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Programme: M.Sc., Environmental Science

Course Title:Water, Soil Pollution and management
Course Code : CC04

Unit-III

Wastewater Treatment

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Objectives of wastewater treatment

- Reduce organic content (reduction of BOD)
- Removal/reduction of nutrients i.e., N,P
- Removal/inactivation of pathogenic microbes

Wastewater treatment

- Primary treatment
  - Sedimentation and screening of large debris
- Secondary treatment
  - Biological treatment
- Tertiary treatment
  - Further chemical treatment

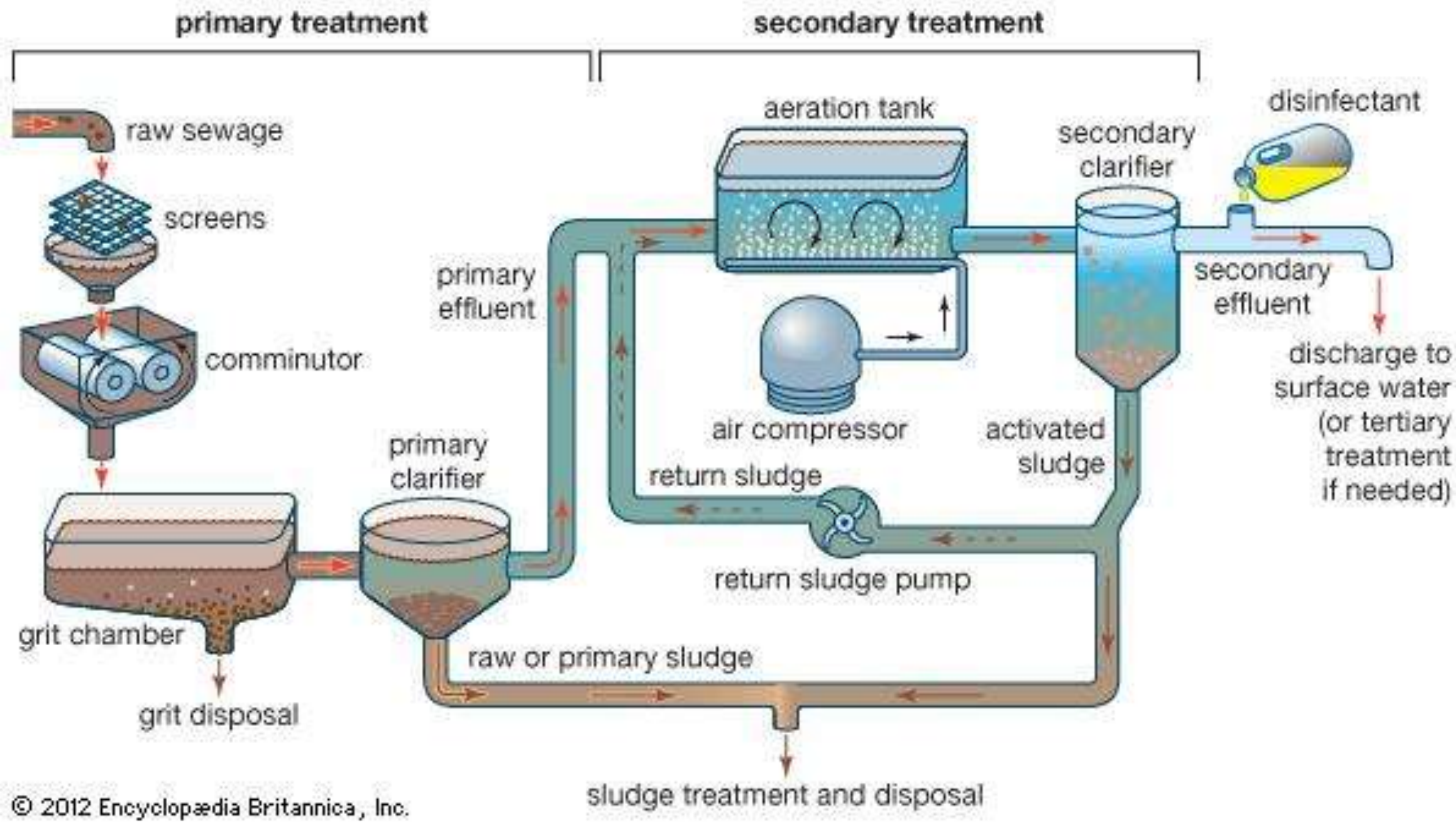
Wastewater treatment

- Treatment includes
  - Primary treatment: Screening and settling
  - Secondary treatment: Biological treatment in which activated sludge “eats” pollutants
  - Disinfection: Kills bacteria, viruses, and protozoa
- There are three levels of wastewater treatment: primary, secondary, and tertiary (or advanced).
- Primary treatment removes about 60 percent of total suspended solids and about 35 percent of BOD; dissolved impurities are not removed.
- It is usually used as a first step before secondary treatment.

Equalization Tanks

- Effluent from the collection tank comes to the equalization tank in wastewater treatment.
- The main function is to act as buffer. To collect the incoming raw effluent that comes at widely fluctuating rates and position to the rest of the ETP at steady (Average) flow rate.
- During the peak hours ETP comes at high flow rate. The equalization tank stores this effluent and lets it out during the non peak time when there is no /little incoming effluent.
- The inlet pipe of equalization tank carries filtered effluent from cooling tower.

Schematic representation of Wastewater treatment



Primary treatment

- Primary treatment removes material that will either float or readily settle out by gravity.
- It includes the physical processes of screening, comminution, grit removal, and sedimentation.
- Screening :Screening is the first unit operation used at wastewater treatment plants (WWTPs). Screening removes objects such as rags, paper, plastics, and metals to prevent damage and clogging of downstream equipment, piping, and appurtenances.
- Screens are made of long, closely spaced, narrow metal bars. They block floating debris such as wood, rags, and other bulky objects that could clog pipes or pumps. In modern plants the screens are cleaned mechanically, and the material is promptly disposed of by burial on the plant grounds.

- Some modern wastewater treatment plants use both coarse screens and fine screens.
- Coarse Screens :Coarse screens remove large solids, rags, and debris from wastewater, and typically have openings of 6 mm (0.25 in) or larger.
- Types of coarse screens include mechanically and manually cleaned bar screens, including trash racks.
- Fine Screens :Fine screens are typically used to remove material that may create operation and maintenance problems in downstream processes, particularly in systems that lack primary treatment.
- Typical opening sizes for fine screens are 1.5 to 6 mm (0.06 to 0.25 in). Very fine screens with openings of 0.2 to 1.5 mm (0.01 to 0.06 in) placed after coarse or fine screens can reduce suspended solids to levels near those achieved by primary clarification.

Screens

❖ Bar Screen

- catches large objects that have entered into sewer system such as bricks, bottles, pieces of wood, etc.

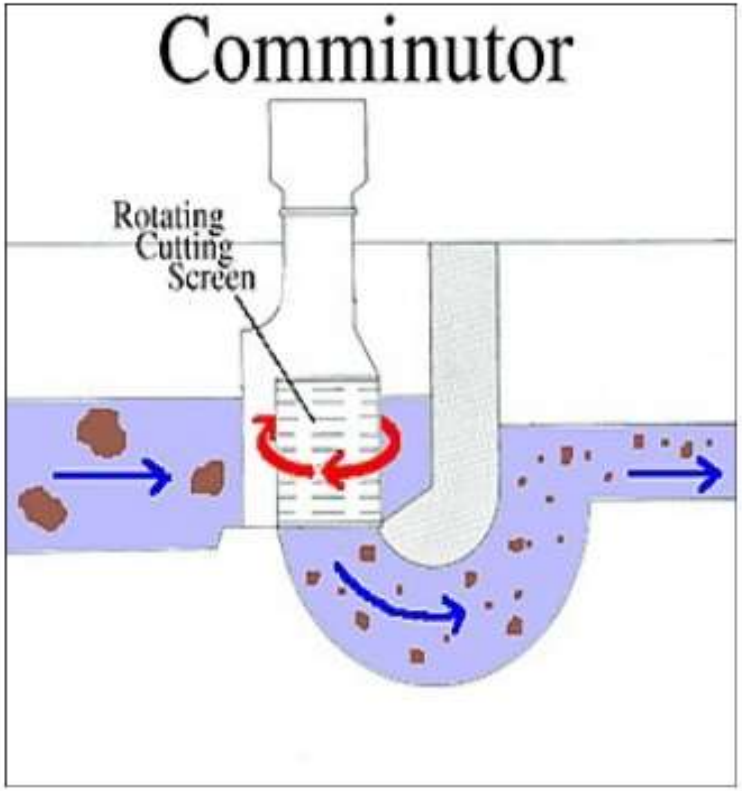
Coarse solids reduction

- Coarse solids reduction is done by employing communitors and macerators. They are used to break coarse solids and grind or shred them in the screen channel.
- Normally the coarse solid reduction is done with communitors, macerators and grinders
- They eliminate the messy and offensive task of handling and disposal of solids in wastewater treatment facility.

