Chapter 5

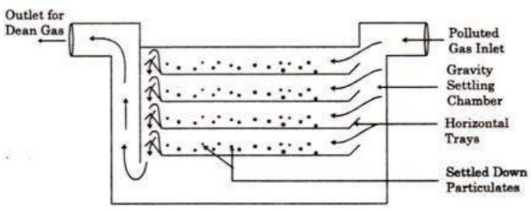
Pollution Control Measures

5.1 Air Pollution Control

The proverb 'prevention is better than cure' applies rightly in the case of air pollution. The best way to combat air pollution is to prevent the formation of the pollutant at the source itself. The various air pollution control measures in practice are as follows:

5.1.1 Gravitational Settling

Gravitational settling chambers help to remove particles bigger than 50 μm from gaseous streams. The gaseous stream containing the particulates is allowed to remain for sufficient time in a chamber provided with several trays so that particles settle under the influence of gravity.



Gravitational Settling Chamber

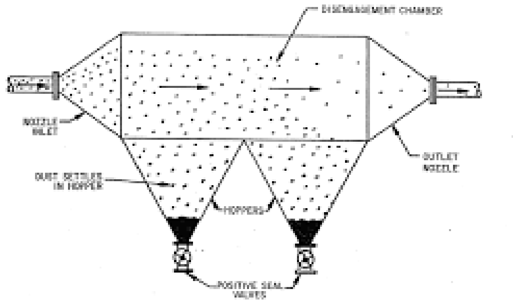
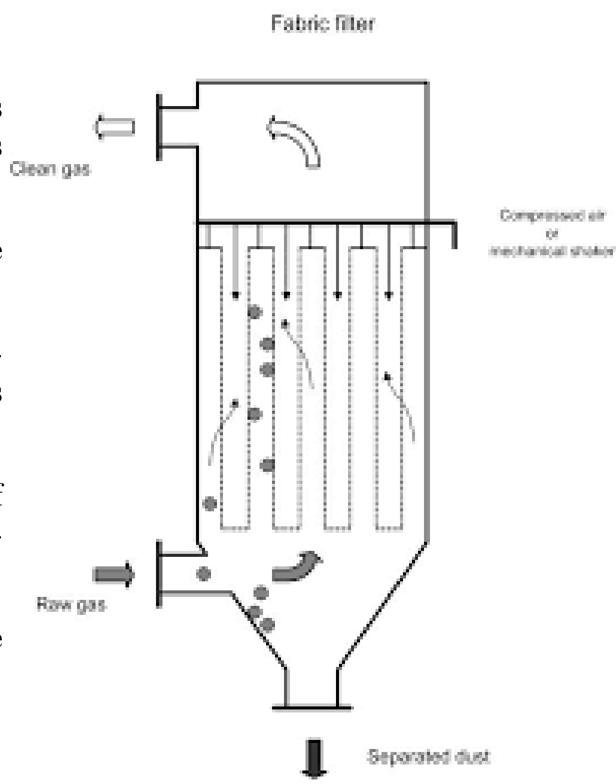


Fig. 6.1. Simple gravity settling chamber.

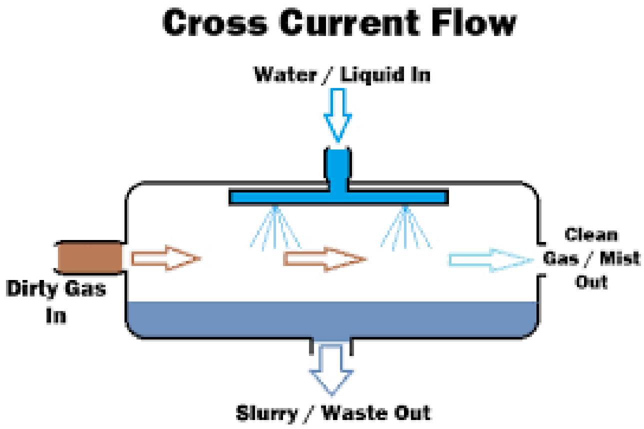
5.1.2 Fabric Filters

- It is a collector designed to remove particles from a carrier gas by filtration of the gas through a porous medium.
- The most common type of fabric filter is the tubular type.
- In this method, the exhaust gases containing particulate matter are forced to pass through a bag of very fine cloth.
- This technique enables effective removal of even small solid particles greater than 1 micron.
- Some of the fabric materials that can be used are cotton, wool, asbestos, nylon, etc.



5.1.3 Wet Scrubbers

Here the exhaust gases stream containing the particulates is allowed to pass through a fine spring of water, This helps to remove particulate matter as well as some gaseous pollutants.

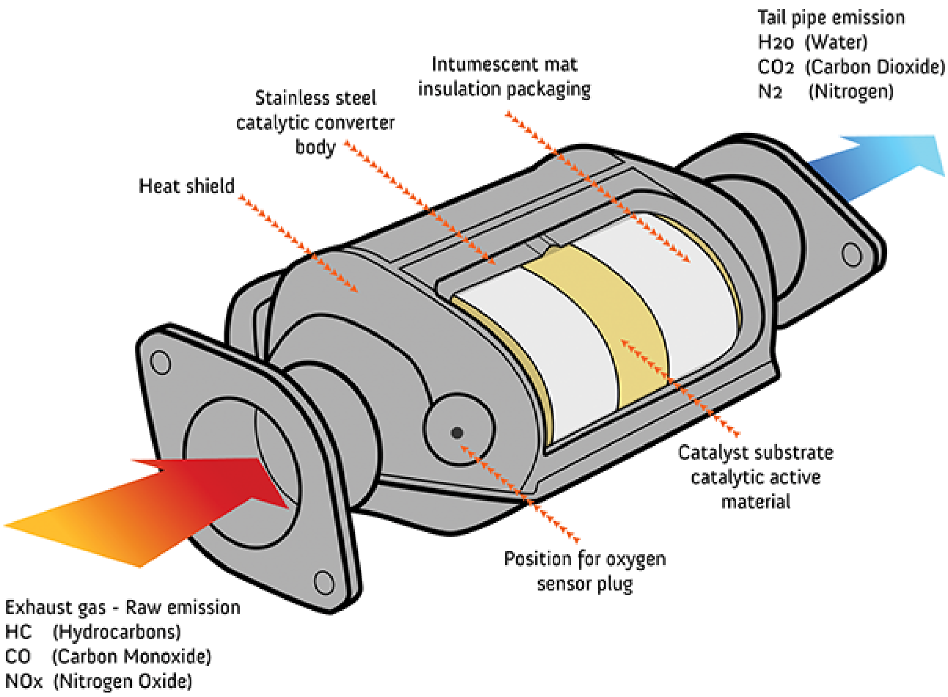


5.1.4 Catalytic Converters

- Catalytic converters help to remove pollutants from exhaust gases of vehicles.
- They work in two stages.

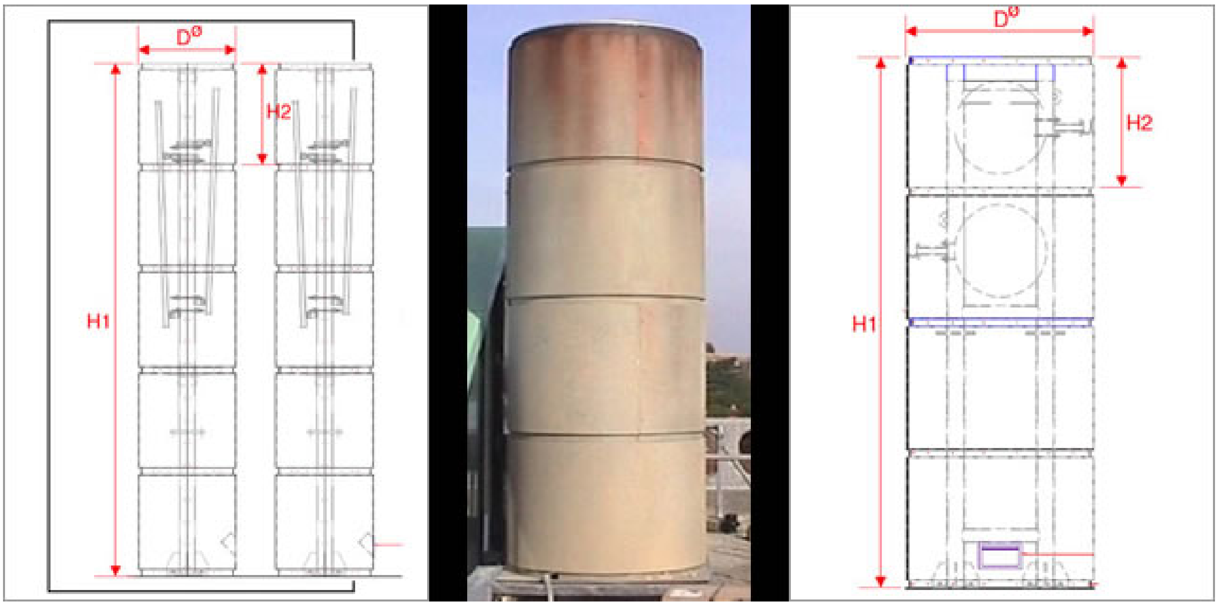
  1. In the first converter NO_x is made to reduce to nitrogen and ammonia using finely divided platinum as catalyst and in the presence of the reducing gases such as carbon monoxide and hydrocarbons. The amount of ammonia formed is kept minimum under carefully controlled conditions.
  2. In the second stage air is introduced to provide an oxidising atmosphere to allow the complete oxidation of hydrocarbon and carbon monoxide into water and carbon dioxide. Here also, finely divided platinum acts as the catalyst.

- Since platinum catalyst is liable to be poisoned by heavy metals like lead, only lead free gasoline can be used in vehicles fitted with catalytic converters.



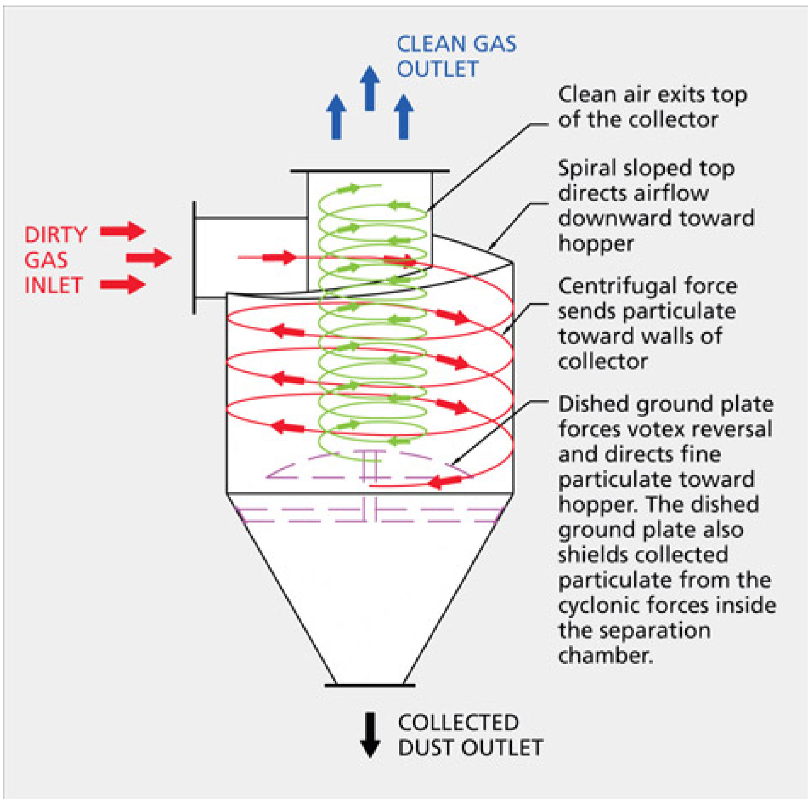
5.1.5 Installation of Tall Stacks and Chimneys

Tall stacks and chimneys help to reduce substantially the concentration of air pollutants at ground level. This is because gases discharged at sufficient heights can undergo proper dilution in a way to undergo proper dispersion in the atmosphere.



