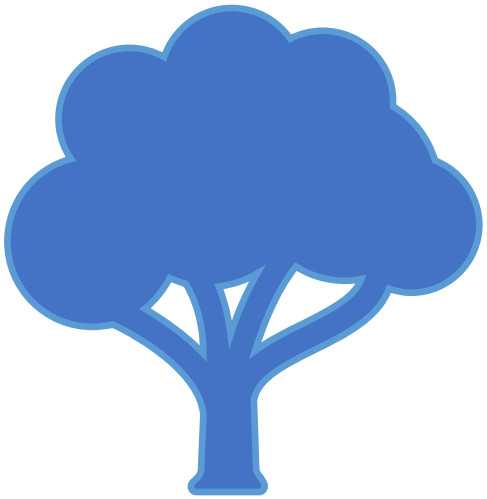
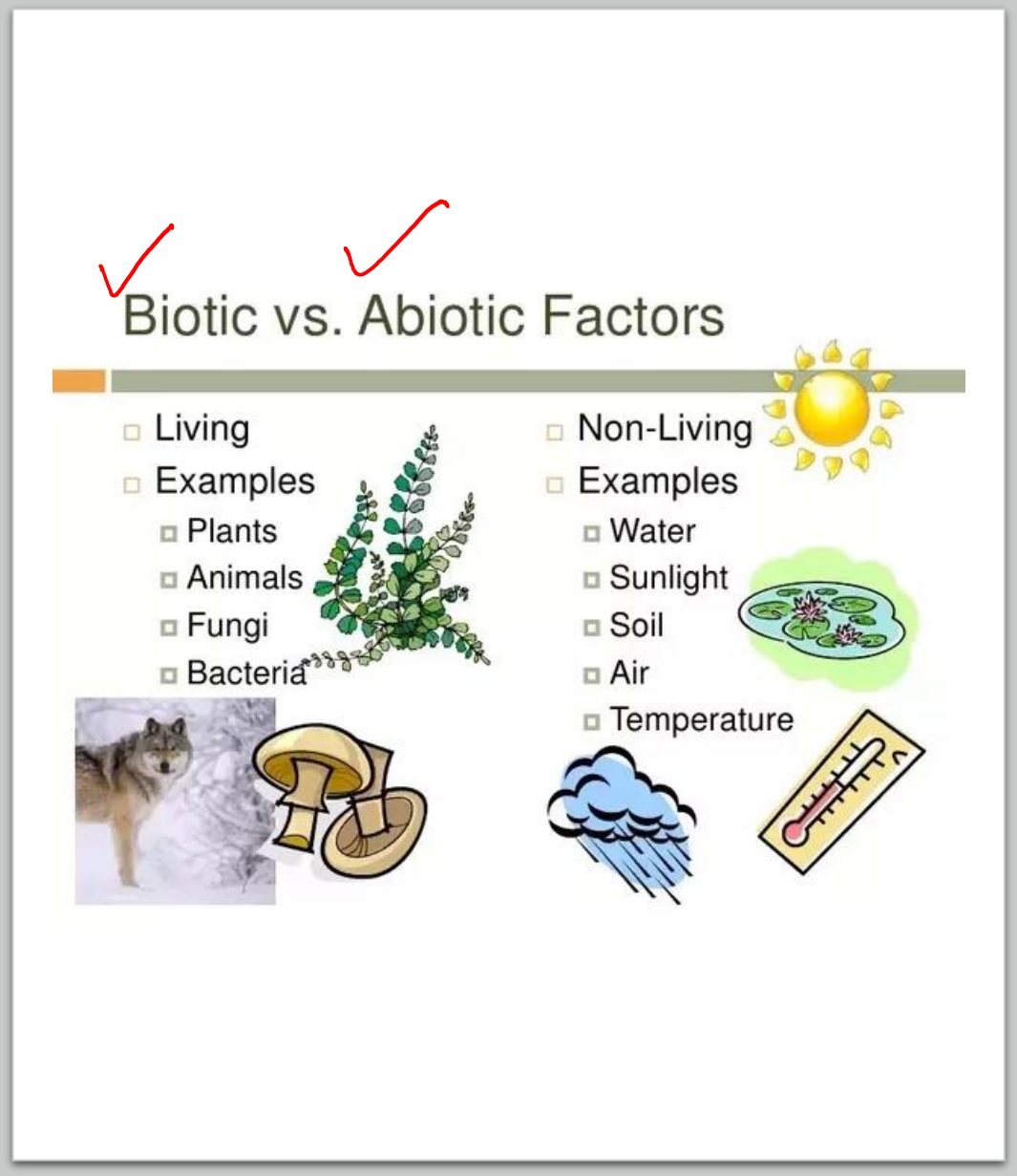
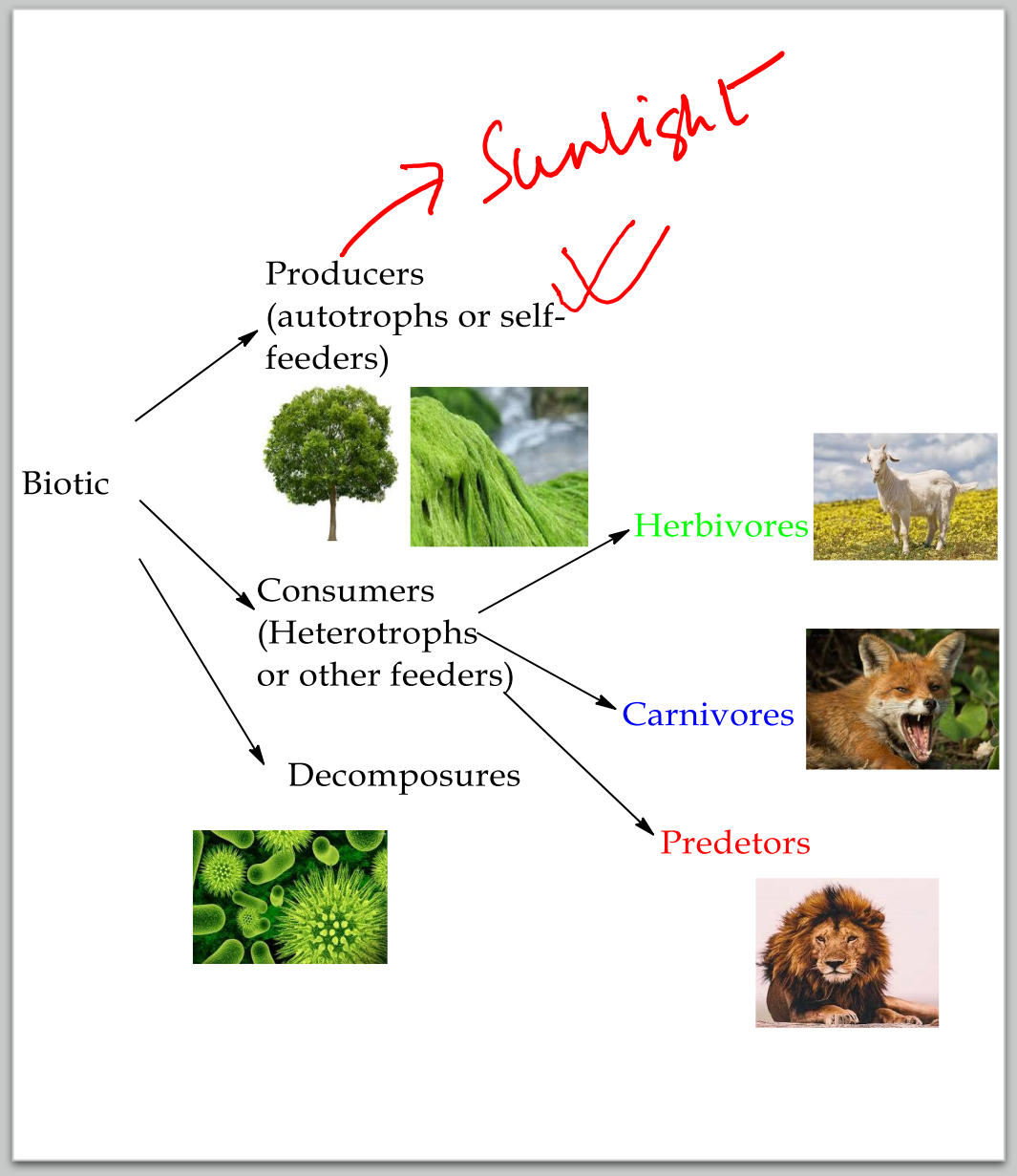


ENVIRONMENTAL SCIENCE



Introduction, Overview on Environment

- Environment means Surrounding in which we are living, which includes all living (biotic) and non living (abiotic) factors on which we are interdependent.

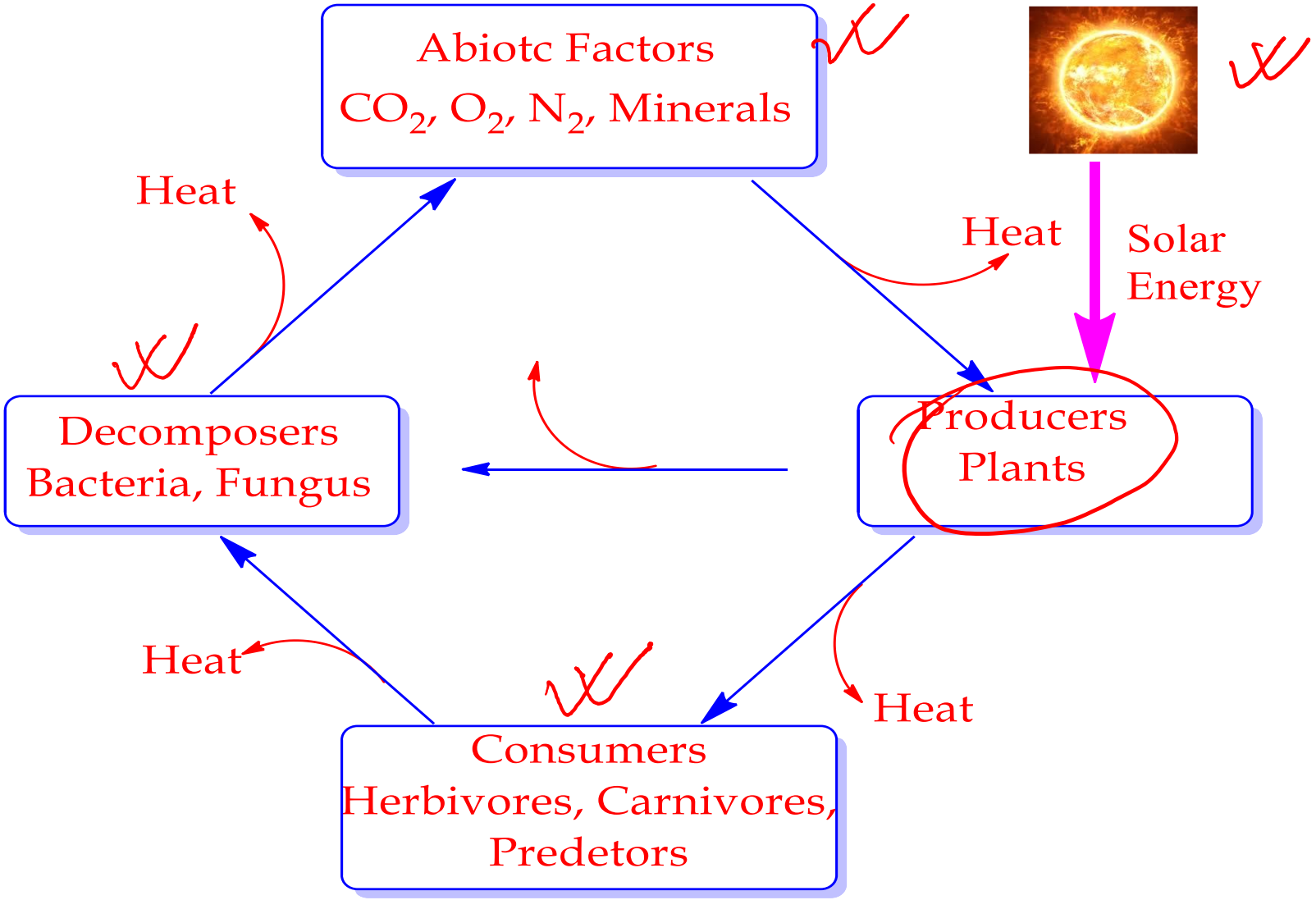


Introduction, Overview on Environment

- **Biotic Factors**

Introduction, Overview on Environment

Energy flow among Biotic and Abiotic components



Introduction, Overview on Environment

Terminologies

Pollutant

A substance which is a constituent of environment but when present in excess imparts detrimental effect on environment is known as pollutant.

e.g. lead, mercury, carbon monoxide etc.

Contaminant

A substance which is not a constituent of environment but introduced by only anthropogenic activity disturbing its composition is known as contaminant. When a contaminant exerts detrimental effect on environment it can be described as also pollutant.

e.g. MIC (methyl isocyanate) released into atmosphere in Bhopal gas tragedy In Dec. 3rd 1984 (10,000 people died, 1,000 became blind and more than 1 lakh people continue to suffer from various disorders)

CFCs (CFC-11, CFC-12)

Introduction, Overview on Environment

Receptor

The medium which is affected by the pollutant is known as receptor. e.g. Human being can be described as a receptor of photochemical smog

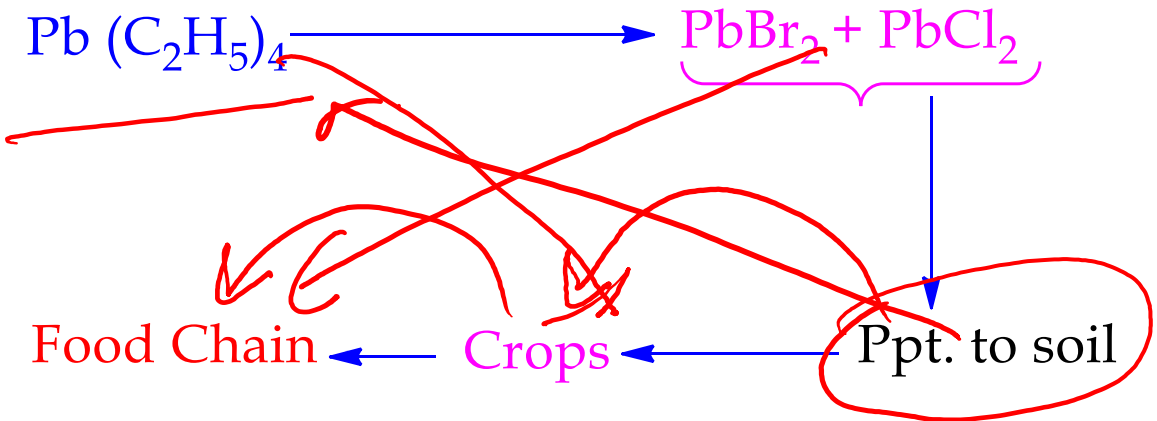
Sink

A medium which retains the pollutant and keep on interacting with it for a long time.

e.g. particulates for human being, acid for marble monuments

Pathway

The mechanism by virtue of which a pollutant is distributed from its source to different environmental segments is known as its pathway.



Introduction, Overview on Environment

Speciation

It refers to segregation and estimation of different species of a particular pollutant present in the environment. This helps to estimate the toxicity level/impact of that pollutant.

e.g. Hg, Hg_2^{2+}, Hg^{2+}, CH_3Hg^+, $(CH_3)_2Hg$ etc.

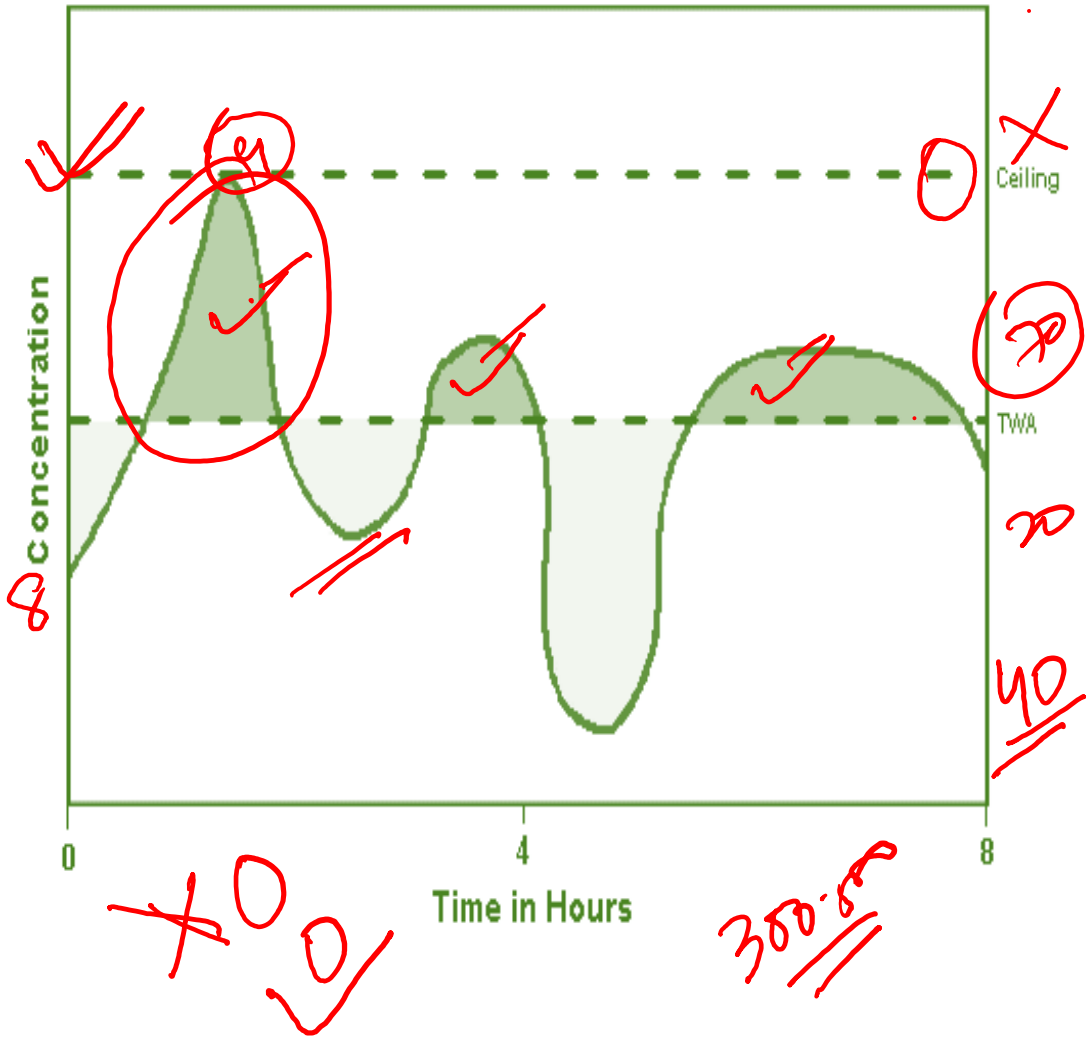
TLV

TLVs are the maximum average airborne conc. of a hazardous material to which healthy adult workers can be exposed during an 8-hour workday and 40-hour workweek—over a working lifetime—without experiencing significant adverse health effects.

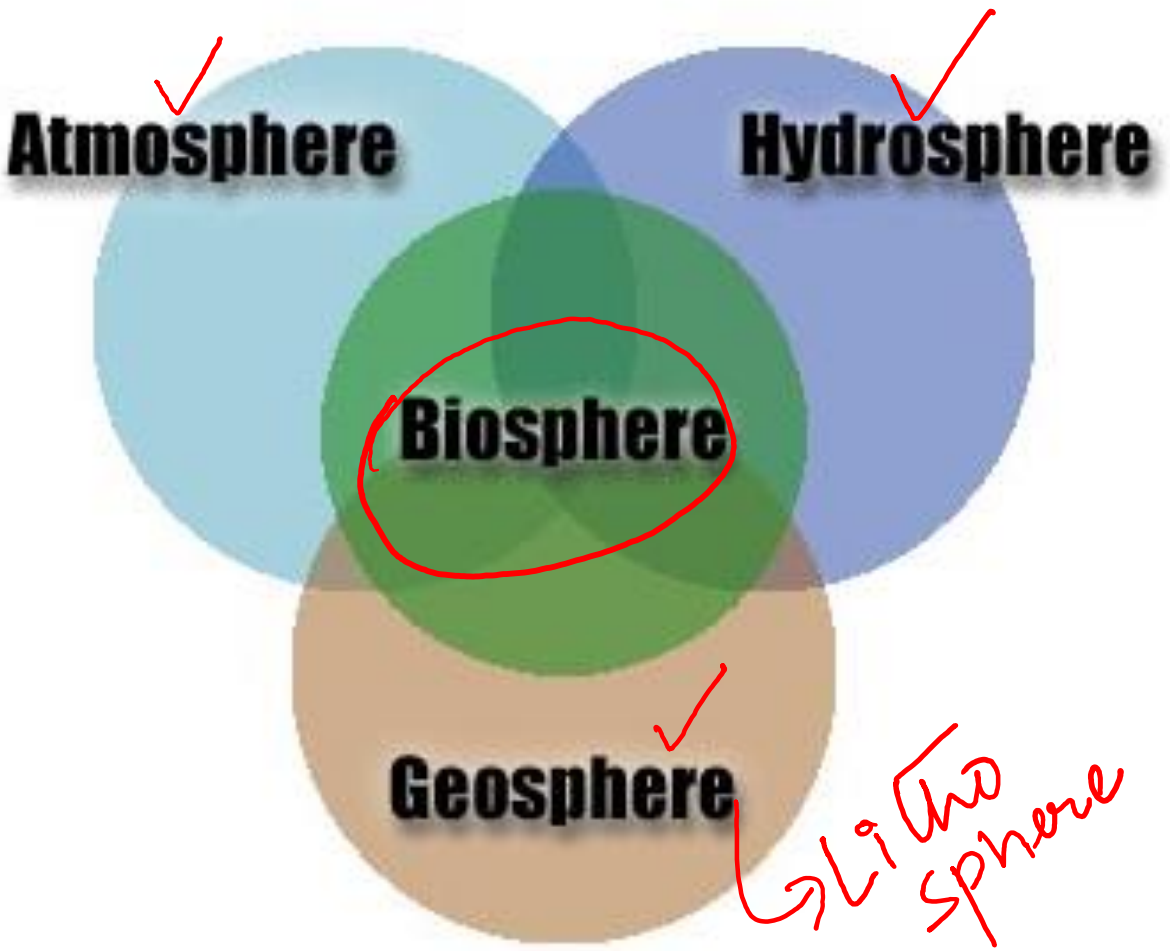
- **Time-weighted Average (TWA) concentration:** The concentration of a contaminant averaged over a workday (usually 8 hours long). It's measured in a workplace by sampling a worker's breathing zone for the whole workday. American Conference of Governmental Industrial Hygienists (ACGIH) recommends that the TWA should not be exceeded for up to an 8-hour workday during a 40-hour workweek.

Introduction, Overview on Environment

- **Ceiling value** A concentration of a toxic substance in air that ACGIH recommends should not be exceeded at any time during the workday. This value is often used in conjunction with the TWA.
- **Short-term Exposure Limit (STEL) value**: A TWA concentration over 15 minutes that ACGIH recommends not to exceed—even if the 8-hour TWA is within the standards.
  TWA-STELs are given for contaminants for which short-term hazards are known.