Comminutor

- A comminutor may be used to grind and shred debris that passes through the screens. The shredded material is removed later by sedimentation or flotation processes.

Comminutor



- In this device all of the wa flow passes through the grinder assembly
- The grinder consists of a screen or slotted basket, a rotating or oscillating cutter and a stationary cutter
- Solids pass through the screen and are chopped or shredded between the two cutters

- Comminutors and Grinders :Processing coarse solids reduces their size so they can be removed during downstream treatment operations, such as primary clarification, where both floating and settleable solids are removed.
- Comminuting and grinding devices are installed in the wastewater flow channel to grind and shred material up to 6 to 19 mm (0.25 to 0.75 in) in size.
- Comminutors consist of a rotating slotted cylinder through which wastewater flow passes. Solids that are too large to pass through the slots are cut by blades as the cylinder rotates, reducing their size until they pass through the slot openings. Grinders consist of two sets of counterrotating, intermeshing cutters that trap and shear wastewater solids into a consistent particle size, typically 6 mm.

- The cutters are mounted on shafts with intermediate spacers. The shafts counter rotate at different speeds to clean the cutters. The chopping action of the grinder reduces the formation of rag “balls” and rag “ropes” (an inherent problem with comminutors). Wastewaters that contain large quantities of rags and solids, such as prison wastewaters, utilize grinders downstream from coarse screens to help prevent frequent jamming and excessive wear.

Macerators

- The purpose of macerators is to provide an easy and convenient means of disposing of waste into drains and sewers. Examples of macerators are food waste disposal units and those designed for disposing of sanitary and hygiene products. Typically, they are installed and in use in commercial kitchens, care homes, hospitals, domestic properties and other premises.

Maceration

- Maceration technology provides the best results when installed after primary screening or headworks systems. These units are specifically designed to sheer cut any material that flows through. Some designs provide heavy debris removal traps, as macerators are not designed to cut hard solids like rocks and metal.
- ***Macerators***
- Macerators are designed for in-line pipe installations. Macerators need to have liquid flowing through the pipe, as they cannot run dry. These units tend to do better with small solids like hair, wipes, rags, and plastics as compared to large heavy solids.

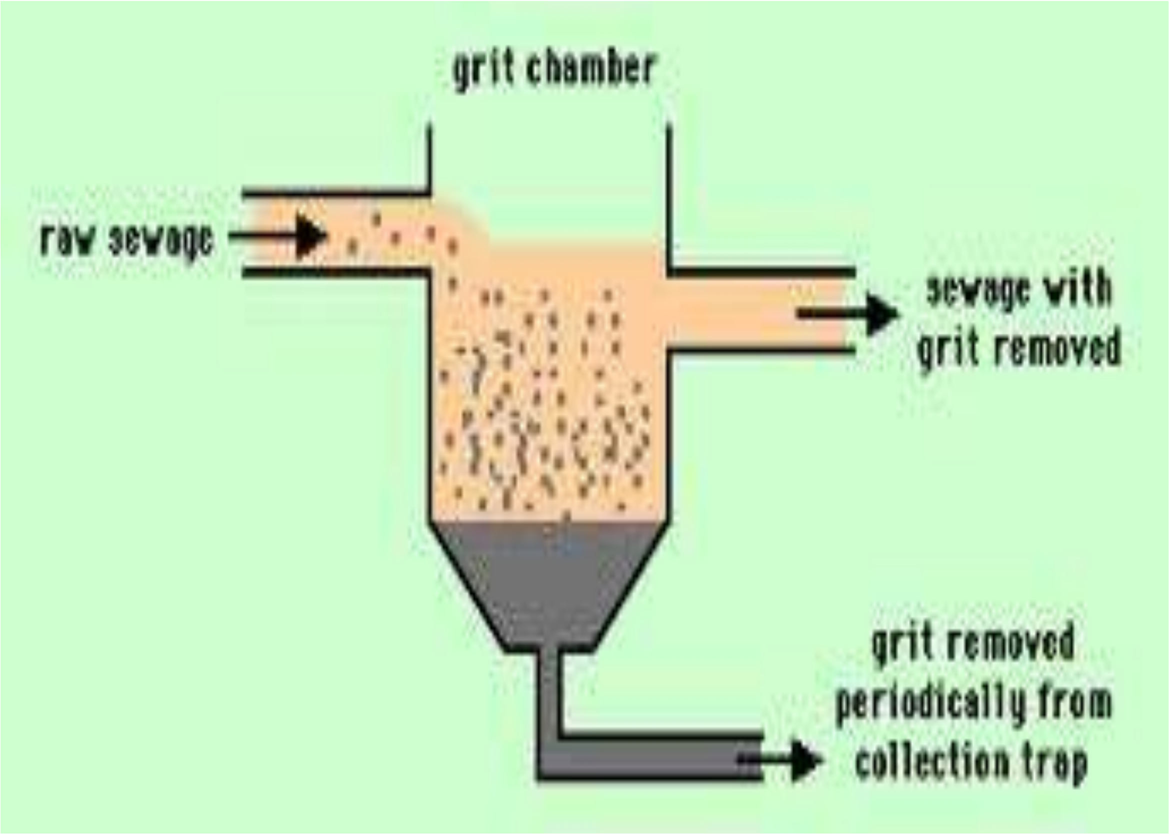
Grit removal

- Grit Removal :Grit includes sand, gravel, cinder, or other heavy solid materials that are “heavier” (higher specific gravity) than the organic biodegradable solids in the wastewater.
- Grit also includes eggshells, bone chips, seeds, coffee grounds, and large organic particles, such as food waste. Removal of grit prevents unnecessary abrasion and wear of mechanical equipment, grit deposition in pipelines and channels, and accumulation of grit in anaerobic digesters and aeration basins.
- Grit removal facilities typically precede primary clarification, and follow screening and comminution. This prevents large solids from interfering with grit handling equipment.

Grit chamber

- Grit chambers are long narrow tanks that are designed to slow down the flow so that solids such as sand, coffee grounds, and eggshells will settle out of the water.
- Grit causes excessive wear and tear on pumps and other plant equipment. Its removal is particularly important in cities with combined sewer systems, which carry a good deal of silt, sand, and gravel that wash off streets or land during a storm.
- Suspended solids that pass through screens and grit chambers are removed from the sewage in sedimentation tanks.

Grit chamber



- Many types of grit removal systems exist, including aerated grit chambers, vortex-type (paddle or jetinduced vortex) grit removal systems, detritus tanks (short-term sedimentation basins), horizontal flow grit chambers (velocity-controlled channel), and hydrocyclones (cyclonic inertial separation).
- Various factors must be taken into consideration when selecting a grit removal process, including the quantity and characteristics of grit, potential adverse effects on downstream processes, head loss requirements, space requirements, removal efficiency, organic content, and cost.