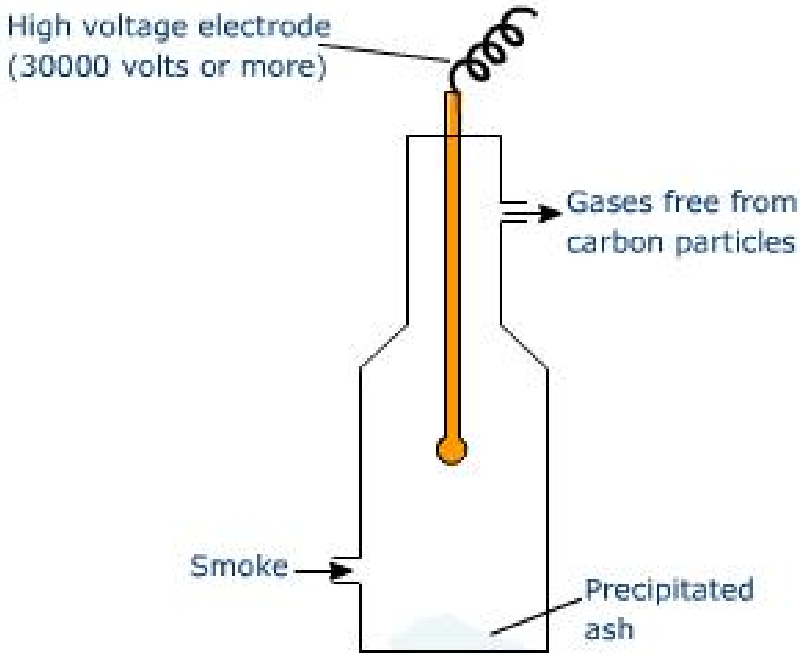
5.1.6 Cyclone Collectors

- This works on the principle that particulates present in a gaseous stream possess greater inertia than the gas molecules.
- Here the gas containing particulates is allowed to flow into a tight circular spiral fitted chamber.
- Then the centrifugal force so developed will exert a great inertial effect on the dispersed particles, thus forcing the particulates to move away from the gas towards the walls and to settle under the force of gravity.
- The Particulates so collected are removed periodically from the bottom of the chamber.
- Efficient separation is observed when the particle size is in the range of 5 - 20μm.
- The particulates must be dry to prevent clogging and plugging at the outlet



5.1.7 Electrostatic Precipitators

- Smoke is a colloidal solution of negatively charged carbon(soot) particles in air.
- Smoke is allowed to pass through a chamber fitted with a plate at a very high potential of 30'000 V or even more.
- Under this influence of this strong electric field, the smoke particles loses their negative charge and settles at the bottom of the chamber.
- Thus only hot dust free gases can go out of the chimney.



5.1.8 Ensuring Complete Combustion of Fuel

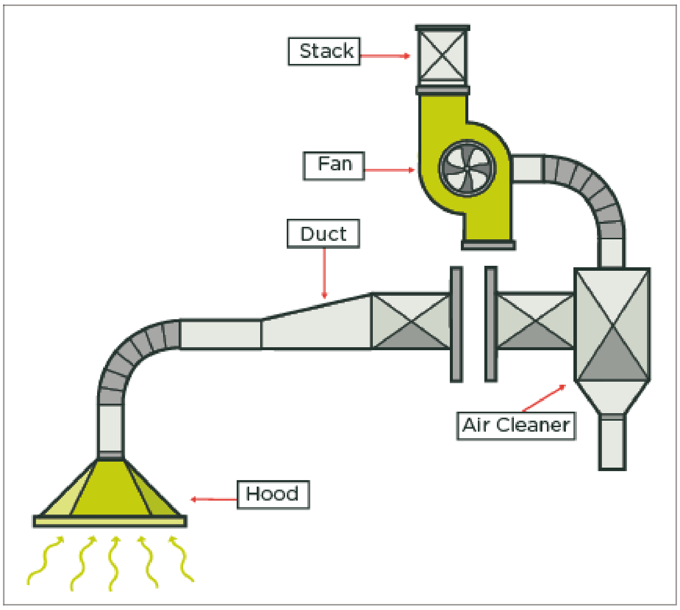
Complete combustion of fuel helps to avoid smoke formation. This is done by ensuring:

1. Correct method of firing.
2. Allowing sufficient quantity of air.
3. Maintaining a sufficiently higher temperature.
4. Feeding the fuel continuously.

'Auto mobile Mechanical Strokers' are now available to regulate 'draught' and the temperature within the combustion chamber.

5.1.9 Extraction Ventilation to Eliminate Dust

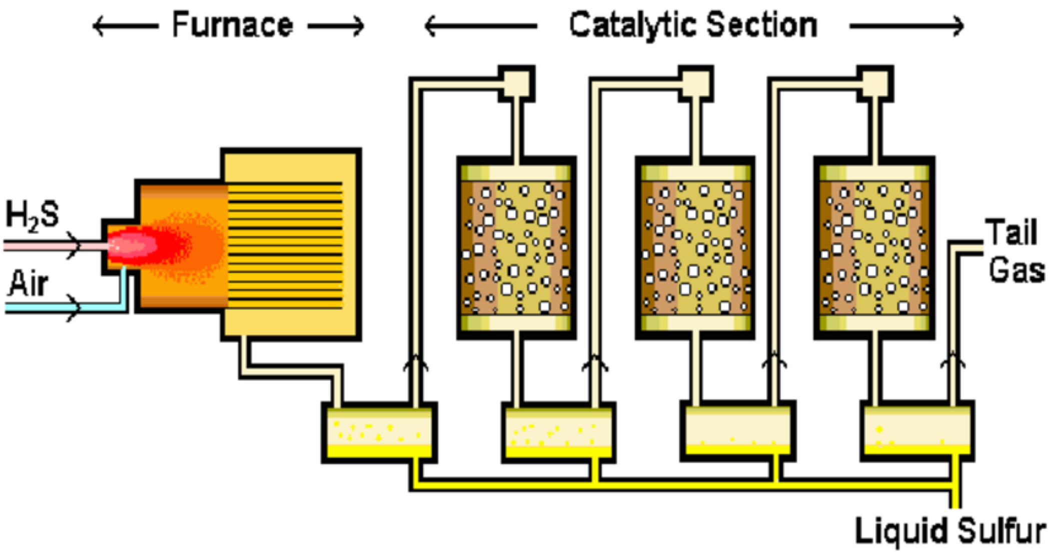
Here the air stream containing the suspended dust particles is maintained first at a high velocity to keep the dust particles in suspension. Then the velocity id reduced suddenly in order to make the dust particles settle in a 'settling chamber'



5.1.10 Control Over H_2S and SO_2 Emission

"Claus Process" enables removal of H_2 and SO_2 by converting the above two pollutants to elemental sulphur.

The Claus process is a two stage process. Here H_2S is divided into two streams. In the first stage apart of H_2S is allowed to undergo combustion in a carefully controlled stream of air when it gets oxidised to SO_2. In the second stage this SO_2 is made to react with the remaining H_2S at a high temperature to give elemental sulphur.



$$2\ H_2S_{(g)} + 3\ O_{2(g)} \longrightarrow 2\ SO_{2(g)} + 2\ H_2O_{(g)}$$
$$SO_{2(g)} + 2\ H_2S_{(g)} \longrightarrow 3\ S_{(l)} + 2\ H_2O_{(g)}$$

5.1.11 Zoning

Air pollution problems can be minimised using the 'industrial zoning method. This involves a "buffer zone" between industrial units and residential complexes in order to facilitate dilution of air pollutants to harmless levels.

5.1.12 Green Belts

Trees and vegetations help a lot to control air pollutants. Firstly they take up CO_2 (and release oxygen to air) for preparing their food by photosynthesis and thus reducing the excess carbon dioxide present in the air. Moreover vegetation slows down the air passing through them in order to allow the deposition of particulate materials on leaves. Some plants can even absorb and remove significant amounts hydrogen sulphide and nitric acid present in air.

5.2 Control of Water Pollution

5.2.1 Various Methods to Control Water Pollution

1. Reduction of waste at source by trapping nutrients, proper aeration, etc.

2. Recycling of the waste water after suitable treatment. Aeration, use of trickling filter, activated sludge treatment, etc. are found effective in the treatment of sewage wastes.

3. Waste water reclamation :- This involves direct use of sewage water for irrigation and fish farm purposes as it contains all the essential nutrients like nitrogen, phosphorous and potassium.

4. Proper dilution of the waste water before their discharge into water bodies. It should be remembered that greater the pollution load in the waste water, larger the dilution required.

5. Get rid of the objectionable compounds like mercury, phosphorous compounds, phenols, cyanides, etc. by the use of techniques like adsorption, ion-exchange, electro-dialysis reverse osmosis etc.

5.3 Industrial Waste Water Treatment

Sewage needs proper treatment to transform the harmful compounds present in it to harmless ones before its ultimate disposal into rivers, lakes or land. The major objectives behind industrial waste water treatment are:

1. To make it inoffensive so that it causes no odour or nuisance.

2. To eliminate possible contaminations of water supplies and the associated health problems.

3. To avoid destruction of fish and other marine life.

Industrial waste water treatment consists of the following steps.

5.3.1 Primary Treatment

Primary treatment aims at removing solids and floating materials. In this method, the waste water is first passed through bar screens consisting typically of parallel iron bars to remove floating objects like rags, plastics, and wood and then through mesh screens where removal of coarse solids, gravel, silt etc., take place. To avoid the disposal problems of the material collected in the screens, a comminutor is often provide for grinding the coarse bigger material into smaller ones, the waste water then flows through a grit chamber where the waste is given a retention time of a few minute to settle down grit and other heavy materials.

The water then flows into a primary settling tank, where it is allowed to remain for 90 to 150 minutes to remove most of the suspended solids by gravity. Sometimes chemical treatment is also given prior to sedimentation using alum or ferrous sulphate to ensure more rapid and complete removal of suspended matter. The settled solids called 'raw sludge' are then removed mechanically. This process helps to reduce about 50% of the whole BOD.

5.3.2 Secondary Treatment

The solids still left behind in the waste water after primary treatment either in the colloidal form or in the dissolved sate are subjected to biological oxidation. Biological oxidation is done in two ways.

A. Aerobic Oxidation and

B. Anaerobic Oxidation.

The pH of water must be ensured in the neutral range for biological oxidation.

