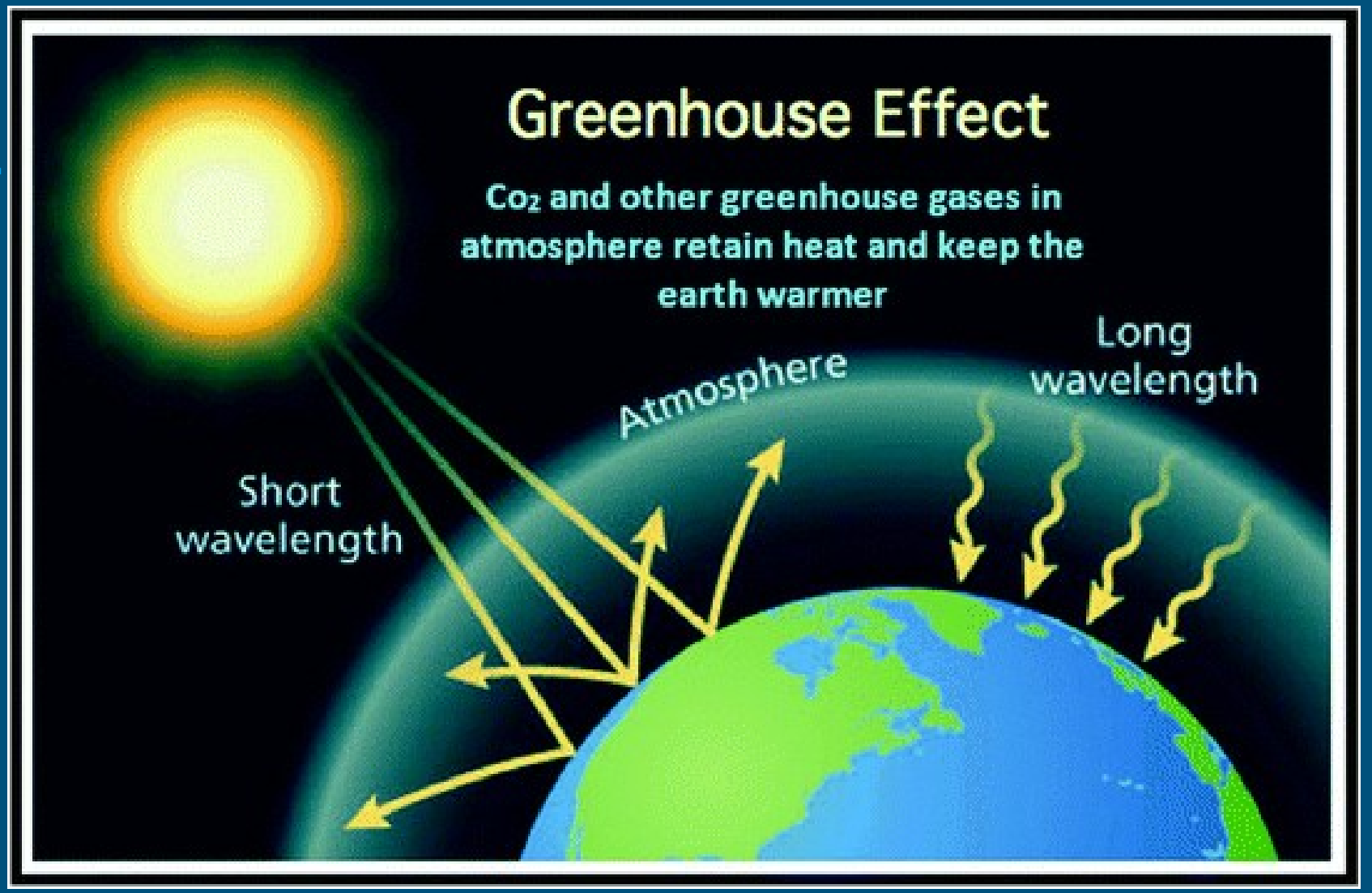
CONSEQUENCE OF GLOBAL WARMING

- There will be climatic changes.
- Rise in the sea level due to increased rate of melting of glaciers.
- This will lead to more floods which will cause more damages to soil and plants.
- Increase infectious diseases such as malaria, dengue fever, yellow fever and sleeping sickness.