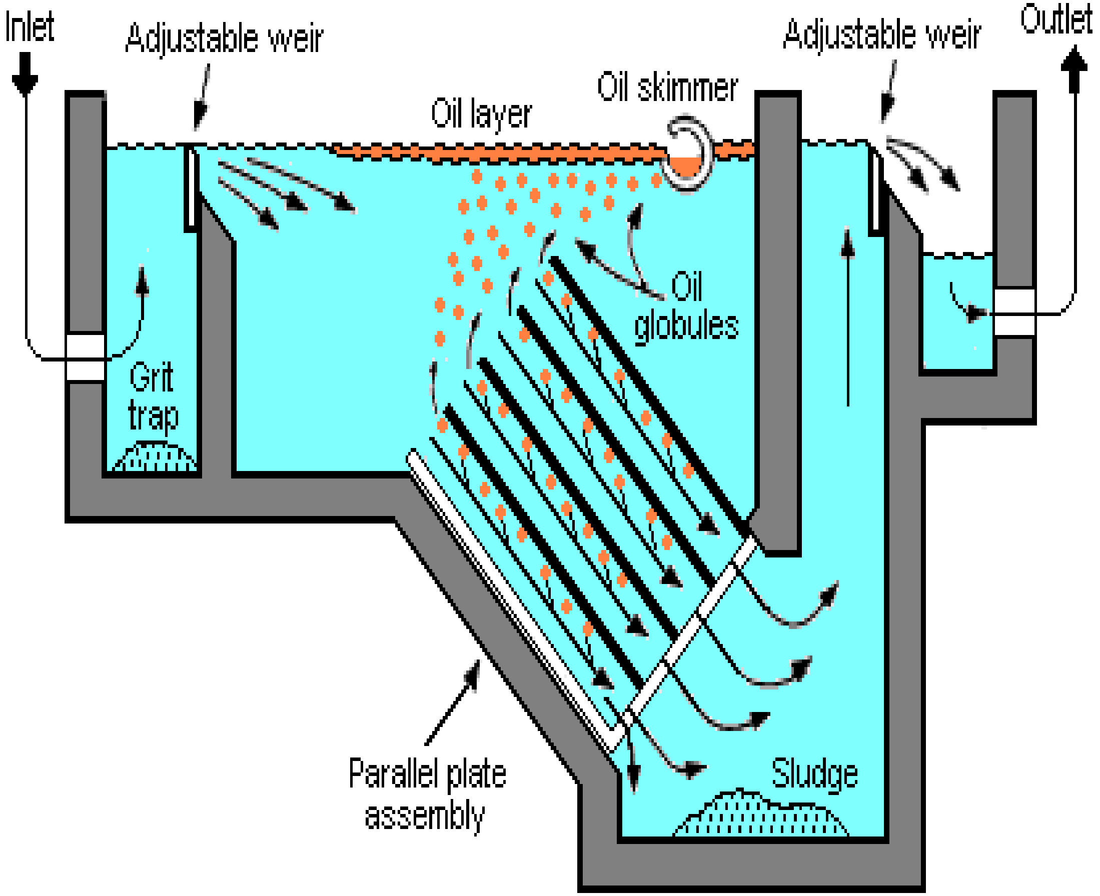
Oil and grease removal

- The effective removal of oils and grease is dependent on the characteristics of the oil in terms of its suspension state and droplet size, which will in turn affect the choice of separator technology. Oil in industrial waste water may be free light oil ,heavy oil, which tends to sink, and emulsified oil, often referred to as soluble oil.
- Analysing the oily water to determine droplet size can be performed with a video particle analyser.
- Each separator technology will have its own performance curve outlining optimum performance based on oil droplet size. the most common separators are gravity tanks or pits, API oil-water separators or plate packs, chemical treatment via Dissolved air flotation, centrifuges, media filters and hydrocyclones.

Parallel plate separators

- Parallel plate separators include tilted parallel plate assemblies (also known as parallel packs).
- The parallel plates provide more surface for suspended oil droplets to coalesce into larger globules.
- Such separators still depend upon the specific gravity between the suspended oil and the water.
- However, the parallel plates enhance the degree of oil-water separation. The result is that a parallel plate separator requires significantly less space than a conventional API separator to achieve the same degree of separation.

Parallel plate separator



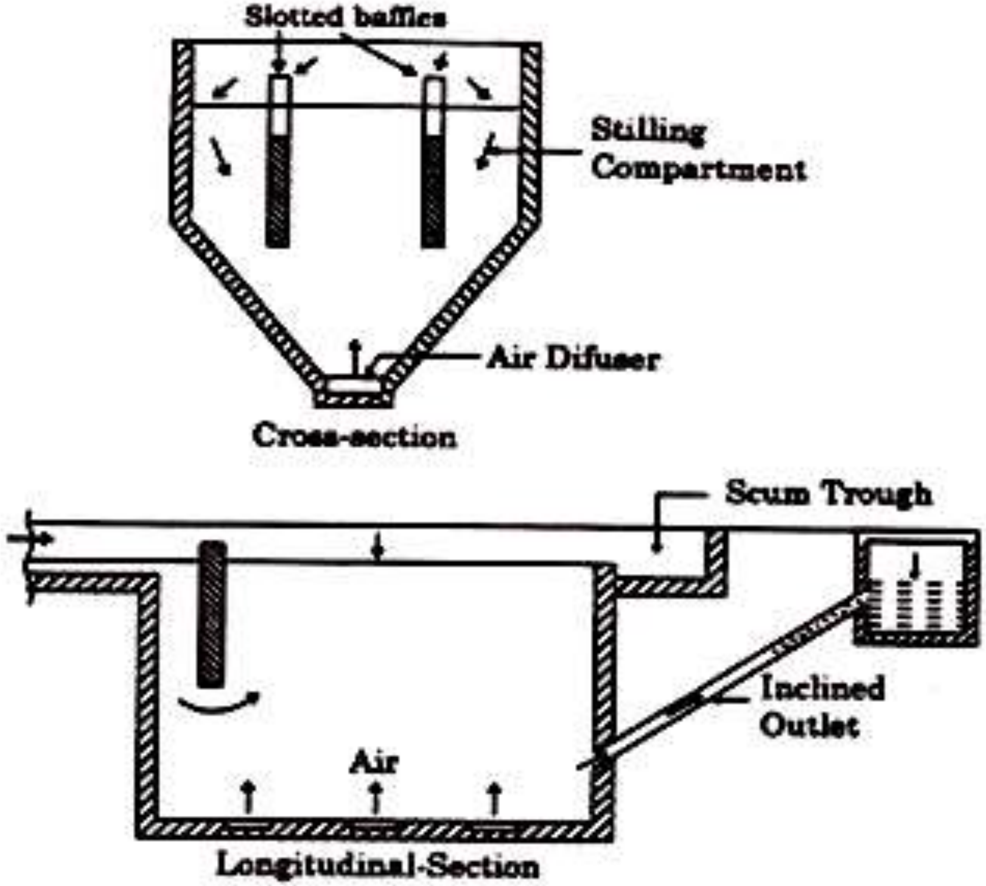
Skimming tanks

- A skimming tank is a chamber so arranged that the floating matter like oil, fat, grease etc., rise and remain on the surface of the waste water (Sewage) until removed, while the liquid flows out continuously under partitions or baffles.
- It is necessary to remove the floating matter from sewage otherwise it may appear in the form of unsightly scum on the surface of the settling tanks or interfere with the activated sludge process of sewage treatment. It is mostly present in the industrial sewage. In ordinary sanitary sewage, its amount is usually too small.
- The chamber is a long trough shaped structure divided up into two or three lateral compartments by vertical baffle walls having slots for a short distance below the sewage surface and permitting oil and grease to escape into stilling compartments.

- The rise of floating matter is brought about the blowing air into the sewage from diffusers placed in the bottom. Sewage enters the tank from one end, flows longitudinally and leaves out through a narrow inclined duct. A theoretical detention period of 3 minutes is enough. The floating matter can be either hand or mechanically removed.

- Grease traps are in reality small skimming tanks designed with submerged inlet and bottom outlet (Fig). The traps must have sufficient capacity to permit the sewage to cool and grease to separate. Frequent cleaning through removable covers is essential for satisfactory operation. Grease traps are commonly employed in case of industries, garages, hotels and hospitals.

Skimming tank



Skimming Tank

Clarification of wastewater

- Suspended matter in raw water supplies is removed by various methods to provide a water suitable for domestic purposes and most industrial requirements.
- The suspended matter can consist of large solids, settable by gravity alone without any external aids, and nonsettleable material, often colloidal in nature. Removal is generally accomplished by coagulation, flocculation, and sedimentation. The combination of these three processes is referred to as conventional clarification.
- Coagulation is the process of destabilization by charge neutralization. Once neutralized, particles no longer repel each other and can be brought together. Coagulation is necessary for the removal of the colloidal-sized suspended matter.

- Flocculation is the process of bringing together the destabilized, or "coagulated," particles to form a larger agglomeration, or "floc."
- Sedimentation refers to the physical removal from suspension, or settling, that occurs once the particles have been coagulated and flocculated. Sedimentation or subsidence alone, without prior coagulation, results in the removal of only relatively coarse suspended solids.
- **Conventional Clarification Equipment**
- The coagulation/flocculation and sedimentation process requires three distinct unit processes:
- high shear, rapid mix for coagulation
- low shear, high retention time, moderate mixing for flocculation
- liquid and solids separation

Primary clarifier

- Further the water is sent to the tanks, also called primary clarifiers, provide about two hours of detention time for gravity settling to take place. As the sewage flows through them slowly, the solids gradually sink to the bottom.
- The settled solids—known as raw or primary sludge—are moved along the tank bottom by mechanical scrapers. Sludge is collected in a hopper, where it is pumped out for removal. Mechanical surface-skimming devices remove grease and other floating materials.

Flotation

- Dissolved air flotation (DAF) is a water treatment process that clarifies wastewaters (or other waters) by the removal of suspended matter such as oil or solids. The removal is achieved by dissolving air in the water or wastewater under pressure and then releasing the air at atmospheric pressure in a flotation tank basin.
- The released air forms tiny bubbles which adhere to the suspended matter causing the suspended matter to float to the surface of the water where it may then be removed by a skimming device.

- Dissolved air flotation is very widely used in treating the industrial wastewater effluents from oil refineries, petrochemical and chemical plants, natural gas processing plants, paper mills, general water treatment and similar industrial facilities. A very similar process known as induced gas flotation is also used for wastewater treatment. Froth flotation is commonly used in the processing of mineral ores.
- In the oil industry, dissolved gas flotation (DGF) units do not use air as the flotation medium due to the explosion risk. Nitrogen gas is used instead to create the bubbles

Aeration

- Aeration brings water and air in close contact in order to remove dissolved gases (such as carbon dioxide) and oxidizes dissolved metals such as iron, hydrogen sulfide, and volatile organic chemicals (VOCs).
- Aeration is often the first major process at the treatment plant. During aeration, constituents are removed or modified before they can interfere with the treatment processes.
- Aeration brings water and air in close contact by exposing drops or thin sheets of water to the air or by introducing small bubbles of air (the smaller the bubble, the better) and letting them rise through the water.
- The scrubbing process caused by the turbulence of aeration physically removes dissolved gases from solution and allows them to escape into the surrounding air.