Components of earth: lithosphere, hydrosphere, atmosphere and biosphere

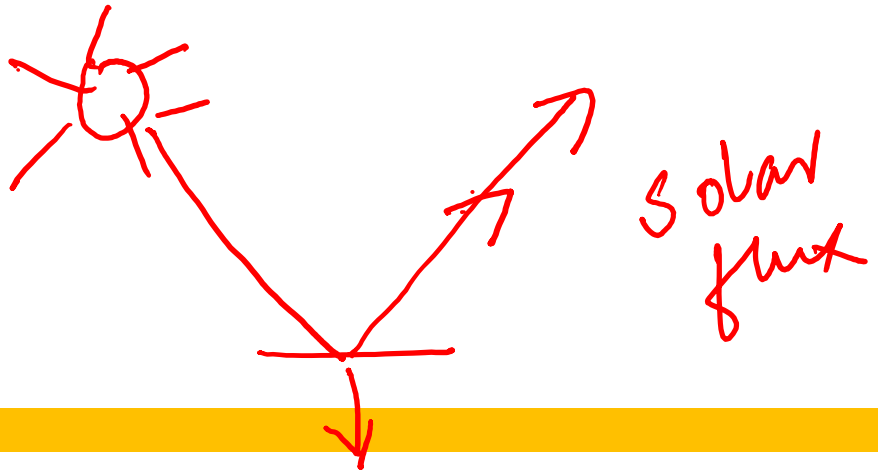


Different segments of environment

Atmosphere

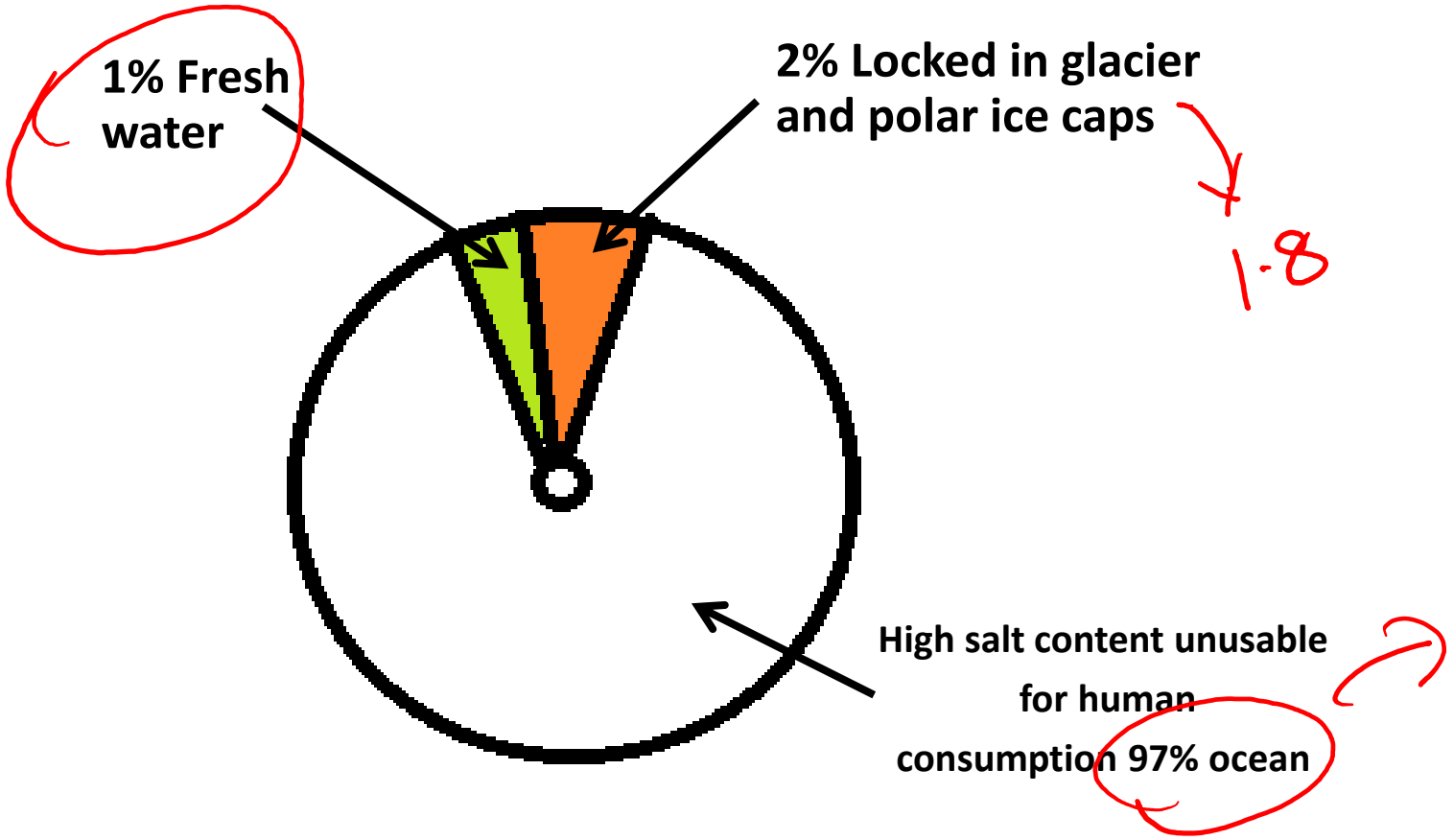
- The air envelope surrounding the earth is known as Atmosphere.
- This protective envelope surrounding earth helps in sustaining life on earth and protect us from unfriendly environment of outer space
- It extends to the height of ~ 500 km from the earth surface
- It absorbs IR radiation emitted by the sun and reemitted from the earth and thereby control the temperature balance of the earth
- It allows radiation only in the regions of 300-2500 nm (near UV, visible and near IR) and 0.01 – 40 meters (radio waves) at the same time it filters harmful UV radiation below 300 nm

Cont.



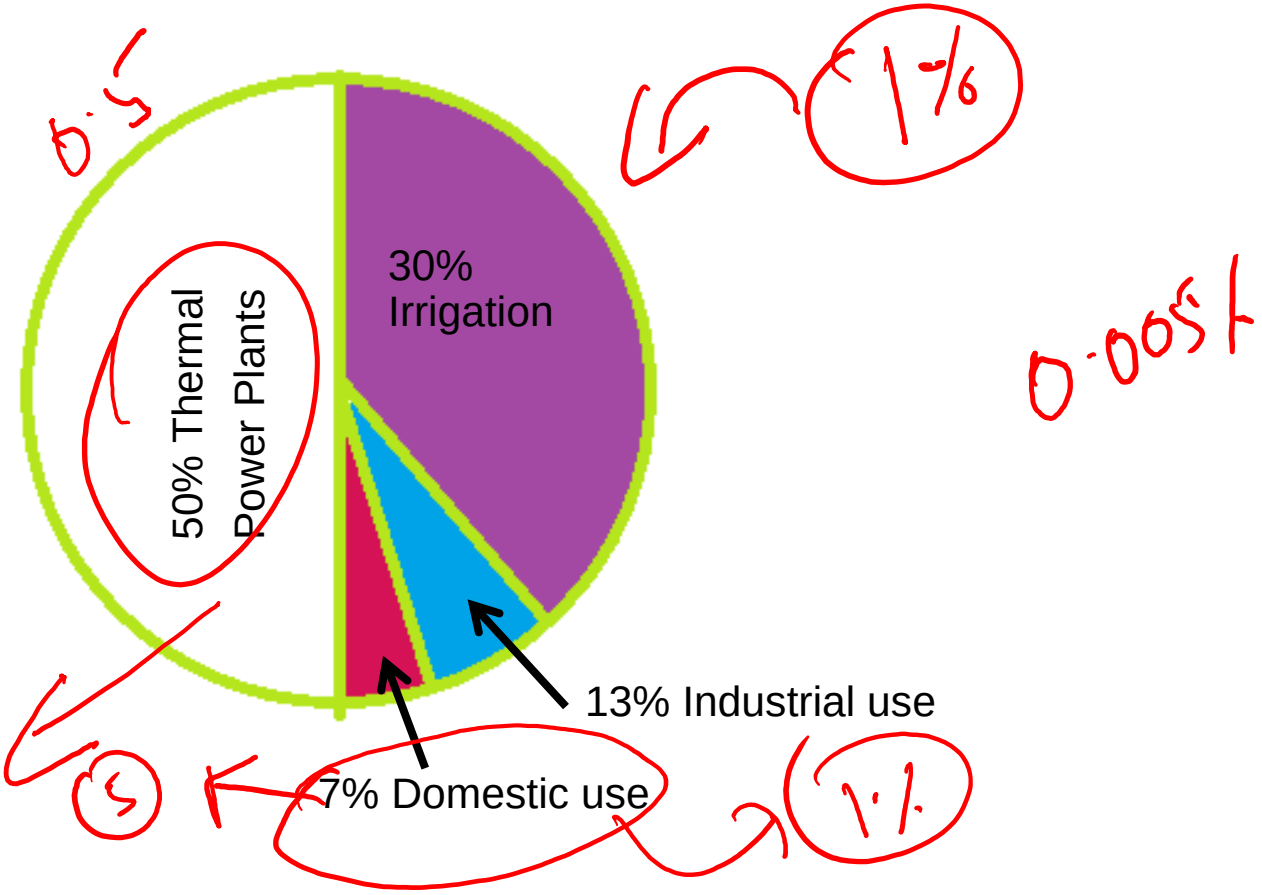
- Acts as a source of CO_2 for photosynthesis in plants and O_2 for respiration of human beings / animals
- Transports water from water bodies to land (Hydrological)
- Acts as a source of nitrogen for nitrogen fixing bacteria (Nitrogen)
- Helps to maintain of nutrient cycles

• Increase of human interference has changed the earth's radiation balance by changing the albedo i.e. fraction of sunlight reflected and scattered back to the atmosphere



Hydrosphere

- The hydrosphere is a collective term given to all different forms of water. It includes all types of water resources such as oceans, seas, rivers, lakes, streams, reservoirs and polar ice caps and ground water. The distribution of earth's water as follows

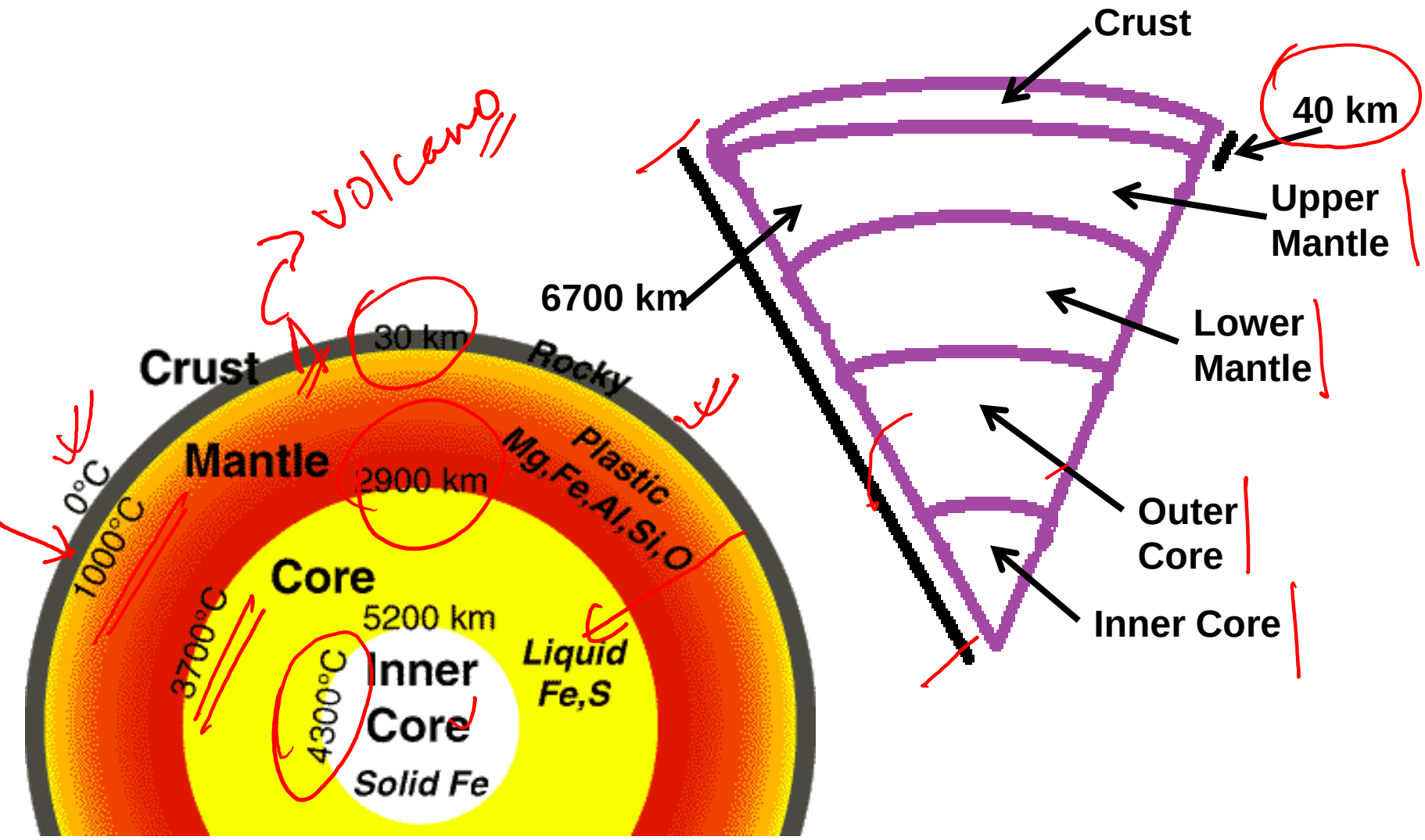


Use of Fresh water

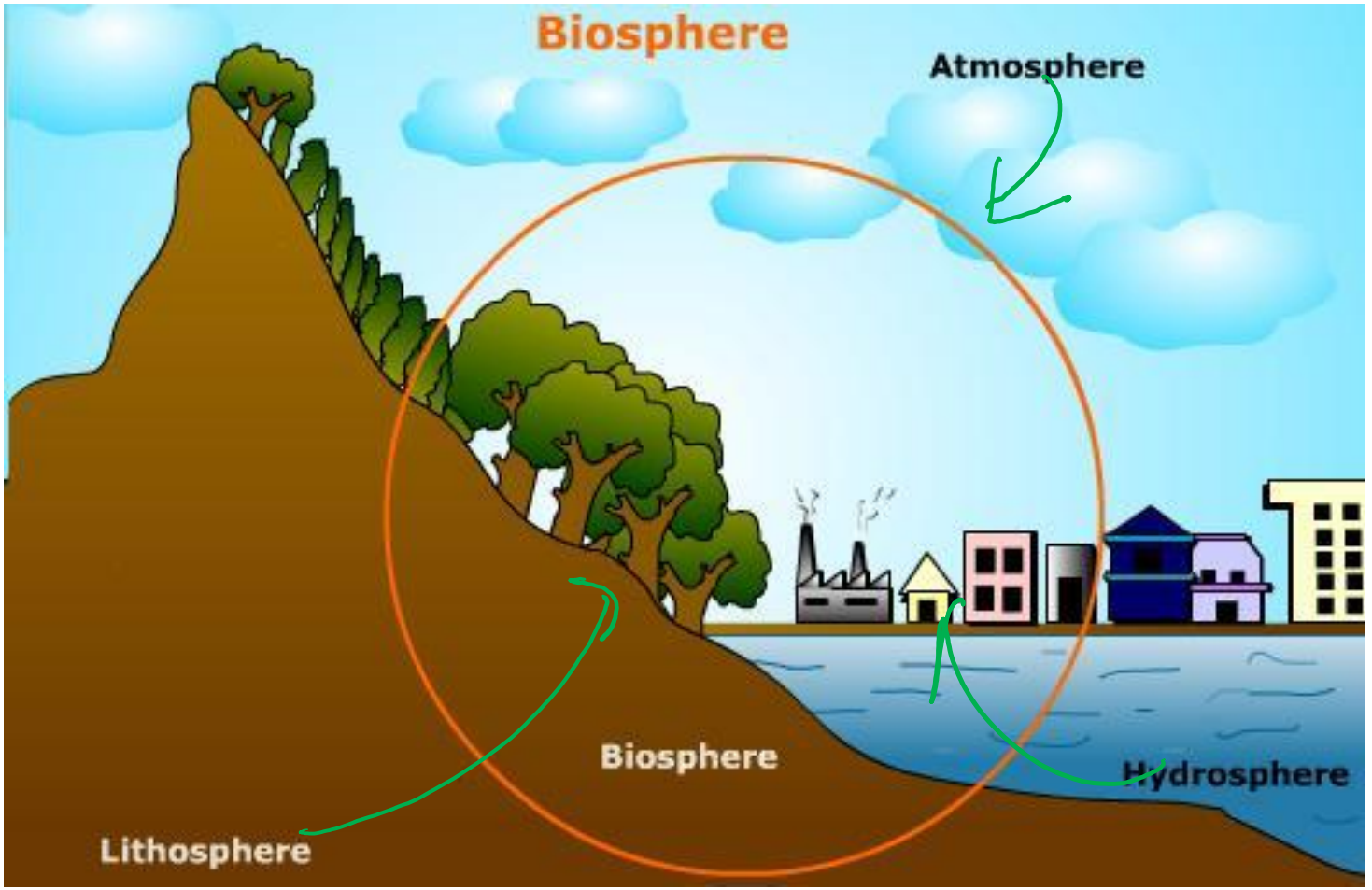
- The 1% of total fresh water in the river, lake and streams and ground water is for human consumption and this is the use of fresh water as follows

Lithosphere

The earth is divided into various layers as shown in the figure



Biosphere

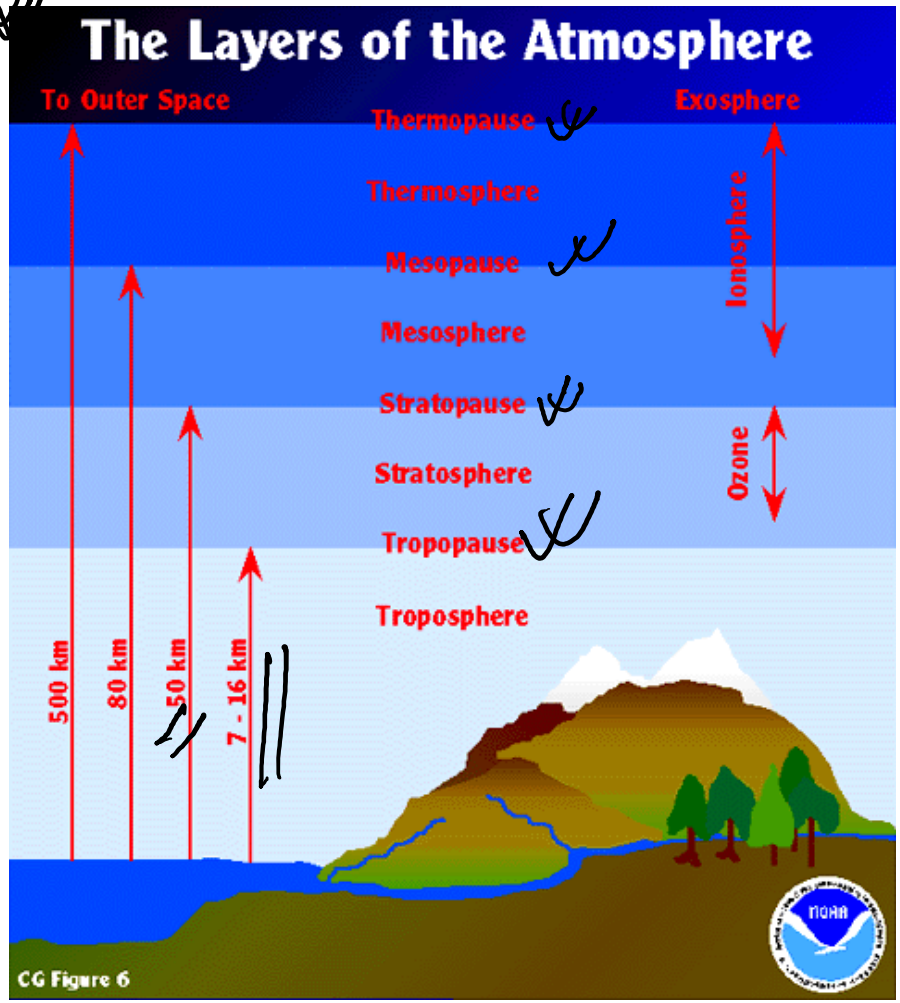


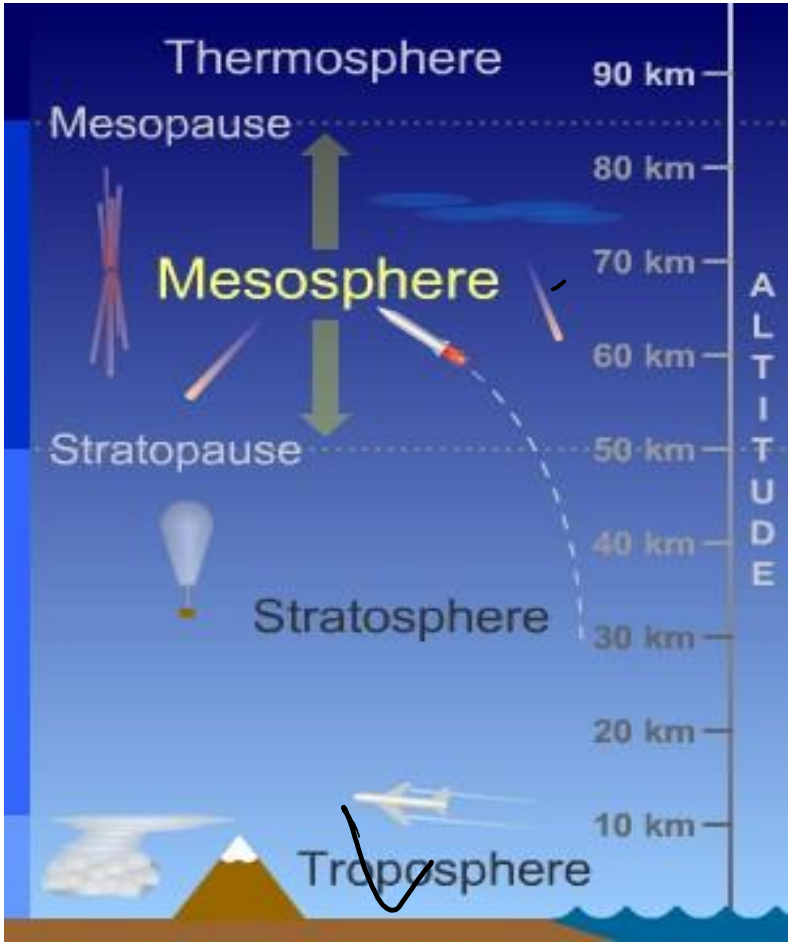
The biotic or living components include plants, animals and microbes living on the earth. A constant interaction between the abiotic and biotic components of the biosphere results in the transfer of food and energy, which makes it a dynamic but stable system. The biosphere is the biggest biological system. It consists of smaller functional units known as ecosystems or ecological systems

Different layers of Atmosphere

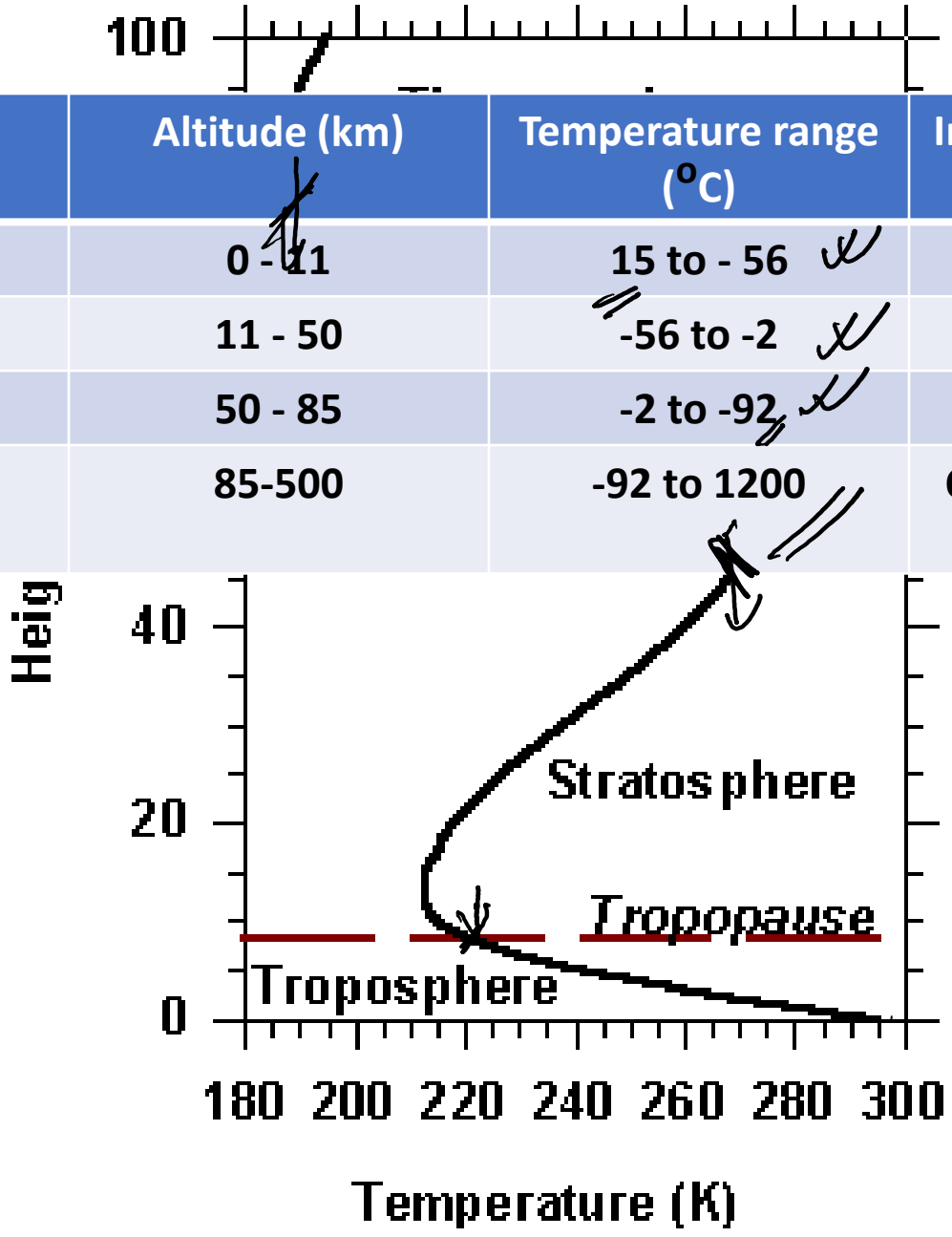
The atmosphere may be broadly divided into four regions

Troposphere
Stratosphere
Mesosphere
Thermosphere





Region	Altitude (km)	Temperature range (°C)	Important chemical species
Troposphere	0 - 11	15 to - 56	N_2, O_2, CO_2, H_2O
Stratosphere	11 - 50	-56 to -2	O_3
Mesosphere	50 - 85	-2 to -92	O_2, NO
Thermosphere	85-500	-92 to 1200	O_2(+), O (+), NO(+)



Lapse Rate

Troposphere

- **The troposphere contains 70% of the mass of the atmosphere. Here the air is far from uniform with respect to density and temperature.**

- **Density decreases exponentially with increasing altitude.**

- **In respect of composition, the troposphere is more or less homogeneous in the absence of air pollution, mainly due to the constant circulation of air in this region.**

- **The water content however varies due to hydrological cycle.**

- **The temperature in the troposphere falls of uniformly with increasing altitude.**

- **The temperature in the troposphere falls of uniformly with increasing altitude. Thus, this layer follows – ve lapse rate.**

Note:- The lapse rate is defined as the rate of change of temperature with height or altitude of the atmospheric variable.

- **The colder layer (-56^{O} C) at the top of the troposphere is called the tropopause, which marks temperature inversion i.e., transition from negative to positive lapse rate.**

Stratosphere

- **The stratosphere having a positive lapse rate. The temperature increases with increasing with increase in altitude with maximum of -2 ^{o}C which in the upper limit of stratosphere.**

- **Ozone in this region absorbs ultra violet (UV) radiation.**

- **It plays an important role in the stratosphere. It acts as a protection shielding for life on the earth from the injurious effects of the sun's ultra violet rays and at the same time, it supplies the heat sources for partitioning the atmosphere into a quiescent stratosphere and turbulent troposphere.**

$$O_3 + h\vartheta \longrightarrow O_2 + O^{\bullet}$$

The hotter layers (-2^{O}C) at the top of the stratosphere is called the stratopouse, which marks temperature inversion i.e., transition from positive to negative laps rate.

Mesosphere

- The mesosphere shows negative laps rate j.e., temperature falls with increasing altitude.

- Concentration of ozone is very low in this region and decreases rapidly with increase in height.

