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SCHOOL OF BIO AND CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

UNIT – I– ENVIRONMENTAL POLLUTION CONTROL– SCHA4004

UNIT-I

INTRODUCTION

ENVIRONMENT

The term environment refers to ones surroundings.

The physical and biological factors along with their chemical interactions that affect an organism or a group of organisms.

The **environment** is the biotic and abiotic surrounding of an organism or population, and consequently includes the factors that have an influence in their survival, development and evolution. The environment can vary in scale from microscopic to global in extent. Examples include the marine environment, the atmospheric environment and the terrestrial environment.

The sum total of all surroundings of a living organism, including natural forces and other

living things, which provide conditions for development and growth as well as of danger and damage.

ENVIRONMENTAL SEGMENTS

The environment consists of various segments such as atmosphere, hydrosphere, lithosphere and biosphere.

Atmosphere

The following points highlight the vital role played by atmosphere in the survival of life in this planet.

• The atmosphere is the protective blanket of gases which is surrounding the earth. It protects the earth from the hostile environment of outer space.

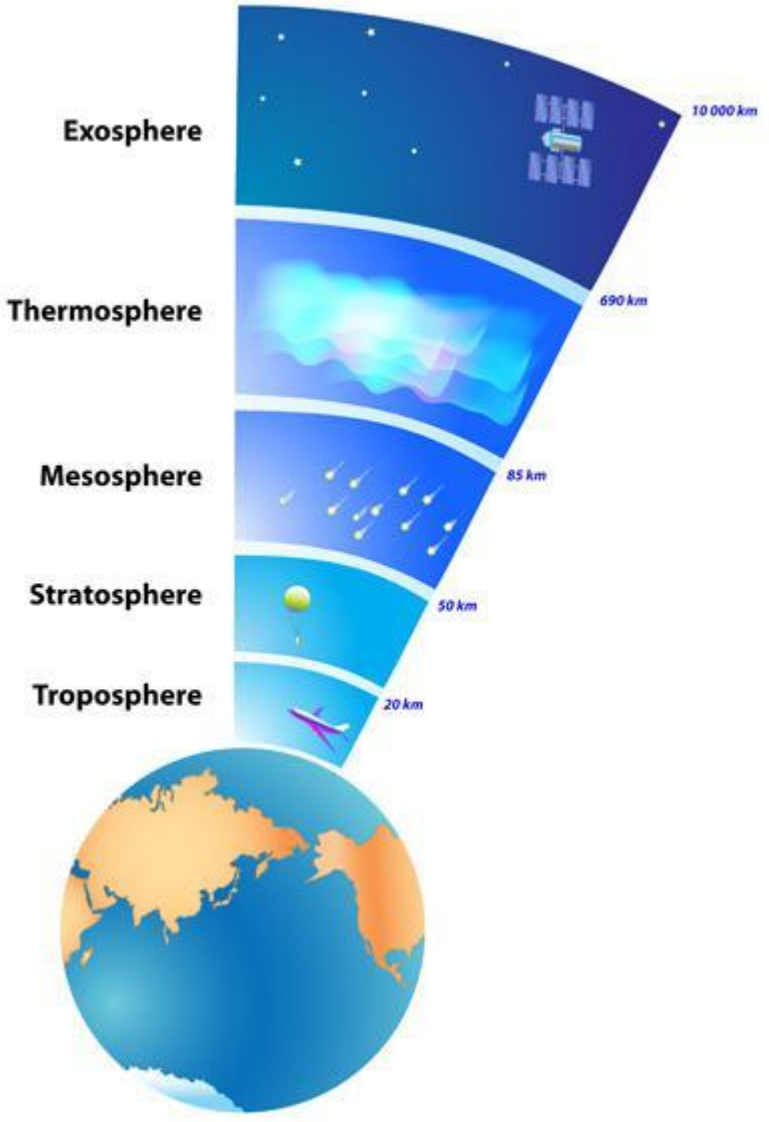
• It absorbs IR radiations emitted by the sun and reemitted from the earth and thus controls the temperature of the earth.

• It allows transmission of significant amounts of radiation only in the regions of 300 – 2500 nm (near UV, Visible, and near IR) and 0.01 – 40 meters (radio waves). i.e it filters tissue damaging UV radiation below 300 nm.

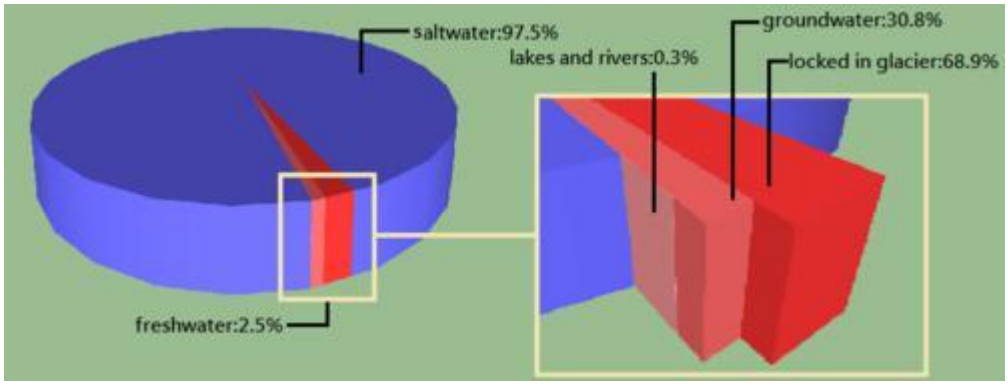
• It acts as a source for CO2 for plant photosynthesis and O2 for respiration

• It acts as a source for nitrogen for nitrogen fixing bacteria and ammonia producing plants.

• The atmosphere transports water from ocean to land.


Exosphere
10 000 km
Thermosphere
690 km
Mesosphere
85 km
Stratosphere
50 km
Troposphere
20 km

Hydrosphere



The hydrosphere is a collective term given to all different forms of water.

It includes all types of water resources such as oceans, seas, rivers, lakes, streams, reservoirs, glaciers and ground waters.

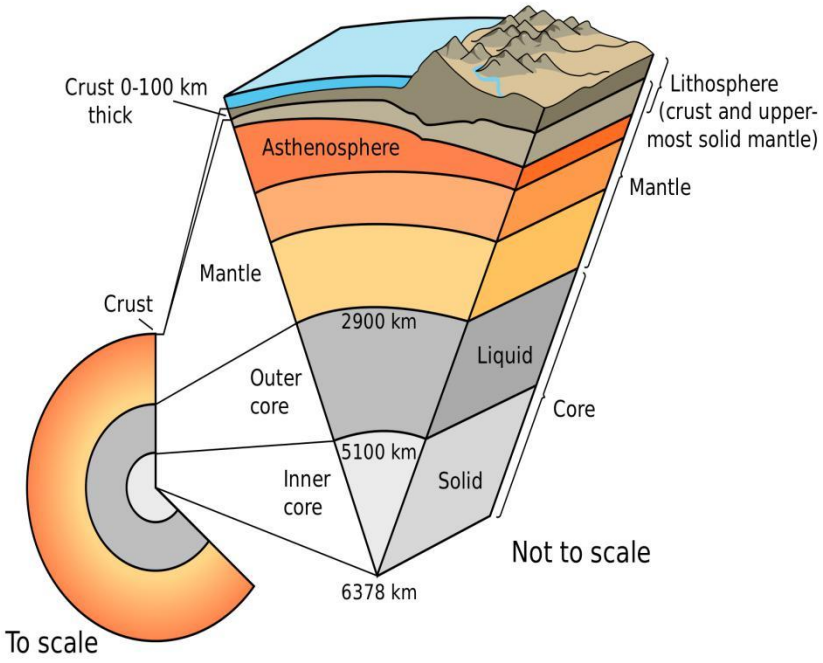
A hydrosphere is the total amount of water on a planet. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. A planet's hydrosphere can be liquid, vapor,or ice.

On Earth, liquid water exists on the surface in the form of oceans, lakes and rivers. It also exists below ground—as groundwater, in wells and aquifers. Water vapor is most visible as clouds and fog.

The frozen part of Earth's hydrosphere is made of ice: glaciers, ice caps and icebergs. The frozen part of the hydrosphere has its own name, the cryosphere.

Water moves through the hydrosphere in a cycle. Water collects in clouds, then falls to Earth in the form of rain or snow. This water collects in rivers, lakes and oceans. Then it evaporates into the atmosphere to start the cycle all over again. This is called the water cycle.

Lithosphere



The lithosphere is the solid, outer part of the Earth.

The lithosphere includes the brittle upper portion of the mantle and the crust, the outermost layers of Earth's structure. It is bounded by the atmosphere above and the asthenosphere (another part of the upper mantle) below.

The lithosphere is the most rigid of Earth's layers. Although the rocks of the lithosphere are still considered elastic, they are not viscous. The asthenosphere *is* viscous, and the lithosphere-asthenosphere boundary (LAB) is the point where geologists and rheologists—scientists who study the flow of matter—mark the difference in ductility between the two layers of the upper mantle. Ductility measures a solid material's ability to deform or stretch under stress. The lithosphere is far less ductile than the asthenosphere. The elasticity and ductility of the lithosphere depends on temperature, stress, and the curvature of the Earth itself.

The lithosphere is also the coolest of Earth's layers. In fact, some definitions of the lithosphere stress its ability to conduct heat associated with the convection taking place in the plastic mantle below the lithosphere.

Biosphere

• The biosphere refers to the realm of living organisms and their interactions with the environment (VIZ: atmosphere, hydrosphere and lithosphere)

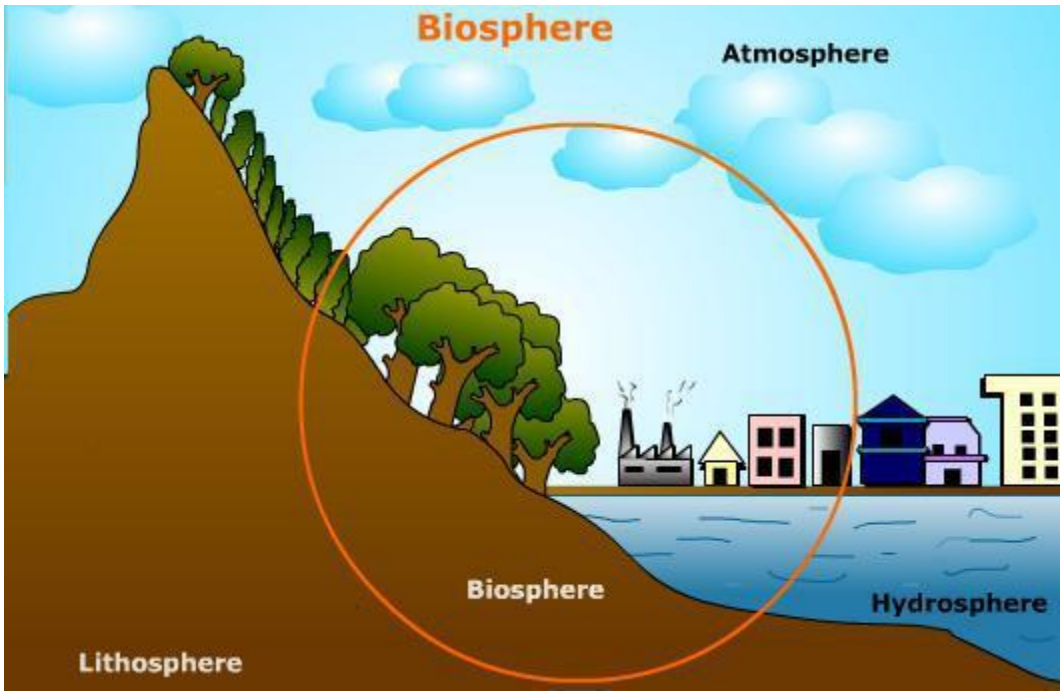
• The biosphere is very large and complex and is divided into smaller units called ecosystems.

• Plants, animals and microorganisms which live in a definite zone along with physical factors such as soil, water and air constitute an ecosystem.

• Within each ecosystems there are dynamic inter relationships between living forms and their physical environment

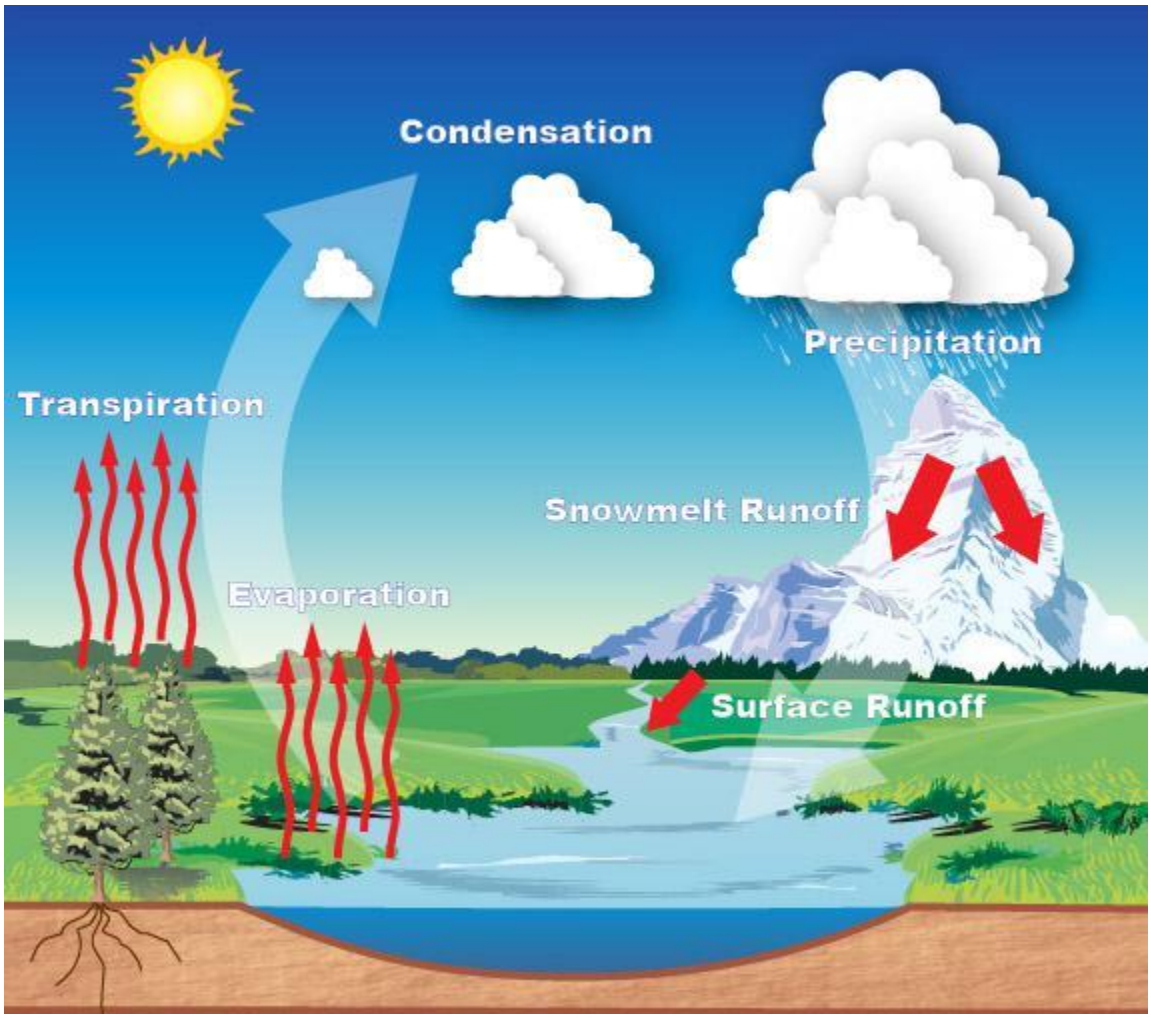
• These inter relationships manifest as natural cycles.(hydrologic cycle, oxygen cycle, nitrogen cycle, phosphorous cycle and sulphur cycle),

• The natural cycles operate in a balanced manner providing a continuous circulation of essential constituents necessary for life and this stabilizes and sustains the life processes on earth.



Hydrologic cycle

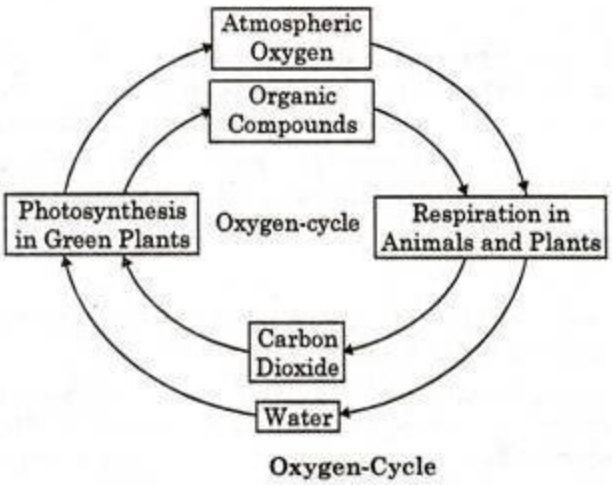
The hydrologic cycle involves a continuous exchange of water between sea, atmosphere, land and living animals through massive evaporation of water from the ocean, cloud formation and precipitation



The land surface and water surfaces on earth lose water by evaporation by solar energy. evaporation of water from ocean exceeds precipitation by rain into seas by 10% . This 10% excess which precipitates on land balances the hydrological cycle. Some of the precipitated rain seeps into the soil as ground water. Ground water moves up by capillary action and there by maintains a continuous supply of water to the surface layer of soil. The water from the surface layer of the soil is absorbed by plants, which in turn is returned to atmosphere through transpiration. Surface water or runoff flows into streams, rivers, lakes and catchment areas or reservoirs. Animals also take water which is also returned to the atmosphere through

evaporation. Thus there is always a balanced continuous cycling of water between earths surface and atmosphere.

