5.4 OPERATION AND MAINTENANCE ASPECTS OF SEWAGE TREATMENT PLANT

OBJECTIVES OF SLUDGE TREATMENT:

- To reduce the water content in the sludge and make it easier for treatment and disposal
- To destroy all the pathogens
- To reduce the volume of sludge
- To stabilize the organic matter

FORMS OF SLUDGE:

• Primary sludge – When raw sewage is settled in a primary clarifier, the suspended solids settle down by gravity. These are drawn out from the conical floor of the clarifier. This is called primary sludge (PS). It will have mostly organic substances and also inorganic substances. If it is stored, the organic substances will undergo anaerobic reaction as in Figure 5.2. This will result in production of Methane and Hydrogen Sulphide gases.

• Secondary sludge – When the sewage is aerated in aeration tanks, biological microorganisms grow and multiply. The aerated liquid is called the mixed liquor. It is settled in secondary clarifiers to separate the microorganisms by gravity. These are drawn out from the conical floor of the clarifier. This is called secondary sludge.

• Return sludge – A major portion of the secondary sludge is returned to the aeration tank for seeding the microorganisms. This is called return sludge (RS).

• Excess sludge – A small portion of secondary sludge is wasted. This is equal to secondary sludge minus return sludge. This is called excess sludge (ES) on waste sludge (WS).

• Chemical sludge – When raw sewage or secondary treated sewage is subjected to chemical precipitation, the resulting sludge is called chemical sludge (CS).

UNIT OPERATIONS AND PROCESSES:

Waste water treatment is any operation / process or combinations of operations and processes that can reduce the objectionable properties of waste water and render it less dangerous. Waste water treatment is a combination of physical, chemical and biological processes.

Methods of treatment in which application of physical forces predominate, are known as unit operations.

Methods of treatment in which chemical or biological activities are involved, known as unit processes.

The unit operations approach in water and waste water treatment has following advantages:

1. Gives better understanding of the processes and the capabilities of these processes in attaining the objectives.
2. Helps in developing mathematical and physical models of treatment mechanisms and the consequent design of treatment plants.
3. Helps in coordination of effective treatment procedure to attain the desired plant performance.

PHYSICAL UNIT OPERATIONS

OPERATION	APPLICATION
1. Screening	Removal of coarse and settleable solids bysurface straining
2. Comminution	Grinding of coarse solids
3. Flow Equalisation	Equalisation of flow and mass loadings ofBOD suspended solids.
4. Mixing	Mixing of chemicals and gases with waste water and maintaining solids in suspension

5. Flocculation	Promotion of aggregation of smaller particles into larger ones.
6. Sedimentation	Removal of settleable solids and thickeningof sludge.
7. Floatation	Removal of finely divided suspended solidsand particles. Also thickens biological sludge.
8. Filtration	Removal of fine residual suspended solids remaining after biological or chemical treatment.
9. Micro screening	Same as filtration. Also removal of algaefrom stabilization pond effluents

CHEMICAL UNIT PROCESSES

PROCESS	APPLICATION
1. Chemical Precipitation	Removal of phosphorous and enhancement of suspended solidsremoval in primary sedimentation
2. Gas Transfer	Addition and removal of gases
3. Adsorption	Removal of organics
4. Disinfection	Disinfection of disease causingorganisms
5. De chlorination	Removal of total combined chlorineresiduals
6. Miscellaneous	Achievement of specific objectives in waste water treatment

BIOLOGICAL UNIT PROCESSES

Biological unit processes are those in which removal of contaminants are brought about by biological activity in biological treatment of waste water, the objectives are to coagulate and remove the non settleable colloidal solids and to stabilize the organic matter. The waste water is generally from three sources

(i) domestic waste water (ii) agricultural return waste water (iii) industrial waste water For domestic waste water, the objectives are to remove various nutrients, specifically nitrogen and phosphorous, which are otherwise capable of stimulating growth of aquatic plants.

Biological processes are classified by the oxygen dependence of the primary microorganisms responsible for waste treatment.

Aerobic processes:

Biological treatment process that occurs in the presence of dissolved oxygen. The bacteria that can survive in the presence of DO are known as obligate aerobes. The aerobic process include the following:

1. Activated sludge process
2. Trickling filters

Anaerobic processes: Involves the decomposition of organic or inorganic matter in the absence of molecular oxygen

Maintenance Scheduling:

• Maintenance of each equipment is done as the recommendations of manufacturer.

• A History card is maintained for each equipment so that record is maintained for equipment performance and maintenance.

• Good housekeeping is an important aspect of plant operation.

Screening Chamber & Wet well:

• Regular Cleaning
• Disposal of Screenings
• Washing of Bar Screens
• Washing sludge layer from walls using water jet
• Desilting of wet well once a year

Receiving Chamber & Fine Screens:

• Should be scoured minimum once in a week.
• Fine Screens should be kept clean of all obstructions. If the screens are of mat type, its operation should be adjusted such that a mat is always on the screen.

Grit chamber:

• Should be used one at a time, alternatively every day.
• Should be cleaned every day.
• Proper & efficient removal of silt in grit channel will improve the functioning of treatment.

SCREENING:

A screen is a device with openings for removing bigger suspended or floating matter in sewage which would otherwise damage equipment or interfere with satisfactory operation of treatment units.