- So ~~the~~ is a decrease in the ~~adsorption~~ of solar radiation ~~takes place~~ and the temperature falls to – 92 ^{o}C.

- The dominant chemical species found in this region are O_2 and NO.

- The colder layers (- 92 ^{o}C) at the top the of the mesosphere is called mesopause, which marks temperature inversion i.e., transition from negative to positive laps rate.

Thermosphere

The thermosphere starts immediately above the mesosphere and the temperature rises once again, giving a positive laps rate.

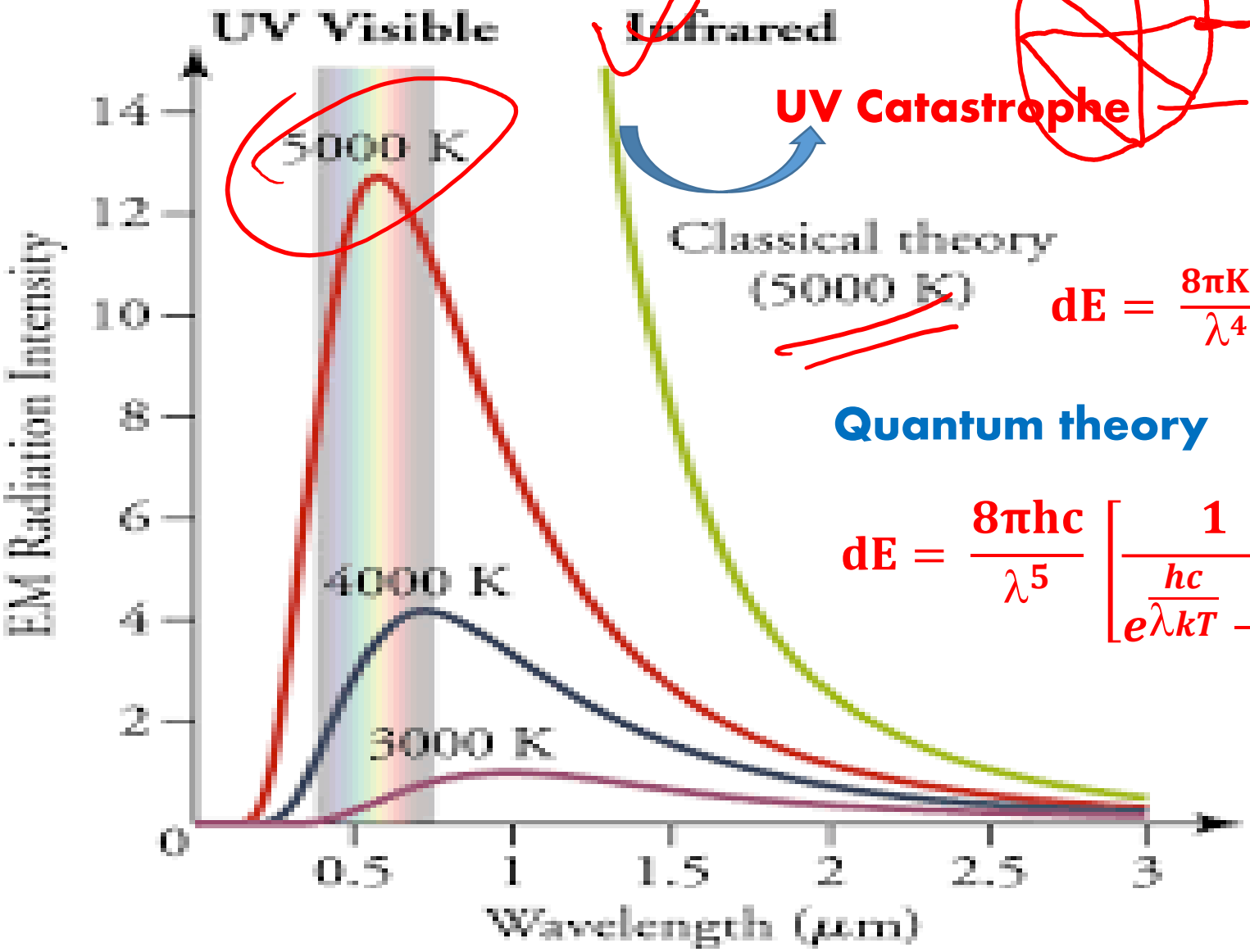
The atmospheric gases are oxygen and nitric oxide and split into atoms and corresponding ions after absorption of solar radiation in the far ultra violet (UV) region.

This is also known as ionosphere and is high electrical conductor as it contains charge particles

O_2^+

Concept of black body radiation and albedo, Importance, scope and principle of EIA

Black body radiation



UV Catastrophe

$$dE = \frac{8\pi KT}{\lambda^4}\, d\lambda$$

Quantum theory

$$dE = \frac{8\pi hc}{\lambda^5}\left[\frac{1}{e^{\frac{hc}{\lambda kT}} - 1}\right] d\lambda$$

Cont.

- **Wien's Law-**

  The dominant wavelength at which a blackbody emits is inversely proportional to the temperature in absolute scale.

  Or, $\lambda_{max} = \frac{b}{T}$

  Where '**b**' is Wien's constant = 2.898×10^{-3} **mK**

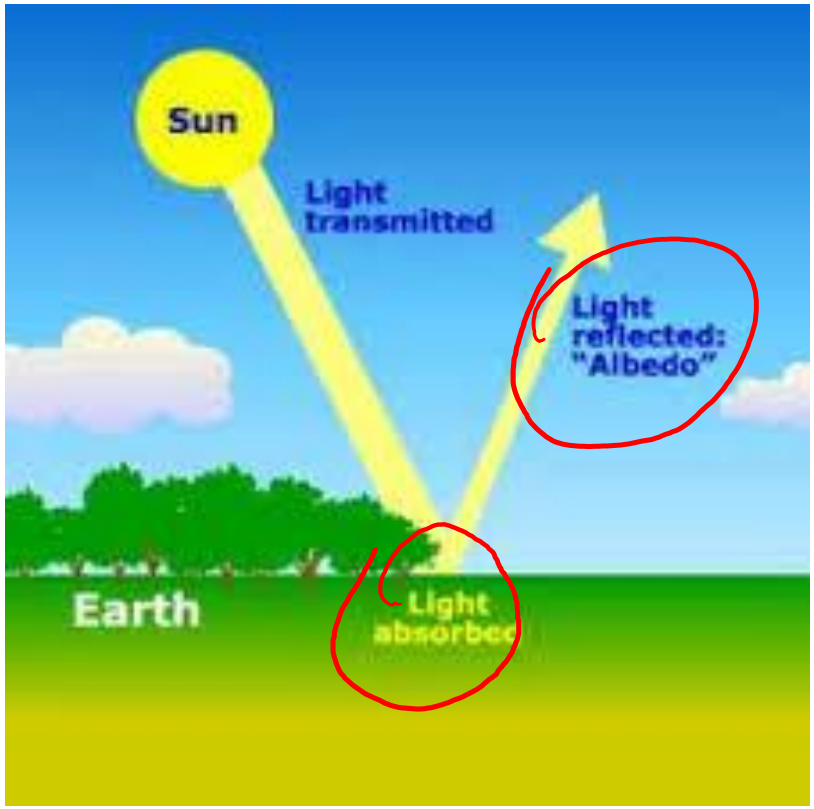
- **Stefan–Boltzmann law-**

  The total energy flux emitted by a blackbody remains proportional to the fourth power of temperature in absolute scale.

  $E = \sigma T^4$

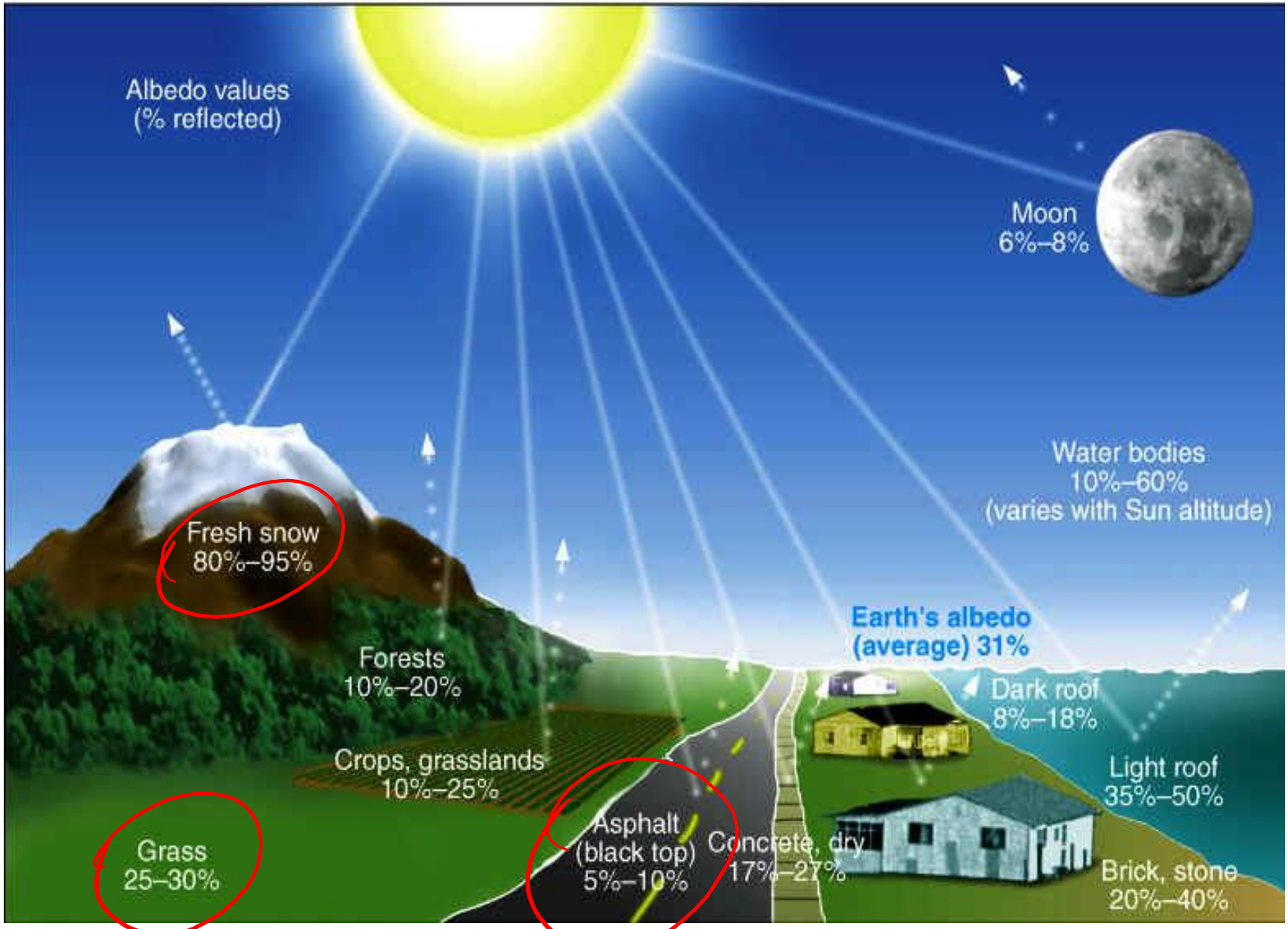
  Where 'σ' is Stefan's constant = 5.672×10^{-8} $Js^{-1}m^{-2}K^{-4}$

Albedo



- Earth receives a very large input of energy daily from the sun and maintains a steady state by giving off the bulk of this energy at the same rate.
- The earth absorbs radiation mainly in the visible region but emits radiation at the same rate in the infrared region.
- The solar flux incident on earth's upper atmosphere is 1372 W/ m^2 /min.
- The earth / atmosphere absorbs about 70 % of solar flux incident on it, while it reflects and scatters back into space 30 % (albedo) of the flux.

Note:- Fraction of sunlight reflected and scattered back to the atmosphere is known as albedo


Albedo values
(% reflected)
Moon
6%–8%
Water bodies
10%–60%
(varies with Sun altitude)
Fresh snow
80%–95%
Earth's albedo
(average) 31%
Forests
10%–20%
Dark roof
8%–18%
Crops, grasslands
10%–25%
Light roof
35%–50%
Grass
25–30%
Asphalt
(black top)
5%–10%
Concrete, dry
17%–27%
Brick, stone
20%–40%

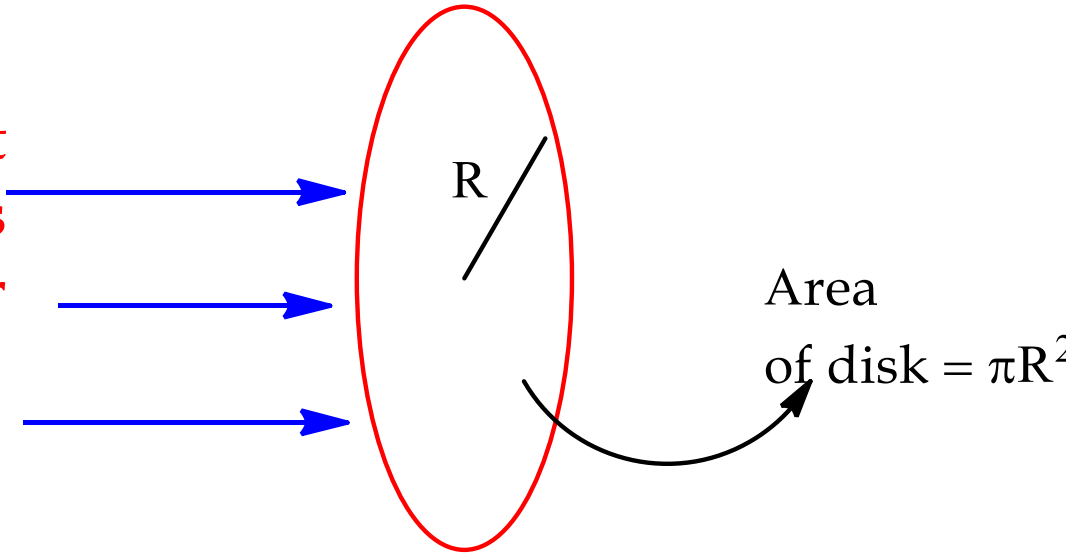
Radiation Balance Model

To overcome the difficulty posed by the fact that the planets are spherical and their surface tilts with respect to the incoming radiation, **is assumed that the amount distributed over the sphere is equal the amount that would be collected on the planets surface if it would have been a disk (with the same radius as the sphere), placed perpendicular to the sunlight**. If the planet's radius is **R** the area of that disk is πR^2.

Heat absorbed by planet = $(1 - \alpha)\ \pi R^2 S_o$

S_o - Solar radiative flux at the top of the planets atmosphere (for solar constant)

α- Albedo of the planet



Cont.

The total heat radiated from the planet is equal to the energy flux implied by its effective temperature, T_e from the entire surface of the planet

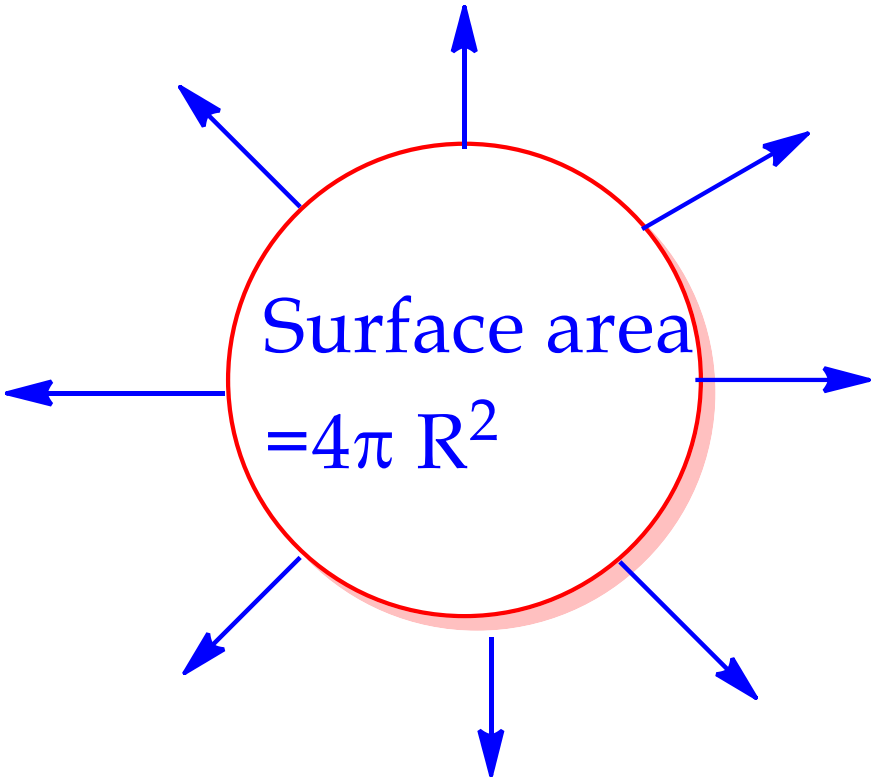
Heat radiated from planet = $(4\pi R^2)\ \sigma T_e^4$

In radiative balance we thus have:

$(4\pi R^2)\ \sigma T_e^4 = (1 - \alpha)\ \pi R^2 S_o$

Solving this equation for effective temperature we obtain:

$$T_e = \left[\frac{(1-\alpha)S_0}{4\sigma}\right]^{1/4}$$



Cont.

- Subscript '**e**' to the temperature is used to emphasize that this would be the temperature at the surface of the planet if it had no atmosphere. It is referred to as the **effective temperature** of the planet. According to this calculation, the effective temperature of Earth is about 255 K (or -18 °C)

- With this temperature the Earth radiation will be centered on a wavelength of about 11 μm, well within the range of infrared (IR) radiation

- The effective temperature of Earth is much higher than what we calculated. Averaged over all seasons and the entire Earth, **the surface temperature of our planet is about 288 K (or 15°C)**

This difference is in the effect of the heat absorbing components of our atmosphere. This effect is known as the **greenhouse effect**

EIA

- **Environmental Impact Assessment** (**EIA**) is the assessment of the environmental consequences (positive and negative) of a plan, policy, program, or actual projects prior to the decision to move forward with the proposed action

- Environmental assessments may be governed by rules of administrative procedure regarding public participation and documentation of decision making, and may be subject to judicial review

- The International Association for Impact Assessment (**IAIA**) defines an environmental impact assessment as **"the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made"**

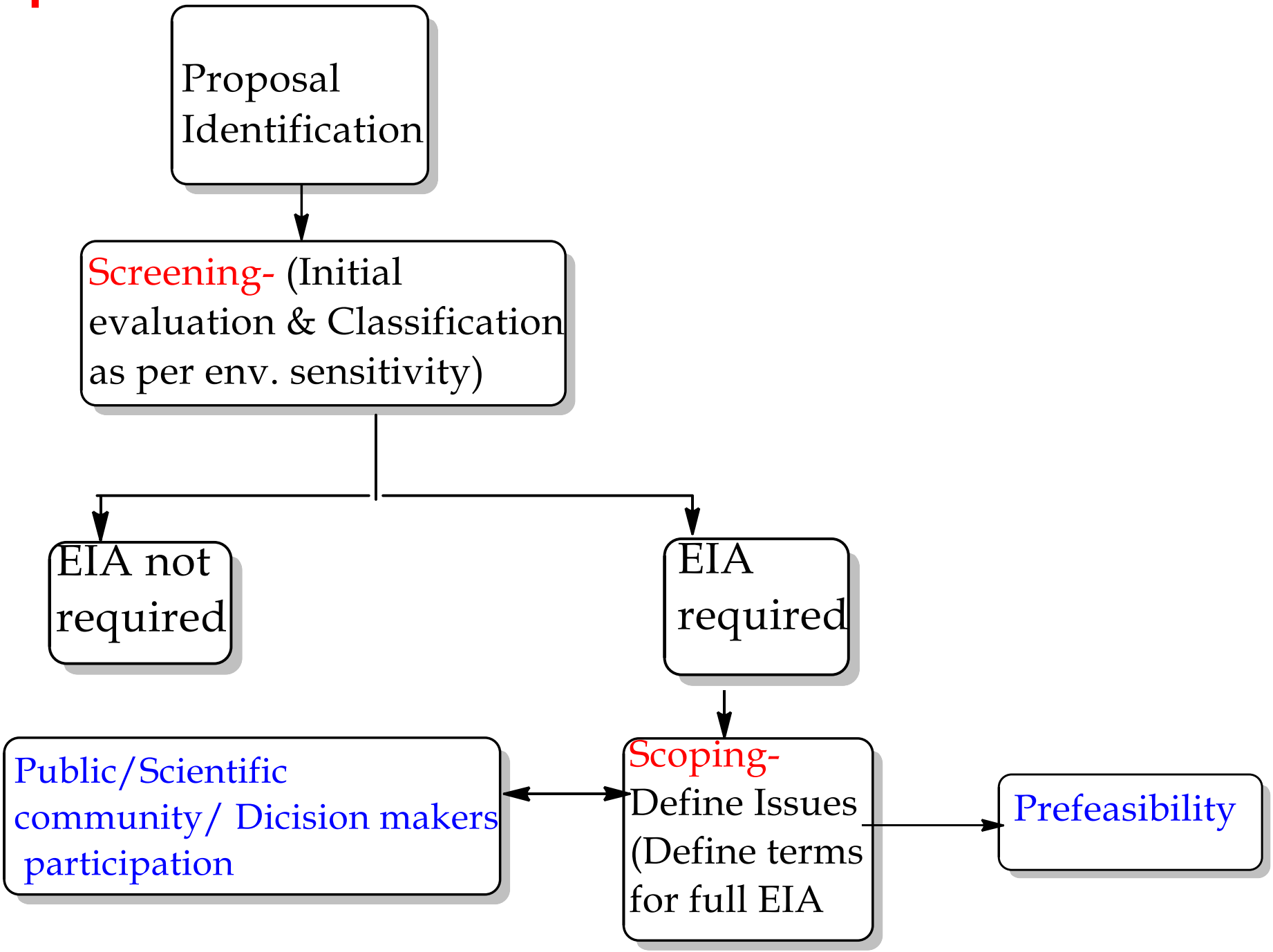
Environmental Clearance from central government is required for 32 categories of development projects – under industrial sectors:

- **Mining**
- **Thermal power plants**
- **River valley**
- **Infrastructure (road, highways, ports, harbours, and airports)**
- **Industries including very small electroplating in foundry units**

EIA benefits:

- Protection of Environment
- Optimum utilization of resources
- Saves overall time and cost of the project
- Promotes community participation
- Helps decision/policy makers to take appropriate decision
- Lays base for environmentally sound projects. History & Evolution of EIA

Steps in EIA


Proposal Identification
Screening- (Initial evaluation & Classification as per env. sensitivity)
EIA not required
EIA required
Public/Scientific community/ Dicision makers participation
Scoping- Define Issues (Define terms for full EIA
Prefeasibility

Screening is the First stage of EIA, which determines whether the proposed project requires an EIA and if requires, then the level of assessment required. Its criteria are based upon:

- **Scales of investment**
- **Type of development**
- **Location of development**

Project Category 'A' : Projects in this category typically require an EIA. The project type, scale and location determine this designation. The potentially significant environmental issues for these projects may lead to changes in land-use, as well as changes to social, physical, and biological environment.

Category 'B' : Only difference between projects in this category and those in Category 'A' is the scale. Larger Power plants fall under category 'A', Medium Sized Power Plants projects are in category 'B'. These projects are not located in environmentally sensitive area. Mitigation measures for these projects are more easily prescribed.

Category 'C': This category is for projects that typically do not require an EIA. These projects are unlikely to have adverse environmental impacts.

Scoping:

- **This stage identifies key issues and impact that should be further investigated**
- **This stage also defines the boundary and the time limit of the study**
- **Quantifiable and non quantifiable impact (aesthetic or recreational value) are to be assessed**
- **Baseline status of these should be monitored and then the likely changes in these on account of the construction and operation of the proposed project should be predicted**

AIR

- Changes in the ambient level and the ground level concentrations due to emissions from point, line and area source
- Effects on soils, materials, vegetation and human health.

NOISE

- Changes in the ambient level due to noise generated from equipment and movement of vehicles
- Effects on fauna and human health.

WATER

- Availability to competing users
- Changes in the quality
- Sediment transport
- Ingress of saline water

LAND

- Changes in the land-use and drainage pattern
- Changes in land quality including effects of waste disposal
- Changes in shoreline/riverbank and their stability.