GREEN HOUSE EFFECT

- The gases like CO_2, CH_4, O_3, CFC, water vapours and oxides of nitrogen present in the atmosphere form a thick cover around the earth.
- The earth receives a large quantity of heat energy coming from the sun.
- Sunlight consists of UV radiations, visible light and IR radiations.
- The IR radiations are not absorbed by atmospheric gases.
- The earth absorbs these IR radiations of short wavelength.

- As a result, temperature of the earth increases.
- The earth emits IR radiations of longer wave lengths.
- These IR radiations are absorbed by the thick cover of gases.
- Due to this, excessive heating of the earth's atmosphere occurs and the temperature increases.
- As more and more IR radiations are trapped, the atmosphere becomes hotter and hotter and the temperature increases.
- This is called greenhouse effect.


Greenhouse Effect
Co2 and other greenhouse gases in atmosphere retain heat and keep the earth warmer
Atmosphere
Long wavelength
Short wavelength

ACID RAIN

- Normally rain water has a pH of 5.6.
- It is due to the presence of H^+ ions formed by the reaction of rain water with CO_2 present in the atmosphere.

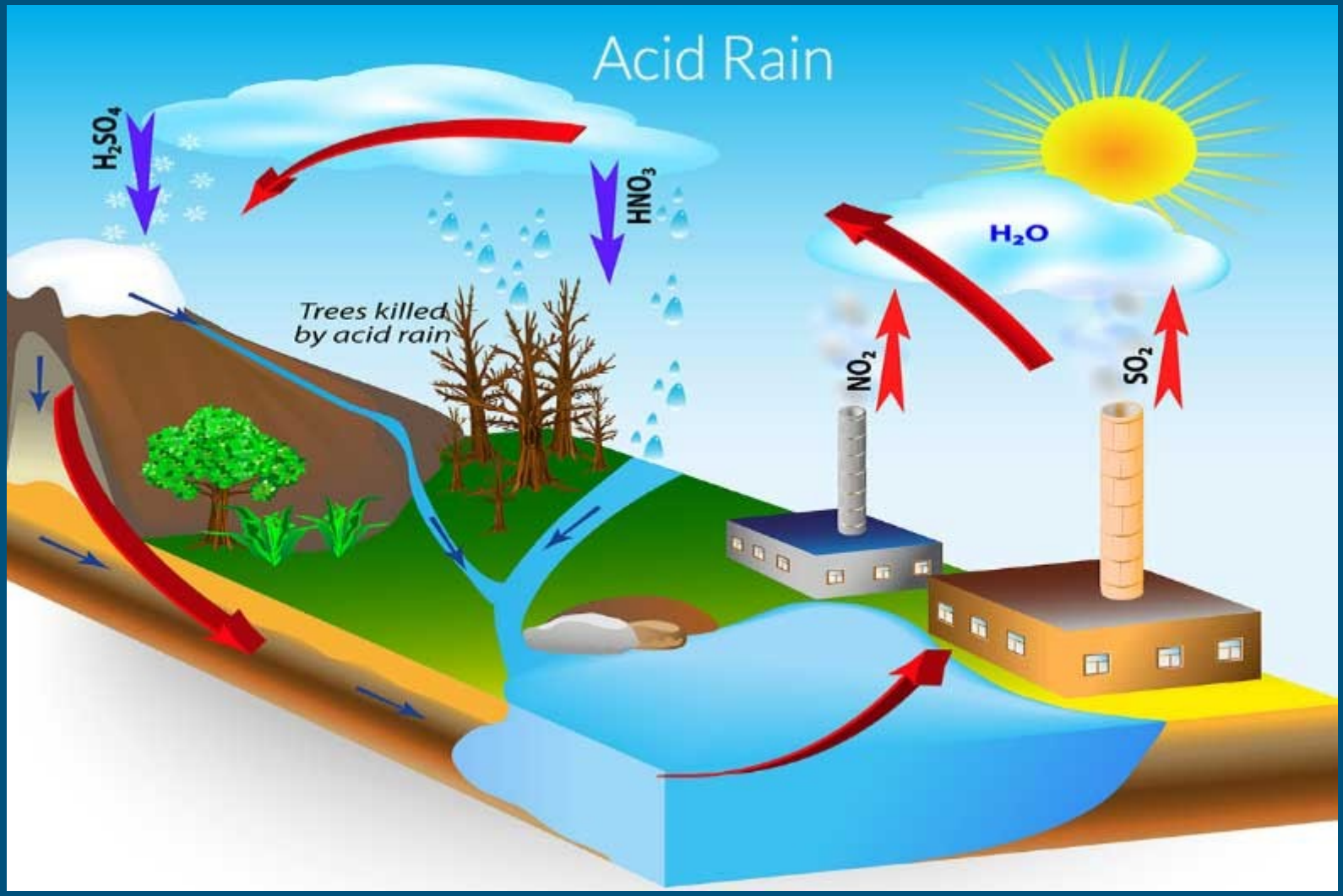
$$H_2O + CO_2 \rightleftharpoons H_2CO_3$$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

