Ecosystem

① Define ecosystem and classified them

or

What is ecosystem ? Explain different type of ecosystem.

⇒ Ecosystem :- it is the community of living thing and non-living component which dependent up on each other in a specific environment.

Example :- Pond, river, Forest, Desert etc.

Ecosystem is classified in to two type :-

(I) Natural ecosystem

(II) Artificial ecosystem

Natural ecosystem :- Natural ecosystem is the system which occurs naturally with out involving any human support or interfarence.

Eg :- Forest, River, Ocean, Pond, Desert etc.---

Artificial ecosystem :- Artificial ecosystem are the ecosystem which are made by human and operated by human.

Eg :- Zoo, lake, Aquarium, Garden, Park etc.

Again natural ecosystem is of two type :-

(I) Aquatic ecosystem

(II) Terrestrial ecosystem

Aquatic ecosystem :- The interaction of living thing and non-living component with each other in water ecosystem.

Eg :- Pond, River, Ocean etc.

Terrestrial ecosystem :- The interaction of living thing and non-living component with each other in land ecosystem.

Eg :- Forest, desert ecosystem etc.....

Again aquatic is of two type :-

(I) Fresh water ecosystem

(II) Marine water ecosystem.

Fresh water ecosystem :- The interaction of living thing and non-living component with each other in fresh water.

Eg :- Pond, Rivers, swamp, bogs etc.....

There are too freshwater ecosystem :-

(1) Lentic ecosystem

(11) lotic ecosystem

Lentic :- it is the relationship between living thing and non-living component with each other in motion less water

Eg :- Pond, swamp, bog etc.....

Lotic :- it is the relationship between living thing and non-living component in flow water

Eg :- River, Ocean, stream etc.....

Marine water ecosystem :- The interaction of living thing & non-living component in ~~marine~~ marine water with each other

Eg :- Ocean, sea etc

Marine ecosystem is also devided in two category :-

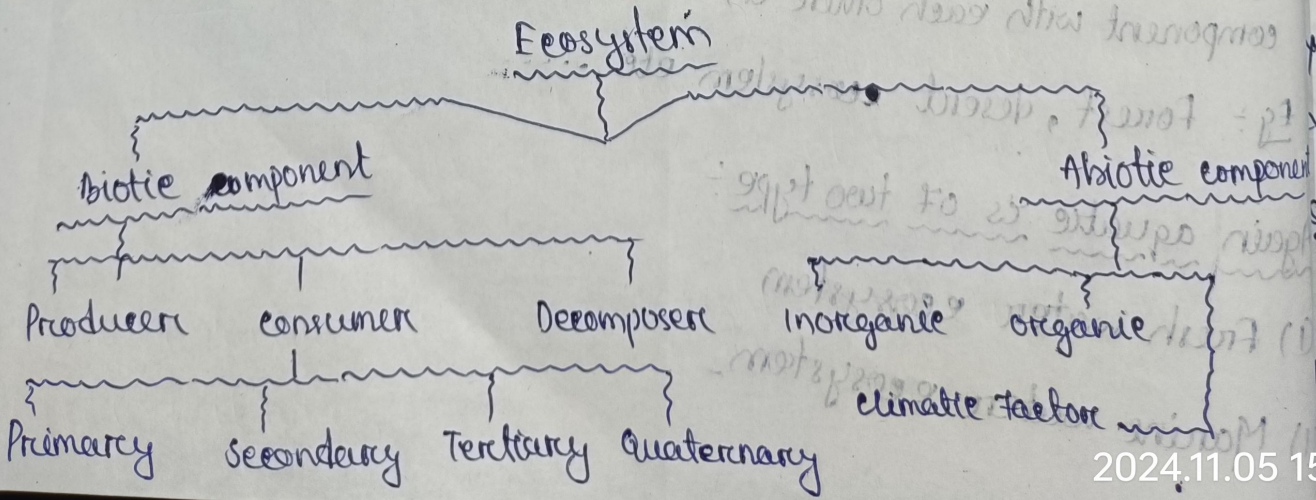
(1) Ocean ecosystem

(11) Coastal ecosystem

Ocean ecosystem :- These include the deep sea, bays, estuaries, coral reefs, mangrove system, salt marshes etc.

Coastal ecosystem :- These include beaches, estuaries, mangrove forest, coral reefs & see grass.....

② Define structure of ecosystem



Biotic :- Biotic refers to the living thing in ecosystem.

→ Biotic are dependent on abiotic element for survival

→ Biotic are directly or indirectly affect the other organism.

→ Animals, Birds & micro-organism are involves in biotic ecosystem.

Biotic is divided in three part :-

(1) Producer

(2) consumer

(3) Decomposer.

Producer :- The organism which produce their own food by the process of photosynthesis.

→ Producer are also called autotrophs.

→ They do not depend on other for the food.

→ Eg :- Green plant, blue-green algae etc.

consumer :- The organism which do not produce their own food & dependent on other for food.

→ consumer are also called hetrotroph

→ Eg :- Rabbit, Goat, Deer, Rat etc ..... or all the animals.

consumer is divided in four types :-

(1) Primary consumer

(ii) secondary consumer

(iii) Tertiary consumer

(iv) Quaternary consumer

Primary consumer :- Primary consumer are organism which eat the producer (directly)

→ Primary consumer also called herbivores.

→ Eg :- Grass hopper, Goat, Deer etc.

secondary consumer :- These are the organism which eat all the primary consumer.

→ secondary consumer also called carnivores.

→ Eg :- Small bird, small fish, frog etc.

2024.11.05 15:52

Tertiary consumer :- These are the organism which feed up on secondary consumer.

→ These organism are also called secondary carnivores.

→ Eg :- Big fish, snake etc.

Quaternary consumer :- These are the organism which eat both the herbivores & carnivores.

→ They are eaten by other animal

→ Eg :- Eagle, Lion, tiger, etc.

Decomposer :- These are the organism which break down the dead body of plant and animal in to simple substance.

Eg :- Bacteria, fungi, micro-organism etc.

Abiotic :- Abiotic refers to non-living component.

→ Abiotic element do not depend up on biotic element.

→ Affect the individual of species, community, population and bioshphere.

→ component include, climate temprature, parent material etc

Abiotic component include

(i) Inorganic substance

(ii) Organic substance

(iii) climatic factor.

Inorganic substance :- Inorganic substance, such as carbon, nitrogen, oxygen, sulphur, calcium etc & their compound form such as water, carbon dioxide, Nitrate etc.

Organic substance :- These include carbohydrates, fats, protein, lipids etc. These are present in living organism and dead organic.

climatic factor :- These include light, temprature, humidity, rainfall etc....

③ Explain food chain with example & write the characteristic of food chain.

→ food chain :- food chain is define as the sequential transfer of energy & nutrient from organism to organism in the form of food.

Eg :- grass → grass hopper → frog → snack → Eagle.
grass → grass hopper → bird → Eagle etc :-

Length of food chain

(i) Producer :- it is the 1st trophic level. These are the organism produce their own food.
Eg :- green plant, blue-green algae etc....

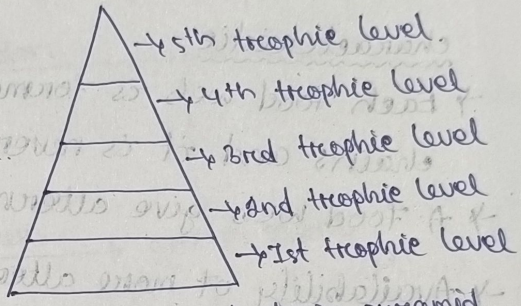


Fig :- food chain pyramid.

(ii) Primary consumer :-
→ it is the 2nd trophic level.
→ These organism eat the producer.
→ Eg :- grass hopper, goat, deer etc....

(iii) Secondary consumer :- These are the organism of third trophic level
→ They eat the primary consumer.
→ Eg :- [redacted], fish (small), small bird etc...

(iv) Tertiary consumer :- it is the fourth trophic level.
→ These organism eat the secondary consumer.
→ Eg :- Big fish, snake etc.

(v) Quaternary consumer :- it is the fifth trophic level. It ~~is~~ can eat the carnivores & herbivore & no one can eat it.
→ Eg :- Eagle, tiger, lion etc.

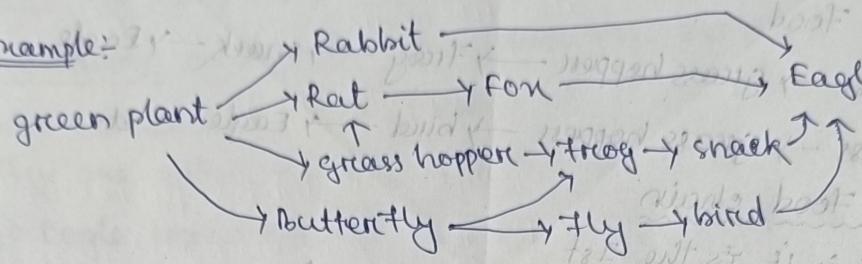
characteristic of food chain :-
→ A food chain involves transfer of food energy from organism to organism of an ecosystem
→ In a food chain, energy ~~is~~ flow is in unidirection.
→ usually there are 3-4 trophic level in a food chain, in few cases there may be 5 trophic level.
→ Omnivores organism occupy any position or different position in different food chain.

2024.11.05 15:52

④ Define food web with example & give it characteristic.

→ Food web :- Food web is define as the network of interconnected food chain, that shows how energy or nutrient transfer in an ecosystem.

Example :-



characteristic :-

→ Each food web is formed by the interlinking of food chains and it is never be straight.

→ A food web give alternating ~~co~~ link of food availability

→ Availability of more alternative in food web, make the ecosystem more stable.

→ Food web help in development of ecosystem.

⑤ Explain carbon cycle with diagram.

→ carbon cycle :- carbon cycle is the process of exchange of carbon between atmosphere, ocean, land and the living thing.

→ carbon play an important role because it can form protein and DNA.

step involving carbon cycle :-

→ carbon present in atmosphere is used by plant or producer to produce their food.

→ These plant are eaten by the animal and digested. Then the carbon is accumulated in to their body.

→

→ These animal and plant eventually die, and the decomposer decompose them, some carbon are release in to atmosphere by decomposer.

→ some carbon that not release back in to the atmosphere, eventually become fossile fuel.

→ These fossil fuel are used for man-made activities. Resulting in more carbon emmision to the atmosphere in the form of carbon dioxide.

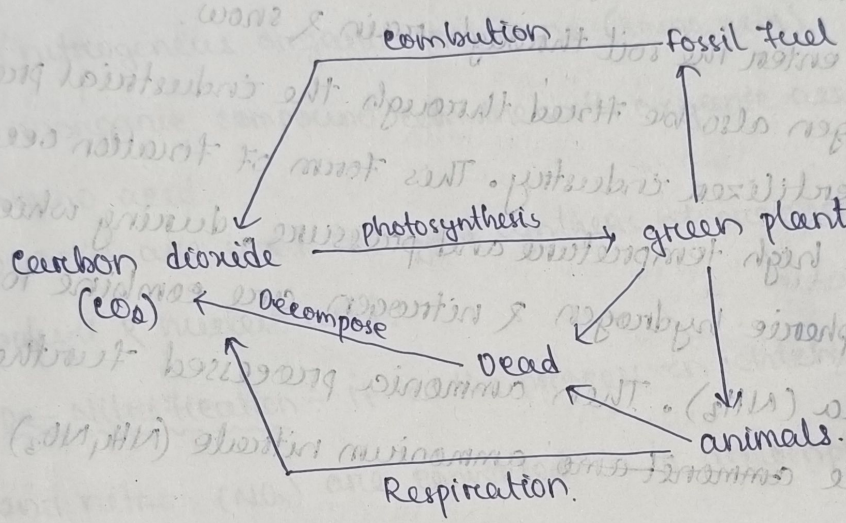


fig: carbon cycle.

⑥ Explain the nitrogen cycle:

⇒ Nitrogen cycle: Nitrogen cycle is the process of movement of nitrogen through both living and non-living things and through the atmosphere, soil, water, plant & animals etc.

There are five stages in the nitrogen cycle which include:

(i) Nitrogen fixation
(ii) Ammonification
(iii) Nitrification
(iv) Nitrogen assimilation
(v) Denitrification.

Stage-1 - Nitrogen fixation

The process of converting nitrogen in to biological available nitrogen (organic compound) is called nitrogen fixation.

→ Eg :- NO, NO_2, NO_3, NH_4^+, NH_3 etc.

→ A small amount of nitrogen fixed when lightning provide the energy needed for nitrogen to react with oxygen to form the nitrogen oxide (NO) & nitrogen dioxide (NO_2) then enter the soil through rain & snow.

→ Nitrogen also be fixed through the industrial process in fertilizer industry. This form of fixation occurs under high temperature and pressure, during which atmospheric hydrogen & nitrogen are combine to form ammonia (NH_3). Then ammonia processed further to produce ~~ammonia and~~ ammonium nitrate (NH_4NO_3)

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

→ Most nitrogen fixation occurs naturally in the soil by bacteria.

Stage-2 :- Ammonification

It is the process of releasing ammonia by micro-organism from dead organic remains of plants & animals. And excrete of animal.

→ Eg :- actinomycetes & bacilli.

Stage-3 - Nitrification :- The process in which the ammonia is converted in to (NO_2) Nitrites & (NO_3) nitrate is called nitrification.

2024.11.05 15:53

→ These nitrate are used by plants & animals, that consume the plants.

→ Nitrification occurs in presence of oxygen that is oxygen rich environment, like circulation of flowing water & surface layer of soil & sediment.

stage:- 4 Nitrogen assimilation :- In this process of inorganic nitrogen that is nitrates, nitrides and ammonia is absorved by the green plant, or through their roots & then it converted in to nitrogeneus orgeanic compound (Amino acid)

→ These inorganic compound combine with orgeanic acid to form the amino acid.

→ Amino acid are used to ~~syn~~ synthesis of proteins, enzyme chlorophyll & nucleic acid.

stage-5 De-Nitrification :- it is the process in which the nitrite (NO_2) and nitrate (NO_3) are converted in to atmosphereic nitrogen is called de-nitrification.

(7) Explain the sulphur cycle.

=> sulphur :- it is associated with the foods heaving high rich protein such as dairy products, eggs, fish, meat & sea food ..

sulphur cycle :- sulphur cycle is described as the movement of sulphur through ocean, land and atmosphere.

Process of sulphur cycle :-

→ In atmosphere sulphur is found in the form of sulphur dioxide (SO_2) and ~~enter~~ enters in three ways. from (i) decomposition of orgeanic molecules (ii) Volcanic & geothermal vents (iii) burning of fossil fuel by human.

→ sulphur deposited on land by four way namely, Precipitation, direct fallout from the atmosphere, rock weathering & go geothermal vent.
→ sulphur enters the ocean via runoff from land, from atmospheric fallout & through under water geothermal vent.
→ In atmosphere the sulphur come in contact with the air & is converted in to sulphate.
→ These sulphate are consumed by plants & microbes & are converted in to organic form.
→ converted organics forms of sulphur is then consumed by animal, & thus sulphur moves in the body of animal.
→ when animal and plant dead some of the sulphur are released to the atmosphere by the decomposers, thus sulphur cycle get completed.

(8) Explain sulphur cycle.

Explain phosphorus cycle :-

→ phosphurus is an essential nutrient for all living organism. like animal and plant.
→ It play an important role in cell development and is key component molecules that store energy, such as DNA, ATP & lipids.
→ phosphurus cycle is defined as the movement of phosphurus between soil & some organism like plant and animal.
→ sulphur cycle involve three step :-

(I) Weathering
(II) Absorption by plant & animal
(III) Return to the enviroment

Weathering :

→ The main source of phosphorus is found in rocks.

→ In phosphurus cycle the rock are breack down in the phosphurus phosphate salt by weathering.

→ These salt are washed away in to the ground & get mixed in to the water & soil.

Absorption by plant and animal :

→ plant, fungi and microorganism are able to absorbs phosphate salts, dissolved in water & ground.

→ The plant are also absorbs the phosphorus from soil directly.

→ The animal are also get phosphurus from the drinking water or eating plant.

→ The phosphorus present in soil is very less, so the farmer us the fertilizer to supply the phosphorus to the crop ~~from~~ for well growing.

Return to the environment :

→ when plant and animal are die they are decomposed by microorganism.

→ In this process the organic form of phosphurus converted in to inorganic form and return back to the environment in the form of rock or in the soil.

(7) Explain the nitrogen cycle

⇒ Nitrogen cycle : Nitrogen cycle is define as the movement of nitrogen through atmosphere, soil, water, plant and animals etc.

→ Nitrogen cycle involves five steps :-

(i) Nitrogen fixation.
(ii) Nitrogen assimilation
(iii) Ammonification
(iv) Nitrification.
(v) De-nitrification.

* Nitrogen fixation :- Nitrogen fixation is the process of converting the nitrogen in to biological available nitrogen (compound organic) called nitrogen fixation.

→ there are three way of nitrogen fixation :-

(a) Lightning :- A small amount of nitrogen can be fixed when lightning provide the energy needed for nitrogen react with oxygen to form nitrogen oxide (NO) & nitrogen dioxide (NO_2)

($N_2 + O_2 \longrightarrow NO$ then $NO + O_2 \Longrightarrow NO_2$)

→ The nitrogen dioxide is combine with water & form nitric acid. ($NO_2 + H_2O \longrightarrow HNO_3$)

→ The nitric acid is react with calcium oxide and form calcium nitrate $Ca(NO_3)_2^+$ & give nitrate ion or nitrate form ($HNO_3 + CaO \longrightarrow Ca(NO_3)_2^+$)

(b) By industrial process (Fertilizer industry)

→ Nitrogen can also be fixed through the industrial process in fertilizer industry. This form of fixation occurs under high heat & pressure, during which the atmospheric hydrogen and

2024.11.05 15:53

nitrogen are combine to form ammonia (NH_3).
($N_2 + H_2 \longrightarrow NH_3$)

→ Further ammonia is passing through the carbon dioxide to form urea. ($NH_3 + CO_2 \longrightarrow NH_2\overset{O}{\overset{\|}{C}}NH_2$ (urea))

→ When urea is combine with water it give ammonia.
($NH_2\overset{O}{\overset{\|}{C}}NH_2 + H_2O \longrightarrow NH_3$)

→ Again ammonia is combine with hydrogen to give ~~ammonium~~ ammonium ion. ($NH_3 + H^+ \longrightarrow NH_4^+$)

(c) Biological process: Most of the nitrogen fixation occures under the soil by bacteria.

→ Here the atmorphereic nitrogen & hydrogen are combine to form ammonia then it combine with hydrogen atom & give ammonium ion. ($N_2 + H_2 \rightarrow NH_3 + H^+ \longrightarrow NH_4^+$)

Step-2 Nitrification: it is the process in which the ammonia is converted in to the Nitrite (NO_2) & Nitrate (NO_3) is called nitrification.

→ The ammonia had produced in industry & biological process is converted in to nitrite (NO_2) & (NO_3) by the process of nitrification. ($NH_3 \rightarrow NO_2^- \longrightarrow NO_3^-$)

→ The nitrate is the only form which can used by plant and animal.

→ Nitrification occures in presence of oxygen that is oxygen rich enviroment like circulation of flowing water, surface layer of soil, sediments etc.

Step-3 Nitrogen assimilation

In this process inorganic nitrogen such as nitrates, nitrite, ammonia are absorbed by the plant through their roots & converted in to organic compound (amino acid).

→ The inorganic compound combine with organic compound to form amino acid -

→ Amino acid is used to prepare proteins, lipids, enzymes & nucleic acid etc -

($NO_3^- \longrightarrow NO_2^- \longrightarrow NH_4^+ \longrightarrow$ Amino acid $\longrightarrow$ Protein)

Step-4 Ammonification : It is process of releasing ammonia by the micro-organism from dead organic remain of plants, animals & excret of animal -

→ Antinomycetes & bacili convert the protein in to amino acid then in to ammonia -

(Protein $\longrightarrow$ Amino acid $\longrightarrow NH_3$)

→ By the process of nitrification the ammonia is converted in to nitrite (NO_2) & nitrate (NO_3).

($NH_3 \longrightarrow NO_2^- \longrightarrow NO_3^-$)

Step-5 Denitrification : It is the process in which Nitrite (NO_2) & Nitrate (NO_3) are converted in to atmoshpheric nitrogen.

→ The nitrate is converted in to nitrite, then nitrite is converted in to nitrogen oxide. Further nitrogen oxide is convert in to Nitrous oxide or laughing gas, then it finally converted in to atmoshpheric nitrogen (N_2)

→ $NO_3^- \longrightarrow NO_2^- \longrightarrow NO \longrightarrow N_2O \longrightarrow N_2\uparrow$.

2024.11.05 15:53

(9) Explain the global warming and it causes

=> Global warming :- Global warming is define as the long term increase in earth's average surface temp. due to increase in amount of green house gasses such as carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O) chlorofluro carbon (CFC) & water vapour etc called global warming.

-> All the green house gasses present in atmosphere filter & scatter a large quantity of solar radiation falling on the earth.

-> 49% of solar radiation reaches to earth & 1% is absorved by the plant.

-> The solar radiation falling on the earth surface reflected back as infra-red radiation in to the atmosphere.

-> Most of the infra-red radiation absorved by the gasses present at the atmosphere & ~~re-emmit~~ re-emitted in all direction.

-> These re-emitted infra-red radiation ~~warm~~ keep the earth surface warm.

Green house effect :- Warming of earth surface and troposphere cause by the presence of water vapour, carbon dioxide, methane, chlorofluro carbon, & Nitrous oxide is called green house effect. The gasses are called green house gasses.

Causes of global warming

-> Human are adding large amount of carbon dioxide to the atmosphere by burning fossil fuels in home,

automobiles, industries & burning associated with agriculture practice. And by the deforestration.

→ A large amount of methane gas is added by biogas, cattle shades, & Paddy field to the atmosphere.

→ chlorofluorocarbon are emitted to the atmosphere by the refrigerator & air conditionar etc.

→ Nitrous oxide is produced from the organic matter & fertilizer by bacteria as well as automobiles & industry.

→ These are the main causes of global warming.

(10) Explain ozone depletion.

⇒ Ozone depletion :

→ Ozone is a tri-atomic molecules made up of three atom oxygen. $(O=O^{+}-O^{+})$

→ ~~Ozon layer~~ Good amount of ozone is present in the upper part of the atmosphere called stratosphere.

→ The rich zone of ozone in atmosphere is called ozon layer or ozonosphere.

→ The layer of ozone allow the low energy uv radiation & do not allow the high energy uv (ultraviolet) radiation to reach the earth surface.

→ The thining of the ozone layer is commonly called ozone depletion.

→ Causes of ozone depletion : Due to the increase of the green house gases and harmful chemical, fire extinguisher, air conditionar, Once release in to air, these harmful chemicals produce "active chlorine" (Cl & ClO radicals) in the presence of

uv radia
etion, They
oxygen.
Ozone depl
→ The substa
in to mol
air conditio
Ozone depl
→ The thining
pass throug
→ These cau
such as sk
cat eye, c
in mother

2024.11.05 15:54

UV radiation. These radicals through the chain reaction, They destroy the ozone by converting in to oxygen.

Ozone depleting substance (ODS)

→ The substance which destroy the ozone by converting in to molecules of oxygen. like CO_2, NH_4, CFC, N_2O, air conditionar, fire extinguisher, & harmful chemical.

Ozone depletion effect:

→ The thining of ozone layer allow the more UV radiation to pass through & strick the earth surface.

→ These cause harmful effect on human, animal, plant such as skin cancer, herpes, dimming of eye sight, cataract eye, lower the immunity system & increased embryos in mothers uterus, & global warming.

GOVT. POLYTECHNIC MAYURBHANJ, TIKARPADA

SUB: ENVIROMENTAL SCIENCE
(COMMON FOR ALL BRANCHES)

TOPIC: AIR & WATER POLLUTION

SEMESTER: 1ST & 2nd

FACULTY NAME : KUNI MAJHI, SR . LECTURER

Introduction:

- ***We still have too much air and water pollution and we still need to work to reduce it. But we also need to put the problem of pollution into a historical as well as scientific perspective***".

Ronald Reagan, Ex-president of United States of America

- The air is composed of 78% nitrogen, 21% oxygen, and 0.9% argon. The remaining elements include carbon dioxide, water vapour, hydrogen, and other trace elements.

- **The atmosphere is a delicate balance of elements and particles**.
- Air pollution **occurs when there is an alteration to the composition of air.**
- The main sources of air pollution are **transportation, factory emissions, biomass consumption, agriculture production etc.**

- The air pollution is **caused due to excessive concentration of suspended particulate matter (SPM), carbon dioxide, nitrogen oxide in the atmosphere emitted from the sources that burns fuel.**

- Air pollution including noise pollution is a significant risk factor for **human health conditions, causing allergies, respiratory and cardiovascular disease as well as lung damage**.
- It is also a major contributors to **global warming** and **climate change**.

DEFINITION OF POLLUTION AND POLLUTANT

- The word pollution come from Latin word **"*polluere*"** that means **contamination**.
- Hence in layman terms, **the pollution is something that contaminates the environment**.
- It may be defined as **the presence of harmful substances in the air, water and soil which can have adverse effect on living beings and on the environment**.
- Due to pollution, **undesirable changes occur in the physical, chemical or biological characteristics of air,water and soil that may be harmful for any living organism**.

Types of Pollution: There are mainly **five types of pollution**:

- Air Pollution
- Water pollution
- Land pollution
- Noise pollution
- Radioactive pollution

Air Pollution

- Air pollution may be defined as **the undesirable presence of one or more contaminants such as dust, fumes, gas, mist, odour, smoke, or vapour which are detrimental to human health in particular and the planet as a whole**.
- Air pollution in many cases **prevents photosynthesis process in plants** which has serious consequences on the purification of air we breathe.
- It is a major contributor to **global warming** and **climate change**.
- Air pollution is indeed a significant risk factor for **human health conditions, causing**

allergies, respiratory and cardiovascular diseases.

Water Pollution

- Water pollution can be defined as **the contamination of a stream, river, lake, ocean or any other water body, degrading water quality and rendering it toxic for the environment and human**.
- The **main causes** of water pollution include **sewage and waste water, urbanisation and deforestation, agriculture, industries, marine dumping and radioactive waste.**
- Water pollution **harms biodiversity and ecosystem**.
- It has **very negative impacts on human health**.
- Many **diseases such as diarrhea, cholera, typhoid, dysentery and skin infection** result from drinking or being in contact with contaminated water.