Aerobic Oxidation

In presence of a good amount of dissolved free oxygen above 8 ml per litre organic compounds in sewage undergo a process of oxidation brought about by aerobic bacterias and the oxidation products are inoffensive smelling, non-putrefying nitrites, nitrates, sulphates, phosphates, etc. This kind of oxidation of sewage is called “aerobic oxidation”.

Aerobic digestion is a biological waste water treatment. Once sediments and substances such as oil are removed from waste water in the primary treatment stage, aerobic treatments are used to break down organic matter through the use of oxygen.

Aerobic biological processes use natural microbial colonies and molecular oxygen to decompose organic substances in the waste water. The microbes feed on undesired biological substances in the water, creating aggregates or “flocks” of organic substances and micro organisms that settle to the bottom of the container. This sludge is stable and usually can be disposed of easily.

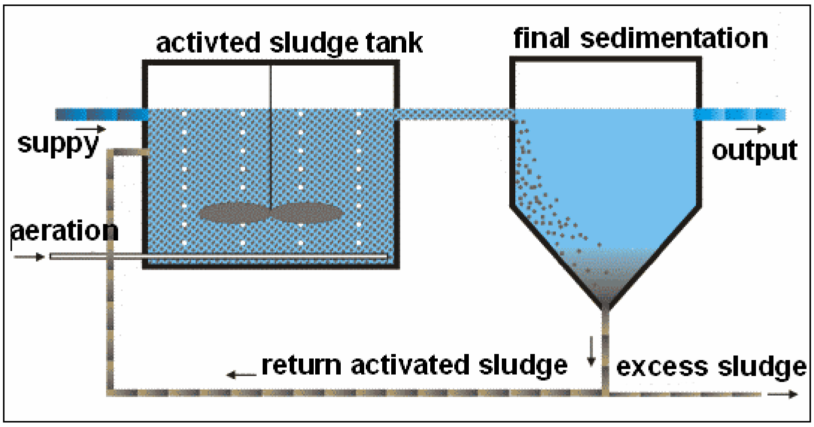
Aerobic treatment is typically part of a multi stage water treatment process. The technology is not confined to use as an intermediate stage, but can also be used for finishing water and to augment other types of treatments.

Aerobic Waste water Treatment Solutions for Industrial and Municipal Clients implements aerobic treatment systems that treat wastes from a range of industries, including industrial processors such as paper and pulp mills, as well as food processing operations such as slaughter houses and food-processing plants.

Aerobic processes include activated sludge, oxidation ditches, trickling filter, lagoon-based treatments, and aerobic digestion

Activated Sludge Process

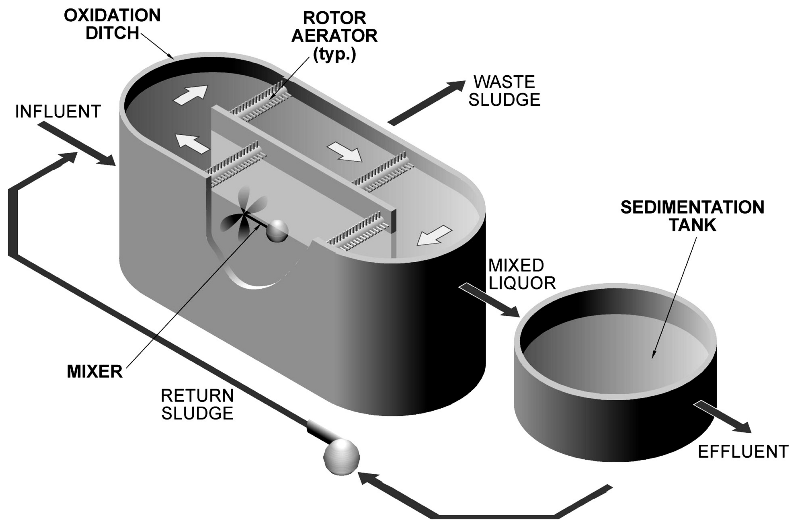
This process needs only little space and the quality of the final effluent obtained is highly satisfactory. In this method the waste is subjected to mechanical aeration in specially designed rectangular or oval tanks. The activated sludge treatment is done as a batch process giving aeration for a period of four to ten hours, The aeration helps the particles of suspended matter to flocculate into small gelatinous masses swarming with aerobic micro-organisms capable of oxidising the organic matter readily.



This gelatinous mass loaded heavily with bacteria is called “activated Sludge”. Gram negative bacteria constitute about 90% of the microbial community and protozoa dominate among the rest. These bacteria can oxidise the carbonaceous matter present to more stable substances like nitrates, sulphate, and carbon dioxide together with the simultaneous synthesis of new microbial cells. The flocs thus formed are allowed to settle in a secondary sedimentation tank. Some amount of the settled floc is returned back each time to the aeration tank along with fresh waste to maintain a high reaction rate.

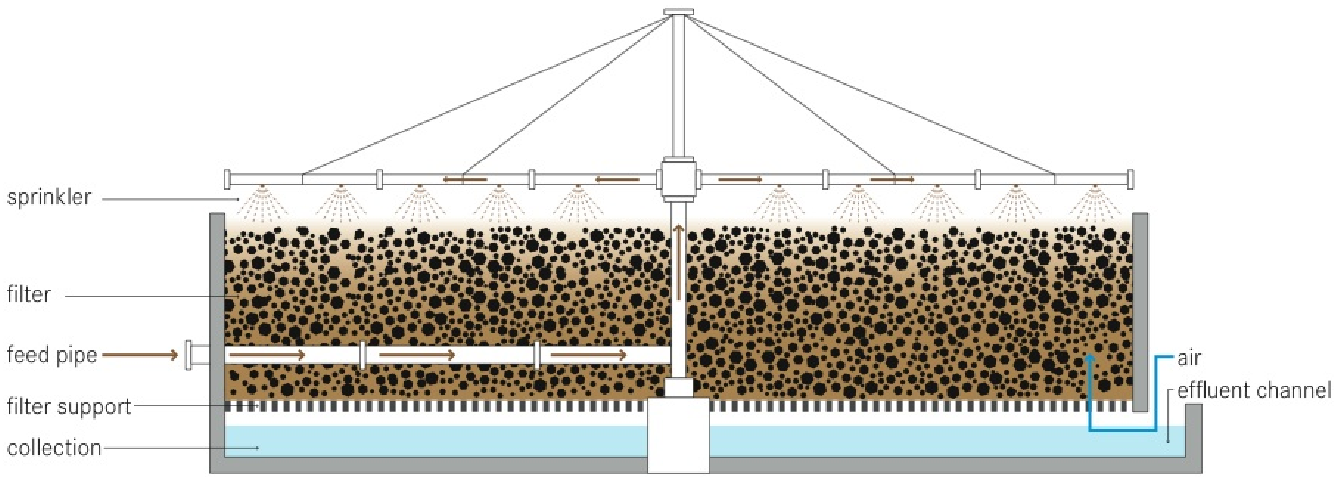
Oxidation Ditch

An oxidation ditch is a basin through which waste water flows. This secondary treatment process is used for both the nitrification and denitrification of waste water. While circulating effluent after primary treatment, the waste water is mixed with other sludge. Aeration adds oxygen into the process and encourages microbial growth in the waste water. Once clarified, additional treatments may be needed, depending on the end use of the treated water.



Trickling Filters

A trickling filter consists of a bed of graded media such as crushed stone, gravel, clinker, if synthetic plastic material, which drains at the bottom to collect the treated waste. A rotating arm with several nozzles help to distribute the waste water evenly over the top surface of the bed. The waste water is thus made to percolate down in the filter to the collecting drains. The spraying mechanism help to saturate the waste water with oxygen and its intermittent application helps to maintain aerobic conditions in the filter bed. Hence a film of microbial growth develops on the filtering medium to a thickness of about 0.2 to 2.0 mm thick.



This film consists of bacteria, fungi, protozoa and algae and is commonly known as 'Zoological film' because of the predominance of the bacterium 'Zoogloea'. When the waste water trickles down over these microbial surfaces, the organic constituents of the waste get metabolised into more stable end products.

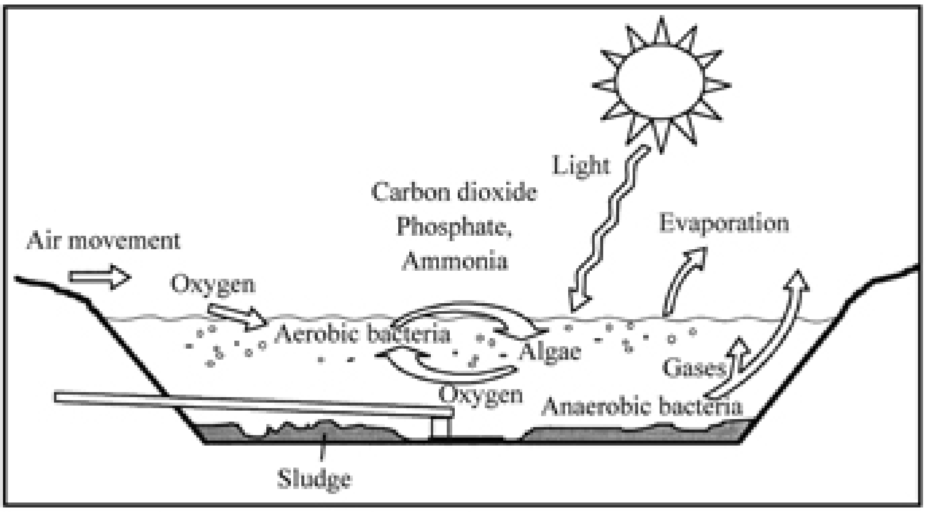
$$H_2N\text{-}CO\text{-}NH_2 \xrightarrow{\text{Aerobic oxidation}} CO_2 + 2\ NH_3$$

$$NH_3 \xrightarrow{\text{Oxidation}} HNO_3,\ HNO_2,\ \text{etc.}$$

$$HNO_3,\ HNO_2,\ \text{etc.} \xrightarrow{\text{In Presence of Soil Bases}} NH_4NO_2,\ Ca(NO_2)_2,\ Ca(NO_3)_2$$

Lagoon Based Treatment

A lagoon is a waste water holding compartment in which aeration is performed. Although these basins can be used for solids settling, the addition of aeration equipment accelerates the biological processes. The waste water, as it enters these large basins or holding ponds, courses down an inlet at which an aerator is positioned to force more air into the waste water. This process produces high oxygen transfer and mixing below the surface.



Sludge Digestion

The accumulated sludge after primary and secondary treatment processes is very offensive and subjected to anaerobic digestion (i.e. microbial degradation under anaerobic conditions). The optimum conditions for anaerobic digestion are pH = 6.8 - 7.2 and temperature 50 - 60^0C. The micro organisms involved are facultative anaerobes and methanogens. A time period of two to three weeks is required for complete digestion. This process helps to stabilize the organic matter and to reduce the solids content by about 60% in weight. The gases formed contain methane (60 -70%), carbon dioxide (20 - 30%) together with a little hydrogen and nitrogen. This gaseous mixture is called 'biogas' and is highly combustible. The sludge still left behind after anaerobic digestion may be disposed on land or by incineration.

Anaerobic Oxidation

On the other band, when the dissolved or free oxygen supply is below a certain value, the sewage is called stale and anaerobic bacterias bring about petrification producing methane, hydrogen sulphide, ammonium sulphide and phosphate, which give offensive odour. This kind of oxidation of sewage is called "anaerobic oxidation". It may be pointed here that in an anaerobic oxidation, the bacterias extract combined oxygen contained in organic matter, nitrates, nitrites and sulphates. The anaerobic decomposition containing sewage is known 'septic sewage'.