- When the pH of the rain water drops below 5.6, it is called acid rain.
- The oxides of nitrogen (NO_2) and sulphur (SO_2) present in the atmosphere after oxidation and reaction with water forms sulphuric acid and nitric acid.
- These acids contribute to acid rain.

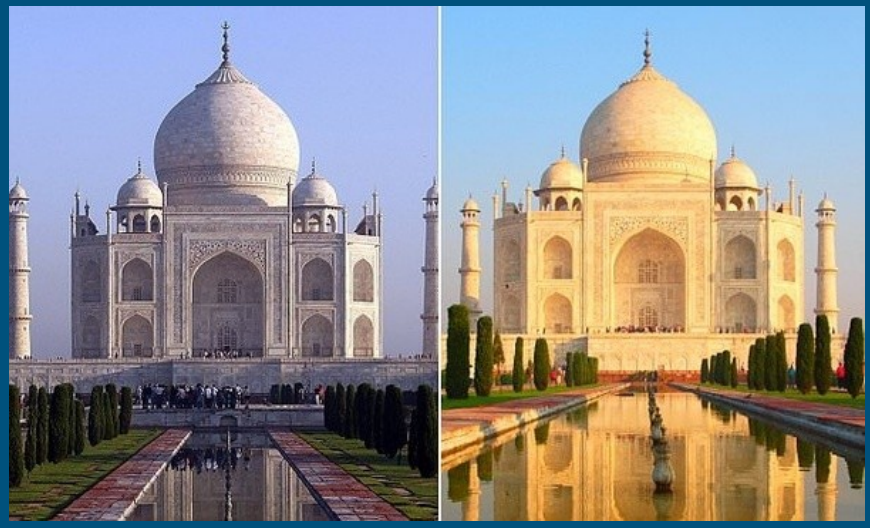
$$2\ SO_2 + O_2 + 2\ H_2O \longrightarrow 2\ H_2SO_4$$

$$4\ NO_2 + O_2 + 2\ H_2O \longrightarrow 4\ HNO_3$$


Acid Rain
H_2SO_4
HNO_3
H_2O
Trees killed by acid rain
NO_2
SO_2

Statues and monuments in India are affected by acid rain. How?

- The statues and monuments are mainly made from marble which is chemically $CaCO_3$.
- Acid rain contains H_2SO_4 dissolved in it.
- When it comes in contact with the various statues or monuments, the acid reacts with $CaCO_3$.