Types of Screens:

Coarse Screens

Coarse screens also called racks, are usually bar screens, composed of vertical or inclined bars spaced at equal intervals across a channel through which sewage flows. Bar screens with relatively large openings of 75 to 150 mm are provided ahead of pumps, while those ahead of sedimentation tanks have smaller openings of 50 mm.

Bar screens are usually hand cleaned and sometimes provided with mechanical devices. These cleaning devices are rakes which periodically sweep the entire screen removing the solids for further processing or disposal.

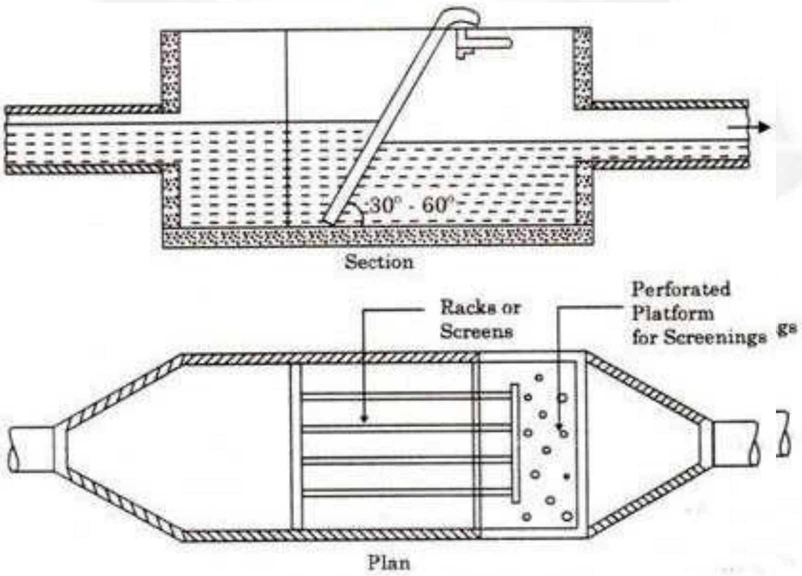
Hand cleaned racks are set usually at an angle of 45 °to the horizontal to increase the effective cleaning surface and also facilitate the raking operations. Mechanical cleaned racks are generally erected almost vertically. Such bar screens have openings 25% in excess of the cross section of the sewage channel.

Medium Screen

Medium screens have clear openings of 2 0t o 50 mm. Bar are usually 10 mm thick on the upstream side and taper slightly to the downstream side. The bars used for screens are rectangular in cross section usually about 10 x 50 mm, placed with larger dimension parallel to the flow.

Fine Screens

Fine screens are mechanically cleaned devices using perforated plates; woven wire cloth or very closely spaced bars with clear openings of less than 20 mm. Fine screens are not normally suitable for sewage because of clogging possibilities.



Bar Screen with Chamber

GRIT CHAMBER:

Grit is the heavy inorganic fraction of the wastewater solids. It includes road grit, sand, eggshells, ashes, charcoal, glass and pieces of metal; it may also contain some heavy organic matter such as seeds and coffee grounds. Grit has an average relative density of ~2.5 and thus it has a much higher settling velocity than organic solid s(~30 mm/s, compared with ~3 mm/s). There are two basic types of grit removal plant: constant velocity grit channels and the various proprietary grit tanks or traps available commercially.

Principle of Working of Grit Chamber

Grit chambers are like sedimentation tanks, designed to separate the intended heavier inorganic materials (specific gravity about 2.65) and to pass forward the lighter organic materials. Hence the flow velocity should neither be too low as to cause the settling of lighter organic matter, nor should it be too high as no to cause the settlement of the silt and grit present in the sewage. This velocity is called "differential sedimentation and differential scouring velocity".

The scouring velocity determines the optimum flow through velocity. This may be explained by the fact that the critical velocity of flow ' vc' beyond which particles of a certain size and density once settled, may be again introduced in to the stream of flow it should always be less than the scouring velocity of grit particles. The critical velocity of scour is given by Schield's formula:

$$V = 3 \text{ to } 4.5 (g(S_s - 1) d)^{1/2}$$

A horizontal velocity of flow of 15 t o 30 cm/sec is used at peak flows. This same velocity is to be maintained at all fluctuation of flow to ensure that only organic solids and not the grit is scoured from the bottom.

Horizontal Velocity in Flow Though Grit Chamber:

The settling of grit particles in the chamber is assumed as particles settling as individual entities and referred as Type – I settling. The grit chamber is divided in four compartments as inlet zone, outlet zone, settling zone and sludge zone.

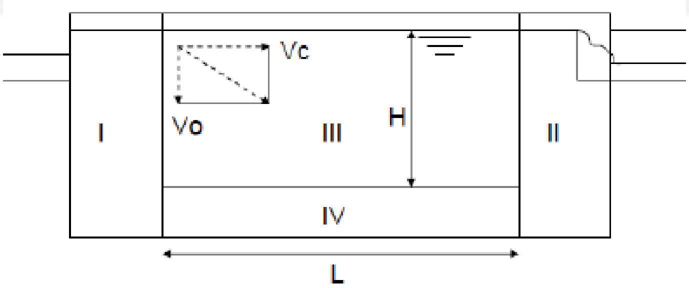


Figure: compartments of Grit chamber

Zone – I:
Inlet zone: This zone distributes the incoming wastewater uniformly to entire cross section of the grit chamber.
Zone – II:
Outlet zone: This zone collects the wastewater after grit removal.
Zone – III:
Settling zone: In this zone settling of grit material occurs.Zone – IV:
Sludge zone: This is a zone where settled grit accumulates.