Oxygen Cycle



Oxygen-Cycle

Nitrogen Cycle

Nitrogen cycle refers to the incorporation of N2 from the atmosphere into living matter and chemically bound nitrogen in soil, water and then back into the atmosphere again.

Nitrogen Fixation

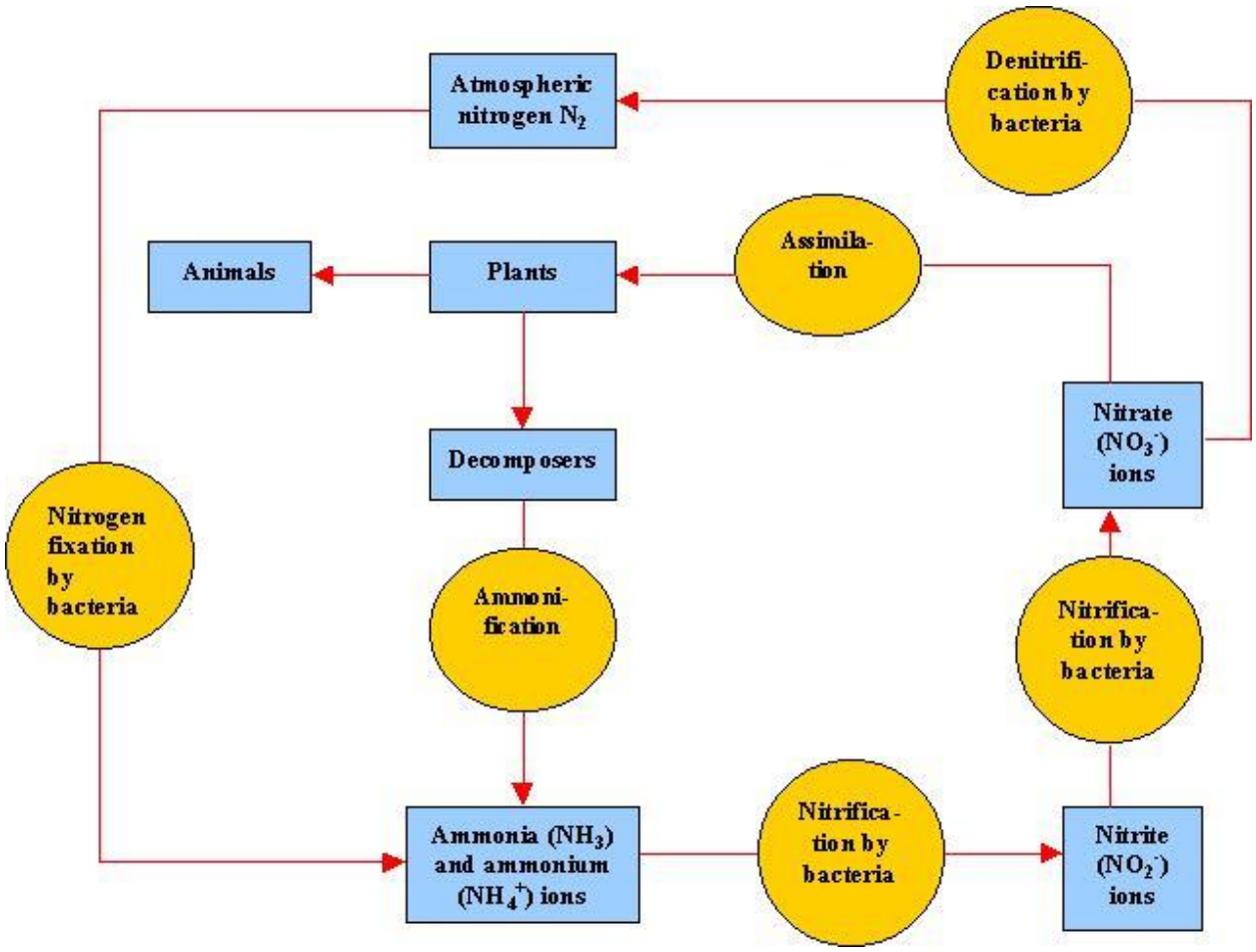
In this step the atmospheric nitrogen is chemically bound to form ammonia by bacteria and algae. Biological nitrogen fixation is mediated by organisms like Rhizobium that live a symbiotic relation with nodules on the roots of particular species of plants. These organisms are capable of catalysing the conversion of atmospheric nitrogen into forms usable by plants.

Nitrification

It is the conversion of N(-III) to N(V) catalysed by Nitrosomonas and Nitrobacter. Nitrification is important in nature, since nitrogen is absorbed by plants primarily as nitrate. Even when nitrogen is applied in the form of ammonium salts as fertilisers, the ammonia is microbially oxidized to nitrate so that it can be assimilated by plants.

Denitrification

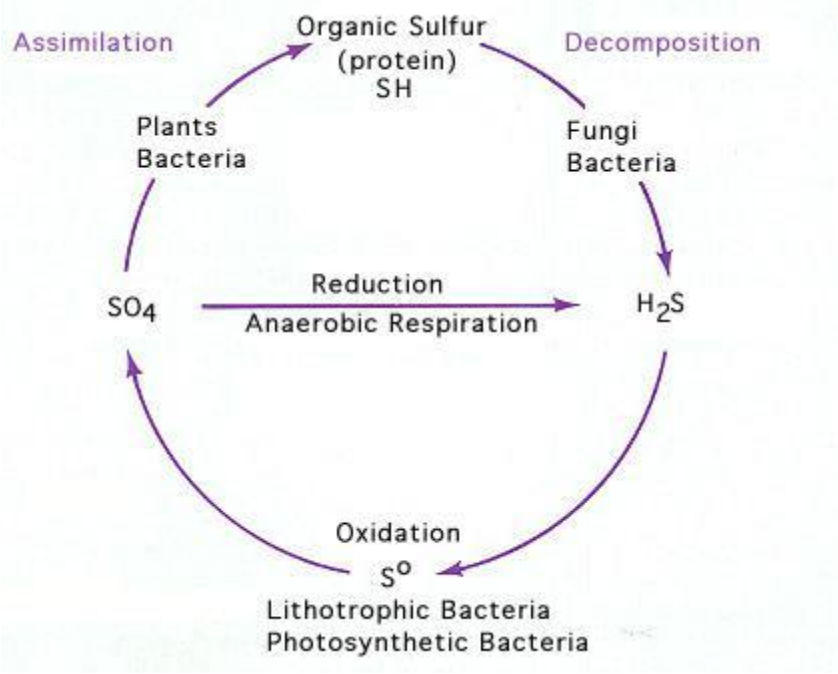
There are involves several steps. A number of heterotrophic bacteria including species of Pseudomonas and several types of denitrification reactions. One of these is the reduction of nitrate to form nitrogen gas. The process Anchromobacter mediate these processes. In this process N2 gas is produced from chemically fixed n



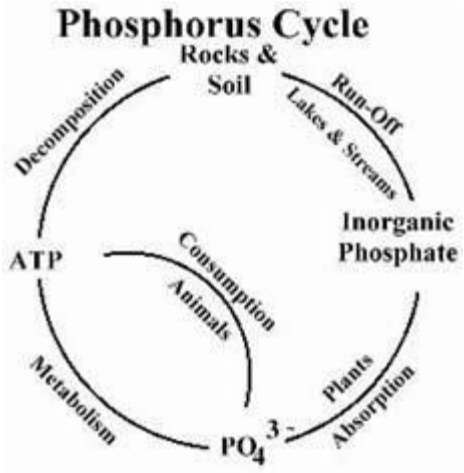
Sulphur Cycle

Sulphur is one of the components that make up proteins and vitamins. Proteins consist of amino acids that contain sulphur atoms. Sulphur is important for the functioning of proteins and enzymes in plants, and in animals that depend upon plants for sulphur. Plants absorb sulphur when it is dissolved in water. Animals consume these plants, so that they take up enough sulphur to maintain their health.

Most of the earth's sulphur is tied up in rocks and salts or buried deep in the ocean in oceanic sediments. Sulphur can also be found in the atmosphere. It enters the atmosphere through both natural and human sources. Natural recourses can be for instance volcanic eruptions, bacterial processes, evaporation from water, or decaying organisms. When sulphur enters the atmosphere through human activity, this is mainly a consequence of industrial processes where sulphur dioxide (SO_2) and hydrogen sulphide (H_2S) gases are emitted on a wide scale. When sulphur dioxide enters the atmosphere it will react with oxygen to produce sulphur trioxide gas (SO_3), or with other chemicals in the atmosphere, to produce sulphur salts. Sulphur dioxide may also react with water to produce sulphuric acid (H_2SO_4). Sulphuric acid may also be produced from demethylsulphide, which is emitted to the atmosphere by plankton species. All these particles will settle back onto earth, or react with rain and fall back onto earth as acid deposition. The particles will then be absorbed by plants again and are released back into the atmosphere, so that the sulphur cycle will start over again.



Phosphorous Cycle



The **phosphorus cycle** is the biogeochemical cycle that describes the movement of phosphorus through the lithosphere, hydrosphere, and biosphere. Phosphorus is an essential nutrient for plants and animals. Phosphorus is a limiting nutrient for aquatic organisms. Phosphorus forms parts of important life-sustaining molecules that are very common in the biosphere. Phosphorus does not enter the atmosphere, remaining mostly on land and in rock and soil minerals. Eighty percent of the mined phosphorus is used to make fertilizers. Phosphates from fertilizers, sewage and detergents can cause pollution in lakes and streams. Over enrichment of phosphate in both fresh and inshore marine waters can lead to massive algae blooms which, when they die and decay, leads to eutrophication of fresh waters only.

Air Pollution

Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing diseases, allergies, death to humans, damage to other living organisms such as animals and food crops, or the natural or built environment. Air pollution may come from anthropogenic or natural sources.

Causes of Air pollution

1. **Burning of Fossil Fuels:** Sulfur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one the major cause of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of pollution. We rely on them to fulfill our daily basic needs of transportation. But, there overuse is killing our environment as dangerous gases are polluting the environment. Carbon Mono oxide.

caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, that is produced from both natural and man made processes.

2. **Agricultural activities:** Ammonia is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere. Use of insecticides, pesticides and fertilizers in agricultural activities has grown quite a lot. They emit harmful chemicals into the air and can also cause water pollution.

3. **Exhaust from factories and industries:** Manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air. Manufacturing industries can be found at every corner of the earth and there is no area that has not been affected by it. Petroleum refineries also release hydrocarbons and various other chemicals that pollute the air and also cause land pollution.

4. Mining operations: Mining is a process wherein minerals below the earth are extracted using large equipments. During the process dust and chemicals are released in the air causing massive air pollution. This is one of the reason which is responsible for the deteriorating health conditions of workers and nearby residents.

5. Indoor air pollution: Household cleaning products, painting supplies emit toxic chemicals in the air and cause air pollution. Have you ever noticed that once you paint walls of your house, it creates some sort of smell which makes it literally impossible for you to breathe.

Suspended particulate matter popular by its acronym SPM, is another cause of pollution. Referring to the particles afloat in the air, SPM is usually caused by dust, combustion etc.

Effects of Air pollution

1. Respiratory and heart problems: The effects of Air pollution are alarming. They are known to create several respiratory and heart conditions along with Cancer, among other threats to the body. Several millions are known to have died due to direct or indirect effects of Air pollution. Children in areas exposed to air pollutants are said to commonly suffer from pneumonia and asthma.

2. **Global warming:** Another direct effect is the immediate alterations that the world is witnessing due to Global warming. With increased temperatures world wide, increase in sea levels and melting of ice from colder regions and icebergs, displacement and loss of habitat have already

signaled an impending disaster if actions for preservation and normalization aren't undertaken soon.

3. **Acid Rain:** Harmful gases like nitrogen oxides and sulfur oxides are released into the atmosphere during the burning of fossil fuels. When it rains, the water droplets combines with these air pollutants, becomes acidic and then falls on the ground in the form of acid rain. Acid rain can cause great damage to human, animals and crop.

4. Effect on Wildlife: Just like humans, animals also face some devastating affects of air pollution. Toxic chemicals present in the air can force wildlife species to move to new place and change their habitat. The toxic pollutants deposit over the surface of the water and can also affect sea animals.

5. Depletion of Ozone layer: Ozone exists in earth's stratosphere and is responsible for protecting humans from harmful ultraviolet (UV) rays. Earth's ozone layer is depleting due to the presence of chlorofluorocarbons, hydro chlorofluorocarbons in the atmosphere. As ozone layer will go thin, it will emit harmful rays back on earth and can cause skin and eye related problems. UV rays also have the capability to affect crops.

Solutions for Air Pollution

1. **Use public mode of transportation:** Encourage people to use more and more public modes of transportation to reduce pollution. Also, try to make use of car pooling. If you and your colleagues come from the same locality and have same timings you can explore this option to save energy and money.

2. Conserve energy: Switch off fans and lights when you are going out. Large amount of fossil fuels are burnt to produce electricity. You can save the environment from degradation by reducing the amount of fossil fuels to be burned.

3. Understand the concept of Reduce, Reuse and Recycle: Do not throw away items that are of no use to you. In-fact reuse them for some other purpose. For e.g. you can use old jars to store cereals or pulses.

4. Emphasis on clean energy resources: Clean energy **technologies**

like solar, wind and geothermalare on high these days. Governments of various countries have been providing grants to consumers who are interested in installing solar panels for their home. This will go a long way to curb air pollution.

5. Use energy efficient devices: CFL lights consume less electricity as against their counterparts. They live longer, consume less electricity, lower electricity bills and also help you to reduce pollution by consuming less energy.

Soil Pollution

Soil pollution is defined as, "contamination of soil by human and natural activities which may cause harmful effect on living organisms".

Causes and effects

Industrial wastes – Disposal of Industrial wastes is the major problem for soil pollution.

Sources: Industrial pollutants are mainly discharged from various origins such as pulp and paper mills, chemical fertilizers, oil refineries, sugar factories, tanneries, textiles, steel, distilleries, fertilizers, pesticides, coal and mineral mining industries, drugs, glass, cement, petroleum and

engineering industries etc. Effect: These pollutants affect and alter the chemical and biological properties of soil. As a result, hazardous chemicals can enter into human food chain from the soil or water, disturb the biochemical process and finally lead to serious effects on living organisms.

Urban wastes – Urban wastes comprise of both commercial and domestic wastes consisting of dried sludge and sewage. All the urban solid wastes are commonly referred to as refuse. Constituents of urban refuse: This refuse consists of garbage and rubbish materials like plastics, glasses, metallic cans, fibres, paper, rubbers, street sweepings, fuel residues, leaves, containers, abandoned vehicles and other discarded manufactured products. Urban domestic wastes though disposed off separately from industrial wastes, can still be dangerous.

Agricultural practices – Modern agricultural practices pollute the soil to a large extent. With the advancing agro-technology, huge quantities of fertilizers, pesticides, herbicides and weedicides are added to increase the crop yield. Apart from these farm wastes, manure, slurry, debris, soil erosion containing mostly inorganic chemicals are reported to cause soil pollution.

Radioactive pollutants/ - Radioactive substances resulting from explosions of nuclear testing laboratories and industries giving rise to nuclear dust radioactive wastes, penetrate the soil and

1. Radio nuclides of Radium, Thorium, Uranium, isotopes of Potassium (K-40) and Carbon (C-14) are commonly found in soil, rock, water and air.
2. Explosion of hydrogen weapons and cosmic radiations include neutron, proton reactions by which Nitrogen (N-15) produces C-14. This C-14 participates in Carbon metabolism of plants which is then into animals and human beings.
3. Radioactive waste contains several radio nuclides such as Strontium90, Iodine-129, Cesium-137 and isotopes of Iron which are most injurious. Strontium get deposited in bones and tissues instead of calcium.

4. Nuclear reactors produce waste containing Ruthenium-106, Iodine-131, Barium-140, Cesium-144 and Lanthanum-140 along with primary nuclides Sr-90 with a half life

28 years and Cs-137 with a half life 30 years. Rain water carries Sr-90 and Cs-137 to be deposited on the soil where they are held firmly with the soil particles by electrostatic forces. All the radio nuclides deposited on the soil emit gamma radiations.

5. **Biological agents** – Soil gets a large amount of human, animal and bird excreta which constitute a major source of land pollution by biological agents.