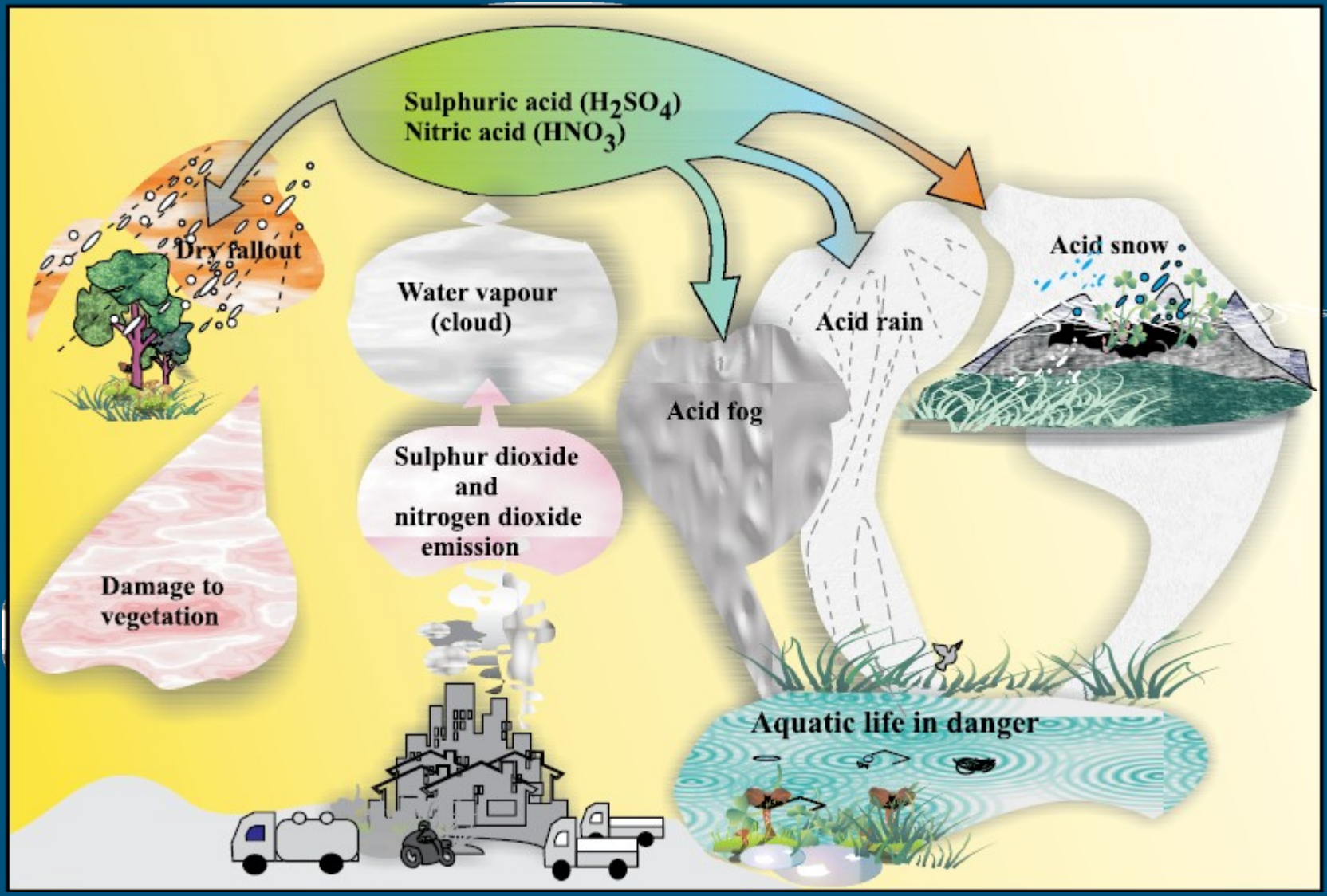


$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$$

Calcium carbonate | Sulphuric acid | Calcium sulphate | Water | Carbon dioxide

HARMFUL EFFECTS OF ACID RAIN

- It causes excessive damages to the buildings and monuments.
- It also damages Iron and Steel structures.
- It damages leaves of trees and plants and retards the growth of forests.
- It increases the acidity of water in the lakes which is fatal to fishes.