L – Length of the settling zone
H – Depth of the settling zone
v – Horizontal velocity of wastewater
Vo – Settling velocity of the smallest particle intended to be removed in grit chamber.

Now, if Vs is the settling velocity of any particle, then
For Vs greater than equal to Vo these particles will be totally removed,
For Vs than less Vo, these particles will be partially removed,

Disposal of Grit:
Considerable quantities of grit will be collected at the sewage treatment plant, about 0.004 to 0.2 m3/ML. Quantity of grit will be more particularly for combined system. Necessary arrangement should be made at the treatment plant for collection, storage and disposal of this grit matter.
The grit collected can be disposed in the following manner:
-In large treatment plant, grit is incinerated with sludge.
-In the past, grits along with screening was dumped into sea.
-Generally, grit should be washed before disposal to remove organic matter.
-Land disposal after washing is most common.

PROBLEM
Design a grit chamber for population 50000 with water consumption of 135 LPCD.
Solution:
Average quantity of sewage, considering sewage generation 80% of water supply, is
= 135 x 50000 x 0.8 = 5400 m3/day = 0.0625 m3/sec
Maximum flow = 2.5 x average flow
= 0.0625 x 2.5 = 0.156 m3/sec
Keeping the horizontal velocity as 0.2 m/sec (<0.228 m/sec) and detention time periodas one minute.
Length of the grit chamber = velocity x detention time
= 0.2 x 60 = 12.0 m

Volume of the grit chamber = Discharge x detention time

= 0.156 x 60 = 9.36 m3

Cross section area of flow 'A' = Volume / Length = 9.36/12 = 0.777 m2 Provide width of the chamber = 1.0 m, hence depth = 0.777 m

Provide 25% additional length to accommodate inlet and outlet zones. Hence, the length of the grit chamber = 12 x 1.25 = 15.0 m

Provide 0.3 m free board and 0.25 m grit accumulation zone depth, hence total depth = 0.777 + 0.3 + 0.25 = 1.33 m and width = 1.0 m

5.4.1 STANDARDS OF EFFLUENT

SL. NO	PARAMETERS	STANDARDS			
		Inland surface water	Public sewers	Land of irrigation	Marine / coastal areas
1	Suspended solids mg/l, max.	100	600	200	a. For process waste water 100 b. For cooling water effluent 10 percent above total suspended matter of influent
2	Particle size of suspended solids	Shall pass 850 micron IS Sieve	-	-	a. Floatable solids, Solids max. 3 mm. b. Settleable solids. Max 856 microns
3	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
4	Temperature	Shall not exceed 5^0C above the Receiving water temperature.	-	-	Shall not exceed 5^0C above the receiving water temperature.
5	Oil and grease, Mg / l max.	10	20	10	20

6	Total residual chlorine, mg/l max	1.0	-	-	1.0
7	Total nitrogen (as N); mg/l, max.	100	-	-	100
8	Biochemical oxygen demand (3 days at 27oC), mg/l, max.	30	350	100	100
9	Chemical oxygen demand, mg/l,	250	-	-	250
10	Mercury (As Hg), mg/l, max.	0.01	0.01	-	0.01
11	Copper (as Cu) mg/l, max.	3.0	3.0	-	30

5.4.2 SEWAGE DISPOSAL

SEWAGE DISPOSAL ON LAND:

Disposal of Sewage Effluents on land for irrigation in this method the sewage effluent (treated or diluted) is generally disposed of by applying it on land.

The percolating water may either soon the water table or is collected below by a system of under drains. This method can then be used for irrigating crops.

This method in addition to disposing of the sewage may help in increasing crop yields (by 33% or so) as the sewage generally contains a lot of fertilizing minerals and other elements.

However the sewage effluent before being used as irrigation water must be made safe. In order to lay down the limiting standards for sewage effluents, and the degree of treatment required, it is necessary to study as to what happens when sewage is applied on to the land as irrigation water.

The pretreatment process may be adopted by larger cities which can afford to conduct treatment of sewage when sewage is diluted with water or disposal for irrigation too large volumes of dilution water are generally not needed, so as not to require too large areas for disposal.

DISPOSAL BY DILUTION:

Disposal by dilution is the process whereby the treated sewage or the effluent from the sewage treatment plant is discharged into a river stream, or a large body of water, such as a lake or sea. The discharged sewage in due course of time, is purified by what is known as self purification process of natural waters. The degree and amount of treatment given to raw sewage before disposing it off into the river stream in question, will definitely depend not only upon the quality of raw sewage but also upon the self purification capacity of the river stream and the intended use of its water.
Dilution Factor:
The ratio of the quantity of the diluting water to that of the sewage is known as the Dilution Factor.

Conditions favouring Disposal by dilution:
The dilution methods for disposing of the sewage can favourably be adopted under the following conditions.