Ex: 1. Heavy application of manures and digested sludge can cause serious damage to plants within a few years

Control measures of soil pollution

1. Soil erosion can be controlled by a variety of forestry and farm practices.

Ex: Planting trees on barren slopes ,Contour cultivation and strip cropping may be practiced instead of shifting cultivation, Terracing and building diversion channels may be undertaken. Reducing deforestation and substituting chemical manures by animal wastes also helps arrest soil erosion in the long term.

2. **Proper dumping of unwanted materials:** Excess wastes by man and animals pose a disposal problem. Open dumping is the most commonly practiced technique. Nowadays, controlled tipping is followed for solid waste disposal. The surface so obtained is used for housing or sports field.

3.Production of natural fertilizers: Bio-pesticides should be used in place of toxic chemical pesticides. Organic fertilizers should be used in place of synthesized chemical fertilizers. Ex: Organic wastes in animal dung may be used to prepare compost manure instead of throwing them wastefully and polluting the soil.

4.Proper hygienic condition: People should be trained regarding sanitary habits.

Ex: Lavatories should be equipped with quick and effective disposal methods.

5.Public awareness: Informal and formal public awareness programs should be imparted to educate people on health hazards by environmental education.

Ex: Mass media, Educational institutions and voluntary agencies can achieve this.

6.Recycling and Reuse of wastes: To minimize soil pollution, the wastes such as paper, plastics, metals, glasses, organics, petroleum products and industrial effluents etc should be recycled and reused.

Ex: Industrial wastes should be properly treated at source. Integrated waste treatment methods should be adopted.

7.Ban on Toxic chemicals: Ban should be imposed on chemicals and pesticides like DDT, BHC, etc which are fatal to plants and animals. Nuclear explosions and improper disposal of radioactive wastes should be banned.

MINAS - Minimum National Standards for polluting industries helps state pollution control board and other industries in implementing standards in a phased manner. These standards are evolved after consultation with experts and experienced people.

Air Quality Standards

Ambient air quality refers to the condition or quality of air surrounding us in the outdoors. National Ambient Air Quality Standards are the standards for ambient air quality set by the Central Pollution Control Board (CPCB) that is applicable nationwide. The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.

Ambient Air Quality Standards in India

The Air (Prevention and Control of Pollution) Act 1981 was enacted by the Central Government with the objective of arresting the deterioration of air quality. The Air (Prevention and Control of Pollution) Act 1981 describes the main functions of the Central Pollution Control Board (CPCB) as follows:

- To advise the Central Government on any matter concerning the improvement of the quality the air and the prevention, control and abatement of air pollution.
- To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
- To provide technical assistance and guidance to the State Pollution Control Board.
- To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
- To collect, compile and publish technical and statistical data related to air pollution; and
- To lay down and annul standards for the quality of air

- National Ambient Air Quality Standards (NAAQS)

POLLUTANTS	Time Weighted Average	Concentration of Ambient Air			
		Industrial Area	**Residential Rural and other area**	**Sensitive area**	**Method of Measurement**
Sulphur Dioxide (SO2)	Annual Average 24 hours	80µg/m^3 120µg/m^3	60µg/m^3 80µg/m^3	15µg/m^3 30µg/m^3	Improved west and Gacke Method Ultraviolet fluorescence
Oxides of Nitrogen (NO2)	Annual Average	80µg/m^3	60µg/m^3	15µg/m^3	Jacab Hochheister

	24 hours	120µg/m^3	80µg/m^3	30µg/m^3	modified (Na-Arsentire method Gas Phase Chemilumine Scene
Suspended Particulate Matter (SPM)	Annual Average 24 hours	360µg/m^3 500µg/m^3	140µg/m^3 200µg/m^3	70µg/m^3 100µg/m^3	High Volume sampling (average flow rate not less than 1.1 m^3/minute)
Respirable Particulate Matter (size Less than 10µm) RPM	Annual Average 24 hours	120µg/m^3 150µg/m^3	60µg/m^3 100µg/m^3	50µg/m^3 75µg/m^3	Respirable particulate matter sampler
Lead as Pb	Annual Average 24 hours	1.0µg/m^3 1.5µg/m^3	0.75µg/m^3 1.0µg/m^3	0.50µg/m^3 0.75µg/m^3	AAS method after sampling using EPM 2000 or equivalent filter paper
Carbon Monoxide	8 hours 1 hour	5.0mg/m^3 10.0mg/m^3	2.0mg/m^3 4.0mg/m^3	1.0mg/m^3 2.0mg/m^3	Non disbersive infrared spectroscopy

Annual Average : Annual Arithmetic Mean of minimum 104 measurements in a year taken twice a week 24-hourly at uniform interval **24 Hours Average :** 24-hourly/8-hourly values should be met 98% of the time in a year. However 2% of the time, it may exceeded but not two consecutive days.
1. The levels of air quality necessary with an adequate margin of safety, to protect the public health, vegetation and property. 2. Whenever and wherever two consecutives values exceeds the limit specified above for the respective category, it shall be considered adequate, reason to institute regular/continuous monitoring and further investigations.

ACID RAIN

Acid rain is a result of air pollution. When any type of fuel is burnt, lots of different chemicals are produced. The smoke that comes from a fire or the fumes that come out of a car exhaust don't just contain the sooty grey particles that you can see - they also contains lots of invisible gases that can be even more harmful to our environment. Some of these gases (especially nitrogen oxides and sulphur dioxide) react with the tiny droplets of water in clouds to form sulphuric and nitric acids. The rain from these clouds then falls as very weak acid - which is why it is known as "acid rain".

Acid rain can be carried great distances in the atmosphere, not just between countries but also from continent to continent. The acid can also take the form of snow, mists and dry dusts. The rain sometimes falls many miles from the source of pollution but wherever it falls it can have a serious effect on soil, trees, buildings and water.

Control measures

Reduce emissions:

• Burning fossil fuels is still one of the cheapest ways to produce electricity so people are now researching new ways to burn fuel which don't produce so much pollution.

• Governments need to spend more money on pollution control even if it does mean an increase in the price of electricity.

• Sulphur can also be 'washed' out of smoke by spraying a mixture of water and powdered limestone into the smokestack.

• Cars are now fitted with catalytic converters which remove three dangerous chemicals from exhaust gases.

Find alternative sources of energy

• Governments need to invest in researching different ways to produce energy.

• Two other sources that are currently used are hydroelectric and nuclear power. These are 'clean' as far as acid rain goes but what other impact do they have on our environment?

• Other sources could be solar energy or windmills but how reliable would these be in places where it is not very windy or sunny?

• All energy sources have different benefits and costs and all these have to be weighed up before any government decides which of them it is going to use.

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UNIT – II– ENVIRONMENTAL POLLUTION CONTROL– SCH1310

CONTROL OF AIR POLLUTION

The atmosphere has several built-in self cleaning processes such as dispersion, gravitational settling, flocculation, absorption, rain-washout, etc to cleanse the atmosphere. However, control of contaminants at their source level is a desirable and effective method through preventive or control technologies.

Source control

1. Using unleaded petrol
2. Using fuels with low sulphur and ash content
3. Encouraging people to use public transport, walk or use a cycle as opposed to private vehicles
4. Ensure that houses, schools, restaurants and playgrounds are not located on busy streets
5. Plant trees along busy streets as they remove particulates, carbon dioxide and absorb noise
6. Industries and waste disposal sites should be situated outside the city preferably on the downwind of the city.
7. Catalytic converters should be used to help control emissions of carbon monoxide and hydrocarbons

Control measures in industrial centers

1. Emission rates should be restricted to permissible levels by each and every industry
2. Incorporation of air pollution control equipment in design of plant layout must be made mandatory
3. Continuous monitoring of the atmosphere for pollutants should be carried out to know the emission levels.

AIR POLLUTION CONTROL EQUIPMENTS

Scrubber systems are a diverse group of air pollution control devices that can be used to remove some particulates and/or gases from industrial exhaust streams. "*Scrubber*" is a pollution control devices that use liquid to wash unwanted pollutants from a gas stream. Scrubbers are one of the primary devices that control gaseous emissions, especially acid gases, Fumes. Industrial Scrubbers can also be used for heat recovery from hot gases by flue gas condensation. Scrubber are used for scrubbing the abnoxious fumes such as silicon tetrafluride, HNO3, HCl, NH3, Phosphoric acid, super phosphate & Fluorine.

The basic scrubber configurations are

- Spray nozzle scrubbers - water are sprayed with high pressure through nozzles to produce the droplets in the air

- Venturi scrubbers - air or gas velocity is increased through a venturi shape - increased turbulence atomize the water droplets

- Packed bed scrubbers - air passes through wet-laden fiber mats where mists are collected. Not suited if solid particles are present in the air since the fiber mats may plug

- Combination Venturi-cum-packed bed Scrubbers

Cyclone Scrubbers

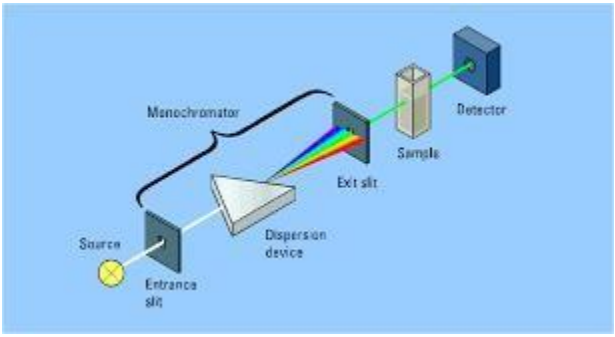
- Impingement-plate scrubber - vertical scrubber with horizontal plates, air flows from bottom to top, water flows from top to bottom

The cyclone is a widely used type of particulate collection device in which dust-laden gas enters tangentially into a cylindrical or conical chamber and leaves through a central opening. When very large gas volumes must be handled and high collection efficiencies are needed a multiple of small diameter cyclones are usually nested together to form a multicyclone.

Bag filter is used for collection of dry free flowing dust; typically dust from the dust- laden air that enters by suction or positive pressure into the hopper. When this air travels across

the filter media, the dust is retained on the filter element and the clean air passes through. The bags are periodically cleaned by Reverse Pulse jet type method.

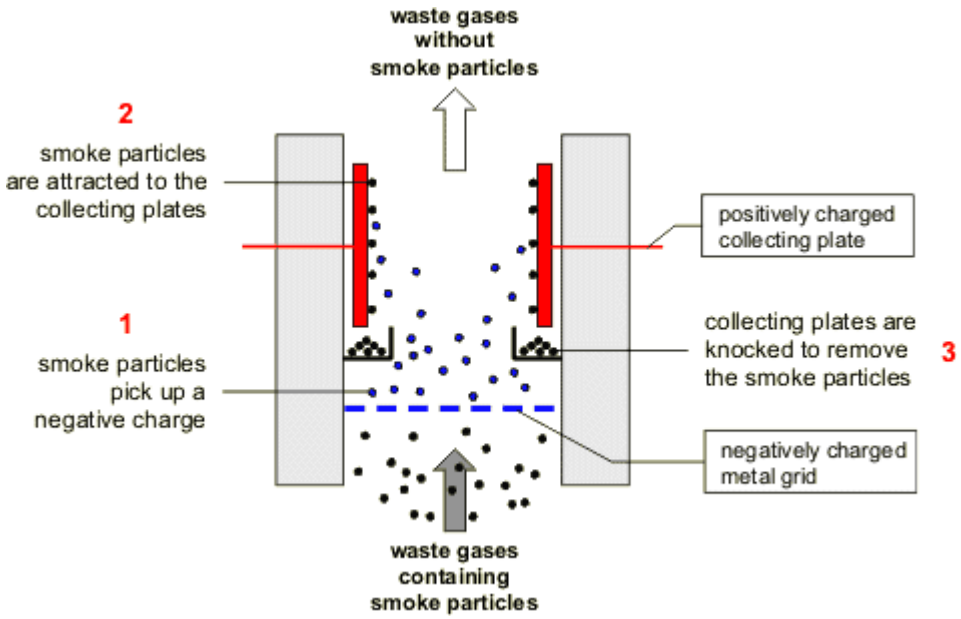
UV SPECTROMETRY



Spectrophotometry is the quantitative measurement of the reflection or transmission properties of a material as a function of wavelength.The most common spectrophotometers are used in the UV and visible regions of the spectrum, and some of these instruments also operate into the near-infrared region as well.Visible region 400–700 nm spectrophotometry is used extensively in colorimetry science. It is a known fact that it operates best at the range of 0.2-0.8 O.D. Ink manufacturers, printing companies, textiles vendors, and many more, need the data provided through colorimetry. They take readings in the region of every 5–20 nanometers along the visible

region, and produce a spectral reflectance curve or a data stream for alternative presentations. These curves can be used to test a new batch of colorant to check if it makes a match to specifications, e.g., ISO printing standards.

Electrostatic Precipitator (ESP)



The first use of corona discharge to remove particles from an aerosol was by Hohlfeld in 1824. However, it was not commercialized until almost a century later.

In 1907 Frederick Gardner Cottrell, a professor of chemistry at the University of California,

Berkeley, applied for a patent on a device for charging particles and then collecting them through electrostatic attraction—the first electrostatic precipitator. Cottrell first applied the device to the collection of sulphuric acid mist and lead oxide fumes emitted from various acid- making and smelting activities. Wine-producing vineyards in northern California were being adversely affected by the lead emissions.

At the time of Cottrell's invention, the theoretical basis for operation was not understood. The operational theory was developed later in Germany, with the work of Walter Deutsch and the formation of the Lurgi company.

Cottrell used proceeds from his invention to fund scientific research through the creation of a foundation called Research Corporation in 1912, to which he assigned the patents. The intent of the organization was to bring inventions made by educators (such as Cottrell) into the commercial world for the benefit of society at large. The operation of Research Corporation is funded by royalties paid by commercial firms after commercialization occurs. Research Corporation has provided vital funding to many scientific projects: Goddard's rocketry experiments, Lawrence's cyclotron, production methods for vitamins A and B_1, among many others.

By a decision of the US Supreme Court, the Corporation had to be split into several entities. The Research Corporation was separated from two commercial firms making the hardware: Research-Cottrell Inc. (operating east of the Mississippi River) and Western Precipitation (operating in the western states). The Research Corporation continues to be active to this day, and the two companies formed to commercialize the invention for industrial and utility applications are still in business as well.

Electrophoresis is the term used for migration of gas-suspended charged particles in a direct-current electrostatic field. Traditional CRT television sets tend to accumulate dust on the screen because of this phenomenon (a CRT is a direct-current machine operating at about 15 kilovolts).

Air Pollution Control Devices

Air pollution control devices (APCD) are a series of devices which are used to prevent a variety of different pollutants, both gaseous and solid, from entering the atmosphere mainly out of the industrial stacks. These control devices can be separated into two broad categories namely (i) devices which control the amount of particulate matter escaping into the environment, and (ii) devices which controls the acidic gas emissions into the atmosphere.

By and large the air pollutants are generated due to the combustion of fuels in the furnaces. The major combustion-generated pollutants are the oxides of nitrogen (NOx), sulphur dioxide (SO2),

carbon monoxide (CO), unburned hydrocarbons, and particulate matter.

The generated pollutants are carried by the exhaust gases produced during the combustion of the fuel. These exhaust gases are then normally passed through the APCDs before releasing them to the atmosphere. The pollutants are removed, destroyed, or transformed in the control devices before the discharge of the exhaust gas into the atmospheric air.

Common methods for removing the pollutants from the exhaust gases work on the following principles.

- Destroying pollutants by thermal or catalytic combustion, such as by use of a flare stack, a high temperature incinerator, or a catalytic combustion reactor. This technique is used when the pollutants are in the form of organic gases or vapours. During flame combustion or catalytic process, these organic pollutants are converted into water vapour and relatively less harmful products, such as carbon dioxide (CO2).
- Changing pollutants to less harmful forms through chemical reactions, such as converting nitrogen oxides (NOx) to nitrogen and water through the addition of ammonia to the exhaust gas in front of a selective catalytic reactor.

In the technique known as ‘absorption’, the gaseous effluents are passed through scrubbers or absorbers. These contain a suitable liquid absorbent, which removes or modifies one or more of the pollutants present in the gaseous effluents.

- In the technique known as ‘adsorption’, the gaseous effluents are passed through porous solid adsorbents kept in suitable containers. The organic and inorganic constituents of the effluent gases are trapped at the interface of the solid adsorbent by physical adsorption.
- Collecting particulate emissions using air pollution control devices before they reach the atmosphere.

The APCDs collect particulate emissions work on the principle of (i) gravity separation, (ii) cyclonic separation, (iii) filtration, (iv) electrostatic precipitation, and (v) wet scrubbing. The most commonly used APCDs are the (i) dust catchers (ii) cyclones or multi cyclones, (iii) fabric filters also known as bag houses, (iv) electrostatic precipitators (wet and dry types), and (v) scrubbers. The first four control devices control the amount of particulate matter escaping into the environment while scrubbers control the acidic gas emissions into the atmosphere.

Dust catchers

The principle of a dust catcher is shown in Fig 1. The internal construction of the dust catcher is such that there is a sudden change in the direction of the flow of exhaust gas. This causes the large dust particles to separate because of its higher momentum. The separated particles then settle down because of gravitational force.