Land Pollution

- Land pollution refers to **any physical or chemical changes in soil condition that may adversely affect the human health, plants and animals.**
- Most soil pollutants are **agricultural chemical, fertilizers and pesticides**.
- **Dumping of waste** which may include municipal wastes, untreated sewage, industrial effluents etc. also pollutes the soil when harmful substances from **dump leak** into it.

Noise Pollution

- Noise pollution can be defined as **any unwanted or disturbing sound that effects the health and wellbeing of humans and other organism.**
- Sound is measured in **decibels**. Sound that reaches **85 decibels or more** is considered **harmful for human ear.**
- Noise pollution has its **impact on millions of people on daily basis**.
- The most common **health problem in human is hearing loss**.
- Exposure to loud noise may also **cause high blood pressure, heart disease, sleep disturbances and stress.**
- The main **sources** of noise pollution include **traffic noise, air traffic noise, construction noise, catering and night life, animals etc.**

Radioactive Pollution

- Radioactive pollution is defined as **increase in the natural radiation level in the environment caused mainly by human activities.**
- The sources of radiation pollution involve **any process that emanates(produced) radiation in the environment**.
- **Causes of radiation** pollution include **research and medical procedures and waste, nuclear power plants, TVs, computers, radio waves, cell phones etc.**
- However, the most common ones that can pose moderate to **serious health risks are: Nuclear explosions and detonations of nuclear weapons, Defensive weapon production, Nuclear waste handling and disposal, Mining and Nuclear accidents.**

Pollutants

- Pollutants are the **harmful substances which brings undesirable and harmful changes in the physical, chemical or biological characteristics of air, water and soil.**
- **Smoke from industries and automobiles, domestic and commercial sewage, radioactive substances from nuclear plants and discarded household articles (tins, bottles, broken crockery etc.) comes under the category of pollutants.**

Types of Pollutants:

Pollutants can be categorised into 5 types as follows:

1.Water Pollutants: The runoff from industries, agriculture fields and even from urban areas contribute largely to the water pollution. In addition, **raw sewage** is a major pollutant of water.

2.Soil Pollutants: The main source of soil pollutant include **municipal and industrial wastes, overdose of pesticides and herbicides etc.**

3.Air Pollutants: The major source of air pollutant is burning fossil fuels and it happens due to factory emission and automobiles. Also **acid rain** has adverse effect on forests and their inhabitants.

4.Noise Pollutants:
Major noise pollutant include **horns of automobiles, loudspeakers, fire crackers, electrical appliances, traffic noise etc.**
5.Radioactive Pollutants:
Radioactive pollutant include **radiation released in nuclear power plant accidents, use of nuclear weapons, mining, spillage of radioactive chemicals, cosmic and other natural sources like gamma rays, radiation used for the treatment of diseases like cancer etc.**

Natural and manmade sources of air pollution:

Air pollution may be caused by various processes and it may be **natural or manmade (anthropogenic).**

1.Natural sources of air pollution:

It is caused due to continuous and temporary natural events and it cannot be prevented. Natural sources of air pollution are described below:

i)Volcano Activities: Volcanic eruptions **emit a series of toxic gases including sulphur and chlorine.** It also **emits particulate matter in the form of ash particles**.
Volcanic eruptions are restricted to localized area.

ii)Winds and Air Current: It can be **mobilise(movable) soil and other pollutants and spread it over the large areas.**

iii)Wild Fires: It emit **carbon monoxide and particulate matter into the atmosphere.**
It may affect significant areas although they can be restricted and contained to small area.

iv)Microbial Decaying Process:

Microorganisms present in the environment have a major role in **natural decaying processes of living organisms.** This activity results in the **natural release of gases** especially **methane gas** and causes air pollution.

v) Increasing Temperature: It contribute to **an increase in the amounts of contaminants volatilizing** from polluted soil and water into the air.

Manmade sources of air pollution:

It is **caused due to human activities** and it has **huge impact on environment and also on all of us.** Manmade sources of air pollution are described below:

i) Mining and Smelting: Crushing & processing of mineralogical deposits emits a variety of metals into the atmosphere and creates pollution.

ii) Foundry Activities: It emits a variety of metals into atmosphere due to processing of metallic raw materials (including the use of furnaces).

iii) Various Industrial Processes:

These may emit both organic and inorganic contaminants through accidental spills and leaks of stored chemicals or mis-handling and storage of chemicals–especially inorganic chemicals of volatile nature.

iv) Transportation:

Vehicles emits a series of air pollutants in the form of gases such as carbon monoxide, sulphur oxides, nitrogen oxides and particulate matter.

v)<u>Construction and Demolition Activities:</u> These activities **pollute the air with various** Construction materials, specially demolition of old buildings which may contain a series of **banned chemicals such as PCBs, PBDEs, Asbestos** etc.

vi)<u>Coal Power Plants:</u> Burning of coal in coal power plant may **emit a series of gases as well as particulate matter with metals (such as As, Pb, Hg) and organic compounds (especially PAHs: Poly Aromatic Hydrocarbons).**

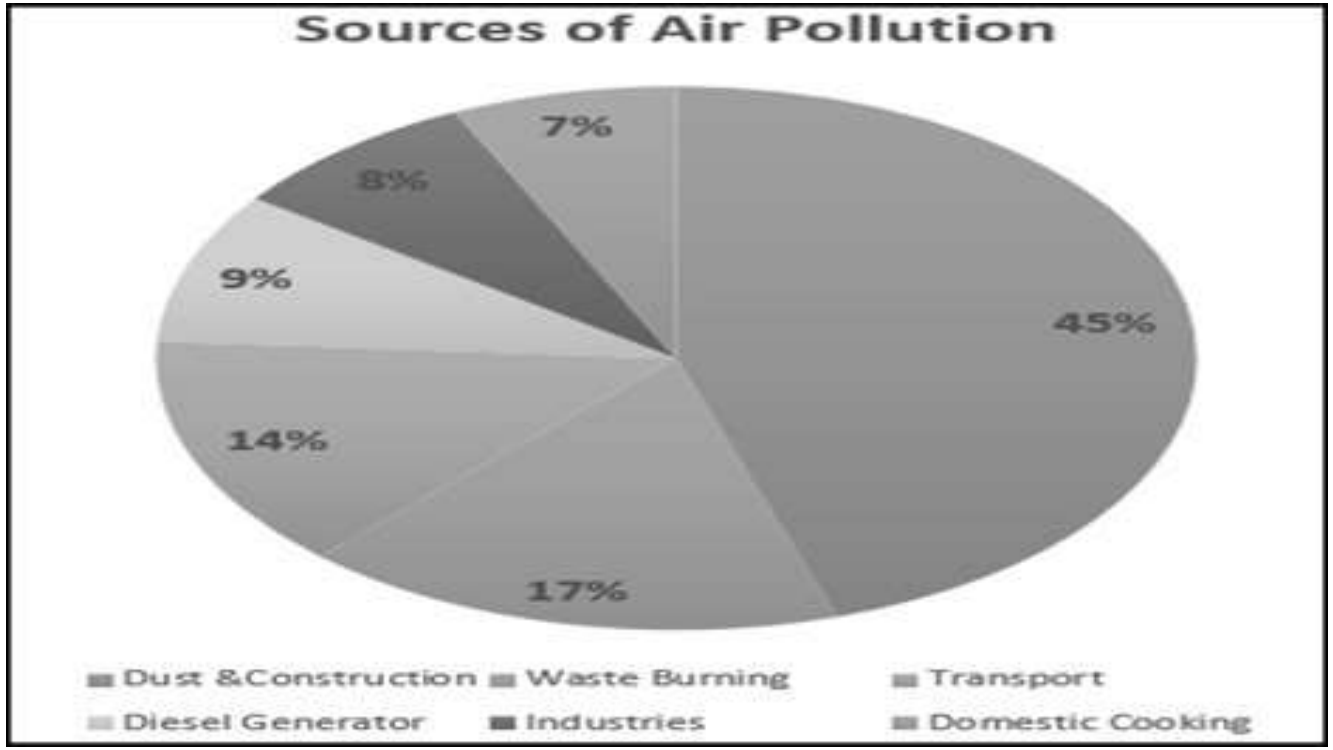
vii)<u>Waste Incineration</u>: In this process, **various toxic gases, and particulate matter is emitted** into the atmosphere, depending on the composition of waste.

viii)<u>Landfill Disposal Practices:</u> Due to the **natural microbial decaying activity in the disposal area methane gas is generated and pollute the environment**.

ix)<u>Agriculture:</u> Agricultural activity pollute the **air through emissions of ammonia gas and the application of pesticides/herbicides/insecticides which contain toxic volatile organic compounds.**

x)<u>Defence Activities:</u> These activities may **pollute the air by emitting toxic gases through practices and training.**

xi)<u>Smoking</u>: Smoking emits a series of toxic chemicals including a series of organic and inorganic chemicals, some of which may be **carcinogenic** also.
xii)<u>Storage and Use of Household Products</u>: House hold products such as **paint, sprays, varnish,** etc. that contains organic solvents which volatilize in the air and we feel smell while using them.
xiii)<u>Refrigerants:</u> It is used in various electronic equipment such as refrigerator, air-conditioner etc. These are mainly **responsible for creating greenhouse effect in the atmosphere, that warms the planet.**



Manmade Sources of Air Pollution

- **I.C. Boilers:** These are **combustion devices used to heat water or to produce steam. I.C. Boilers creates** air pollution by **emitting hazardous air pollutants in the atmosphere.**

Air Pollutants

- ***"Air pollution is the excessive concentration of foreign matter in the air which adversely affects the well-being of the individual or cause damage to property".***

-American Medical Association

- The foreign matter which causes air pollution are called air pollutants. Air pollutants include gasses, liquid droplets and solid particles. They are classified according to the source of emission into two main groups: **(i) Primary Pollutants and (ii) Secondary Pollutants.**
- **i)Primary Pollutants :**The Primary Pollutants are **emitted from a source directly into the atmosphere.**
- The **source** can either be a **natural processes such as sand storms, volcanic eruption or anthropogenic (by humans) such as industrial and vehicle emissions**.
- The **major primary pollutants** are **oxides of Sulphur, Nitrogen,Carbon, Particulate matter, Methane, Ammonia, Chlorofluorocarbons(CFCs),Toxic metals etc.**

ii)Secondary Pollutants :

- The Secondary Pollutants are **not emitted directly.** They are **formed in the atmosphere when the primary pollutants react with themselves or with the other components of the atmosphere.**
- Major secondary pollutants include **photochemical oxidants and secondary particulate matter.**
- Photochemical oxidants result from the photochemical reactions between sunlight and nitrogen oxides, Sulphur dioxide, or volatile organic compounds. They mainly include acids, nitrogen dioxide, Sulphur trioxide, and ozone.
- **Ozone** is considered as highly dangerous air pollutant. Exposure to ozone can cause many **lung diseases** such as **asthma, emphysema, and bronchitis. Repeated and long exposures to ozone may even permanently scar the lung tissues.**

❖ Particulate Pollutant (particulate matter):

- Air quality at any location is determined by the level of pollutants present in the air and it depends on the types and amount of pollutants released into the air. The level of pollutants in the air can vary greatly from one location to the other and from one hour to the next.
- Particulate pollution is **one of the most complicated forms of air pollution. The pollutant responsible for particulate pollution is called particulate pollutant** & also known as **particulate matter**.
- It is an amalgamation(combining) of different particles both solid and liquid, that behave in a similar ways and are of similar size.

- **Particulate matter is sub-divided** into different categories **based on particle size <u>i.e. PM10, PM2.5 and PM0.1</u>.**

- **<u>PM10:</u> PM10** also known as ***coarse particles***, is defined as **all particles with an aerodynamic diameter of 10 µm or smaller.**
- **PM10** also contains **PM2.5 and PM0.1**. These particles can pose significant **health threat** as it can **penetrate into our lungs**. Once these particles get into our lungs, it can **irritate the lung tissue** and can **prompt asthma attacks**.
- It can also **irritate our airways, nose, throat and eyes**.
- Its **sources** may include **construction site dust, road dust or natural dust storm, agricultural processes, plant, insects, pollen grains as well as non-combustible materials released during the burning of fossil fuels.**
- **<u>PM2.5 :</u> PM2.5** also known as ***fine particles***, is defined as **all particles with an aerodynamics diameter of 2.5 µm or smaller.**

Fine particles:

- Fine particles can come from **natural or human-made sources, like: vehicle exhaust, wildfires, power plant emissions and other combustion activities.** Unlike PM10, PM2.5 can not only enter into our lungs but also permeate our bloodstream.
- **PM10 particles get stuck up in our respiratory track** and can't penetrate deep into our body, as PM2.5 does.
- **PM2.5** can **flow to other parts of our body like our brain and heart and can cause inflammation and damage**. PM2.5 contributes to the same problems as PM10 and additional ones like, **respiratory disease, reduced immune response, congenital Disabilities**.

❖ Fine particles:

- **PM0.1** also known as ***ultrafine dust***, is defined as **all particles with an aerodynamics diameter of 0.1 µm or smaller.** It is **smaller than fine dust** and originates from the similar sources as PM2.5. Research indicates that ultrafine dust poses a worse threat than PM2.5, as the smaller particle size can infiltrate into our body to an greater extent.
- Recent studies show that **PM0.1 displays** enhanced **cardiovascular toxicity** and greater potential for **oxidative stress**. Overall, ultrafine dust is to be taken seriously and additional research will shed light on the further differences between it and PM2.5.
- **Emission of particulate matter can be controlled or removed from a polluted stream by a variety of physical processes.** Common types of **equipment for collecting particulate matter** include **Bag filters, cyclone separators, electrostatic precipitators, and scrubbers.** Once collected, particulates adhere to Each other, forming agglomerates(collect) that can readily be removed from the equipment and disposed off, usually in a landfill.

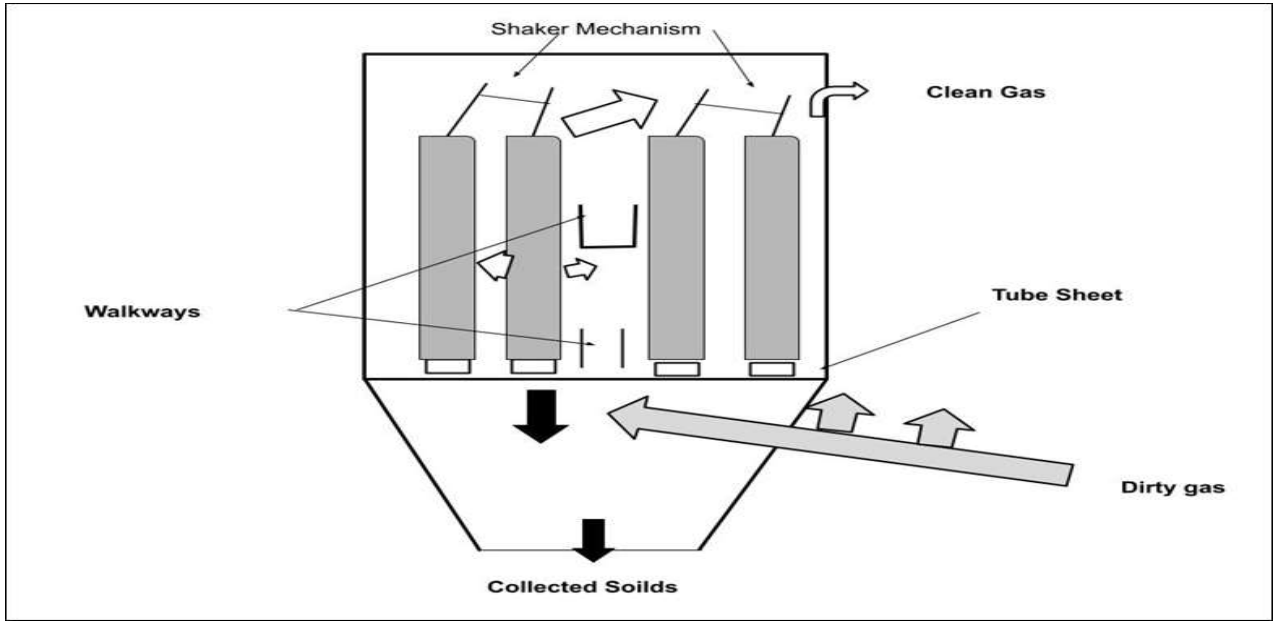
Bag filters (Bag house) :

- Bag filters, commonly known as ***baghouse or dust collector*** is an pollution control device used to **remove particulate matter from the contaminated gas stream by depositing the particles on bag filters.**
- These bag filters are **made up of fabric materials**. The filter is usually in the form of **cylindrical fabric bags** but it may also be in the form of **cartridges that are made up of fabric, sintered metal(Powdered metal) or porous ceramic.**
- In general, **bag filters are capable of collection efficiencies greater than 99 percent.**
- There are following **three types of bag filters** and they differ from each other **in the method of cleaning the filter material**.

1. Shaker bag filters
2. Reverse air bag filters
3. Pulse jet type bag filters

1.Shaker Bag Filters:

- The shaker bag filters consists of **vertical casing made up of cylindrical bags, bottom hopper and a tube sheet between the vertical casing and the hopper**.
- The cylindrical bags are closed at the top. At the top of the casing, a shaking mechanism is attached.
- The **contaminated gas stream enters into the hopper, flows through the holes of the vertical sheet and inside the vertical bags, leaving the dust cake on the inside surface of the bag filters.**
- Periodically, the gas flow is stopped and bags are shaken to clean them.
- The dislodged(remove) dust cake falls into the hopper and finally removed from the collector.



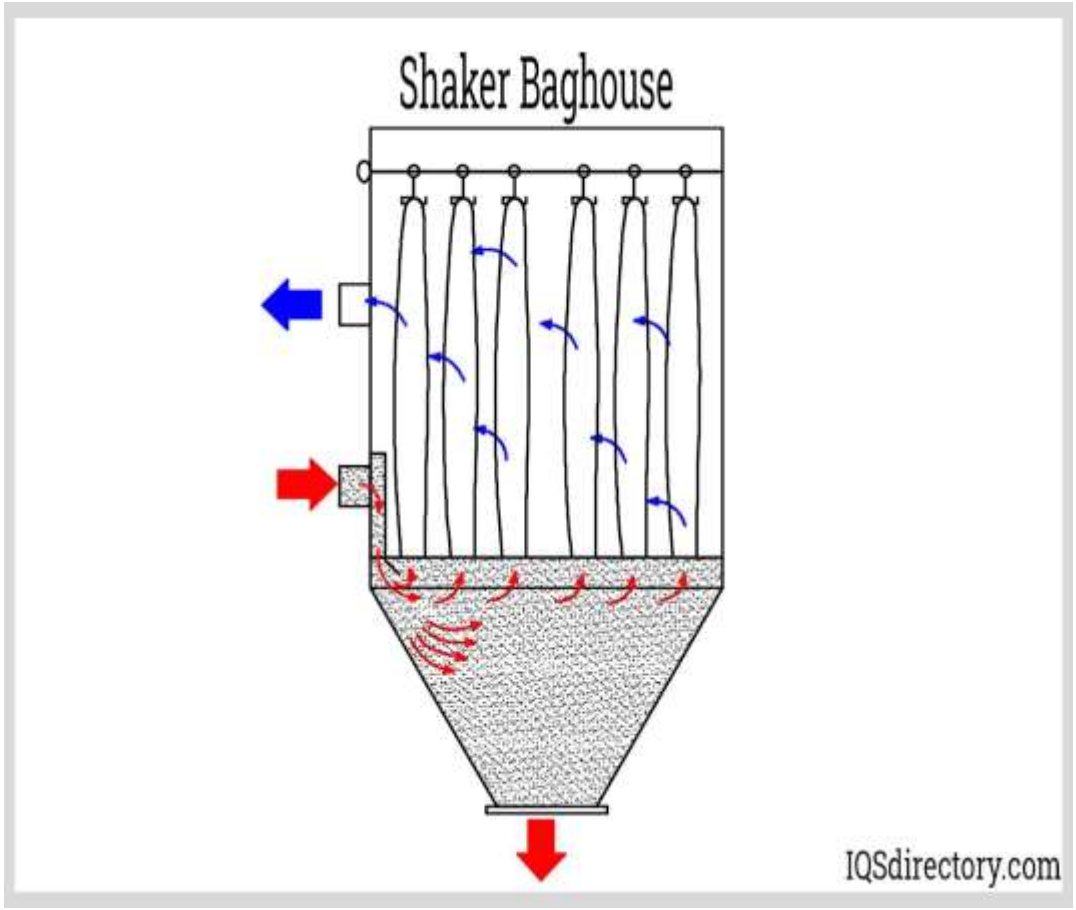


Figure: Shaker Bag Filters

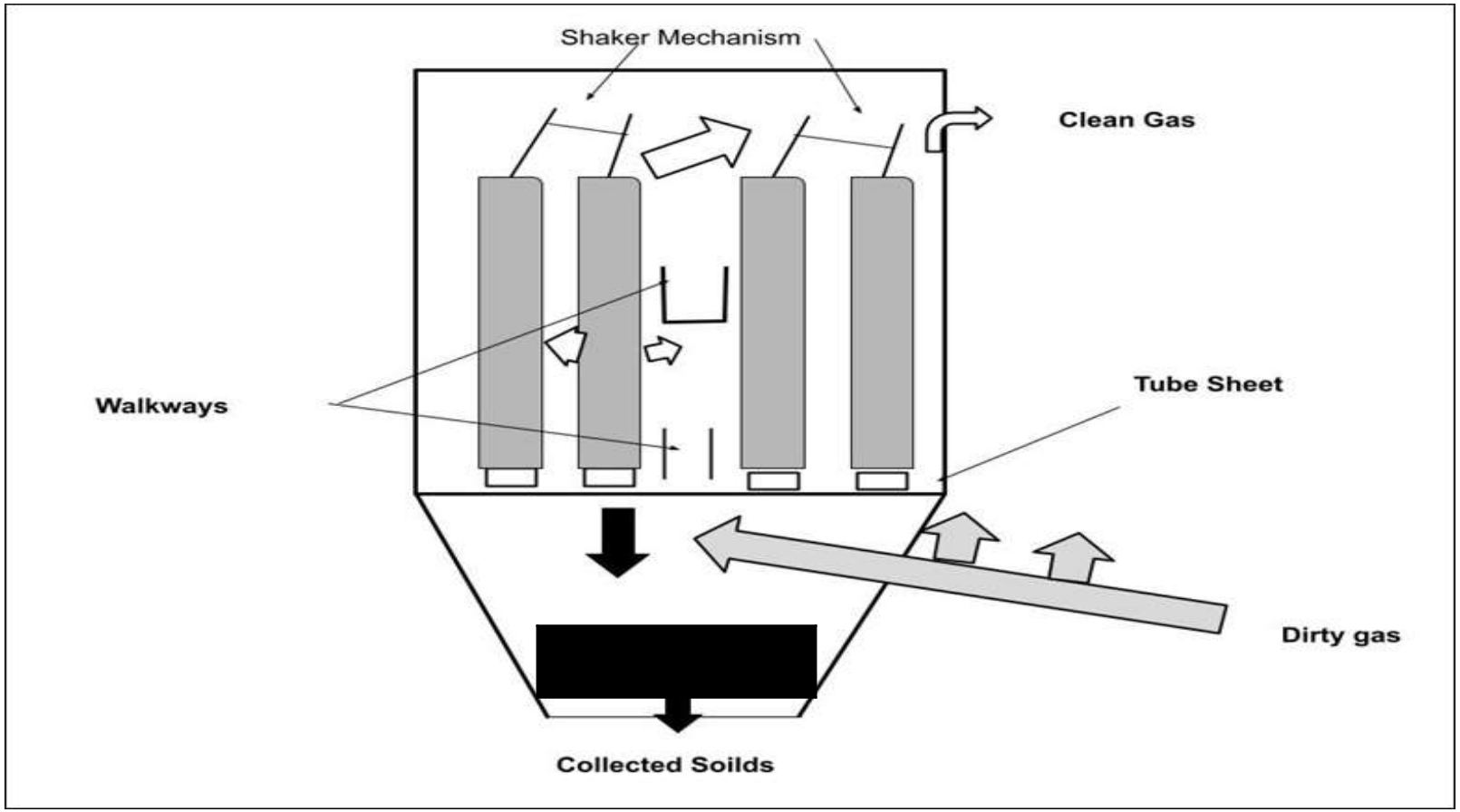


Figure : Typical shaker bag filters

2.Reverse Air Bag Filters:

- These filters are **similar to the shaker bag filters**. The contaminated gas stream enters from the hopper flows into and through the bags. The gas stream leaves out the dust cake on the inside bag surface.
- For cleaning the bags, the flow of contaminated gas stream is stopped and another clean gas flow is introduced which flows in the reverse direction. This gas flow is usually taken from the cleaned gas stream discharged from the bag filters. The dust cake, dislodged by the reverse airflow falls into the hopper and finally removed from the collector.