- When sewage is comparatively fresh (4 to 5 hr old) and free from floating and settleable solids. (or are easily removed by primary treatment)

- When the diluting water (is the source of disposal) has a high dissolved oxygen (0-0) content.
- Where diluting waters are not used for the purpose of navigation or water supply for at least some reasonable distance on the downstream from the point of sewage disposal.
- Where the flow currents of the diluting waters are favourable, causing no deposition, nuisance or destruction of aquatic life.

When the out fall sewer of the city or the treatment plant is situated near some natural water having large volumes.

DISPOSAL OF DIGESTED SLUDGE:

The digested sludge from the digestion tank contains a lot of water, and is therefore, first of all, dewatered or dried up before further disposal either by burning or dumping. Dewatering, drying and disposal of sludge by sludge drying beds:

Drying of the digested sludge on open beds of land is quite suitable for hot countries like India. Sludge drying beds are open beds of land, 4 5to 60 cm deep and consisting of about 30 to 45 cm thick graded layer of gravel or crushed stone varying in size from 15 cm at bottom t o 1.25 cm a t op, and overlain by 10 to 15 cm thick coarse sand layer.

The sewage sludge from the digestion tank is brought and spread over the top of the drying beds to a depth of about 20 to 30 cm. A portion of the moisture drains through the bed while most of it is evaporated to the atmosphere. It usually takes about two weeks to two months for drying the sludge, depending on the weather and condition of the bed.

Disposal of dewatered sludge:

The dewatered sludge obtained from mechanical devices in western countries is generally heat dried, so as to produce fertilizers. The wet sludge after mechanical dewatering is sometimes directly disposed of either in sea or in underground trenches or burnt.

Disposal by dumping into the sea:

The dewatered wet sludge may sometimes be discharged at sea from hopper barges or through outfall sewers. This method can, however be adopted only in case of cities situated on sea shores and where the direction of the normal winds are such as to take the discharged sludge in to the sea away from the shore line.

Disposal by burial in to the Trenches:

In this method, the digested sludge without dewatering is run in to trenches. When the sludge has dried to a firm state, it is covered a top with a thin layer of soil. After about a month, the land is ploughed up with powered lime and planted with crops.

Disposal by incineration:

The dewatered wet sludge produced in waste water treatment plant may also be disposed of by burning in suitably designed incinerators, when sufficient space is not available for its burial near the plant site or the sludge cannot be dried and used as manure.

MECHANISM OF AEROBIC AND ANAEROBIC SLUDGE DIGESTION WITH MERITS AND DEMERITS:

Sludge digestion is a biochemical phenomenon involving organisms, enzymes, food and environment. The principal objective of sludge digestion is to subject the organic matter present in the settled sludge of the primary and final sedimentation tanks to anaerobic or aerobic decomposition so as to make it amenable to dewatering on sand beds or mechanical filter before final disposal on land, lagoon or sea. Sludge digestion brings about reduction in volume. While anaerobic digestion of sludge produces gas which can be utilized wherever feasible, aerobic digestion does not produce any utilizable by product other than well stabilized sludge.

Anaerobic digestion is the biological decomposition of organic matter in absence of oxygen. It consists of two distinct stages

First stage (Acid fermentation)

Second stage (Methane fermentation)

Advantages

a. Lower BOD concentration in digester supernatant

b. Production of odourless and easily dewaterable biologically stable digested sludge.

c. Recovery of more basic fertilizer value in digested sludge.

d. Lower capital cost

e. Fewer operational problems

Disadvantages

a. Higher power costs generate higher operating costs comparable with anaerobic digestion

b. Gravity thickening process following aerobic digestion and to generate high solids concentration in the supernatant

c. Some aerobically digested sledges do not dewater easily in vacuum filtration

d. No methane gas is produced for recovery as a byproduct.

ANAEROBIC SLUDGE DIGESTION:

General:

This is the biological degradation of organic matter in the absence of oxygen. In this process, much of the organic matter is converted to methane, carbon-dioxide and water and therefore, it is a net energy producer. Since, little carbon and energy alone is available to sustain further biological activity, the remaining solids are rendered stable.

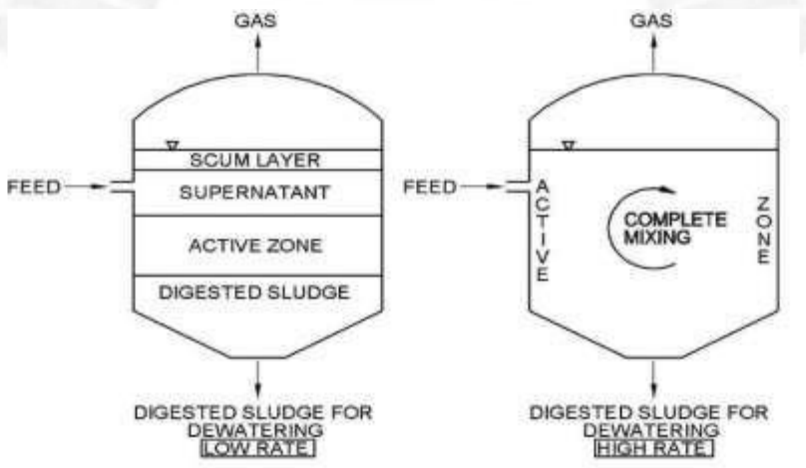
Microbiology of the Process:

Anaerobic digestion involves several successive biochemical reactions earned by a mixed culture of microorganisms. There are three degradation stages namely, hydrolysis, acid formation and methane formation.In the first stage of digestion, complex organic matter like proteins, cellulose, lipids are converted by extra cellular enzymes into simple soluble organic matter. In the second stage, soluble organic matter is converted by acetogenic bacteria into acetic acid, hydrogen, carbon dioxide and other low molecular weight organic acids. In the third stage, two groups of strictly anaerobic methanogenic bacteria, are active. While one group converts acetate into methane and bicarbonate, the other group converts hydrogen and carbon-dioxide into methane. For satisfactory performance of an anaerobic digester, the second and third stages of degradation should be in dynamic equilibrium, that is, the volatile organic acids should be converted into methane at the same rate as they are produced.

However, methanogenic microorganisms are inherently slow growing compared with the volatile acid formers and they are adversely affected by fluctuations in pH, concentration of substrates and temperature. Hence, the anaerobic process is essentially controlled by the methanogenic microorganisms.

Digestion Types:

Two different types in anaerobic sludge digestion processes are namely, low rate and high rate and are used in practice. The basic features are in Figure



Low Rate Digestion:

Raw sludge is fed into the digester intermittently. Bubbles of sewage gas are generated and their rise to the surface provides some mixing. In the case of few old digesters, screw pumps have been installed to provide additional intermittent mixing of the contents, say once in 8 hours for about an hour. As a result, the digester contents are allowed to stratify, thereby, forming four distinct layers: a floating layer of scum, layer of supernatant, layer of actively digesting sludge and a bottom layer of digested sludge; essentially the decomposition is restricted to the middle and bottom layers. Stabilized sludge that accumulates and thickens at the bottom of the tank is periodically drawn off from the centre of the floor. Supernatant is removed from the side of the digester and returned to the treatment plant.

High Rate Digestion:

The essential elements of high rate digestion are complete mixing and more or less uniform feeding of raw sludge. Pre-thickening of raw sludge and heating of the digester contents are optional features of a high rate digestion system. All these four features provide the best environmental conditions for the biological process and the net results are reduced digester volume requirement and increased process stability. Complete mixing of sludge in high rate digesters creates a homogeneous environment throughout the digester. It also quickly brings the raw sludge into contact with microorganisms and evenly distributes toxic substances, if any, present in the raw sludge. Furthermore, when stratification is prevented because of mixing, the entire digester is available for active decomposition, thereby increasing the effective solids retention time.

Pre-thickening of raw sludge before digestion results in the following benefits:

1. Large reduction in digester volume requirements
2. The thickener supernatant is of far better quality than digester supernatant; thereby, it has less adverse impact when returned to the STP
3. Less heating energy requirements
4. Less mixing energy requirements

NEED FOR SLUDGE DEWATERING AND EXPLAIN THE VARIOUS SLUDGE DEWATERING METHODS

Sludge dewatering:

Dewatering is a physical unit operation used to reduce the moisture content of the sludge and thus to increase the solids concentration.

Need for sludge dewatering:

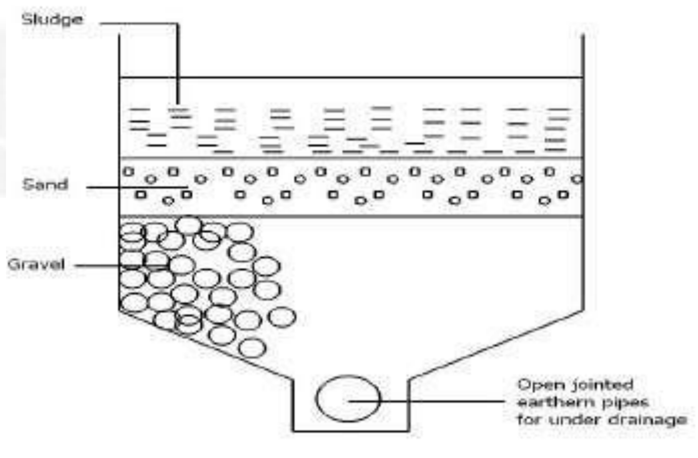
1. Cost of trucking sludge to ultimate disposal site is reduced because of reduced sludge volume consequent to dewatering.
2. Ease in handling dewatered sludge.
3. Increase in calorific value of sludge by removal of moisture, prior to incineration.
4. Rendering the sludge totally odourless and non-putrisible.
5. Sludge dewatering is commonly required prior to land filling to reduce lechate production at landfill site.

Various methods:

1. Sludge drying beds.
2. Mechanical methods.
3. Vacuum filters.

1. Sludge drying beds.

This method of dewatering and drying the sludge is especially suitable for those locations where temperature is higher,similar to the one prevailing in our country



A sludge drying bed usually consists of a bottom layer of gravel of uniform size over which is laid a bed of clean sand. Open jointed tile under drains are laid in the gravel layer to provide positive drainage as the liquid passes through the sand and gravel.