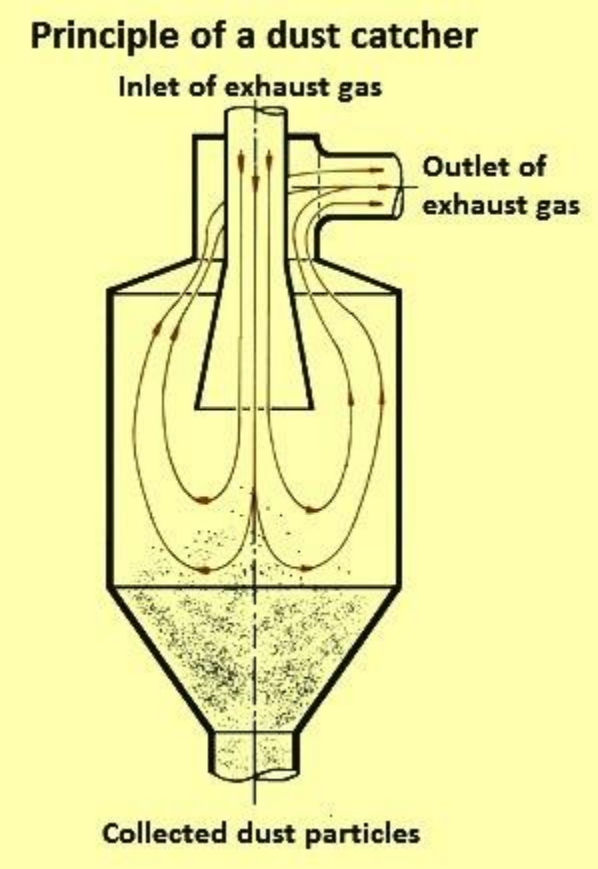


Fig 1 Principle of a dust catcher Cyclones

Cyclones are also known as centrifugal collectors. They uses cyclonic separation method for the removal of the particulate matter from the exhaust gases. They remove particulate matters by causing the dirty exhaust gas stream to flow in a spiral path inside a cylindrical chamber (Fig 2). Dirty exhaust gas enters the chamber from a tangential direction at the outer wall of the device forming a vortex as it swirls within the chamber. The centrifugal force created by the circular flow throws the dust particles toward the wall of the cyclone. After striking the wall, these particles fall into a hopper located underneath.

The larger particulates because of their greater inertia move outward and are forced against the chamber wall. Slowed by friction with the wall surface, they then slide down the wall into a conical dust hopper at the bottom of the cyclone. The cleaned exhaust gas swirls upward in a narrower spiral through an inner cylinder and emerges from an outlet at the top and accumulated particulate dust is periodically removed from the hopper situated in the bottom for disposal.

Fig 2 Spiral path of exhaust gas in a cyclone

The most common types of cyclones in use are (i) single cyclone separators, and (ii)) multi cyclone separators. The single cyclone separators create a dual vortex to separate coarse particles from fine dust. The main vortex spirals downward and carries most of the coarser dust particles. The inner vortex created near the bottom of the cyclone, spirals upward and carries finer dust particles. The multiple-cyclone separators consist of a number of small diameter cyclones, operating in parallel and having a common gas inlet and outlet. They operate on the same principle as cyclones by creating a main downward vortex and an ascending inner vortex. They are more efficient than single cyclones because they are longer and smaller in diameter. The longer length provides longer residence time while the smaller diameter creates greater centrifugal force. These two factors result in better separation of dust particulates. The pressure drop of multi cyclone separators is higher than that of single cyclone separators.

Cyclones are best at removing relatively coarse particulates. They can routinely achieve efficiencies of 90 % for particles larger than about 20 micro meters. However, cyclones are not sufficient to meet stringent air quality standards. They are typically used as pre-cleaning devices and are normally used along with other more efficient cleaning equipment such as fabric filters and electrostatic precipitators.

Fabric filters (Bag houses)

Fabric filter are also known as ‘bag houses’. They use filtration to separate dust particulates from dusty gases. They are one of the most efficient and cost effective types of dust collectors available. Dust-laden gases enter the fabric filter and pass through fabric bags which act as filters. The bags can be of woven or felted cotton, synthetic, or glass-fiber material in either a tube or envelope shape.

The high efficiency of these filters is due to the dust cake formed on the surfaces of the bags. The fabric filters primarily provides a surface on which dust particulates collect through the following four mechanisms.

- Inertial collection – Dust particles strike the fabrics placed perpendicular to the gas flow direction instead of changing direction with the gas stream.
- Interception – Particles which do not cross the fluid streamlines come in contact with fabrics because of the fiber size.
- Brownian movement – Sub micro metre particles are diffused, increasing the probability of contact between the particles and collecting surfaces.
- Electrostatic forces – The presence of an electrostatic charge on the particles and the filter can increase dust capture.

A combination of these mechanisms results in formation of the dust cake on the filter which eventually increases the resistance to gas flow. The filter is required to be cleaned periodically.

A typical fabric filter (Fig 3 shows the cross section) consists of an arrangement of long, narrow bags (each with a diameter of around 250 mm). These bags are suspended upside down in a large enclosure. Dust-laden exhaust gas is blown upward through the bottom of the enclosure by fans. Particulates are trapped inside the filter bags while the clean exhaust gas passes through the fabric filter and exits at the top of the bag house.

A fabric filter dust collector can remove practically 100 % of particles as small as 1 micro meter and a significant fraction of particles as small as 0.01 micro meters. Fabric filters however, offer relatively high resistance to gas flow and they are expensive to operate and maintain. Also, to prolong the useful life of the filter fabric the exhaust gases to be cleaned need to be cooled (usually below 300 deg C) before they are passed through the bag house. The cooling coils needed for this purpose add to the capital cost. Further, certain filter fabrics (e.g. those made of ceramic or mineral materials) can operate at higher temperatures.

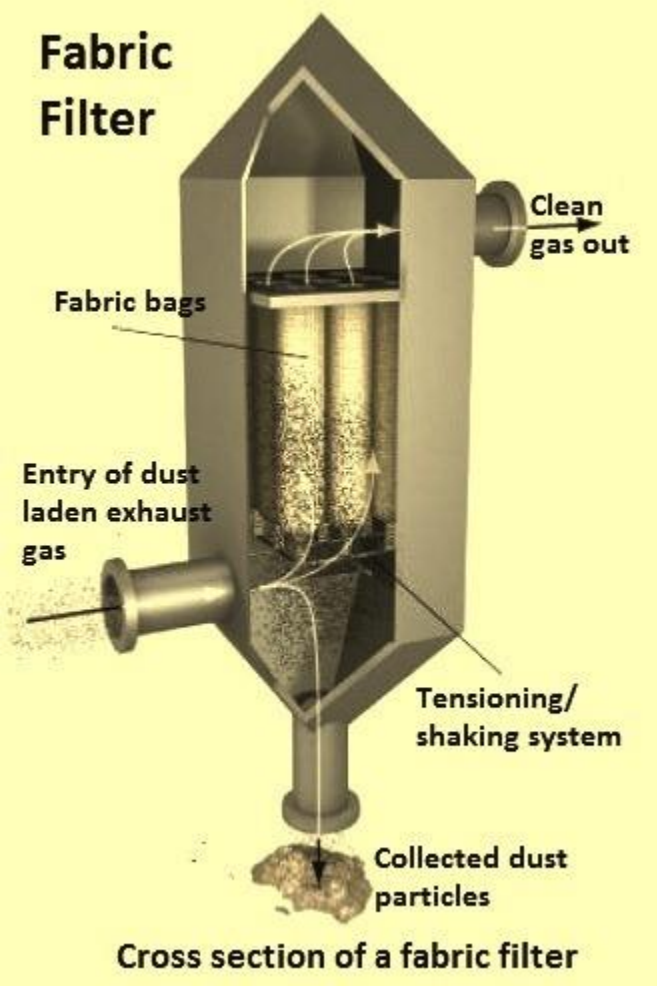


Fig 3 Cross section of s fabric filter

Several compartments of filter bags are often used in a single bag house installation. This arrangement allows individual compartments to be cleaned while others remain in service. The filter bags are cleaned by mechanical shakers or by reversing the flow of exhaust gas and the loosened particulates are collected and removed for disposal.

Based on the cleaning method, there are three common types of fabric filters. These are (i) mechanical shaker, (ii) reverse air, and (iii) reverse jet.

In mechanical-shaker type of fabric filters, tubular filter bags are fastened onto a cell plate at the bottom of the filter and suspended from horizontal beams at the top. Dirty gas enters the bottom of the filter and passes through the filter, and the dust collects on the inside surface of the bags. Cleaning is accomplished by shaking the top horizontal bar from which the bags are suspended. Vibration produced by a motor-driven shaft and cam creates waves in the bags to shake off the dust cake. These filters can operate intermittently or continuously. Intermittent units can be used when processes operate on a batch basis. When a batch is completed, the filter can be cleaned. Continuous processes use compartmentalized filters. When one compartment is being cleaned, the exhaust gas flow can be diverted to other compartments. In these filters, there must be no positive pressure inside the bags during the shake cycle. Pressures (as low as 0.5 mm water gauge) can

interfere with the cleaning process of the bags. The air to cloth ratio for these filters is relatively low. Hence, the space requirements are quite high.

In reverse air fabric filters, the bags are fastened onto a cell plate at the bottom of the filter and suspended from an adjustable hanger frame at the top. Dirty gas normally enters the filter and passes through the bag from the inside, and the dust collects on the inside of the bags. These filters are compartmentalized to allow continuous operation. Before a cleaning cycle begins, filtration is stopped in the compartment to be cleaned. Bags are cleaned by injecting clean air into the dust collector in a reverse direction, which pressurizes the compartment. The pressure makes the bags collapse partially, causing the dust cake to crack and fall into the hopper below. At the end of the cleaning cycle, reverse airflow is discontinued and the compartment is returned to the main stream. The flow of the dirty gas helps maintain the shape of the bag. However, to prevent total collapse and fabric chafing during the cleaning cycle, rigid rings are sewn into the bags at intervals. Space requirements for a reverse air fabric filter are comparable to those of a mechanical shaker filter. The maintenance needs are somewhat greater.

In reverse pulse jet fabric filter, individual bags are supported by a metal cage, which is fastened onto a cell plate at the top of the filter. Dirty gas enters from the bottom of the filter and flows from outside to inside the bags. The metal cage prevents collapse of the bag. Bags are cleaned by a short burst of compressed air injected through a common manifold over a row of bags. The compressed air is accelerated by a venturi nozzle mounted at the reverse jet filter top of the bag. Since the duration of the compressed-air burst is short (0.1second), it acts as a rapidly moving air bubble, traveling through the entire length of the bag and causing the bag surfaces to flex. This flexing of the bags breaks the dust cake, and the dislodged dust falls into a storage hopper below. Reverse pulse jet fabric filters can be operated continuously and cleaned without interruption of flow because the burst of compressed air is very small compared with the total volume of dusty air through the collector. Because of this continuous cleaning feature, these filters are normally not compartmentalized. The short cleaning cycle of these filters reduces recirculation and redeposit of the dust. These filters provide more complete cleaning and reconditioning of bags than shaker or reverse air cleaning methods. Also, the continuous-cleaning feature allows them to operate at higher air-to-cloth ratios, so the space requirements are lower. This cleaning system works with the help of digital sequential timer attached to the fabric filter. This timer indicates the solenoid valve to inject the air to the blow pipe.

Fabric filters generally have the parts namely (i) clean plenum, (ii) dusty plenum, (iii) bag, cage, venturi assembly, (iv) tube plate, (v) Rotary airlock valve/Screw, (vi) compressed air header, (vii) blow pipe, and (viii) housing, and (ix) hopper.

Electrostatic precipitators

An electrostatic precipitator (ESP) is a particulate collection device which removes particles from a flowing gas (such as exhaust gas) using the force of an induced electrostatic charge. ESPs are highly efficient filtration devices which minimally impede the flow of gases through the device, and can easily remove fine particulate matter from the exhaust gas stream. ESP applies energy only to the particulate matter being collected and therefore is very efficient in its consumption of energy (in the form of electricity).

The ESP consists of (i) baffles for the distribution of the flow of exhaust gas, (ii) discharge and collection electrodes, (iii) a dust clean-out system, and (iv) collection hoppers. A high DC voltage is applied to the discharge electrodes to charge the particles, which then are attracted to oppositely charged collection electrodes on which they get trapped.

The most basic precipitator contains a row of thin vertical wires, and followed by a stack of large flat metal plates oriented vertically, with the plates typically spaced around 10 mm to 180 mm apart, depending on the application. The exhaust gas stream flows horizontally through the spaces between the wires, and then passes through the stack of plates. A negative voltage of several thousand volts is applied between wire and plate. If the applied voltage is high enough an electric (corona) discharge ionizes the gas around the electrodes. Negative ions flow to the plates and charge the gas-flow particles. The ionized particles, following the negative electric field created by the power supply, move to the grounded plates. Particles build up on the collection plates and form a layer. The layer does not collapse because of the electrostatic pressure (given from layer resistivity, electric field, and current flowing in the collected layer). The performance of ESP is very sensitive due to two particulate properties namely (i) resistivity and (ii) particle size distribution. The cross section of an ESP is shown in Fig 4.

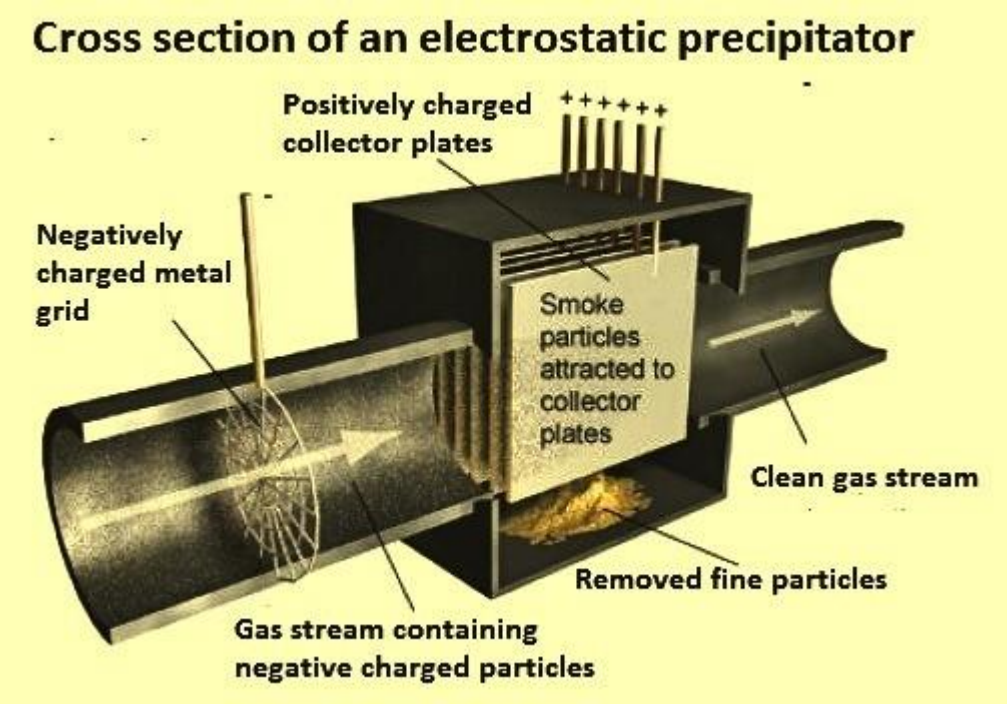


Fig 4 Cross section of an electrostatic precipitator

In a typical ESP, the collection electrodes comprise a group of large rectangular metal plates suspended vertically and parallel to each other inside a boxlike structure. There are usually hundreds of plates having a combined surface area of around 10,000 sq m. Rows of discharge electrode wires hang between the collection plates. The wires are given a negative electric charge whereas the plates are grounded and thus become positively charged.

Particles which stick to the collection plates are removed periodically when the plates are shaken, or 'rapped'. Rapping is a mechanical technique for separating the trapped particles from the plates which typically become covered with a 6 mm layer of dust. Rappers are either of the impulse (single-blow) or vibrating type.

The dislodged particles are collected in a hopper at the bottom of the ESP and removed for disposal. An ESP can remove particulates as small as 1 micro meter with an efficiency exceeding 99 %. The ESPs are very effective in removing fly ash from the combustion gases of coal fired furnaces.

A wet electrostatic precipitator (wet ESP) operates with saturated exhaust gas streams (100 % relative humidity). Wet ESPs are generally used to remove liquid droplets such as sulphuric acid mist from the process gas streams. The wet ESP is also used normally where the gases are (i) high in moisture content, (ii) contain combustible particulate, and (iii) have particles which are sticky in nature. The preferred and most modern type of wet ESP is a down flow tubular design. This design allows the collected moisture and particulate to form slurry that helps to keep the collection surfaces clean. Plate style and up flow design wet ESPs are very unreliable and are not to be used in applications where particulate is sticky in nature.