Reverse Air Bag Filters

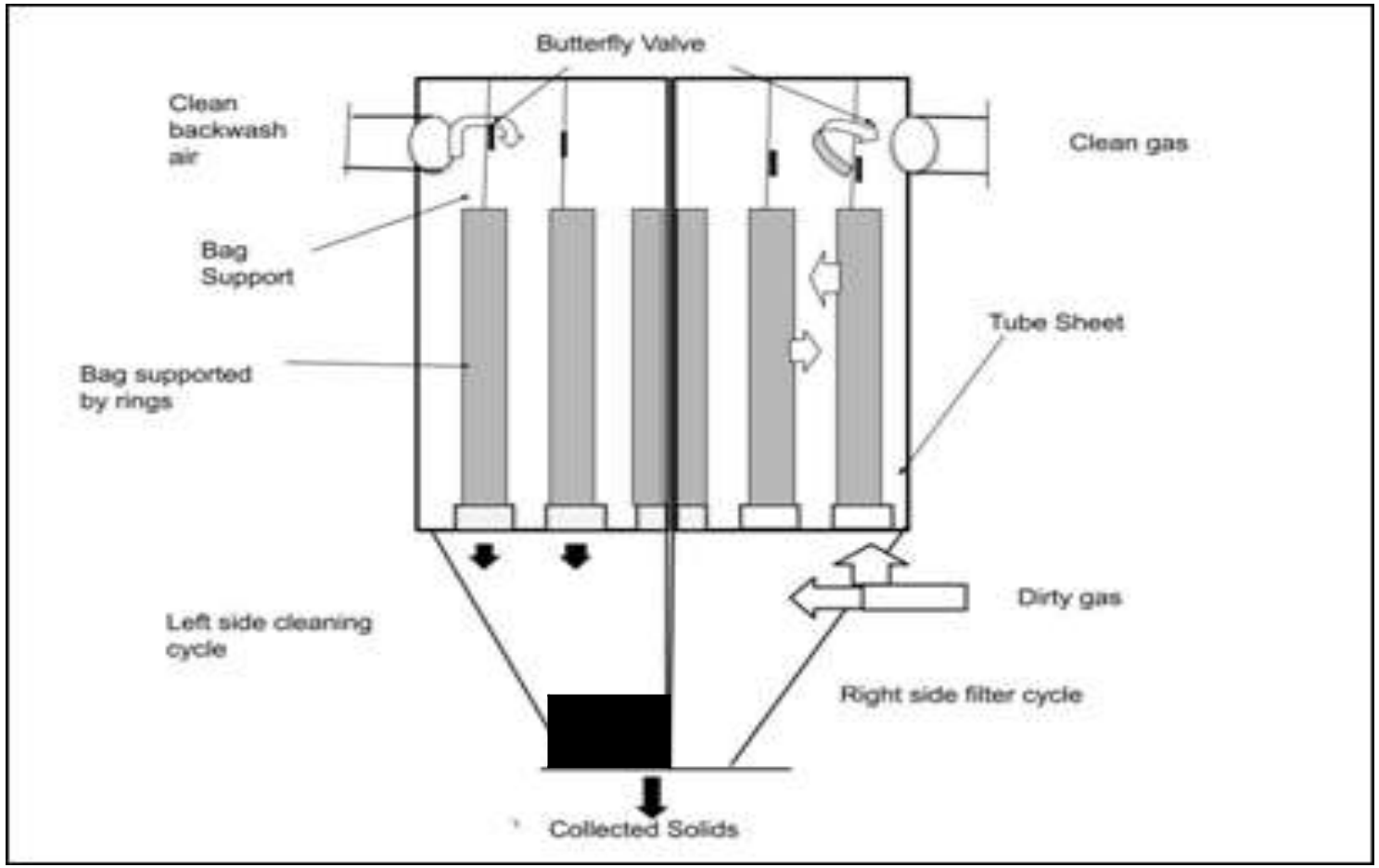
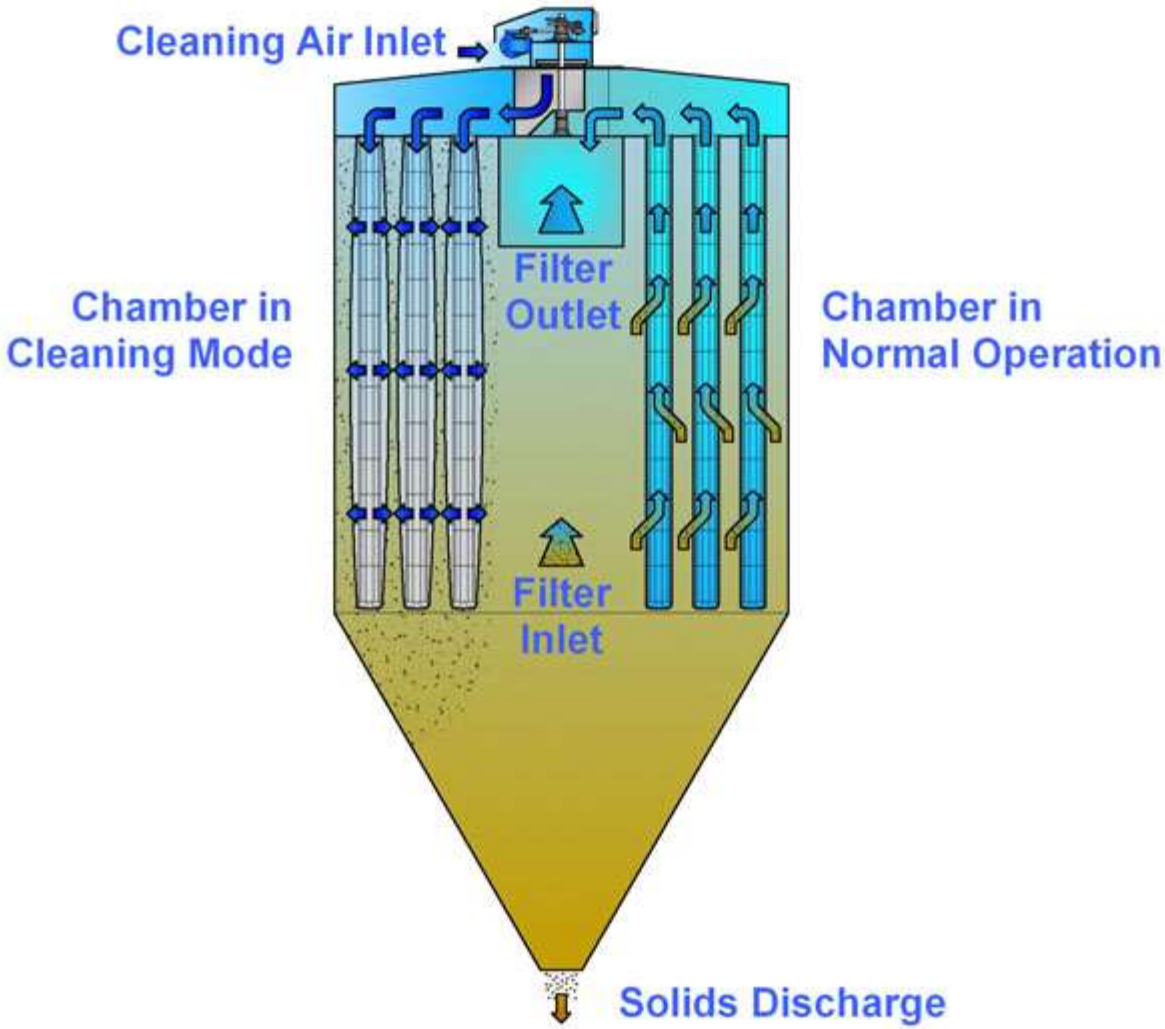
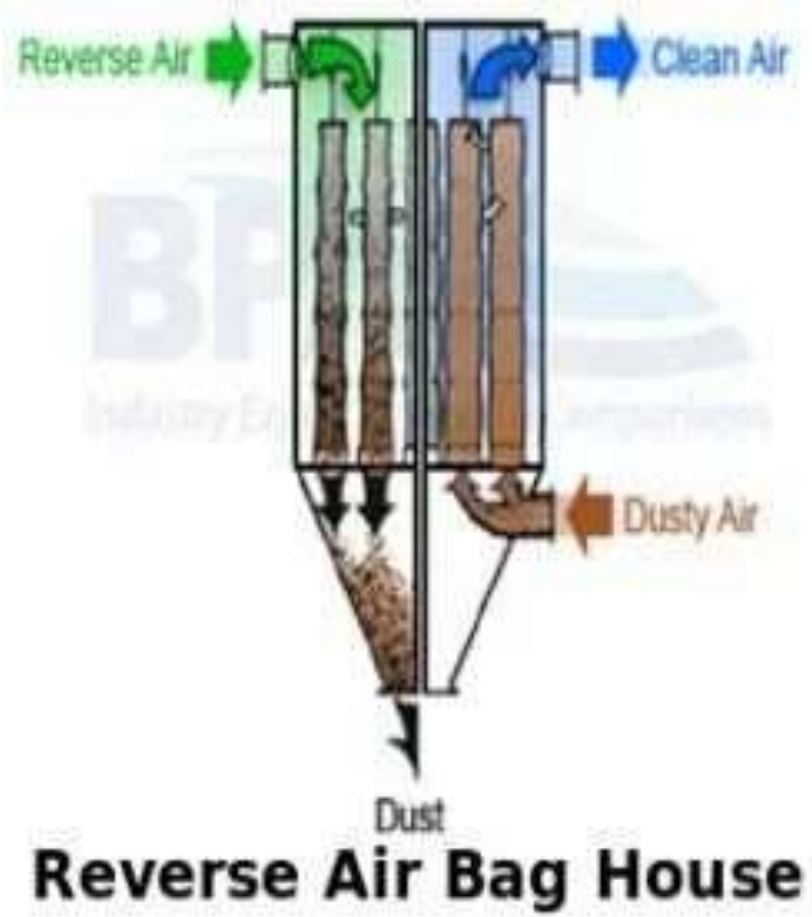


Figure: Typical reverse air bag filters





Reverse Air Bag House

3.Pulse Jet Type Bag Filters:

- The pulse jet type bag filters has a tube sheet located near top of the vertical casing, and the filter bags are hanged from the tube sheet.
- A wire mesh cage is fixed inside the bags to support and prevent them from collapsing.
- The contaminated gas stream enters through the hopper, flows into the bags and up through the tube sheet, leaving the dust cake on the bag surface.
- These bag surfaces are cleaned by applying short duration pulses of compressed air.
- The dust cake dislodged by the compressed air pulses falls into the hopper and finally removed from the collector.

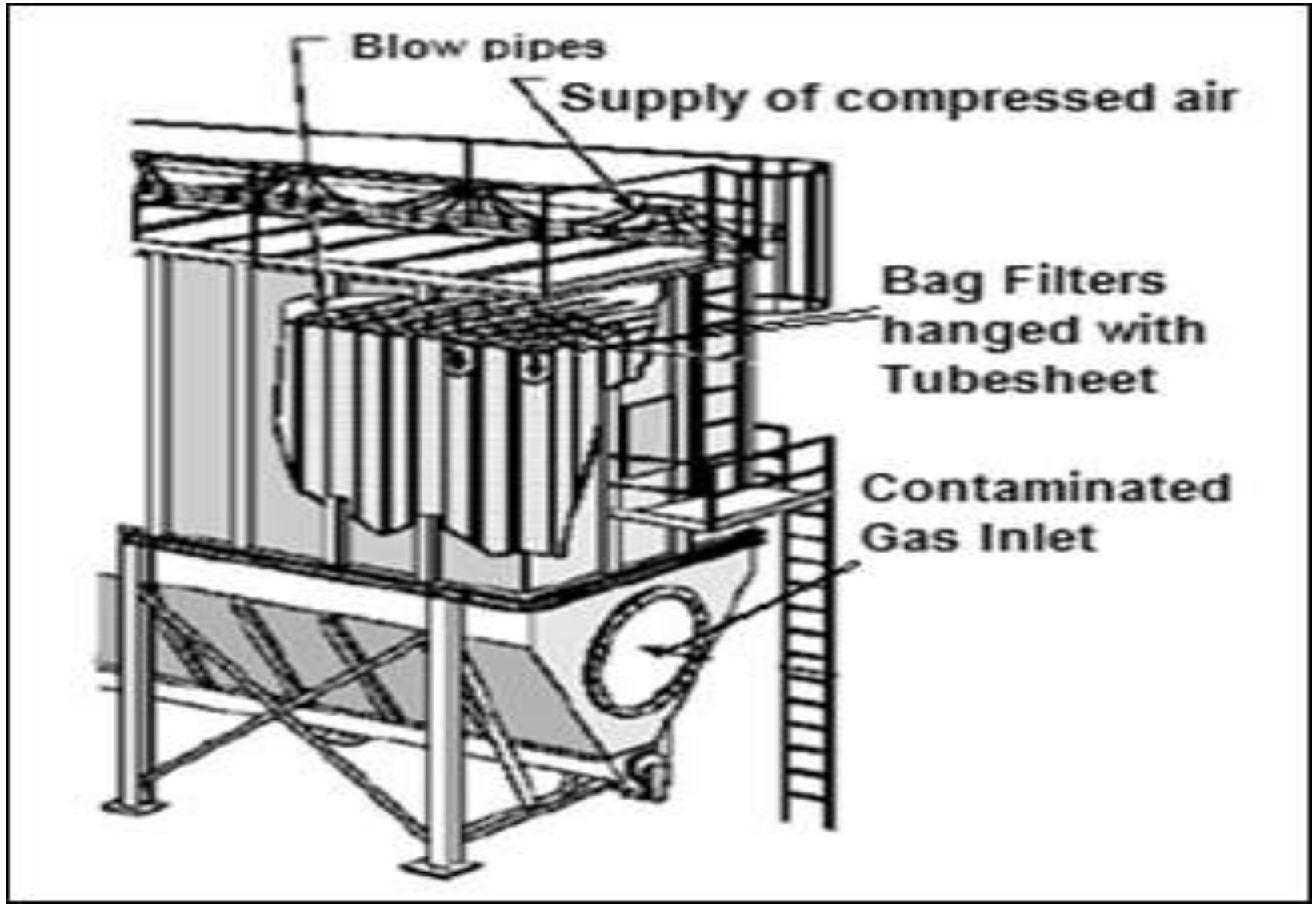
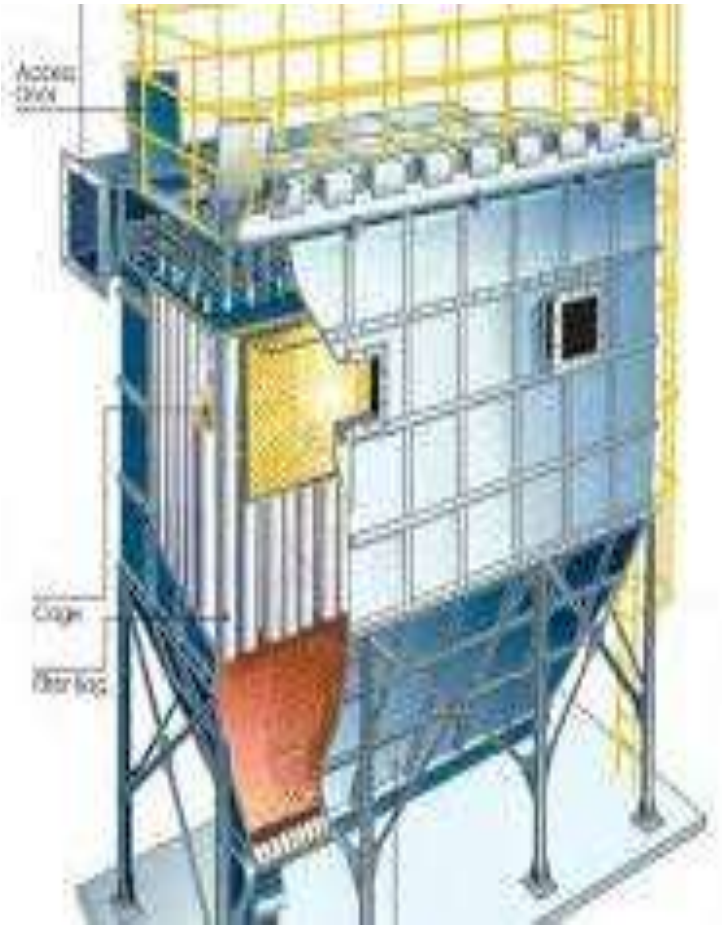


Figure : Typical pulse jet bag filters



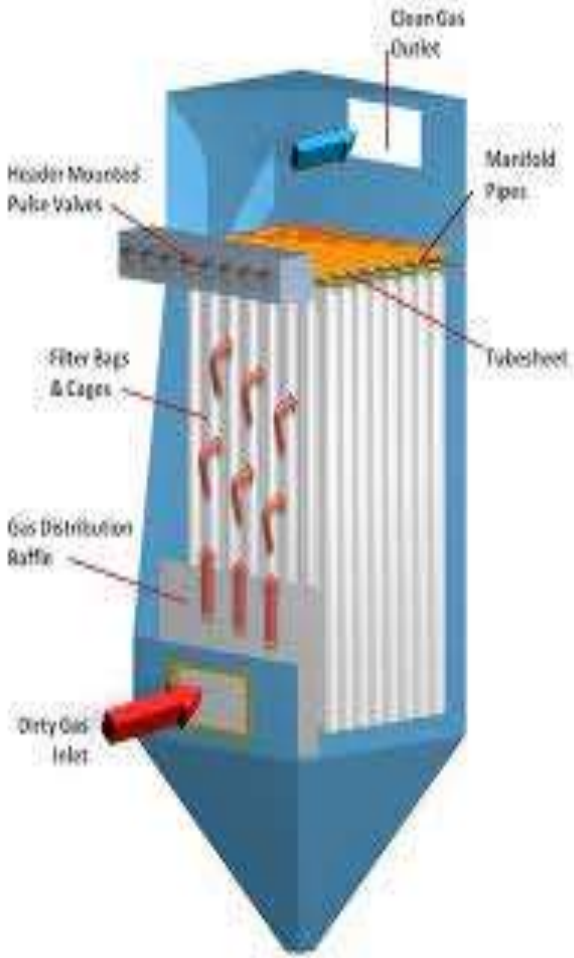


Figure: Pulse Jet Type Bag Filters

Cyclone Separators:

- Cyclone separators or simply cyclones are separation device used for removing the particulate matter from air or other gas stream. It works in the principle of inertia to remove particulate matter.
- The size of the cyclone may vary from 1.2 meters to 9 meters depending upon the volume of air or other gas stream to be filtered. Cyclone separators are basically centrifugal separators and work much like a centrifuge.
- It consists of an upper cylindrical part referred to as the barrel and a lower conical part referred to as cone.
- A vortex is generated in the cyclone body which simply transform the inertia force of flowing gas or air particle to a centrifugal force.
- The particle laden air stream enters tangentially at the top of the barrel and travels downward into the cone forming an outer vortex. The increasing air velocity in the outer vortex results in a centrifugal force on the particles separating them from the air stream. When the air reaches the bottom of the cone, it begins to flow radially inwards, reaches at the top and comes out as clean air/gas while the particulate matter fall into the dust collection chamber attached to the bottom of the cyclone.

Cyclone Separators:

- Most cyclones are built to control and remove particulate matter that is larger than 10µm. However, high efficiency cyclones are also available that are designed to remove the particles as small as 2.5µm.
- Out of all of the particulate-control devices, cyclone separators are the least expensive device. They are often used as a pre-treatment before the contaminated gas enters more effective pollution control devices.
- Therefore, cyclone separators can be seen as "rough separators" before the air/ gas reaches the fine filtration stages. Cyclone separators are generally able to remove somewhere between 50-99% of particulate matter presents in the air/gas.
- There are several advantages associated with the cyclone separators such as (i) Less installation and maintenance cost (ii) Occupy very little space (iii) Separated particulate matter is collected in dry condition which makes it easier to disposed off.
- However, there are few disadvantage also, like standard models are not available to remove particulate matter smaller than 10µm effectively and also the equipment are unable to handle sticky materials.

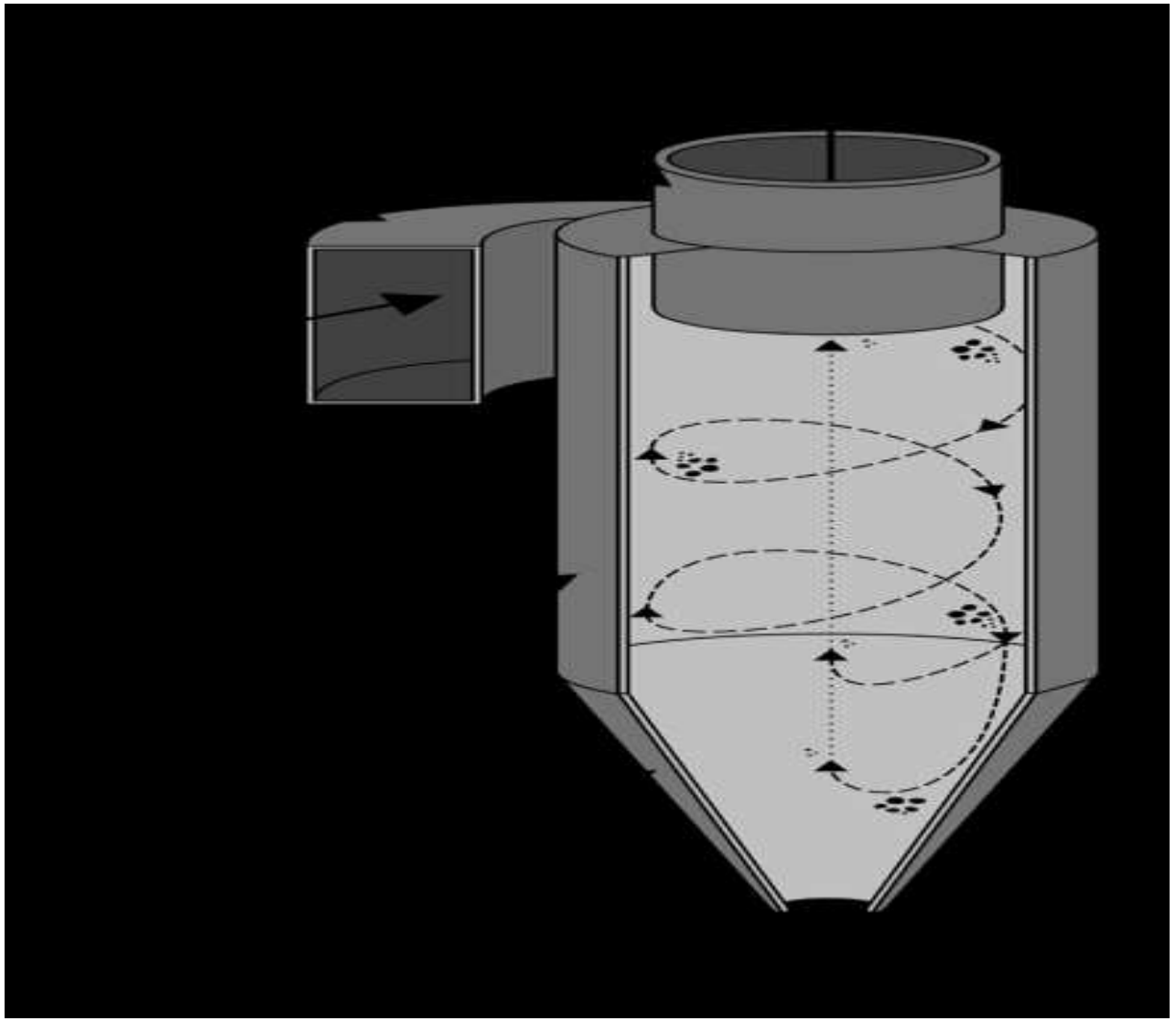
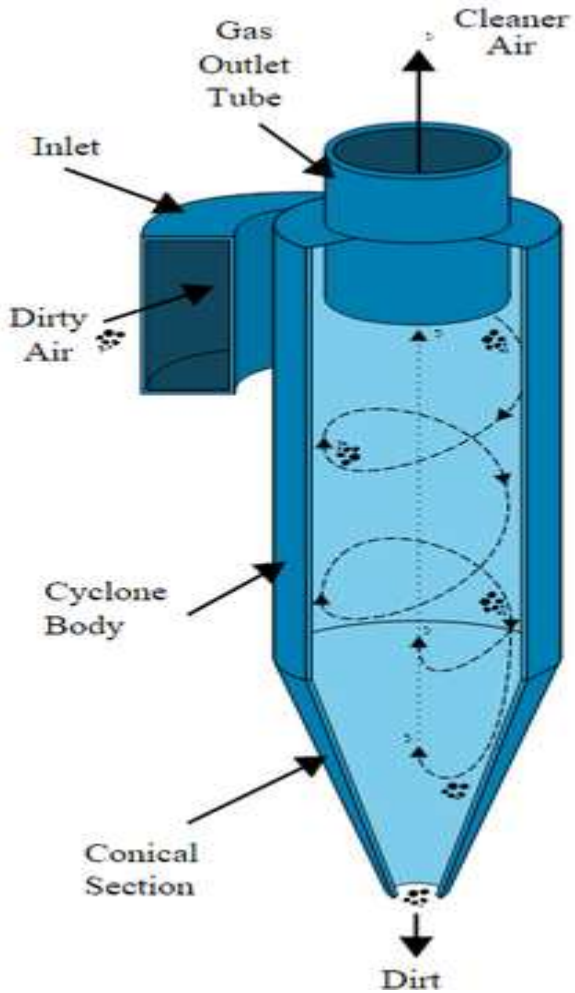


Figure 2.4: Typical Cyclone Separators



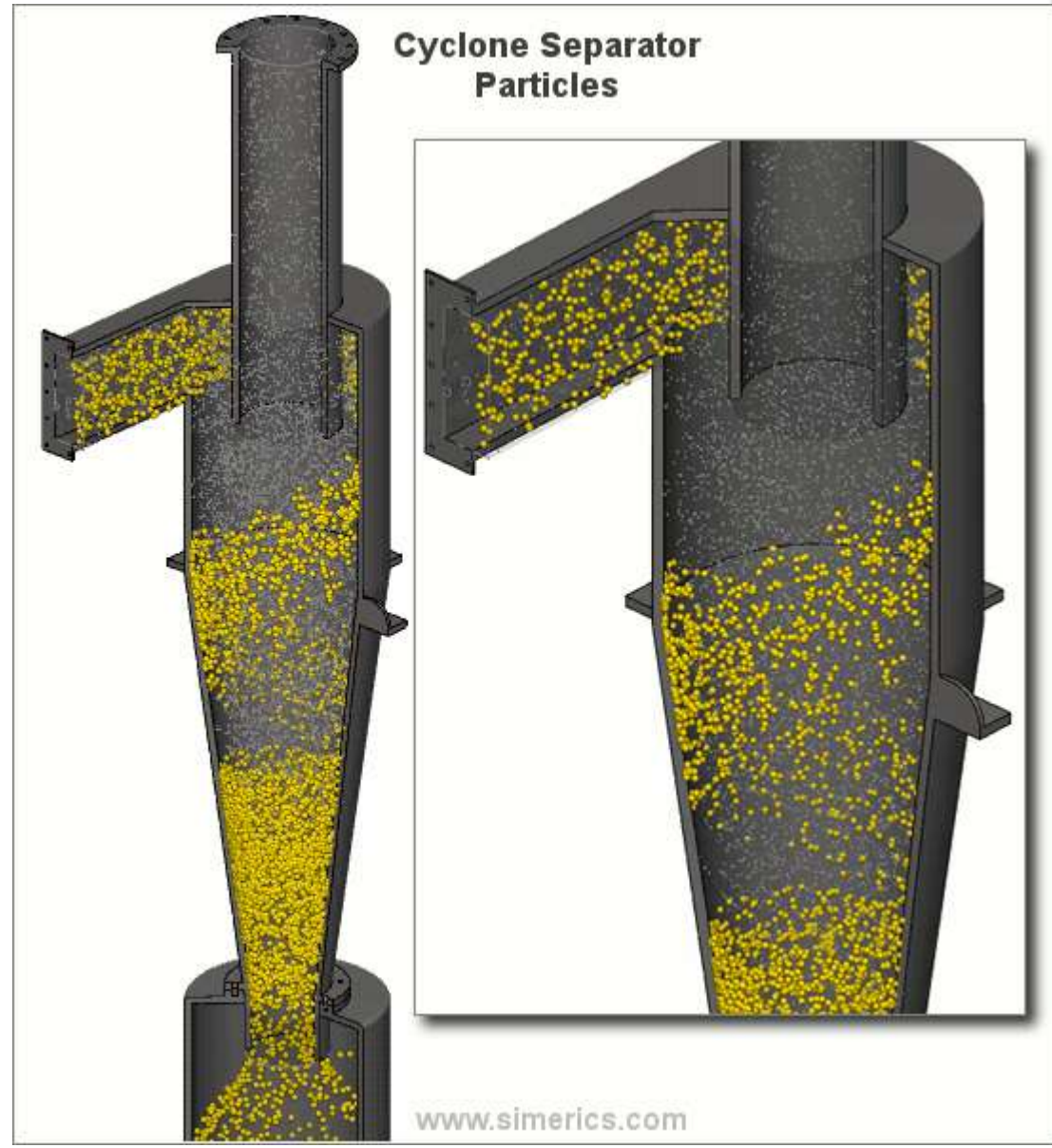


Figure: Cyclone Separators

Electrostatic Precipitators:

- Electrostatic Precipitators are used to remove the fine particles like smoke and dust from the flowing gas.
- It is a commonly used device for air pollution control and mostly used in steel plants, thermal power plants etc. The operation of electrostatic precipitators is quite simple.
- It uses an electric charge to remove particulate matter either in the form of solid or liquid droplets from air or other gasses in smokestacks or other flues. The precipitators consists of a row of thin vertical wires and a stack of large vertical metal plates.
- The plates are spaced from 1 cm to 17 cm apart depending on the type of application.
- One of the electrode is charged with a high negative voltage whereas second electrode charged with high positive charge.
- The gas stream flows horizontally between the wires and through the stack of plates.
- The particulates present in the gas stream are charged with the negative charge as they pass through the negatively charged electrodes.
- The particulates thus charged with the negative charge are pulled towards the positive electrode (plate) and deposited on plates or other collection devices.