Sulphuric acid (H_2SO_4)
Nitric acid (HNO_3)
Dry fallout
Water vapour (cloud)
Acid rain
Acid snow
Acid fog
Sulphur dioxide and nitrogen dioxide emission
Damage to vegetation
Aquatic life in danger

SMOG

- **Smog is a combination of smoke and fog.**

CLASSIFICATION OF SMOG

No.	Classical Smog	Photochemical Smog
1	It is formed due to the presence of SO_2 and humidity in air which combines to form H_2SO_4 which deposits over particulates.	It is formed due to the photochemical reactions taking place when air contains NO_2 and hydrocarbons.
2	It involves smoke and fog	It does not involve smoke and fog
3	It is reducing in character	It is oxidizing in character
4	First observed in London in 1952	First observed in Los Angeles in 1950
5	It occurs in cool and humid climate	It occurs in warm, dry and sunny climates
6	It causes bronchitis, irritations, problems in the lungs etc.	It causes irritation in the eyes and respiratory problems.

EFFECTS OF PHOTOCHEMICAL SMOG

- The common components of photochemical smog are ozone, nitric oxide, acrolein, formaldehyde and peroxyacetyl nitrate (PAN).
- Photochemical smog causes serious health problems.
- Ozone and PAN act as powerful eye irritants.
- Ozone and nitric oxide irritate the nose and throat and their high concentration causes headache, chest pain, dryness of the throat, cough and difficulty in breathing.
- Photochemical smog leads to cracking of rubber and extensive damage to plant life.
- It also causes corrosion of metals, stones, building materials, rubber and painted surfaces.

How can photochemical smog be controlled ?

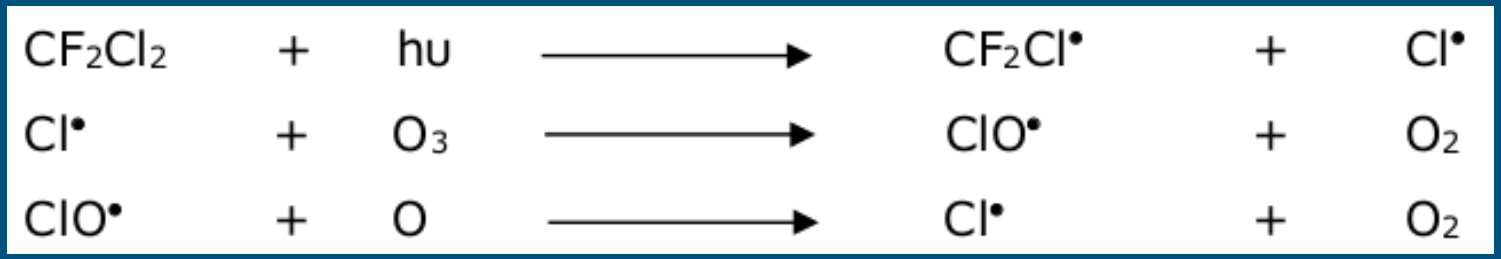
- By controlling the primary precursors of photochemical smog, such as NO_2 and Hydrocarbons.
- By controlling the secondary precursors such as ozone and PAN.
- Catalytic converters should be used in the automobiles, which prevent the release of nitrogen oxide and hydrocarbons to the atmosphere.
- Certain plants like Pinus can metabolise nitrogen oxide and therefore, their plantation could reduce Photochemical Smog.

OZONE HOLE AND ITS CONSEQUENCES

- Ozone hole implies destruction of the ozone layer by the harmful UV radiations.
- The depletion will virtually result in creating some sort of holes in the blanket of ozone which surrounds us.
- As a result, the harmful radiations of sun will cause skin cancer, loss of eye sight and will also affect our immune system.

REACTIONS INVOLVED IN OZONE LAYER DEPLETION

- Chlorofluorocarbons such as freons present in the stratosphere are involved in the chemical reaction with ozone.
- These are of free radical nature and carried in the presence of UV radiations.



- Since ozone takes part in the chemical reaction, there is depletion of ozone layer.