Anaerobic biological conversion of organic waste to methane is a complex process involving a number of microbial populations linked by their individual substrate and product specificities. The product of one bacterium is often the substrate for others and hence, a balance between the bacterial numbers and the substrate concentrations must be maintained.

The biological conversion of organic matter occurs in three steps.

1. The first step in the process involves transformation of highermolecular- mass compounds into compounds suitable for use as a source of energy and cell carbon (hydrolysis).

2. The second step (acidogenesis) involves the bacterial conversion of the compounds resulting from the first step into identifiable lower-molecular-mass intermediate compounds. Lower chain volatile fatty acids produced during acidogenesis are utilized by a group of bacteria (acetogens) to produce acetate.

3. The third step (methanogenesis) involves the bacterial conversion of the intermediate compounds into simpler end products, such as methane and carbon dioxide. According to trophic requirements the bacteria involved can be conveniently divided into three groups as follows.

a. Hydrolytic bacteria - acidogens: These bacteria hydrolyze the substrate (macromolecule) into short-chain organic acids and other small molecules, which can be taken up and converted into soluble short-chain organic molecules, e.g., carbohydrates are converted into low-chain fatty acids, alcohols, hydrogen and carbon dioxide under anaerobic condition.

b. Obligate Hydrogen Producing Acetogens (OHPA): This group converts compound formed in the first stage into acetic acid and hydrogen. Low hydrogen pressure favours these reactions.

c. Methanogenic bacteria - methanogens: These bacteria produce methane. The doubling time of these bacteria is 2 - 10 days. These are further divided into two groups as:

   i. :- Hydrogen utilisers (lithotrophs) $CO_2 + 4\ H_2 \longrightarrow CH_4 + 2\ H_2O$ convert ADP to ATP.

   ii. :- Acetic acid users (acetotrophs):- $CH_3COOH \longrightarrow CH_4 + CO_2$ produce 0.25 mole of ATP.

Factors affecting Anaerobic Digestion

Several environmental factors can affect anaerobic digestion such as specific growth rate, decay rate, gas production, substrate utilization, etc. The environmental factors of primary importance are discussed below.

1. pH, acidity and alkalinity :- Methanogenic micro-organisms are susceptible to the minute changes in the pH values. Optimum pH range of 6.6 – 7.6 is considered favourable for the methane producing bacteria, which cannot tolerate the fluctuations. The non-methanogenic bacteria do not exhibit such strong sensitivity for environmental conditions and are able to function in a range of pH form 5 – 8.5.
2. Temperature:- The higher the temperature, higher is the microbial activity until an optimum temperature is reached. Anaerobic process can take place over a wide range of temperatures ($4 - 60^0$C).
3. Amount of Nutrients Present :- Anaerobic waste water treatment processes are often used for industrial waste with only minor amount of nutrients present. This might result in nutrient deficiency, unless additional nutrients are supplemented. Optimum N/P ratio can be considered to be 7.
4. Inhibitory Substances :- Inhibition of the anaerobic digestion process can be mediated to varying degrees by toxic materials present in the system. Inhibitory toxic compounds include sulphides, consequential in the processing of waste from sources such as molasses fermentation, petroleum refining and tanning industries. Various examples are:

   i. Volatile Acids.

   ii. Ammonia-Nitrogen.

   iii. Sulphides.

   iv. Heavy metals like copper, chromium, nickel, lead, etc.

Merits of Anaerobic Digestion

It has been recognized that the anaerobic treatment is in many ways ideal for waste water treatment and has several merits mentioned as below:

1. A high degree of waste stabilization;
2. A low production of excess biological sludge and this sludge can be directly dried on sludge drying bed without further treatment due to better de watering ability;
3. Low nutrient requirements, hence anaerobic treatment is attractive for the treatment of waste water where external nutrient addition is required;
4. No oxygen requirement, hence saving in power required for supply of oxygen in aerobic methods;

5. Production of valuable by product, methane gas;
6. Organic loading on the system is not limited to oxygen supply hence higher loading rate as compared to aerobic processes can be applied.
7. Less land required as compared to many aerobic process.
8. Non-feed conditions for few months do not affect adversely to the system and this makes it attractive option for seasonal industrial waste water treatment.

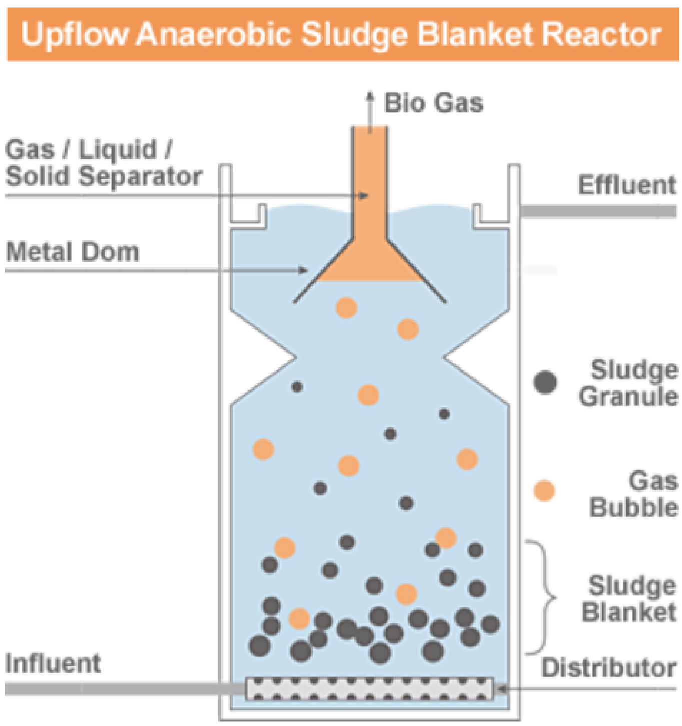
5.3.3 Tertiary Treatment

Tertiary treatment is given to polish or to make the water suitable for disposal in natural water bodies. The effluent coming out after secondary treatment may contain ammonia, nitrates, ortho phosphates etc. Ammonium ions are converted into ammonia gas by increasing the pH followed by forcing air upwards through the trickling effluent in a metal tower containing a series of small baffle plates to remove the gaseous ammonia. Phosphorous ca be removed as Calcium phosphate by adding lime. Nitrates can be removed by de nitrification. Refractory organic compounds if present can be removed by carbon adsorption. The pathogenic organisms are removed finally by chlorination.

The treated water so obtained is then discharged into water bodies.

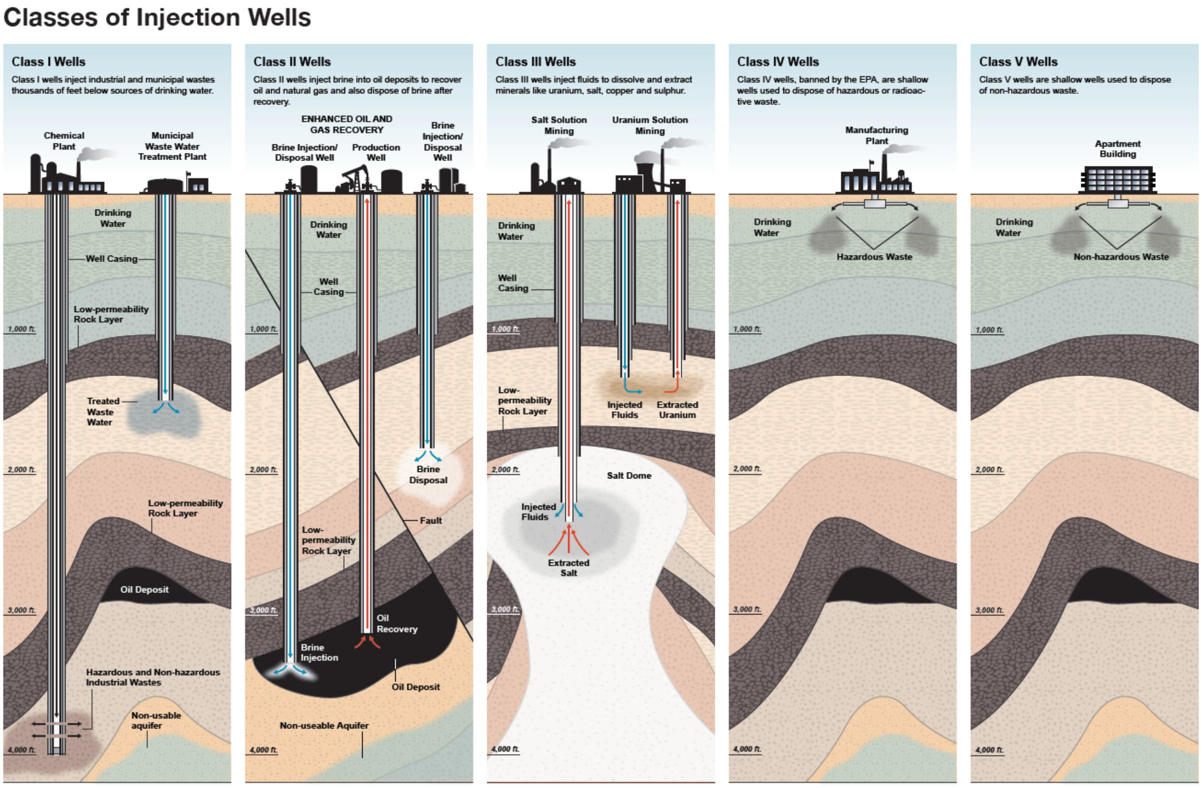
5.3.4 Upflow Anaerobic Sludge Bed Reactor (UASB) Process

In this process the effluent to be treated is fed from the bottom of UASB reactor so that it flows upward through a sludge blanket composed of biologically formed granules or particles. The diameter of the flocs caries from 1 to 5 mm. As the waste water comes in contact with the granules, treatment occurs. Gases like methane and carbon dioxide formed under anaerobic conditions make internal internal circulation this helping the formation and maintenance of the biological granules. The gases set free and the associated particles rise to the top of the reactor where they strike the bottom of the degassing baffles and release the attached gas bubbles. The degassed granules drop back to the top surface of the sludge blanket. The gases released escape through the gas collector domes located at the top of the reactor, Upflow velocities of 0.6 to 0.9 m/h are sufficient to keep the sludge blanket in suspension.



5.3.5 Deep Well Injection

The most common way for disposal of liquid hazardous wastes is to force them underground at least 700 m below the surface through deep injection wells. The wells are constructed into geological formations beneath and isolated from groundwater drinking supplies in order to percent contamination of ground water. The formations should have sufficient volume and porosity to accept the wastes for permanent containment While designing the well considerations should be given to the volume chemical and physical characteristics of the waste and the injection pressure. Wastes that are viscous or high in suspended solids should be avoided, as they will foul the injection process. Wastes that are hard to dispose like converted solutions of acids, bases, heavy metals, pesticides etc., can be safely disposed using this technique.



5.4 Potable Water

Potable water is water of sufficiently high quality that it can be consumed or used without the risk of immediate or long term harm. i.e. it is the water fit for consumption by humans and other animals.