Electrostatic Precipitators:

- The treated gas steam then passes out of the precipitators and through a stack to the atmosphere. When sufficient quantity of particles are accumulated on the collector devices, they are shaken off mechanically from the collectors.
- The particulates which can be dry or wet, fall into a hopper at the bottom of the unit and are transported to the disposal or recycling site through belt conveyeor.
- The soot or ash collected from coal burning power plants in this manner is referred to as fly ash.
- Electrostatic precipitators are very important tool in the process of cleaning up contaminated gases.
- They are extremely effective and are capable of removing more than 99% of particulate matter of size smaller than 10 μm size.
- However, this level of effectiveness comes at a very high cost – about 2-4% of a power plant's electrical energy output.

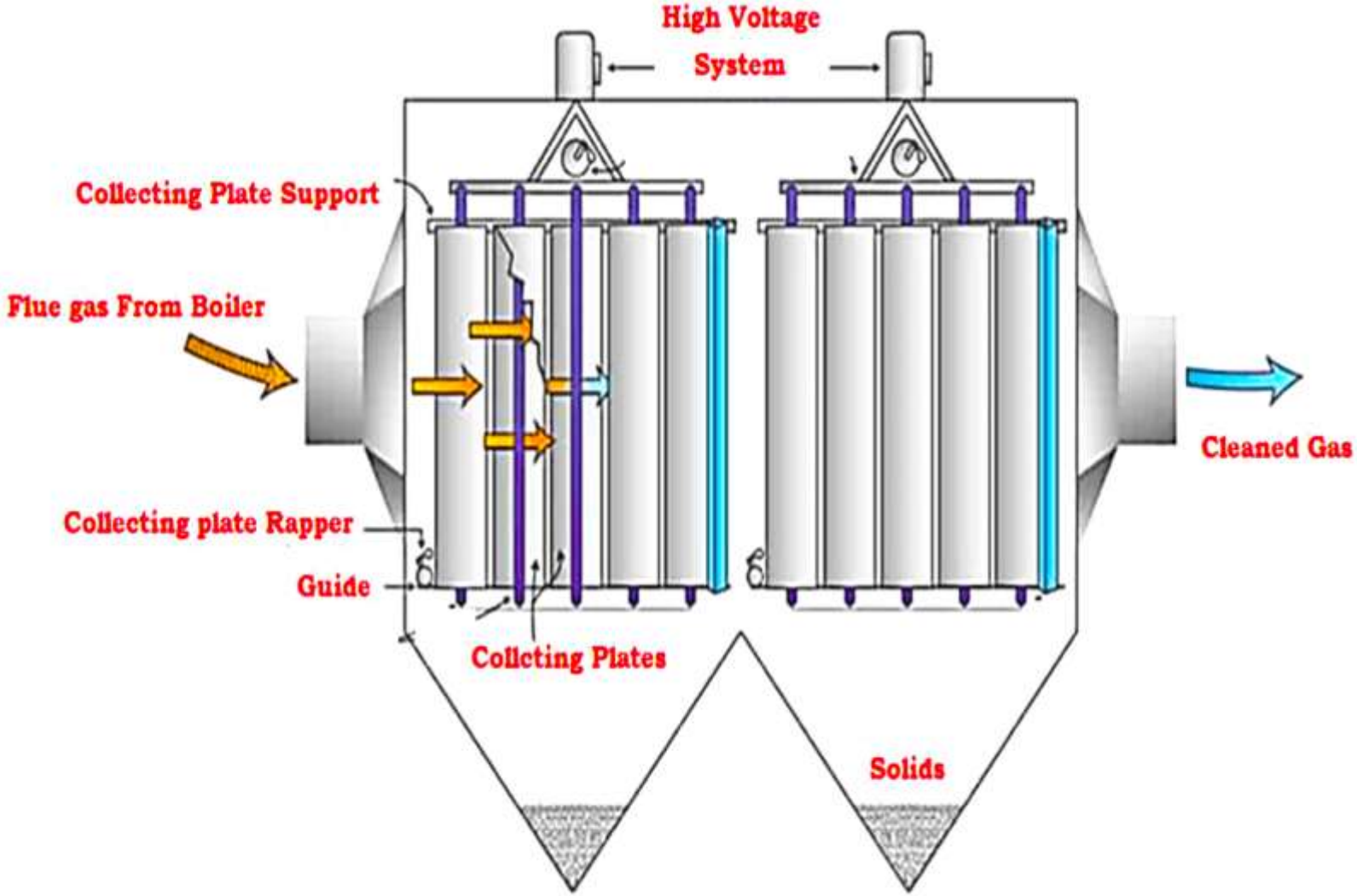


Figure: Electrostatic Precipitators

GASEOUS POLLUTION CONTROL:

- Gaseous pollution is created by : **primary and secondary pollutants.**
- *Primary gaseous pollutants* include **Sulphur and Nitrogen dioxide, Nitrogen oxide, Carbon monoxide and VoCs etc.,**
- whereas *secondary gaseous pollutants* include **Ozone and other photochemical oxidants, Sulphuric acid etc.**
- These *gaseous pollutants are removed by means of* ***three basic techniques***;

i)Absorption ii)Adsorption iii) combustion

- Here, two methods namely, Absorber and Catalytic converter which comes under combustion method, are discussed.

❖Absorber:

➢Absorber is a **process of removing gaseous pollutants by dissolving it into a solvent media**. **Most commonly used solvent media is a liquid phase, but it can also be a dry bulk solid in certain cases.**

➢ The material that absorbs is called the **solvent,** and the gas that is to be absorbed is called **solute.**

➢ The common form of absorption is **wet scrubbing**. The types of scrubber include **cross flow scrubber, bubble, plate and tray scrubbers, packed-bed counter flow scrubber etc.**

➢The most common type of wet scrubber is a **packed-bed counter flow scrubber**. **The gas stream containing the pollutant enters from the bottom of the scrubber and moves upwards towards the exhaust provided at the top of the scrubber.**

➢**The liquid scrubbing media or solvent enters from the top of the scrubber and gets distributed over the random packing. The gas stream also passes through the random packing which provides necessary surface area and facilitate contact between the two media.**

➢The liquid media absorbs the pollutants from the gas stream which are collected in the sump of the scrubber. Before exiting the gas stream passes through a mist eliminator and disperse to the atmosphere.

➢Water is commonly used scrubbing fluids, but there are many processes or pollutants that require different fluids or solvent materials.

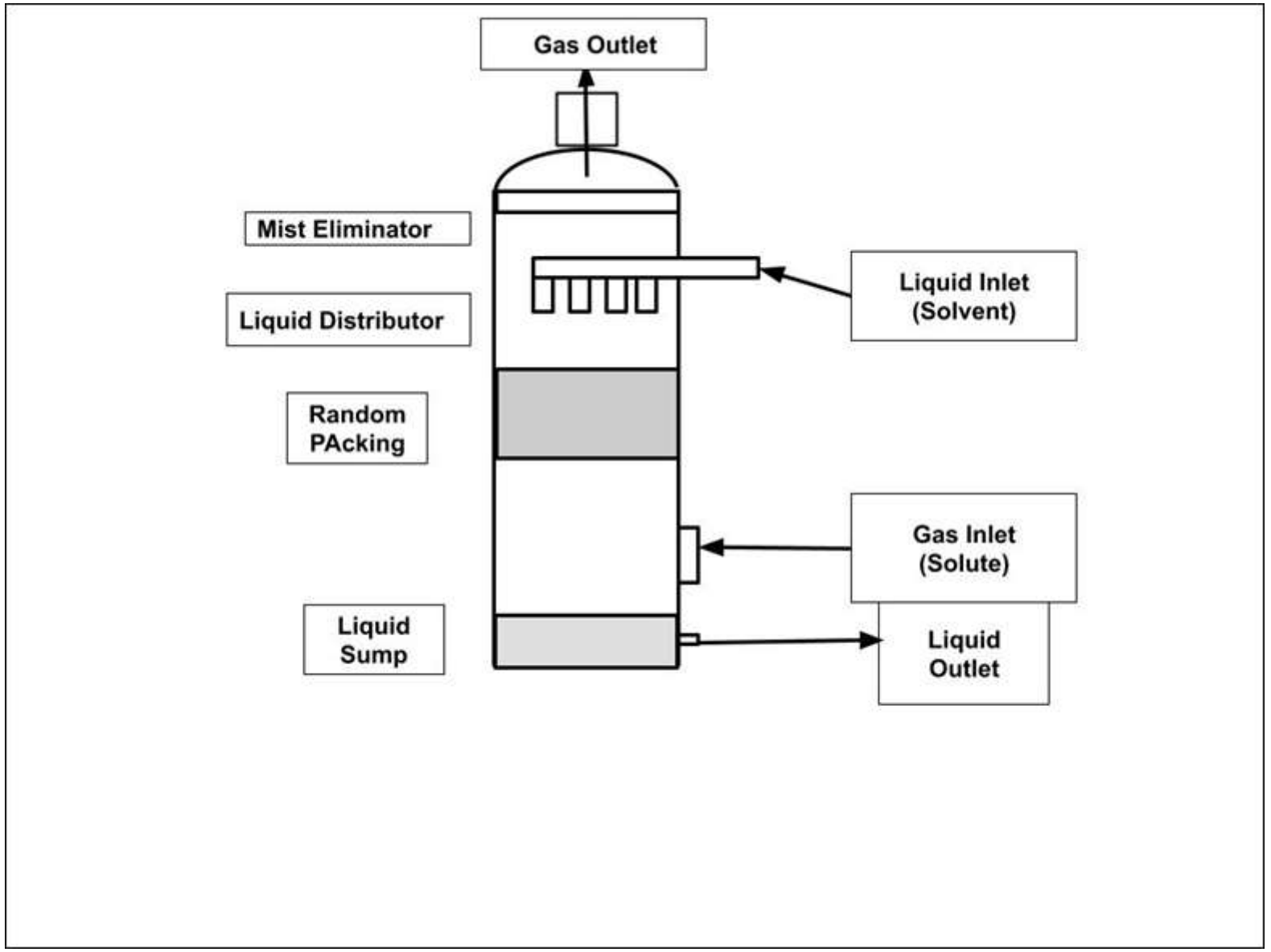


Figure : Packed-bed counter flow scrubber

❖Catalytic converter:

- There are enormous number of cars on the road in India specially in big cities like Mumbai, Kolkata, Bangalore, Pune etc. and each one is source of air pollution.
- To overcome this problem, an interesting device called a catalytic converter was invented by Eugene Houndry, a French mechanical engineer and expert in catalytic oil refining in mid 1950s. The car emissions contains harmful toxic by-products like nitrogen oxides, carbon monoxide and hydrocarbons.
- A catalytic converter **is a simple device that uses oxidation and reduction reactions to covert these harmful fumes to less harmful fumes.**
- It is composed of a metal housing with a ceramic honeycomb interior with insulating layers. This honeycomb interior is coated with precious metals like platinum, rhodium, and palladium.
- It is located near front portion of the car.

❖Catalytic converter:

- There are mainly **two types of catalysts** used in the catalytic converter: **(i) Reduction catalyst and (ii) Oxidation catalyst**
- Gas Outlet Mist Eliminator Liquid Distributor Random Packing Liquid Sump Liquid Outlet Gas Inlet (Solute) Liquid Inlet (Solvent)
- **Reduction catalyst**: It reduces nitrogen oxide pollution by removing oxygen. Nitrogen oxides are broken up into nitrogen and oxygen gases which are harmless.
- **Oxidation catalyst**: It converts carbon monoxide into carbon dioxide and hydrocarbons into carbon dioxide and water.
- Based on the type of catalyst used, the converter is categorized into two category:

A) **Two-way type catalytic converter:**

In this type of converter, only oxidation catalysts are used, which converts carbon monoxide to carbon dioxide and hydrocarbons to carbon dioxide and water by oxidation process.

- $CO + O2 \rightarrow CO2$
- $CxH4x + 2xO2 \rightarrow xCO2 + 2xH2O$

B) Three-way type catalytic converter:

- In this converter, both the catalysts, oxidation & reduction are used.
- Hence, it performs similar to the two-way converter with the addition of a reduction catalyst which reduces nitrogen oxide to nitrogen and oxygen gases by reduction process.
- $NOx \rightarrow Nx + Ox$

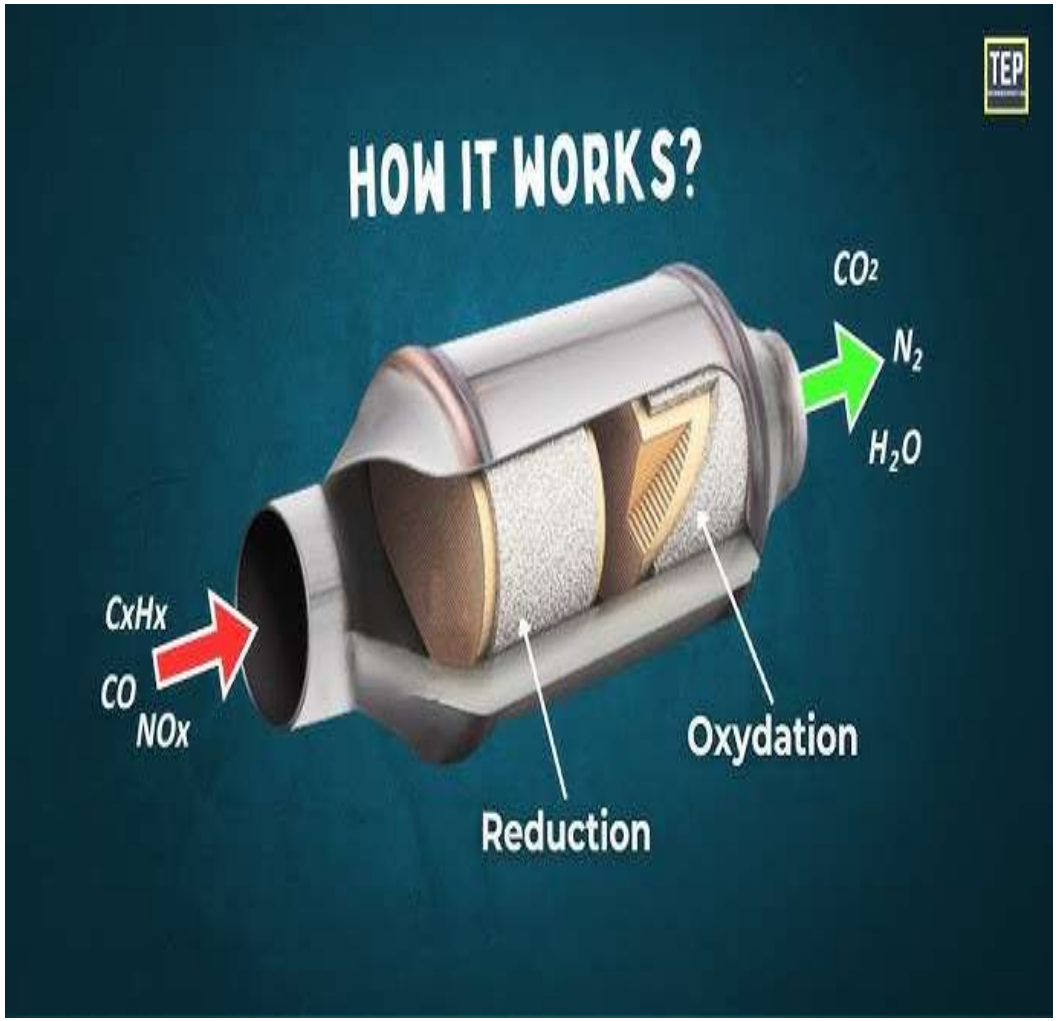


Figure: Catalytic converter

B) Three-way type catalytic converter:

- Hence, it performs similar to the two-way converter with the addition of a reduction catalyst which reduces nitrogen oxide to nitrogen and oxygen gases by reduction process.
- In this converter, both the catalysts, oxidation & reduction are used.
- $NOx \rightarrow N x + Ox$
- In addition to the converters discussed above, an oxygen sensor is also located near the converter which helps to tell car's electronic control unit (ECU) about the availability of oxygen in the exhaust gases.
- It helps vehicle to run on a more efficient air/fuel ratio, allowing engine to supply the converter with enough oxygen to complete the oxidation process

Noise pollution

- Noise pollution can be **defined as any unwanted or disturbing sound that effects the health and well-being of human and other organism**.
- The sound is typically described in terms of **loudness and it is measured in logarithmic units called decibels (dB).** Not all sound is considered as noise pollution.
- According to World Health Organization(WHO), **noise above 65 dB can be considered as noise pollution.**
- To be very precious, noise becomes harmful when it exceeds 75dB and painful above120 dB
- The noise pollution is caused mainly due to **Industrialization, urbanization and modern civilization.**
- The **source of noise pollution** can be categorised into two category:

a)Industrial sources

b) Non-industrial sources.

a)Industrial sources :

Industrial sources include **noise from various industries and big machines working at very high speed and with very high noise intensity**.

b) Non-industrial sources:

Non-industrial sources include **noise created by transport/vehicular traffic, loudspeaker, radio etc.**

iii)Household noise:

- The household activity is also a source of many indoor noises such as noise of playing children, infants crying, moving of furniture etc.
- Domestic gadgets like mixer-grinder, pressure cookers, exhaust fans, washing machines and entertainment equipment such as radio, music system, television sets are all indoor sources of noise pollution.

iv)Public address system (PA system):

- Many public functions such as political rallies, strikes, elections, religious and other social events etc. use PA system normally in a very loud volume and thus are become the source of noise pollution.

v) Agriculture machines:

- Heavy types machinery and equipment such as tractors, thrashers, tube wells, powered tillers, harvesters etc. are being used in many agricultural farms. These machinery may create noise pollution of level more than 90 dB to 98 dB.

❖ Noise pollution:

- However, the major source of noise pollution may be categorized as follows:

❖ i)Industrial sources:

- The industries such as textile mills, engineering establishments, printing press, metal works etc. contribute heavily towards noise pollution.
- Many industrial cities in India like Kolkata, Kanpur etc. are more affected as industrial zones are not separated from residential zones specially in case of small scale industries.
- It is therefore advisable to keep industrial zone away from the residential zone and they may be separated by a sufficiently wide green belt.

❖ ii)Transport vehicles:

- Automobile revolution in urban areas turned out to be a big source of noise pollution.
- In the recent past, there is an enormous growth in traffic volume due to increase in number of vehicles such as busses, trains, trucks etc. resulting in increased noise pollution.
- Airport located in the vicinity of residential areas creates lots of noise pollution as the airplanes passes over the residential areas during its landing and taking off.
- Heavy trucks, busses, trains, motor bikes, mopeds etc. are also contribute to the noise pollution.

vi)Defence equipment:

- A lot of noise pollution is created by artillery, tanks, explosions, shooting practices etc. by defence personnel.
- Noise created by jet engines and sonic booms have been known to shatter the window panes and old dilapidated buildings and also it has deafening impact on the ears.

Vii)Miscellaneous sources:

- The construction site, blasting, stone crusher etc. are some of the other sources of noise pollution.

Measurement of noise pollution level

- The sound can be described ***physically as well as physiologically.***
- **Physically**, sound is a mechanical disturbance propagated as a wave motion in air or other media such as water, steel etc.
- **Physiologically,** sound is an auditory sensation or perception evoked by this physical phenomenon.
- The physical properties and perception of sound or noise are expressed and measured in different concepts and units.
- Sound pressure is used as the fundamental measure of sound (amplitude) as it can be measured directly by instruments.
- The weakest sound pressure disturbance that can be detected by an average person at 1000 Hz has been found to be 20 μN/m2 and the largest sound pressure perceived without discomfort is of the order of 10^7 μN/m2. Because of such a wide range, the use of a linear pressure scale has been found to be impractical.

Measurement of noise pollution level

- It has been found convenient to employ sound pressure level, a quantity, which is proportional to the logarithm of sound pressure.
- By this, the sound pressure range of interest is compressed between 0 to 130, a range convenient to use.
- The sound pressure level is expressed in the unit of decibel (dB).
- Sound pressure level is defined as: Lp = 10 Log10 (P/Pr)2 Where Lp = sound pressure level, dB P = root mean square sound pressure, usually in μN/m2 Pr = reference sound pressure Log10 = Logarithm to the base 10 .
- The reference sound pressure, Pr has an internationally agreed value of 20 μN/m2.
- Sound is measured with a sound level meter which is usually a portable, self-contained instrument incorporating a microphone, amplifier, a voltmeter and attenuators, the whole of which is calibrated to read sound pressure levels directly.

Unit-3
Water and Soil pollution

Short Answer type questions (each 2 marks)

1. **What is soil pollution?**

   Ans:

   Soil pollution is the contamination of the soil by harmful chemicals, waste, or toxins that negatively impact the environment and human health.

2. **Define e- waste with example.**

   Ans:

   E-waste, or electronic waste, refers to discarded electrical or electronic devices, including outdated or broken gadgets such as computers, smartphones, televisions, and household appliances, that are no longer in use and may contain harmful substances.

3. **Explain reverse osmosis.**

   Ans:

   Reverse osmosis (RO) is a water purification process in which water is forced through a semi-permeable membrane under pressure, removing impurities, contaminants, and dissolved solids by allowing only clean water molecules to pass through, leaving behind unwanted substances.

4. **Define pesticide and give one example**.

   Ans:

   A pesticide is a chemical substance used to prevent, control, or eliminate pests such as insects, weeds, fungi, or rodents that can harm crops, animals, or humans.

   Example: Glyphosate, a widely used herbicide for controlling weeds.

5. **Define insecticide and give one example.**

   Ans:

   An insecticide is a chemical substance used to kill or control insects that are considered pests.

   Example: DDT (dichlorodiphenyltrichloroethane)

6. **What is eutrophication and its ill effect?**

   Ans:

   Eutrophication is the process in which a water body becomes overly enriched with nutrients such as nitrogen and phosphorus, leading to the plentiful growth of aquatic plants, especially algae causing coloration of water known as algal bloom. It leads to depletion of dissolved oxygen in water resulting in killing of aquatic organisms (e.g., fish).

7. **Which is greater between BOD & COD and why?**

   Ans:

COD values are always higher than the BOD values. Because, COD includes both the chemical oxidation of biodegradable and non- biodegradable substances whereas BOD value is only for the breakdown of biodegradable/ organic matter.

8. **What is turbidity of water and write down the most common causes of high turbidity?**

Ans:

The turbidity of water is a measurement of how clear or cloudy it is. The cloudier the water, the higher its turbidity. The most common causes of high turbidity are phytoplankton, erosion, urban runoff, wastewater discharge, algae and sediment disruption.

9. **Define water pollution.**

Ans:

Water pollution is defined as the addition of any substance to water or changing of water's physical and chemical characteristics in any way which interferes withits use for legitimate purpose.

10. **What is waste water treatment?**

Ans:

Wastewater treatment or sewage treatment generally refers to the process of cleaning or removing all pollutants, treating wastewater and making it safe and suitable for drinking before releasing it into the environment.

11. **What do you mean by sedimentation?**

Ans:

Sedimentation is the process of removing the heavier solid particles from suspended particles from dirty water through gravitational settling. This procedure is carried out in a basin or tank known as a sedimentation tank by allowing the water to stand undisturbed for several hours/days to settle down at the bottom of the container.

12. **What is the difference between total solids and total suspended solids of water?**

Ans:

The key difference between total solids and total suspended solids is that total solids are the material residue that is left in a vessel after the evaporation of a sample water, whereas total suspended solids are the dry weight of suspended particles that remains undissolved in a sample of water.

13. **How does pH affect the quality of water?**

Ans:

Excessively high and low pHs can be detrimental for the use of water. A high pH makes the taste bitter and decreases the effectiveness of the chlorine disinfection, thereby causing the need for additional chlorine. The amount of oxygen in water increases as pH rises. Low-pH water will corrode or dissolve metals and other substances.

14. **What is RAS and what is its purpose in the water treatment?**

Ans:

RAS stands for Return Activated Sludge, which is a process in water treatment that involves returning settled activated sludge to the aeration basin. The purpose of RAS is to maintain the population of microorganisms in the aeration tank and prevent them from being lost.