- Aeration also helps remove dissolved metals through oxidation, the chemical combination of oxygen from the air with certain undesirable metals in the water.
- Once oxidized, these chemicals fall out of solution and become particles in the water and can be removed by filtration or flotation.
- The efficiency of aeration depends on the amount of surface contact between air and water, which is controlled primarily by the size of the water drop or air bubble.
- Oxygen is added to water through aeration and the amount of oxygen the water can hold depends primarily on the temperature of the water.
- Constituents commonly affected by aeration are: Volatile organic chemicals, such as benzene (found in gasoline), or trichloroethylene, dichloroethylene, and perchloroethylene (used in dry-cleaning or industrial processes) , Ammonia , Chlorine , Carbon dioxide , Hydrogen sulfide , Methane , Iron and Manganese

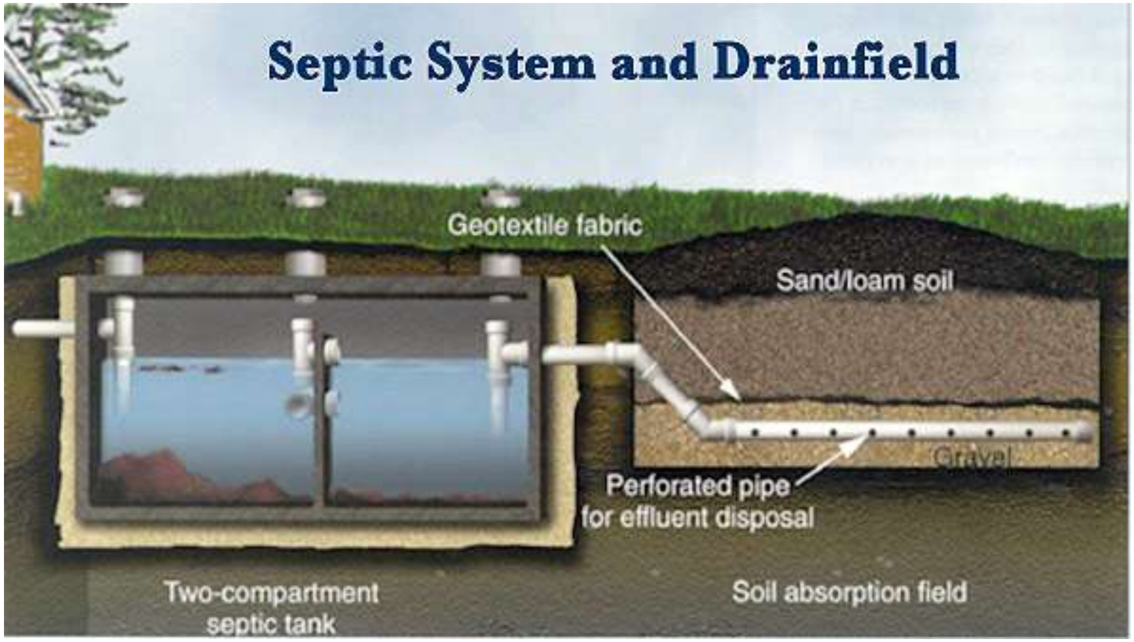
Secondary treatment

- Secondary treatment involves biological processes to remove dissolved and suspended organic matter in wastewater after primary treatment. Two common methods in small-scale or decentralized settings are Septic Tanks and Imhoff Tanks.

Septic Tank

- Definition: A septic tank is an underground chamber where wastewater undergoes anaerobic digestion, allowing solids to settle, and scum to float, while clarified liquid exits for further treatment or dispersal.
- Structure:Usually made of concrete, fiberglass, or plastic.Consists of an inlet pipe, a sedimentation chamber, and an outlet pipe.
- Process:
- Influent Collection:Wastewater enters the tank.
- Sedimentation:Heavier solids settle to form sludge at the bottom.
- Anaerobic Digestion:Microorganisms break down organic material in the sludge, reducing volume and producing gases like methane and carbon dioxide.
- Effluent Discharge:Clarified liquid exits the tank for further treatment in a soak pit or drain field.
- Advantages:Simple design and low cost.Requires minimal maintenance.Suitable for small-scale applications, such as households or small communities.
- Disadvantages:Ineffective at removing pathogens and nutrients.Periodic removal of sludge is necessary.Potential groundwater contamination if poorly constructed.

Septic tanks



Imhoff Tank

- An Imhoff tank is a two-story tank designed for combined sedimentation and sludge digestion. It is used in larger communities or decentralized wastewater treatment systems.
- Structure:Upper Chamber:Settling chamber for sedimentation of solids.Lower Chamber:Digestion chamber for anaerobic breakdown of sludge.
- Process:Influent Entry:Wastewater enters the settling chamber where solids settle by gravity.
- Sludge Collection:Settled solids slide through inclined slots into the digestion chamber below.
- Anaerobic Digestion:Microorganisms digest organic matter, reducing sludge volume and producing biogas.
- Effluent Discharge:Clarified liquid exits from the top for further treatment.
- Advantages:Separate chambers minimize mixing of sludge and clarified water.Better sludge stabilization than septic tanks.Biogas production can be utilized.
- Disadvantages:More complex design than septic tanks.Requires careful operation and maintenance.Limited pathogen and nutrient removal.

Imhoff tanks

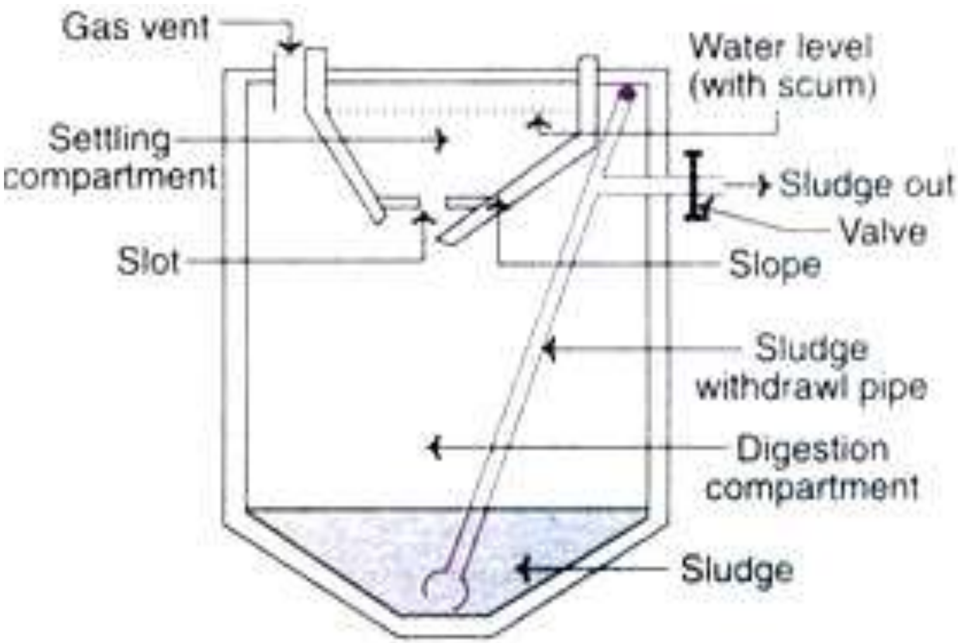


Fig. 57.24 : A diagrammatic view of imhoff tank.

Comparison of Septic Tank and Imhoff Tank

Parameter	Septic Tank	Imhoff Tank
Capacity	Small-scale	Medium to large-scale
Treatment Process	Single chamber, simple	Dual chamber, more efficient
Pathogen Removal	Low	Moderate
Sludge Handling	Requires frequent removal	Biogas production reduces sludge
Cost	Lower	Higher

Trickling filters

- Trickling filters are conventional aerobic biological wastewater treatment units.
- The advantage of all these systems is that they are compact and that they efficiently reduce organic matter (JENSSEN et al. 2004).
- Trickling filters are a secondary treatment after a primary setting process
- The trickling filter consists of a cylindrical tank and is filled with a high specific surface area material, such as rocks, gravel, or special pre-formed plastic filter media.
- A high specific surface provides a large area for biofilm formation. Organisms that grow in the thin biofilm over the surface of the media oxidize the organic load in the wastewater to carbon dioxide and water, while generating new biomass.

- The incoming pre-treated wastewater is ‘trickled’ over the filter, e.g., with the use of a rotating sprinkler.
- In this way, the filter media goes through cycles of being dosed and exposed to air.
- However, oxygen is depleted within the biomass and the inner layers may be anoxic or anaerobic.
- The removal of organic substances occurs by use of bacterial action (UNEP & MURDOCH UNIVERSITY 2004).
- Therefore trickling filters are also called bio-, or biological filters to emphasise that the filtration.