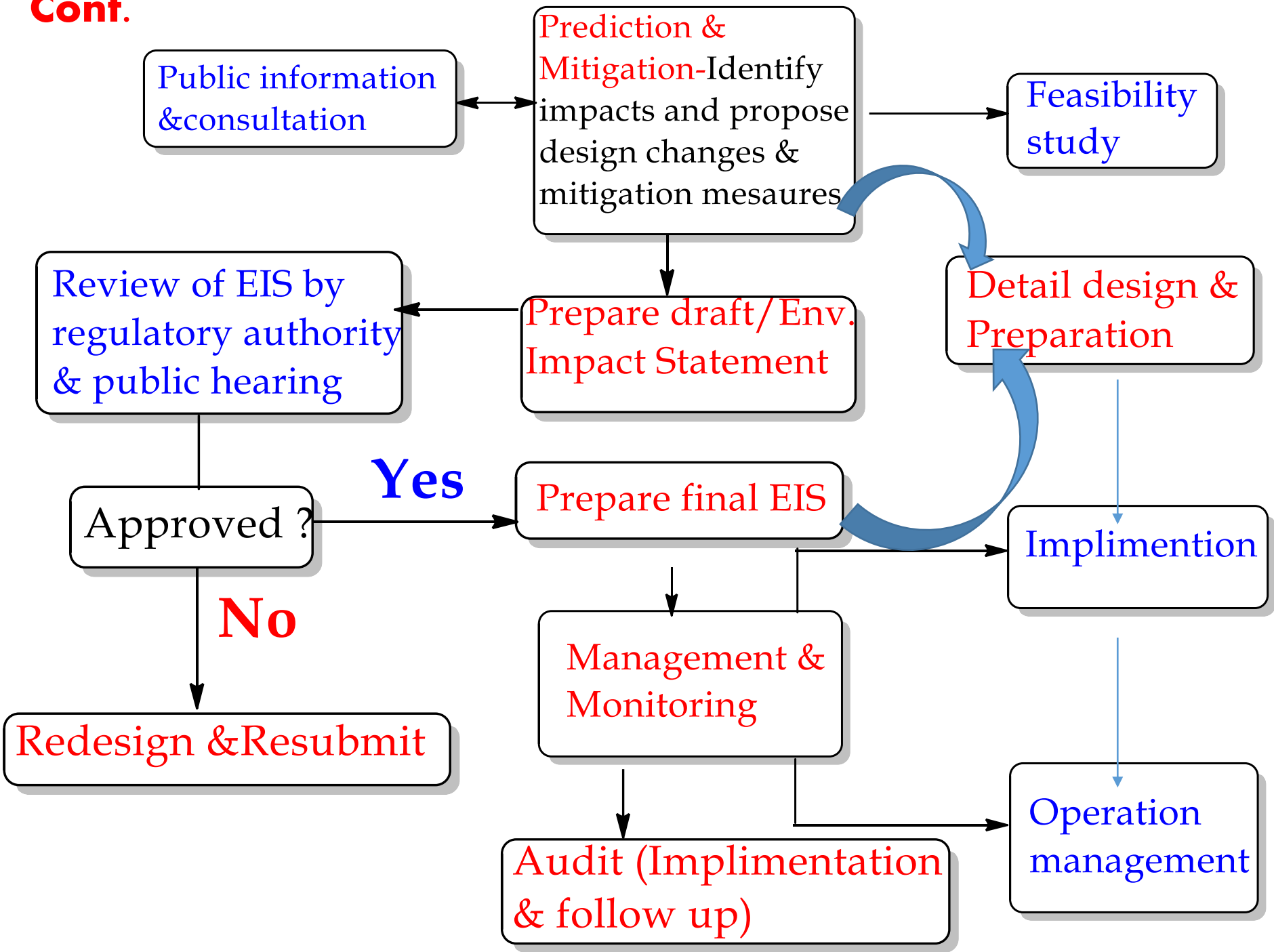
BIOLOGICAL

- Deforestation and shrinkage of animal habitat
- Impact on flora and fauna due to contaminants /pollutants
- Impact on rare and endangered species, endemic species and migratory path of animals including birds
- Impact on breeding and nesting grounds

SOCIO-ECONOMIC

- Impact on the local community including demographic changes
- Impact on economic status
- Impact on human health
- Impact of increased traffic

Cont.

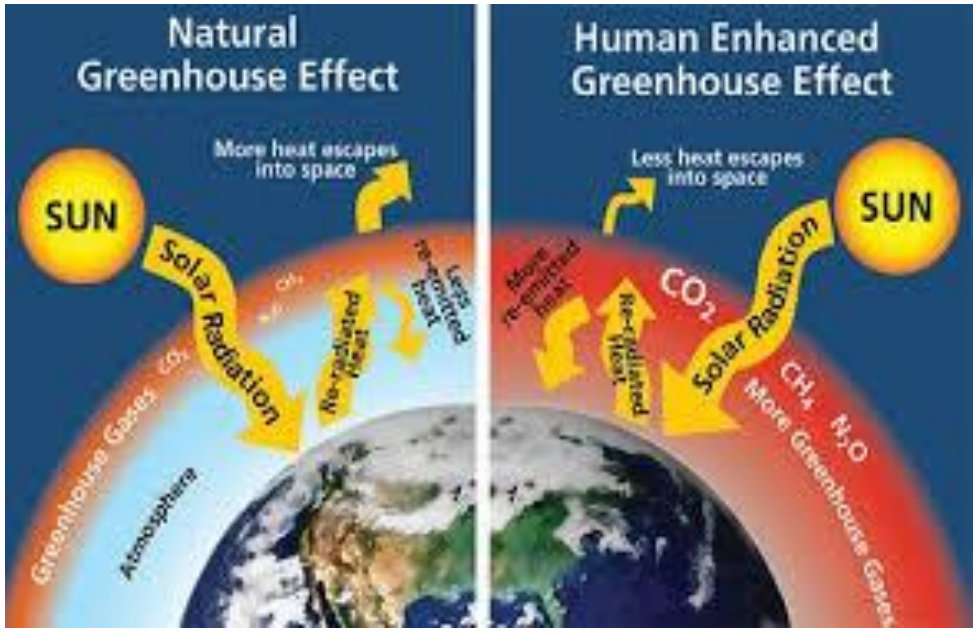

Public information &consultation
Prediction & Mitigation-Identify impacts and propose design changes & mitigation mesaures
Feasibility study
Review of EIS by regulatory authority & public hearing
Prepare draft/Env. Impact Statement
Detail design & Preparation
Yes
Approved ?
Prepare final EIS
Implimention
No
Management & Monitoring
Redesign &Resubmit
Audit (Implimentation & follow up)
Operation management

Prediction and Mitigation

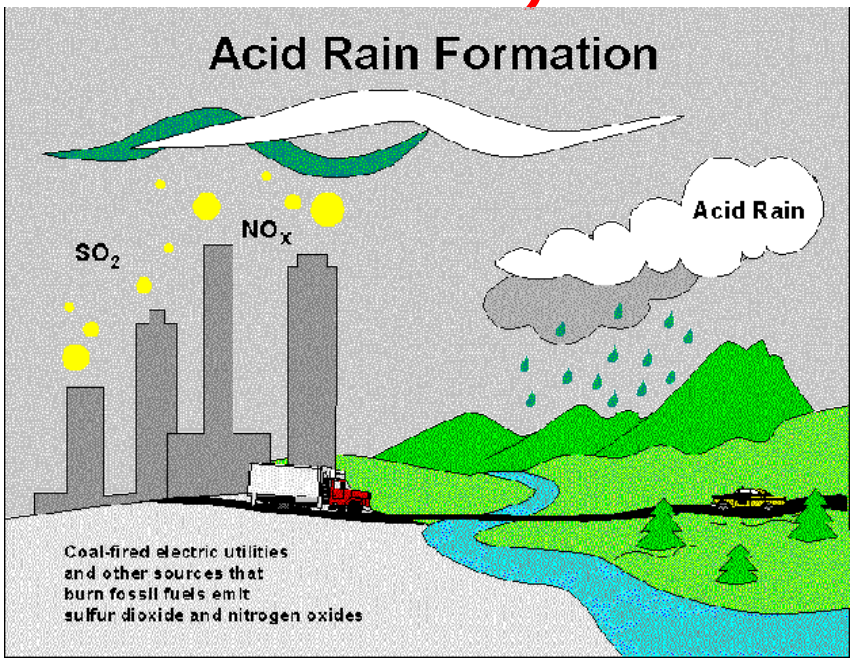
- **Possible alternative should be identified and environmental attributes compared**
- **Alternatives for project location & process technologies**
- **Alternative of 'no project' should also be considered**
- **Ranking of alternatives based on the best environmental option for optimum economic benefits to the community at large**
- **Mitigation plan for the selected option have to be drawn, and is supplemented with the Environmental Management Plan (EMP) to guide towards, Environmental Improvement**

Quiz Test
Total: 10 Marks (Time: 1 hour)

1. Define pollutant and contaminant along with examples [2].
2. What do you mean by speciation. Give examples [1]
3. What do you mean by Albedo [1]
4. What do you mean by scoping in EIA? [2]
5. How much fresh water is available on earth surface and how is it distributed? [2]
6. State the different layers of atmosphere along with its altitude. What are the important chemical species found in each layer [2]



Unit 2: Air, Water and Soil Pollution



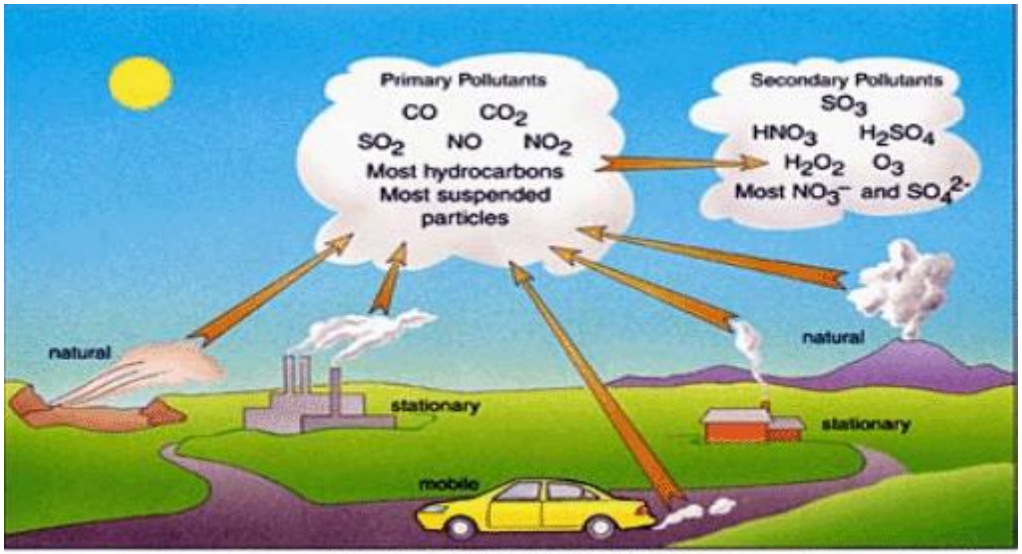
Air Pollution

- **Air pollution may be described as contamination of the atmosphere by gaseous, liquid, or solid wastes or by-products that can endanger human health and welfare of plants and animals, attack materials, reduce visibility or produce undesirable odors.**

- **Air pollution is the introduction of chemical, particulates, biological materials, or other harmful materials into the earth's atmosphere possibly causing disease, death to humans, damage to other living organisms such as food crops, or the natural or built environment .**

- **The atmosphere is a complex natural gaseous system that is essential to support life on planet earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems.**

- **Primary air pollutants are emitted directly into the air from sources. They can have effects both directly and as precursors of secondary air pollutants (chemicals formed through reactions in the atmosphere), which are discussed in the following section.**



Types and sources of air pollutants

- **Air pollution occurs in many forms but can generally be thought of as gaseous and particulate contaminants that are present in the earth's atmosphere.**

- **Gaseous pollutants include sulfur dioxide (SO_2), nitrogen oxides (NO_x), ozone (O_3), carbon monoxide (CO), volatile organic compounds (VOC), hydrogen sulfide (H_2S), hydrogen fluoride (HF), and various gaseous forms of metals.**

- **These pollutants are emitted from large stationary sources such as fossil fuel fired power plants, smelters, industrial boilers, petroleum refineries, and manufacturing facilities as well as from area and mobile sources.**

- **They are corrosive to various materials which causes damage to cultural resources, can cause injury to ecosystems and organisms, aggravate respiratory diseases, and reduce visibility.**

Sources of Air Pollution

Stationary and Area Sources

- Stationary sources include factories, power plants, dry cleaners and degreasing operations.

- The term area source is used to describe many small sources of air pollution located together whose individual emissions may be below thresholds of concern, but whose collective emissions can be significant. Residential wood burners are a good example of a small source, but when combined with many other small sources, they can contribute to local and regional air pollution levels.

- Area sources can also be thought of as non-point sources, such as construction of housing developments, dry lake beds, and landfills.

Mobile Sources

A mobile source of air pollution refers to a source that is capable of moving under its own power. In general, mobile sources imply "on-road" transportation, which includes vehicles such as cars, sport utility vehicles, and buses. In addition, there is also a "non-road" or "off-road" category that includes gas-powered lawn tools and mowers, farm and construction equipment, recreational vehicles, boats, planes, and trains.

Agricultural Sources

Agricultural operations, those that raise animals and grow crops, can generate emissions of gases and particulate matter. For example, animals confined to a barn or restricted area (rather than field grazing), produce large amounts of manure. Manure emits various gases, particularly ammonia into the air. This ammonia can be emitted from the animal houses, manure storage areas, or from the land after the manure is applied. In crop production, the misapplication of fertilizers, herbicides, and pesticides can potentially result in aerial drift of these materials and harm may be caused.

Natural Sources

Although industrialization and the use of motor vehicles are overwhelmingly the most significant contributors to air pollution, there are important natural sources of "pollution" as well. Wild land fires, dust storms, and volcanic activity also contribute gases and particulates to our atmosphere.

Pollution due to following gases….

Sulfur dioxide (SO_2) is a gas formed when sulfur is exposed to oxygen at high temperatures during fossil fuel combustion, oil refining, or metal smelting. SO_2 is toxic at high concentrations, but its principal air pollution effects are associated with the formation of acid rain and aerosols. SO_2 dissolves in cloud droplets and oxidizes to form sulfuric acid (H_2SO_4).

Some major sources of SO_2

- **Thermal power plants**
- **Fertilizer plants**
- **Textile industry**
- **Steel Plants**
- **Sulfuric acid plants**
- **Petroleum industry**
- **Oil refining**
- **Smelting of Sulphide ores**

Effects of SO_2

- **High solubility is water allows it to get absorbed in the moist passages of upper respiratory tract, causing increased breathing rate and feeling starvation.**
- **Suffocation**
- **Respiratory irritation**
- **Asthma and chronic bronchitis**
- **Irritation of throat and eye.**

Nitrogen oxides (NO and NO_2, referred together as NO_x) are highly reactive gases formed when oxygen and nitrogen react at high temperatures during combustion or lightning strikes. Nitrogen present in fuel can also be emitted as NO_x during combustion. Emissions are dominated by fossil fuel combustion at northern mid-latitudes and by biomass burning in the tropics.

In the atmosphere NO_x reacts with volatile organic compounds (VOCs) and carbon monoxide to produce ground-level ozone through a complicated chain reaction mechanism. It is eventually oxidized to nitric acid (HNO_3). Like sulfuric acid, nitric acid contributes to acid deposition and to aerosol formation.

Effects of NO_x

Respiratory irritation
Impairment of lung defense
Headache
Bronchitis
Loss of appetite
Corrosion of teeth
Leaf damage to sensitive plants

Carbon monoxide (CO) is an odorless, colorless gas formed by incomplete combustion of carbon in fuel. The main source is motor vehicle exhaust, along with industrial processes and biomass burning. Carbon monoxide binds to hemoglobin in red blood cells, reducing their ability to transport and release oxygen throughout the body. Low exposures can aggravate cardiac ailments, while high exposures cause central nervous system impairment or death.

Effects of CO

- **Carbon monoxide interferes with the blood's ability to carry to oxygen to the cell of the body.**

- **During inhaled it readily binds to haemoglobin in the blood stream to form carboxy haemoglobin (COHb).**

- **Carbon monoxide infact has a much great affinity for haemoglobin than oxygen, so that even small amounts of CO can seriously reduce the amount of oxygen conveyed through out the body.**

Smog

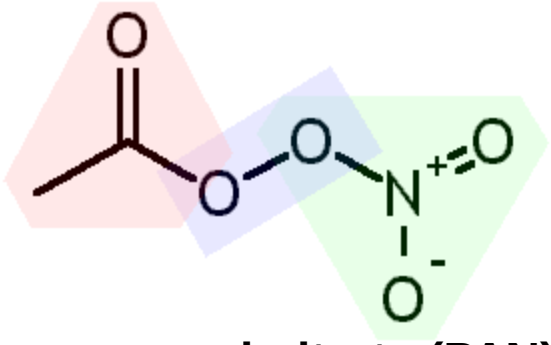
Smog is the combination of smoke and fog.

Photochemical Smog

When oxides of nitrogen, various hydrocarbons and sunlight come together, they can initiate a complex set of reactions that produce a number of secondary pollutants known as photochemical oxidants. Ozone is the most abundant of the photochemical oxidants, but it is responsible for many of the undesirable properties of photochemical smog. It causes eye irritation.

Eye irritation is caused by other components of photochemical smog, principally formaldehyde, peroxy benzoyl nitrare, peroxy acyl nitrate (PAN) and acrolenic.

Hydrocarbons NOx + Sunlight ⟶ Photochemical Smog



peroxy acyl nitrate (PAN)

- **The probable mechanism of smog forming reactions are**

- **Reactive hydro carbons those with C═C groups) from auto exhaust with O_3 to form hydrocarbon free radical $RCH_2^{\cdot}$.**

- **$RCH_2^{\cdot}$ rapidly reacts with O_2 to form another free radical $RCH_2O_2^{\cdot}$.**

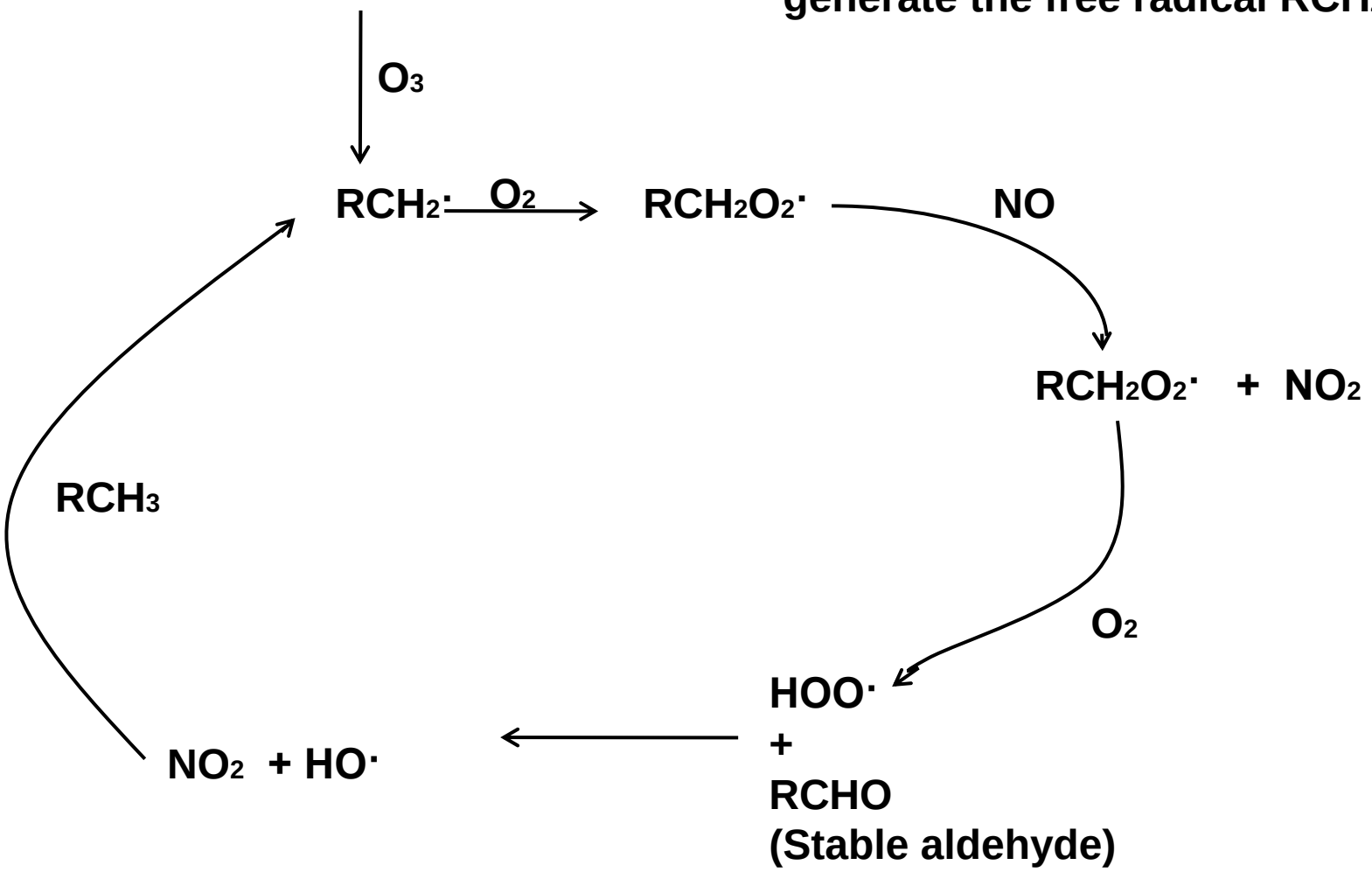
- **$RCH_2O_2^{\cdot}$ reacts with NO to form NO_2 and free radical $RCH_2O^{\cdot}$.**

- **This new free radical next interacts with O2 to yield a stable aldehyde, RCHO and hydroperoxyl radical.**

- **$HO_2^{\cdot}$ then reacts with another molecule of NO to give NO_2 and $^{\cdot}OH$.**

- **$^{\cdot}OH$ is extremely reactive and rapidly reacts with a stable hydrocarbon RCH_3 to yield H_2O and regenerate hydrocarbon free radical $RCH_2^{\cdot}$, thereby completing cycle.**

One complete cycle two molecules of NO_2, one molecule of RCHO and generate the free radical $RCH_2\cdot$



PAN is one of the most potent eye irritants found in smog.

London Smog

✓**The smog formed form oxides of sulphur (SOx), particulate matter coming from smoke and humidity or water is known as London Smog or Sulphurous Smog.**

✓**The smog affected London city badly in 1952, killing about 4000 people. The fuel introduced at that time was coal and was found to be main culprit.**

✓**The mixture of smoke, SOx and fog is chemically a reducing mixture and is also known as reducing smog.**

✓**SO_2 in the atmosphere gets converted into SO_3 by oxidation by a number of chemicals present in the particulates. SO_3 so formed combines with water in the atmosphere forming a fog of sulphuric acid droplets.**

✓**These droplets then condense on the carbon particles of soot (smoke), and the smog which is formed known as sulphurous smog.**

$$2SO_2 + O_2 \longrightarrow 2SO_3 \qquad SO_2 + H_2O \longrightarrow H_2SO_3$$

or

$$SO_3 + H_2O \longrightarrow H_2SO_4 \qquad H_2SO_3 + O_2 \longrightarrow H_2SO_4$$

Ozone-depleting substances (ODS)

➢**The ozone layer prevents most harmful UV wavelengths (280–315 nm) of ultraviolet light (UV light) from passing through the Earth's atmosphere.**

➢**The chemicals such as carbon tetrachloride and trichloroethane cause deplation in ozone layer.**

➢**It is suspected that a variety of biological consequences such as increases in skin cancer, cataracts, damage to plants, and reduction of plankton populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.**

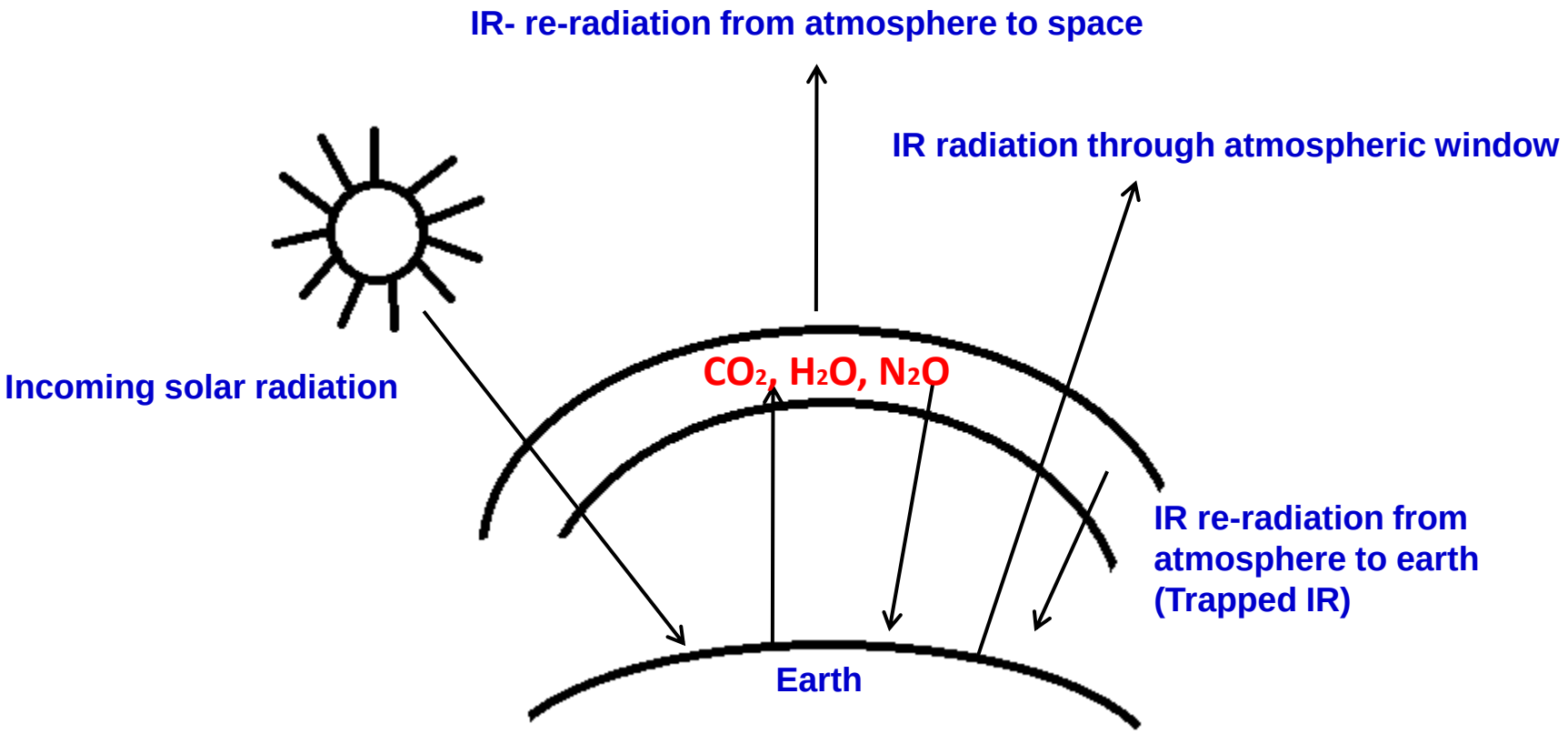
$$CFCl_3 + \text{electromagnetic radiation} \longrightarrow CFCl_2 + Cl$$
$$Cl + O_3 \longrightarrow ClO + O_2$$
$$ClO + O_3 \longrightarrow Cl + 2\,O_2$$

The chlorine atom changes an ozone molecule to ordinary oxygen. The ClO from the previous reaction destroys a second ozone molecule and recreates the original chlorine atom, which can repeat the first reaction and continue to destroy ozone.