5.4.1 Characteristics of potable water.

Potable water should meet the following qualities:

1. It should be sparking clear and odourless.
2. It should be pleasant in taste.
3. It should be perfectly cool.
4. Its turbidity should not exceed 10 ppm.
5. It should be free from objectionable dissolved gases like Hydrogen sulphide, ammonia etc.
6. It should be free objectionable minerals such as lead , arsenic, chromium, and manganese salts.
7. Its alkalinity should not be high. Its pH should be about 8.0.
8. It should be reasonably soft.
9. Its dissolved solids should be less than 500 ppm.
10. It should be free from disease producing micro-organisms.

5.4.2 Treatment of Potable Water

Natural water from rivers, canals etc. does not conform to the required specifications of drinking water. For removing various types of impurities, the following treatment processes are employed. The actual methods vary from one place to another, but all such methods aim at

i. Eliminating health hazards and sanitary defects.

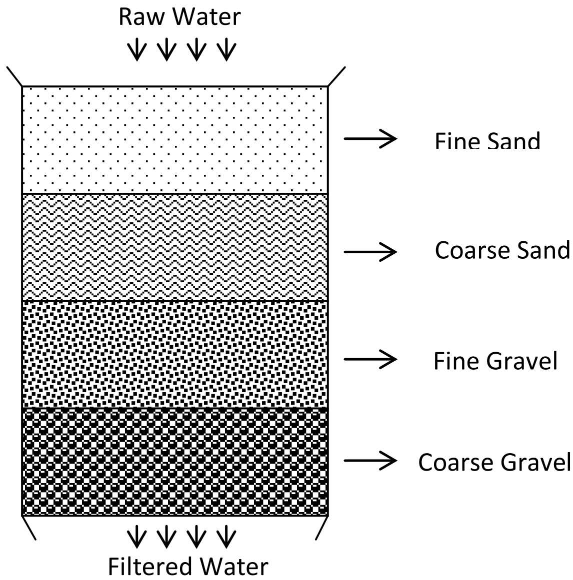
ii. removal of colour or turbidity and suspended impurities.

iii. destroying the bacteria and viruses. and

iv. restricting the presence of soluble mineral salts within the prescribed limits.

1. Screening :- The raw water is passed through screens, having large number of holes to remove the suspended particles from the water.
2. Sedimentation :- It is a process of allowing water to stand undisturbed in big tank, about 5 m deep, for about 4 to 6 hours, thus most of the suspended particles settle down at the bottom, due to the force of gravity.
3. Coagulation :- After sedimentation there may be fine clay particles and some colloidal matter which cannot be separated by usual methods. These colloidal particles are precipitated or coagulated by adding certain electrolytes called coagulants. Usually used coagulants are alums, sodium aluminates, ferrous sulphate etc. The precipitated colloidal matter can be easily separated by filtration.
4. Filtration :- It is the process of removing precipitated colloidal matter and most of the bacteria, micro organisms etc., by passing water through a bed of sand and other proper sized granular materials. Most commonly filtration is done by using sand filter.

   A sand filter consists of a thick top layer of fine sand placed over coarse sand layer and gravels. It is provided with an inlet for water at the top and an outlet valve at the bottom. Sedimented water entering the sand filter is uniformly distributed over the entire sand bed. During the filtration the sand pores gets clogged due to retention of impurities in the pores. So when the rate of filtration becomes low 2-3 cm of top sand layer is scrapped off and replaced with clean sand. The scrapped sand is washed with water, dried and stored for reusing again.



A Cross Section of Sand Filter

5. Sterilisation :- Water even after passing through screening, sedimentation, coagulation, filtration, may contain small amount of pathogenic micro organisms. The process of destroying the disease producing bacteria, micro organisms fungi etc. from water and thereby making it safe for drinking purpose is called sterilization or disinfection. Disinfection of water is carried out in several ways.

   (a) By boiling :- By boiling the water for $10 - 15$ minutes, all the disease causing micro organism are killed and water becomes safe for drinking. But this process can kill only the existing micro-organisms and does not provide any protection against future contamination. Not only that, this method is expensive and suitable only for individual purposes.
   (b) By adding bleaching powder :- Bleaching powder can act as an active disinfectant at a concentration of 1 ppm. Water which is to be sterilized is mixed with bleaching powder in the above concentration and is allowed to stand for several hours. The germicidal action of bleaching powder is as follows.

$$CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$$

$$Cl_2 + H_2O \longrightarrow HOCl + HCl$$

The disinfection action of bleaching powder is due to the formation hypochlorous acid (HOCl) which can kill almost all micro-organisms. But this method introduces calcium into water which can cause hardness. Also it gives a bad taste and smell to water.

(c) By chlorination :- Chlorine either in gaseous form or concentrated solution is applied to water which needs disinfection. This added chlorine can produces hypochlorous acid which has the same germicidal action as in the above method. But care must be taken to see that the concentration of residual chlorine is lower than 0.2 ppm. Otherwise it is harmful to humans.

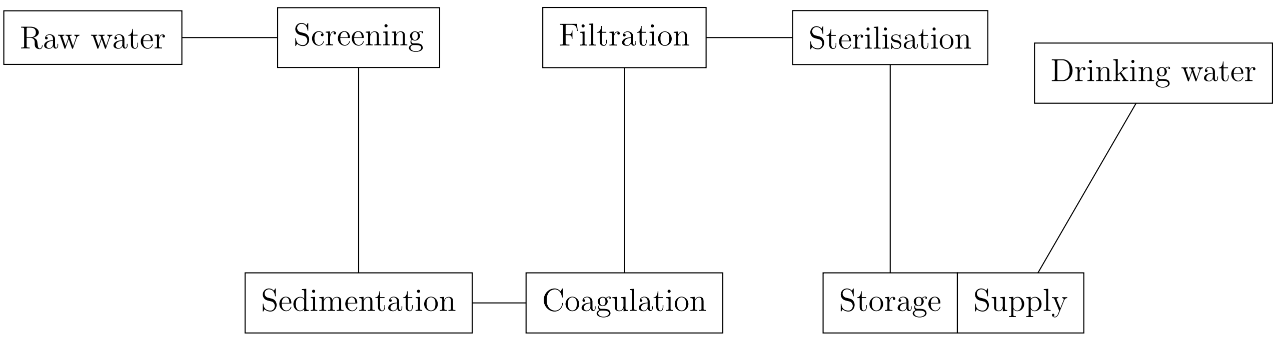
(d) By Ozone :- Ozone is a powerful disinfectant whose sterilising action is due to the formation of nascent oxygen which is cytotoxic, which can kill all the germs and bacteria.

$$O_3 \longrightarrow O_2 + O$$

Disinfection through ozonisation is very effective. Ozone is a strong bleaching, de colourising and deodorising agent. Its excess is not harmful and it introduces oxygen into water which is good for health.

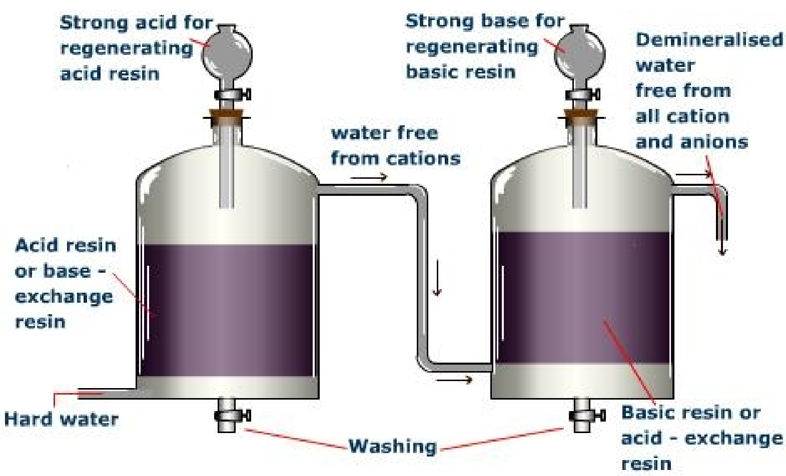
(e) By UV treatment :- UV radiation coming out of electric mercury lamp can destroy all pathogenic bacteria. This method can be adopted when other chemical methods fail. But this method is expensive.

The entire process for production of potable water can be summarised as follows:



5.5 Demineralisation (Desalination) of Water : Ion – Exchange Method.

Ion exchange method removes all soluble minerals without distillation and the water obtained from this method is as good as distilled water. This method makes use of certain ion exchange resins. The ion exchange resins are of different type. Some resins are acidic in nature where as certain others are basic. The acid resins are known as cation exchange resins, which contain acidic groups and are capable of removing cations like Ca^{2+}, Mg^{2+}, Fe^{2+} etc., from water through ion exchange process. These may be represented as 'R−COOH'. These cations are replaced by H^+ ions from the resins.



$$2\,R{-}COOH + Ca^{2+} \longrightarrow (R{-}COO)_2Ca + 2\,H^+$$
$$2\,R{-}COOH + Mg^{2+} \longrightarrow (R{-}COO)_2Mg + 2\,H^+$$

The out coming water is from cation exchanger is acidic in nature. This solution is then allowed to pass through anion exchanger. Anion exchange resins are basic in nature. They contain basic groups and may be represented as 'R$-NH_3^+OH^-$'. These OH^- are replaced by anions like SO_4^{2-} and Cl^-.

$$2\ R-NH_3^+OH^- + SO_4^{2-} \longrightarrow (R-NH_3^+)_2SO_4^{2-} + 2\ OH^-$$
$$R-NH_3^+OH^- + Cl^- \longrightarrow R-NH_3^+Cl^- + OH^-$$

The replaced OH^- ions will combine with H^+ ions of the acidic water coming out of the cation exchanger.

$$H^+ + OH^- \longrightarrow H_2O$$

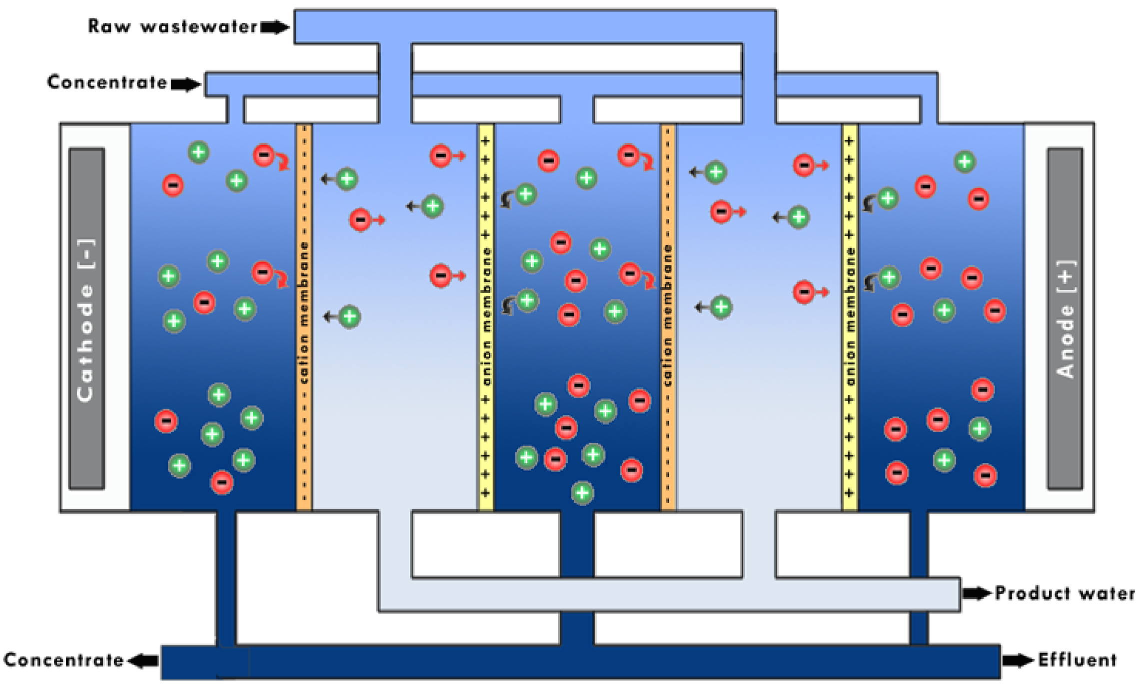
The resins used in the ion exchangers can be used again and again. When these resins are exhausted ,cation exchanger and anion exchanger are treated by an acid and base respectively to regenerate the corresponding resins as shown below.

$$(R-COO)_2Ca + H_2SO_4 \longrightarrow 2\ R-COOH + CaSO_4$$
$$R-NH_3^+Cl^- + NaOH \longrightarrow R-NH_3^+OH^- + NaCl$$

5.5.1 Electro dialysis

Sea water or brackish water is taken in large electrolytic cells divided into three compartments by two ion-selective semi-permeable membranes.The electrodes are present in the outer compartments. The arrangements are such that the membrane nearer to the cathode is permeable to only the cations while that nearer to the anode is permeable to only the anions.