EFFECTS OF THE DEPLETION OF THE OZONE LAYER

- More UV radiation filters into troposphere.
- UV radiations lead to ageing of skin, cataract, sunburn, skin cancer, killing of many phytoplanktons, damage to fish productivity etc.
- Plant proteins get easily affected by UV radiations which leads to the harmful mutation of cells.
- It also increases evaporation of surface water through the stomata of the leaves.
- It decreases the moisture content of the soil.
- Increase in UV radiations damage paints and fibres, causing them to fade faster.

WATER POLLUTION

WATER POLLUTION

- Water pollution may be defined as any change in physical, chemical and biological properties of natural water.
- It is due to the contamination of water with any foreign substance.

CAUSES OF WATER POLLUTION

1. PATHOGENS

- Pathogens include bacteria and other organisms that enter water from domestic sewage and animal excreta.
- Human excreta contain bacteria such as Escherichia coli and Streptococcus faecalis which cause gastrointestinal diseases.

CAUSES OF WATER POLLUTION

2. ORGANIC WASTES

- The other major water pollutant is organic matter such as leaves, grass, trash etc.
- They pollute water as a consequence of run off.
- Excessive phytoplankton growth within water is also a cause of water pollution.
- These wastes are biodegradable.

CAUSES OF WATER POLLUTION

3. CHEMICAL POLLUTANTS

- Include heavy metals such as cadmium, mercury, nickel etc
- All these metals are dangerous to humans because our body cannot excrete them.
- These metals can damage kidneys, central nervous system, liver etc.
- Acids (like sulphuric acid) from mine drainage and salts from many different sources including raw salt used to melt snow and ice in the colder climates are water soluble chemical pollutants.

MAJOR WATER POLLUTANT AND THEIR SOURCES

Sl. No.	Pollutant	Source
1	Microorganisms	Domestic sewage
2	Organic wastes	Domestic sewage, animal wastes, discharge from food processing plants, decaying animals and plants etc.
3	Plant nutrients	Chemical fertilizers
4	Pesticides	Chemicals used for killing insects, fungi and weeds
5	Toxic heavy metals	Industries and chemical fertilizers
6	Sediments	Erosion of soil by agriculture

BIOCHEMICAL OXYGEN DEMAND

- Biochemical Oxygen Demand (BOD) is the amount of oxygen in milligrams dissolved in water needed by microorganisms to breakdown the organic matter present in one litre of water for five days at 20^0 C.

CHEMICAL OXYGEN DEMAND

- Chemical Oxygen Demand (COD) is the measure of dissolved oxygen in milligrams, dissolved in water which is needed by microorganisms for the oxidation of both organic and inorganic compounds dissolved in one litre of water for five days at 20^0 C.

EUTROPHICATION

- It is the addition of phosphorous to water in the form of phosphate ions which encourages the formation of algae.
- This algal growth reduces the oxygen concentration in water and results in subsequent loss of biodiversity.

INTERNATIONAL STANDARDS FOR DRINKING WATER

1. FLUORIDE

- The deficiency of fluoride in drinking water is harmful to man.
- It causes tooth decay.
- The fluoride ion makes the enamel on teeth much harder.
- Fluoride converts hydroxyapatite, the enamel on the surface of the teeth, into much harder fluorapatite.
- Fluoride ion concentration above 2ppm causes brown mottling of teeth.
- Excess fluoride causes harmful effect to bones and teeth.

2. LEAD

- The prescribed upper limit concentration of lead in drinking water is about 50 ppb.
- Lead can damage kidney, liver, reproductive system etc.

3. SULPHATE

- Excessive sulphate in drinking water causes laxative effect.
- At moderate levels it is harmless.

4. NITRATE

- The maximum limit of nitrate in drinking water is 50 ppm.
- Excess nitrate in drinking water can cause disease such as methemoglobinemia (Blue Baby Syndrome).

HOW CAN LEAD POISONING BE CURED?

- **Feed the patient with an aqueous solution of calcium complex of EDTA.**

- **Lead EDTA Complex is obtained.**
- **The soluble Pb—EDTA chelate is excreted through urine.**

SOIL POLLUTION

SOIL POLLUTION

- Any factor which deteriorates the quality, texture and mineral content of the soil or which disturbs the biological balance of the organisms in the soil is called a soil pollutant.
- If these pollutants are introduced into the soil, the soil is polluted.