Scrubbers

The exhaust gases of combustion may contain substances considered harmful to the environment, and the scrubber can remove or neutralize these substances. Scrubber systems are a diverse group of APCDs which can be used to remove some particulates and/or gases from exhaust gas streams. Traditionally, the term ‘scrubber’ is being referred to pollution control devices which use liquid to wash unwanted pollutants from a gas stream. Recently, the term is also used to describe systems which inject a dry reagent or slurry into a dirty exhaust stream to ‘wash out’ acid pollutants. Scrubbers are one of the primary devices which control gaseous emissions, especially acid gases. Scrubbers can be either wet scrubber or dry scrubber.

The term wet scrubber describes a variety of devices which remove pollutants from the exhaust gas streams. In a wet scrubber, the contaminated gas stream is brought into contact with the scrubbing liquid usually (i) by spraying it with the liquid, (ii) by forcing it through a pool of liquid, or (iii) by some other contact method, so as to remove the pollutants. The design of wet scrubbers depends on the process conditions and the nature of the pollutants involved. Inlet gas characteristics and dust properties (if particles are present) are of primary importance. Scrubbers can be designed to collect particulate matter and/or gaseous pollutants. Wet scrubbers remove dust particles by capturing them in liquid droplets. Wet scrubbers remove pollutant gases by dissolving or absorbing them into the liquid. Any droplets which are in the scrubber inlet gas must be separated from the outlet gas stream by means of another device referred to as a mist eliminator or entrainment separator (these terms are interchangeable). Also, the resultant scrubbing liquid must be treated prior to any ultimate discharge or being reused. There are numerous configurations of scrubbers and scrubbing systems, all designed to provide good contact between the liquid and polluted gas stream. Fig 5 shows a packed bed wet scrubber.

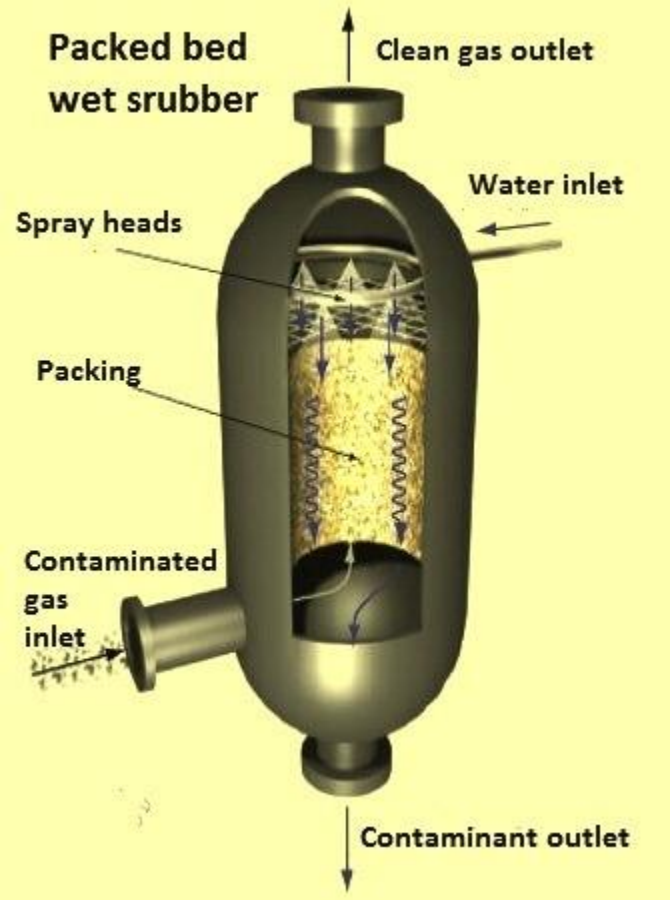


Fig 5 Packed-bed wet scrubber

The wet scrubber is used to clean air, exhaust gas or other gases of various pollutants and dust particles. Wet scrubber works via the contact of the particulate matter with the scrubbing solution. Solutions can simply be water (for dust) or solutions of reagents that specifically target certain compounds. Removal efficiency of pollutants is improved by increasing residence time in the scrubber or by the increase of surface area of the scrubber solution by the use of a spray nozzle, packed towers or an aspirator. Wet scrubbers may increase the proportion of water in the gas, resulting in a visible stack plume, if the gas is sent to a stack.

A dry or semi-dry scrubbing system, unlike the wet scrubber, does not saturate the exhaust gas stream which is being treated with moisture. In some cases no moisture is added, while in some other case only that amount of moisture is added which can be evaporated in the exhaust gas without its condensation. Hence, dry scrubbers normally do not have a stack steam plume or wastewater handling/disposal requirements. Dry scrubbing systems are used to remove acidic vapours (such as SO2 and HCl) which primarily come from combustion sources.

There are a number of dry types scrubbing system designs. However, all consist of two main sections or devices namely (i) a device to introduce the acid gas sorbent material into the gas

stream, and (ii) a particulate matter control device to remove reaction products, excess sorbent material as well as any particulate matter already in the exhaust gas. Dry scrubbing systems can be categorized as dry sorbent injectors or as spray dryer absorbers. Spray dryer absorbers are also called semi-dry scrubbers or spray dryers.

Dry scrubbing systems are often used for the removal of odorous and corrosive gases from wastewater treatment plant operations. The media used is typically an activated alumina compound impregnated with materials to handle specific gases such as hydrogen sulphide. Media used can be mixed together to offer a wide range of removal for other odorous compounds such as methyl mercaptans, aldehydes, volatile organic compounds, dimethyl sulphide, and dimethyl disulphide.

Dry sorbent injection involves the addition of an alkaline material (usually hydrated lime or soda ash) into the gas stream to react with the acid gases. The sorbent can be injected directly into several different locations such as the combustion process, the exhaust gas duct (ahead of the particulate control device), or an open reaction chamber (if one exists). The acid gases react with the alkaline sorbets to form solid salts which are removed in the particulate control device. These simple systems can achieve only limited acid gas (SO2 and HCl) removal efficiencies. Higher collection efficiencies can be achieved by increasing the exhaust gas humidity (i.e., cooling using water spray). In spray dryer absorbers, the flue gases are introduced into an absorbing tower (dryer) where the gases are contacted with finely atomized alkaline slurry. Acid gases are absorbed by the slurry mixture and react to form solid salts which are removed by the particulate control device. The heat of the exhaust gas is used to evaporate all the water droplets, leaving a non-saturated exhaust gas to exit the absorber tower. Spray dryers are capable of achieving high (more than 80 %) acid gas removal efficiencies.

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UNIT – III– ENVIRONMENTAL POLLUTION CONTROL– SCHA4004

UNIT-III

WATER POLLUTION AND ANALYSIS

Water Pollution

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds.

Sources of Water Pollution

There are various classifications of water pollution. The two chief sources of water pollution can be seen as **Point and Non Point.**

Point Sources refer to the pollutants that belong to a single source. An example of this would be emissions from factories into the water.

Non Point Sources on the other hand means pollutants emitted from multiple sources. Contaminated water after rains that has traveled through several regions may also be considered as a Non point source of pollution.

Causes of Water Pollution

Industrial waste: Industries produce huge amount of waste which contains toxic chemicals and pollutants which can cause air pollution and damage to us and our environment. They contain pollutants such as lead, mercury, sulphur, asbestos, nitrates and many other harmful chemicals. Many industries do not have proper waste management system and drain the waste in the fresh water which goes into rivers, canals and later in to sea. The toxic chemicals have the capability to change the color of water, increase the amount of minerals, also known as Eutrophication, change the temperature of water and pose serious hazard to water organisms.

Sewage and waste water: The sewage and waste water that is produced by each household is chemically treated and released in to sea with fresh water. The sewage water carries harmful bacteria and chemicals that can cause serious health problems. Pathogens are known as a common water pollutant; The sewers of cities house several pathogens and thereby diseases. Microorganisms in water are known to be causes of some very deadly diseases and become the breeding grounds for other creatures that act like carriers. These carriers inflict these diseases via various forms of contact onto an individual. A very common example of this process would be Malaria.

- **Mining activities:** Mining is the process of crushing the rock and extracting coal and other minerals from underground. These elements when extracted in the raw form contains harmful chemicals and can increase the amount of toxic elements when mixed up with water which may result in health problems. Mining activities emit several metal waste and sulphides from the rocks and is harmful for the water.

- **Marine dumping:** The garbage produce by each household in the form of paper, aluminum, rubber, glass, plastic, food if collected and deposited into the sea in some countries. These items take from 2 weeks to 200 years to decompose. When such items enters the sea, they not only cause water pollution but also harm animals in the sea.

- **Accidental Oil leakage:** Oil spill pose a huge concern as large amount of oil enters into the sea and does not dissolve with water; there by opens problem for local marine wildlife such as fish, birds and sea otters. For e.g.: a ship carrying large quantity of oil may spill oil if met with an accident and can cause varying damage to species in the ocean depending on the quantity of oil spill, size of ocean, toxicity of pollutant.

- **Burning of fossil fuels:** Fossil fuels **like** coal and oil when burnt produce substantial amount of ash in the atmosphere. The particles which contain toxic chemicals when mixed with water vapor result in acid rain. Also, carbon dioxide is released from burning of fossil fuels which result in global warming.

- **Chemical fertilizers and pesticides:** Chemical fertilizers and pesticides are used by farmers to protect crops from insects and bacterias. They are useful for the plants growth. However, when these chemicals are mixed up with water produce harmful for plants and animals. Also, when it rains, the chemicals mixes up with rainwater and flow down into rivers and canals which pose serious damages for aquatic animals

- **Leakage from sewer lines:** A small leakage from the sewer lines can contaminate the underground water and make it unfit for the people to drink. Also, when not repaired on time, the leaking water can come on to the surface and become a breeding ground for insects and mosquitoes.

9. Global warming: An increase in earth's temperature due to greenhouse effect results in global warming. It increases the water temperature and result in death of aquatic animals and marine species which later results in water pollution.

• **Radioactive waste:** Nuclear energy **is** produced using nuclear fission or fusion. The element that is used in production of nuclear energy is Uranium which is highly toxic chemical. The nuclear waste that is produced by radioactive material needs to be disposed off to prevent any nuclear accident. Nuclear waste can have serious environmental hazards if not disposed off properly. Few major accidents have already taken place in Russia and Japan.

1. Leakage from the landfills: Landfills are nothing but huge pile of garbage that produces awful smell and can be seen across the city. When it rains, the landfills may leak and the leaking landfills can pollute the underground water with large variety of contaminants.

2. Animal waste: The waste produce produce by animals is washed away into the rivers when it rains. It gets mixed up with other harmful chemicals and causes various water borne diseases like cholera, diarrhea, jaundice, dysentery and typhoid.

3. **Underground storage leakage:** Transportation of coal and other petroleum products through underground pipes is well known. Accidentals leakage may happen anytime and may cause damage to environment and result in soil erosion.

Effects of Water Pollution

There are many different types of water pollution and all have a different adverse effect on the environment.

Heavy metals from industrial processes can accumulate in nearby lakes and rivers. These are toxic to marine life such as fish and shellfish, and can affect the rest of the food chain. This means that entire animal communities can be badly affected by this type of pollutant.
Industrial waste often contains many toxic compounds that damage the health of aquatic animals and those who eat them. Some toxins affect the reproductive success of marine life and can therefore disrupt the community structure of an aquatic environment.
Microbial pollutants from sewage often result in infectious diseases that infect aquatic life and terrestrial life through drinking water. This often increases the number of mortalities seen within an environment.
Organic matter and nutrients causes an increase in aerobic algae and depletes oxygen from the water column. This is called eutrophication and causes the suffocation of fish and other aquatic organisms.
Sulfate particles from acid rain change the pH of water making it more acidic, this damages the health of marine life in the rivers and lakes it contaminates, and often increases the number of mortalities within an environment.

Suspended particles can often reduce the amount of sunlight penetrating the water, disrupting the growth of photosynthetic plants and micro-organisms. This has subsequent effects on the rest of the aquatic community that depend on these organisms to survive.

Control measures of water pollution

4. Administration of water pollution control should be in the hands of state or central government
5. Scientific techniques should be adopted for environmental control of catchment areas of rivers, ponds or streams
6. Industrial plants should be based on recycling operations as it helps prevent disposal of wastes into natural waters but also extraction of products from waste.
7. Plants, trees and forests control pollution as they act as natural air conditioners.
8. Trees are capable of reducing sulphur dioxide and nitric oxide pollutants and hence more trees should be planted.
9. No type of waste (treated, partially treated or untreated) should be discharged into any natural water body. Industries should develop closed loop water supply schemes and domestic sewage must be used for irrigation.
10. Qualified and experienced people must be consulted from time to time for effective control of water pollution.
11. Public awareness must be initiated regarding adverse effects of water pollution using the media.
12. Laws, standards and practices should be established to prevent water pollution and these laws should be modified from time to time based on current requirements and technological advancements.
13. Basic and applied research in public health engineering should be encouraged.

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. Wastewater can originate from a combination of domestic, industrial, commercial or agricultural activities, surface runoff or stormwater, and from sewer inflow or infiltration.

Wastewater can come from:

Human excreta (feces and urine) often mixed with used toilet paper or wipes; this is known as black water if it is collected with flush toilets
Washing water (personal, clothes, floors, dishes, cars, etc.), also known as greywater or sullage
Surplus manufactured liquids from domestic sources (drinks, cooking oil, pesticides, lubricating oil, paint, cleaning liquids, etc.)
Urban rainfall runoff from roads, carparks, roofs, sidewalks/pavements (contains oils, animal feces, litter, gasoline/petrol, diesel or rubber residues from tires, soap scum, metals from vehicle exhausts, etc.)
Highway drainage (oil, de-icing agents, rubber residues, particularly from tires)

Storm drains (may include trash)
Manmade liquids (illegal disposal of pesticides, used oils, etc.)
Industrial waste
Industrial site drainage (silt, sand, alkali, oil, chemical residues);
Industrial cooling waters (biocides, heat, slimes, silt)
Industrial process waters
Organic or biodegradable waste, including waste from abattoirs, creameries, and ice cream manufacture
Organic or non bio-degradable/difficult-to-treat waste
(pharmaceutical or pesticide manufacturing)
Extreme pH waste (from acid/alkali manufacturing, metal plating)
Toxic waste (metal plating, cyanide production, pesticide manufacturing, etc.) Solids and emulsions (paper manufacturing, foodstuffs, lubricating and hydraulic oil manufacturing, etc.)
Agricultural drainage, direct and diffuse
Hydraulic fracturing
Produced water from oil & natural gas production

Some examples of pollutants that can be found in wastewater and the potentially harmful effects these substances can have on ecosystems and human health include:

decaying organic matter and debris can use up the dissolved oxygen in a lake so fish and other aquatic biota cannot survive;
excessive nutrients, such as phosphorus and nitrogen (including ammonia), can cause eutrophication, or over-fertilization of receiving waters, which can be toxic to aquatic organisms, promote excessive plant growth, reduce available oxygen, harm spawning grounds, alter habitat and lead to a decline in certain species;
chlorine compounds and inorganic chloramines can be toxic to aquatic invertebrates, algae and fish;
bacteria, viruses and disease-causing pathogens can pollute beaches and contaminate shellfish populations, leading to restrictions on human recreation, drinking water consumption and shellfish consumption;
metals, such as mercury, lead, cadmium, chromium and arsenic can have acute and chronic toxic effects on species.
other substances such as some pharmaceutical and personal care products, primarily entering the environment in wastewater effluents, may also pose threats to human health, aquatic life and wildlife.

Wastewater is simply water that has been used. It usually contains various pollutants, depending on what it was used for. It is classified into two major categories, by source

Domestic or sanitary wastewater. This comes from residential sources including toilets, sinks, bathing, and laundry. It can contain body wastes containing intestinal disease organisms.

Industrial wastewater. This is discharged by manufacturing processes and commercial enterprises. Process wastewater can contain rinse waters including such things as residual acids, plating metals, and toxic chemicals.

Special Precautions for Wastewater Sampling

1. A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.

2. Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

3. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background/control samples.

4. If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.

Sample Handling and Preservation Requirements

2. Wastewater samples will typically be collected either by directly filling the sample container or by using an automatic sampler or other device.

3. During sample collection, if transferring the sample from a collection device, make sure that the device does not come in contact with the sample containers.

Site selection for waste water sampling

Influent

Influent wastewaters are preferably sampled at locations of highly turbulent flow in order to ensure good mixing; however, in many instances the most desirable location is not accessible. Preferable influent wastewater sampling locations include: 1) the upflow siphon following a comminutor (in absence of grit chamber); 2) the upflow distribution box following pumping

from main plant wet well; 3) aerated grit chamber; 4) flume throat; 5) pump wet well when the pump is operating; or 6) downstream of preliminary screening.

Effluent

Effluent samples should be collected at the site specified in the permit, or if no site is specified in the permit, at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters.

Sample Types

Grab Samples

Grab samples consist of either a single discrete sample or individual samples collected over a period of time not to exceed 15 minutes. The grab sample should be representative of the wastewater conditions at the time of sample collection. The sample volume depends on the type and number of analyses to be performed.