Under drains are made of vitrified clay pipes or tiles of at least 10cm diameter laid with open joint. Under drains are placed not more than 6m apart. Graded gravel is placed around the under drains in layers up to 30cm with a minimum of 15cm above the top of the under drains. At least 8cm of the top layer should consist of gravel of 3t o 6mm size.

Clean sand of effective size of 0. 5 to 0.75mm and uniform co-efficient not greater than 4.0 is placed over the gravel. The depth of sand may vary from 1 5t o 30cm. The drying beds are commonly 6t o 8m wide and 3 0t o 45m long. A length of 30m away from the inlet should not be exceeded with a single point of wet sludge discharge, when the bed slope is about 0.5% multiple discharge points should be used with large sludge beds to reduce the length of wet sludge travel. In order to have flexibility in operation, beds should be atleast two in number.

The area needed for dewatering the sludge is dependent on total volume of sludge, climate, temperature and location. Areas required for drying beds range from 0. 1t o 0.15m2/capita with dry solids loading of 60 to 120Kg/m2/year for digested mixed sludge. Sludge should be deposited evenly to a depth of not greater than 20cm.

When digested sludge is deposited on a well drained bed of sand described above, the dissolved gases tend to buoy up float the solids leaving a clear liquid at the bottom which drains off in a few hours after which drying commences by evaporation. The sludge cake shrinks producing cracks which accelerates evaporation from the sludge surface. With good drying conditions t, he sludge will dewater satisfactorily and become fit for removal in about 2t o 3 weeks producing a volume reduction of 20 to 40%.driedsludge can be removed by shovel or forks when the moisture content is less than 70%.when the moisture content reaches 40%, the cake becomes lighter and suitable for grinding wheel barrows or pickup trucks are used for hauling of sludge cakes.

2. Mechanical methods.

Vacuum filtration is the most common mechanical method of dewatering, filter presses and centrifugation being the other methods. Chemical conditioning is normally required prior to the mechanical methods of dewatering.

Mechanical methods may be used to dewater raw or digested sludge’s preparatory to heat treatment by vacuum filtration because the coarse solids are rendered fine during digestion. Hence filtration of draw primary or a mixture of primary and secondary sludge’s permits slightly better yields, lower chemical requirements and lower cake moisture contents than filtration of digested sludge’s.

When the ratio of secondary and primary sludge increase, it become more and more difficult to dewater the filter. The feed solids concentration would demand unduly large filter surface I. n t his method, conditioned sludge is spread out in a thin layer on t he filtering medium, the water portion being separated due to the vacuum and the moisture content is reduced quickly.

3. Vacuum filters:

Vacuum filters consists of a cylindrical drum over which is laid a filtering medium of wool, cloth or felt, synthetic fiber or plastic or stainless steel mesh or coil springs. The drum is suspended horizontally so that one quarter of its diameter is submerged in a tank containing sludge. The valves and piping's are arranged to apply a vacuum on the inner side of the filter medium as the drum rotates slowly in the sludge. The vacuum holds the sludge against the drum as it continues to be applied as the drum rotates out of the sludge tank. This pulls water away from the sludge leaving a moist cake mat at the outer surface. The sludge cake on the filter medium is scraped from the drum just before it enters the sludge tank again. The filtration rate is expressed in kg of dry solids per square meter of medium per hour. It varies from 10kg/m2/h for activated sludge alone to 50kg/m2/hr f \or primary sludge's.

SLUDGE THICKENING:

This is to thicken the concentration of sludge solids generated in the clarifier to make sludge digestion and sludge dewatering more effective. Sludge to be thickened may be primary sludge or combined sludge from primary and excess sludge. Thickening may be broadly classified into three types namely, gravity, centrifugal and floatation. The floatation can further be dissolved-air floatation or dispersed-air floatation. When the thickening of sludge is inadequate, the filtrate from dewatering will have large amounts of suspended solids returning to the STP and affect the water quality.

Hence, excess sludge is increasingly being mechanically thickened using centrifugal thickening machines or floatation thickeners. Moreover, when performing sludge treatment for sludge collected from various STPs, sludge with varying properties is likely to be treated; therefore, forced sludge thickening process such as by using mechanical thickening equipment is indispensable. De gritting and debris removal equipment preferably be installed as the pre-treatment process before thickening unless the STP itself has such facilities in the raw sewage stage.

Gravity Thickening:

Gravity thickening is the most common practice for concentrating the sludge. It is adopted for primary sludge or combined primary and activated sludge, but is not successful in dealing with excess sludge independently. Gravity thickening of combined sludge is not effective when excess activated sludge exceeds 40% of the total sludge weight. In such cases, other methods of thickening of the excess activated sludge have to be considered.

Gravity thickeners are either continuous flow or fill and draw type, with or without addition of chemicals. Use of slowly revolving stirrers improves the efficiency. Continuous flow tanks are deep circular tanks with central feed and overflow at the periphery. They are designed for a hydraulic loading of 20,000 to 25,000 lpd/m2. Loading rates less than 12.000 lpd/m2 are likely to give too much solids to permit this loading hence, it is necessary to dilute the sludge with plant effluent and it is referred to as dilution water. Better efficiencies can be obtained for gassy sludge by slow revolving stirrers.