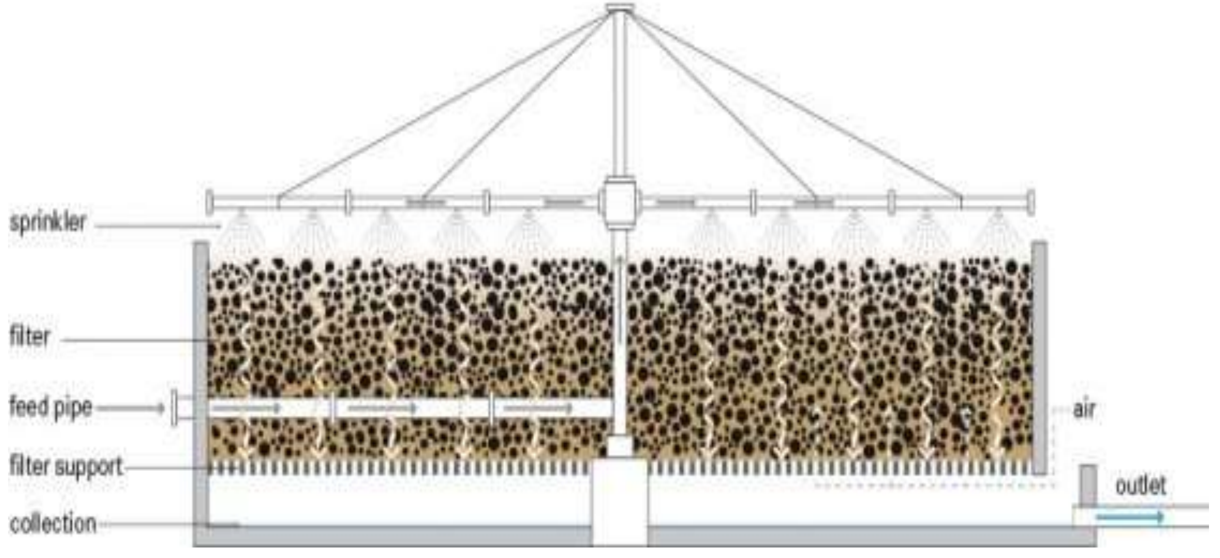
Design cosiderations

- The filter is usually 1 to 2.5 m deep.
- Oxygen is obtained by direct diffusion from air into the filter and the biological film (UNEP 2004) from the bottom through a spontaneous airflow due to temperature difference.
- Therefore, both ends of the filter should be ventilated (TILLEY et al. 2008),).
- The primary factors that must be considered in the design of *trickling filters* include
- the type of filter media to be used
- the spraying system, and
- the configuration of the under-drain system

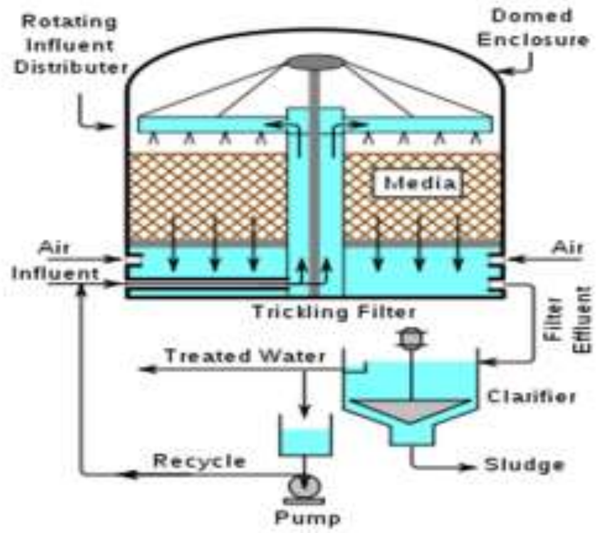
Filter media

- The ideal filter material is low-cost and durable, has a high surface to volume ratio, is light, and allows air to circulate.
- Whenever it is available, crushed rock or gravel is the cheapest option. Specially manufactured plastic media, is also used.
- The particles should be uniform and 95% of them should have a diameter between 7 and 10 cm.
- A material with a specific surface area between 45 and 60 m^2/m^3 for rocks and 90 to 150 m^2/m^3 for plastic packing is normally used. Larger pores (as in plastic packing) are less prone to clogging and provide for good air circulation.
- Primary treatment is also essential to prevent clogging and to ensure efficient treatment. Plastic sheets or hollow plastic cylinders, that optimise surface area for bacteria to attach free movement of air are also available.

Trickling Filter system



Trickling Filters

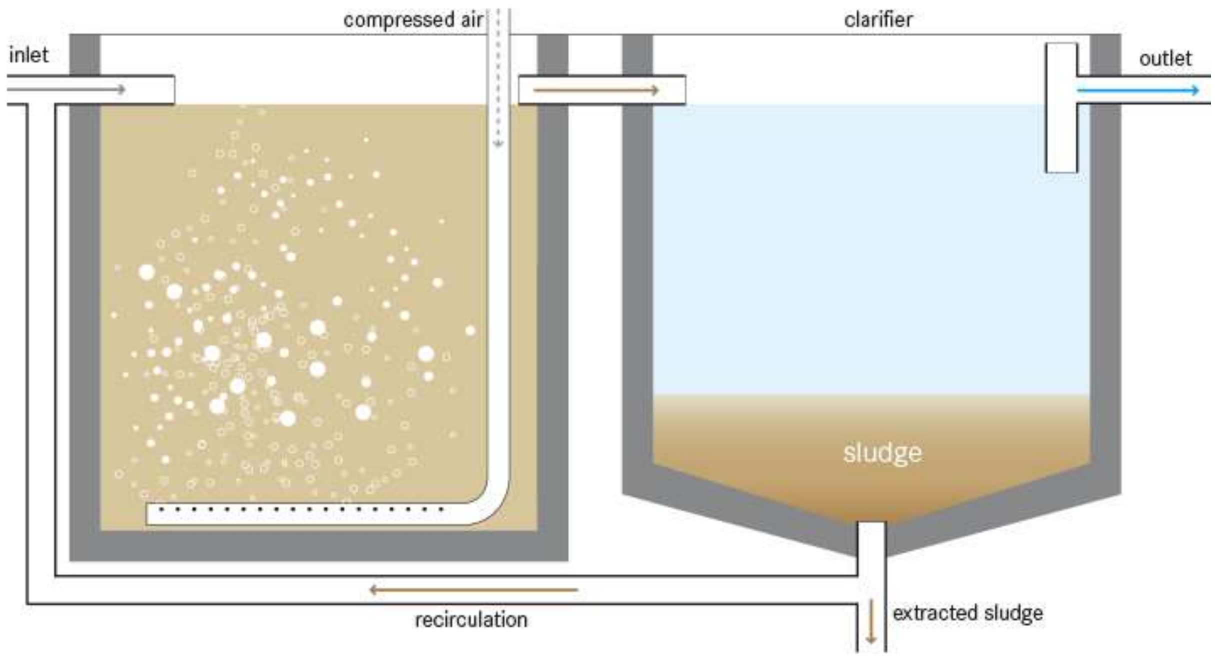


- The underdrains should provide a passageway for air at the maximum filling rate. A perforated slab supports the bottom of the filter, allowing the effluent and excess sludge to be collected.
- The trickling filter is usually designed with a recirculation pattern for the effluent to improve wetting and flushing of the filter material.
- With time, the biomass will grow thick and the attached layer will be deprived of oxygen; it will enter an endogenous state, will lose its ability to stay attached and will slough off (U.S. EPA 2000). High-rate loading conditions will also cause **sloughing**.
- When *microbes* fall off the medium and are carried with the effluent, this process is known as **sloughing** (U.S. EPA 2000)

Activated Sludge Process

- The term activated sludge refers to suspended aerobic sludge consisting of flocs of active bacteria, which consume and remove aerobically biodegradable organic substances from screened or screened and pre-settled wastewater.
- Activated sludge systems can treat greywater, faecal sludge and industrial wastewater as long as the pollutants to be treated are biodegradable.

