Primary and Secondary Treatment

- Sewage is a mixture of domestic and industrial wastes.
- It is more than 99% water, but the remainder contains some ions, suspended solids and harmful bacteria that must be removed before the water is to be released outside.
- Wastewater is not just sewage. All the water used in the home that goes down the drains or into the sewage collection system is wastewater. This includes water from baths, showers, sinks, dishwashers, washing machines etc.

- Wastewater is about 99 percent water by weight and is generally referred to as influent as it enters the wastewater treatment facility.

- “Domestic wastewater” is wastewater that comes primarily from individuals, and does not generally include industrial or agricultural wastewater.

- The biological treatment of wastewater is divided into three phases primary treatment secondary treatment, & : tertiary treatment.

1. Primary treatment

Screening

- Large solids (i.e. those with a diameter of more than 2cm) and grit (heavy solids) are removed by screening.

- removes the large solids (such as rags and sticks) that are carried in with the wastewater.

- These are removed by screens consisting of metal bars which are placed across the influent channels. Larger suspended or floating objects are held back in the **screening chambers.**

- After screening waste waters are run through a series of **grit chambers**. These chambers contain large stones or brick ballast.

- Passage through these chambers removes much of coarse particulate material.

- Special mechanical devices are also available to remove coarse particles from waste waters. These are known as **hydrocyclones** or **centrifugal separaters.**

- The sewage is subjected to **rapid circular motion** in hydrocyclones which generates strong centrifugal force.

- The coarse particles are pushed towards the periphery of the circular chambers. Clean water is drawn out from the centre of the tank.

- Waste water still contain plenty of fine particulate material. To remove these they are stocked in large tanks for a variable period of time which depends upon the nature of suspended material.

- Lighter particles float over the surface. Heavier ones settle down. Later the liquid is drawn out from the middle layers which leaves the upper and lower layers back in the sedimentation tank.

- Oils, fats and greases are also retained in the upper layers as they are lighter. These tanks , therefore combine the process of floatation as well as sedimentation.

- In order to make the process of floatation more effective some emulsifying or foaming agent may be added to the tank and the contents of the tank agitated with the help of compressed air or mechanically.

- Particles gets adsorbed on to the surface of the bubbles and come up on the surface. This process is known as **froth floatation**. Certain chemicals and coagulants may also be used to raise the efficiency of the process of sedimentation.

- A coagulant is finely powdered material which is mixed waste waters. Its particles add on to the lighter particles present in the sewage and make them heavier which facilitates their sedimentation. This process is commonly known as **coagulation**.

- Salts of iron, aluminium, activated silica etc. are used as coagulants.

- The practice of adding or flocculants improves the efficiency of process in primary treatment.

- But it suffers from the basic disadvantage that such substances are added in waste waters which later interfere with the process of biodegradation in the secondary phase of the treatment.

Secondary Treatment

- Primary treatment removes most of the solids and particulate materials.
- Waste waters now have plenty of dissolved organic matter. It may also contain a little amount of very fine organic debris and particulate materials.
- It is now subjected to secondary treatment which is in fact the **biological treatment.**

- Secondary treatment is carried out to convert organic matter present in sewage into a stable form by oxidation or nitrification.

- Secondary treatment normally utilizes biological treatment processes (activated sludge, trickling filters, etc.) followed by settling tanks and will remove approximately 85% of the BOD and Total suspended solids in wastewater.

- Secondary treatment for municipal wastewater is the minimum level of treatment required by the Clean Water Act.

- There are two kinds of secondary treatments:
  - **Aerobic treatment**
  - **Anaerobic treatment**

Aerobic Treatment

- Involves biodegradation in presence of oxygen. Conditions suitable for rapid growth & multiplication of microorganisms are created in especially designed filters or tanks.

- Proper temperature and availability of oxygen are the two important requirements of the treatment.

- Low temperatures slows down the growth and activity of the microbes. Lack of oxygen inhibits aerobic activity.

- Aerobic treatment is usually carried out in

1. **Trickling filters**
2. **Oxidation ponds**.

Trickling filters

- The sewage is gently sprayed over the filter beds and allowed to trickle down through a thick layer of sand and gravel, prepared over a perforated plate.

- As it moves down, the microbial population which occur in different zones of the filter beds cause rapid oxidation or mineralisation of organic matter content of the liquid. These giant filters are called **trickling filters**.