Composite Samples

Composite samples are collected over time, either by continuous sampling or by mixing discrete samples. A composite sample represents the average wastewater characteristics during the compositing period

Characteristics of waste water

Physical Characteristics

The physical characteristics of wastewater include those items that can be detected using the physical senses. They are temperature, color, odor, Dissolved oxygen, Insoluble substances (settleable solids, suspended solids),and foamability.

Dissolved Oxygen

The measurement of DO gives the ready assessment of purity of water.The determination of DO is the basis for BOD test which is commonly used to evaluate the pollution strength of waste waters.

Chemical Characteristics

The chemical characteristics of wastewater of special concern are pH, acidity or alkalinity,COD, Hardness, total carbon,chlorine demand, known organic and inorganic compounds, hydrocarbons,oils,greases etc

Oxygen Demand

It is the amount of oxygen used by bacteria and other wastewater organisms as they feed upon the organic solids in the wastewater.

COD

By definition the COD is the amount of oxygen required to stabilized the organic matter chemically, i.e. the COD is used as a measure of the oxygen equivalent of the organic matter contents of a sample that is susceptible to oxidation by a strong chemical oxidant.

Biological Characteristics of Wastewater

BOD

is defined as the amount of oxygen required by the bacteria while stabilizing decomposable organic matter under aerobic condition. It is written as by BOD or BOD520. “It is the amount of oxygen required by aerobic bacteria to decompose/stabilized the organic matter at a standard temperature of 20oC for a period of 05 days”.

The three biological organisms present in wastewater are bacteria, viruses, and parasites.

Bacteria

Sewage consists of vast quantities of bacteria, most of which are harmless to man. However, pathogenic (disease-causing) organisms such as typhoid, dysentery, and other intestinal disorders may be present in wastewater. The bacteria in raw sewage may be expected to in the range from 500, 000 to 5,000,000 per mL. These bacteria are responsible for the decomposition of complex compounds to stable compounds with the help of some extracellular and intracellular enzymes. Depending upon the mode of action of bacteria may be divided into the following three categories;

- Aerobic Bacteria
- Anaerobic Bacteria
- Facultative Bacteria

Determination of BOD

The BOD test takes 5 days to complete and is performed using a dissolved oxygen test kit. The BOD level is determined by comparing the DO level of a water sample taken immediately with the DO level of a water sample that has been incubated in a dark location for 5 days. The difference between the two DO levels represents the amount of oxygen required for the decomposition of any organic material in the sample and is a good approximation of the BOD level.

- Take 2 samples of water

Record the DO level (ppm) of one immediately using the method described in the dissolved oxygen test.

- Place the second water sample in an incubator in complete darkness at 20o C for 5 days. If you don't have an incubator, wrap the water sample bottle in aluminum foil or black electrical tape and store in a dark place at room temperature (20o C or 68 °F).

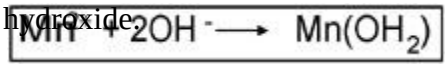
- After 5 days, take another dissolved oxygen reading (ppm) using the dissolved oxygen test kit.

- Subtract the Day 5 reading from the Day 1 reading to determine the BOD level. Record your final BOD result in ppm

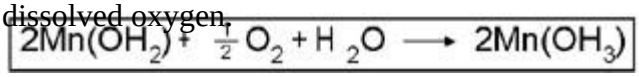
Determination of dissolved oxygen

Steps in the Winkler method of oxygen determination.

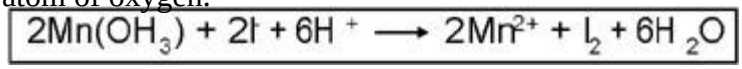
1. Manganese(II) ions liberated from the manganese sulfate are loosely bound with excess hydroxide.



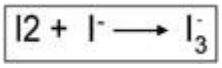
2. Manganese(II) is oxidized to Manganese(III) in the presence of a strong base and binds the dissolved oxygen.



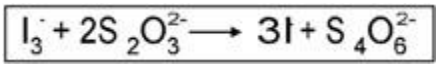
3. Free iodine is produced upon acidification of the sample at a rate of one I_2 molecule for each atom of oxygen.



4. Free iodine complexes with excess iodide ions.



5. The iodine/iodide complex is reduced to iodide with thiosulfate.



BACTERIAL EXAMINATION OF WATER

The bacteriological examination of water is performed routinely by water utilities and many governmental agencies to ensure a safe supply of water for drinking, bathing, swimming and other domestic and industrial uses. The examination is intended to identify water sources which

have been contaminated with potential disease-causing microorganisms. Such contamination generally occurs either directly by human or animal feces, or indirectly through improperly treated sewage or improperly functioning sewage treatment systems. The organisms of prime concern are the intestinal pathogens, particularly those that cause typhoid fever and bacillary dysentery.

Since human fecal pathogens vary in kind (viruses, bacteria, protozoa) and in number, it would be impossible to test each water sample for each pathogen. Instead, it is much easier to test for the presence of nonpathogenic intestinal organisms such as E. coli. E. coli is a normal inhabitant of the intestinal tract and is not normally found in fresh water. Therefore, if it is detected in water, it can be assumed that there has been fecal contamination of the water. In order to determine whether water has been contaminated by fecal material, a series of tests are used to demonstrate the presence or absence of coliforms. The coliform group is comprised of Gram-negative, nonspore-forming, aerobic to facultatively anaerobic rods, which ferment lactose to acid and gas. Two organisms in this group include E. coli and Enterobacter aerogenes; however, the only true fecal coliform is E. coli, which is found only in fecal material from warm-blooded animals. The presence of this organism in a water supply is evidence of recent fecal contamination and is sufficient to order the water supply closed until tests no longer detect E. coli.

STANDARD WATER ANALYSIS

The Presumptive Test

In the presumptive test, a series of lactose broth tubes are inoculated with measured amounts of the water sample to be tested. The series of tubes may consist of three or four groups of three, five or more tubes. The more tubes utilized, the more sensitive the test. Gas production in any one of the tubes is presumptive evidence of the presence of coliforms. The most probable number (MPN) of coliforms in 100 ml of the water sample can be estimated by the number of positive tubes

The Confirmed Test

If any of the tubes inoculated with the water sample produce gas, the water is presumed to be unsafe. However, it is possible that the formation of gas may not be due to the presence of coliforms. In order the confirm the presence of coliforms, it is necessary to inoculate EMB (eosin methylene blue) agar plates from a positive presumptive tube. The methylene blue in EMB agar inhibits Gram positive organisms and allows the Gram-negative coliforms to grow. Coliforms produce colonies with dark centers. E. coli and E. aerogenes can be distinguished from one another by the size and color of the colonies. E. coli colonies are small and have a green metallic sheen, whereas E. aerogenes forms large pinkish colonies. If only E. coli or if both E. coli and E. aerogenes appear on the EMB plate, the test is considered positive. If only E. aerogenes appears on the EMB plate, the test is considered negative. The reasons for these interpretations are that,

as previously stated, E. coli is an indicator of fecal contamination, since it is not normally found in water or soil, whereas E. aerogenes is widely distributed in nature outside of the intestinal tract.

The Completed Test

The completed test is made using the organisms which grew on the confirmed test media. These organisms are used to inoculate a nutrient agar slant and a tube of lactose broth. After 24 hours at 37°C, the lactose broth is checked for the production of gas, and a Gram stain is made from organisms on the nutrient agar slant. If the organism is a Gram-negative, nonspore-forming rod and produces gas in the lactose tube, then it is positive that coliforms are present in the water sample.

Traditional visible region spectrophotometers cannot detect if a colorant or the base material has fluorescence. This can make it difficult to manage color issues if for example one or more of the printing inks is fluorescent. Where a colorant contains fluorescence, a bi-spectral fluorescent spectrophotometer is used. There are two major setups for visual spectrum spectrophotometers, d/8 (spherical) and 0/45. The names are due to the geometry of the light source, observer and interior of the measurement chamber. Scientists use this instrument to measure the amount of compounds in a sample. If the compound is more concentrated more light will be absorbed by the sample; within small ranges, theBeer-Lambert law holds and the absorbance between samples vary with concentration linearly. In the case of printing measurements two alternative settings are commonly used- without/with uv filter to control better the effect of uv brighteners within the paper stock.

Samples are usually prepared in cuvettes; depending on the region of interest, they may be constructed of glass, plastic (visible spectrum region of interest), or quartz (Far UV spectrum region of interest).

Applications

Estimating dissolved organic carbon concentration
Specific Ultraviolet Absorption for metric of aromaticity Bial's Test
for concentration of pentoses

type of photosensors that are available for different spectral regions, but infrared measurement is also challenging because virtually everything emits IR light as thermal radiation, especially at wavelengths beyond about 5 μm.

Another complication is that quite a few materials such as glass and plastic absorb infrared light, making it incompatible as an optical medium. Ideal optical materials are salts, which do not absorb strongly. Samples for IR spectrophotometry may be smeared between two discs of potassium bromide or ground with potassium bromide and pressed into a pellet. Where aqueous solutions are to be measured, insoluble silver chloride is used to construct the cell.

EMISSION SPECTROMETRY

Atomic emission spectrometry (AES) is a method of chemical analysis that uses the intensity of light emitted from a flame, plasma, arc, or spark at a particular wavelength to determine the quantity of an element in a sample. The wavelength of the atomic spectral line gives the identity of the element while the intensity of the emitted light is proportional to the number of atoms of the element.

A sample of a material (analyte) is brought into the flame as either a gas, sprayed solution, or directly inserted into the flame by use of a small loop of wire, usually platinum. The heat from the flame evaporates the solvent and breaks chemical bonds to create free atoms. The thermal energy also excites the atoms into excited electronic states that subsequently emit light when they return to the ground electronic state. Each element emits light at a characteristic wavelength, which is dispersed by a grating or prism and detected in the spectrometer.

A frequent application of the emission measurement with the flame is the regulation of alkali metals for pharmaceutical analytics.

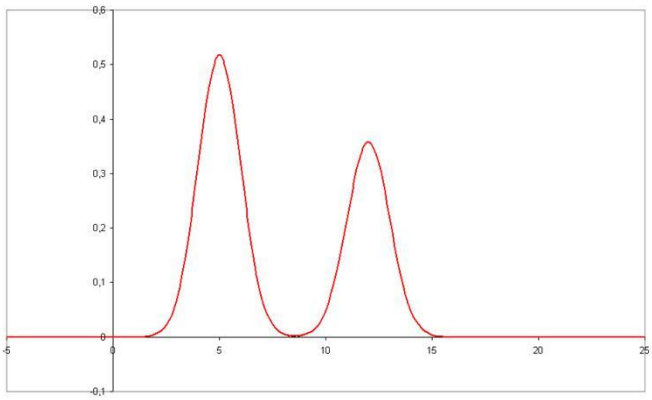
CHROMATOGRAPHY

Chromatography is the collective term for a set of laboratory techniques for the separation of mixtures. The mixture is dissolved in a fluid called the *mobile phase,* which carries it through a structure holding another material called
the *stationary phase.* The various constituents of the mixture travel at different

speeds, causing them to separate. The separation is based on differential partitioning between the mobile and stationary phases. Subtle differences in a compound's partition coefficient result in differential retention on the stationary phase and thus changing the separation.

Chromatography may be preparative or analytical. The purpose of preparative chromatography is to separate the components of a mixture for more advanced use (and is thus a form of purification). Analytical chromatography is done normally with smaller amounts of material and is for measuring the relative proportions of analytes in a mixture.

The **analyte** is the substance to be separated during chromatography. It is also normally what is needed from the mixture.
Analytical chromatography is used to determine the existence and possibly also the concentration of analyte(s) in a sample.
A **bonded phase** is a stationary phase that is covalently bonded to the support particles or to the inside wall of the column tubing.
A **chromatogram** is the visual output of the chromatograph. In the case of an optimal separation, different peaks or patterns on the chromatogram correspond to different components of the separated mixture.



Column chromatography is a separation technique in which the stationary bed is within a tube. The particles of the solid stationary phase or the support coated with a liquid stationary phase may fill the whole inside volume of the tube (packed column) or be concentrated on or along the inside tube wall leaving an open, unrestricted path for the mobile phase in the middle part of the tube (open tubular

column). Differences in rates of movement through the medium are calculated to different retention times of the sample.

CONTROL OF WATER POLLUTION

The following points may help in reducing water pollution from non-point sources.

2. Judicious use of agrochemicals like pesticides and fertilizers which will reduce their surface run-off and leaching. Use of these on sloped lands should be avoided.

3. Use of nitrogen fixing plants to supplement the use of fertilizers.

4. Adopting integrated pest management to reduce greater reliance on pesticides.

5. Prevent run-off of manure. Divert such run-off to basin for settlement. The nutrient rich water can be used as fertilizer in the fields.

6. Separate drainage of sewage and rain water should be provided to prevent overflow of sewage with rain water.

7. Planting trees would reduce pollution by sediments and will also prevent soil erosion.

For controlling water pollution from point sources, treatment of waste waters is essential before being discharged. Parameters which are considered for reduction in such water are: Total solids, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates and phosphates, oil and grease, toxic metals etc. Waste waters should be properly treated by primary and secondary treatments to reduce the BOD, COD levels up to the permissible levels for discharge.

Sewage treatment, or domestic wastewater treatment, is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and

domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce an environmentally-safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer).

Sewage is created by residential, institutional, and commercial and industrial establishments and includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers. In many areas, sewage also includes liquid waste from industry.

Sewage can be treated close to where it is created (in septic tanks, bio-fitter's or aerobic treatment systems), or collected and transported via a network of pipes and pump stations to a municipal treatment plant.

VARIOUS APPROACHES TO PREVENT AND CONTROL WATER POLLUTION

1. **Sewage treatments:** The household water should be treated properly so that they become environmentally safe. Adequate care should be taken to ensure that effective sewage treatment process is in place and that contaminated water does not get mixed with the environment. in order to prevent water pollution, human and animal excreta should be prevented from mixing with its sources. Construction of pit toilet and proper sewage treatments can offer some solution to this problem.

2. **Prevent river water to get polluted:** The flowing water of the river cannot be cleaned easily by natural process. Since, a large number of external substances are discharged into the water, the river water becomes polluted. This may cause diseases to the people using river water. Thus, every effort should be made to prevent the river water to get contaminated. People should not be allowed to throw wastes into the river water.

14. Treatment of wastes before discharge: Factories are expected to treat its effluent wastes prior to discharge. Toxic material must be treated chemically and converted into harmless materials. If possible, factories should try to recycle the treated water.

15. Strict adherence to water laws: Laws and legislation relating to pollution should be strictly followed by all. People should be made aware that adherence to water laws are in their own interest.

16. Treatment of drainage water: It cities, a huge amount of water is put into drains every day. The water that flows through the city drainage system should be properly treated. Harmful pollutants be removed, before they are introduced into reservoirs. If this water allowed going into water reservoirs without treatment, it will pollute them.

17. Treatment plants: Big cities and towns usually have effluent treatment plants. These plants filter out undissolved materials. Chemical treatment is also given to separate out unwanted dissolved chemicals. The treated water is either allowed to go into the water reservoirs or refused in houses. Occasionally, the treated water is used for farming if the fields to be irrigated lie in the vicinity of the water treatment plants.

18. Keep the pond water clean and safe: Washing, bathing of cattle in the pond that is used by human should not be done. Washing of dirty clothes and bathing of cattle make the pond water dirty and unsuitable for human use. If these ponds are continually misuses, then it may lead of severe consequences.

19. Routine cleaning: Ponds, lakes and wells meant for human use should be routinely cleaned and treated, so that it remains fit for human use. It is an essential step that should not be avoided. A system of regular testing of pond and lake water can be introduced to ensure the safety of the water.

1. **Don’t pour insecticides in sinks and toilets:** Never pour household insecticides, medicines, etc. down the sink, drain or toilet. At homes, people often throw wastes and old medicines into the bathroom toilet. This practice is discouraged for the reason that the chemical compounds of medicines, insecticides, etc., when mixed with other chemicals, may result in formation of harmful substances.

2. **Self hygiene:** Self hygiene must be maintained and drinking water must not be polluted. Drinking water should be kept undercover in a clean place. One should not put his hands into the drinking water containers. Also, the practice of cleaning the drinking water reservoirs on a regular basis need to be strictly followed. The water meant for drinking should be purified prior to use. In the absence of good water purifier, it is recommended to drink boiled water. This is also important
to prevent water borne diseases.

3. **Sanitation:** Sanitation system must be improved. The benefits of cleanliness on human health need to be understood. Human contact with hazardous materials should be prevented. After using the toilet, one should always use the flush and wash their hands with soap and water.

4. **Public Awareness:** Common public should be aware about the effect of water pollution. Voluntary organization should go door-to-door to educate the people about environmental problems. They should perform street plays for creating awareness about the environment. They should run environmental education centers. Students can impart health education to enable people to prevent water pollution

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DEPARTMENT OF CHEMICAL ENGINEERING

UNIT – IV– ENVIRONMENTAL POLLUTION CONTROL– SCHA4004

UNIT-IV

NOISE POLLUTION

Sound, a normal feature of our life, is the means of communication and entertainment in most animals, including human beings. It is also a very effective alarm system. A low sound is pleasant whereas a loud sound is unpleasant and is commonly referred to as ‘noise’. Noise can be defined as an unpleasant and unwanted sound.