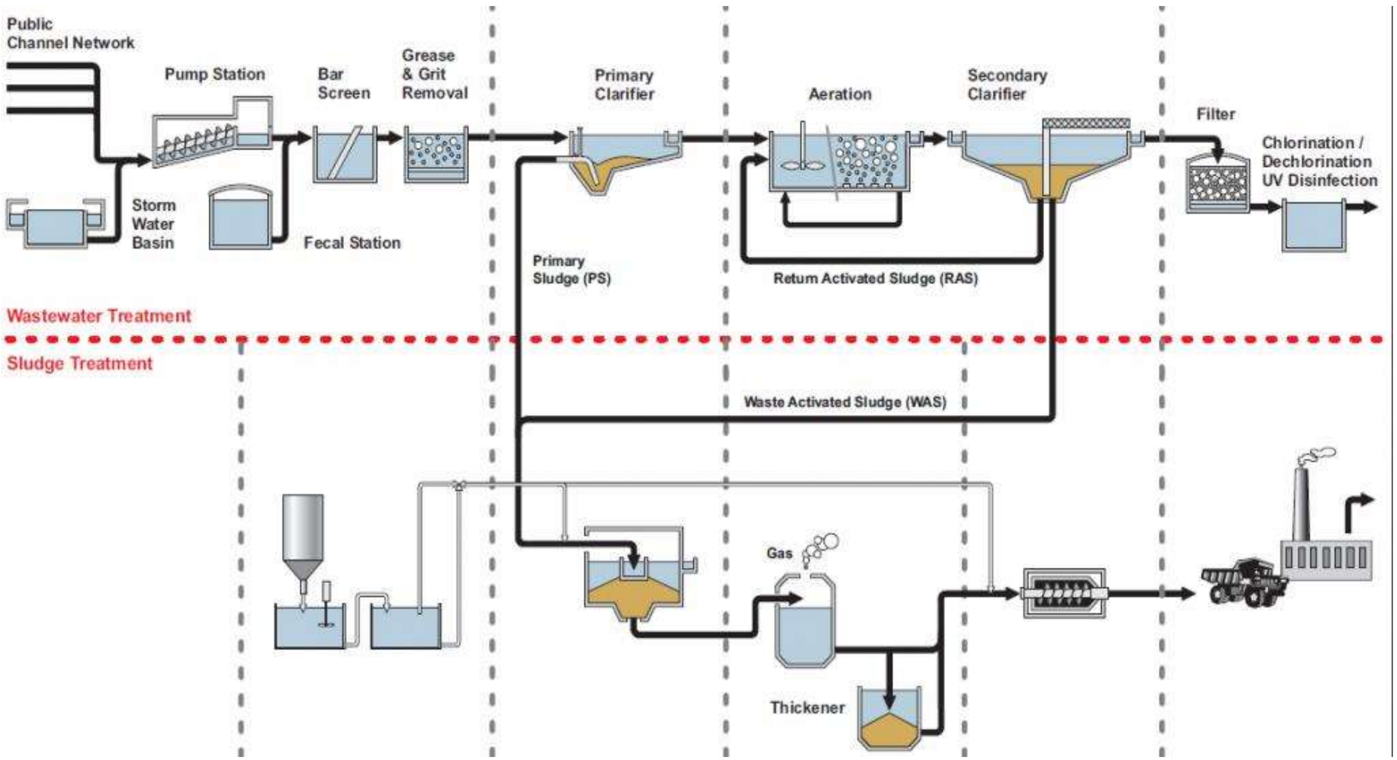
Schematic of the aeration tank and secondary settling tank (clarifier) of an activated sludge system. Source: Tilley et al. (2014)



- Different configurations of the activated sludge process can be employed to ensure that the wastewater is mixed and aerated in an aeration tank.
- Aeration and mixing can be provided by pumping air or oxygen into the tank or by using surface aerators.
- The microorganisms oxidize the organic carbon in the wastewater to produce new cells, carbon dioxide and water. Although aerobic bacteria are the most common organisms, facultative bacteria along with higher organisms can be present.
- The exact composition of bacteria depends on the reactor design, environment, and wastewater characteristics.
- The flocs (agglomerations of sludge particles), which form in the aerated tank, can be removed in the secondary clarifier by gravity settling.
- Some of this sludge is recycled from the clarifier back to the reactor. The effluent can be discharged into a river or treated in a tertiary treatment facility if necessary for further use.


Activated Sludge Process
Screens
Grit Removal
Primary clarifier
Ultra Violet
Disinfection
Final clarifier
Aeration section
Primary sludge
Return Activated Sludge
Waste Sludge
Incineration
Sludge storage tanks
Belt Press
Trucked to the Landfill
Bioset

Activated sludge process



Waste stabilization Ponds

- Waste stabilization ponds are large man-made basins in which greywater, or faecal sludge can be treated to an effluent of relatively high quality and apt for the reuse in agriculture (e.g. irrigation) or aquaculture (e.g. macrophyte or fish ponds).
- They are semi-centralised treatment systems combined after wastewater has been collected.
- For the most effective treatment, WSPs should be linked in a series of three or more with effluent being transferred from the anaerobic pond to the facultative pond and, finally, to the aerobic pond.
- The anaerobic pond is the primary treatment stage and reduces the organic load in the wastewater. The entire depth of this fairly deep man-made lake is anaerobic.
- Solids and BOD removal occurs by sedimentation and through subsequent anaerobic digestion inside the accumulated sludge . Anaerobic bacteria convert organic carbon into methane and through this process, remove up to 60% of the BOD.

- In a series of WSPs, the effluent from the anaerobic pond is transferred to the facultative pond, where further BOD is removed. The top layer of the pond receives oxygen from natural diffusion, wind mixing and algae-driven photosynthesis.
- The lower layer is deprived of oxygen and becomes anoxic or anaerobic. Settleable solids accumulate and are digested on the bottom of the pond. The aerobic and anaerobic organisms work together to achieve BOD reductions of up to 75%.
- Anaerobic and facultative ponds are designed for BOD removal, while aerobic ponds are designed for pathogen removal.
- An aerobic pond is commonly referred to as a maturation, polishing, or finishing pond because it is usually the last step in a series of ponds and provides the final level of treatment.
- It is the shallowest of the ponds, ensuring that sunlight penetrates the full depth for photosynthesis to occur. Photosynthetic algae release oxygen into the water and at the same time consume carbon dioxide produced by the respiration of bacteria. Because photosynthesis is driven by sunlight, the dissolved oxygen levels are highest during the day and drop off at night. Dissolved oxygen is also provided by natural wind mixing.

- The major disadvantages of WSPs are a rather long process of days to week (MARA & PEARSON 1998 in ROSE 1999) and requirement of large areas of land far away from homes and public spaces for the construction (DFID 1998).
- However, because of the low capital and particularly low O&M costs it is a good option for decentralised treatments in developing countries. In addition, it is one of the few low-cost natural processes, which provides good treatment of pathogens.

Comparison of the treatment performance of different waste stabilisation ponds. Source: WSP (2007)

Pond	BOD Removal	Pathogen Removal	HRT
Anaerobic Pond	50 to 85%		1 to 7 days
Facultative Pond	80 to 95%		5 to 30 days
Maturation Pond	60 to 80%	90%	15 to 20 days

Anaerobic Pond

- The main function of anaerobic ponds is BOD removal, which can be reduced 40 to 85 % (WSP 2007). As a complete process, the anaerobic pond serves to:
- Settle undigested material and non-degradable solids as bottom sludge
- Break down biodegradable organic material
- BOD removal in anaerobic ponds is governed by the same mechanisms that occur in all other anaerobic reactors (MARA et al. 1992) and anaerobic ponds do not or only rarely contain algae.
- The process relies on the sedimentation of settable solids and subsequent anaerobic digestion in the resulting sludge layer.
- During anaerobic digestion, biogas is produced which could be collected by covering the anaerobic pond with a floating plastic membrane.

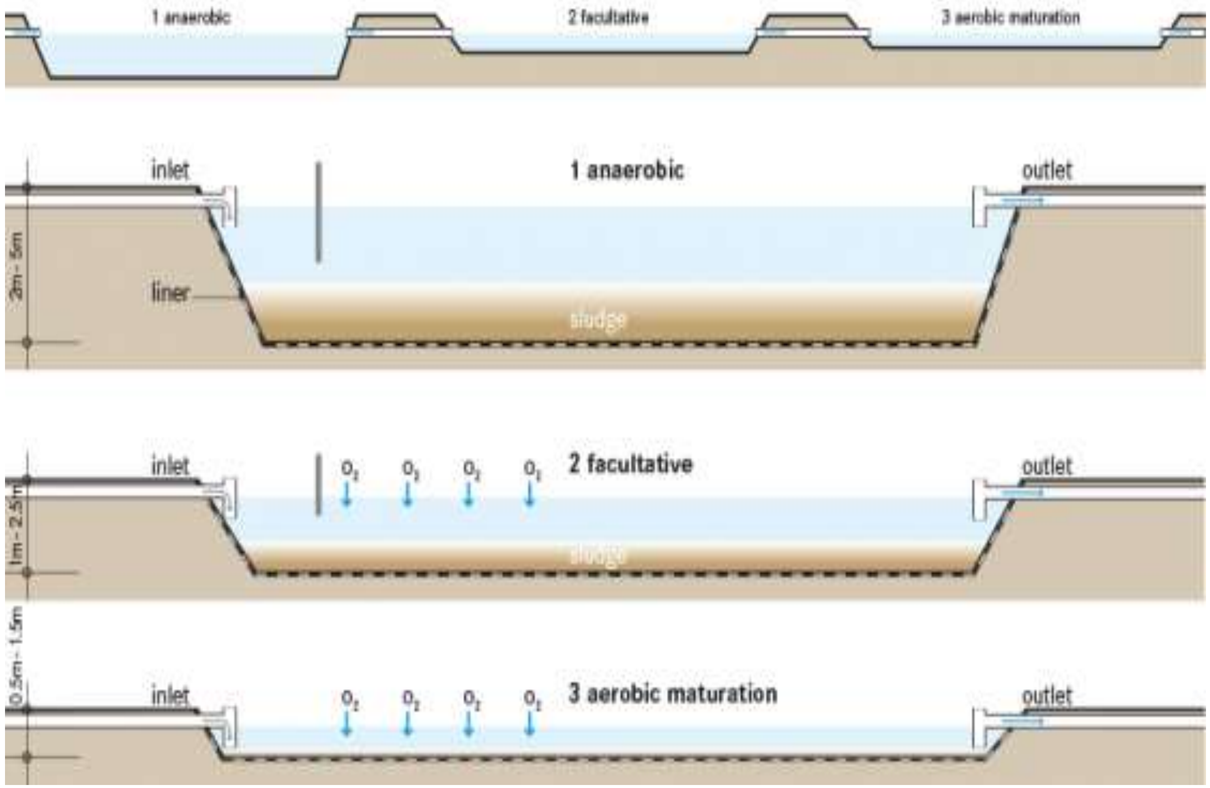
Facultative treatment ponds

- Facultative Treatment Ponds are the simplest of all WSPs and consist of an aerobic zone close to the surface and a deeper, anaerobic zone. They are designed for BOD removal and can treat water in the BOD range of 100 to 400 kg/ha/day corresponding to 10 to 40 g/m2/day at temperatures above 20°C (MARA and PEARSON, 1998).
- The algal production of oxygen occurs near the surface of aerobic ponds to the depth to which light can penetrate (i.e. typically up to 500 mm). Additional oxygen can be introduced by wind due to vertical mixing of the water.
- The facultative pond serves to:
- Further treat wastewater through sedimentation and aerobic oxidation of organic material
- Reduce odour
- Reduce some disease-causing microorganisms if pH raises
- Store residues as bottom sludge