- These are beds of coarse media (often stones or plastic) 3-10 ft. deep. Wastewater is sprayed into the air (aeration), then allowed to trickle through the media.

- Microorganisms attached to and growing on the media, break down organic material in the wastewater. Trickling filters drain at the bottom; the wastewater is collected and then undergoes sedimentation.

- Many such filters are equipped with means to force compressed air through pipes under the filter bed.
- The air provides oxygen to the microbial populations. The microbial populations grow and multiply in-between the sand and gravel particles.
- These includes various bacteria, green and blue green algae, diatoms in upper zone where plenty of light is available.

Conventional Trickling Filter

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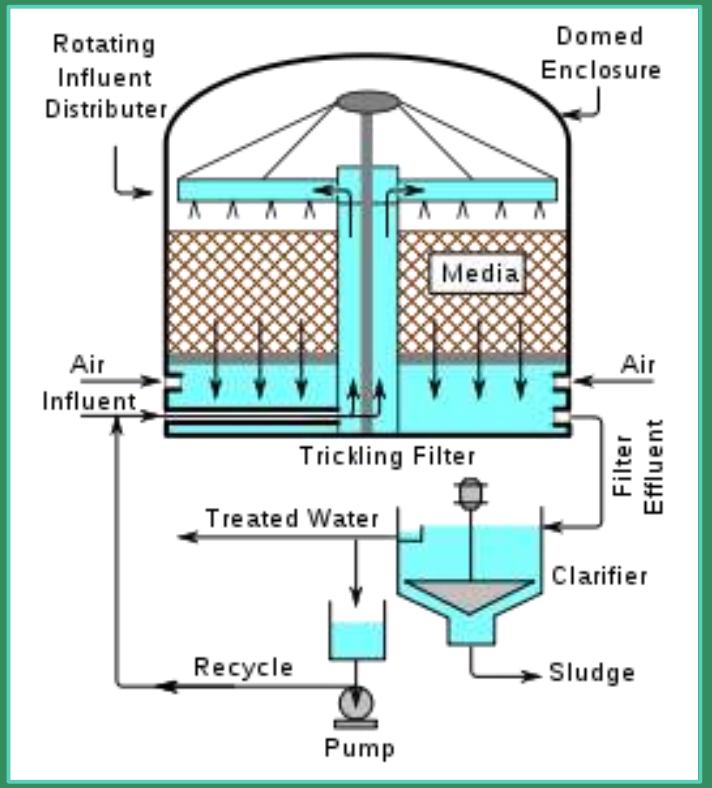

- In the lower zone various fungi, bacteria, protozoans, and other small animals which live and thrive on dead and decaying organic matter are found.

- Passage through biologically active layers oxidises much of the organic matter present in the waste waters.

- After treatment in trickling filters, waste waters are usually subjected to further oxidation in a series of tanks which are referred to as **oxidation pond**.

Oxidation Pond

- Treatment in an oxidation pond, also known as aeration tanks, involves slow passage of waste waters, through a large tank in which a large number & variety of microorganisms are added. Waste waters are mixed with **activated sludge** in this tank.

- **Activated sludge** is a solid or semi-solid sediment derived from the settlement of particulate matter in waste waters. It comprises of complex mixture of microbes present in sewage. It also includes pathogenic organisms.

When dry it forms a dark coloured powder, 1 gm of which may contain as many as 10^{14} bacteria.

- Activated sludge treatment is the most common option and uses microorganisms in the treatment process to break down organic material with aeration and agitation, then allows solids to settle out.

- Bacteria-containing “activated sludge” is continually recirculated back to the aeration basin to increase the rate of organic decomposition.

- The specific composition of microbes in sludge depends chiefly on the composition of waste water.
- These microbes rapidly decompose most of the organic matter present in water.
- Compressed air is blown through the bottom of the tank which provides oxygen necessary for the oxidative decomposition.

- The liquid from the tank is then taken out to the settling tanks where activated sludge and other particulate material is allowed to settle down and the clear supernatant is taken out for disinfection and final disposal or subjected to tertiary treatment.

2. Anaerobic treatment

- Involves degradation of organic wastes under conditions of oxygen deficit or its total absence.

- Many of the common heterotrophs of the soil, water and intestinal track are anaerobes or facultative anaerobes.