Whether a given sound is as pleasant as music or as unpleasant as noise depends on its loudness, duration, rhythm and the mood of the person. But loudness is definitely the most significant criterion which converts sound into noise. Exposure to loud noise is indeed annoying and harmful too.

Noise is a physical form of pollution and is not directly harmful to the life supporting systems namely air, soil and water. Its effects are more directly on the receiver i.e. man. Noise pollution is the result of modern industrialized urban life and congestion due to over population. Noise is unwanted sound. Sound is a form of energy which is emitted by a vibrating body and on reaching the ear causes the sensation of hearing through nerves. Sounds produced by all vibrating bodies are not audible.

Even though noise pollution is not fatal to human life, yet its importance cannot be overlooked because repeated exposure to noise reduces the sleeping hours and productivity or efficiency of a human being. It affects the peace of mind and invades the privacy of a human being. The importance of noise pollution as environmental problem is being recognised as the ill effects of noise on human health and environment are becoming evident with each passing day.

NOISE UNITS

The frequency limits of audibility are from 20 HZ to 20,000 HZ. A noise problem generally

consists of three inter-related elements- the source, the receiver and the transmission path. This transmission path is usually the atmosphere through which the sound is propagated, but can include the structural materials of any building containing the receiver. Decibel represents the intensity and is defined as one tenth of a bel where one bel represents a difference in level between two intensities I,, I_0 where one is ten times greater than the other.

Sources of Noise Pollution:

Major sources of noise pollution are:

(i) Industrial Sources:

Progress in technology (industrialization) has resulted in creating noise pollution. Textile mills, printing presses, engineering establishments and metal works etc. contribute heavily towards noise pollution. In industrial cities like Kolkata, Ludhiana, Kanpur etc., often the industrial zones are not separated from the residential zones of the city especially in the case of small scale industries.

These operate from workshops located on the ground floors of the residential areas and cause annoyance, discomfort and irritation to the residents exposed to the noise that is inevitably produced. The situation is much better in modern planned cities like Chandigarh where the industrial area is kept away from the residential areas and both are separated from each other by a sufficiently wide green belt.

(ii) Transport Vehicles:

Automobile revolution in urban centers has proved to be a big source of noise pollution. Increasing traffic has given rise to traffic jams in congested areas where the repeated hooting of horns by impatient drivers pierce the ears of all road users.

Noise from airplanes constitutes an increasing serious problem in big cities like Delhi & Mumbai. Airport situated in the vicinity of population centres and the air planes pass over

residential areas. Heavy trucks, buses trains, jet-planes, motor-cycles, scooters, mopeds, jeeps— the list of vehicles is endless but the outcome is same — noise pollution.

(iii) Household:

The household is an industry in itself and is a source of many indoor noises such as the banging of doors, noise of playing children, crying of infants, moving of furniture, loud conversation of the inhabitants etc. Besides these are the entertainment equipment in the house, namely the radio, record-players and television sets. Domestic gadgets like the mixer-grinders, pressure cookers, desert coolers, air- conditioners, exhaust fans, vacuum cleaners, sewing and washing machines are all indoor sources of noise pollution.

(iv) Public Address System:

In India people need only the slightest of an excuse for using loud speakers. The reason may be a religious function, birth, death, marriage, elections, demonstration, or just commercial advertising. Public system, therefore, contributes in its own way towards noise pollution.

(v) Agricultural Machines:

Tractors, thrashers, harvesters, tube wells, powered tillers etc. have all made agriculture highly mechanical but at the same time highly noisy. Noise level 90 dB to 98 dB due to running of farm machines have been recorded in the state of Punjab.

(vi) Defence Equipment:

A lot of noise pollution is added to the atmosphere by artillery, tanks, launching of rockets, explosions, exercising of military airplanes and shooting practices. Screams of jet engines and sonic booms have a deafening impact on the ears and in extreme cases have been known to shatter the window panes and old dilapidated buildings.

(vii) Miscellaneous Sources:

The automobile repair shops, construction-works, blasting, bulldozing, stone crushing etc. are other sources of noise pollution.

Effects of Noise:

Noise is generally harmful and a serious health hazard. It has far-reaching consequences and has many physical, physiological as well as psychological effects on human beings.

(i) Physical Effects:

The physical manifestation of noise pollution is the effect on hearing ability. Repeated exposure to noise may result in temporary or permanent shifting of the hearing threshold of a person depending upon the level and duration of exposure. The immediate and acute effect of noise pollution is impairment of hearing (i.e. total deafness.)

Human ears have sensory cells for hearing. If these cells are subjected to repeated sounds of high intensity before they have an opportunity to recover fully, they can become permanently damaged leading to impairment of hearing. Besides the sensory cells, the delicate tympanic membrane or the ear drum can also be permanently damaged by a sudden loud noise such as an explosion.

(ii) Physiological Effects:

The physiological manifestations of noise pollution are several as mentioned below:

(a) Headache by dilating blood vessels of the brain.

(b) Increase in the rate of heart-beat.

(c) Narrowing of arteries.

(d) Fluctuations in the arterial blood pressure by increasing the level of cholesterol in the blood.

(e) Decrease in heart output.

(f) Pain in the heart.

(g) Digestive spasms through anxiety and dilation of the pupil of the eye, thereby causing eye-strain.

(h) Impairment of night vision.

(i) Decrease in the rate of colour perception.

(j) Lowering of concentration and affect on memory,

(k) Muscular strain and nervous breakdown.

(l) Psychological Effect

The psychological manifestations of noise pollution are:

(a) Depression and fatigue which considerably reduces the efficiency of a person.

(b) Insomnia as a result of lack of undisturbed and refreshing sleep

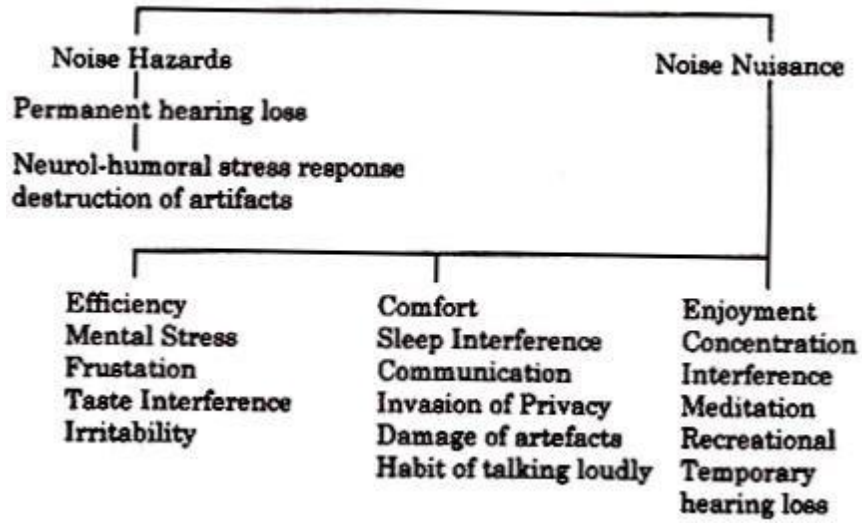
(c) Straining of senses and annoyance as a result of slow but persistent noise from motorcycles, alarm clocks, call bells, telephone rings etc.

(d) Affecting of psychomotor performance of a person by a sudden loud sound

(e) Emotional disturbance

For a talkative person, the most important effect of noise pollution would invariably be that noise interferes with our conservation. So, noise is annoying and the annoyance depends on many factors not merely the intensity of the sound but also repetition, because even a sound of small intensity (e.g. dripping tap or clicking of clock) may become annoying, simply by repetition.

Some of the well- known effects of noise on human beings and the relation of noise pollution level and its harmful effects are shown in Table



Noise Pollution Level and its Harmful Effects:

Level (in db)	Effects
up to 30	No disturbance
30—60	Stress, tension, psychological (illness, heart attact) effects especially at upper range.
60—90	Damage to health, psychological and vegetative (disturbance in stomach-gall function, pains in muscles, high blood pressure, disturbance in sleeping)
90—120	Damages to health and ontological (ear diseases) effects

Above 120	Painful effects in long run.

Effects of Noise Pollution on Human Beings

Decreases the efficiency of a man-Regarding the impact of noise on human efficiency there are number of experiments which shows that human efficiency increases with noise reduction.
Lack of concentration-For better quality of work there should be concentration , Noise causes lack ofconcentration. In big cities , mostly all the offices are on main road. The noise of traffic or theloud speakers of different types of horns divert the attention of the people working in offices.
Fatigue:Because of Noise Pollution, people cannot concentrate on their work. Thus they have to give their more time for completing the work and they feel tiring.
Abortion is caused-There should be cool and calm atmosphere during the pregnancy. Unpleasantsounds make a lady of irritative nature. Sudden Noise causes abortion in females.
Causes Blood Pressure-Noise Pollution causes certain diseases in human. It attacks on the person's peace of mind. The noises are recognized as major contributing factors in accelerating the already existing tensions of modern living. These tensions result in certain disease like blood pressure or mental illness etc.
Temporary of permanent Deafness-The effect of noise on audition is well recognized. Mechanics ,locomotive drivers, telephone operators etc. All have their hearing impairment as a result of noise at the place of work. Physicians & psychologists are of the view that continued exposure to noise level above. 80 to 100 db is unsafe, Loud noise causes temporary or permanent deafness.

- Noise pollution damage the nervous system of animal.
- Animal looses the control of its mind and becomes dangerous

Impacts of Noise:

a. Annoyance:

It creates annoyance to the receptors due to sound level fluctuations. The aperiodic sound due to its

b. Physiological Effects:

The physiological features like breathing amplitude, blood pressure, heart-beat rate, pulse rate, blood cholesterol are affected.

c. Loss of Hearing:

Long exposure to high sound levels cause loss of hearing. This is mostly unnoticed, but has an adverse impact on hearing function.

d. Human Performance:

The working performance of workers/human will be affected as they'll be losing their concentration.

e. Nervous System:

It causes pain, ringing in the ears, feeling of tiredness, thereby effecting the functioning of human system.

f. Sleeplessness:

It affects the sleeping there by inducing the people to become restless and loose concentration and presence of mind during their activities

g. Damage to Material:

The buildings and materials may get damaged by exposure to infrasonic / ultrasonic waves and even get collapsed.

Control of Noise Pollution:

a. Reducing the Noise Levels from Domestic Sectors:

The domestic noise coming from radio, tape recorders, television sets, mixers, washing machines, cooking operations can be minimized by their selective and judicious operation. By usage of carpets or any absorbing material, the noise generated from felling of items in house can be minimized.

b. Maintenance of Automobiles:

Regular servicing and tuning of vehicles will reduce the noise levels. Fixing of silencers to automobiles, two wheelers etc., will reduce the noise levels.

c. Control over Vibrations:

The vibrations of materials may be controlled using proper foundations, rubber padding etc. to reduce the noise levels caused by vibrations.

d. Low Voice Speaking:

Speaking at low voices enough for communication reduces the excess noise levels.

e. Maintenance of machines:

Proper lubrication and maintenance of machines, vehicles etc. will reduce noise levels. For example, it is a common experience that, many parts of a vehicle will become loose while on a rugged path of journey. If these loose parts are not properly fitted, they will generate noise and cause annoyance to the driver/passenger. Similarly is the case of machines. Proper handling and regular maintenance is essential not only for noise control but also to improve the life of machine.

RADIOACTIVE POLLUTION(RAP)

The radioactive pollution is defined as the physical pollution of air, water and the other radioactive materials. The ability of certain materials to emit the proton, gamma rays and electrons by their nuclei is known as the radioactivity. The protons are known as the alpha particle and the electrons are also known as the beta particle. Those materials are known as the radioactive elements. The environmental radiations can be from different sources and can be natural or manmade.

The natural radiations are also known as the background radiations. In this the cosmic rays are involved and reach the surface of earth from space. It includes the radioactive elements like radium, uranium, thorium, radon, potassium and carbon. These occur in the rock, soil and water. The man made radiations include the mining and refining of plutonium and thorium. This production and explosion of nuclear weapons include the nuclear fuels, power plants and radioactive isotopes.

The first atom bomb was exploded in the Japan in the year 1945. It affected the Hiroshima and Nagasaki cities. It adversely affected the flora, fauna and humans of that area. In spite of these destructions the nuclear race is still going on between different nations. The nuclear arms are tested with the production of nuclear weapons.

The radioactive elements are produced in the environment and affect other materials also. It includes the strontium, radium and iodine. The gases and particles are produced by the radioactive materials. They are carried by the wind and the rain brings down the radioactive particles to the ground which is referred as nuclear fallout. The soil transfers these radioactive substances to the plants and ultimately they reach the human body and cause many side effects. The iodine may affect the white blood cells, bone marrow, spleen, lymph, skin cancer, sterility, eye and damage to the lung. The strontium has the ability to aggregate in the bones and form a bone cancer and leads to tissue degeneration.

The radioactive materials are passed through the land to water and cause an adverse effect on the aquatic animals. They reach to human through the food chain. The nuclear power generates a lot of energy which is used to run turbines and produces electricity. The fuel and the coolant produce a large amount of pollution in the environment. The atomic reactors are also rich in the radioactive materials. There biggest problem is in their disposal and if they are not properly disposed they can harm the living organisms. If they escape they can cause a hell lot of

destruction. The gases escape as a vapor and cause pollution on the land and water. The use of radioactive isotopes is multipurpose. They are of a great scientific value and they may be present in the waste water. From these water resources they reach to the human body via food chain. The people who work in power plants have more chances of the exposure to harmful radiations. The human beings also receive the radiation and radiotherapy from the x rays.

Radiation is the process by which radiant energy is transferred from one place to another in the form of electro-magnetic waves.

he various types of radiation differ from one another by their frequency or wavelength. Higher the frequency or lower the wavelength of a radiation, higher will be its energy. Again, higher the energy of the radiation, it will cause higher damage to the living organisms.

Non-ionising Radiation:

These are the radiations which induce the ionisation of atoms and molecules. An atom is ionised when energy supplied to it separates one or more of its electrons. Ionisation of a molecule produces two fragments. The radiation pollution is mainly caused by non-ionising radiation.

Alpha (α), beta (β), and gamma (γ) radiations are mainly responsible for radiation pollution. Alpha radiation contains energetic -alpha particles. Each alpha particle carries two units of positive charges and interacts strongly with living tissues.

Beta, radiation is made up of energetics electrons. Each beta particle carries one unit of negative charge and interacts strongly with matter. Gamma radiations are made up of high energy photons. Photons bring about strong electro-magnetic interaction with matter.

Sources of Radiation Pollution:

Radiation sources are mainly natural but partly manmade.

The natural sources of radiation may be:

1. Radioactive minerals;

2. Cosmic rays;

3. Radio nuclides.

1. Radioactive Minerals:

The minerals containing Uranium- 235 (U^{235}), Uranium-238 (U^{238}), Thorium-232 (Th^{232}), Plutonium- 239 (Pu^{239}) etc. are capable of emitting energetic radiations causing pollution.

2. Cosmic Rays:

The cosmic rays containing highly energetic particles reach the surface of the earth causing pollution. The intensity of cosmic rays depends on latitudes and altitude of the place. The intensity is maximum at the poles and minimum at the equator.

3 .Radio nuclides:

The unstable radio-nuclides in the atmosphere can be splitted up into smaller parts emitting energetic radiation. The smaller radio-nuclides enter into the body of organism along with air during respiration.

The various sources of manmade radiation pollutions may be:

1. Nuclear power plants;

2. Radio-active wastes;

3. Nuclear explosions; and

4. Radio-isotopes.

1. Nuclear Power Plants:

Nuclear power plants emit radiation to a very smaller extent except accidental leaks (Chernobyl accident of undivided USSR).

2. Radio-active Wastes:

The nuclear power plants produce a lot of nuclear radio-active wastes. The disposal of these wastes has become a global problem. Some countries producing large quantity of nuclear wastes dump them in ocean near other countries.

3. Nuclear Explosion:

During nuclear explosion, a large number of radio-nuclides are generated in the atmosphere. The radio nuclides settle down with rain contaminating the soil and water bodies. Finally, these enter into food chain causing serious problem to the living organisms.

4. Radio-isotopes:

Radio-isotopes are also prepared artificially either by nuclear fusion or by nuclear fission. If these radio-isotopes are not properly handled, these emit radiations causing pollution.

5. Television Set:

Television sets produce radiations which can also cause cancer.