15. **What are the main types of water pollutions based on its origin?**

Ans:

There are two main types of water pollutions based on its origin: point source and non-point source. Point source pollution occurs when pollutants are released from a specific location, such as a factory or wastewater treatment plant. Non-point source pollution happens when pollutants come from multiple diffuse sources, such as runoff from farmland or urban areas.

Long answer type questions (each 5 marks)

1. **Explain various causes of soil pollution.**

Ans:

Industrial Activities: The disposal of toxic waste, heavy metals, and chemicals from factories, refineries, and manufacturing units directly into the soil is a major cause of soil contamination.

Agricultural Practices: Excessive use of chemical fertilizers, pesticides, and herbicides in farming leads to the accumulation of harmful chemicals in the soil, affecting its quality and biodiversity.

Deforestation: Clearing forests for agriculture or urbanization reduces the natural soil protection, leading to soil erosion and the infiltration of pollutants.

Waste Disposal: Improper disposal of municipal and industrial waste, including plastics, electronic waste, and chemicals, pollutes the soil, leading to long-term degradation.

Mining Activities: Mining operations release harmful substances like mercury, arsenic, and lead, which contaminate the soil around mining sites.

2. **Explain how fertilizers affect soil pollution.**

Ans:

- Chemical fertilizers, especially those rich in nitrogen, phosphorus, and potassium, can leave harmful residues in the soil when applied in excess.
- Over time, these chemicals accumulate, leading to soil acidification, nutrient imbalances, and degradation of soil structure.
- Excess nutrients from fertilizers, especially nitrogen and phosphorus, can leach into nearby water bodies, causing eutrophication.
- This leads to algae blooms, depletion of oxygen in water, and negative impacts on aquatic ecosystems, which in turn affect the soil-water interaction.
- High concentrations of synthetic fertilizers can disrupt the natural microbial community in the soil.

- Beneficial microorganisms, such as nitrogen-fixing bacteria, may be suppressed, while harmful ones may thrive, leading to reduced soil fertility and health.

3. Differentiate between BOD and COD.

Ans:

BOD	COD
BOD stands for Biological Oxygen Demand.	COD stands for Chemical Oxygen Demand.
It is the amount of oxygen the microbes require to decompose the organic matter under aerobic conditions.	It is the total amount of oxygen required to break down both the biodegradable and non-biodegradable organic matter by chemical oxidation.
BOD is a biochemical oxidation process	COD is a chemical oxidation process.
It can be determined by putting a sealed water sample under specific temperature conditions(20^oc) for five days.	It can be determined by placing a water sample with a strong oxidizing agent under specific temperature conditions(150^oc) for a short period.
Takes several days for the incubation period.	Can be measured relatively quickly, often within a few hours.
Specifically measures biodegradable organic matter.	Measures both biodegradable and non-biodegradable organic substances.
It is always lower than COD.	It is always higher than BOD.
IT is used to assess the level of organic pollution, microbial activity, and treatment efficiency.	It is used to quantify the amount of oxidisable pollutants found in water bodies.

4. Explain the sources of water pollution?

Ans:

The most significant sources of water pollution are:

- **Sewage (Waste Water):** The sewage water carries pathogens, a typical water pollutant, other harmful bacterias, and chemicals that can cause serious health problems and thereby diseases.
- **Agricultural Pollution:** Chemical fertilizers and pesticides are used by farmers to protect crops from insects and bacterias. However, when these chemicals are mixed up with water, they produce harmful pollutants for plants and animals.
- **Oil Pollution:** Oil spill poses a huge threat to marine life when a large amount of oil spills into the sea and does not dissolve in water. It causes problems for local marine wildlife, including fish, birds, and sea otters.

- **Industrial Waste:** Industries produce a tremendous amount of waste, which contains toxic chemicals and pollutants, causing air pollution and damage to our environment and us.

- **The burning of fossil fuels:** Fossil fuels like coal and oil, when burnt, produce a substantial amount of ash in the atmosphere. The particles which contain toxic chemicals when mixed with water vapour result in acid rain.

- **River dumping and Marine Dumping:** The garbage produced by households in the form of paper, plastic, food, aluminium, rubber, glass, is collected and dumped into the rivers and seas., they not only cause water pollution but also harm aquatic animals.

5. What is the main purpose of Secondary treatment of waste water? Describe about Trickling filter used in this method.

Ans:

In secondary treatment, dissolved or colloidal organic matters are present in sewage are removed by utilizing microorganisms. In this step, microorganisms utilize organic matter and converts them into inorganic minerals. Following changes occurs in sewage during secondary treatment;

- Organic matter (carbon) is oxidized into CO_2 and H_2O
- Organic nitrogen compounds are first converted into NH_3 and then into NO_3
- Colloidal matters are coagulated or precipitated out.

Thus, main purpose of secondary treatment of sewage is to reduce BOD level.

Trickling filter:

- Trickling filter consists of filtering bed, spraying arm and water collecting chamber.
- Filtering bed consists of well graded gravel, broken stone of size (40-150mm diameter).
- Effluent or sewage from primary treatment tank is sprayed uniformly over the filter bed. During filtration a gelatinous layer of bacteria, algae, protozoa and some fungi is produced on the surface of filter bed. This layer is called Zoogleal layer.
- As the water trickles through the filter bed, organic matter present in it is oxidized by microorganism of zoogleal layer.
- Although trickling filter is classified as aeration process of sewage treatment, it is facultative system. It is because aerobic bacteria lie on the top of the filter bed whereas anaerobic bacteria lie in middle or bottom of filter bed.
- Trickling filter can reduce BOD of sewage by about 65-85% depending on the rate of filtration.

GOVT. POLYTECHNIC MAYURBHANJ, TIKARPADA

SUB: ENVIROMENTAL SCIENCE
(COMMON FOR ALL BRANCHES)

TOPIC: Renewable Sources of Energy

SEMESTER: 1ST Semester

FACULTY NAME : KUNI MAJHI, SR . LECTURER

Introduction:

UNIT SPECIFICS :
This unit concentrates on the following main aspects:

- **Solar Energy**: Basics of Solar energy, Flat plate collector (Liquid & Air) and its theory, Advanced plate collector, Solar pond, Solar water heater, Solar dryer and Solar stills.

- **Biomass**: Overview of biomass as energy source and its thermal characteristics as fuel, Anaerobic digestion, Biogas production mechanism, Utilization and storage of biogas.

- **Wind energy**: Current status and future prospects of wind energy, Wind energy in India, Environmental benefits and problem of wind energy.

- **New Energy Sources**: Need of new sources, Different types new energy sources and its applications, Concept and origin of geothermal energy, power plants of geothermal energy.

RATIONALE :

- Today, the world is heavily depended on **fossil fuels.**
- Fossil fuels has many applications such as to **produce heat, steam to drive generators that can supply electricity, gas turbines used in jet aircrafts etc**.
- At the same time, **fossil fuel creates pollution by emitting climate-damaging greenhouse gasses to health-endangering particles into our environment. Hence, there is a need for alternative source of energy.**
- In the recent past, **renewable energy growing faster than all other forms of energy.**
- **It has many advantages over fossil fuels: from reduction of water and land use, less air and water pollution, less wildlife and habitat loss, to no or lower greenhouse gas emissions**.
- ***This unit aims at introducing basic concepts of renewable sources of energy which includes; solar energy, wind energy, hydrogen energy, ocean energy and biomass.***
- After completion of this unit, the students will develop ***basic concepts of renewable source of energy which will give them an opportunity to protect our health and environment from hazardous impacts of fossil fuels.***

PRE-REQUISITES :

High School Chemistry

- UNIT OUTCOMES :

Students will be able to:

U3-O1: Explain solar energy and methods of harnessing.

U3-O2: Discuss characteristics of biomass and its digestion process.

U3-O3: Explain wind energy and its impact on environment.

U3-O4: Describe new energy sources and their applications

UNIT OVERVIEW :

3.1 Introduction

3.2 Solar Energy: Basics of Solar energy. Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills.

3.3 Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of biogas.

3.4 Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.

3.5 New Energy Sources: Need of new sources. Different types new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

3.6 Unit Summary

3.7 Innovative Activities

3.8 Interesting Facts

3.9 Exercises

3.10 Suggested Learning Resources

3.1 INTRODUCTION :

"I have no doubt that we will be successful in harnessing the Sun's energy. If sunbeams were weapon of war, we would have had solar energy centuries ago.".

George Porter, Noble Prize Winner in Chemistry, 1967

- ***Usage of renewable sources of energy became unavoidable to protect our environment from hazardous impact of fossil fuels.***
- These sources are available in nature in various forms such as ***solar energy, wind energy, hydrogen energy, ocean energy, biomass etc.***
- ***The usage of renewable source of energy has many advantages over traditional forms of energy; such as, it emits no or low greenhouse gases, no or low air pollutants, low cost, accessible to all, creates job etc.***
- **In this unit**, ***different methodology of harnessing of solar energy, wind energy, biomass, application of new sources of energy; hydrogen and ocean energy including their advantages are discussed in detail.***

3.2 SOLAR ENERGY :

- ***We receive a pure, non-polluting, and inexhaustible form of energy from the sun.***
- ***This energy comes in the form of radiant light and heat and known as solar energy.***
- Although the sun is 150 million km away from us, but still an enormous amount of solar energy falls on the earth.
- ***The energy what we get from Sun in one hour is more than the energy consumed by everyone in the entire world in one year.***
- ***Solar energy is our most reliable source of energy and is source of most of the other forms of energy on our planet.***
- Historically, people have been using solar energy for heating buildings, creating fire and driving industrial processes etc.
- ***Solar energy is a powerful source of energy***, however, only a small portion of it can be mainly used to/for:

• ***Generate electricity*** • ***Heating and cooling*** • ***Cooking and*** • ***Water desalination***

3.2.1 Flat Plate Collector (liquid and air) :

➢The flat plate collector is the ***most fundamental solar power collector***. It is ***mainly used for domestic hot water system***.

➢**The typical flat-plate collector includes following features:**

- ***Black plate surface*** – to absorb incident solar radiation
- ***Glass cover*** – a transparent layer of glass to transmit radiation to the absorber at the same time prevent heat loss from the surface
- ***Tubes containing the fluid/air*** to transfer the heat from the collector
- ***Support structure*** to provide protection and hold the collector components
- ***Insulation*** in sides and bottom of the collector to prevent heat losses .

Flat Plate Collector (liquid and air) :

- In the plate collector, ***the solar radiation is absorbed by the plate having black surface and then absorbed heat get transferred to the fluid/air filled in the tubes.***
- ***The thermal insulation in the bottom and sides of the collector, and the glass screen above the plate prevents heat loss during transfer of heat.***
- ***The flat-plate systems normally operate within the temperature range from 30° to 80° C.***
- However, ***advanced collectors that employ vacuum insulation and selective coatings can achieve temperature up to 200° C.***
- Some of the ***advantages*** of flat plate collector includes; ***easy to manufacture, low manufacturing cost, little maintenance ,Permanently fixed , collect both beam & diffuse radiation etc***.
- For ***transfer of heat, either a medium, liquid or air can be used in the flat plate collectors***. For liquid, water is one of the common options due to its accessibility and good thermal properties.

Water based flat plate collector:

➢In this type, ***water is used as a medium of heat transfer.*** Water is most commonly used as liquid fluid because of its high volumetric heat capacity and high mass density, which allows using small tubes and pipes for the heat transfer.

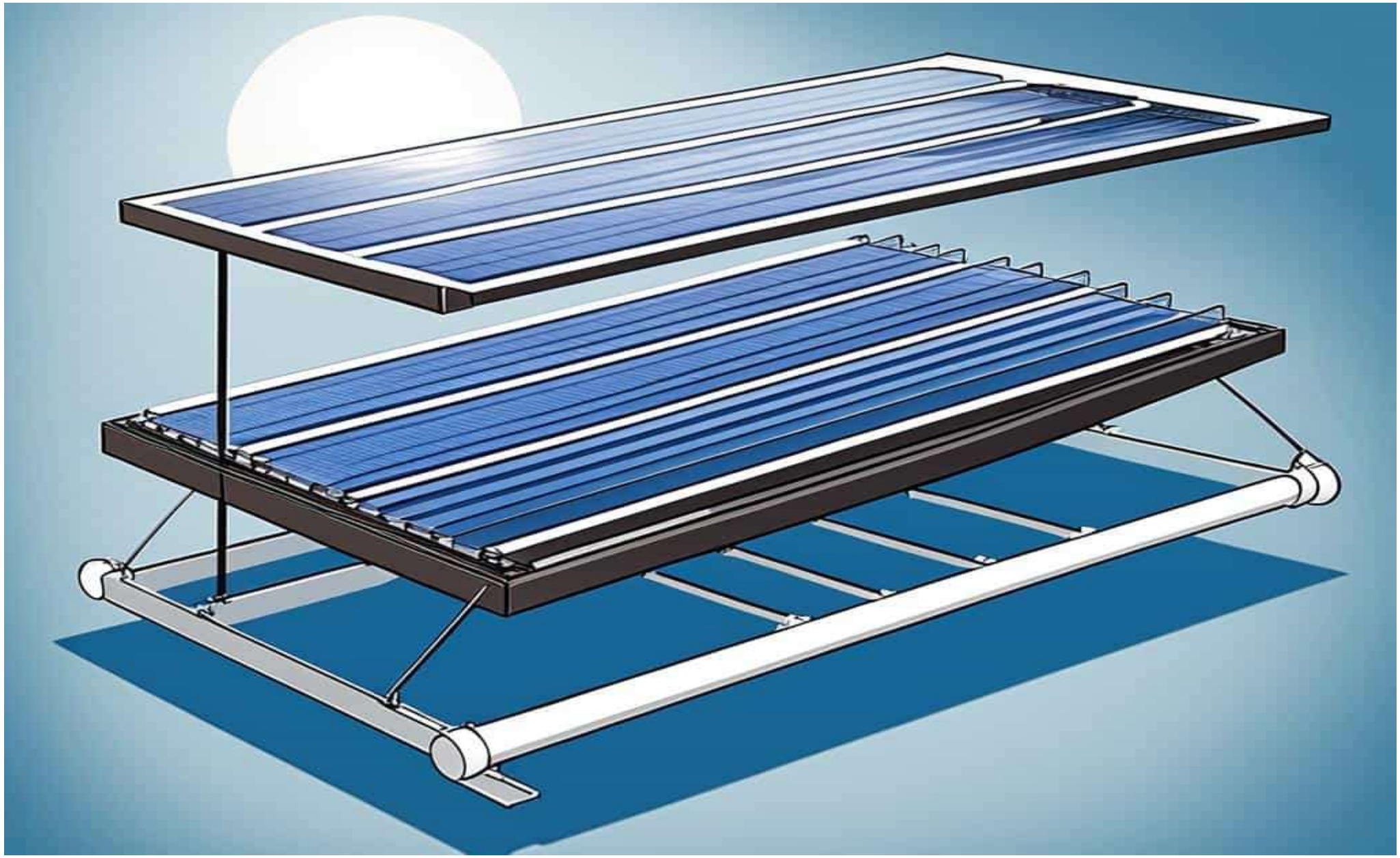
➢One ***disadvantage of water is that it freezes during winter, which can damage the collector or piping system.*** This can be managed by draining down the collector time-to-time.

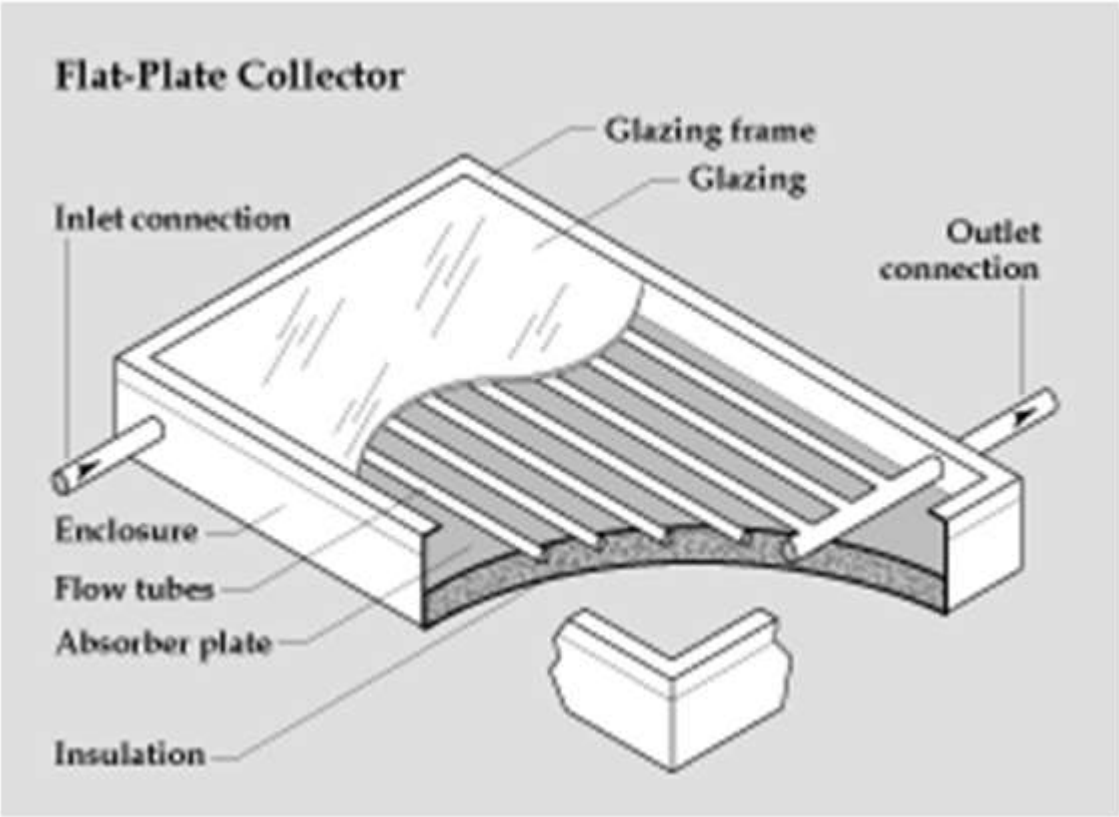
Air based flat plate collector:

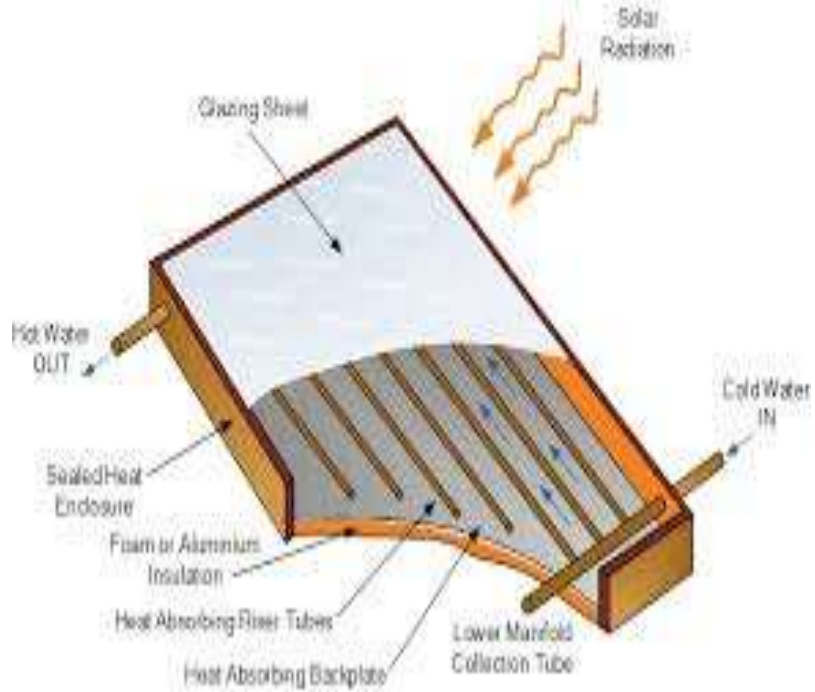
➢ In this type of collector, ***air is used as the medium of heat transfer instead of liquid/water.*** This type of plate collector is ***used for space heating or crop drying.*** A fan is usually required to facilitate air low in the pipe.

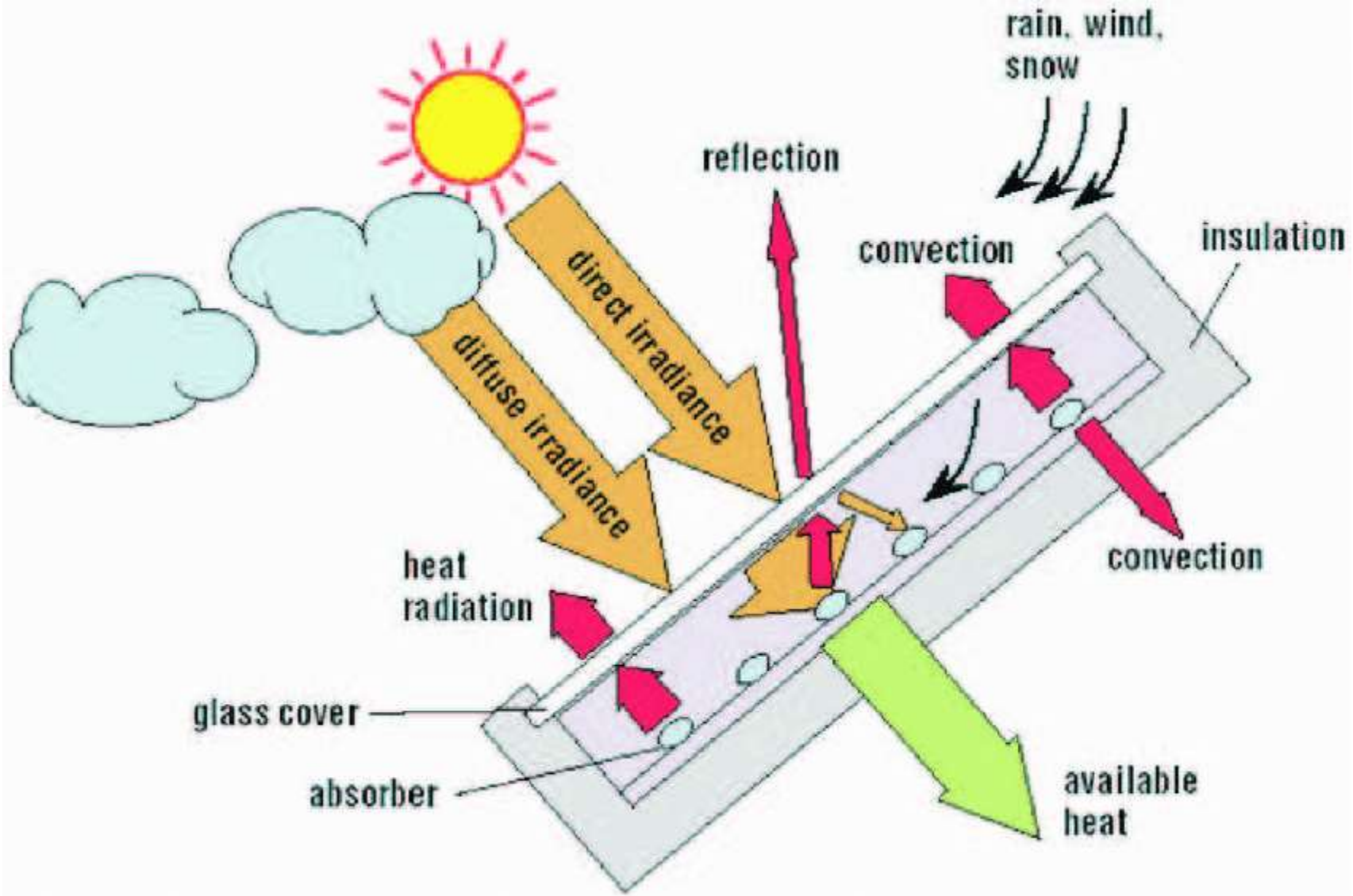
3.2.2 : Theory of flat plate collector:

- Theory of flat plate collector is ***very simple.***
- *When a metal sheet is placed to solar radiation, temperature of the sheet will start rising till the rate at which energy (solar radiation) is received is equal to the rate at which energy is getting transferred or lost from the metal sheet.*
- *The temperature of the metal sheet after which no further increment is noted is termed as the "equilibrium" temperature. Now, if the back of the plate is protected with heat insulating material, and the exposed surface of the plate is painted in black colour and it is covered with glass sheets, then the equilibrium temperature will be much higher than that for the simple exposed sheet.*
- *This metal sheet can be converted into a heat collector by adding a water/air circulating system.*
- *The absorbed heat from the heat collector gets transferred to the water/air in the tube and finally transferred to a storage tank.*




Flat-Plate Collector
Glazing frame
Glazing
Inlet connection
Outlet connection
Enclosure
Flow tubes
Absorber plate
Insulation


Solar Radiation
Glazing Sheet
Hot Water OUT
Cold Water IN
Sealed Heat Enclosure
Foam or Aluminium Insulation
Heat Absorbing Riser Tubes
Heat Absorbing Backplate
Lower Manifold Collection Tube


rain, wind,
snow
reflection
convection
insulation
direct irradiance
diffuse irradiance
heat
radiation
convection
glass cover
absorber
available
heat

3.2.3 Importance of coating and Advanced collector :

- The solar absorber surface is the fundamental part of a solar thermal collector, as it is responsible for the solar radiation absorption and for reduction of radiation heat losses.
- The solar absorption and emittance by solar absorbers surface have great impact on solar thermal collector efficiency.
- These plates are usually made out of metal having good heat conductor property, usually copper or aluminium.
- Sometimes these absorber plates are painted with special coatings designed to absorb and retain heat better than the normal black paint.
- Special coatings helps enhancing the plate absorber properties such as high temperature tolerance, resistance to UV and moisture degradation, durability, optical characteristics etc.

Advanced plate collectors:

- In conventional plate collector system, water can be heated up to 80°C, which limits their applications largely for providing hot water and space heating.
- However, the heating capacity of plate collectors can be enhanced by minimising the heat losses from the collector to the surroundings.
- For other applications such as power generation etc. the fluid temperatures in the range of **120 0C - 130 0C** is required.

- To achieve this range of temperature, in place of normal plate absorber, evacuated (vacuum) glass tubes coated with selective coating black absorber are used.