- These microbes acting together possess a remarkable capacity to decompose proteins, fats, carbohydrates, cellulose, woody materials, phenols, and many other complex substances.

- The products of anaerobic degradation are reduced substances such as hydrogen sulphide, ammonia, methane & other simpler compounds.

- Methane is a common product of anaerobic degradation of organic matter which can be used as a fuel gas.

- Solid material left after anaerobic decomposition is rich in plant nutrients. It can also be used as fertilizers.

- Septic tanks are employed for anaerobic treatment of waste waters. A septic tank is usually a large elongate reservoir with a curved or funnel like bottom.

- Lighter part (solids, greases and fats) of the sewage rises to the surface to form a continuous layer to form **floating scum.**

- The sludge as well as floating scum thus are then retained in the tank for several months.

- During this period they undergo decomposition by anaerobic bacteria to gasses and liquids through a process called sludge digestion.

- And there occurs a reduction in the volume of sludge to be disposed off.

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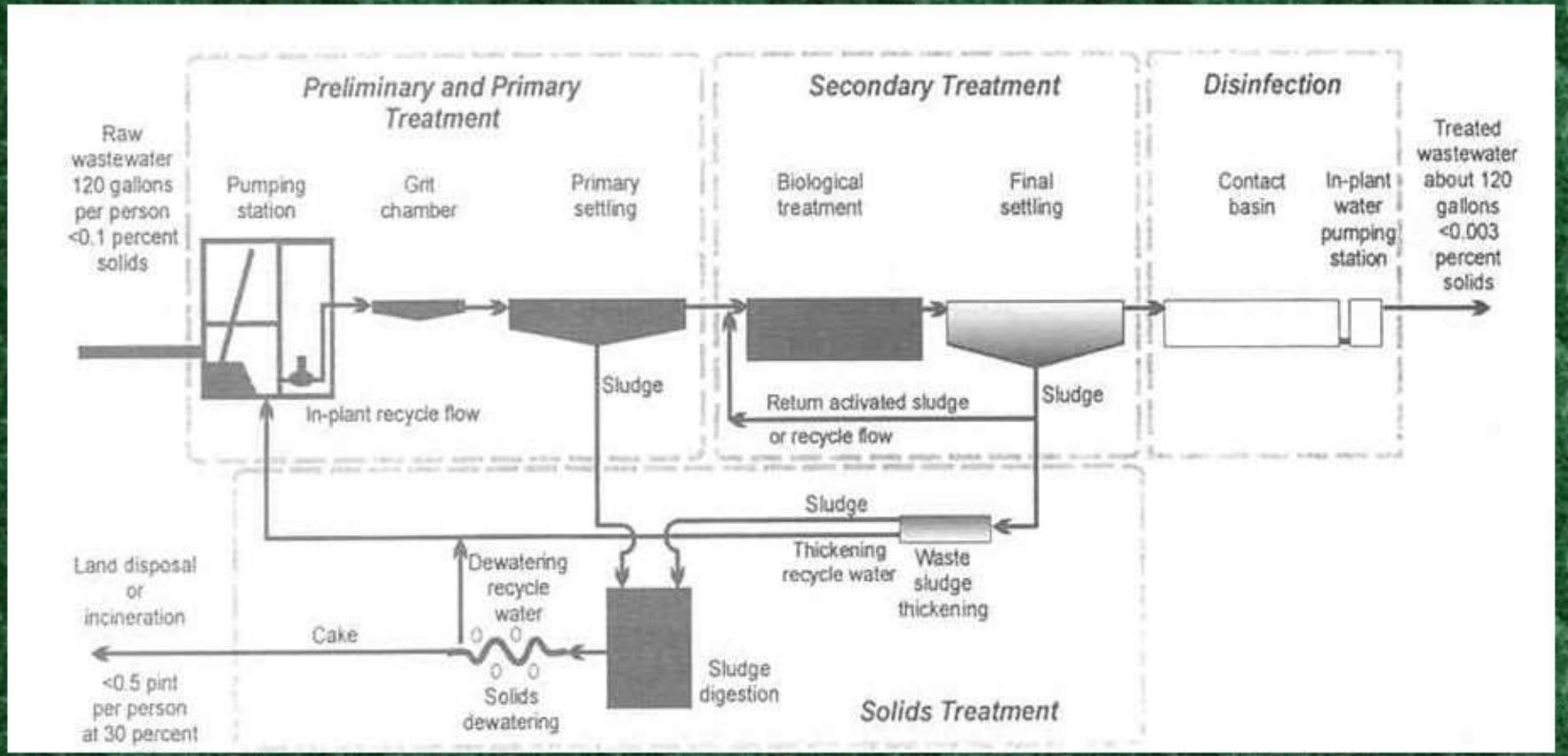
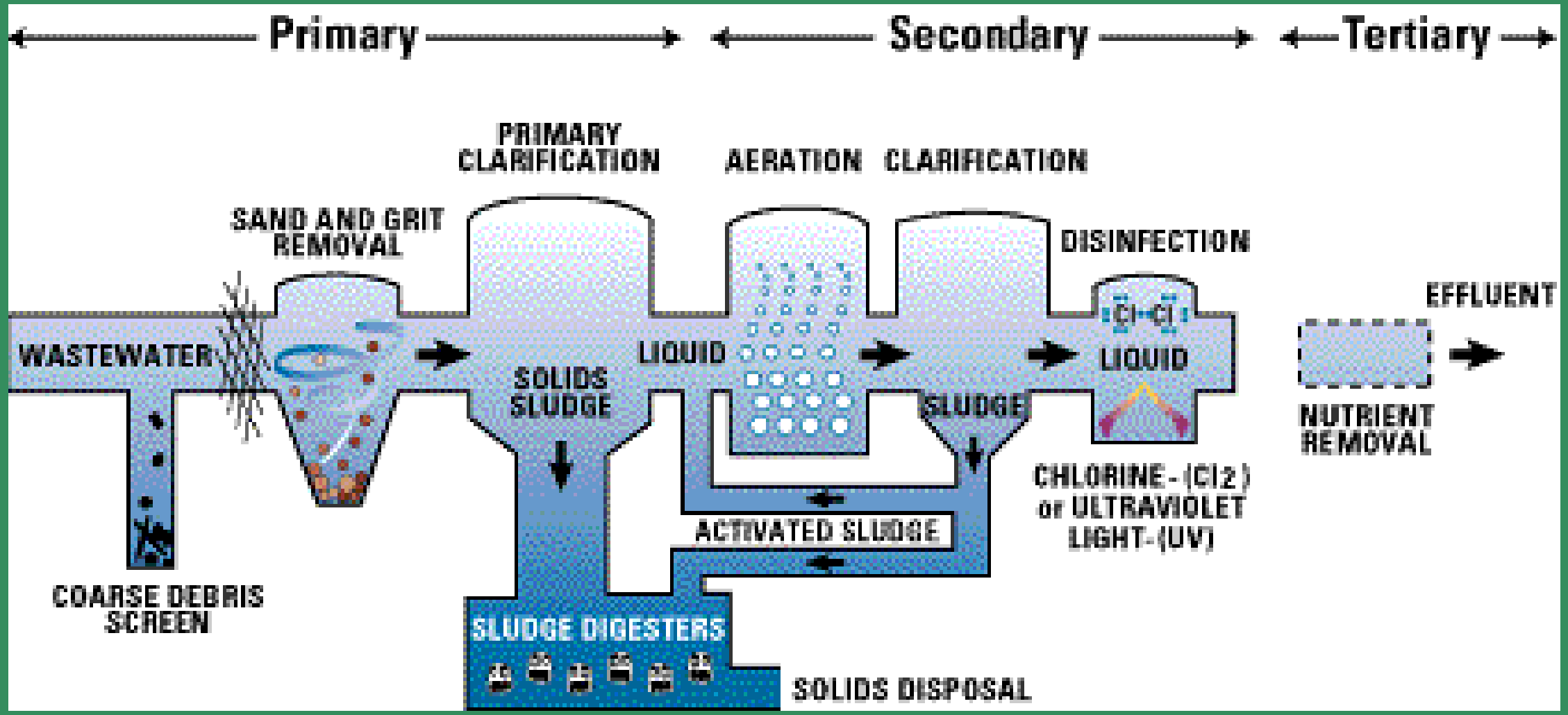
Secondary Treatment Processes



- After primary and secondary treatment, municipal wastewater is usually disinfected using chlorine (or other disinfecting compounds, or occasionally ozone or ultraviolet light).

- An increasing number of wastewater facilities also employ tertiary treatment, often using advanced treatment methods.