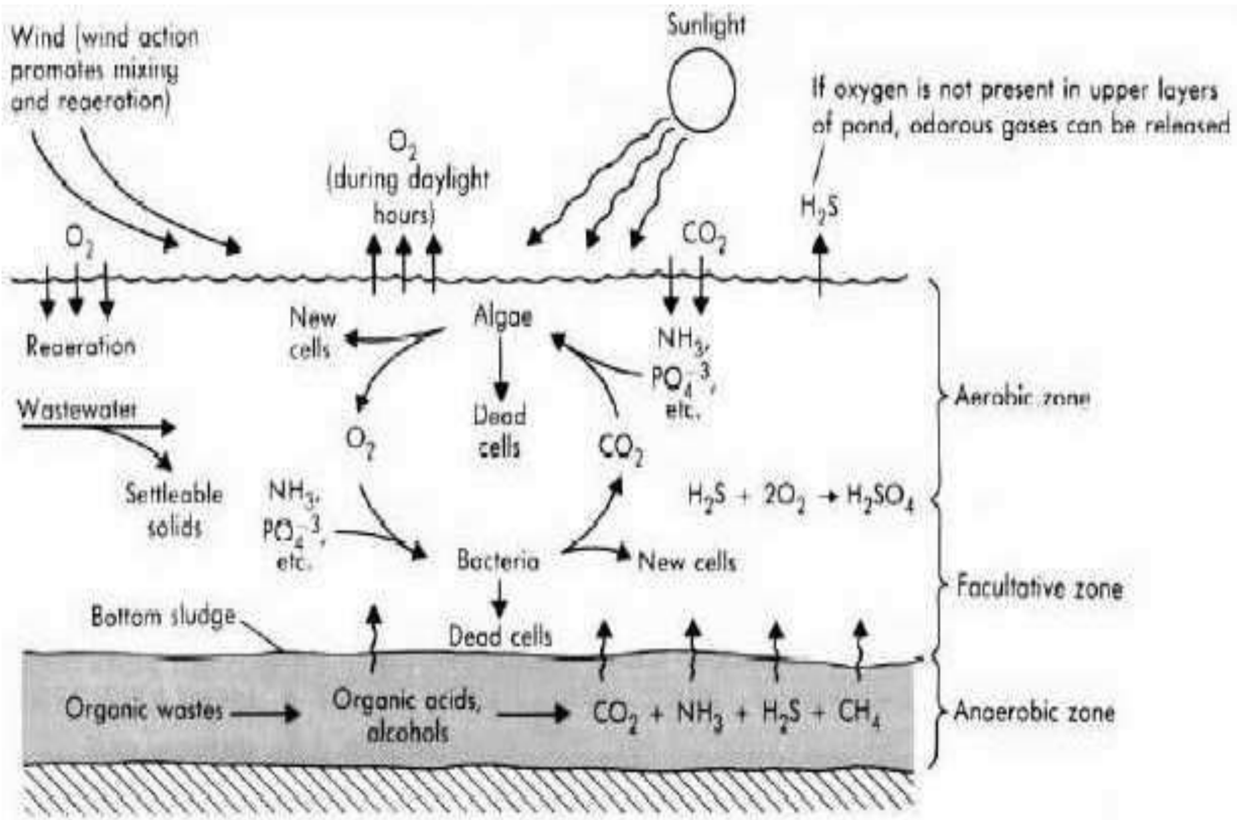
Aerobic Ponds

- Whereas anaerobic and facultative ponds are designed for BOD removal, maturation or polishing ponds are essentially designed for pathogen removal and retaining suspended stabilised solids (MARA et al. 1992; SASSE, 1998; TILLEY et al. 2008).
- The size and number of maturation ponds depends on the required bacteriological quality of the final effluent.
- The principal mechanisms for faecal bacterial removal in facultative and maturation ponds are HRT, temperature, high pH (> 9), and high light intensity.
- Virus and microorganisms get also removed. If used in combination with algae and/or fish harvesting, this type of pond is also effective at removing the majority of nitrogen and phosphorus from the effluent

WSP


1 anaerobic
2 facultative
3 aerobic maturation
inlet
1 anaerobic
outlet
2m - 5m
liner
sludge
inlet
2 facultative
outlet
1m - 2.5m
sludge
0.5m - 1.5m
inlet
3 aerobic maturation
outlet

Pathways of BOD removal in
facultative waste stabilisation ponds



OXIDATION POND

- Oxidation ponds, also known as stabilization ponds or lagoons, are shallow, man-made bodies of water designed to treat wastewater through natural biological processes. These ponds utilize the power of sunlight and microbial activity to break down organic matter and remove contaminants from sewage, industrial effluents, or agricultural runoff before the treated water is discharged into the environment or reused.

The treatment process in oxidation ponds typically involves three zones:

1. Aerobic Zone: The surface layer of the pond, where oxygen is plentiful due to atmospheric diffusion and photosynthetic activity of algae and aquatic plants. Aerobic bacteria decompose organic matter, converting it into simpler compounds such as carbon dioxide, water, and minerals.

2. Anaerobic Zone**: The bottom layer of the pond, where oxygen is depleted due to microbial consumption and sedimentation. Anaerobic bacteria further degrade organic material in the absence of oxygen, producing gases such as methane and hydrogen sulfide.

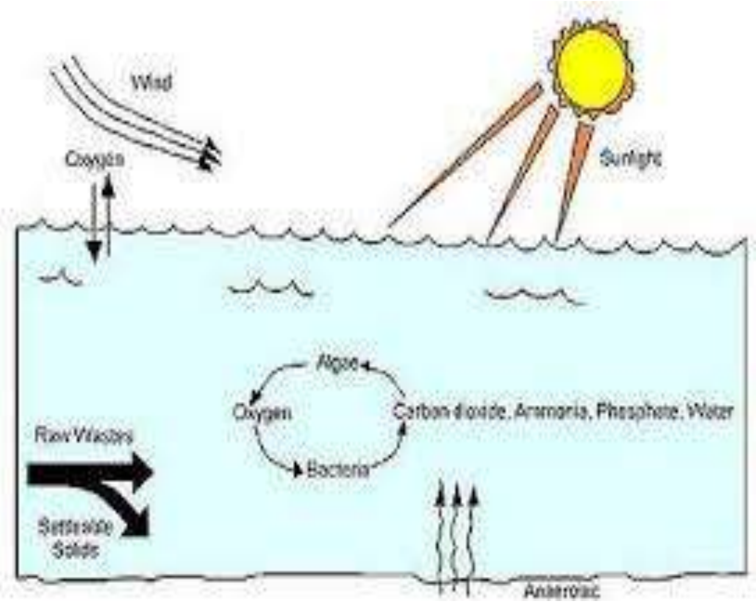
3. Algal Zone: Algae and aquatic plants proliferate in the shallow waters of the pond, utilizing nutrients like nitrogen and phosphorus for growth. Algal photosynthesis helps oxygenate the water and remove nutrients, enhancing the overall efficiency of the treatment process.

Key features and benefits of oxidation ponds include:

- -Low Operating Costs: Oxidation ponds are relatively low-cost wastewater treatment solutions compared to conventional treatment plants, as they rely on natural processes and minimal mechanical equipment.
- - Minimal Energy Requirements: Since oxidation ponds operate primarily through passive mechanisms such as sunlight-driven photosynthesis and microbial activity, they consume minimal energy, making them environmentally sustainable options for wastewater treatment.