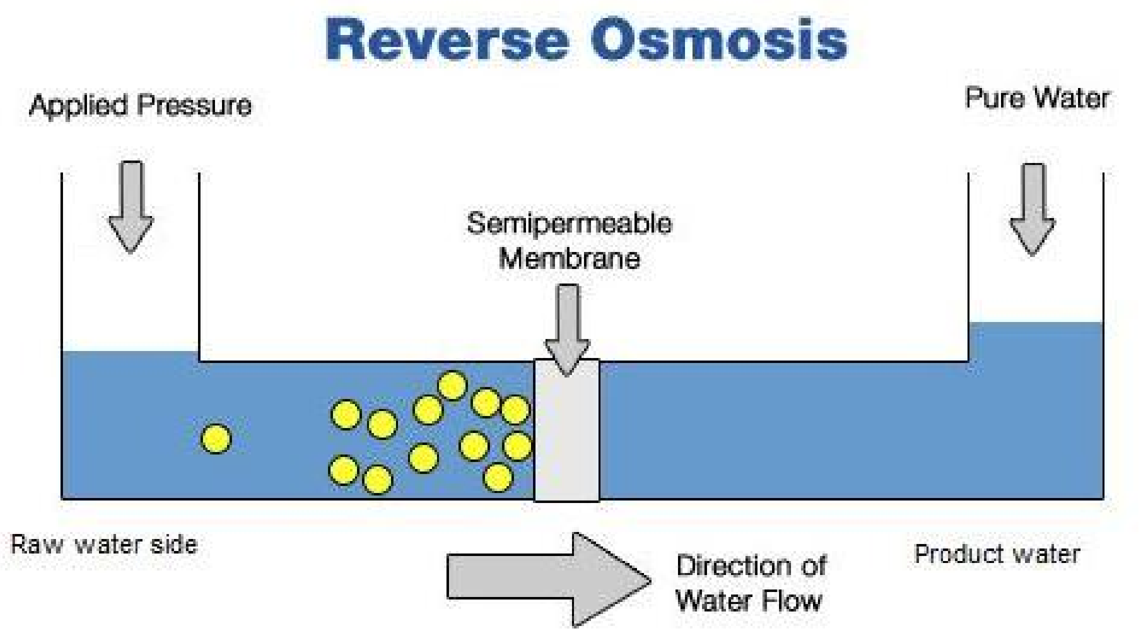
On applying electricity, the anions and cations move from the central compartment into two different outer compartments and oppositely charged electrode. The water in the central compartment gradually gets salt free.



5.5.2 Reverse Osmosis

When saline water is kept separated from a pure sample of water by means of a semi-permeable membrane, water will flow into the solution by osmosis. If a pressure just higher than the osmotic pressure is applied on the saline water, water will flow out from the solution to pure sample. i.e. in a direction opposite to the osmosis. This process is called reverse osmosis and is used to desalinize sea water and brackish water.

Membranes are specially prepared from nylon, cellulose acetate. etc. are used because they are able to withstand the high pressure needed to be applied. Thus un this process, the water is forced out of saline water, not the salt.



5.6 Solid Waste Management

Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area. It may be categorised according to its origin (domestic, industrial, commercial, construction or institutional); according to its contents (organic material, glass, metal, plastic paper etc); or according to hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc).

Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life. Waste management is the collection, transport, processing, recycling or disposal of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is also carried out to recover resources from it. Waste management can involve solid, liquid, gaseous or radioactive substances, with different methods and fields of expertise for each. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial, producers. Management for non-hazardous residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator.

Solid wastes typically may be classified as follows:

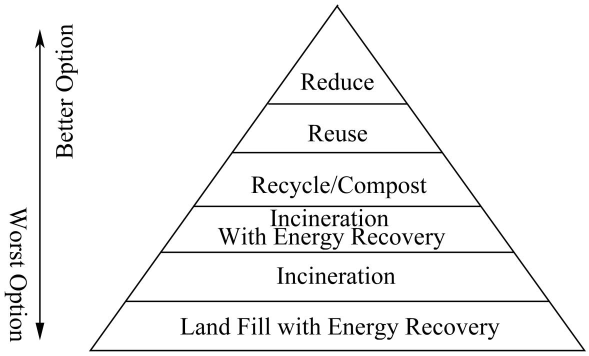
1. Garbage :- decomposable wastes from food.
2. Rubbish :- non decomposable wastes, either combustible (such as paper, wood, and cloth) or non-combustible (such as metal, glass, and ceramics).
3. Ashes :- residues of the combustion of solid fuels.
4. Large wastes :- demolition and construction debris and trees, dead animals.
5. Sewage-treatment solids :- material retained on sewage-treatment screens, settled solids, and biomass sludge.
6. Industrial wastes :- such materials as chemicals, paints, and sand.

7. Mining wastes :- slag heaps and coal refuse piles.

8. Agricultural wastes :- farm animal manure and crop residues.

Reduce, Reuse and Recycle

Methods of waste reduction, waste reuse and recycling are the preferred options when managing waste. There are many environmental benefits that can be derived from the use of these methods. They reduce or prevent green house gas emissions, reduce the release of pollutants, conserve resources, save energy and reduce the demand for waste treatment technology and landfill space. Therefore it is advisable that these methods be adopted and incorporated as part of the waste management plan.



5.6.1 Waste Management Methods

Waste management methods vary widely between areas for many reasons,including type of waste material, nearby land uses, and the area available.

5.6.2 Dumps and Land fills

Sanitary landfills

Sanitary Landfills are designed to greatly reduce or eliminate the risks that waste disposal may pose to the public health and environmental quality. They are usually placed in areas where land features act as natural buffers between the landfill and the environment. For example the area may be comprised of clay soil which is fairly impermeable due to its tightly packed particles, or the area may be characterised by a low water table and an absence of surface water bodies thus preventing the threat of water contamination. In addition to the strategic placement of the landfill other protective measures are incorporated into its design. The bottom and sides of landfills are lined with layers of clay or plastic to keep the liquid waste, known as leachate, from escaping into the soil. The leachate is collected and pumped to the surface for treatment. Boreholes or monitoring wells are dug in the vicinity of the landfill to monitor groundwater quality.

A landfill is divided into a series of individual cells and only a few cells of the site are filled with trash at any one time. This minimizes exposure to wind and rain. The daily waste is spread and compacted to reduce the volume, a cover is then applied to reduce odours and keep out pests. When the landfill has reached its capacity it is capped with an impermeable seal which is typically composed of clay soil.

Some sanitary landfills are used to recover energy. The natural anaerobic decomposition of the waste in the landfill produces landfill gases which include Carbon Dioxide, methane and traces of other gases. Methane can be used as an energy source to produce heat or electricity. Thus some landfills are fitted with landfill gas collection (LFG) systems to capitalise on the methane being produced. The process of generating gas is very slow, for the energy recovery system to be successful there needs to be large volumes of wastes. These landfills present the least environmental and health risk and the records kept can be a good source of information for future use in waste management, however, the cost of establishing these sanitary landfills are high when compared to the other land disposal methods.

Controlled dumps

Controlled dumps are disposal sites which comply with most of the requirements for a sanitary landfill but usually have one deficiency. They may have a planned capacity but no cell planning, there may be partial leachate management, partial or no gas management, regular cover, compaction in some cases, basic record keeping and they are fenced or enclosed. These dumps have a reduced risk of environmental contamination, the initial costs are low and the operational costs are moderate.

While there is controlled access and use, they are still accessible by scavengers and so there is some recovery of materials through this practice.

Bio reactor Landfills

Recent technological advances have lead to the introduction of the Bioreactor Landfill. The Bioreactor landfills use enhanced microbiological processes to accelerate the decomposition of waste. The main controlling factor is the constant addition of liquid to maintain optimum moisture for microbial digestion. This liquid is usually added by re-circulating the landfill leachate. In cases where leachate in not enough, water or other liquid waste such as sewage sludge can be used. The landfill may use either anaerobic or aerobic microbial digestion or it may be designed to combine the two. These enhanced microbial processes have the advantage of rapidly reducing the volume of the waste creating more space for additional waste, they also maximise the production and capture of methane for energy recovery systems and they reduce the costs associated with leachate management. For Bioreactor landfills to be successful the waste should be comprised predominantly of organic matter and should be produced in large volumes.

5.6.3 Thermal Treatment

This refers to processes that involve the use of heat to treat waste. Listed below are descriptions of some commonly utilized thermal treatment processes.

Incineration

Incineration is the most common thermal treatment process. This is the combustion of waste in the presence of oxygen. After incineration, the wastes are converted to carbon dioxide, water vapour and ash. This method may be used as a means of recovering energy to be used in heating or the supply of electricity. In addition to supplying energy incineration technologies have the advantage of reducing the volume of the waste, rendering it harmless, reducing transportation costs and reducing the production of the green house gas methane.

Pyrolysis and Gasification

Pyrolysis and gasification are similar processes they both decompose organic waste by exposing it to high temperatures and low amounts of oxygen. Gasification uses a low oxygen environment while pyrolysis allows no oxygen. These techniques use heat and an oxygen starved environment to convert biomass into other forms. A mixture of combustible and non-combustible gases as well as pyroligenous liquid is produced by these processes. All of these products have a high heat value and can be utilised. Gasification is advantageous since it allows for the incineration of waste with energy recovery and without the air pollution that is characteristic of other incineration methods.