- Tertiary treatment may include processes to remove nutrients such as nitrogen and phosphorus, and carbon adsorption to remove chemicals. These processes can be physical, biological, or chemical.


Primary
Secondary
Tertiary
PRIMARY CLARIFICATION
AERATION
CLARIFICATION
SAND AND GRIT REMOVAL
DISINFECTION
EFFLUENT
WASTEWATER
LIQUID
SOLIDS SLUDGE
LIQUID
SLUDGE
NUTRIENT REMOVAL
ACTIVATED SLUDGE
CHLORINE - (Cl2) or ULTRAVIOLET LIGHT - (UV)
COARSE DEBRIS SCREEN
SLUDGE DIGESTERS
SOLIDS DISPOSAL

Sludge Disposal

- Sludge is semi-solid slurry produced from solids of the sewage, accumulated at the bottom of the settling tanks.

- Sludge contains moisture in varying proportions ranging from 90-95% and has a specific gravity almost same as that of water.

Sludge Disposal Methods

1. Disposal on land

- Sludge can be disposed on land either by ploughing or trenching.

- In ploughing the sludge is mixed with lime or milk of lime or powdered lime.

- It is then allowed to spread on land and which is then ploughed.

- In trenching method, trenches are made and then filled with sludge.
- Then a thin layer of soil is placed over it to cover the sludge.
- This method requires plenty of land.

2. Distribution by pipelines

- In this method the sludge is send through pipes lines to nearby farms, where it will be used as fertilizers.

3. Drying on drying beds

- The sludge is discharged on a bed of earth which has underdrains.

- The latter consists of open-jointed pipes over which gravel and sand are piled up.

- The sludge is allowed to dry and the liquid which enters the pipe is drained away in to a natural stream.

- The dried sludge is made in to cakes which are used as fertilizers. The sludge can also be dumped into low lying areas or buried or incinerated.

4. Dumping in to Sea

- Sludge is discharged in to Sea through pipelines. Sludge should be sufficiently deep in the sea to avoid any chances of possible nuisance by the sludge.

5. Lagooning or Ponding

- A lagoon is a shallow pit formed by excavating the ground. The sludge is conveyed and discharged in to the lagoon. The wet sludge is allowed to dry by natural process. The sludge dries in 2-6 months and the dried sludge can be used as manure. This method is cheap but causes foul smell and fly nuisance. The lagoons may be covered with lime or fine soil to educe fly nuisance as well as odour. This method is usually carried out in non-residential areas.

6. Sludge digestion

- It is the decomposition of complex organic substances present in sludge to simple stable compound by biochemical reactions with the help of anaerobic bacteria.

- The sludge is first digested in sludge digestion tanks and is then dried on sludge digestion beds.

- The digestion of sludge takes place in 3 stages:

a) **In acid production stage,** anaerobic bacteria acts upon simple compounds such as sugar, starch, cellulose, soluble nitrogen compounds and fermentation occurs and as a result, decomposition products such as acids and gasses are produced. The gasses produced includes CH_4, CO_2, and H_2S and pH of sludge during this stage will be between 5-6 and BOD also increases to some extent.

b) In acid regression stage, organic acids and nitrogenous compounds are converted to acid carbonates and ammonia compounds by anaerobic bacteria.

- In this stage, the decomposed sludge has a foul smell & is foamy in nature and it tends to rise to the surface to form scum. The pH will be between 6 -7 and BOD also remains high.

c) In alkaline fermentation stage, bacteria converts proteins and some organic compounds to ammonia, organic acids and gases.

- This is the final stage of sludge digestion. Liquid separate out from solids and the digested sludge thus formed is known as ripened sludge. pH will be about 7.5 and BOD reduces greatly.

Combined Aerobic and Anaerobic Treatment Process

- Anaerobic digestion is among the oldest processes used for the stabilization of solids and biosolids.
- Anaerobic technology has been traditionally used for excess sludge digestion in wastewater treatment plants.
- Because of the emphasis on energy conservation and recovery, anaerobic digestion continues to be the dominant process for stabilizing sludges.

- Systems composed of anaerobic units followed by aerobic processes for effluent polishing utilize the benefits of both technologies.

- Series of reactors of anaerobic-aerobic processes have been shown feasible for treating municipal wastewaters in warm climates resulting in lower energy requirements and less sludge production.