MAJOR SOIL POLLUTANTS

- Industrial wastes
- Urban wastes
- Agricultural pollutants
- Radioactive pollutants

MEASURES TO CONTROL SOIL POLLUTION

- By applying biofertilizers and manures.
- Biological pest control methods may be used.
- By using proper sewage system.
- By recycling waste products.

HUMIFICATION

- The decomposition of organic materials such as leaves, roots etc in the soil by microorganisms to produce humus are called humification.

PESTICIDES

- Pesticides are substances which are used to kill or block the reproductive processes of unwanted organisms.
- Eg:- DDT, BHC etc.
- Pesticides may be put into three main categories.

1. INSECTICIDES

- These are chemical substances which protect the crops from certain insects.
- Also they destroy the bacteria causing malaria and yellow fever.
- Eg:- DDT, BHC etc.

2. HERBICIDES

- These are chemical substances which are used to kill weeds.
- Eg: - Sodium chlorate, sodium arsenite, triazines etc.

3. FUNGICIDES

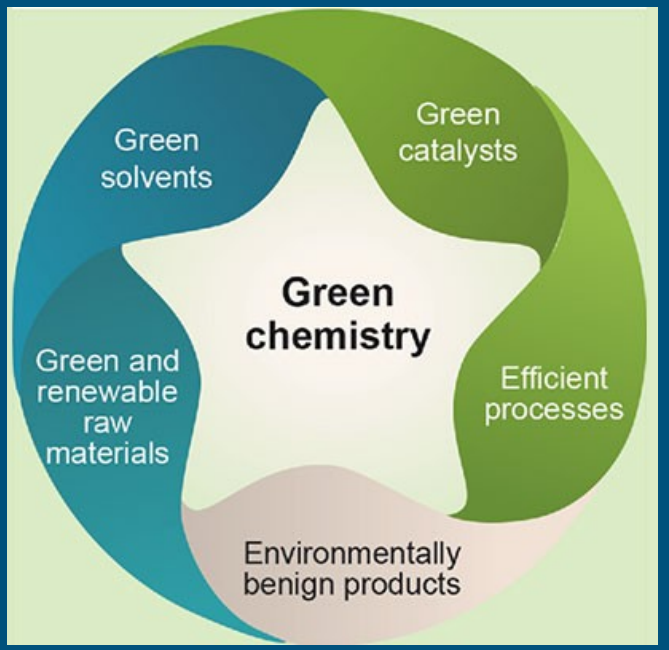
- These are chemical substances which are used to destroy fungi.
- Eg: - Compounds of mercury