Greenhouse effect

➢CO_2 (present level 356 ppm), is a significant non-pollutant species, however it has a major role in greenhouse effect. Among the constituents of the atmosphere only CO_2 and water vapour strongly absorb infrared radiation (1400-2500 nm) and effectively large fraction of earth's emitted radiation.

➢The radiation thus absorbed by CO_2 and water vapour is party re-emitted to earth's surface. The net result is that the earth's surface gets heated up by a phenomenon called the greenhouse effect.



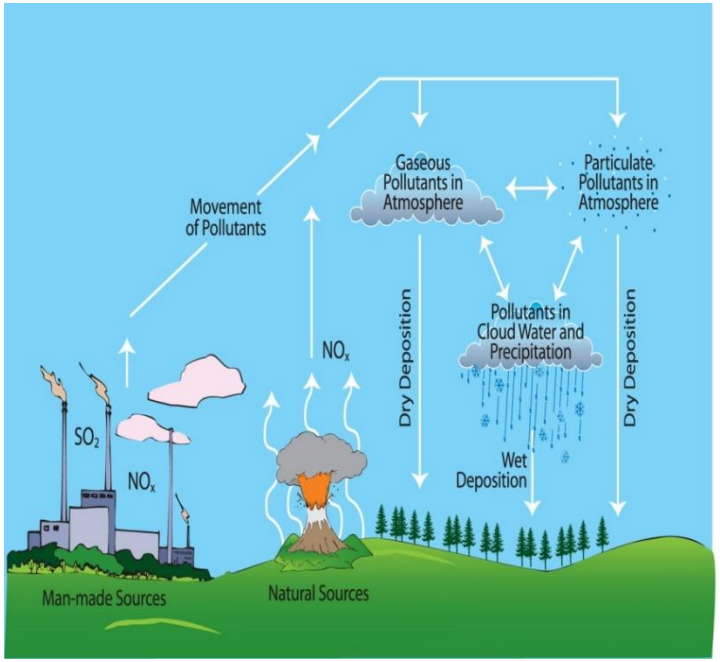
Other Greenhouse Gases

CO_2 is not only culprit contributing greenhouse effect and global warming. It is the major greenhouse gas but there are other greenhouse gases such as metane (19%), chlorofluoro carbon (17%), nitrous oxide (4%), ozone (8%) and water vapour (2%)

Greenhouse gas	Concentration (ppm)	Increase % per year
CO_2	356	0.4
CH_4	1.7	1.0
N_2O	0.3	0.3
CFC	0.0005	5

It is the carbon dioxide concentration that is increasing, due to the burning of fossil fuels (as well as from some rainforest burning). Compared to a pre-industrial atmospheric concentration of around 270 parts per million (ppm), the average concentration has increased to close to 400 ppm in 2012. This causes the man-made portion of the greenhouse effect, and it is believed by many scientists to be responsible for the global warming of the last 50 years or more.

Acid Rain



- Acid rain means the presence of excessive acids in rain water. The pH of acid rain generally varies from 3 to 6.
- Acid rain mainly contains H_2SO_4 and HNO_3 with weak H_2CO_3.
- The oxides of sulphur, nitrogen and carbon (NOx, SOx and COx) interact with other components of the atmosphere, and form corresponding acids.

- Acid rain is a rain or any other form of precipitation that is unusually acidic, meaning that it possesses elevated levels of hydrogen ions (low pH). It can have harmful effects on plants, aquatic animals and infrastructure. Acid rain is caused by emissions of sulfur dioxide and nitrogen oxide, which react with the water molecules in the atmosphere to produce acids.

- Nitrogen oxides can also be produced naturally by lightening strikes and sulfur dioxide is produced by volcanic eruptions. The chemicals in acid rain can cause paint to peel, corrosion of steel structures such as bridges, and erosion of stone statues.

Sources of Oxides

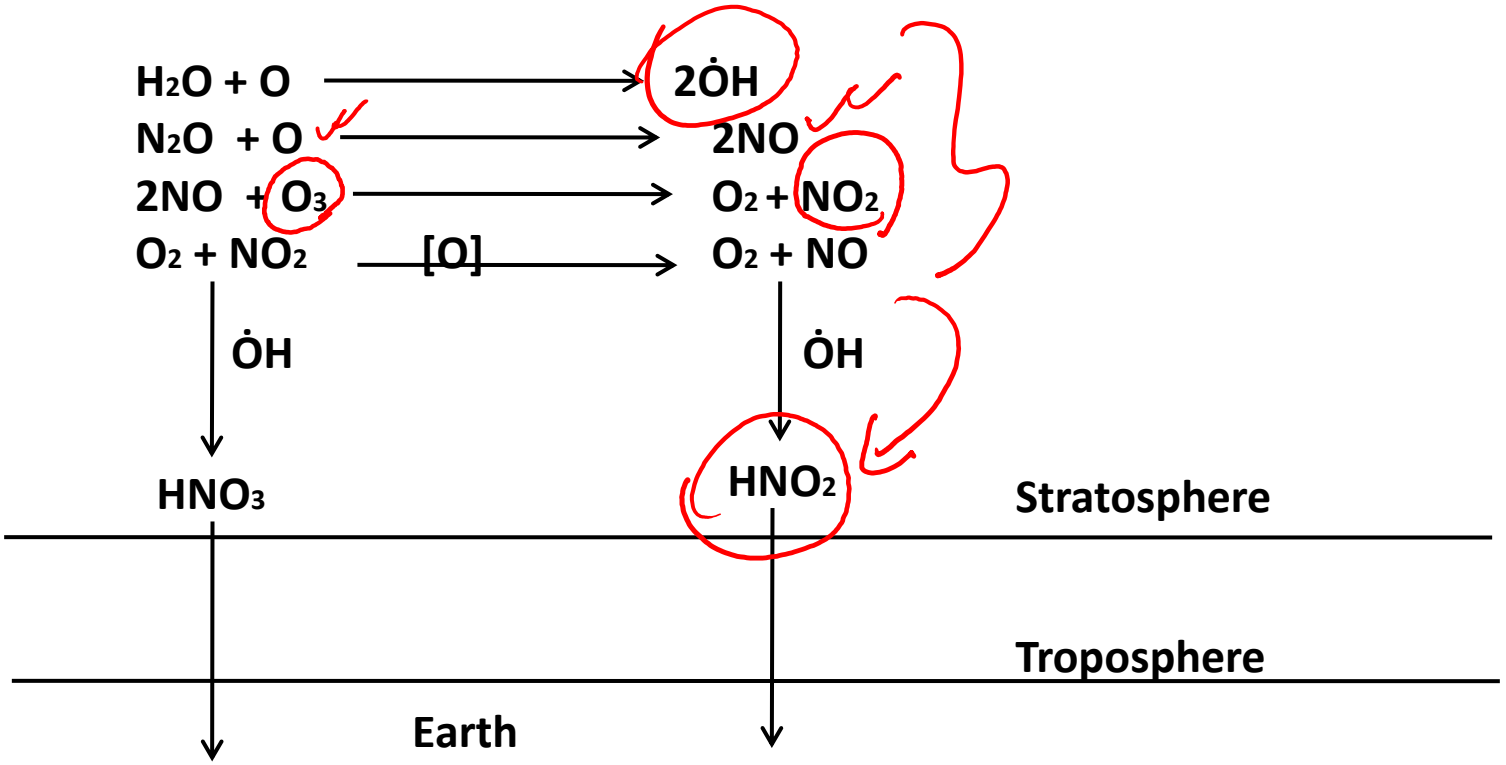
- ✓Burning of fossil fuel.
- ✓Thermal power plants.
- ✓Textile industry.
- ✓Steel plants.
- ✓Oil refining
- ✓Automobile exhaust
- ✓Explosive industry
- ✓Coal and gas fired furnace
- ✓Fertilizer industry

Source of NOx

The bulk of NOx on a global basis originates from microbial action in the earth's surface which yield N_2O.

This N_2O is inert in troposphere but it reacts with the oxygen atom in the stratosphere to form nitrogen oxide.

Then the NO enters into O_3 destruction cycle



Formation Acid rain form SOx

In natural sunlight, at the 5-30 ppm level of SO_2 and relative humidity 32-90%, the overall reaction is

$$SO_2 + \tfrac{1}{2} H_2O \longrightarrow H_2SO_4$$

Which is promoted by the presence of hydrocarbons and nitrogen oxides, key component of photochemical smog.

In water droplets, ions such as Mn (II), Fe (II), Ni (II) and Cu (II) catalyze the oxidation reaction. These acids being soluble in water are quickly rained out.

Sulphur dioxide absorb solar radiation in region of 300-400 nm and produce electronically excited state of SO_2*.

$$SO_2 + h\vartheta \longrightarrow SO_2^*$$

This undergoes oxidation to SO_3 and in the presence of H_2O, forms H_2SO_4.

Formation of acid rain from COx

Complete combustion of carbon containing materials forms CO_2 in atmosphere. CO2 in the atmosphere. CO_2 reacts with H_2O to form carbonic acid, which is another cause of acid.

$$C + O \longrightarrow CO_2$$

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

Adverse Effect of Acid Rain

Effects on aquatic biota

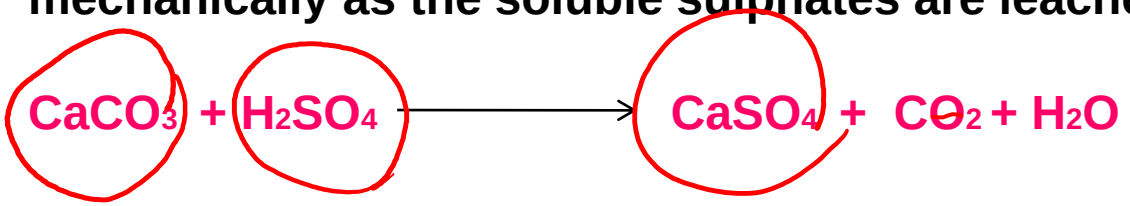
- Many aquatic species disappear due to the acidification of lakes.
- Acid rain reduces the production of phytoplankton in the lake.
- Many bacteria and blue green algae are killed due to acidification.
- Activity of bacteria and many other microscopic animals are reduced in acidic condition. Thus the dead materials and many other accumulated materials lying at the bottom of the lakes are not decomposed rapidly. Therefore essential nutrients like nitrogen and phosphorus are locked up and less available for use.

Effects on terrestrial eco-system

- Leaves of the plants and trees are damaged and become yellow and brown, retarding photo synthesis.
- Acid rain weakens the structure of the trees, therefore making it vulnerable to pathogen.
- The reduction in photosynthesis results in reduced in agricultural productivity.
- Many essential nutrients like Fe, Ca, Mg, S, Mo, Co are leached out due to acid rain, hampering productivity.

Effects of Acid Rain on Building

- Acid rain causes extensive damage to build and sculpture materials of marbles, lime stone, slate, mortar etc. These materials become weakened mechanically as the soluble sulphates are leached out by rain water.



- Acid rain attacks monuments, statues, bridges etc. this is one of the reasons why the Taj Mahal is in danger.

Effects on human beings

- Solublilization of heavy metals like Cd, Hg and Cr due to acid water may reach human body via the plants and animals in food chain or through drinking water supplies.
- Acid rain causes respiratory and skin disease and may attack nervous system in the extreme case.

Control measures for acid Rain

- Short team control of acid deposition problem can be achieved by using lime (CaO).
- The major step can be taken is to reduce acid forming gas like NOx and SO_2 and if possible, to stop.
- General public awareness should be created regarding the ill effects of environmental pollution and consequences of acid rain.

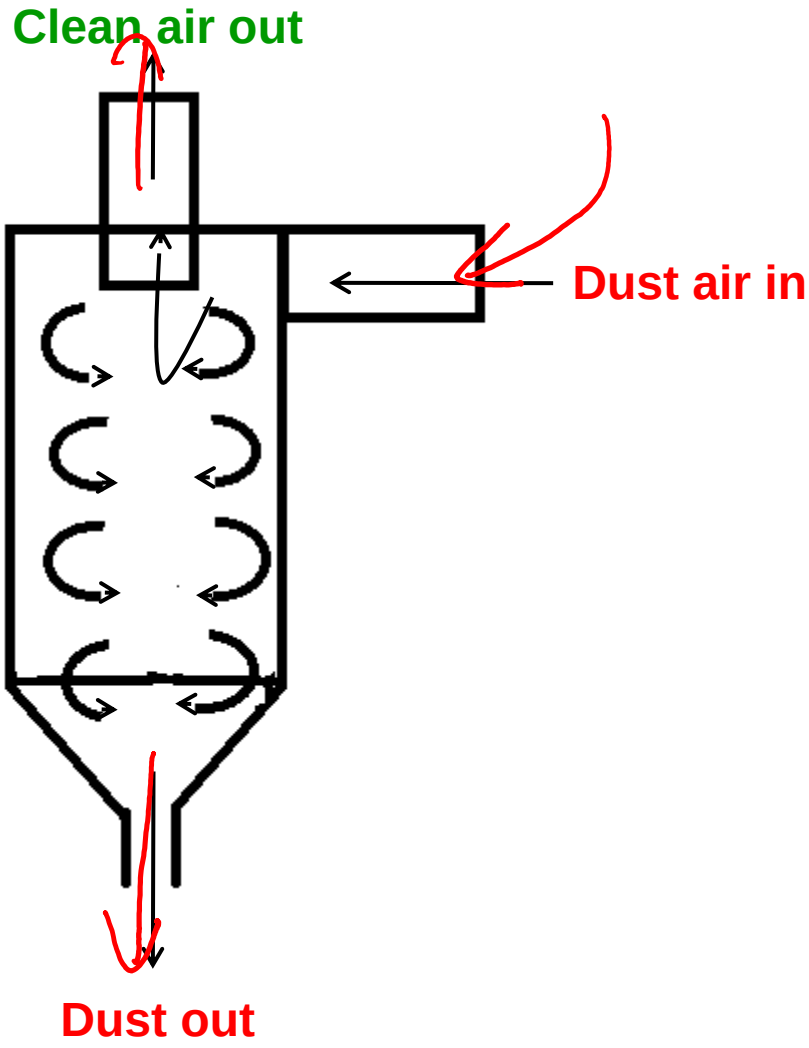
Control of Air Pollution

There are different devices for removal of particulate matter from the air.

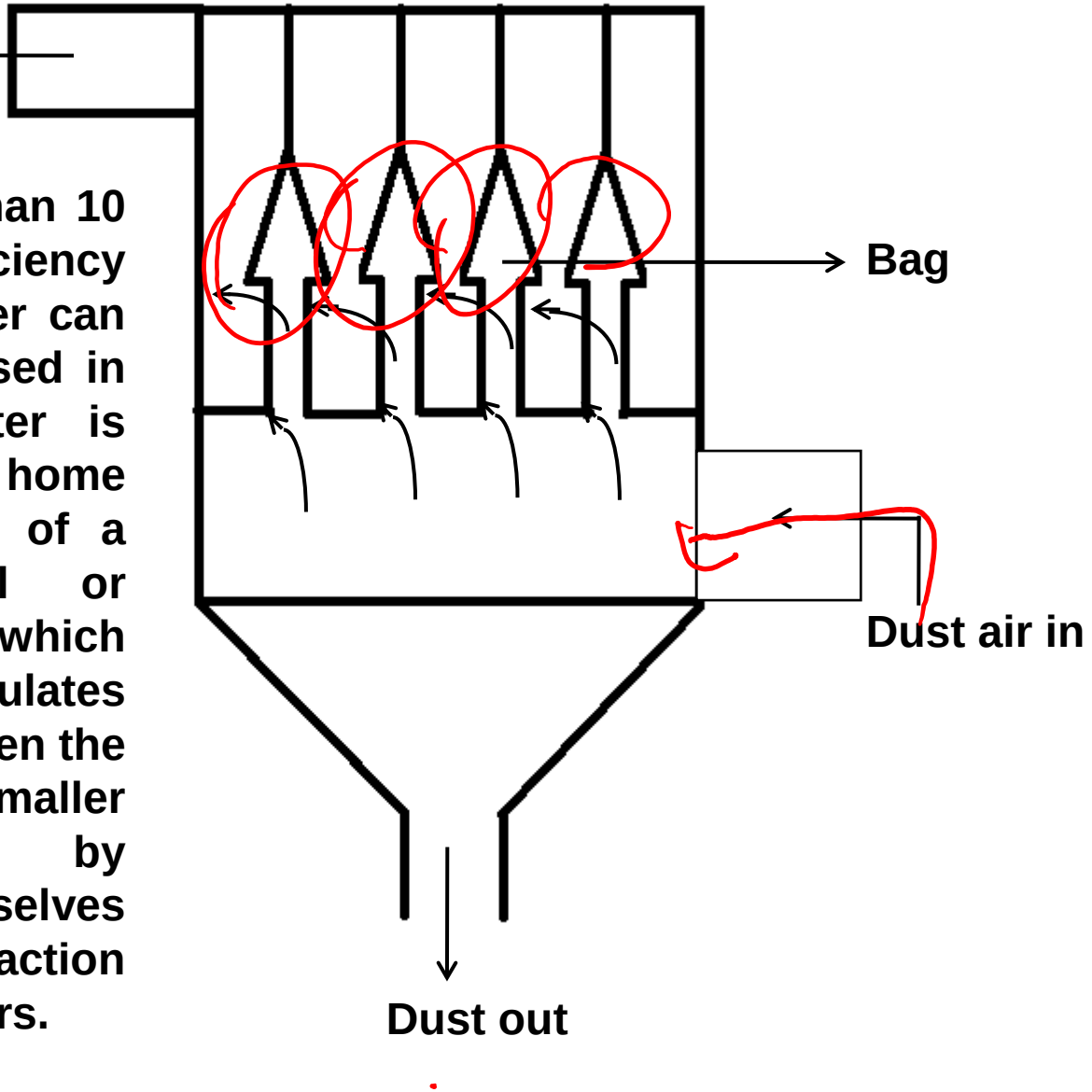
- **Cyclone separator.**
- **Baghouse**
- **Scrubber.**
- **Electrostatic precipitator.**
- **Catalytic convertor.**

Cyclone separator

For particle diameter down to about 10 μm, the Collection device of choice is usually a cyclone. This is a simple economical unit with no moving parts, that relies on inertial effects for particulate removal. Particulate containing air is sent into a conical cylinder, where it is forced into a spiral flow path and accelerates. The centrifugal force imparted on the particulates forces them to move to the wall of the chamber, where they then slide down to the bottom of the cone and are removed. The clean air exists up through the centre of the cyclone.



Baghouse Filter



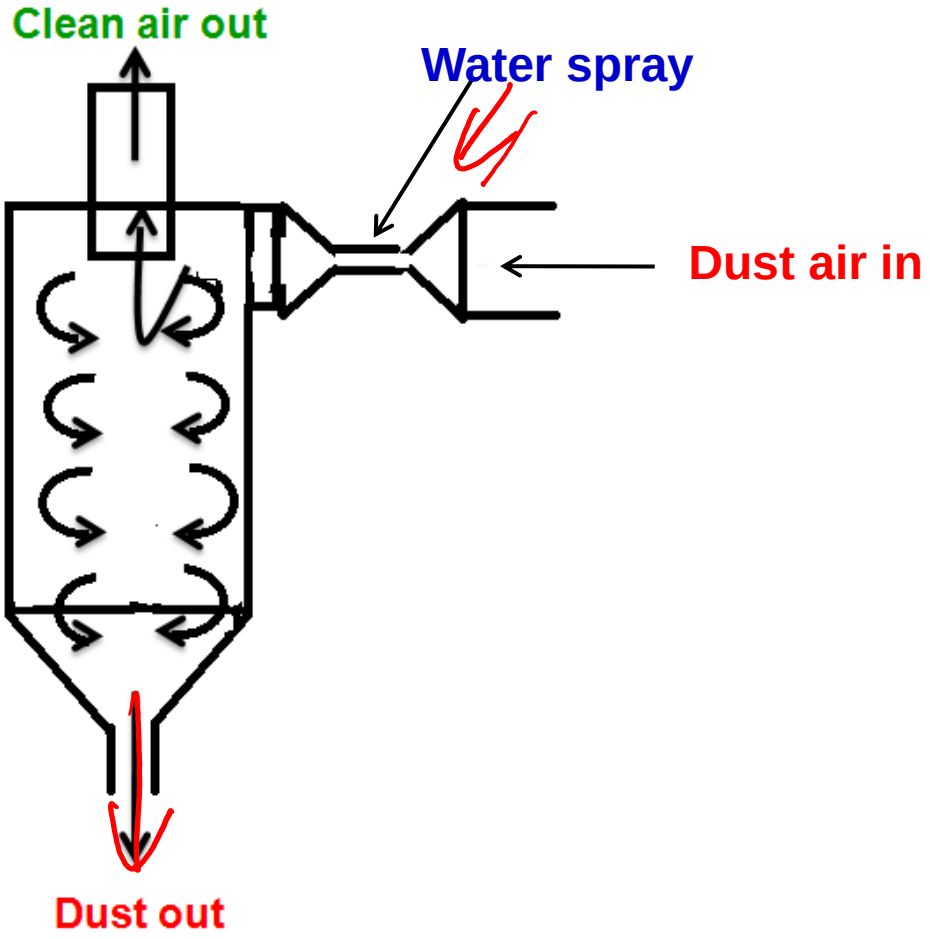
When particles are smaller than 10 µm or a higher collection efficiency is required, a bag house filter can be used. There are widely used in industry. A bag house filter is similar to a conventional home vacuum cleaner. It consists of a chamber housing natural or synthetic cloth bags through which the dirty air is pumped. Particulates larger than the opening between the fibers are filtered out, smaller particles are removed by interception on the fiber themselves and by electrostatic attraction between the particles and fibers.

Once particle begin to accumulate the openings become smaller and the importance of sieving increases. The cleaned air passes through the bag fabric and exists through an opening in the bag house chamber. Particulates collects on the inside surface of the bags. The bags are periodically shaken to remove the accumulated dust or the bag is isolated and air is blown into the bag from outside to dislodge particles. The released dust into a hoper below.

Baghouse filters are very efficient and can remove even sub micrometer size particles. However, they cannot be used for wet air stream, because the particulate may cake on the filter.

Scrubber

A scrubber is another device that can be used to remove particulates from air. Scrubber are of particular value where the contaminated air is wet, corrosive or hot applications where bag house can not be used. Simply spray chambers can be used for removal of large particle sizes. Dirty air flows through a chamber into which droplets are sprayed. The water droplets accumulate on the particulates in air, increase their size and weight and cause them to settle more rapidly and efficiently than in a settling chamber. The removed particulates in the collected spray water at the bottom of the spray chamber are drawn off to a setting basis, where the particulates are settled.



Particulate removal efficiency can be as high as 99% with a well designed scrubber system.

Electrostatic Precipitator (ESP)

The ESP is a high efficiency dry collector of particulates from air. The particulate matter is removed by applying a high electrical direct current potential (30 – 75 kv) between alternating plates and wires.

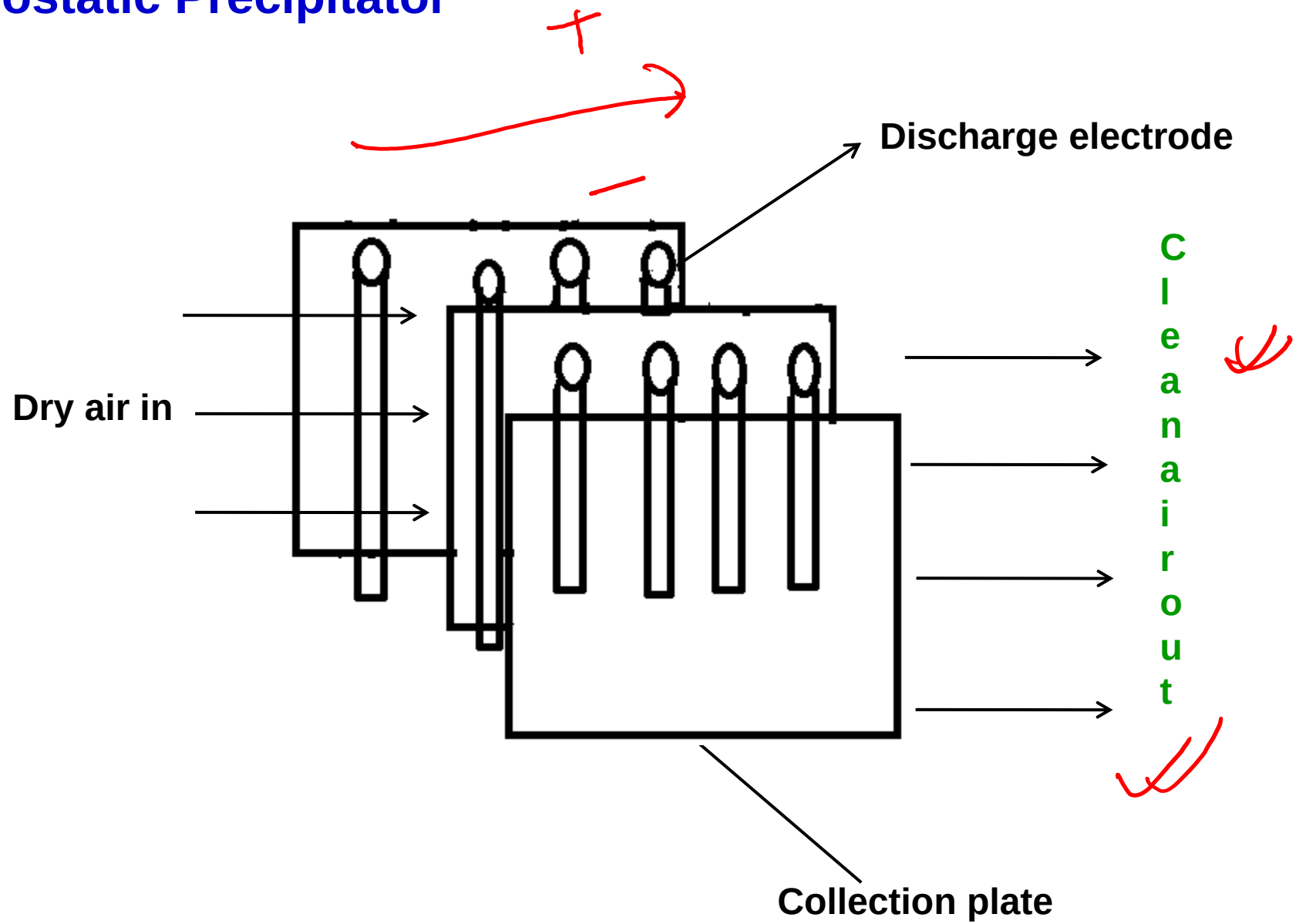
A full scale ESP may have hundred of parallel plates, with very large surface areas.