- Plate collector with these arrangements is called as **Advanced plate collector.** Using advanced plate collector, ***temperature can be enhanced to 1500C thereby enhancing application range of the collector to power generation, solar air conditioning system etc***

3.2.4. Solar pond, Solar water heater, Solar dryer and Solar stills :

- ***The sun is the largest source of renewable energy and this energy is abundantly available in all parts of the earth.***
- It is, in fact one of the best alternatives to the non-renewable sources of energy.
- There are many ways to ***harness solar energy for example through the use of solar ponds, solar water heater, solar dryer and solar stills.***

3.2.4.1 Solar pond :

- It is a ***solar energy collector, fairly large in size and looks like a pond.***
- The solar pond ***works on a very simple principle***. We all know that ***when water or air is heated they become lighter and rise upward e.g., a hot air balloon.***
- Similarly, ***in an ordinary pond, the sun rays fall on the water and the heated water from within the pond rises and reaches the top but loses the heat into the atmosphere through evaporation.***
- ***The net result is that the pond water remains at the atmospheric temperature.***
- In solar pond, ***loss of heat from the water is prevented by dissolving salt, concentration of which increases with the depth of water in the pond and making it too heavy to rise.***

Solar pond :

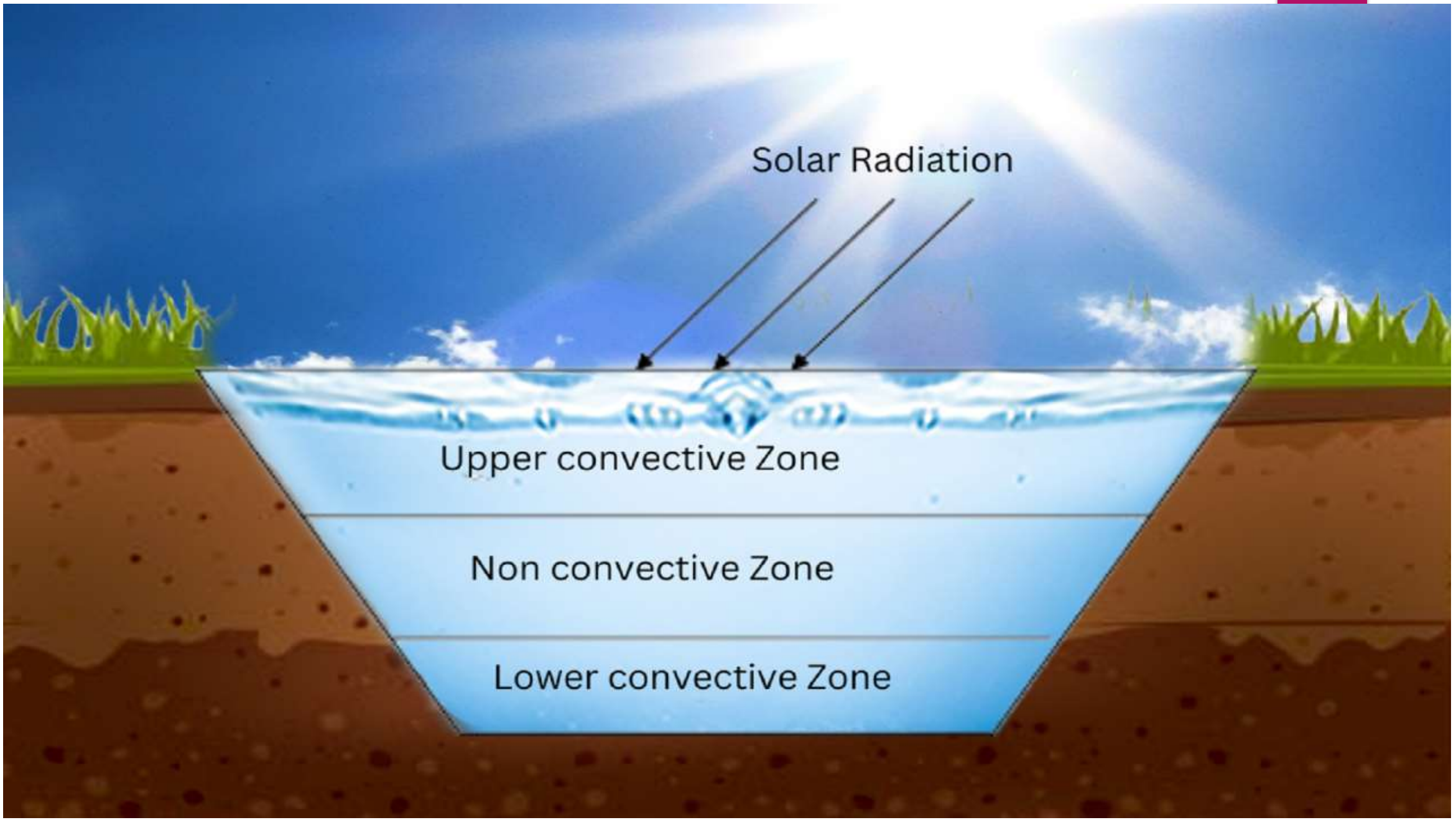
- A solar pond mainly has **three zones:**

i)Top zone(Upper Convective Zone)
ii)Bottom zone (Lower Convective Zone)
iii)Gradient zone (Non-Convective Zone)

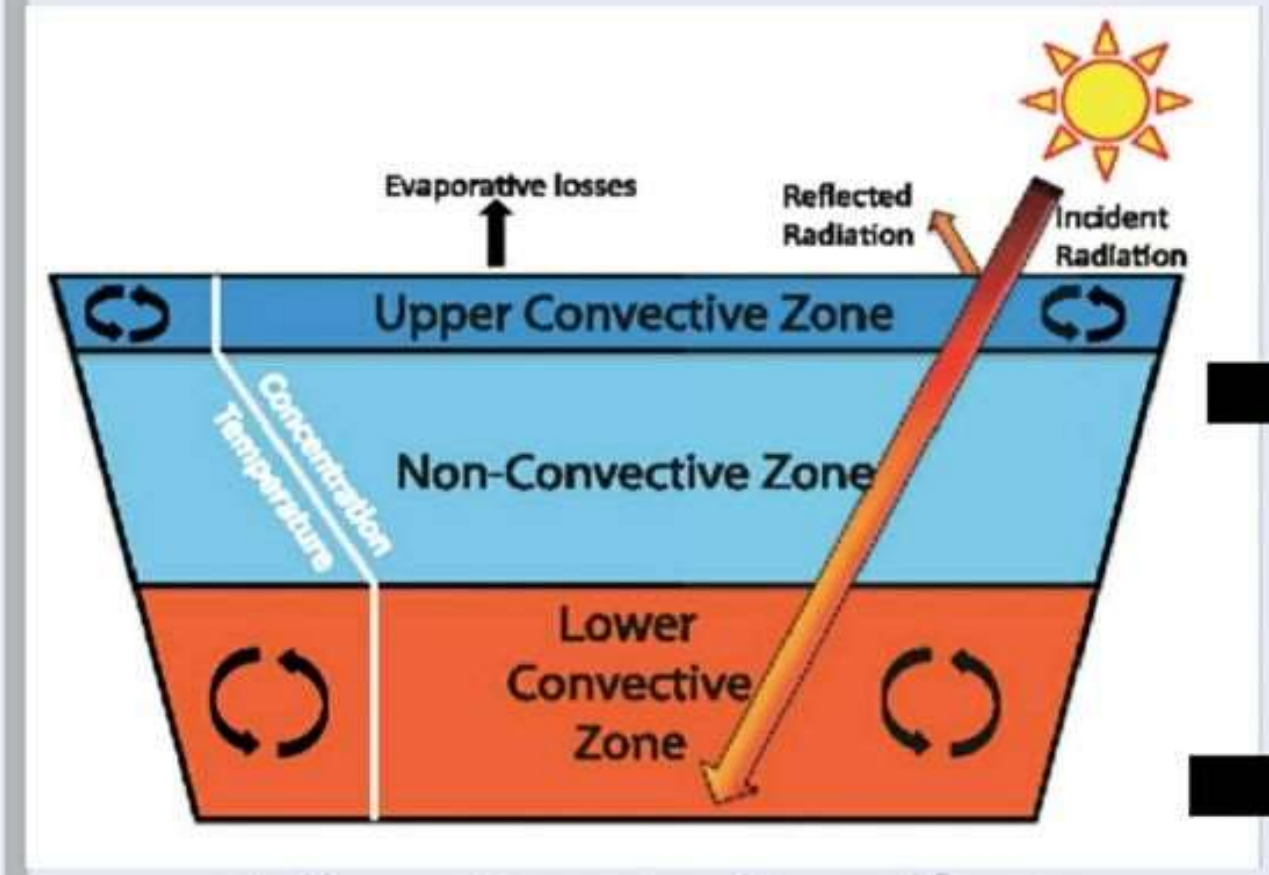
- The **top zone** is the ***surface zone*** called ***Upper Convective Zone***, which is ***normally at atmospheric temperature*** and has ***very little salt content.***
- The **bottom zone** is the ***most salty zone***. In this zone, ***the solar energy is stored in the form of heat,*** and therefore, it is called as the ***storage zone or Lower Convective Zone.***
- In between these two zones an important zone called as **gradient zone** or **Non-Convective Zone** exists. In this zone, the ***salt content increases with increase in the water depth and thereby creats a density gradient.***

Solar pond :

- ***If we consider a particular layer in this zone, water of that layer cannot rise, as the layer of water above this zone has less salt content and is, therefore, lighter.***
- ***Similarly, the water from this layer cannot fall as the water layer below this zone has a higher salt content and is, therefore, heavier.***
- This ***gradient zone acts as a transparent insulator permitting sunlight to reach the bottom zone but also entrapping it there.***
- Therefore, ***when sunlight is incident on solar pond, most of the incoming sunlight reaches the bottom and thus the "storage zone" heats up.***
- ***As the loss of heat is prevented from this zone due to the insulator zone just above it, the bottom of the pond is warmed to extremely high temperature and sometimes it may reach more than 80 0C.***
- ***Finally, heated water from the bottom level is transferred to pipes, circulating through the pond to extract thermal energy.***


Solar Radiation
Upper convective Zone
Non convective Zone
Lower convective Zone

Solar pond



Solar pond

A pool with a bottom layer of salt water and top layer of fresh water, designed to capture solar radiation as a source of energy for generating heat or electricity

Follow @agriculturalfacts

Application of Solar pond :

- ***Heat generated by solar ponds*** has many applications and may contribute in ***cutting down the use of fossil fuels.***
- The heat extracted from the pond may be used for ***the production of chemicals, food, textiles and other industrial products.***
- It can also be used to ***warm greenhouse, swimming pools, and other buildings and offices.***
- The heat can also be ***converted to electricity.***
- The ***cost of conversion of electricity is very less and economical***. It is especially ***useful in remote locations.***
- The solar pond can also ***purify water for municipal water systems through desalination.***

Advantages:

- The use of a solar pond has several benefits.
- Since it has built-in thermal energy storage, it can be used all year, day and night, regardless of condition of weather.
- The solar pond is especially attractive as an alternative to fossil fuel technologies in rural areas, in less-developed countries, where large ponds can be built.
- Energy from a solar pond is more cost-effective than energy from the flat-plate solar water-heating systems that are commonly used in the buildings.
- Since the pond provides heat energy without burning any fuel, it does not contribute to air pollution at the same time contributes in conserving the traditional energy resources such as fossil fuels.

Disadvantages:

- The solar pond has few drawbacks. It requires a large area of land and therefore, may be unsuitable for densely populated areas.
- The pond also requires a continuous and large supply of salt water and also high level of solar energy inputs.
- Additionally, a regular maintenance is very much needed to keep it in a working condition.
- Though solar ponds can be constructed anywhere, it is economical to construct them at places where low cost salt, good supply of sea water or water for filling and flushing, high solar radiation, and land at low cost are available.
- Coastal areas in Tamil Nadu, Gujarat, Andhra Pradesh, and Orissa are ideally suited for such solar ponds in India.

Solar Water Heater :

- It is a device that helps in heating water utilising the radiation energy from the sun.
- Using this device, water can easily be heated up to the temperature 600C to 800C.
- A solar water heater (SWH) of capacity 100 to 300 litres are suitable for domestic use.
- Larger system can be used in restaurants, canteens, guest houses, hotels, hospitals etc.
- A 100 litres capacity SWH may save approximately 1500 units of electricity annually by replacing electric geysers for residential use.
- It can also prevent emission of 1.5 tons of carbon dioxide annually.
- **The main components of solar water heater includes:**

1. *A collector to collect energy from solar radiation*
2. *Insulated tank for storing heated water*
3. *Supporting arrangements*
4. *Connecting pipes and associated instrumentation*

Solar Water Heater :

- The sun rays fall on the collector plate and get absorbed by the black absorbing surface of the collector.
- The absorbed heat energy get transferred to the water flowing through it.
- The heated water is collected in a storage tank.
- The tank is insulated to prevent heat loss.
- Solar water heaters are one of the most cost-effective uses of solar energy.
- Every year, several thousands of new solar water heaters are installed world-wide.
- It can be used for homes, community centres, nursing homes, hotels, hostels, industry etc.
- Use of solar water heaters can curtail electricity bills considerably.
- A residence can save 70%-80% on electricity bill by replacing conventional water heater with solar water heater.
- Solar water heaters are the fastest repayment of investment in 2 to 4 years depending upon its usage.

Solar Dryer Solar energy :

- Solar Dryer Solar energy has become a viable alternative energy and can be converted into heat energy for various applications such as heating water, power generation, food drying, drying of agricultural products particularly vegetables and fruits etc.
- In old days, the traditional method of food drying was to place the foodstuffs in the sun in the open air.
- Although, this method was effective for small quantity of food but the food may easily be contaminated as was kept in open air.
- In contrast to the sun drying, where the food is exposed directly to the sun, the solar drying uses indirect solar radiation.

Solar Dryer Solar energy :

- The principle of solar drying technique is to collect solar energy by heating up the air volume in solar collectors and transmit the hot air from the collector to an attached drying food chamber where food to be dried are kept.
- This is more hygienic technique of food drying as there is no secondary contamination of food products through rain, dust, insects, birds etc.
- The products are drying by hot air only and there is no direct impact of solar radiation (sunshine) on the products.
- Solar dryer are suitable for drying large quantity of food products and for small scale farmers and food producers

Solar Stills:

- A solar still is a green energy product that uses natural sun energy to purify water. Solar stills are able to supply pure water for drinking and cooking, even in the areas where there are no other source of energy, while still being friendly to the environment.
- It works on the principle of evaporation and condensation process.
- The still, consisting of a basin (where impure water is kept) is fully insulated along all its side and closed with the transparent glass cover to permit the solar energy.
- First, the water that needs to be purified is placed in the basin.
- The solar still is then allowed to sit in the sun, which allows the still to absorb the solar radiation.
- As the energy is absorbed, it starts to heat the water. As the temperature of the water rises, the liquid H2O is converted into steam and evaporates towards the glass ceiling, leaving impurities in the basin below.

Solar Stills:

- The second scientific principle on which a solar still acts is condensation.
- The water slowly condenses on the glass, forming pure water droplets.
- Since the glass is angled down toward the second basin, the water droplets roll down into clean water basin.
- Because none of the minerals, bacteria or other substances are able to evaporate with the pure H2O, the water droplets that end up in the second basin are simply purified, and safe for drinking and cooking.
- In most other sources of purification, such as commercial water-bottling plants etc.
- usually, the water is boiled as part of the purification process. As the water is boiled, its PH value drops drastically, causing flat-tasting water. Whereas in a solar still, the water is purified naturally, allowing the PH levels to stay balanced and hence, the test of water remains intact

BIOMASS:

- Biomass refers to the mass of renewable organic materials that comes from living organism, including plants, animals and microorganisms or from a biochemical perspective, cellulose, lignin, sugars, fats and proteins.
- Biomass is a source of renewable energy. It has been in use since people first began burning wood for cooking food and keeping warm the surroundings.
- Biomass has always been a major source of energy for mankind and estimated to contribute 10% to14% of the world's total energy supply
- The most common biomass sources used for energy are plants, wood and organic wastes.
- **However, major biomass sources may include:**

1. **Wood and wood processing wastes:** Firewood, wood pellets, and wood chips, furniture mill sawdust and waste, and black liquor from pulp and paper mills.
2. **Agricultural crops and waste materials**: Various types of agricultural crops such as corn, soybeans, sugar cane, switchgrass, woody plants, and algae, including crop and food processing residues.
3. **Municipal solid wastes:** It includes, paper, cotton, wool products, food and wood wastes.
4. **Animal manure and sewage waters.**

BIOMASS:

- Biomass contains energy which is first derived from the sun.
- Plants absorb the sun's energy through photosynthesis, and convert carbon dioxide and water into nutrients (carbohydrates).
- This energy from these organism can be transformed into usable energy.
- Biomass can be burned to create heat, converted into electricity or it may be processed into biofuel.
- Thermal characteristics of biomass as fuel If you plan to use biomass for fuel, it is necessary to understand it's thermal characteristics in order to avoid possible problems and utilize biomass effectively.
- Biomass can be a source of liquid fuel or gaseous fuel or solid fuel. Out of these fuels, solid fuel is most commonly used.
- The important thermal characteristics of solid biomass fuel may include: • ***Heat value • Moisture content • Composition • Fuel size and density***

Heat Value:

- Amount of heat available in a fuel (kJ/kg) denotes its heat value.
- It is one of the most important characteristics of a fuel as it indicates the total amount of energy available in a particular fuel.
- The heat value in a given fuel type is mostly a function of the fuel's chemical composition.
- The heat value of a fuel can be expressed as: the higher heating value or the lower heating value.
- The higher heating value (HHV) is the total amount of heat energy available in the fuel, which includes the energy contained in the exhaust gases, whereas, lower heating value (LHV) does not include the energy contained in the exhaust gases.
- Generally, the HHV is used for biomass combustors.
- The heat content of a fuel, usually do not have the fixed value.
- It can vary significantly depending on the climate and soil in which the fuel is grown. Hence, the heat value of a biomass fuel should be expressed as a range rather than a fixed value.

Moisture Content:

- Moisture content effects the burning property of a biomass fuel.
- Biomass fuel with high moisture content burn less readily than a low moisture content biomass fuel, hence provide less useful heat per unit mass. Therefore, low moisture level fuels are preferred than the high moisture level fuels.
- Much of the energy in wet fuel is used to heat and vaporize the water. However, extremely dry fuel can cause problems such as dust that fouls equipment or can even contribute to an explosion hazard. The moisture content in a fuel can be calculated either on wet basis or dry basis.
- In wet basis calculations, the moisture content is equal to the mass of water in the fuel divided by the total mass of the fuel.
- In the case of dry-basis calculations, the moisture content is equal to the mass of water in the fuel divided by the mass of the dry portion of the fuel.
- Practically, the maximum required moisture level for combusting fuel is about 50 to 60 percent, calculated on wet basis.

Composition:

- In addition to heat and moisture content, composition of various biofuels affects its performance.
- The main compositional properties includes; ash content, susceptibility to slagging and fouling, and percent volatiles. “Ash contents” are the mass fraction of incombustible materials in a biofuel.
- It is an important parameter, which can reduce the combustion efficiency or clog the ash handling mechanisms. “Slagging and fouling” problems occurs when the generated ash begins to melt and start depositing inside the combustion equipment.
- In most of the time, ash remains in a powdery form, however, under certain circumstances, the ash can partially melt, forming deposits on the combustor surfaces (fouling) or hard chunks of material in the base of the combustion chamber (slagging/clinkering).
- It is observed that the high mineral content as well as dirt in the fuel may cause fouling and slagging problem. Therefore, fuel should be kept free of soil and other contaminants.

Composition:

- Slagging and fouling can be minimized by keeping the combustion temperature low enough to avoid the ash formation. The "percent volatiles" in a fuel is a property that refers to the fraction of the fuel which gets volatilize and turn to gas when heated to a high temperature.
- Fuels with "high volatiles" will tend to vaporize before combusting. It is called as flaming combustion. This property may affect the performance of the combustion chamber and should be taken into account while designing a biomass fuel combustor.
- Fuel size and density: The size and density of the biomass fuel particles is also one of the important factors that affects its thermal characteristics.
- They affect the rate of heating and drying during the combustion process and thus burning characteristics of the fuel gets affected.
- The type of handling equipment depends mainly on the size of the fuel particles. The wrong size fuel may have an impact on the efficiency of the combustion process and it may result in jamming or damage of the handling equipment.
- Smaller-sized fuel is mostly preferred for commercial systems as it is easier to use it in an automatic feed system.
- Normally, fuel size and density are over-looked and should be given careful consideration while selecting a fuel type

Anaerobic digestion :

- Anaerobic digestion is ***a chemical process through which organic matter such as animal manure, food wastes, wastewater biosolids etc. is broken down by microorganisms (bacteria) in the absent of oxygen.***
- Anaerobic digestion process results in ***generation of biogas and bio-fertiliser***.
- ***Biogas*** is mostly comprised of carbon dioxide ***(CO2)*** and methane ***(CH4)*** with very little amount of ***water vapour*** and ***other gases.***
- The ***methane gas*** thus produced may be collected by removing carbon dioxide and other gases and may be ***used as a fuel for cooking or heating or to generate electricity***
- Anaerobic digestion process is ***also used in the municipal waste water treatment***. The quantity of ***solids produced from waste water treatment can be reduced through anaerobic digestion process thereby reducing its disposal cost.***
- When a ***good number of animals stay in one farm,*** the resulting ***manure and wastewater can have significant environmental impacts if they are simply allowed to run over open land, storm sewars etc. Such environmental pollution*** can be ***avoided using anaerobic digestion process which reduces the volume of waste, produces useful methane and also provides a by-product that can be used as fertilizer.***

Anaerobic digestion :

- In addition to the ***animal waste, plant waste from agriculture can also be processed by anaerobic digestion process to produce biogas.***
- The ***residual material left*** after anaerobic digestion process is called ***"digestate."***
- ***Digestate is a wet mixture*** which is usually ***separated into a solid and a liquid form. Digestate is rich in nutrients and can be used as fertilizer for crops.***

Biogas production mechanism :

- Biogas is produced by ***biomass using anaerobic digestion process which involves multistep biological and chemical process.***
- It is beneficial in not only ***waste management but also energy creation.*** The biggest role in the biogas production process is ***played by microbes feeding on the biomass.***
- Biogas can be ***produced from a variety of raw materials,*** which may include:

- ***From industry and enterprises***
- ***Food wastes from shops***
- ***Biowaste generated by consumers***
- ***Sludge from wastewater treatment plants***
- ***Manure and biomass generated from agriculture wastes***

Biogas production mechanism :

- The mechanism of biogas production from biomass involves following steps:

- 1. Biogas production starts from the ***arrival of biowastes***
- 2. After that, it ***is crushed to make its consistency as even as possible***. In this step, ***any unwanted nonbiodegradable waste, is separated from the mixture.***
- 3. ***The crushed biowaste is made in slurry form by adding liquid to prepare it for the anaerobic digestion process.***
- 4. Biomass is then ***delivered in the form of slurry to the biogas plant and pumped into the pre-digester tank where enzymes secreted by bacteria break down the biomass into an even finer consistency.***

- 5. In the next step, ***the biomass is sanitized by heating the mixture at 700 C and above for minimum one hour.*** During this process ***any harmful bacteria present in the biomass is removed.***

Biogas production mechanism :

- 6. After sanitization process, ***the mass is pumped into the main biomass reactor in which biogas production takes place.***
- 7. ***In the biogas reactor, microbial action begins and the biomass enters into a gradual process of fermentation. In this process, microbes feed on the organic matter, such as proteins, carbohydrates and lipids, and their digestion transforms these matters into methane and carbon dioxide.***
- 8. Most of the ***organic matter is broken down into biogas which is mainly a mixture of methane and carbon dioxide , water vapour and other gases, approximately in three weeks duration.***
- 9. ***The biogas thus generated is collected in a spherical gas holder placed at the top of the biogas reactors.***

➢ After this, ***the biogas is ready for use by industries, enterprises and consumers***.

➢ The ***residual solids and liquids created in biogas production are referred to as digestate.*** This digestate goes into a ***post-digester reactor*** and from there further into ***storage tanks. Digestates are well suited for uses such as fertilization or for other gardening purpose.***

Utilization and storage of biogas :

- ***Biogas generated from anaerobic digestion processes is an environmental friendly renewable fuel.*** But it is important to ***clean or upgrade it before using, mainly to increase its heating value and to make it useable in some gas appliances such as engines, boilers etc.***
- ***Biogas mainly contains 50% to 70% methane (CH4), 25% to 30% carbon dioxide (CO2), traces of other gases and fractions of water vapor.***
- It is about ***20% lighter than air and has an ignition temperature in the range of 650 0C to 750 0C.***
- It is an ***odourless and colourless gas*** that ***burns with a clear blue flame*** similar to that of natural gas.

Utilization of biogas:

- Biogas is ***produced throughout the anaerobic digestion process***.
- Biogas is a ***renewable energy*** source that can be ***used in a variety of ways.*** Communities and enterprises across the country use biogas to:

- ***Produce mechanical power, heat and/or electricity***
- ***Fuel boilers and furnaces, hot water systems, air heaters;***
- ***To run fuel vehicles; and***
- ***Supply in homes and other business centres*** for their use with appropriate cleaning or upgrade, biogas can be used in all applications that were developed for natural gas.

- The ***three basic end uses for biogas may categorised as:***

- ***Production of heat:*** The most straightforward use of biogas is as ***thermal (heat) energy.*** In areas where fuels are scarce, small biogas systems can provide the heat energy for ***basic cooking and water heating.*** It may also be used in ***gas lighting systems for illumination.***

Utilization of biogas:

- ***Electricity generation:*** In most cases, biogas is ***used as fuel for combustion engines,*** which ***convert it to mechanical energy which in turn provide power to an electric generator to produce electricity.***
- ***Vehicle fuel:*** Biogas can be ***used as a fuel in gasoline vehicles*** provided the biogas is upgraded to natural gas quality. It can be used in vehicles that have been adjusted for using natural gas.
- Most vehicles in this category are ***retro-fitted with a gas tank and a gas supply system in addition to the normal petrol fuel system.*** However, ***dedicated vehicles (using only biogas) are more efficient than these retro-fits vehicles.***

- Biogas can be ***distributed through the natural gas pipeline and used in homes and business centres*** after proper treatment to meet pipeline quality standard.
- Cleaned and upgraded ***biogas also can be used to produce*** compressed natural gas ***(CNG)*** or liquefied natural gas ***(LNG).***
- CNG and LNG can be used to provide ***fuel for cars and trucks.***
- ***Digestate*** is the material that is left over following the anaerobic digestion process. ***Digestate can be made into products like, Flower pots, Soil treatment and Fertilizers.***

Storage of biogas :

- Appropriate biogas storage system is essential ***for the efficiency and safety of a biogas plant.***
- There are ***two main reasons for storing biogas:***
  - ***(i) Storage at plant location for on-site usage, as and when it is required and***
  - ***(ii) Storage at distribution points or systems.***

A biogas storage system also takes care of fluctuations in the production and consumption of biogas.