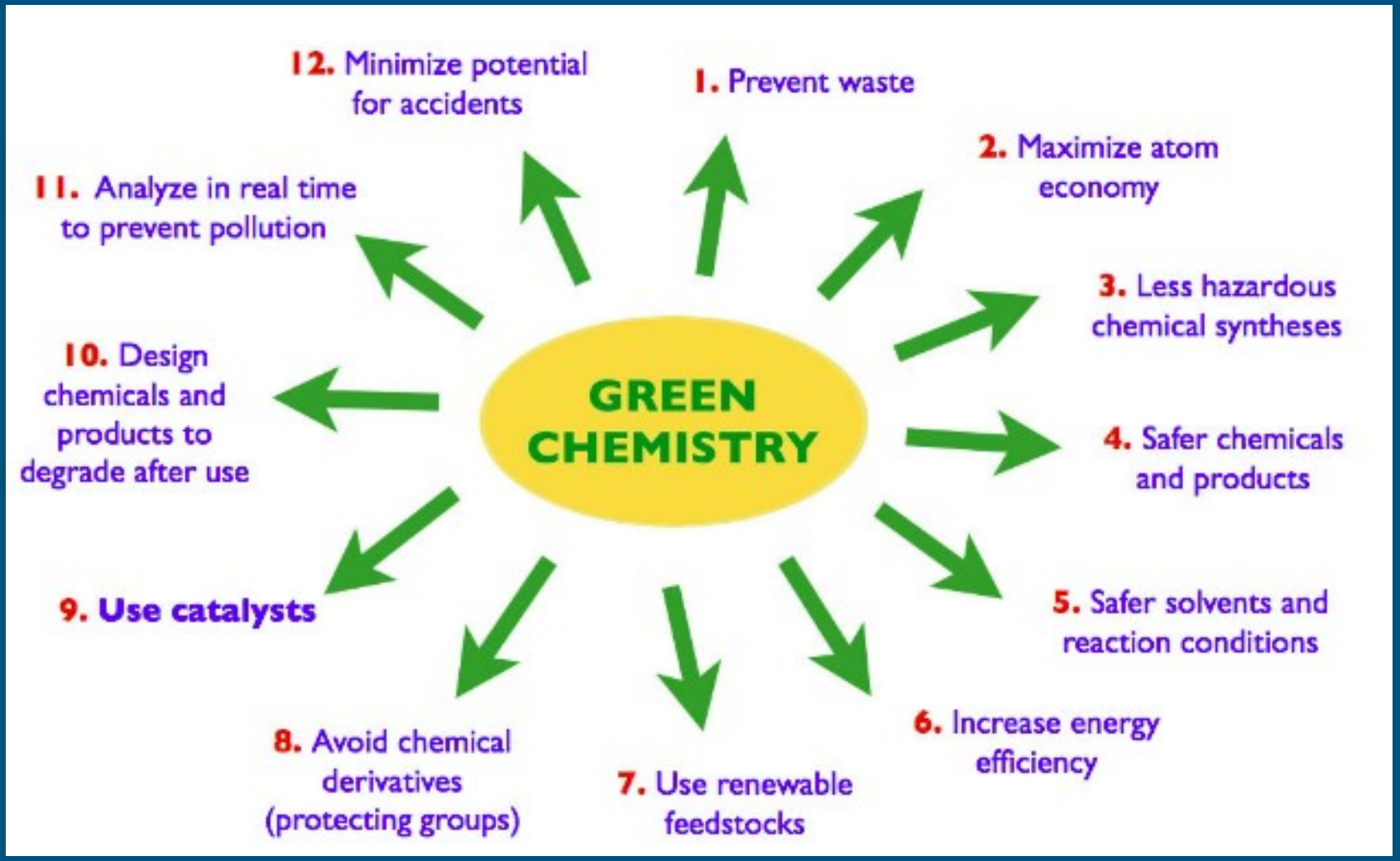
METHODS OF WASTE MANAGEMENT

- Recycling
- Burning
- Incineration
- Sewage treatment
- Dumping

GREEN CHEMISTRY

- Green chemistry is a way of thinking and is about utilising the existing knowledge and principles of chemistry and other sciences to reduce the adverse impact on environment.
- It is a production process that would bring about minimum pollution or deterioration to the environment.
- It is a cost effective approach which involves reduction in material, energy consumption and waste generation.




GREEN CHEMISTRY
1. Prevent waste
2. Maximize atom economy
3. Less hazardous chemical syntheses
4. Safer chemicals and products
5. Safer solvents and reaction conditions
6. Increase energy efficiency
7. Use renewable feedstocks
8. Avoid chemical derivatives (protecting groups)
9. Use catalysts
10. Design chemicals and products to degrade after use
11. Analyze in real time to prevent pollution
12. Minimize potential for accidents

ABBREVIATIONS

- DDT-Dichloro Diphenyl Trichloro Ethane
- BHC- Benzene Hexa Chloride
- PCB- Poly Chlorinated Biphenyls
- EDTA-Ethylene Diammine Tetra Acetic Acid
- BOD-Biochemical Oxygen Demand
- COD-Chemical Oxygen Demand
- PAN-Poly Acrylo Nitrile
- CFC-Chloro Fluoro Carbon

ABBREVIATIONS

- PAN : Peroxy Acetyl Nitrate
- SBM-U : Swachh Bharat Mission Urban
- SBM-G : Swachh Bharat Mission Gramin
- DO : Dissolved Oxygen


thank you!