As the particle gas stream passes through this ion-field, ions attached to the particulates, giving them a net negative charge.

The particulates then migrate to positively charged plates, where they are neutralized and stick.

They are periodically removed from the ESP plate surfaces by rapping the plates.

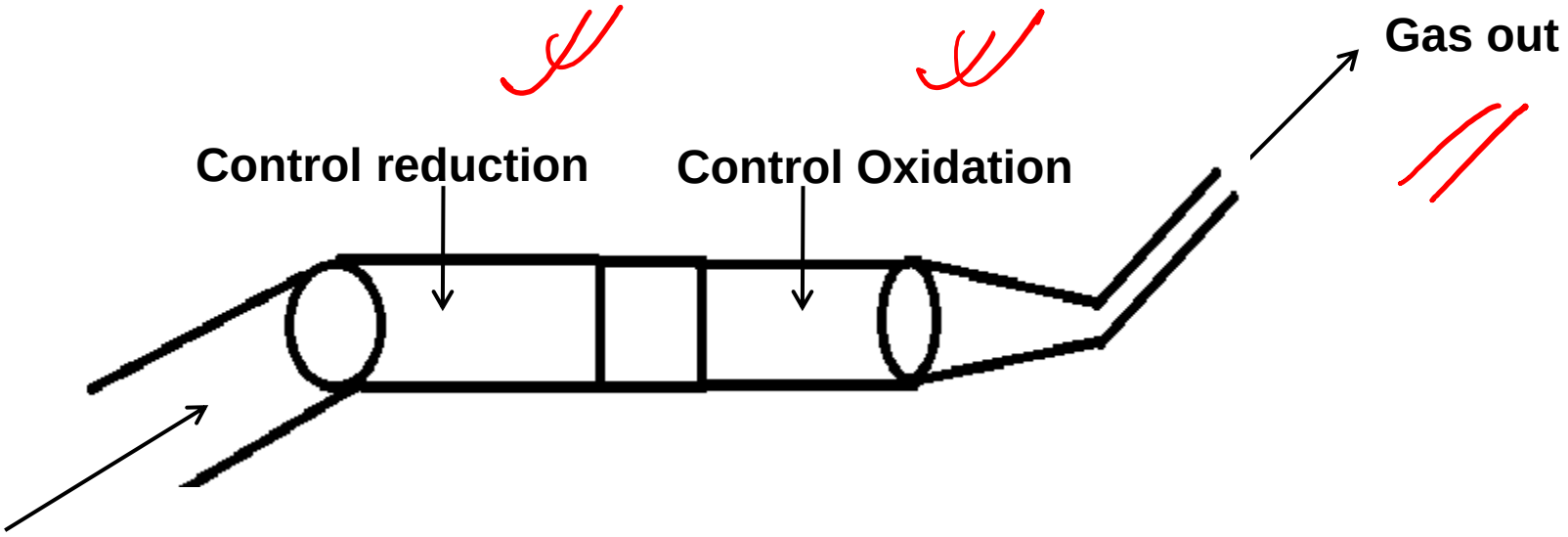
Electrostatic Precipitator



Catalytic Convertor

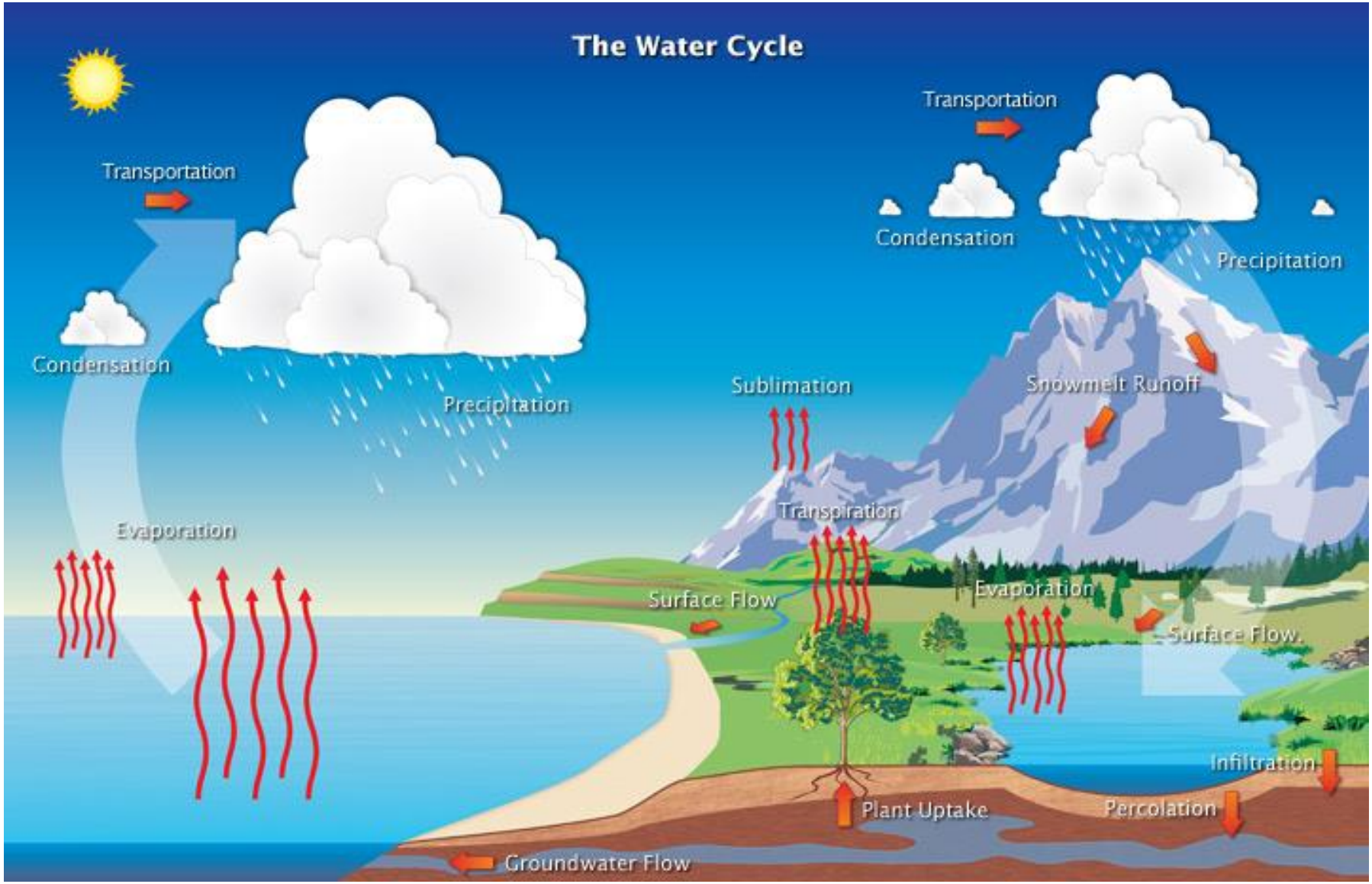
Catalytic convertor is used in the automobile engine for controlling emissions very effectively. Three way catalytic convertor is now available in the market. Three way means removal of three pollutants such as CO and NOx is reduced to N_2 in the same catalytic bed.

The catalytic convertors not only control emissions but also allow engines to operate at near stochiometric conditions. The efficiency of catalytic convertor however, gets reduced drastically when leaded petrol is used.



Water Pollution and Remedies

The Hydrological Cycle



The Sources of Natural Water

1. Surface Water: (a) Flowing of Water (streams and rivers) and
(b) Still Water (Lakes, ponds and reservoirs)
2. Under Ground Water : Water from wells and springs.
3. Rain Water
4. Sea Water

Pollutants of Water

- ✓Oxygen demanding waste
- ✓Pathogens
- ✓Nutrients
- ✓Salts
- ✓Thermal Pollution
- ✓Heavy Metals
- ✓Pesticides

Pollutants of Water

Oxygen Demand Wastes

One of the most important measures of water quality is the amount of dissolved oxygen (DO) present in it. The saturated value of DO in water is in order of 8-12 mg/L, depending on temperature and salinity. Optimum DO required for healthy fish and other aquatic life in natural water is 5-8 mg/L, or as low as 3 mg/L for less desirable species, such as crop.

The oxygen demanding wastes are substances that oxidize in receiving body of water reducing the amount of dissolved oxygen (DO) available in water.

Origin

Oxygen demanding wastes are usually biodegradable organic substances contained in municipal waste waters or effluents from certain industries, such as food processing and paper production. The oxidation of certain inorganic compounds may also contribute to the oxygen demanding wastes.

Effects of drop of DO

Oxygen demanding wastes are usually biodegradable organic substances contained in municipal wastes or effluents from certain industries, such as food processing and paper production. The oxidation of certain inorganic compounds may contribute to oxygen demanding wastes.

Effects of drop of DO

1. If DO drops, fish and other aquatic life are threatened and in the extreme case, killed.

2. The effect of reduced DO is undesirable odors, tastes, and colours, reduces the acceptability of water as a domestic supply and recreational purpose.

Measurement of Oxygen Demand

1. Chemical Oxygen Demand (COD):- It is the amount of oxygen required to chemically oxidize the wastes.

2. Biochemical Oxygen Demand (BOD):- It is the amount of oxygen required by micro organisms to biologically degrade the wastes.

Pathogens

Pathogens are disease producing organisms that grow and multiply within the host. The resulting growth of micro organisms in a host is known as infection.

Water is the carrier of such pathogenic micro-organisms.

✓Bacteria are responsible for cholera, bacillary dysentery, typhoid and paratyphoid fever.

✓Viruses are responsible for infections hepatitis and poliomyelitis.

✓Protozoa causes amebic dysentery and giardiasis.

✓Helminths or parasitic worms causes diseases such as schisstosomiasis and dracontiasis.

Nutrients

Nutrients are chemicals such as nitrogen, phosphorus, carbon, sulphur, calcium, potassium, manganese, boron and cobalt, that are essential for the growth of living organisms. These nutrients are considered as pollutants when the concentration of are sufficient to allow excessive growth of aquatic plants, particularly algae.

Salts

Water naturally accumulates a variety of dissolved solids or salts. Generally, the cations in the salts are Na (+), Ca (+2), Mg (+2) and K(+) and the anions are Cl(-), SO_4 (-2) and HCO_3(-) .

More commonly used measure of salinity is the concentration of total dissolved solids (TDS). Fresh water contains 1500 mg/lit. TDs, brackish water may have TDS up to 5000 mg/lit., saline has a recommended maximum TDS of 500 mg/lit and sea water contains 30,000-35,000 mg/lit TDS. Drinking water has recommended maximum TDS of 500 mg/lit as per WHO,s specification but for Indian conditions, drinking water having TDS up to 1500 mg/lit has been permitted under certain conditions.

Thermal Pollution

In thermal power plants, nuclear power plants etc., where water from the nearby river or lakes is used as a coolant, the waste hot water is returned to the original water body and on an average the temperature is raised by 10 ^{o}C
Within certain limits, the increase in temperature of water promote fish growth and harvesting may actually be improved in the vicinity of a power plant.

Metabolic rates tend to increase with increase in temperature, generally by a factor of 2 for each 10 ^{o}C rise in temperature. The rise in temperature decrease the amount of dissolved oxygen (DO) in water, adversely affecting the aquatic life.

Heavy Metals

Heavy metals are referred to as metals with specific gravity greater than 4 or 5. the most important heavy metals pollutants are mercury (Hg), lead (Pb), Cadmium (Cd) are Arsenic (As).
Cr and Fe are essential nutrients in our diets, but in higher doses are extremely toxic.
The most important route for the elimination of metals is via the kidneys. So kidneys can be considered as complex filters, whose primary purpose is to eliminate toxic substances from the body. The kidneys contain millions of excretory units called nephrons and the chemicals that are toxic to kidneys are called nephrotoxins e,g., Cd, Pb, Hg etc. Metals also have adverse effect on nervous system and cause kidney damage, induce tumors.

Volatile Organic Compounds (VOC)

Volatile organic compounds are the most commonly found contaminants in water. Five VOC's are specially toxic.

(a) Vinyl chloroethylene used in the production of PVC.
(b) Tetrachloro ethylene used as solvent and in the manufacture of chorofluro carbon,
(c) Trichloro ethylene used as solvent to clean electronic parts
(d) 1,2- dichloroethane used in the manufacture of number of products.
(e) Carbon tetrachloride used in grain fumigants, fire extinguishers.

Effects of VOCs

Chlorinated solvents are easily absorbed through the digestive tract and lungs. Once absorbed they move throughout the body in the blood. For a short time, they collect in the liver, kidney, brains and fatty tissues.

High amount of chlorinated solvents were found to cause dizziness, reduce the ability to concentrate and remember, damage the nervous system, and produce an irregular heart beat in people who are exposed in the work place and in laboratory animals. Leukemia, a form of cancer of the white blood cells, was more likely to occur in industrial workers as compared to other workers.

Biochemical Oxygen demand

The biochemically oxygen demand (BOD) test in an indirect measure of the biodegradable organic matter in aqueous sample. The test is indirect because oxygen used by microbes as they degrade organic matter is measured, rather than the depletion of the organic materials themselves.

When biodegradable organic matter is released into a body of water, micro-organisms, especially bacteria, feed on the wastes, breaking it down into simple organic and inorganic substances.

The aerobic decomposition of wastes present in water by micro-organisms produces non objectionable, stable end products such as CO_2, sulphate, orthophosphate and nitrate ions.

Organic Matters + O_2 $\xrightarrow{\text{Micro-organism}}$ CO_2 + H_2O +New Cells + Stable products

BOD values of various effluents are

Characteristics	BOD (mg/L)
Domestic Sewage	165
Industrial waste water	200
Paper industry effluent	372
Food industry effluent	747
Metal industry effluent	13

Anaerobic Decomposition of Wastes in Water

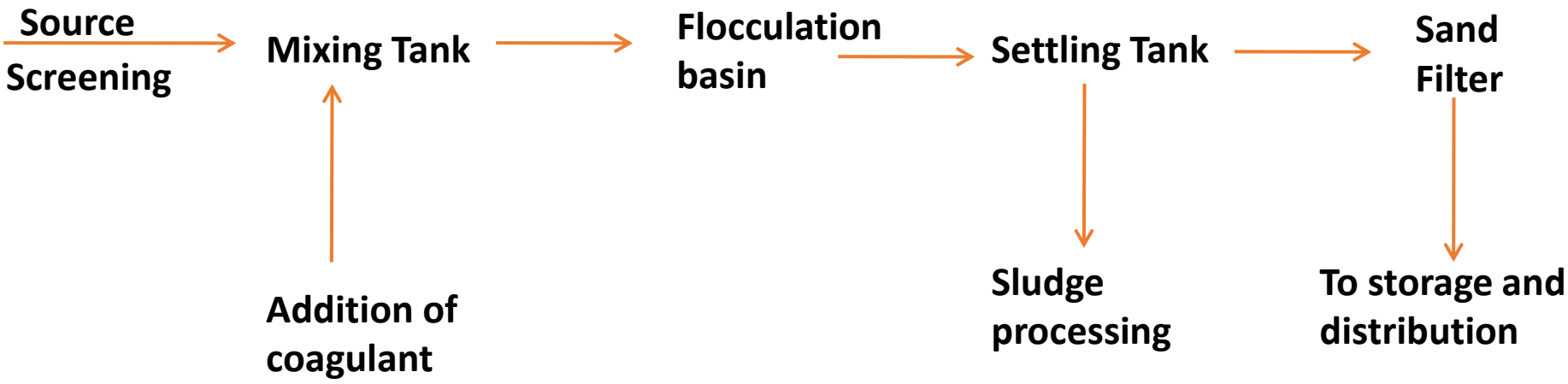
Anaerobic decomposition of wastes of water present in water by micro-organisms produces methane (CH4), which is physically stable, biologically degradable, and a potent green house gas. When methane is emitted from bodies it is often called swamp gas.

Organic matter $\xrightarrow{\text{micro-organisms}}$ $CO_2 + CH_4$ **+ New cells + Unstable products**

Water Treatment Operations

The treatment of water can be classified into three categories.
(i) Treatment of raw water for drinking purposes.
(ii) Treatment of raw water for industrial applications.
(iii) Treatment of waste water to make it acceptable for release or reuse.

Municipal waste water treatment



Screening to remove relatively large floating and suspended debris.

Mixing the water with chemicals that encourage suspended solids to coagulate into large particles that will more easily settle.

Flocculation, which is the process of gently mixing the water and coagulant allowing the formation of large floc.

Sedimentation is which the flow is slowed enough so that gravity will cause the floc to settle.

Sludge processing where the mixture of solids and liquids collected from the settling tank are dewanted and disposed of.

Disinfection of the liquid effluent to ensure that the water is free from harmful pathogens.

Primary treatment of waste water

Pretreatment

It consists of screening and grit removal. Screening removes or reduces the size and large solids that get into sewage system. These solids are collected on screens and scraped of for subsequent disposal. Particle size may be reduced to the extent that the particles can be returned to the sewage flow. After screening, the waste water is allowed to enter a grit chamber for the removal of inorganic grit consisting of sand, gravels and pebbles. Grit chambers are provided to protect pumps from abrasion and to reduce the formation of heavy deposits in the pipe and channels. Grit is normally allowed to settle in a tank under condition of flow velocity and it is then scraped mechanically from the bottom of tank.

Primary Sedimentation

Primary sedimentation removes both the settleable and floatable solids. Also the flocculant particles which tend to aggregate will be allowed to settle by addition of chemicals (iron slats, lime and alum). The material that floats in the primary settling basin is collectively known as grease. Normally some of the grease settles with the sludge and floats to the surface, which can be removed by skimming.

This process of flocculant settling takes place when the settling velocity of the particles increases due to aggregation with other particles.

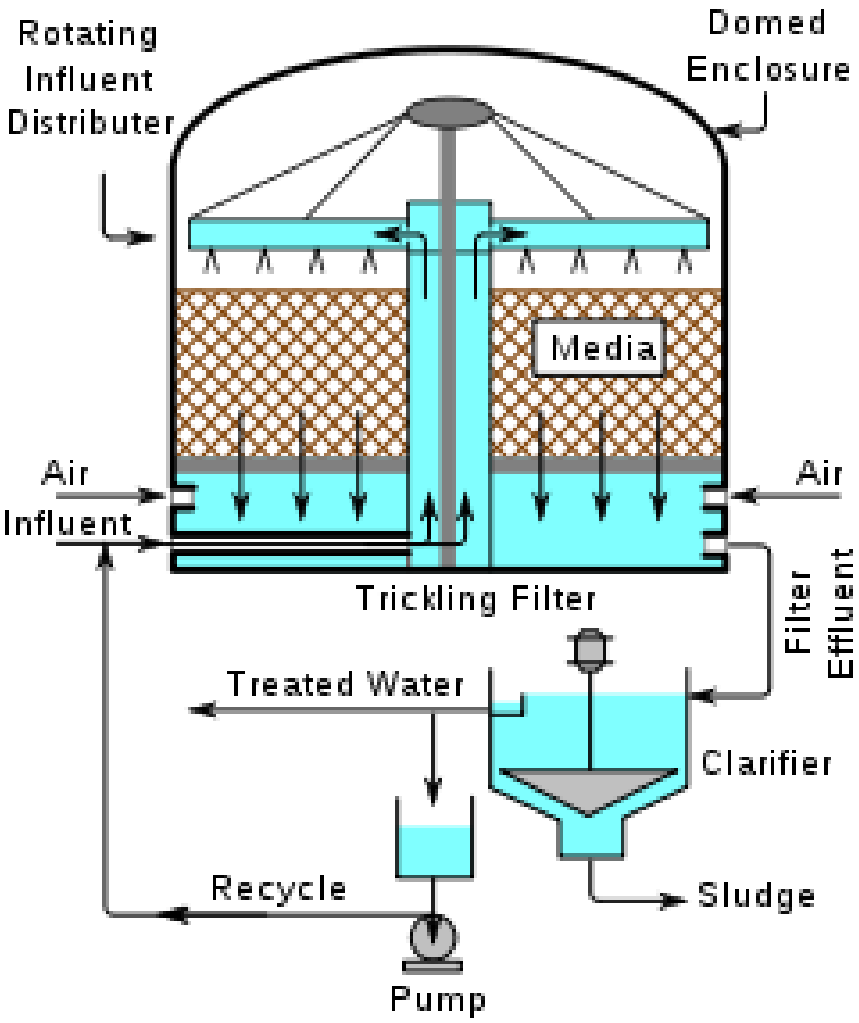
Secondary treatment for municipal waste water

In secondary or biological treatment, oxygen supplied to the bacteria is consumed under controlled conditions so that most of the BOD is removed in the treatment plant rather than in the water course. The principal requirement of a biological waste water, oxygen and good contact between bacteria and organics present in the waste.

The most commonly used systems for the biological waste treatment are the biological film system and the activated sludge system. The biological film system is also known as trickling filter.

- **Trickling filter**
- **Rotating Biological Contractor**
- **Activated Sludge Process**
- **Oxidation Ponds**

Trickling Filter



✓**Conventional trickling filters normally consist of a rock bed, 1 to 3 meters in depth, with sufficient opening between the rocks to allow air to circulate easily.**

✓**The influent is sprayed over a bed of packing which is coated with a biological slime.**

✓**This slime consists of bacteria, but it may include fungi, algae, protozoa, worms, insects and snails.**

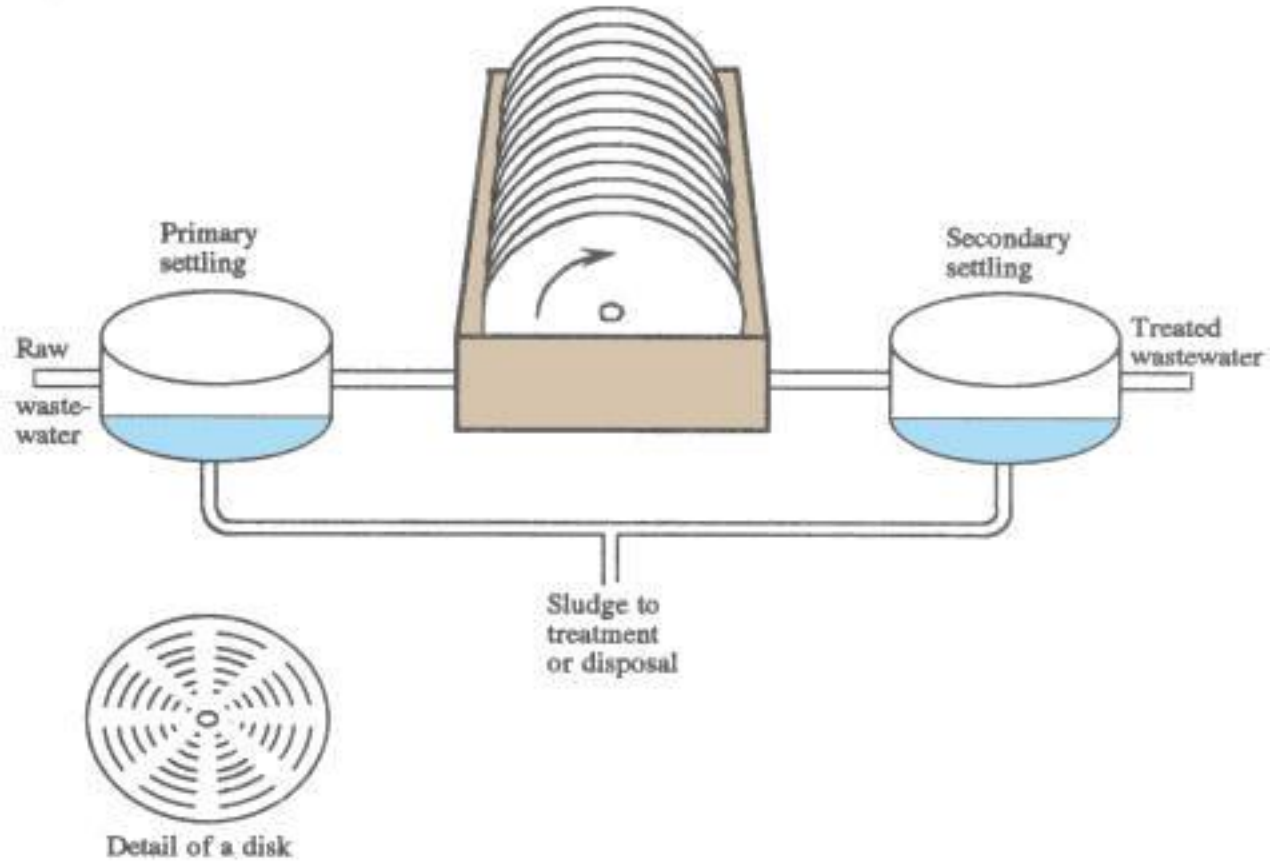
✓**As the liquid trickles over the packing, oxygen and dissolved organic matter diffuse into the film to be metabolised by the micro-organisms in the slime layer.**

✓**End products such as CO_2, NO_3(-) etc, diffuses back, out of the film and appear in the filter effluent.**

✓**The effluents from milk processing, paper mills and pharmaceutical industries are treated by trickling filters**

✓**Like all biological units trickling filters are affected by temperature, therefore cold weather slows down the biological activity of the filter.**

Rotating Biological Contactor



✓**Trickling filters are examples of devices that rely on micro-organisms that grow on the surface of the rocks, plastic or other media.**

✓**A variation of this attached growth approach is provided by the rotating biological contactor (RBC).**

✓**RBC consists of a series of closely spaced circular plastic discs, that are typically 3.6 m in diameter and attached to a rotating horizontal shaft.**

✓**The bottom of 40% of each disc is submerged a tank containing waste water to be treated.**

✓**The biomass film that grows on the surface of the discs moves into and out of the waste water as RBC rotates.**

✓**The microorganism are submerged in waste water, they absorb organics, while they were rotated out of waste water, they are supplied with required oxygen.**

✓**By placing modular RBC units in series, treatment levels that exceed the conventional secondary treatment.**

Activated Sludge Process

The most versatile and effective of all the waste treatment processes is the activated sludge process.