- The combination of both anaerobic processes (excess sludge stabilization and wastewater pretreatment) in a

single anaerobic unit would represent an enormous advantage for these combined (anaerobic pretreatment-aerobic polishing.

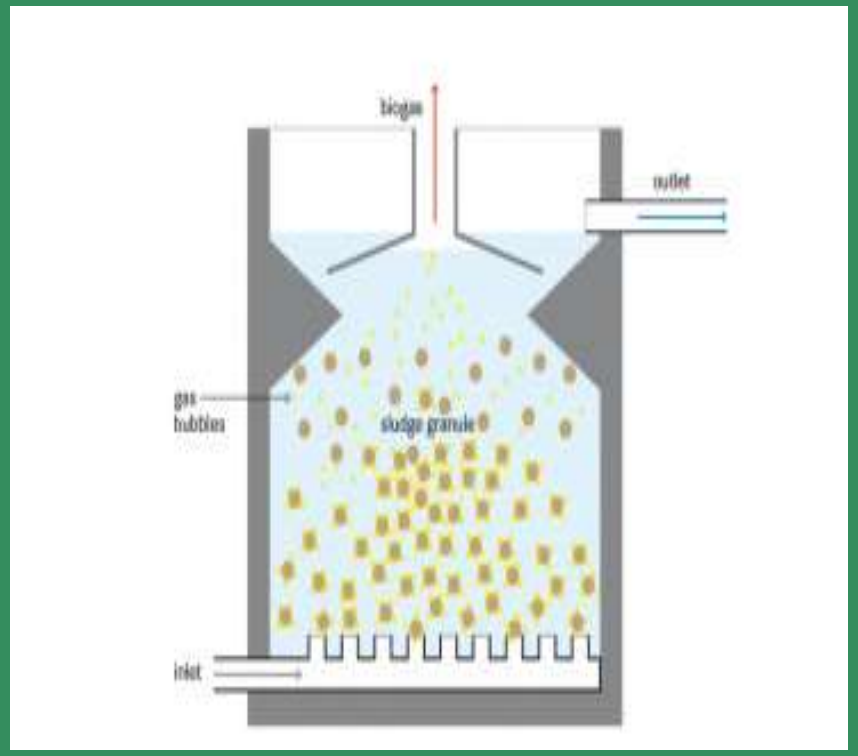
- Combined anaerobic-aerobic treatment concept is composed of a **UASB reactor** (Upflow Anaerobic Sludge Blanket reactor) with complementary secondary treatment in an activated sludge process and stabilization of the excess active sludge in the reactor.

- The upflow anaerobic sludge blanket reactor (UASB) is a single tank process in an anaerobic centralised or decentralised industrial wastewater or black water treatment system achieving high removal of organic pollutants.

- Wastewater enters the reactor from the bottom, and flows upward. A suspended sludge blanket filters and treats the wastewater as the wastewater flows through it.

- Bacteria living in the sludge break down organic matter by anaerobic digestion, transforming it into biogas.
- Solids are also retained by a filtration effect of the blanket.
- The upflow regime and the motion of the gas bubbles allow mixing without mechanical assistance.
- Baffles at the top of the reactor allow gases to escape and prevent an outflow of the sludge blanket.

- As all aerobic treatments, UASB require a post-treatment to remove pathogens, but due to a low removal of nutrients, the effluent water as well as the stabilised sludge can be used in agriculture.



Cross-section of an Upflow Anaerobic Sludge Blanket (UASB) reactor.

Advantages of USAB reactor

Advantages

- High reduction of BOD
- Can withstand high organic and hydraulic loading rates
- Low sludge production (and, thus, infrequent desludging required)
- Biogas can be used for energy (but usually first requires scrubbing)
- No aeration system required (thus little energy consumption)
- Effluent is rich in nutrients and can be used for agricultural irrigation
- Low land demand, can be constructed underground and with locally available material
- Reduction of CH_4 and CO_2 emissions

Disadvantages of USAB reactor

Disadvantages

- Treatment may be unstable with variable hydraulic and organic loads
- Requires operation and maintenance by skilled personnel; difficult to maintain proper hydraulic conditions (upflow and settling rates must be balanced)
- Long start-up time to work at full capacity
- A constant source of electricity is required
- Not all parts and materials may be locally available
- Requires expert design and construction
- Effluent and sludge require further treatment and/or appropriate discharge
- Not adapted for cold regions