Air Floatation Thickening:

Air floatation units employ floatation of sludge by air under pressure or vacuum and are normally used for thickening the waste activated sludge. These units involve additional equipment, higher operating costs, higher power requirements, and more skilled maintenance and operation. However, the removal of oil and grease, solids, grit and other material as also odour control are distinct advantages.

In the pressure type floatation units, a portion of the subnatant is pressurized from 3 to 5 kg/cm2 and then saturated with air in a pressurization chamber. The effluent from this is mixed with influent sludge immediately before it is released into the flotation tank. Excess dissolved air then rises up in the form of bubbles at atmospheric pressure attaching themselves to particles which form the sludge blanket. Thickened blanket is skimmed off while the un-recycled subnatant is returned to the plant.

The vacuum type employs the addition of air to saturation and applying vacuum to the unit to release the air bubbles which float the solids to the surface. The efficiency of air floatation units is increased by the addition of chemicals like alum and polyelectrolytes. The addition of polyelectrolytes does not increase the solids concentration, but improves the solids recovery rate from 90% to 98%.

Centrifugal Thickening:

Thickening by centrifugation is applied only when there is space limitation or sludge characteristics will not permit the adoption of the other two methods. This method involves high maintenance and power costs. Centrifuges employed are of either disc or solid bowl type. Disc centrifuges are prone to clogging while the latter gives a lower quality of effluent.

Sludge Feed Pump:
Decide the sludge feed pump after considering the following:

1. Select a pump with adequate capacity.
2. Install separate pumps for each centrifugal thickener.

Appurtenances:

Decide the appurtenances after considering the following:

1. If necessary, install de-gritting and debris removal equipment before thickening.
2. Install sludge feed tank.
3. Install thickened sludge storage tank.
4. Install water supply system for internal cleaning of the centrifugal thickener and for cooling the bearing.
5. Install equipment for controlling the water content of thickened sludge.
6. If necessary, install chemical dosing equipment.

SEWAGE SICKNESS:

When sewage is applied continuously, once the Piece of land, the soil pores or void may get filled up and clogged with sewage matter retained in them. The time taken for such a clogging will, of course depend upon the type and the load prevent in sewage. But when once these voids are clogged, free circulation for air will be prevented and anaerobic conditions will develop on the pores. Due to this the aerobic decompositionof organic matter will stop, and anaerobic decomposition will start. The organic matter will there, of course, be minor load but with the evolution of foul gases like H_2S, CO_2, CH_4. This phenomenon of soil getting clogged is known as sewage sickness of land

Preventive measure in adopted for sewage sickness

1. Primary treatment of sewage
2. Choice of land
3. Under-drainage of soil.
4. Giving rest to the land.
5. Rotation of crops
6. Applying shallow depths.

SEWAGE FARMING:

When sewage is applied on agricultural land for the growth of crops, then it is termed as sewage farming. The sewage contains much fertilizing elements such as nitrates,sulphates and phosphates.These elements are extracted from the soil by the roots of the plants.

Conditions of sewage farming:

The following conditions should be remembered while providing the method of sewage farming

a. The farm should be located far away from the locality, because it may create bad smell and insanitary condition.
b. The raw sewage should never be supplied to the farm.
c. It is better to apply the sewage after primary treatment.
d. Precautions should be taken to avoid sewage sickness.

Sewage is discharged on vacant land which is provided underneath with a system of properly laid under drains. These under drains basically consist of 15 to 20 cm river process tile pipes, load open founded at a spacing of 12 to 30 m. The effluent collected in these drains after getting filtered through the pores is a generally small (as a large quantity gets evaporated) and well stabilized, and can be early disposal into some natural water courses, without any further treatment.

In case of sewage farming, however the trees are load upon the use of sewage efficient for irrigation crops and increasing the fertility of the soil. The pre-treatment of sewage in removing the ingredients which may prove harmful and toxic to the plant is therefore, necessary in this case.

Application of sewage:

The sewage may be applied on the land by the following methods

1. Surface irrigation system
2. Sub-surface irrigation system
3. Sprinkler irrigation system

1. Surface irrigation system

This system may be of following types

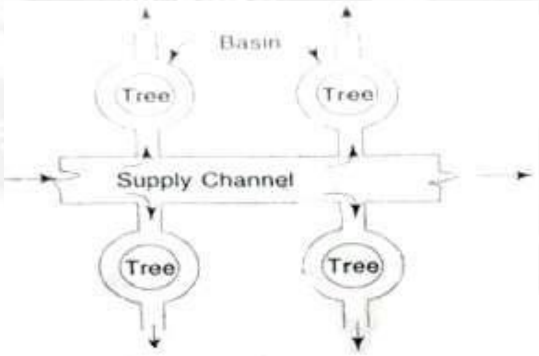
a) Basin method

b) Furrow method

c) Flooding method

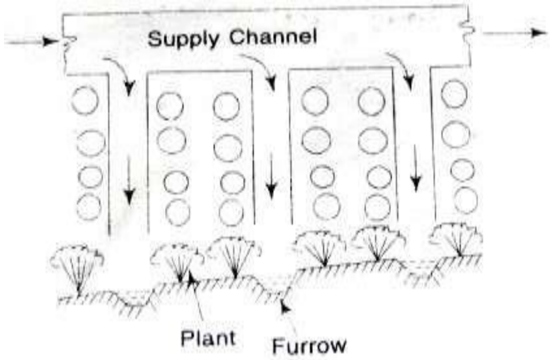
a) Basin method

In this method, each tree or group of trees are enclosed by circular channel through which sewage flows. This circular channel is known as basin. The basins are connected to the supply channel. When the basins are filled up, the supply is cut-off.