- There are **two broad categories of biogas storage system:**
  - (i) ***Internal biogas storage tanks*** that are integrated with the anaerobic digester and
  - (ii) ***External Biogas storage tanks*** which are separated from the anaerobic digester. Further, based on its application, it can be classified as; ***Low-pressure biogas storage, Medium-pressure biogas storage, and High-pressure biogas storage***

i)Low-pressure biogas storage:

- It is the ***simplest and least expensive storage systems used for onsite applications and intermediate storage of biogas.***
- This system ***operates at low pressures below 2 psi.***
- The ***floating biogas storage tank on the digester form falls under this category.*** It can be ***made of steel, fiberglass or a flexible fabric material.***
- ***Flexible fabric materials*** commonly ***used*** for these gas holders include ***high-density polyethylene (HDPE), low-density polyethylene (LDPE), and linear low density polyethylene (LLDPE).***
- Sometimes, a separate tank is also installed along with floating gas holder for the storage of digestate and raw biogas as well.

ii) Medium-pressure biogas storage:

- Biogas can also be stored at ***medium pressure (between 2 and 200 psi) biogas storage***. However, the additional requirements of ***safety, scrubbing and high maintenance associated with these tanks makes them more costly.***
- ***To prevent corrosion of the tank*** components and to ensure safe operation, the biogas must first be ***cleaned by removing H2S***.
- ***Biogas*** that has been ***upgraded to bio-methane by removing H2S, moisture, and CO2 are stored in these tanks***. However, ***the cleaned biogas must be slightly compressed prior to the storage.***

iii)High-pressure biogas storage:

- ***Bio-methane is stored*** in this type of storage.
- Bio-methane is ***less corrosive than biogas***, in addition being ***more valuable as a fuel.***
- Usually, ***production of such fuel exceeds immediate on-site demand***; hence the ***bio-methane must be stored for future use.***
- It is normally ***stored*** either as ***compressed bio-methane (CBM) or liquefied bio-methane (LBM).***
- It is ***stored in high pressure ranges between 2000 psi to 5000 psi***

WIND ENERGY :

- At present, ***renewable energy became the first choice for alternative energy source.*** It is ***mainly due to the pollution generated by traditional source of energy i.e. burning of fossil fuels.***
- The ***fossil fuels are not renewable source hence, it may get completely exhausted due to its continuous usage.*** Therefore, ***renewable source of energy become the obvious choice.***
- Out all the available renewable sources, ***wind and solar energy contributes about 90% world-wide. Wind energy is the kinetic energy associated with the movement of atmospheric air.***
- It **captures the natural wind in our environment** and ***converts the air's motion into mechanical energy.*** This is ***transformed into electrical energy by using wind turbines or wind energy conversion system.***
- ***Wind first hits a turbine's blade, causing them to rotate and turn the turbine connected to them. The turbine shaft is connected to a generator, which produced electricity through electromagnetism principle.***
- The ***amount of power that can be generated from wind depends upon the size of the turbine and its blade length.***

Current status and future prospects of wind energy :

- ***Wind power technology is one of the fastest growing renewable energy technologies***.
- Due to the ***various environmental issues*** associated with the usage of traditional source of energy, most of the users are on high pressure to start looking for ***alternatives and sustainable energy to minimize the carbon foot prints and its emission***.
- Globally the ***wind generation capacity is increasing very fast.*** It has increased many folds from ***7.5 gigawatts (GW) in 1997 to 598 GW by 2018***.
- It has been ***increased by 7% in 2019 to reach the value of 645 GW.***
- ***Between 2009 to 2013*** the ***production of electricity using wind energy has doubled and in 2016, wind energy accounted for 16% of the electricity generated by all other renewable energy source.***
- ***Worldwide renewable jobs have increased*** considerably and reached more than 11 million people in 2018. For creating jobs, China was the highest in the list followed by EU, Brazil, Us and India.

Current status and future prospects of wind energy :

- In the recent years, the ***wind power installations have increased many folds(Increase in many times to get power potentials).*** The developments and advancements in wind power generation systems are ***rapidly updated*** and thereby ***attracting worldwide interest.***
- ***Global Wind Energy Council suggest*** that ***wind energy systems could provide 20% of the global demand for electricity by 2030.***
- They have suggested that the ***total electricity generated capacity may reach up to 2110 GW by 2030.***
- It is also expected that the ***price of wind power installations will reduce drastically, which will result in making wind energy systems economically competitive.***
- Due to the ***growing demand for electric vehicles as well as public transport, future demand for electricity may increase many folds.***

Current status and future prospects of wind energy :

- ***Potential of wind energy to provide 20% of global electricity production by 2050 has been established through various research work.***
- In this respect, ***the Global Wind Energy Council (GWEC) envisions 5.8 TW of wind energy by 2050. GWEC anticipated that the China would remain the world's largest market with 1789 GW of wind power by 2050.***
- ***India is predicted to generate (452 GW) of wind power by 2050.***
- Currently ***India has the fourth highest wind installed capacity in the world with total installed capacity of 39.25 GW (as on 31st March 2021)***

Wind energy in India :

- India's wind energy sector is ***progressing consistently.***
- It is led by ***indigenous(produced/growing) wind power industry. Continuous progress and expansion of the wind power industry in India resulted in protection of ecosystem.***
- It's project operation capabilities and ***manufacturing base has been increased to about 10,000 MW per annum.***
- As on ***March 2021, India currently has the uwind installed capacity in the world with total installed capacity of 39.25 GW. It has also generated around 60.149 billion Units during 2020-21.***
- The ***compound annual growth rate for wind generation has been 11.39% between 2010 and 2020, and for installed capacity, it has been 8.78%.***
- The ***Government is promoting wind power projects in the entire country through private sector investment.***
- ***India government is helping private sectors by providing various fiscal and financial incentives such as Accelerated Depreciation benefit; concessional custom duty exemption on certain components of wind electric generators.***

Wind energy in India :

- In addition to this, **Generation Based Incentive (GBI) Scheme** was available for the wind projects commissioned before 31 March 2017.
- In addition to ***the facilities stated above, following steps have also been taken to promote the installation of wind power generating facilities:***

1. ***Providing technical support including identification of potential sites and wind resource assessment with help of National Institute of Wind Energy, Chennai.***

2. The inter-state transmission charges and losses have been waived out, in order to facilitate inter-state sale of wind power. However, to avail this facility, wind power project need to be commissioned by March, 2022.

3. With an objective to provide a frame work for procurement of wind power through transparent process of bidding, guidelines have been issued for Tariff Based Competitive Bidding Process for procurement of power from grid connected wind power projects.

4. Bidding process have been standardised and roles and responsibilities of various stakeholders are also clearly defined.

5. These guidelines are provided with the aim to facilitate the distribution licenses to procure wind power at competitive rates and in a cost-effective manner.

Potential of Wind Energy in India :

- An extensive wind resource assessment is essential for the ***selection of the potential sites as the wind is an intermittent(not occurring regularly/not steady) and site-specific resource of energy.***
- The Government, through ***National Institute of Wind Energy (NIWE), Chennai has installed over 800 wind-monitoring stations all over country and issued wind potential maps at 50m, 80m, 100m and 120m above ground level.***
- The recent assessment indicates a ***gross wind power potential of 302.25 GW in the country at 100 meter and 695.50 GW at 120 meter above ground level.***
- Most of this ***potential exists in seven windy States as given below: Gujurat, Rajasthan, Maharashtra, Tamil Nadu, Madhya Pradesh, Karnataka & Andhra Pradesh.***

Environmental benefits and problem of wind energy :

The Environmental benefits of wind energy are more apparent than the problem. ***The main Environmental benefits include:***

- ***Wind is an unlimited, freely available renewable resource. Therefore, it is a sustainable technology.***
- ***As the wind is a natural occurrence resource, harvesting the kinetic energy of wind doesn't affect currents of wind cycles in any way.***
- ***It is a clean, non-polluting way to generate electricity.***
- ***Unlike other types of power plants, it does not emit air pollutants or greenhouse gases. The wind turbines harmlessly generate electricity utilizing the kinetic energy of passing by wind.***
- ***Wind energy is far more eco-friendly than the burning of fossil fuels for generating electricity.***
- ***Once the turbines and energy centres are installed, the maintenance cost of turbines and generation of wind power is minimal.***
- ***Wind power turbines can be placed wherever necessary as it needs very little space.***

Problem of wind energy:

The major problem of wind energy is the ***initial cost involved for constructing turbines and wind facilities which is extremely expensive***. Other problems may include the following:

- ***The giant size of wind power turbines distracts viewers from the beautiful surroundings.***
- ***Wind turbines may be dangerous to flying animals. Many birds and bats have been killed by flying into the rotors.***
- Usually, the ***wind turbines are located in the remote areas. Hence, the cost of travel and maintenance on the turbines increases and is time consuming.***
- ***Offshore wind turbines require boats and can be dangerous to manage.***
- ***Some wind turbines tend to generate a lot of noise which can be unpleasant.***
- ***In the darkness/at night it may be difficult for incoming boats to see wind turbines thus may lead to collisions(crash).***

NEW ENERGY SOURCES :

- Fossil fuel (coal, oil and natural gas) are our most traditional source of power generation.
- Therefore, the energy produced from any source other than fossil fuels may be termed as new energy or alternative energy. At present, we are mostly dependent on the fossil fuels for the power generation, causing depletion of these finite materials.
- Hence, if we are not careful now, our precious, non-renewable resources may get exhausted soon. That means no more oil, natural gas and even coal. Also, burning fossil fuel in power plants has much adverse impact on our environment.
- Entire ecosystem gets destructed due to the various types pollution created by burning of fossil fuel. Hence, there is a need of new energy sources to overcome all the above stated issues.

Different types new energy sources :

- New energy sources may be renewable or non-renewable type.
- Renewable energy sources are derived from naturally available energy sources such as sun, wind and water. These sources are referred as renewable or sustainable because naturally occurring continual renewal makes them inexhaustible.
- There are new energy sources which falls under non-renewable category; e.g., nuclear energy source .

Different types new energy sources :

The material used in nuclear power plants to create nuclear fusion is typically a rare type of uranium, which is non-renewable.

There are **eight (08) most commonly used new energy sources:**

1. ***Wind energy: Wind farms capture the wind flow by using turbine and converting it into electricity.***

2. Solar energy: Solar energy is harnessed directly from radiant energy emitted through sunlight and converting it into heat, electricity or hot water.

3. Hydroelectric energy: This energy is generated mostly in the dams. Water flows through the turbines located in the dam site to produce electricity.

4. Geothermal energy: Geothermal power is generated by tapping underground reservoir of hot water and steam. Geothermal electricity can be directly used for the purpose of heating and cooling of buildings.

5. Bioenergy: Bioenergy is generated from organic materials known as biomass or biofuel. Biogas generated from anaerobic digestion process and used to generate electricity.

Different types new energy sources :

6. Nuclear energy: Nuclear energy is created in the form of heat through the fission process of atoms.

7. Hydrogen energy: Hydrogen is used as clean burning fuel as it generates fewer pollutants leading to cleaner environment.

8. Ocean Energy: Ocean energy refers to all forms of energy derived from sea. The movement of the ocean's waves, tides, and currents carries energy that can be harnessed and converted into electricity to power homes, buildings and cities. Ocean energy is environmentally friendly and renewable source of energy.

Applications of Hydrogen energy:

- Hydrogen with one proton and one electron, is the most simplest and abundant element on earth. But it does not exist by itself in nature and produced from the sources that contain it such as biomass, solar energy, wind energy, natural gas etc.
- Hydrogen is not a energy source rather it is an energy carrier and can store or deliver a tremendous amount of energy. It can be used in fuel cell to generate electricity, or power and heat.
- Hydrogen is a clean fuel and produces only electricity, heat and water when used in fuel cell.
- Hydrogen and fuel cell together have the broad range of applications almost in all the sectors such as transportation, industrial, residential etc.
- In addition, it may provide power for trucks, aircraft, rail, ships, cars, busses etc. Hydrogen and fuel cells have the potential to reduce greenhouse gas emission in many applications.

Application Ocean energy resources:

- Oceans cover more than 70% of earth's surface, making them the world's largest solar collectors. Just a small portion of heat trapped in the ocean can power the entire world. From the ocean mainly ***two types of energy can be harvested; Thermal energy and Mechanical energy.***

i)Thermal energy:

It is harvested from the temperature difference of the warm surface waters and the cool deeper water.

The technological concept to harvest the thermal energy in the ocean is universally called "Ocean Thermal Energy Conversion (OTEC)" and is currently under development stage.

OTEC converts the temperature difference of warm surface water and cold deeper waters into energy. Depth of cold water zone is about 1000 m below the surface. The required water temperature difference is minimum 200C to operate the OTEC power cycle on a satisfactory way. Thermal energy resource is concentrated on certain zones.

On this zone, approximately 66 developing nations including USA and Australia are located. Ocean thermal energy is used to generate electricity.

ii)Mechanical energy:

- This energy consisting of both potential and kinetic energy is harvested from the tides, waves and currents of the ocean.
- Ocean mechanical energy is very different from the ocean thermal energy. Tides, waves and currents are intermittent source of energy whereas; ocean thermal energy is quite constant.
- The electricity conversion from all the three energy sources usually involves mechanical devices.

iii)Tidal energy conversions:

- The interaction of sun-moon-earth system causes tides. Tides rise and fall is the product of the gravitational and centrifugal forces, of primarily the moon with the earth.
- The difference of level between low and high tide is used to produce electricity.
- The technology is similar to the one used in the traditional hydroelectric power plants. The use of tidal energy requires a barrage (dam) across a shallow area, where the difference in the level of low and high tide should be at least 5 meters.
- The tide basin is filled and gets emptied everyday with the flood tides when the water level rises and with the ebb tides when the water level falls. Low-head turbines are installed in the barrage along with the sluice gates that allows water to flow from one side of the barrage to inside the tidal basin. The difference in elevation creates a hydrostatic head that generates electricity through electrical turbines.

Concept, origin and power plants of geothermal energy :

- The word geothermal comes from the Greek word Geo means earth and theme means heat.
- Geothermal energy is basically heat stored within the earth.
- People all over the world use geothermal energy primarily to heat buildings and to produce electricity.

Concept and Origin of geothermal energy :

- People in ancient time, including Romans, Chinese and Native Americans has used hot mineral water from natural pools and springs for bathing, cooking and heating purpose. Initially, such uses of geothermal energy were limited to the places where hot water and steam were accessible.
- The hottest part our planet called the core is situated about 2900 kilometres below earth's surface. Majority of earth's heat is constantly generated by the decay of radioactive isotopes. Temperature of the core is more than 50000C. Radiating heat from core is warming rocks, water, gas and other geological materials.
- If underground rock formations are heated to temperature about 7000C-13000C they get partly melted and become magma. Magma heats nearby rocks and underground aquifers. From this heated aquifers, hot water can be released through geysers, hot springs, steam vents and mud pots.
- These are the sources of geothermal energy. Their heat can be captured and used directly to heat structures such as buildings, vehicle parking space etc.

Concept and Origin of geothermal energy :

- The Geothermal heat was delivered in the residences of United States in 1892.
- However, the importance and economic potential of geothermal energy was realised only in the late 19th century.
- Geothermal power plants were commissioned in New Zealand in 1958 and at the Geysers in north California in 1960.
- In the early 21st century, 24 countries including Unites States, Mexico, Italy, New Zealand have used geothermal energy to produce electricity.
- In 2016, the total worldwide installed capacity for electrical power generation using geothermal energy was about 13,400 MW

Power plants of geothermal energy:

- Geothermal power plants are used to generate electricity using geothermal energy.
- Their working principle is similar to the coal or nuclear power plant except the source of power.
- In geothermal power plant, earth's heat replaces the boiler of a coal plant or reactor of a nuclear plant. Hot water or steam is extracted from the earth through a series of wells and used in the giothermal power plant.
- There are mainly three types of geothermal power plants and the choice of plant depends on the state (steam and water) and temperature of the available geothermal energy.

1. Dry steam power plant
2. Flash steam power plant and
3. Binary cycle power plant

Dry steam power plant:

- These plants uses dry steam from geothermal reservoir. The steam from the production well travels directly to a turbine, which drives a generator to produce electricity. After transferring its energy to the turbine, steam gets condensed and injected back into the earth.
- These are the oldest type of geothermal power plants and the first one was built at Italy in 1904. These plants require highest temperature and can only be used where underground temperature is quite high.
- Steam technology is still effective today and is currently in use at The Geysers in northern California, the world's largest source of geothermal power.

Flash steam power plant:

- Flash steam power plants are the most commonly used geothermal power generation plant today. This is mainly due to the lack of naturally occurring high-quality steam. For this plant, water temperature must be over 1800C.
- The underground hot water is pumped through the well into a tank kept at the surface level. The surface water tank is kept under much lower pressure, causing some of the fluid to rapidly vaporise, or flash.
- The vapour then drives the turbine which in turn drives generator and thus electricity is generated.
- The unused water, which could not become steam, is cycled back into the well or it can be flashed again in a second tank to extract some more energy. It can also be used for some other heating purposes.

Binary cycle power plant:

- Binary cycle power plant differs from other two types of geothermal plant. In this, the water or steam from geothermal reservoir never comes in contact with the turbine or generator unit.
- Here, a secondary loop (hence the name binary) containing a fluid with a low boiling point, such as pentane or butane is used.
- The water from the well flows through a heat exchanger, which transfers its heat to the fluid having low boiling point. Water vaporizes from these fluids due to its low boiling point.
- It is then passed through a turbine, drives it and subsequently, the generator to produce electricity.
- It is expected that these plants will be most commonly used in future simply because it can make use of water with low temperature than other two types of power plants.

UNIT SUMMARY

1. We receive a pure, non-polluting, and inexhaustible form of energy from the Sun. This energy comes in the form of radiant light and heat and known as solar energy.
2. Solar energy is a powerful source of energy, however, only a small portion of it can be mainly used to/for: Generate electricity, Heating and cooling, Cooking and Water desalination.
3. The flat plate collector is the most fundamental solar power collector mainly used for domestic hot water system.
4. In the plate collector, the solar radiation is absorbed by the plate having black surface and then absorbed heat get transferred to the fluid/air filled in the tubes.
5. The flat-plate systems normally operate within the temperature range from 300C to 800C.
6. For transport of heat, either liquid or air can be used in the flat plate collectors. For liquid, water is one of the common options due to its accessibility and good thermal properties.
7. Special coatings helps enhancing the plate absorber properties such as high temperature tolerance, resistance to UV and moisture degradation, durability, optical characteristics etc.

8. Using advanced plate collector temperature can be enhanced to 1500C thereby enhancing application range of the collector to power generation, solar air conditioning system etc.
9. There are many ways to tap solar energy for example through the use of solar ponds, solar water heater, solar dryer and solar stills.
10. Solar pond is a solar energy collector, fairly large in size and looks like a pond.
11. A solar pond mainly has three zones: Upper Convective Zone, Middle Non-Convective Zone and Lower Convective Zone.
12. Solar water heater is a device that helps in heating water utilising the radiation energy from the Sun. 13. The main components of heater includes: a collector to collect energy from solar radiation, insulated tank for storing heated water, supporting arrangements, and connecting pipes and associated instrumentation
14. The principle of solar drying technique is to collect solar energy by heating up the air volume in solar collectors and transmit the hot air from the collector to an attached drying food chamber where food to be dried are kept.
15. A solar still is a green energy product that uses natural sun energy to purify water. 16. Biomass refers to the mass of renewable organic materials that comes from living organism, including plants, animals and microorganisms or from a biochemical perspective; cellulose, lignin, sugars, fats and proteins.

16. Biomass refers to the mass of renewable organic materials that comes from living organism, including plants, animals and microorganisms or from a biochemical perspective; cellulose, lignin, sugars, fats and proteins.
17. The important thermal characteristics of solid biomass fuel may include: heat value, moisture content, composition, fuel size and density.
18. Anaerobic digestion is a chemical process through which organic matter such as animal manure, food wastes, wastewater biosolids etc. is broken down by microorganisms (bacteria) in the absent of oxygen.
19. Biogas is produced by biomass using anaerobic digestion process which involves multistep biological and chemical process.
20. There are two basic reasons for storing biogas: (i) storage for later on-site usage and (ii) storage before and/or after transportation to off-site distribution points or systems.
21. Wind energy is the kinetic energy associated with the movement of atmospheric air. It captures the natural wind in our environment and converts the air's motion into mechanical energy.

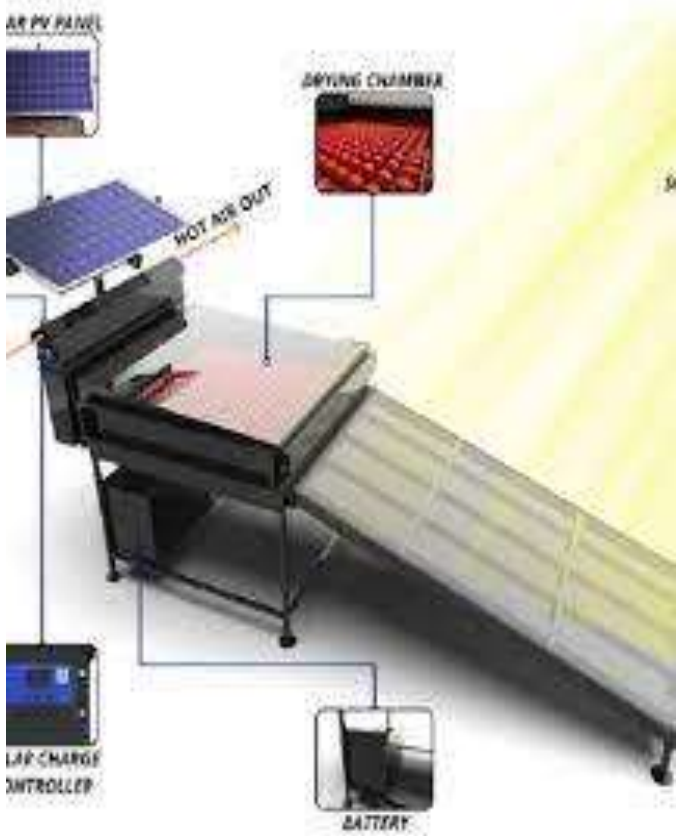
22. Currently India has the fourth highest wind installed capacity in the world with total installed capacity of 39.25 GW (as on 31st March 2021).

23. The energy produced from any source other than fossil fuels may be termed as new energy or alternative energy.

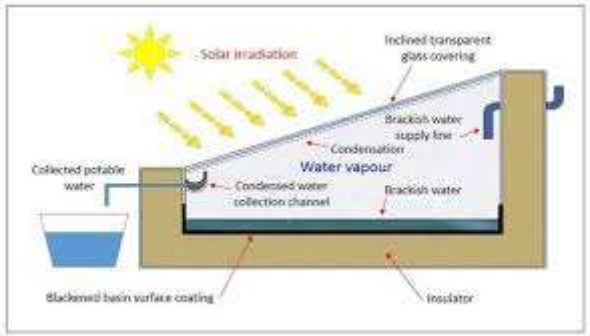
24. There are mainly three types of geothermal power plants; Dry steam power plant, Flash steam power plant and Binary cycle power plant.

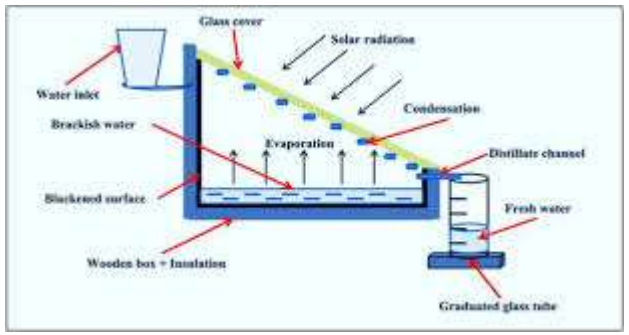
3.7 INNOVATIVE ACTIVITIES 1. Seminar: A topic may be divided into sub-topics among to10 students for presentation. 2. Symposium: Paper presentation by students on the topic of their choice. 3. Group discussion: In a group of 10 students with one group leader, one moderator and one recorder. Group leader to ensure participation by all students, moderator to ensure no cross talks and recorder to record the observations including his/her own. 4. Project Work: Project work on a suitable topic may be assigned to a group of 3 to 4 students. Project may be experimental or investigation type. 5. Educational Tour: An educational tour to solar energy power plant, wind energy power installations and biogas plant. 6. Social Activities: A group of students may be involved for door-to-door campaign to encourage occupants to use solar power water heaters instead of electric geysers in their houses. They should also convey them the importance of renewable source of energy such as solar energy, biomass and wind energy

3.8 INTERESTING FACTS 1. One hour of sunlight is equivalent to one year's worth of energy for the planet. 2. 174,000 terawatts of energy consistently strike the earth as solar radiation at any moment, even on the cloudiest of days. 3. The average solar panel system operates at 20% efficiency, meaning that it converts 20% of the sunlight that hits it into electricity. 4. Solar energy users save up to 35 tons of carbon dioxide and 75 million barrels of oil each year. 5. Wind energy was first developed with windmills in 200 BC in Persia and China. 6. Wind energy was then used for hundreds of years to pump water and crush grain. People also used sails on sail boats as a form of wind power. 7. The largest turbine created is located in Hawaii. It is twenty stories tall and each blade is the length of a football field. 8. Wind energy is the only form of alternative energy that doesn't require water. 9. The US Energy Department provides a wind resource map that shows average wind speeds and potential wind energy capacity if you want to install a wind turbine in your area. 10. China produces the most wind energy in the world. The United States closely follows asthe second largestwind energy producer. 11. One small turbine in your backyard could power your home. 12. In 2015, the United States planned to reduce 12.3 gigatons of greenhouse gases and save 260 billion gallons of water by increasing the use of wind energy to power homes, schools, and businesses. 9. Tidal power plants can last much longer than wind or solar forms of energy.