Open burning

Open burning is the burning of unwanted materials in a manner that causes smoke and other emissions to be released directly into the air without passing through a chimney or stack. This includes the burning of outdoor piles, burning in a burn barrel and the use of incinerators which have no pollution control devices and as such release the gaseous by products directly into the atmosphere (Department of environmental quality 2006). Open burning has been practised by a number of urban centres because it reduces the volume of refuse received at the dump and therefore extends the life of their dump site. Garbage may be burnt because of the ease and convenience of the method or because of the cheapness of the method. In countries where house holders are required to pay for garbage disposal, burning of waste in the backyard allows the householder to avoid paying the costs associated with collecting, hauling and dumping the waste. Open burning has many negative effects on both human health and the environment. This uncontrolled burning of garbage releases many pollutants into the atmosphere. These include dioxins, particulate matter, polycyclic aromatic compounds, volatile organic compounds, carbon monoxide, hexachlorobenzene and ash. All of these chemicals pose serious risks to human health. The Dioxins are capable of producing a multitude of health problems; they can have adverse effects on reproduction, development, disrupt the hormonal systems or even cause cancer. The polycyclic aromatic compounds and the hexachlorobenzene are considered to be carcinogenic. The particulate matter can be harmful to persons with respiratory problems such as asthma or bronchitis and carbon monoxide can cause neurological symptoms.

The harmful effects of open burning are also felt by the environment. This process releases acidic gases such as the halo-hydrides; it also may release the oxides of nitrogen and carbon. Nitrogen oxides contribute to acid rain, ozone depletion, smog and global warming. In addition to being a green house gas carbon monoxide reacts with sunlight to produce ozone which can be harmful. The particulate matter creates smoke and haze which contribute to air pollution.

5.6.4 Recycling

The process of extracting resources or value from waste is generally referred to as recycling, meaning to recover or reuse the material. There are a number of different methods by which waste material is recycled: the raw materials may be extracted and reprocessed, or the calorific content of the waste may be converted to electricity. New methods of recycling are being developed continuously, and are described briefly below.

Physical Reprocessing

The popular meaning of 'recycling' in most developed countries refers to the wide spread collection and reuse of everyday waste materials such as empty beverage containers. These are collected and sorted into common types so that the raw materials from which the items are made can be reprocessed into new products. Material for recycling may be collected separately from general waste using dedicated bins and collection vehicles, or sorted directly from mixed waste streams

The most common consumer products recycled include aluminium beverage cans,steel food and aerosol cans,HDPE and PET bottles,glass bottles and jars, paper board cartons,newspapers, magazines, and cardboard. Other types of plastic(PVC,LDPE,PP, and PS: see resin identification code) are also recyclable,although these are not as commonly collected. These items are usually composed of a single type of material, making them relatively easy to recycle into new products. The recycling of complex products (such as computers and electronic equipment) is more difficult, due to the additional dismantling and separation required

Biological Reprocessing

Waste materials that are organic in nature, such as plant material, food scraps, and paper products, can be recycled using biological composting and digestion processes to decompose the organic matter. The resulting organic material is then recycled as mulch-or compost for agricultural or landscaping purposes. In addition,waste gas from the process (such as methane) can be captured and used for generating electricity. The intention of biological processing in waste management is to control and accelerate the natural process of decomposition of organic matter. There are a large variety of composting and digestion methods and technologies varying in complexity from simple home compost heaps, to industrial-scale enclosed-vessel digestion of mixed domestic waste (see Mechanical biological treatment). Methods of biological decomposition are differentiated as being aerobic or anaerobic methods, though hybrids of the two methods also exist.

An example of waste management through composting is the Green Bin Program in Toronto, Canada, where household organic waste (such as kitchen scraps and plant cuttings) are collected in a dedicated container and then composted

Energy Recovery

The energy content of waste products can be harnessed directly by using them as a direct combustion fuel, or indirectly by processing them into another type of fuel.Recycling through thermal treatment ranges from using waste as a fuel source for cooking or heating, to fuel for boilers to generate steam and electricity in a turbine. Pyrolysis and gasification are two related forms of thermal treatment where waste materials are heated to high temperatures with limited oxygen availability. The process typically occurs in a sealed vessel under high pressure. Pyrolysis of solid waste converts the material into solid, liquid and gas products. The liquid and gas can be burnt to produce energy or refined into other products. The solid residue(char) can be further refined into products such as activated carbon. Gasification and advanced Plasma arc gasification are used to convert organic materials directly into a synthetic gas (syngas) composed of carbon monoxide and hydrogen. The gas is then burnt to produce electricity and steam

5.6.5 Biological Waste Treatment

Composting

Composting operations of solid wastes include preparing refuse and degrading organic matter by aerobic micro organisms. Refuse is presorted, to remove materials that might have salvage value or cannot be composted, and is ground up to improve the efficiency of the decomposition process. The refuse is placed in long piles on the ground or deposited in mechanical systems, where it is degraded biologically to a humus with a total nitrogen, phosphorus, and potassium content of 1 to 3 percent, depending on the material being composted. After about three weeks, the product is ready for curing, blending with additives, bagging, and marketing.

Anaerobic Digestion

Anaerobic digestion like composting uses biological processes to decompose organic waste. However, where composting can use a variety of microbes and must have air, anaerobic digestion uses bacteria and an oxygen free environment to decompose the waste. Aerobic respiration, typical of composting, results in the formation of Carbon dioxide and water. While the anaerobic respiration results in the formation of Carbon Dioxide and methane. In addition to generating the humus which is used as a soil enhancer, Anaerobic Digestion is also used as a method of producing bio-gas which can be used to generate electricity. Optimal conditions for the process require nutrients such as nitrogen, phosphorous and potassium, it requires that the pH be maintained around 7 and the alkalinity be appropriate to buffer pH changes, temperature should also be controlled.

5.7 Green Chemistry

Green chemistry is the utilisation of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.

Green Chemistry deals with production of chemicals of our daily use by reactions and process which neither use toxic chemicals nor emit such chemicals into the atmosphere. Environment friendly reagents and solvents and also energy sources like sunlight, microwaves, etc. are usually used.

Scope of Green Chemistry

presently green chemistry coverage includes:

1. The application of innovative technology to establish industrial procedures
2. The development of environmentally improved routes and methods to important products
3. The design of new, greener and safer chemicals and materials
4. The use of sustainable resources
5. The use of biotechnology alternatives to chemistry-based solutions
6. Methodologies and tools for measuring environmental impact
7. Chemical aspects of renewable energy.

Presently Green Chemistry uses,

1. Using liquid CO_2 and a detergent for dry cleaning instead of carcinogenic tetrachloroethane.
2. Using H_2O_2 for bleaching of clothes in laundry instead of toxic chlorine.
3. Using H_2O_2 for bleaching paper in the place of toxic chlorine.

It is evident from the above examples that if concerted efforts are made to develop green chemistry, environmental pollution can be controlled to great extent.

5.8 Pollution Control Board

The Central Pollution Control Board (CPCB) of India is a statutory organisation under the Ministry of Environment, Forest and Climate Change (MoEF&CC). It was established in 1974 under the Water (Prevention and Control of pollution) Act, 1974. CPCB is also entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests under the provisions of the Environment (Protection) Act, 1986. It Co-ordinates the activities of the State Pollution Control Boards by providing technical assistance and guidance and also resolves disputes among them. It is the apex organisation in country in the field of pollution control.

The board conducts environmental assessments and research. It is responsible for maintaining national standards under a variety of environmental laws, in consultation with zonal offices, tribal, and local governments. It has responsibilities to conduct monitoring of water and air quality, and maintains monitoring data. The agency also works with industries and all levels of government in a wide variety of voluntary pollution prevention programs and energy conservation efforts. It advises the central government to prevent and control water and air pollution. It also advises the Governments of Union Territories on industrial and other sources of water and air pollution.

5.8.1 Duties and Functions

According to Section 16-A, the following are the functions of the Central Board:

1. The main functions of the Central Board shall be to promote the cleanliness and improve the quality of the air/water in streams and wells and to prevent control for abate air pollution/ water pollution in the country.

2. Advice the Central Government, on any matter concerning the improvement of the quality of air and prevention control or abatement of air pollution/water pollution.

3. Plan and cause to be execute a nation-wide programme through mass media for the provision, control or abatement of air/water pollution.

4. Provide technical assistance and guidance to the state boards carry out and sponsor investigations and research relating to problems of air pollution/water pollution and its control and abatement.

5. Plan organize the training of persons engaged or to be engaged in programmes for prevention, control and abatement of air pollution on such terms and conditions as the central board may specify.

6. Organize through mass media a comprehensive programme towards prevention, control and abatement of air pollution or water pollution.

7. Collect, compile and publish technical and statistical data relating to air pollution/water pollution and the measures devised for its effective prevention, control and abatement and prepared manuals.

8. Collect and disseminate information in respect of matters relating to air/water pollution.

5.8.2 Functions of State Boards

Under Section 7-B, the following are the functions of a State Board:

1. To advice the Central Government, in any matter concerning the prevention, control or abatement of air/water pollution.

2. To advice the State Government, on any matter to plan and cause to be executed a nationwide programme for the prevention, control or abatement of air/water pollution.

3. To collect information relating water/air pollution and to encourage, conduct, participate in investigations and research relating to problems of water pollutions.

4. To plan a comprehensive programme through mass media for prevention, control or abatement of air /water pollution. To inspect sewage or trade effluents, works and plants for the treatment of sewage or trade effluent.

5. To lie down, modify or annual Effluent standards for the sewage and trade effluents and for the quality or receiving waters resulting from the discharge of effluents and to classify

6. water resulting from the discharge for effluents and classify waters of the state.

7. To evolve economical and reliable methods of effluents of sewage and trade effluents.

8. To evolve methods of utilization of sewage and suitable trade effluents in agriculture.

9. To evolve efficient methods of disposal of sewage and trade effluents on land

10. To lay down standards of treatment of sewage and trade effluents, to be discharged into any particular stream.

11. For prevention, control, abatement of discharged of wastes into stream or wells.

5.9 Major Environmental Movements in Idia

5.9.1 Narmada Bachavo Andholan

The Narmada, also called the Rewa and previously also known as Nerbudda,is a river in central India and the sixth longest river in the Indian subcontinent. It is the third longest river that flows entirely within India, after the Godavari, and the Krishna. It is also known as "Life Line of Gujarat and Madhya Pradesh" for its huge contribution to the state of Gujarat and Madhya Pradesh in many ways.

Narmada rises from Amarkantak Plateau near Anuppur district. It forms the traditional boundary between North India and South India and flows westwards over a length of 1,312 km (815.2 mi) before draining through the Gulf of Khambhat into the Arabian Sea, 30 km (18.6 mi) west of Bharuch city of Gujarat. The Sardar Sarovar Dam idam on the Narmada river near Navagam, Gujarat in India. Four Indian states, Gujarat, Madhya Pradesh, Maharastra and Rajasthan, receive water and electricity supplied from the dam. The foundation stone of the project was laid out by Prime Minister Jawaharlal Nehru on April 5, 1961. The project took form in 1979 as part of a development scheme to increase irrigation and produce hydroelectricity. The dam was inaugurated by Prime Minister Modi on September 17, 2017.