- - Efficient Removal of Pathogens: The combined action of sunlight exposure, microbial predation, and competition in oxidation ponds helps in reducing pathogen concentrations, thereby improving the microbiological quality of treated effluent.
- - Versatility and Adaptability: Oxidation ponds can be designed and operated to suit various wastewater characteristics and treatment objectives, making them suitable for diverse applications ranging from municipal sewage treatment to industrial and agricultural wastewater treatment.
- However, oxidation ponds also have limitations and considerations:
- - Land Requirement: Oxidation ponds require significant land area for construction, which may be a constraint in densely populated or urbanized areas with limited available space.
- - Climate Sensitivity: Performance of oxidation ponds can be influenced by climatic factors such as temperature, sunlight intensity, and precipitation, which may vary seasonally and regionally.
- - Longer Treatment Time: Compared to conventional treatment processes, oxidation ponds typically have longer detention times, which may necessitate larger footprint and land area for effective treatment.
- Overall, oxidation ponds offer a cost-effective and environmentally sustainable approach to wastewater treatment, particularly in areas with favorable climatic conditions and ample land availability. However, careful design, operation, and monitoring are essential to ensure optimal performance and compliance with regulatory standards for effluent quality.

Oxidation Pond

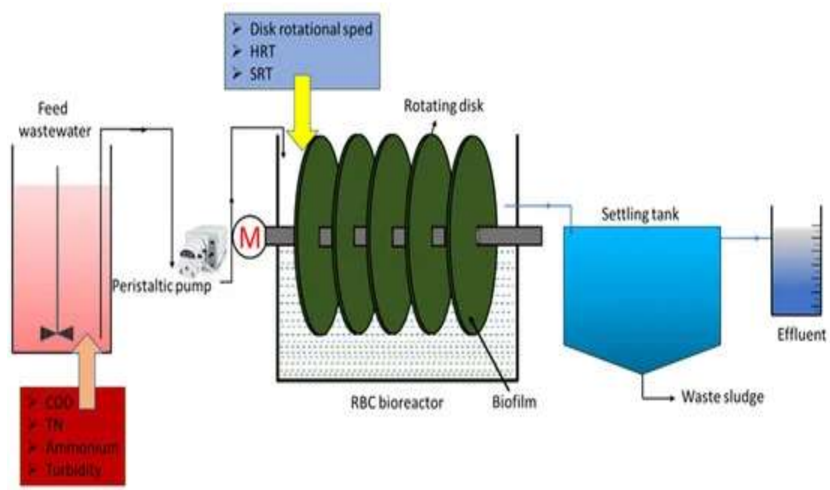


ROTATING BIOLOGICAL CONTACTER

- In this treatment system a series of large plastic disks mounted on a horizontal shaft are partially submerged in primary effluent. As the shaft rotates, the disks are exposed alternately to air and wastewater, allowing a layer of bacteria to grow on the disks and to metabolize the organics in the wastewater.

RBC

Schematic diagram of an RBC bioreactor.



- Principles of the Rotating Biological Contactor
- In the Rotating Biological Contactor, wastewater is purified using microorganism membranes which are attached to disks. The disks slowly rotate with approximately 40% of surface area submerged in the wastewater.
- By absorbing oxygen from the air and pollutants from the wastewater, the pollutants are decomposed aerobically. While new microorganisms are continuously increase on the disks, old microorganisms whose activation has declined drop off the disks.
- The biofilm in an RBC bioreactor comprises multiple layers, with the outermost layers containing aerobic bacteria that consume organic matter and produce carbon dioxide and water .
- Deeper layers of the biofilm may contain anaerobic bacteria that break down more complex organic compounds. The biofilm is constantly exposed to oxygen as the discs rotate, promoting aerobic microorganisms' growth and activity. Deeper layers of the biofilm may be anoxic or anaerobic, meaning that they are not exposed to oxygen .
- Microorganisms may use different electron acceptors to break down organic matter in these layers. In the anoxic layer, microorganisms may use nitrate or other oxidized nitrogen compounds as electron acceptors, while in the anaerobic layer, they may use sulfate or other oxidized sulfur compounds

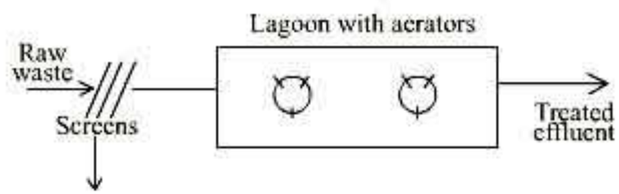
Organics Removal

- RBC is widely used for biological wastewater treatment due to its high efficiency in organic matter removal, including COD. The COD removal efficiency of an RBC bioreactor depends on various factors, including the characteristics of the influent wastewater, design and operational parameters, and the microbial population in the biofilm .
- The characteristics of the influent wastewater, such as the concentration and nature of organic matter, affect the COD removal efficiency of the RBC. High OLR decreases COD removal efficiency, as the biofilm may not have sufficient time to degrade the organic matter. The nature of organic matter, biodegradability, and toxicity, also impacts COD removal efficiency.
- Design and operational parameters of the RBC, such as the disc rotational speed, HRT, and temperature, also affect the COD removal efficiency .
- The disc rotational speed determines the biofilm thickness and the exposure to the wastewater, thus affecting the efficiency of COD removal. HRT should be optimized to ensure sufficient contact time between the wastewater and the biofilm for efficient COD removal .
- Temperature affects microbial activity and COD removal efficiency, as high temperatures lead to increased biological activity and improved removal efficiency .
- Overall, RBC bioreactors achieve high COD removal efficiencies, with reported values ranging from 70% to 95%.
- However, the removal efficiency depends on the influent wastewater characteristics, design and operational parameters, and other factors that may affect the performance of the RBC bioreactor .

Aerated lagoons

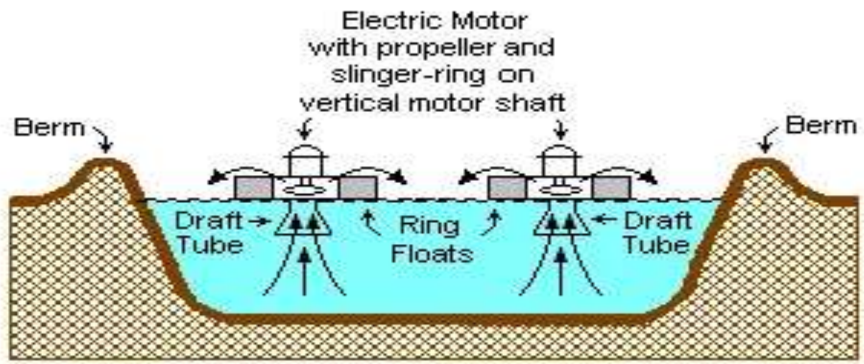
- Aerated lagoons fall in between the algal ponds and activated sludge systems. Oxygen is supplied through aeration. The unit is deeper (3 to 5 m) and hence require much less land than algal ponds.

An aerated lagoon system



Types of aerated lagoons or basins

- **There are many methods for aerating a lagoon or basin:**
- Motor-driven floating surface aerators
- Motor-driven submerged aerators
- Motor-driven fixed-in-place surface aerators
- Injection of compressed air through submerged diffusers



A TYPICAL SURFACE – AERATED BASIN

Note: The ring floats are tethered to posts on the berms.

- A Typical Surface-Aerated Basing (using motor-driven floating aerators) Ponds or basins using floating surface aerators achieve 80 to 90% removal of BOD with retention times of 1 to 10 days. The ponds or basins may range in depth from 1.5 to 5.0 meters.
- In a surface-aerated system, the aerators provide two functions: they transfer air into the basins required by the biological oxidation reactions, and they provide the mixing required for dispersing the air and for contacting the reactants (that is, oxygen, wastewater and microbes).
- Typically, the floating surface aerators are rated to deliver the amount of air equivalent to 1.8 to 2.7 kg O_2/kWh. However, they do not provide as good mixing as is normally achieved in activated sludge systems and therefore aerated basins do not achieve the same performance level as activated sludge units.

Aerated lagoons, also known as aerated stabilization ponds or aerobic ponds, are wastewater treatment systems that utilize mechanical aeration to promote the growth of aerobic bacteria for the breakdown of organic matter. These lagoons are engineered systems designed to enhance the natural processes occurring in oxidation ponds by providing controlled aeration and mixing to optimize treatment efficiency.

Here's how aerated lagoons typically function:

1. Aeration: Mechanical aerators, such as surface aerators or diffused aeration systems, are used to introduce oxygen into the wastewater. This aeration promotes the growth and activity of aerobic bacteria, which thrive in oxygen-rich environments and metabolize organic pollutants.

2. Mixing: Aeration devices also serve to mix the wastewater within the lagoon, ensuring uniform distribution of oxygen and nutrients and preventing the formation of stratified layers. Adequate mixing helps in maximizing contact between the wastewater and aerobic bacteria, thereby enhancing treatment performance.

3. Biological Treatment: As organic matter is aerobically decomposed by bacteria, it is converted into simpler compounds such as carbon dioxide, water, and microbial biomass. Nutrients like nitrogen and phosphorus may also be assimilated by microbial communities, leading to their removal from the wastewater.

4. Clarification: Treated effluent undergoes clarification as suspended solids settle out due to gravity or are entrapped within microbial flocs. Clarified effluent is then discharged or subjected to further treatment processes depending on the desired quality standards and regulatory requirements.

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