Effect of Radiation Pollution:

When radiation passes through different living organisms the following disorder takes place:

1. Radiation splits the molecules of the tissues into ions and free radicals and causes mutation by

2. Radiation in bone marrow may cause

3. Radiation may cause skin burns which may lead to skin cancer.

4. Radiation at pelvic regions of pregnant ladies, cause damage to the foetus.

Radiation pollution can be controlled in the following ways:

1. Care should be taken to check manmade radiation pollution at source.

2. Nuclear reactor should be perfectly maintained to avoid accidental leakage.

3. Nuclear tests should be banned.

4. Radioactive materials should be properly labeled and handled.

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DEPARTMENT OF CHEMICAL ENGINEERING

UNIT – V– ENVIRONMENTAL POLLUTION CONTROL– SCHA4004

UNIT-V

UNIT V -SOLID WASTE AND ITS MANAGEMENT

Contents

5.0 Introduction to solid waste

Due to rapid increase in the production and consumption processes, societies generate as well as reject solid materials regularly from various sectors – agricultural, commercial, domestic, industrial and institutional. The considerable volume of wastes thus generated and rejected is called solid wastes. In other words, solid wastes are the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted. This inevitably places an enormous strain on natural resources and seriously undermines efficient and sustainable development. One of the ways to salvage the situation is through efficient management of solid wastes, and this is the focus of this unit

Solid wastes are the organic and inorganic waste materials such as product packaging, grass clippings, furniture, clothing, bottles, kitchen refuse, paper, appliances, paint cans, batteries, etc., produced in a society, which do not generally carry any value to the first user(s). Solid wastes, thus, encompass both a heterogeneous mass of wastes from the urban community as well as a more homogeneous accumulation of agricultural, industrial and mineral wastes. While wastes have little or no value in one setting or to the one who wants to dispose them, the discharged wastes may gain significant value in another setting. Knowledge of the sources and types of solid wastes as well as the information on composition and the rate at which wastes are generated/ disposed is, therefore, essential for the design and operation of the functional elements associated with the management of solid wastes.

5.1 Classification of Solid Wastes

Solid wastes are classified on the basis of source of generation

5.1.1 Source-based classification

Historically, the sources of solid wastes have been consistent, dependent on sectors and activities (Tchobanoglous, et al., 1977), and these include the following:

(i) Residential: This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

(ii) Commercial: This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.

(iii) Institutional: This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

(iv) Municipal: This includes dust, leafy matter, building debris, treatment plant residual sludge, etc., generated from various municipal activities like construction and demolition, street cleaning, landscaping, etc.

(v) Industrial: This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.

(vi) Agricultural: This mainly consists of spoiled food grains and vegetables, agricultural remains, litter, etc., generated from fields, orchards, vineyards, farms, etc.

(vii) Open areas: this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.

5.1.2 Type-based classification

Classification of wastes based on types, i.e., physical, chemical, and biological characteristics of wastes, is as follows (Phelps, et al., 1995):

(i) Garbage: This refers to animal and vegetable wastes resulting from the handling, sale, storage, preparation, cooking and serving of food. Garbage comprising these wastes contains putrescible (rotting) organic matter, which produces an obnoxious odour and attracts rats and other vermin. It, therefore, requires special attention in storage, handling and disposal.

(ii) Ashes and residues: These are substances remaining from the burning of wood, coal, charcoal, coke and other combustible materials for cooking and heating in houses, institutions and small industrial establishments. When produced in large quantities, as in power-generation plants and factories, these are classified as industrial wastes. Ashes consist of fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass. Since ashes and residues are almost entirely inorganic, they are valuable in landfills.

(iii) Combustible and non-combustible wastes: These consist of wastes generated from households, institutions, commercial activities, etc., excluding food wastes and other highly putrescible material. Typically, while combustible material consists of paper, cardboard, textile, rubber, garden trimmings, etc., non-combustible material consists of such items as glass, crockery, tin and aluminium cans, ferrous and non-ferrous material and dirt.

(iv) Bulky wastes: These include large household appliances such as refrigerators, washing machines, furniture, crates, vehicle parts, tyres, wood, trees and branches. Since these household wastes cannot be accommodated in normal storage containers, they require a special collection mechanism.

(v) Street wastes: These refer to wastes that are collected from streets, walkways, alleys, parks and vacant plots, and include paper, cardboard, plastics, dirt, leaves and other vegetable matter. Littering in public places is indeed a widespread and acute problem in many countries including India, and a solid waste management system must address this menace appropriately.

(vi) Biodegradable and non-biodegradable wastes: Biodegradable wastes mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., generated from various household and industrial activities. Because of the action of micro-organisms, these wastes are degraded from complex to simpler compounds. Nonbiodegradable wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals, etc.

(vii) Dead animals: With regard to municipal wastes, dead animals are those that die naturally or are accidentally killed on the road. Dead animals are divided into two groups – large and small. Among the large animals are horses, cows, goats, sheep, pigs, etc., and among the small ones are dogs, cats, rabbits, rats, etc. The reason for this differentiation is that large animals require special equipment for lifting and handling when they are removed. If not collected promptly,

dead animals pose a threat to public health since they attract flies and other vermin as they decay. Their presence in public places is particularly offensive from the aesthetic point of view as well.

(viii) Abandoned vehicles: This category includes automobiles, trucks and trailers that are abandoned on streets and other public places. However, abandoned vehicles have significant scrap value for their metal, and their value to collectors is highly variable.

(ix) Construction and demolition wastes: These are wastes generated as a result of construction, refurbishment, repair and demolition of houses, commercial buildings and other structures. They consist mainly of earth, stones, concrete, bricks, lumber, roofing and plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream.

(x) Farm wastes: These wastes result from diverse agricultural activities such as planting, harvesting, production of milk, rearing of animals for slaughter and the operation of feedlots. In many areas, the disposal of animal waste has become a critical problem, especially from feedlots, poultry farms and dairies.

(xi) Hazardous wastes: Hazardous wastes are those defined as wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment. This is due to their physical, chemical and biological or radioactive characteristics like ignitability, corrosivity, reactivity and toxicity. Typical examples of hazardous wastes are empty containers of solvents, paints and pesticides, which are frequently mixed with municipal wastes and become part of and become part of the urban waste stream. Certain hazardous wastes may cause explosions in incinerators and fires at landfill sites. Others such as pathological wastes from hospitals and radioactive wastes also require special handling. Effective management practices should ensure that hazardous wastes are stored, collected, transported and disposed of separately, preferably after suitable treatment to render them harmless.

(xii) Sewage wastes: The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derived from the treatment of organic sludge separated from both raw and treated sewages. The inorganic fraction of raw sewage such as grit and eggshells is separated at the preliminary stage of treatment, as it may entrain putrescible organic matter with pathogens and must be buried without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but is invariably uneconomical. Solid sludge, therefore, enters the stream of municipal wastes, unless special arrangements are made for its disposal.

5.2 Solid waste management (SWM)

Solid waste management (SWM) is associated with the control of waste generation, its storage, collection, transfer and transport, processing and disposal in a manner that is in accordance with the best principles of public health, economics, engineering, conservation, aesthetics, public attitude and other environmental considerations. Put differently, the SWM processes differ depending on factors such as economic status (e.g., the ratio of wealth created by the production of primary products to that derived from manufactured goods, per capita income, etc.), degree of industrialisation, social development (e.g., education, literacy, healthcare, etc.) and quality of life of a location. In addition, regional, seasonal and economic differences influence the SWM processes. This, therefore, warrants management strategies that are economically viable, technically feasible and socially acceptable to carry out such of the functions as are listed below

Protection of environmental health. Promotion of environmental quality. Supporting the efficiency and productivity of the economy. Generation of employment and income. SWM has socio-economic and environmental dimensions. In the socio-economic dimension, for example, it includes various phases such as waste storage, collection, transport and disposal, and the management of these phases has to be integrated. In other words, wastes have to be properly stored, collected and disposed of by co-operative management. In addition, poor management of wastes on the user side such as disposing of wastes in the streets, storm water drains, rivers and lakes has to be avoided to preserve the environment, control vector-born diseases and ensure water quality/resource.

5.3 SWM system

A SWM system refers to a combination of various functional elements associated with the management of solid wastes. The system, when put in place, facilitates the collection and disposal of solid wastes in the community at minimal costs, while preserving public health and ensuring little or minimal adverse impact on the environment. The functional elements that constitute the system are:

(i) Waste generation: Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. The source of waste generation, determines quantity, composition and waste characteristics . For example, wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services. The most important aspect of this part of the SWM system is the identification of waste.

(ii) Waste storage: Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. The heterogeneous wastes generated in residential areas must be removed within 8 days due to shortage of storage space and presence of biodegradable material. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved. Some of the options for storage are plastic containers, conventional dustbins (of households), used oil drums, large storage bins (for institutions and commercial areas or servicing depots), etc.

(iii) Waste collection: This includes gathering of wastes and hauling them to the location, where the collection vehicle is emptied, which may be a transfer station (i.e., intermediate station where wastes from smaller vehicles are transferred to larger ones and also segregated), a processing plant or a disposal site. Collection depends on the number of containers, frequency of collection, types of collection services and routes. Typically, collection is provided under various management arrangements, ranging from municipal services to franchised services, and under various forms of contracts.

(iv) Transfer and transport: This functional element involves: the transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations; the subsequent transport of the wastes, usually over long distances, to disposal sites.

The factors that contribute to the designing of a transfer station include the type of transfer operation, capacity, equipment, accessories and environmental requirements.

(v) Processing: Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, manual separation of waste components, incineration and composting.

(vi) Recovery and recycling: This includes various techniques, equipment and facilities used to improve both the efficiency of disposal system and recovery of usable material and energy. Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass. The selection of any recovery process is a function of economics, i.e., costs of separation versus the recovered-material products. Certain recovered materials like glass, plastics, paper, etc., can be recycled as they have economic value.

(vii) Waste disposal: Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment plants, incinerator residues, composts

or other substances that have no further use to the society. Thus, land use planning becomes a primary determinant in the selection, design and operation of landfill operations. A modern sanitary landfill is a method of disposing solid waste without creating a nuisance and hazard to public health. Generally, engineering principles are followed to confine the wastes to the smallest possible area, reduce them to the lowest particle volume by compaction at the site and cover them after each day's operation to reduce exposure to vermin. One of the most important functional elements of SWM, therefore, relates to the final use of the reclaimed land.

5.4 Effects of Solid Waste Pollution:

Municipal solid wastes heap up on the roads due to improper disposal system. People clean their own houses and litter their immediate surroundings which affects the community including themselves.

This type of dumping allows biodegradable materials to decompose under uncontrolled and unhygienic conditions. This produces foul smell and breeds various types of insects and infectious organisms besides spoiling the aesthetics of the site. Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in physicochemical and biological characteristics thereby affecting productivity of soils.

Toxic substances may leach or percolate to contaminate the ground water. In refuse mixing, the hazardous wastes are mixed with garbage and other combustible wastes. This makes segregation and disposal all the more difficult and risky.

Various types of wastes like cans, pesticides, cleaning solvents, batteries (zinc, lead or mercury), radioactive materials, plastics and e-waste are mixed up with paper, scraps and other non-toxic materials which could be recycled. Burning of some of these materials produces dioxins, furans and polychlorinated biphenyls, which have the potential to cause various types of ailments including cancer.

5.5 Methods of Solid Wastes Disposal:

i. Sanitary Landfill

ii. Incineration

iii. Composting

iv. Pyrolysis

i. Sanitary Land Filling:

In a sanitary landfill, garbage is spread out in thin layers, compacted and covered with clay or plastic foam. In the modern landfills the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate.

Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Several wells are drilled near the landfill site to monitor if any leakage is contaminating ground water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat. Sanitary Landfills Site Selection:

i. Should be above the water table, to minimize interaction with groundwater.

ii. Preferably located in clay or silt.

iii. Do not want to place in a rock quarry, as water can leech through the cracks inherent in rocks into a water fracture system.

iv. Do not want to locate in sand or gravel pits, as these have high leeching. Unfortunately, most of Long Island is sand or gravel, and many landfills are located in gravel pits, after they were no longer being used.

v. Do not want to locate in a flood plain. Most garbage tends to be less dense than water, so if the area of the landfill floods, the garbage will float to the top and wash away downstream.

A large number of adverse impacts may occur from landfill operations. These impacts can vary:

i. Fatal accidents (e.g., scavengers buried under waste piles).

ii. Infrastructure damage (e.g., damage to access roads by heavy vehicles).

iii. Pollution of the local environment (such as contamination of groundwater and/or aquifers by leakage and residual soil contamination during landfill usage, as well as after landfill closure).

iv. Off gassing of methane generated by decaying organic wastes (methane is a greenhouse gas many times more potent than carbon dioxide, and can itself be a danger to inhabitants of an area).

v. Harbouring of disease vectors such as rats and flies, particularly from improperly operated landfills.

ii. *Incineration:*

The term incinerates means to burn something until nothing is left but ashes. An incinerator is a unit or facility used to burn trash and other types of waste until it is reduced to ash. An incinerator is constructed of heavy, well-insulated materials, so that it does not give off extreme amounts of external heavy metal.

The high levels of heat are kept inside the furnace or unit so that the waste is burned quickly and efficiently. If the heat were allowed to escape, the waste would not burn as completely or as rapidly. Incineration is a disposal method in which solid organic wastes are subjected to combustion so as to convert them into residue and gaseous products. This method is useful for disposal of residue of both solid waste management and solid residue from waste water management. This process reduces the volumes of solid waste to 20 to 30 per cent of the original volume.

Incineration and other high temperature waste treatment systems are sometimes described as "thermal treatment". Incinerators convert waste materials into heat, gas, steam and ash. Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and gaseous waste. It is recognized as a practical method of disposing of certain hazardous waste materials. Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

iii. *Composting:*

Due to shortage of space for landfill in bigger cities, the biodegradable yard waste (kept separate from the municipal waste) is allowed to degrade or decompose in a medium. A good quality nutrient rich and environmentally friendly manure is formed which improves the soil conditions and fertility.

Organic matter constitutes 35%-40% of the municipal solid waste generated in India. This waste can be recycled by the method of composting, one of the oldest forms of disposal. It is the natural process of decomposition of organic waste that yields manure or compost, which is very rich in nutrients.

Composting is a biological process in which micro-organisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance. This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants.

The process of composting ensures the waste that is produced in the kitchens is not carelessly thrown and left to rot. It recycles the nutrients and returns them to the soil as nutrients. Apart from being clean, cheap, and safe, composting can significantly reduce the amount of disposable garbage.

The organic fertilizer can be used instead of chemical fertilizers and is better specially when used for vegetables. It increases the soil's ability to hold water and makes the soil easier to cultivate. It helped the soil retain more of the plant nutrients.

Vermi-composting has become very popular in the last few years. In this method, worms are added to the compost. These help to break the waste and the added excreta of the worms makes the compost very rich in nutrients. In the activity section of this web site you can learn how to make a compost pit or a vermi-compost pit in your school or in the garden at home.

To make a compost pit, you have to select a cool, shaded corner of the garden or the school compound and dig a pit, which ideally should be 3 feet deep. This depth is convenient for aerobic composting as the compost has to be turned at regular intervals in this process.

Preferably the pit should be lined with granite or brick to prevent nitrite pollution of the subsoil water, which is known to be highly toxic. Each time organic matter is added to the pit it should be covered with a layer of dried leaves or a thin layer of soil which allows air to enter the pit thereby preventing bad odour. At the end of 45 days, the rich pure organic matter is ready to be used. Composting: some benefits

i. Compost allows the soil to retain more plant nutrients over a longer period.

ii. It supplies part of the 16 essential elements needed by the plants.

iii. It helps reduce the adverse effects of excessive alkalinity, acidity, or the excessive use of chemical fertilizer.

iv. It makes soil easier to cultivate.

v. It helps keep the soil cool in summer and warm in winter.

vi. It aids in preventing soil erosion by keeping the soil covered.

vii. It helps in controlling the growth of weeds in the garden.

iv. Pyrolysis:

Pyrolysis is a form of incineration that chemically decomposes organic materials by heat in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C (800 °F).

In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs. If volatile or semi-volatile materials are present in the waste, thermal desorption will also occur.

Organic materials are transformed into gases, small quantities of liquid, and a solid residue containing carbon and ash. The off-gases may also be treated in a secondary thermal oxidation unit. Particulate removal equipment is also required. Several types of pyrolysis units are available, including the rotary kiln, rotary hearth furnace, and fluidized bed furnace. These units are similar to incinerators except that they operate at lower temperatures and with less air supply.

5.6 Limitations and Concerns:

i. The technology requires drying of soil prior to treatment.

ii. Limited performance data are available for systems treating hazardous wastes containing polychlorinated biphenyls (PCBs), dioxins, and other organics. There is concern that systems that destroy chlorinated organic molecules by heat have the potential to create products of incomplete combustion, including dioxins and furans. These compounds are extremely toxic in the parts per trillion ranges. The MSO process reportedly does not produce dioxins and furans.

iii. The molten salt is usually recycled in the reactor chamber. However, depending on the waste treated (especially inorganics) and the amount of ash, spent molten salt may be hazardous and require special care in disposal.

iv. pyrolysis is not effective in either destroying or physically separating in organics from the contaminated medium. Volatile metals may be removed as a result of the higher temperatures associated with the process, but they are not destroyed. By-products containing heavy metals may require stabilization before final disposal.

v. When the off-gases are cooled, liquids condense, producing an oil/tar residue and contaminated water. These oils and tars may be hazardous wastes, requiring proper treatment, storage, and disposal.