One of the 30 dams planned on river Narmada, Sardar Sarovar Dam (SSD) is the largest structure to be built. It is one of the largest dams in the world. Narmada Bachao Andolan is the most powerful mass movement, started in 1985, against the construction of huge dam on the Narmada river. Narmada is the India's largest west flowing river, which supports a large variety of people with distinguished culture and tradition ranging from the indigenous (tribal) people inhabited in the jungles here to the large number of rural population. The proposed Sardar Sarovar Dam and Narmada Sagar will displace more than 250,000 people. The big fight is over the resettlement or the rehabilitation of these people. The two proposals are already under construction, supported by the world bank. There are plans to build over 3000 big and small dams along the river. After the country won its independence, India's first Prime Minister, Jawaharlal Nehru, began calling for the construction of dams to aid in India's development. Two of the largest proposed dams were Sardar Sarovar and Narmada sagar have been under construction since 1961. The Narmada Water Disputes Tribunal approved the Narmada Valley Development Project, which included 30 large dams, 135 medium dams, and 3,000 small dams includin raising the hieght of Sardar Sarovar dam.

It is a multi crore project that will generate a big revenue for the government. In 1985, the World Bank agreed to finance the Sardar Sarovar dam with a contribution of 450 million dollars, without consulting the indigenous communities that were to be displaced. In 1987, construction began on the Sardar Sarovar dam, and the injustices of the government's relocation program were exposed: there was not enough land available for redistribution, amenities were low quality, and the settlers had difficulty adjusting to new environments. In 1985, after hearing about the Sardar Sarovar dam, Medha Patkar and her colleagues visited the project site and noticed that project work being checked due to an order by the Ministry of Environment and Forests, Government of India. The people who were going to be affected by the construction of the dam were given no information but the offer for rehabilitation.Villagers weren't consulted and weren't asked for a feedback on the assessment that had taken place.

In May of 1990, NBA organized a 2,000-person, five-day sit-in at Prime Minister V. P. Singh's residence in New Delhi, which convinced the Prime Minister to 'reconsider' the project. In December of the same year, five to six thousand men and women began the Narmada Jan Vikas Sangharsh Yatra (Narmada People's Progress Struggle March), marching over 100 kilometers. Marchers, who each had their hands voluntarily tied together to demonstrate their non-violence, were beaten, arrested, and dragged into trucks in which they were driven miles away and dumped in the wilderness. Finally on January 7, 1991, the seven-member team began an indefinite hunger strike. Two days earlier Baba Amte had himself committed to a sit-in unto death.

5.9.2 Chipco Movement

The Chipko movement of the Uttarakhand region in the north west part of India began as a communal reaction of local villagers to protect their forests from commercial deforestation practices. The term "Chipko" which literally means "to embrace", was designated to these villagers who reacted by actually hugging the trees. It became so popular that the movement spread throughout all of India and different parts of Asia. Local women of the region are central to the movement's success and continue to be its backbone. In fact over the decades, Chipko has been known for its ecofeminist strategies.

This case study will examine the development of the environmental problems over the decades and study the social and cultural elements implicit in the communities of the Uttarkhand Himalyan region. From 1815 to 1949 Uttarakhand was divided into two kingdoms, Tehri Garhwal state and the colonial territory of Kumaun. The political structure of hill society in those two kingdoms was distinct from the rest of India n that along with the presence of communal tradition, there as an absence of sharp class division.

The land was understood to belong to the community rather as a whole even though there was a caste system in place. The natural environment for the hill people consisted of a system of village and methods of crop rotation. The production was directed towards subsistence in which the surplus was exported to Tibet and southwards to the plains. In fact, the communities living in the hill usually had six months of stock in grain with supplement of fish, fruit, vegetable, and animal meat.

The hill district constituted over 60% of owner-cultivators and 80% of the total population farmed with the help of family labour. By the turn of the century, nine-tenths of the hill men cultivated with full-ownership rights. " The absence of sharp inequalities in land ownership within body cultivating proprietors -who formed bulk population-was basis for sense solidarity village community. Because those who owned worked community together to sustain their existence. Men not only maintained household economy by collecting food or fuel and food family they equally with husbands field cultivated reared cattle as well. The absence of intermediaries and class divisions within the villages is also due to the "ecological characteristics of mountain society". for the way tradition played a role in the preservation of the environment and the way villagers worked with nature. The building of railway network that began the science forestry and social change of the community. Forestry in Gharwal Forestry in Kumaun Early Resistence to the forestry techniques and rules.

In the recent decades, the availability of natural resources to the rural communities of the Uttarakhand region as well as in other rural communities has eroded tremendously due to two linear, interrelated processes that have undermined the traditional institutional arrangement of resource use and management which existed in many of the areas: 1) the degradation of the forests both in quantity and quality and 2) the appropriation of land by state to preferred individuals and the privatization of land to timber or profit-seeking corporations. As a result there has been a shift away from community resource management and control which was proven to be more effective in ecological regeneration and deteriorating soil conditions, depleting water resources, and disappearing forests. Although there is no exact data as to the extent of the degeneration, there is enough that indicates the depletion of the resources as real and substantial, increasing at a rapid rate under the control of external hands.

5.9.3 Silent valley movement

Silent valley is situated in Palakkad district, Kerala. Region is locally known as "Sairandhri-vanam" . Silent valley- an evergreen tropical forest . It is home to the largest population of lion-tailed macaque. The Kuntipuzha is a major river that flows in silent ValleyBackground . In 1931 British Engineer S. Dowson proposed idea of dam for the first time. In 1951, the Government conducted a survey to check feasibility of silent valley hydroelectric project . Foreign scientists like Steven Green and Romulus Whitaker, they alerted about ecological importance of silent valley, also they showed concern about the nearly extinct species of the macaque.

In 1973, the Planning Commission formally approved the Silent Valley Hydroelectric Project. Movement started in 1973 to protect reserve forest from being affected by a hydroelectric project . Kerala State Electricity Board had to slacken the work on the project due to construction of Idukki hydroelectric project. In April,1976 - National Council for Environmental Planning studied feasibility of hydroelectric project. The taskforce suggested that project should be abandoned and the valley to be declared a biosphere reserved area. In 1977,Kerala Sastra Sahitya Parishad (KSSP) adopted a resolution opposing the implementation of the SVHP. In 1977, expert team from Kerala Forest Research Institute (KFRI) studied and submitted report strongly urging to abandon project. The International Union for the Conservation of Nature and Natural Resources (IUCN) adopted a resolution specifically urging the Government of India to conserve the Western Ghats more effectively, including the undisturbed forests of the Silent Valley.

Recommended protection of lion tailed macaques – another controversy against Silent Valley Hydroelectric Project. In 1980 Indira Gandhi requested the Government of Kerala to abandon the construction of the SVHP. Gandhi requested the chief minister of Kerala to consider possibilities of alternative projects for meeting the power needs of the state. Kerala Sashtra sahitya Parishad observed March 15, 1980 as the Silent Valley day. The Menon Committee submitted its report in the December of 1982 after thoroughly examining various aspects of the SVHP. This report too emphasized the ecological significance of the Silent Valley . Finally in 1983, the Silent Valley Hydroelectric Project was shelved . Thus, the SVHP became the only case in which a hydroelectric project once sanctioned was abandoned for purely ecological reasons in India.

On September 7, 1985, the area was notified as a National Park Since then - a long-term conservation effort undertaken to preserve the Silent Valley ecosystem. Mobilization and awareness through editorials in Malayalam and English newspapers. Various activists groups used different strategies ranging from distributing pamphlets to holding public meetings . In July 1982, the Prakrithi Samrakshana Samithi an eco-social organisation submitted a united appeal from scientists, writers and social activists to save the Silent Valley. The poet activist Sugathakumari's poem "Marathinu Stuthi" - became a symbol for the protest.

The Kerala Government has not taken any decision on reviving the Silent Valley Hydro Project. In 2001 a new hydro project was proposed which was alternative for silent valley project but it was also abandoned . In 2007 silent valley buffer zone was formally approved by the Kerala Cabinet, the cabinet also sanctioned staff to protect the area.

5.9.4 Plachimada Movement

On 8 October 1999, Hindustan Coca-Cola Beverages Private (HCBLP), a subsidiary of the Coca-Cola Company, applied for a license at Perumatty panchayat to establish a factory in Plachimada. On 27 January 2000 the company was granted permission to open the factory. The firm purchased a roughly 34.64-acre (14.02 ha) plot, which had previously been used to cultivate paddy, peanuts and vegetables. The factory employed 130 permanent workers and approximately 250 temporary labourers. Brands produced at the Plachimada factory included Coca-Cola, Limca, Fanta, Thums Up, Sprite, Kinley Soda, and Maaza. The factory used 500,000 litres of groundwater a day for its production after obtaining permission from Perumatty panchayat, which was later confirmed by the Kerala High Court. Villagers living nearby the factory started reporting increased water pollution six months after the factory was opened. Accessing water for agricultural purposes became an issue.

The factory had also made a practice of distributing its sludge waste from the manufacturing process as free fertilizer to the villagers. In 2003, a BBC journalist visited the village to investigate the claims made by the villagers that the sludge was contaminated. As part of his reporting for BBC Radio 4's Face the Facts, he has picked up samples of the sludge and sent to the United Kingdom to be analyzed. A lab at the University of Exeter found unacceptably high levels of cadmium and lead in the sludge. Lead is toxic to human development and the nervous system, while cadmium is a documented carcinogen. Mounting pressure on the Kerala Government to shut down the factory, Greenpeace Campaign Head Ameer Shahul shared the University of Exeter analysis report to the Kerala State Pollution Control Board and to the local media, demanding permanent closure of the factory. Soon, the Kerala State Pollution Control Board confirmed these test results and ordered The Coca-Cola Company to stop distribution of its waste and to recover what had been dispersed in the past.

After mounting evidence that The Coca-Cola Company was polluting the environment and harming local citizens, the Coca-Cola Virudha Janakeeya Samara Samithy (Anti-Coca-Cola Peoples Struggle Committee) launched their protests on 22 April 2002 by blocking the entrance to the factory. Over 1,300 people participated in this protest, mostly Adivasis and women. Scientific tests were conducted on the water by Sargram Metals Laboratories in March 2002 which deemed the water unfit for "human consumption, domestic use and for irrigation." The independent report was backed up by the government primary health center which also reported that the water was not potable in May 2003. Coca-Cola eventually admitted that there was an issue with the water, unrelated to their activities, and offered to provide drinking water to the community via trucks and to start rainwater harvesting programs at the factory and in the community. As the villagers maintained the protest outside the factory, support grew for the movement. In January 2004, a three-day International Water Conference at Plachimada was organized to bring together activists from around the world to discuss water issues. Two environmentalists, Canadian Maude Barlow and Indian Vandana Shiva, attended the conference and issued the Plachimada Declaration stating that "water is not a private property, not a commodity" but a common resource and a fundamental right.

On 3 April 2003, the Perumatty panchayat revoked the license for the plant. Coca-Cola took the case to the Kerala High Court, which at first sided with the firm, saying the panchayat's claims were unscientific and unfounded. The legal battle lasted years. At times, for example, between 8 and 15 August 2005, the plant operated, but eventually, the plant was closed permanently. In 2018, the factory sat empty with a few security guards. The case was said to turn upon the legal doctrines of public trust and the polluter pays principle, as well as the legal role of local government. The wells are still contaminated and water must be piped in from a nearby village. A High Powered Committee has determined that the damage to the community amounts to 216.26 crores of rupees or (28 million dollars). This figure was broken down into categories of agriculture loss, health damage, cost of providing water, wage loss and opportunity cost and the cost of pollution of water resources. However, as of 2018, no compensation has been paid to the villagers

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