✓The essential features of the process are : aeration tank where the organic matter is brought into intimate contact with the sludge from the secondary clarifier.

✓This sludge is heavily laden with micro-organisms which are in an activated state of growth.

✓Air introduced into the tank either in the form of bubbles through diffusers or by surface aerators.

✓The micro-organisms utilise oxygen in the air and convert the organic matter containing N and P into stabilised, low energy compounds such as NO3(-), SO_4(-), NH_4(+), H_2PO_4(-), HPO_4(2-), CO_2, H_2O and synthesis of new bacteria cell.

✓The effluent from the aeration tank containing the flocculation biomass, known as sludge, is separated in a settling tank, sometimes called secondary settler or clarifier.

✓These solids settle out in the settler and fraction of them is discarded. Part of the solid is recycled as return sludge to the head of the aeration tank and comes into contact with fresh sewage.

Mechanism of activated sludge process

In the activated process BOD is removed by two path ways:

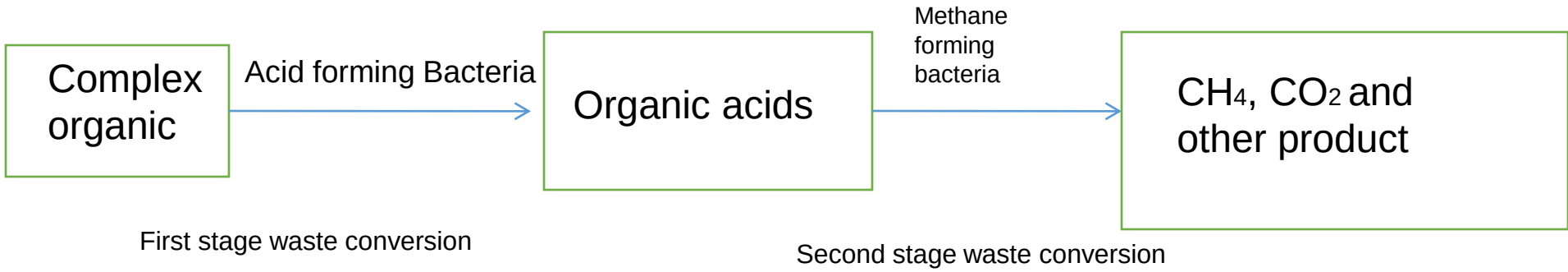
(i) Organic matter is oxidised in the course of providing energy for the metabolic processes of the micro-organisms.

(ii) Synthesis and incorporation of organic matter into cell mass.

In the first process, carbon is removed in the gaseous form as CO_2. The second process provides for removal of carbon as a solid biomass. The carbon which is present in the waste converted to CO_2 is released to the atmosphere and does not create any disposal problem.

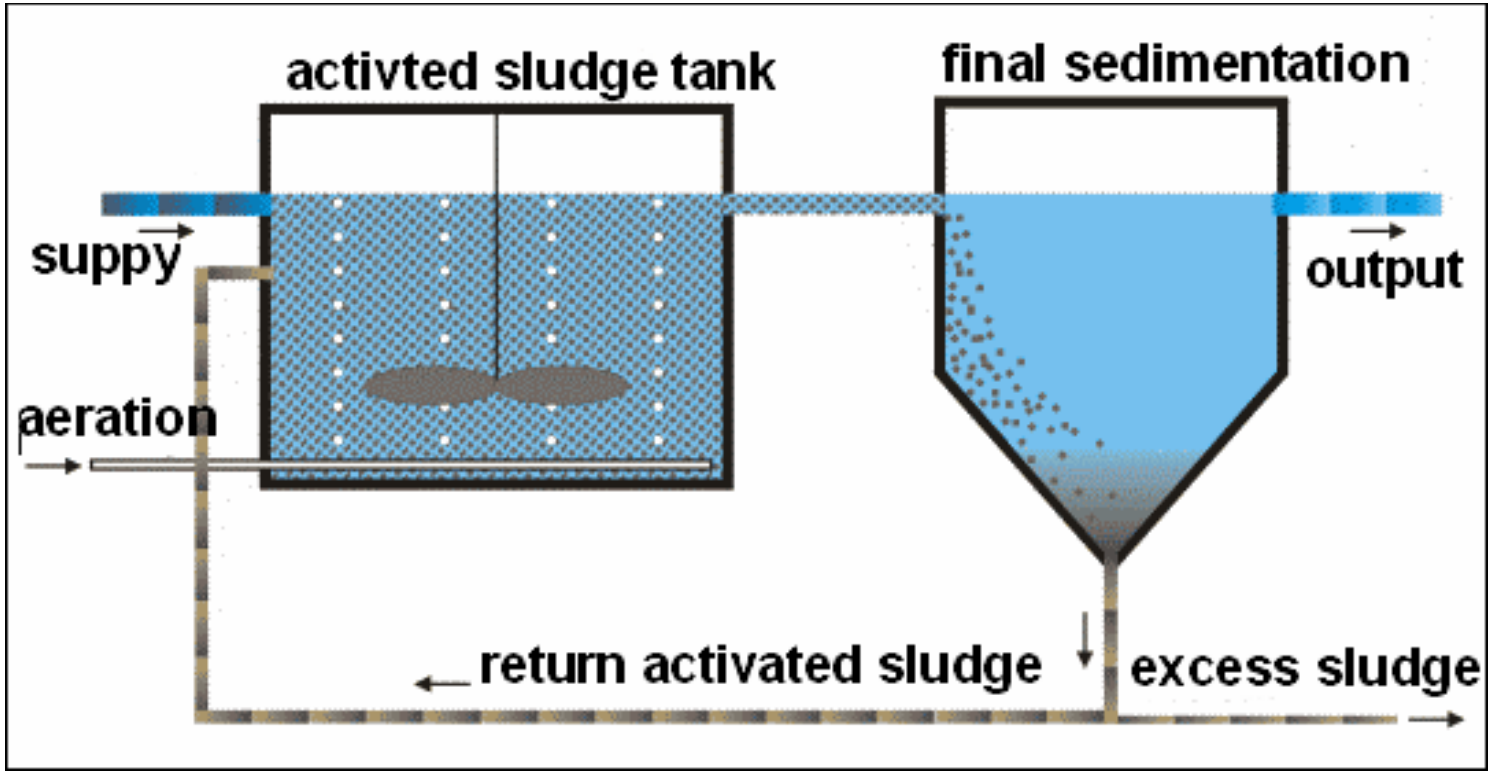
Sludge Treatment

Mixture of solid and liquids is called sludge. The traditional process of sludge processing is anaerobic digestion. Although anaerobic digestion is slower than aerobic digestion, but anaerobic digestion is advantageous because only a small percentage of the wastes are converted into new cells. The anaerobic digestion process follows two steps.



➢In the first phase, complex organics such as fats, proteins and carbohydrates are biologically converted into simple organic materials, mostly fatty acids.

➢The bacteria that involved in this process are known as acid formers.



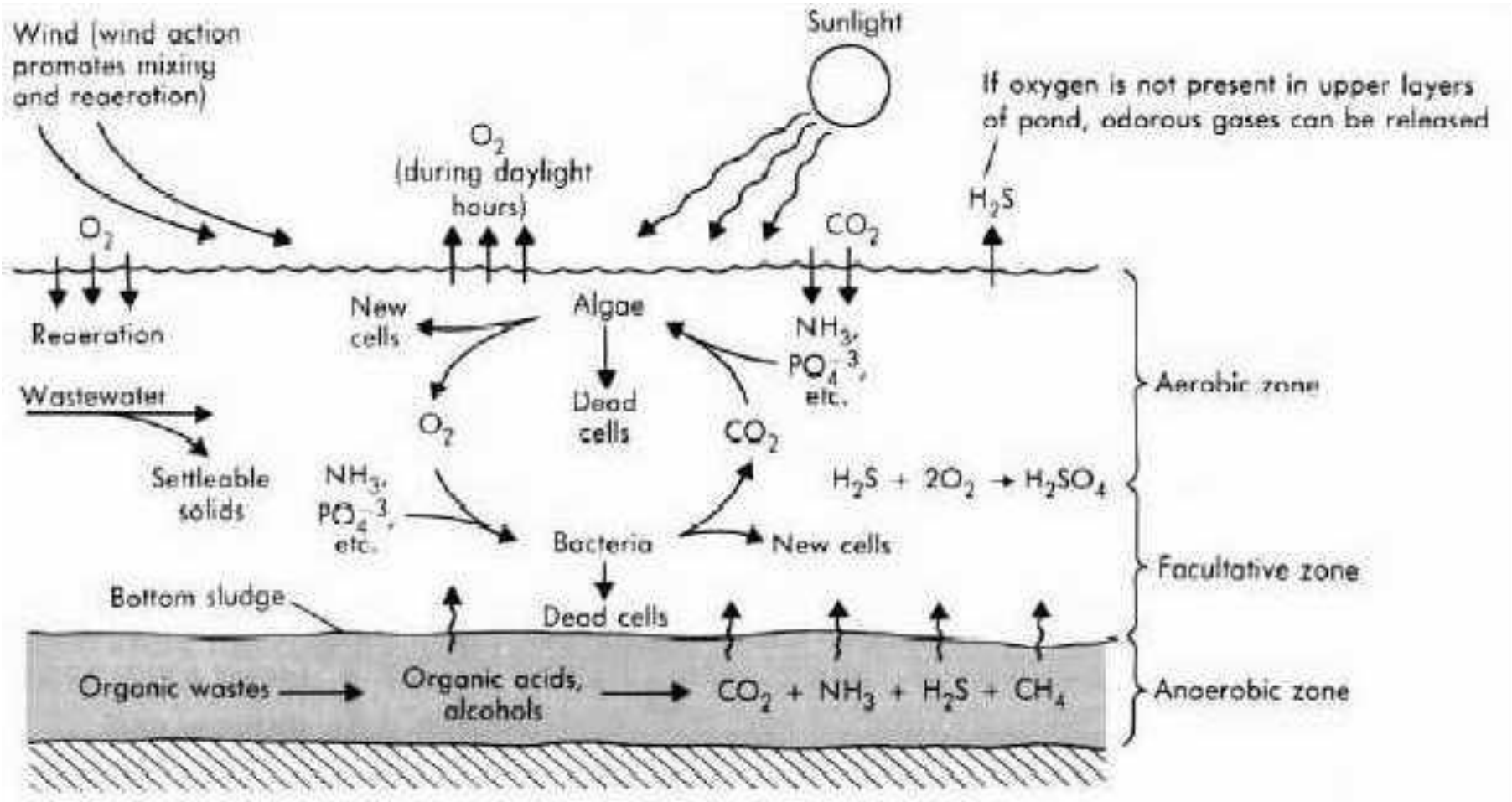
✓**Sludge in the first stage is thoroughly mixed and heated to increase the rate of digestion.**

✓**The second stage tank is neither heated nor thoroughly mixed and likely to have a floating cover to accommodate the varying amount of gas being stored.**

✓**The gas produced in the digest is about 60% CH_4, which is available fuel with may potential uses within the treatment plant.**

✓**Digested sludge removed from the second stage of the anaerobic digest is still mostly liquid.**

Oxidation Ponds



✓**Oxidation ponds are large, shallow typically 1-2 m deep, where raw or partially treated sewage is decomposed by micro-organisms.**

✓**The ponds can be designed to maintain aerobic conditions throughout, but more the decomposition taking place near the surface is aerobic, while that near the bottom is anaerobic.**

✓**Such ponds having mixture of aerobic and anaerobic conditions, are called facultative ponds.**

✓**The oxygen required for aerobic decomposition is derived from surface aeration and algal photosynthesis, deeper ponds called lagoons, are mechanically aerated.**

✓**Oxidation ponds can be designed to provide complete treatment of raw sewage, but they require good deal of space.**

Hardness of Water

The presence of multivalent cations, specially calcium, magnesium, strontium, aluminium, ferrous and manganous ions are responsible for hardness of water.

Effect of hard water

When hard water is heated, calcium carbonate ($CaCO_3$) and manesium hydroxide ($Mg(OH)_2$ readily precipitated out from the solution, forming scale which ultimately affect water pipes, reduces the efficiency of water heaters, boilers and heat exchangers.

Types of hardness

Hardness are classified into temporary hardness and permanent hardness.

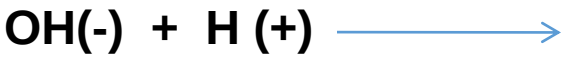
(i) Temporary or carbonate hardness is due to the dissolved salts of bicarbonates of calcium and magnesium and can be removed by boiling.

(ii) Permanent or non carbonate hardness is mainly due to the dissolved salts of chlorides and sulphates of calcium and magnesium.

Alkalinity of Water

The alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity of natural waters primarily due to the salts of weak acids, although weak or strong bases may contribute. Bicarbonates represent the major form of alkalinity, since they are formed in considerable amounts form the action of carbon dioxide upon basic minerals in the soil as shown in the following reaction .

The bicarbonates along with carbonates and hydroxides which are responsible for the alkalinity of water can be explained by the following reactions



Eutrophication

- **Eutrophication is a process whereby water bodies, such as lakes or slow moving streams receives excess nutrients that stimulate excessive plant growth. This enhanced plant growth, often called an agal bloom, reduces dissolved oxygen in water when dead plant material decomposes and can cause other organisms to die.**

- **Nutrients can come from many sources, such as fertilizers applied to agricultural fields, golf courses and deposition of nitrogen from the atmosphere, erosion of soil containing nutrients and sewage treatment plant discharges.**

- **Water with low concentration of dissolved oxygen is called hypoxic.**

- **Eutrophication generally promotes excessive plant growth and decay, favours certain weedy species over others, and is likely to cause severe reduction in water quality.**

- **In aquatic environments, enhanced growth of choking aquatic vegetation or phytoplankton disrupt normal functioning of the ecosystem, causing a variety of problems.**

Adverse effect of Eutrophication

- Adverse effects of eutrophication on lake, reservoirs, rivers and costal marine water.
- Toxic or inedible phytoplankton species.
- Increase in blooms of glatinous zooplankton.
- Increased biomass of benthic and epiphytic algae.
- Changes in macrophyte species composition and biomass.
- Decrease in water transparency.
- Taste, odour and water treatment problems.
- Dissolved oxygen depletion.
- Increased incidences of fish kills.
- Loss of desirable fish species.
- Reductions in harvestable fish and shell fish.
- Decrease in perceived aesthetic value of the water body.

Waste Management

The unwanted solid materials which is generated due to our activity is known as solid waste.

Due to increase in pollution, the amount of solid waste generation has been increased day by day.

Generally domestic solid wastes are biodegradable. Where as industrial solid wastes are non-biodegradable.

The solid wastes coming from industries is 15.25%, Mining solid wastes is 67%. The domesteic wastes is only 8.5%, 2% solid wastes produces due to construction activities.

Solid wastes also include Municipal solid waste, Sewage, sludge, plastics, medical wastes from hospital.

Proper solid waste management is necessary to avoid environmental pollution.

Classification of Solid Wastes

Classification of solid wastes in broader sense is

(a) Domestic Waste (b) Trade waste and (c) Industrial waste

- **Domestic waste: Waste material from houses and other residential area are classified as domestic waste.**
- **Trade waste: Unwanted material from retail, commercial and business premises are termed as trade waste. This can also termed as commercial waste.**
- **Industrial waste: Waste originated from different types of industries are termed as industrial waste.**

Classification of Municipal Wastes

Depending on the origin of municipal waste it can be classified as

(a) Institutional Waste: Schools, college, research organizations, religious places, community halls produces paper, polymer packaging material, rejected office stationeries are waste material. These waste material is generally use to call as institutional waste material.

(b) Constitutional Wastes: Repairing and construction activities produce huge amount of solid waste. Specially demolition of old construction activities generate large quantity of solid waste which include bricks, roofing, pipe, rods etc.

(c) Biomedical Wastes: The wastes are generated from hospital, nursing homes, clinics are treated as biomedical solid wastes. These biomedical wastes are also fall into the hazardous waste due to the presence of different infectious substances. The biomedical wastes are disposable syringes, used surgical dressing and gloves, expired drug etc.

(d) Agricultural Waste: Agricultural residue after harvesting of crop is generally treated as agricultural solid waste. Generally these consists of roots and stems of crop. Different type of insecticides are also contributing towards this type of waste materials.

(e) Burning Ashes: Ashes are produced after burning of solid fuel like wood, coal, coke etc. Burning of different type solid waste material will also produce ash.

(f) Hazardous Wastes: Those wastes which affect human, plant or animal life in adverse way. Some examples of hazardous wastes are toxic chemicals, radioactive wastes, explosives etc.

Causes of Solid Waste Pollution

The reason for the rapid growth in the quantity of solid wastes are:

(a) **Over-population:** The quantity of solid wastes generation in big cities is fixed per person. But due to increase in population density the total amount of solid waste generation is increasing day by day.

(b) **Affluence:** With affluence there is an increase in per capita consumption. As a result of which solid waste formation will increase.

(c) **Technology:** due to the advancement in technology for most economic goods indicate a shift in technology from the returnable packaging to non-returnable packaging. As a result of which returnable glass containers or bottles are being replaced by non-returnable and plastic containers. It is difficult to reuse those plastic packaging specially in food packaging industry. Ultimately it will increase the solid waste formation.

Solid Waste Management

Huge disposal of solid wastes, especially of hazardous wastes causes adverse effect to environment. The main objective of solid waste management is to minimize this adverse effect. Solid waste management can be done by the following steps:
(1) Collection, (2) Storage (3) Transportation (4) Recycling (5) Treatment and (6) Disposal.

Collection: the efficient collection of solid waste leads to dumping of waste management. Improper collection of solid waste leads to dumping of waste in the open spaces.

Storage: The waste bins act as storage points. Cleaning of those waste bins is necessary for avoiding unhygienic condition. Storage facilities are not yet developed in some urban areas.

Transportation: the solid waste collected from the bins are finally transported to waste disposal site by truck. The frequency of transportation is controlled by municipal authorities and entirely depend on the rate of solid waste formation.

Disposal: this is the final step in solid waste management. Due to the unorganized solid waste disposal causes environment pollution. Generally solid wastes are disposed off in low land area. Disposal of solid waste can be done by three ways (1) Land fill (2) Incineration and (3) Composting.

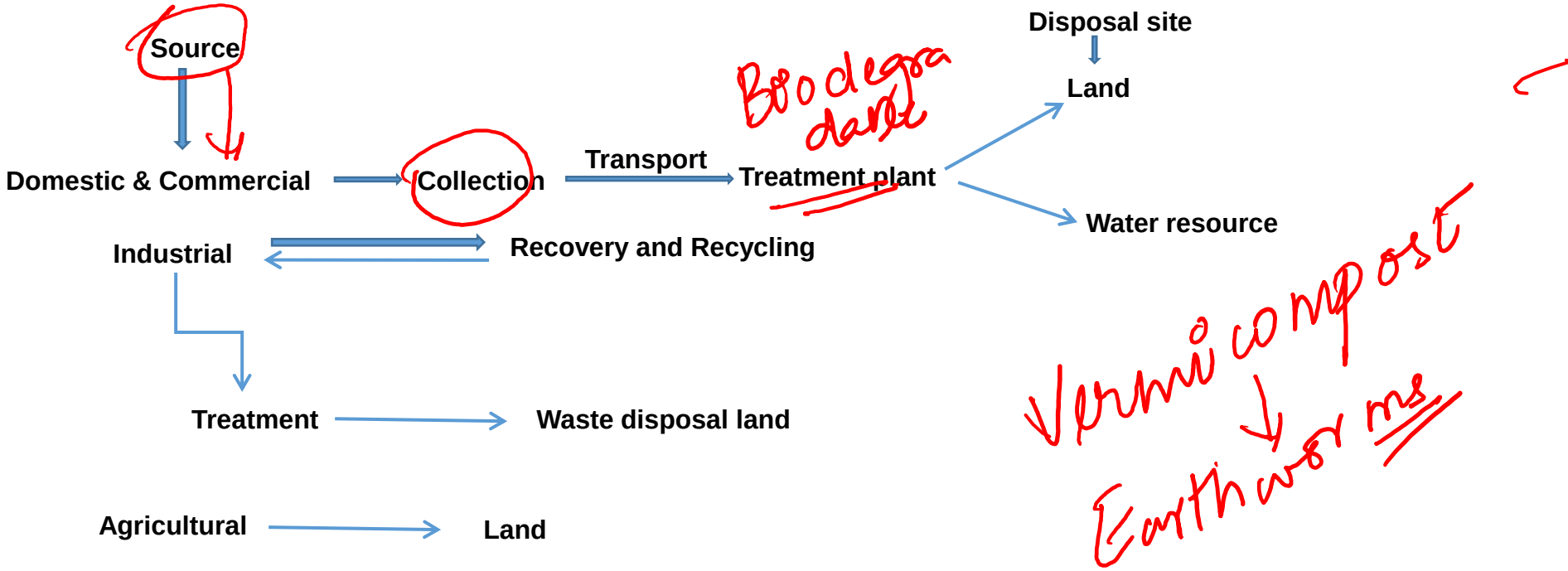
(1) **Landfill:** landfill method is a very useful method for solid waste disposal. By using this method we can reduce the storage of huge amount of solid waste into space. Which ultimately pollute water, land and air. In land filling, the solid wastes are compacted and spread in thin layers over a low land area, each layer being uniformly covered by thin layer of soil. The final layer is covered by a final cover of about one meter of earth to prevent solid waste scattering. Land filling is a biological method of solid waste degradation and it will produce CO_2, CH_4, NH_3 as renewable source of energy.

(2) **Incineration:** Combustion of solid waste at a temperature range of 900-1200 ^oC in a specially designed furnace is known as incineration. Various types of rotary kil, air –controlled incinerators have been used for this purpose. Volume of the waste an be reduced up to 90% by this process. The completion of combustion in an incinerator depends on following factors:

(a) The temperature in the combustion chamber.
(b) The time span that combustion takes place.
(c) The amount of turbulence or degree of mixing.
(d) The amount of oxygen available for combustion.

(3) Composting: Bacterial decomposition of the organic compounds of the municipal solid wastes result in the formation of compost and the process is named as composting. For composting a pit is prepared in a waste land. All the biodegradable wastes are put into pit and covered by the soil. Here the soil is act as a source of micro-organisms. Sometimes water and nutrients are also added into that soil for sufficient growth of micro-organisms. Biodegradation of waste is an aerobic process. Micro-organism convert the degradable organic waste into humus like substances. Periodically, the waste is turned over to allow aeration i,e., penetration of oxygen to all parts of the waste materials.

Depending on the nature of waste, there are different methods of waste disposal.



Hazardous Wastes

Hazardous wastes are those wastes which has more detrimental effect on surrounding environment in comparison to ordinary wastes. US Federal Resources Conservation and Recovery Act define hazardous waste as "corrosive ignitable, reactive or toxic or capable of posning substantial threats to human health and the environment and are to be treated separately from all over wastes".

Hazardous wastes has following characteristics.

1. **Ignitability: Catches fire easily. The several types of petroleum hydrocarbon wastes are more ignitable than other wastes due to their low flash point. Those wastes are also categorized as hazardous waste.**
2. **Corrosiveness: It can corrode both living and non-living substances by different types of chemicals reaction. Generally this type of corrosive wastes are highly acidic or alkaline in nature.**
3. **Toxicity: Hazardous wastes has toxic effect on the living system when they are absorbed by living system. It can causes poisoning, metabolic disorders, cancer etc.**
4. **Reactivity: Those wastes are very reactive towards natural environment, also termed as hazardous wastes. This type of wastes can easily react with water and other chemical very easily. Due to this type of reaction they can produce toxic gases to the environment.**

Toxic Chemicals in Air

Occupational safety and Heath Administration and Consumer Product safety Commission listed 24 extremely hazardous substances in the atmosphere.

These Chemicals are

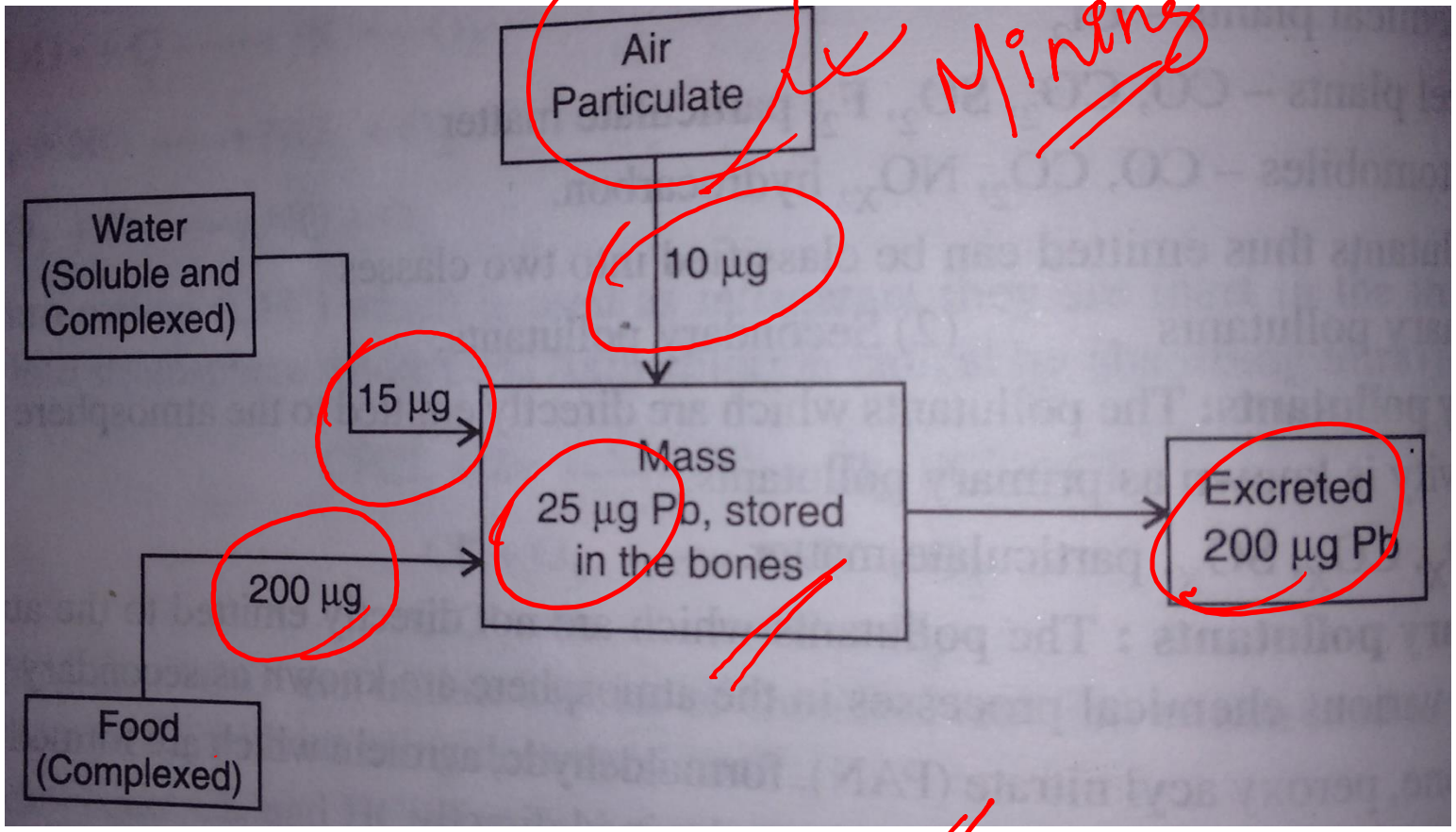
Acrylonitrile, As, asbestos, benzene, Be, Cd, chlorinated solvents, chloro fluro carbons, chromates, coke oven emissions, diethyl stilbeesterol, dibromo chloropropapne, ethyl dibromide, ethylene oxide, Pb, Hg, nitroso amines, O_3, polybrominated biphynyls, radiations, SO_2, vinyl chlorides etc.