Solar Dryer


Solar irradiation
Inclined transparent glass covering
Brackish water supply line
Condensation
Water vapour
Collected potable water
Condensed water collection channel
Brackish water
Blackened basin surface coating
Insulator


Glass cover
Solar radiation
Water inlet
Condensation
Brackish water
Evaporation
Distillate channel
Blackened surface
Fresh water
Wooden box + Insulation
Graduated glass tube


DIY Solar Still
ByzantineFlowers Facebook Page

Solid Waste Management

Solid waste refers to any unwanted or discarded material that is in a solid form and is typically produced by human activities.

Refuse what you do not need; reduce what you do need; reuse what you consume; recycle what you cannot reuse, reduce, or reuse; and rot (compost) the rest".

SOLID WASTE GENERATION

Solid waste can be categorized into:

- **Municipal Solid Waste (MSW):** Commonly known as trash or garbage, it includes household items like food scraps, packaging, old furniture, and electronics.
- **Industrial Waste:** Waste produced by manufacturing processes, including chemicals, metals, and plastics.
- **Hazardous Waste:** Dangerous or harmful materials such as chemicals, batteries, and medical waste that require special disposal methods.
- **Construction and Demolition Waste:** Materials like concrete, wood, metal, and other debris from building and construction projects.
- **Organic Waste:** Biodegradable materials such as food scraps, yard waste, and agricultural by-products.

Sources of Municipal Solid Wastes

Main sources of municipal solid wastes may be classified into the following categories:

1. Residential sources: Wastes from household and residential areas. These are the major sources of municipal solid wastes.
2. Institutional sources: Wastes from government and public institutions such as schools, colleges universities, government offices etc.
3. Commercial establishments: Wastes from business centers such as food and drink establishments, shops, banks etc.

4. Health facilities: Wastes from hospitals and other health facilities.
5. Construction and demolition activities: Wastes from various types of construction and demolition activities such as construction of apartments, demolition of slums etc.
6. Industrial sources: Wastes from various types of industrial processes.
7. Agricultural sources: Wastes from agricultural activities.
8. Open areas: Wastes from roadside dustbins, street sweeping and other public places.
9. Electronic and electrical wastes (e-wastes): Waste from electronic devices like computers, phones, radio etc. and household appliances such as cookers, washing machines etc.

Characteristics of Municipal Solid Wastes

1. Physical characteristics:

Knowing the physical characteristics of MSW allows for more efficient, cost-effective, and environmentally friendly waste management practices, from collection to disposal and recycling.

- **Density:** Density of a waste is its mass per unit volume (Kg/m3). It is required for the design of landfills, storage, type of collection and transport vehicles.
- **Moisture content:** It is the ratio of the weight of water to the total weight of waste. Cost of collection, transport and economic feasibility of waste treatment by incineration depends upon the moisture content of the waste.

- **Size of waste constituents:** Size of raised constituents are required for the design of mechanical separators, shredder and waste treatment processes.
- **Calorific value:** It is the amount of heat generated from combustion of unit weight of a substance, expressed in kcal/kg.
- **Permeability:** The permeability of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill.
- **Compressibility:** It is the degree of physical changes in the solid waste when subjected to pressure.

2. Chemical characteristics

- **pH Level**: The acidity or alkalinity of the waste. Waste with a high or low pH can cause environmental issues, such as corrosion of waste handling equipment, and may require special treatment methods. For example, highly acidic waste can damage landfills or contaminate groundwater.
- **Organic Content**: The presence of biodegradable materials (e.g., food waste, paper, and yard trimmings). These materials decompose over time, producing gases like methane.

- **Heavy Metals**: The presence of metals such as lead, mercury, cadmium, arsenic, and chromium. These toxic metals can leach into the environment if not properly managed and pose significant health risks, so knowing their levels is essential for proper disposal and recycling.
- **Toxicity and Hazardous Substances**: Identifying the presence of toxic substances such as asbestos, pesticides, certain plastics, or industrial chemicals. These require specialized handling, disposal, and often, regulatory compliance to prevent contamination and health risks.

- **Nutrient Content**: The levels of nutrients like nitrogen, phosphorus, and potassium in organic waste. These nutrients are important for composting and can be used to create fertilizer if the waste is processed appropriately.
- **Presence of Gases (e.g., Methane and Carbon Dioxide)**: Gases produced from the anaerobic decomposition of organic waste in landfills. Monitoring and controlling these gases is important for both landfill management and the potential for energy recovery.

Biodegradable and Non-biodegradable Solid Wastes

- We must know that everything we use in our daily life is either biodegradable or non-biodegradable.
- **Biodegradable wastes:** These are the waste materials which can be easily degraded by natural factors like microorganisms (e.g., bacteria, fungi etc.), abiotic components (e.g., sunlight, water, oxygen etc.).
- They transform them into simple organic matters which can be used as fertilizers, manure, compost, biogas and more.
- Biodegradable wastes, found in municipal solid wastes include green waste, food waste, paper waste, biodegradable plastics etc.
- Some of the wastes includes human waste, slaughterhouse waste etc.

Non-biodegradable wastes:

- These are the wastes which cannot be decomposed or degraded by natural agents.
- Therefore, they remain in the ecosystem for long duration without decompose and harm our environment.
- They are not at all ecofriendly. Most of the inorganic waste such as plastic cups, bottles, e-wastes etc. are comes under non-biodegradable category.
- Some of these wastes which can be recycled and can be used again are known as “Recyclable waste and those which cannot be used again are known as “non-recyclable waste”.

e-waste

- The term “e-waste” is an abbreviation of “electronic and electrical waste”.
- Due to the revolution in IT sector, production of electrical and electronic equipment (EEE) became one of the fastest manufacturing activities.
- Due to rapid economic growth, the production and consumption of EEE has increased many folds.

Sources of e-waste:

- **Home Appliances:** It may include, Microwaves, Home Entertainment Devices, Electric cookers, Heaters, Fans etc.
- **Electronic Utilities:** Heating Pads, Remote Controls, Television Remotes, Electrical Cords, Lamps, Night Lights, Treadmills, Smart Watches, Heart Monitors, etc. may be included in this category.
- **Communications and Information Technology Devices:** Cell phones, Smartphones, Desktop Computers, Computer Monitors, Laptops, etc. may fall under this category.

Sources of e-waste:

- **Office Equipment:** This category may include, Copiers/Printers, IT Server Racks, IT Servers, Cords and Cables, Phone & PBX systems, Audio & Video Equipment, Network Hardware, Power Strips & Power Supplies, Uninterrupted Power Supplies (UPS Systems), Power Distribution Systems (PDU's), etc.
- **Medical Equipment:** This category may include, Dialysis Machines, Imaging Equipment, Video Equipment, Power Supplies, Uninterrupted Power Supplies (UPS Systems), etc.
- **Home Entertainment Devices:** It may include, DVDs, Stereos, Televisions, Video Game Systems, etc.

Characteristics of e-Waste

- **Hazardous substances:** The hazardous substances that are mostly found are plastic, lead, mercury, cadmium, arsenic, CFCs, PVC etc.
- These substances have a great potential to harm or pollute the environment (the flora, the fauna, the soil etc.) and human health (carcinogenic diseases, liver, kidney, brain damages etc.).

Characteristics of e-Waste

- **Non-Hazardous substances:** The recycling of e-wastes helps to identify the non-hazardous substances which can be used again without harming the environment.
- The different metals when they are recycled back, have a great advantage in the manufacturing processes of different industries.
- For example, the aluminum, copper and gold that is often found in electronic goods is considered to be nonhazardous.
- Plastic and glass are the material found in computer parts are also not hazardous.

Biomedical waste

- Biomedical wastes can be defined as wastes that are generated in hospitals, biological activities, veterinarian clinics and health care units.
- Biomedical waste may be hazardous or non-hazardous.
- According to WHO (World Health Organization), about 85% of biomedical wastes falls under non-hazardous category, whereas 15% falls under hazardous category.

Sources of Bio-medical waste

- The sources may be classified into two broad categories; Major and Minor sources.
- **Major sources** generate more amount of the wastes compared to the minor sources and on regular basis.
- These sources include; Hospitals, Emergency care facilities, dialysis centers, transfusion centers, blood banks, clinical laboratories, research laboratories, mortuaries, veterinarians and nursing homes.
- **Minor sources** include; medical clinics, cosmetic clinics, home care, paramedics and institutions

Characteristics of Bio-medical waste

It can be classified into two categories; non-hazardous wastes and hazardous wastes.

Non-hazardous wastes

- These type of waste which does not pose any direct threat to the people and environment as they are non-toxic by nature.
- But still, it should not be thrown be in open areas or sewer line because of the risk it may pose threat to the environment.
- The non-hazardous wastes may include; wash water, paper cartoons, packaging materials, food remnants etc. These wastes are generated mainly from various organizations, maintenance of hospital and health care centres.

Characteristics of Bio-medical waste

Hazardous wastes

These type of waste which pose direct threat to the people and environment because of their toxic and infectious characteristics.

- The various hazardous wastes may include:
- **Infectious wastes**: Infectious wastes include human/animal tissue, and urine from the infected patients, blood-soaked bandages, surgical gloves, cultures, swabs used to inoculate cultures, isolation wards waste, equipment that have been in contact with the infected patient etc.

Characteristics of Bio-medical waste

- **Pathological wastes:** Human tissues or fluids e.g., body parts, blood and other body fluids, fetuses etc.
- **Pharmaceutical wastes:** It contains pharmaceuticals of expiry date, contaminated pharmaceutical bottles, boxes etc.
- **Radioactive wastes:** nuclear medicine treatments, cancer therapies and medical equipment.
- **General Wastes:** Waste like paper, plastics, liquids and all the waste which are not included in the above three wastes, falls under this category.

METALLIC WASTES and RECYCLE

- Heavy metals like Au, Ag, Ni, Cu, Zn, Cr etc. are found in these metallic wastes.
- These valuable metals can be recovered from these waste materials by recycling process such as calcination, roasting, smelting, refining etc. and reused.
- Microorganisms such as Penicillium, Aspergillus acid, thiobacillus trioxane, Leptospiral ferroxidase and Sulphurous acid are also used for recovering the metals.

METALLIC WASTES and RECYCLE

- Metals can be recycled repeatedly without degrading their properties.
- Because of its recycling property, scrape/waste metal has value, which motivates people to collect it for the sale and recycling processes.
- The recycling of scrap metals, enables us to preserve natural resources. It also has social impact as it helps in creating jobs in the society.

Non-metallic wastes

- A large portion of non-metallic wastes consists of waste paper, wood, lubricants, plastics, glass, rubber textiles, printed circuit boards etc.
- ***Lubricant:*** It is a substance used to reduce the friction between various parts of the machinery and thereby extending the life by minimizing wear and tear which in-turn save energy and resources.
- Used oils such as engine lubrication oil, hydraulic fluids, and gear oils which are used in cars, bikes, or lawnmowers can pollute the environment,

COLLECTION AND DISPOSAL

Solid waste management involves three basic functional elements; collection, processing and disposal of the solid wastes.

Collection of Municipal Solid Waste (MSW):

1. **Door-to-door collection:** This is the most commonly used system of solid waste collection. It is carried out on regular basis as per the pre-informed timings and scheduling.
2. **Collection from road kerbside/alley:** In this system, waste generators place their waste containers or bags on the road kerbside or in the alley on a pre-decided day/or days for collection.
3. **Block collection system:** In this system, waste generators are responsible for bringing their waste to collection vehicle.

COLLECTION AND DISPOSAL

4. <u>Communal system:</u>

- In this system, the collection points/container is located in a public place and the waste generators need to keep their waste into the designated place/container.
- Based on the mode of operation, methods of collection of solid waste from collection points, may be of two types; (i) Hauled-container system and (ii) Stationary-container system.

In Hauled-container system: An empty storage container also called as drop-off box is hauled to the storage site to replace the container full of waste, which is then hauled to the processing point, transfer station or disposal site.

In Stationary-container system: The containers used for the storage of waste, remain at the point of collection.

- The collection vehicle stops alongside the storage containers, and collection crews load the waste from the storage containers into the collection vehicles and then transport the wastes to the processing point, transfer station or disposal site.

Stationary-container

Disposal of Municipal Solid Waste (MSW)

- Disposal is the third functional element of solid waste management after collection and processing.
- At present, sanitary landfill method is used more frequently for the disposal of municipal solid waste.
- The principle of reducing waste, reusing and recycling resources and products is referred to as 3Rs

3R, Principles

- It is one of the principles of solid waste management. Basically, the 3R concept is a sequence of steps on how to manage waste properly.
- The first of 3Rs, **reducing** is the best way to go about managing solid waste.
- The less you use the less waste you will produce.
- Buying products with less packaging to minimize the waste generated from product packaging.
- Avoiding disposable goods such as paper plates, cups, napkins, etc.
- Buying durable goods to avoid frequent disposal.
- Use electronic mail for communication wherever possible.

- **Reuse** products in different ways. For example, use plastic microwave dinner trays as picnic dishes.
- Sell old clothes, appliances, toys and furniture or donate them to charities.
- Use ceramic coffee mug instead of paper cups.
- Use grocery bags or bring your own bags to the store. Do not take a bag from the store unless you need one.

REUSE

- **Reuse** products in different ways. For example, use plastic microwave dinner trays as picnic dishes.
- Sell old clothes, appliances, toys and furniture or donate them to charities.
- Use ceramic coffee mug instead of paper cups.
- Use grocery bags or bring your own bags to the store. Do not take a bag from the store unless you need one.

RECYCLE

- The final and probably the best-known R of 3Rs stands for **recycling**.
- It involves manufacturing of new products from the old and used materials, using necessary recycling process.
- Buy products from recycled materials.
- Purchase recycled materials for office supply, equipment etc.
- Use recycled paper for letterhead, copier paper, newsletter etc

Energy Recovery

- Energy production by conversion of waste into various forms of energy such as heat, electricity, fuel etc.
- It can be done through variety of processes, such as combustion, gasification, anaerobic digestion etc.
- few additional benefits as mentioned below:
- The total quantity of waste gets reduced drastically depending upon the waste composition and the adopted technology.
- Demand for space for landfilling gets reduced. The cost of transportation of waste to far-away landfill sites also gets reduced proportionately.
- Overall reduction in environmental pollution.

Energy Recovery

- Energy can be recovered from the organic fraction of waste (biodegradable as well as non-biodegradable) basically through two methods
- Thermo-chemical conversion
- Bio-chemical conversion

Thermo-chemical conversion

- In this process, organic matters are decomposed using thermal de-composition to produce either heat energy or fuel oil/gas.
- This process is useful for the wastes containing high percentage of organic non-biodegradable matter and low moisture content.
- The main technological options under this category include Incineration and Pyrolysis/ Gasification.

Bio-chemical conversion:

- In this process, organic matters are decomposed by microbial action to produce methane gas.
- This process, is preferred for wastes having high percentage of organic bio-degradable matter with high level of moisture/ water content, which helps microbial activity.
- The main technological option under this category is Anaerobic Digestion.

Sanitary landfill

- It is an engineering burial of wastes.
- It consists of spreading waste on the ground, compacting it, and covering it with the soil.
- There are generally two methods of sanitary land filling.

➢ Area method

➢ Trench method.

1. **Area method:**
   The area method is used, when excavation is not possible, especially when the ground water level is high.
2. **Trench method:**

- When it is possible to excavate, trench method is used.
- This method has the benefit of having the cover material right at the site from the earth excavated from the trench.

Hazardous waste

Defination:

The wastes generated from industry, hospital, household containing toxic substances are known as Hazardous waste.

Ex: Many pesticides, herbicides, paints, industrial solvents, fluorescent light bulbs and mercury-containing batteries are classified as hazardous wastes, so are the medical waste products such as cultures, human tissue, contaminated gloves, sharps, PPE kit etc.

Disposal of Hazardous waste

- The methods discussed below can be adopted for the safe disposal of hazardous wastes:

1. **Incineration:**

- By burning the waste materials in high temperature can destroy the toxic wastes.
- Although the method of incineration releases toxic gases which may affect our environment, but now a days more effective incinerators are developed that limit the quantity of emissions released in the atmosphere.
- Flammable wastes can also be burned and used as energy sources.

2. Recycling:

- It is one of the best methods to reduce quantity of hazardous wastes.
- We must try to reuse the used materials instead of just throwing them away, although it may need some creativity.
- Most flammable materials can be recycled into industrial fuel.
- Some materials with hazardous constituents can be recycled, such as lead acid batteries etc.

3. **Sharing or Donating:** If you have anything extra and find it unusable, may be shared or donated to someone who need it.
4. By sharing or donating, you will be able to reduce hazardous wastes generation.

What are greenhouse gases?

- Greenhouse gases (also known as GHGs) are gases in the earth’s atmosphere that trap heat.
- During the day, the sun shines through the atmosphere, warming the earth’s surface. At night the earth's surface cools, releasing heat back into the air. But some of the heat is trapped by the greenhouse gases in the atmosphere. That's what keeps the earth’s temperature at an average 14˚C (57˚F).

What are the main greenhouse gases?

Carbon dioxide (CO_2)

- CO_2 is released through natural processes
- such as volcanic eruptions
- Animals and humans breathing.
- But **the atmospheric CO_2 concentration has increased by 50%** since the Industrial Revolution began in the 1800s, due to human activities like the burning of fossil fuels and large-scale deforestation.
- Due to its abundance, CO_2 is the main contributor to climate change.

Natural and man-made GHGs

- Three industrial fluorinated gases – **hydrofluorocarbons (HFC)**, **perfluorocarbons (PFC)** and **sulphur hexafluoride (SF_6)** (It offers excellent electrical insulation properties and high thermal stability) – are solely man-made during industrial processes and do not occur in nature.
- Though they are present in very small concentrations in the atmosphere, they trap heat very effectively, meaning they are extremely potent.
- SF_6, which is used in high-voltage electricity equipment, has a 'Global Warming Potential' 23,000 times greater than CO_2.

Methane

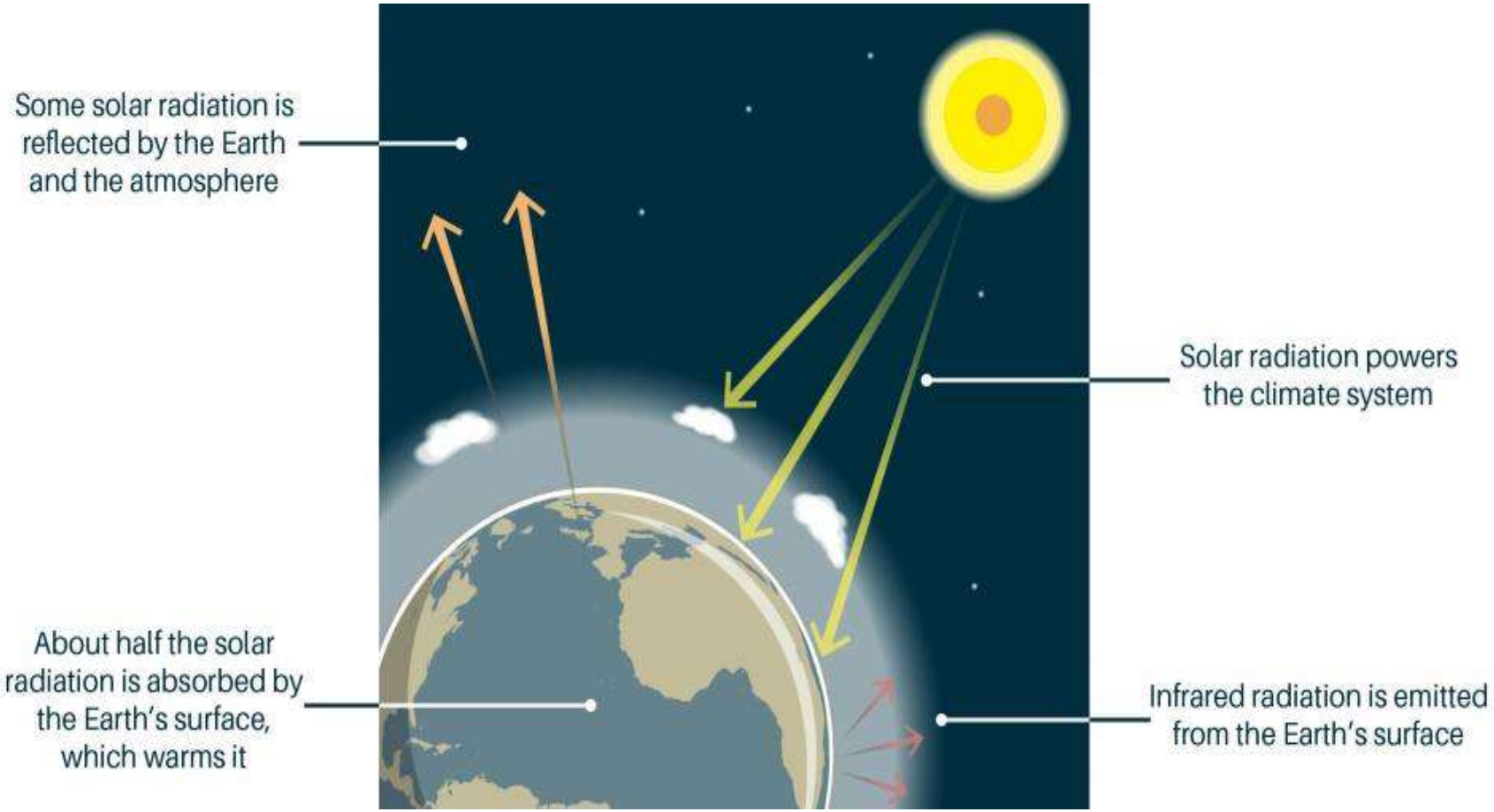
- Methane is produced naturally through decomposition.
- But again, human activity has displaced the natural balance.
- Large amounts of methane are released by cattle farming, landfill waste dumps, rice farming and the traditional production of oil.

Nitrous oxide

- Nitrous oxide is produced through the large-scale use of commercial and organic fertilisers, fossil-fuel combustion, nitric-acid production and biomass burning.

Water vapour

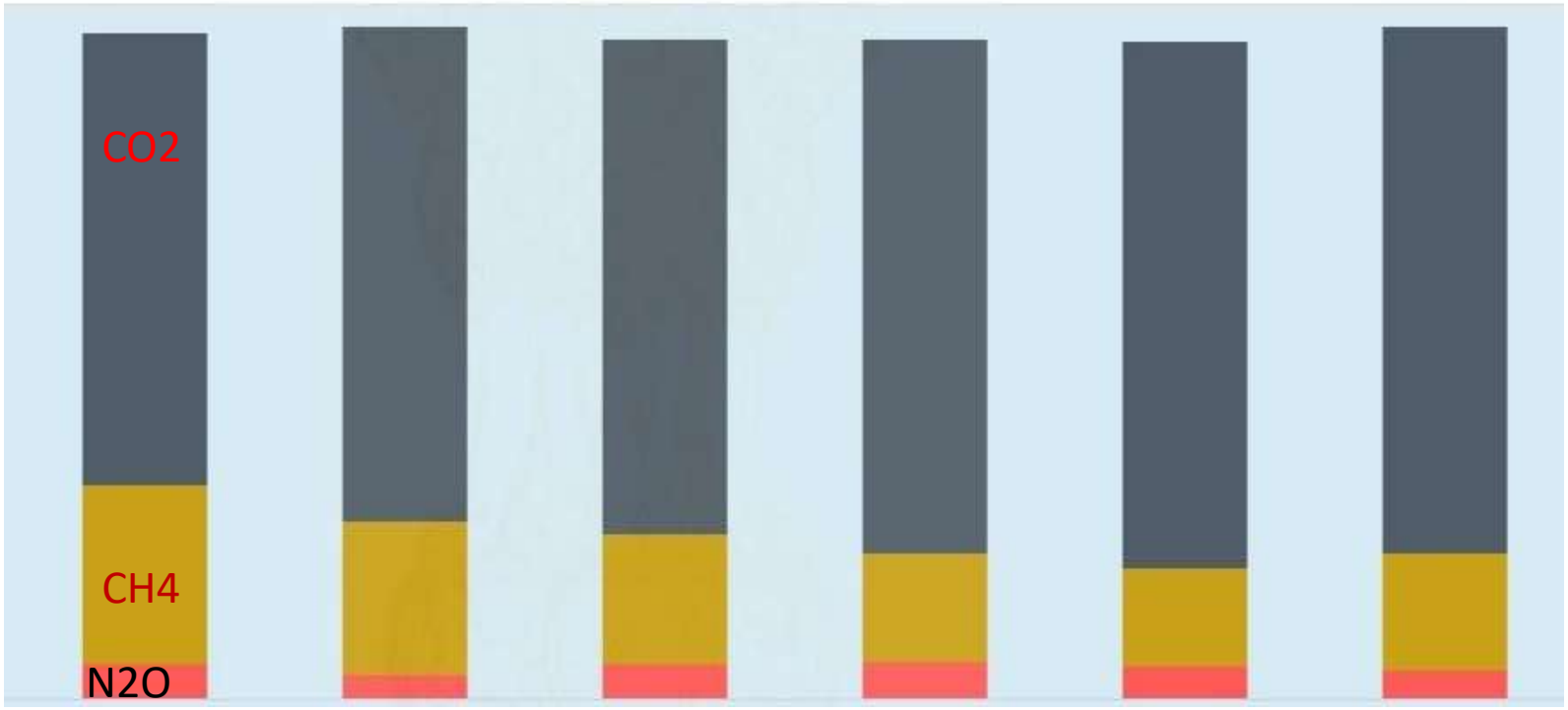
- Water vapour is the most abundant greenhouse gas.
- It increases as the earth's atmosphere warms but unlike CO_2, which can remain in the earth’s atmosphere for centuries, water vapour persists for only a few days.


Some solar radiation is reflected by the Earth and the atmosphere
Solar radiation powers the climate system
About half the solar radiation is absorbed by the Earth's surface, which warms it
Infrared radiation is emitted from the Earth's surface

Which gas contribute more?

- In terms of the amount of heat these gases can absorb and re-radiate (known as their global warming potential or GWP), CH_4 is 23 times more effective and N_2O is 296 times more effective than CO_2.
- However, there is much more CO_2 in the Earth's atmosphere than there is CH_4 or N_2O.

Proportion of Gases to India's Total Emissions
2007-2019



CARBON FOOTPRINT

- William Rees and Swiss-born regional planner Mathis Wackernagel