Toxic Elements

Lead (Pb)

Sources of Lead Pollution

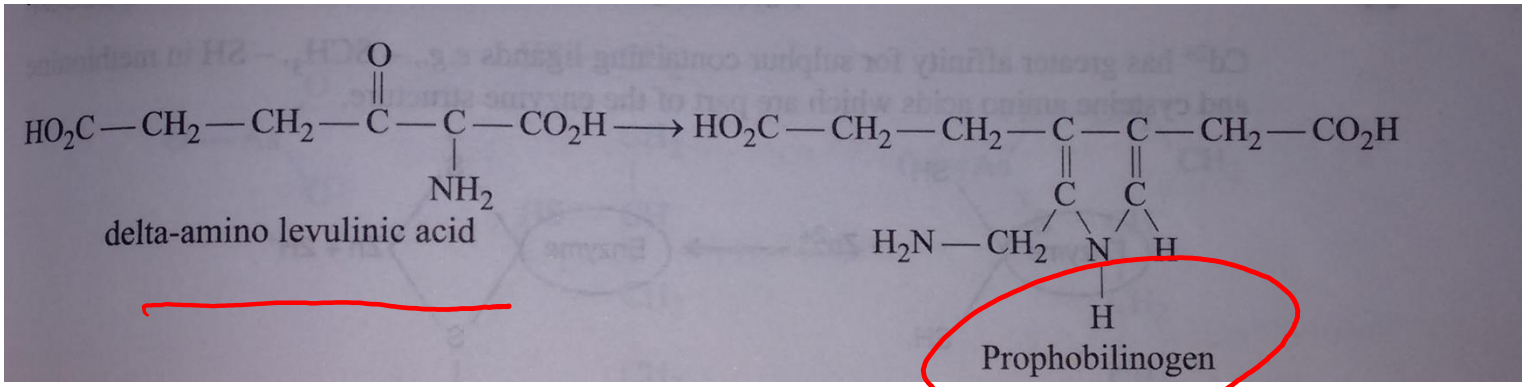
- The major sources of air borne lead is the combustion of leaded petrol/gasoline. Pb is added in the form of tetra-alkyl lead, primarily $Pb(CH_3)_4$ and $Pb(C_2H_5)_4$, together with scavangers 1,2- dichloro ethane and 1, 2- dibromo ethane.
- Mining and refining.
- Electrical storage battery industry.
- Ceramic industry.
- Agricultural industry (Preparation of insecticides ex:- lead arsenate)
- Paints, pigments, varnishes.
- Hair dyer, eye paints, canned foods, sea food, painted toys etc.
- Water pipes made of lead can get leached, causing further lead pollution.


Air
Particulate
Water
(Soluble and
Complexed)
10 µg
15 µg
Mass
25 µg Pb, stored
in the bones
Excreted
200 µg Pb
200 µg
Food
(Complexed)

Bio-Chemical Effects of Lead (Pb)

The major biochemical effect of Pb is its interference with heme synthesis, which leads to hematological damage.

1. Pb inhibits the reaction of the key enzymes involved in the overall process of heme synthesis. One such intermediate is delta-amino levulinic acid. An important phase of heme synthesis is the conversion of delta amino levulinic acid to prophobilinigen.



Pb inhibits the activity of delta amino levulinic acid enzyme so that it cannot proceed futher to form porphobiliniogen. The overall effect is the disruption of the synthesis of haemoglobin as well as other respiratory pigment such as cytochrome which require heme. Finally Pb does not permit utilization of O_2 and glucose for life sustaining energy production.

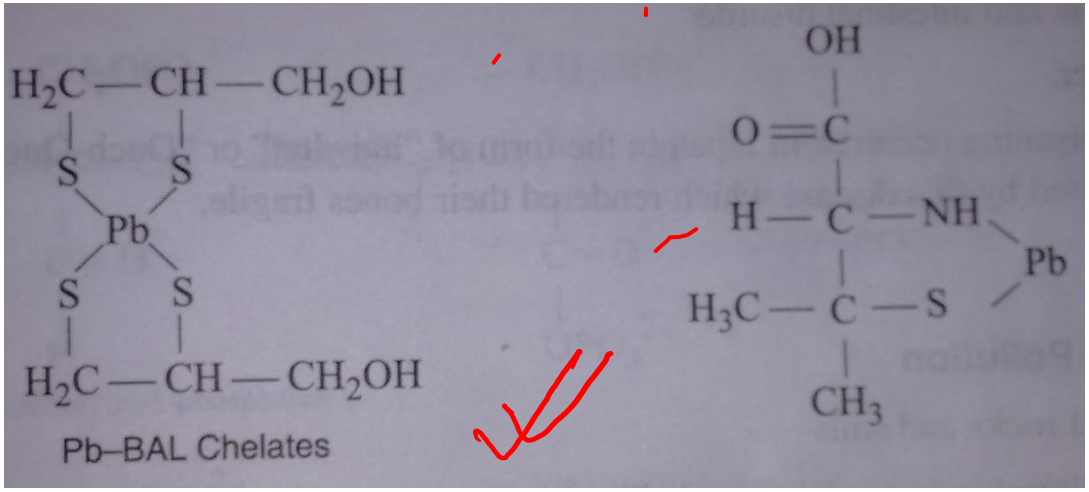
1. Liver and Kidney damage
2. Mental retardation in children.
3. Genetic modification.

Antidote for Lead Poisoning

1. Lead poisoning can be cured by treatment with chelating agents which strongly bind Pb (+2). Thus if we incorporate Ca- chelate of EDTA in our body system then Pb(+2) replaces Ca (+2) from the chelate and the resulting Pb(+2) chelate is rapidly excreted in urine.

Ca-EDTA + Pb (+2) ⟶ Pb-EDTA + Ca (+2)

2. Other two types of chelates are generally used for Pb- poisoning.



Pb–BAL Chelates

Cadmium

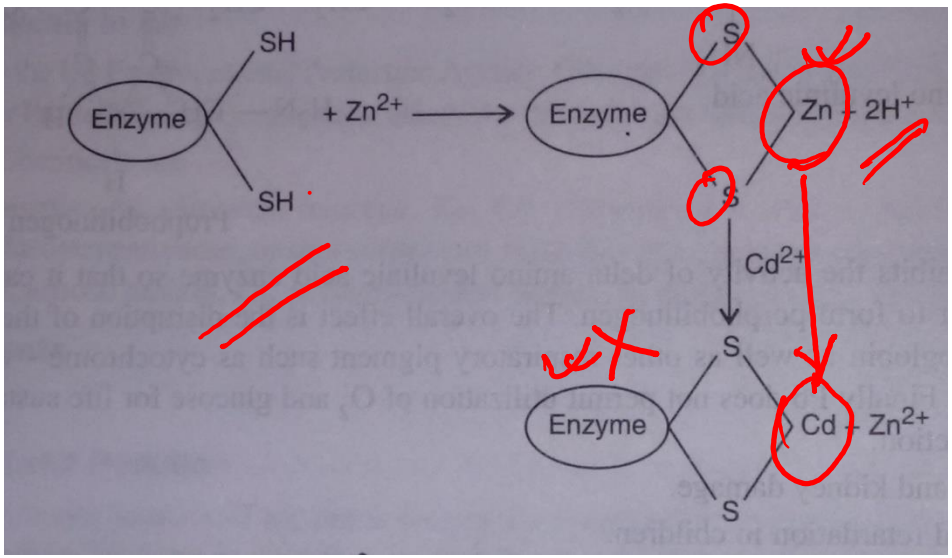
Sources of Cd pollution

1. Industrial effluent
2. Cadmium nickel batteries.
3. Nuclear fission plants.
4. Water pipes.

Biochemical effect of cadmium

Cadmium occurs in nature in association with zinc minerals. Growing plants acquire Zn and they also take up and concentration Cd with the same biochemical set up.

1. The Cd (+) thus absorbed, replace Zn(+) as they have similar size and charge, and get attached to the active sites of enzymes which leads to cadmium toxicity inhibiting its essential enzymatic function.



Cd (+2) has greater affinity for sulphur containing ligands e,g., -SCH_3, -SH in methionine and cysteine amino acids which are part of the enzyme structure.

The enzymes inhibited by Cd (+2) include (1) adenosine triphosphate (2) alkaline phosphate (3) Carbonic anhydrase.

2. Kidney damage.

3. Renal dysfunction.

4. Hypertension

5. Bone marrow disorder.

6. Gastric and intestinal disorder.

7. Cancer

8. Anaemia

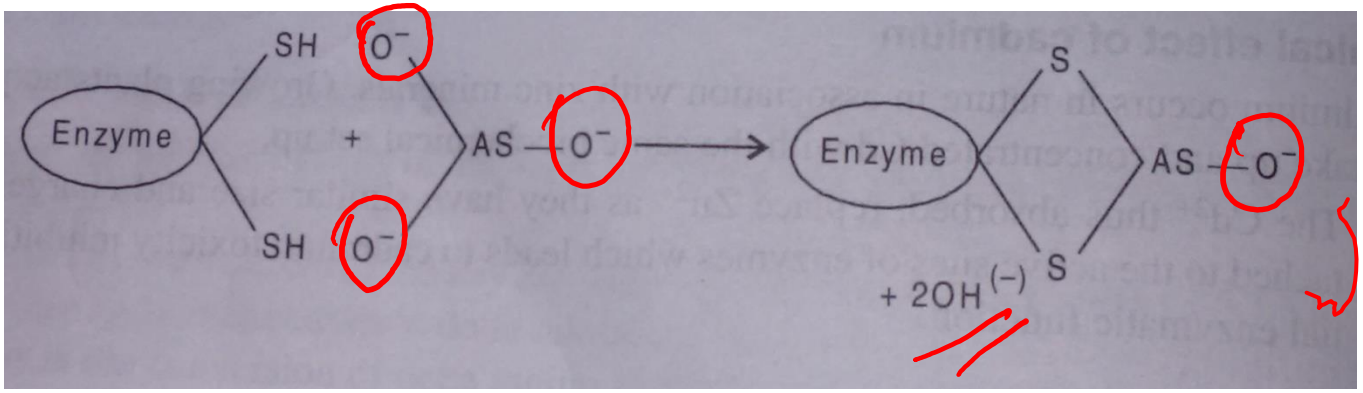
Arsenic (As)

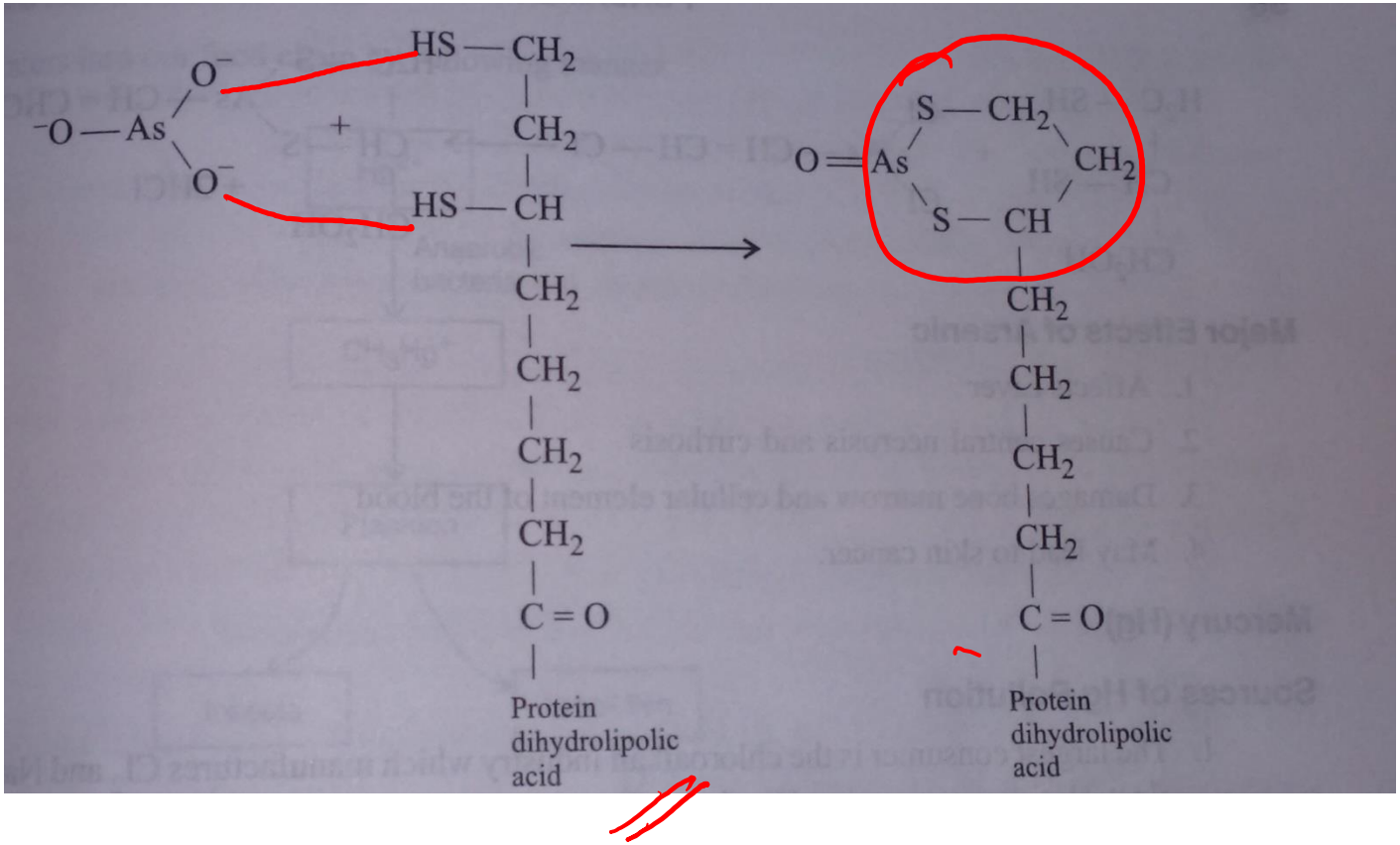
Sources

1. Natural rocks.
2. Agricultural industry (chemicals like As_2O_3, lead arsenate.
3. Fungicides, pesticides, herbicides.
4. Mining and extraction.
5. Glass industry.

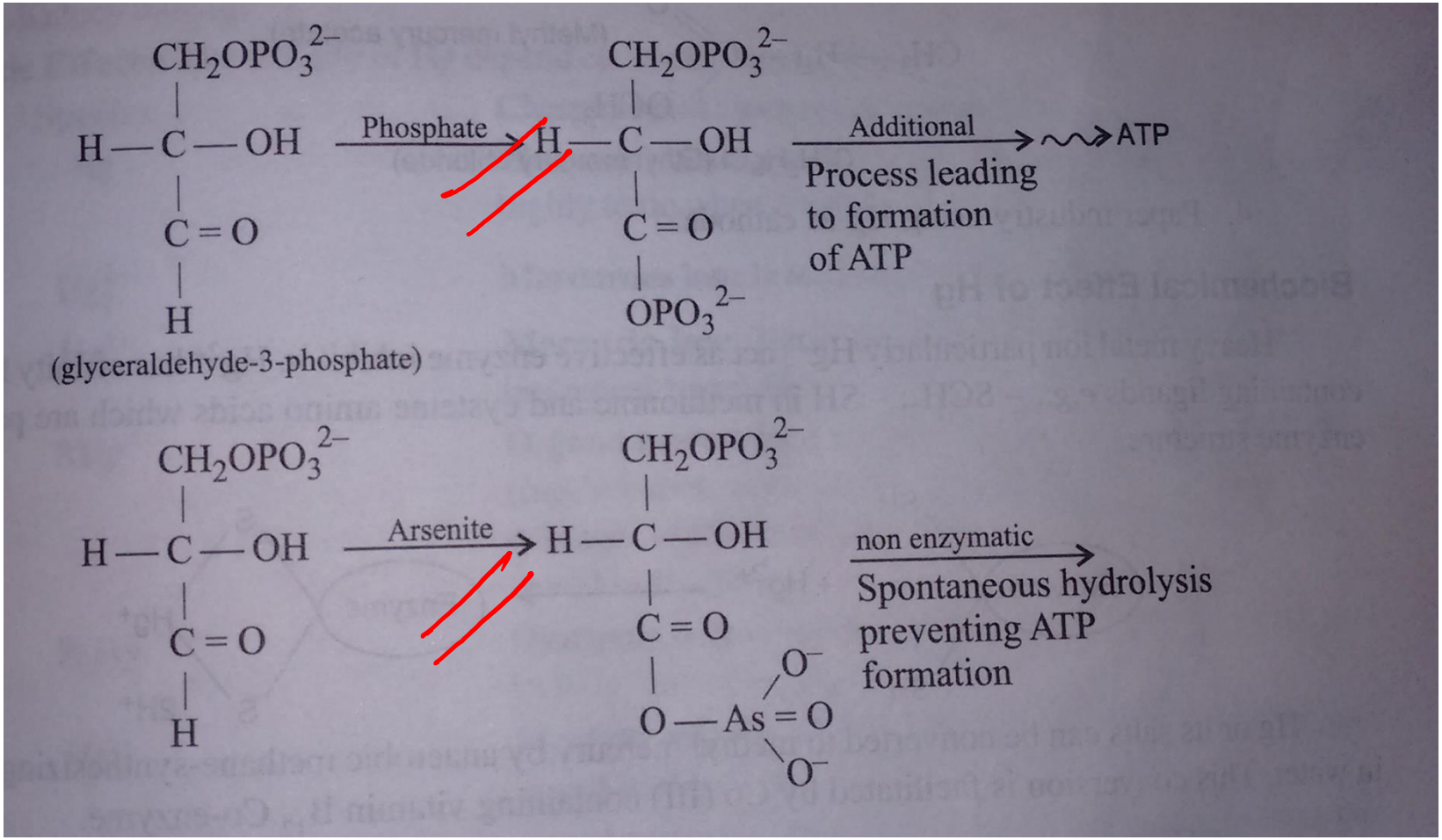
Biochemical effects of As

1. Among its compounds As(III) are toxic. As (III) exerts its toxic action by attacking –SH group of an ezyme and thereby inhibiting the enzyme action.





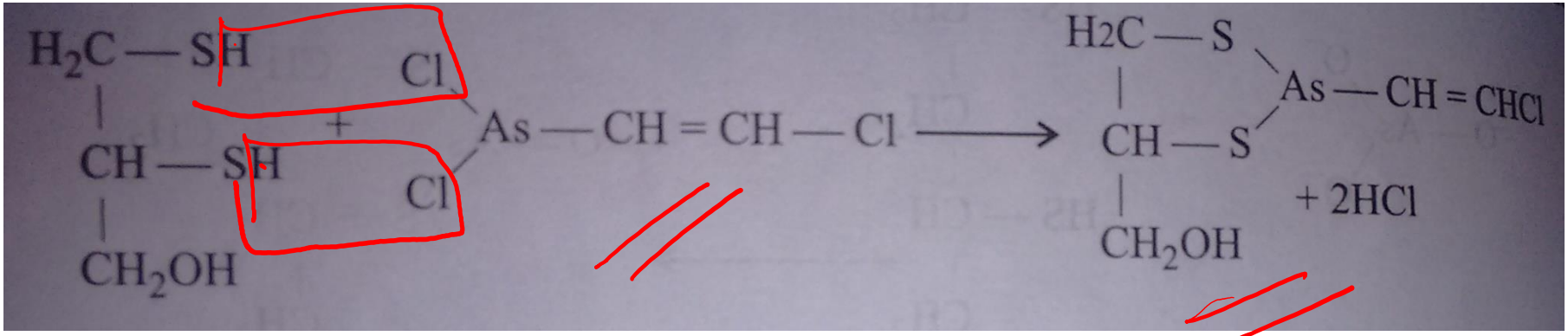
2. Due to its chemical similarity with P, As interferes some biochemical processes involving P. As inhibits the formation of biochemical generation of energy yielding substance ATP.


CH2OPO3 2–
H — C — OH
C = O
H
(glyceraldehyde-3-phosphate)
Phosphate
CH2OPO3 2–
H — C — OH
C = O
OPO3 2–
Additional
ATP
Process leading to formation of ATP
CH2OPO3 2–
H — C — OH
C = O
H
Arsenite
CH2OPO3 2–
H — C — OH
C = O
O
O⁻
As = O
O⁻
non enzymatic
Spontaneous hydrolysis preventing ATP formation

Antidote for Arsenic Poisoning

The antidote for As poisoning is 2, 3 dimercapto propanol which is popularly known as B. A. L.

B. A. L. binds to arsenic strongly and removes it from the system in the form of complex.



Major Effects of Arsenic

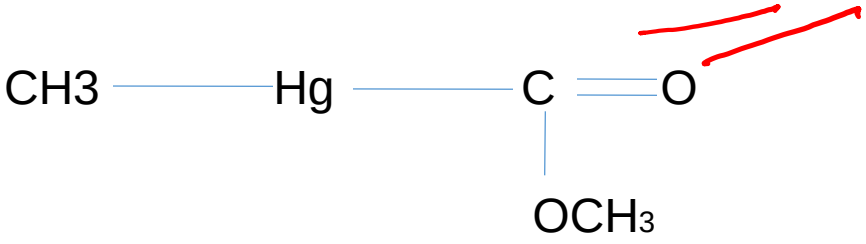
1. Affects Liver.
2. Causes central nercrosis and cirrhosis.
3. Damages bone marrow and cellular element of the blood.
4. May lead to skin cancer.

Mercury (Hg)

Sources of Hg Pollution

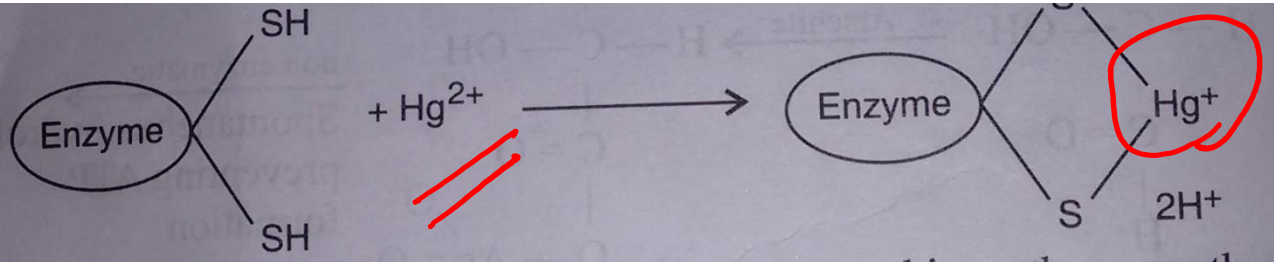
1. The largest consumer is the chloroalkali industry which manufactures Cl_2 and NaOH by an electrolytic process using Hg electrode.
2. The second largest consumption of Hg in the production of electrical apparatus such as Hg-vapour lamp, electrical switches, Hg-batteries etc.
3. The third largest consumer is the agricultural industry using a large number of fungicides. Some typical compounds which has been used as fungicides are

CH3-Hg-C ≡ N (Methyl mercury nitrile)

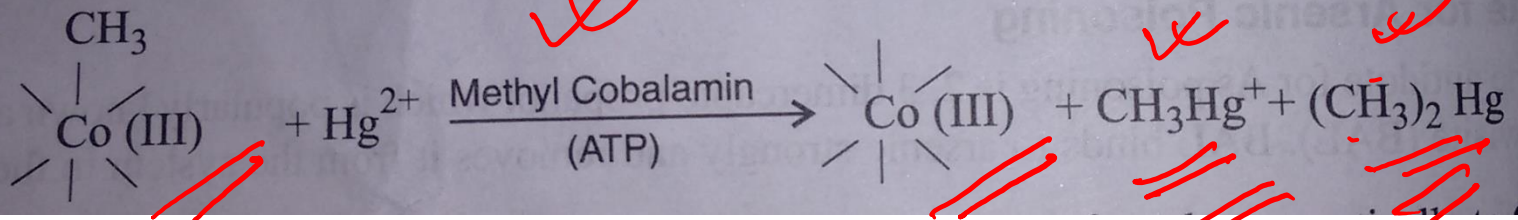


Speciation

Biochemical Effect of Hg



Hg or its salts can be converted to methyl mercury by anaerobic methane-synthesizing bacteri in water. This conversion is facilitated by Co (III) containing vitamin B_{12} Co-enzyme.



Adverse Effects of Mercury

I. Blurred vision
II. Deafness
III. Mental disorder
IV. Kidney damage

Hg enters into the food chain by following manner