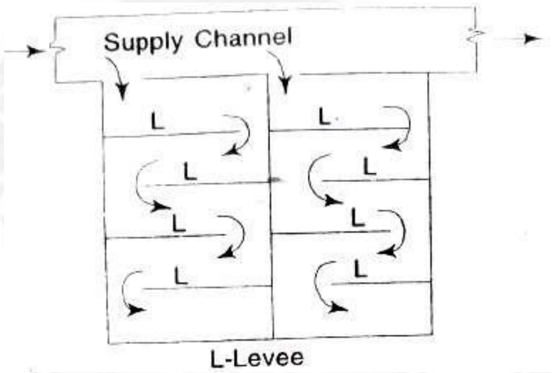
b) Furrow method

In this method, the sewage is supplied to the land through narrow channels, which are known as furrows. This method is suitable for the crops which are sown in rows. The crops are potato, ground nut, sugar cane, etc.



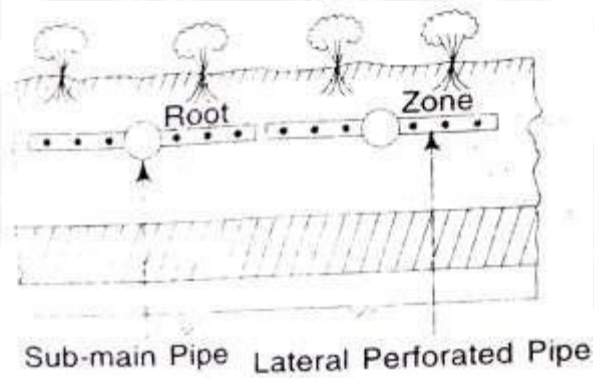
c) Flooding method

In this method, agricultural land is divided into small plots by levees (i.e. low bunds). The sewage is supplied to the plots through the supply channel. The sewage covers the entire area by flowing in Zigzag way.



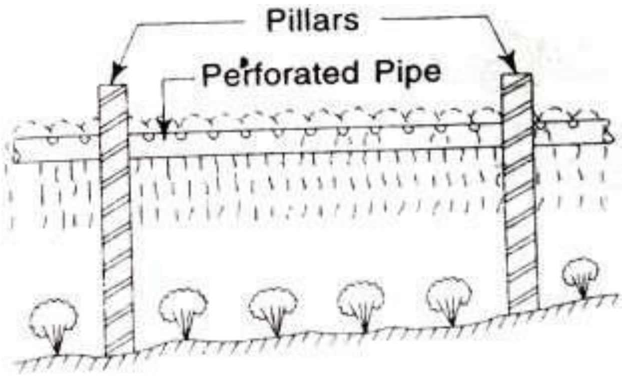
2. Sub-surface irrigation system

In this method, sewage is applied to root zone of crops by underground network of pipes. It consists of lateral perforated pipes which are connected to sub-main pipe line. The perforated pipe allows the sewage to drip out slowly and the soil below the root zone absorbs the sewage continuously.



3. Sprinkler irrigation system

In this method, sewage is applied to the land in the form of spray. The system is achieved by the network of main pipes and lateral pipes are perforated through which the sewage comes out.



STAGES IN THE SLUDGE DIGESTION PROCESS:

Three distinct stages have been found to occur in the biological action involved in the natural process of sludge digestion. The stages are

1. Acid fermentation
2. Acid regression
3. Alkaline fermentation

1. Acid fermentation stage or acid production stage:

In this first stage of sludge digestion, the fresh sewage-sludge begins to be acted upon by anaerobic and facultative bacteria called acid formers. These organisms solubilize the organic solids through hydrolysis. The soluble products are then fermented to volatile acids and organic alcohols of low molecular weight like propionic acid, acetic acid, etc. Gases' like methane, CO2, and H2S are also evolved. Intensive acid production makes the sludge highly acidic, and lowers the pH, value to less than 6.Highly putrefaction odours are evolved during this stage, which continues for about 15 days or so(at about 21°C). BOD of the sludge increases to some extent, during this stage.

2. Acid regression stage:

In this intermediate stage, the volatile organic acids and nitrogeneous compounds of the first stage are attacked by the bacteria, so as to form acid carbonates and ammonia compounds, small amount of H2S and CO2 gases are also given off. The decomposed sludge has a very offensive odour and its pH value rises a little, and to be about 6.8, the decomposed sludge also entraps the gases of decomposition, becomes foamy and rises to the surface form scum. This sludge continues for a period of about 3 months or so. BOD of the sludge remains high even during this stage.

3. Alkaline fermentation stage:

In this final stage of sludge digestion more resistant materials like proteins and organic acids are attacked at broken up by anaerobic bacteria, called methane formers, into simple substances like ammonia, organic acids and gases. During this stage, the liquid separates out from the solids, and the digested sludge is formed. This sludge is granular and stable, and does not give offensive odours (. It has a musty earthy odour). This digested sludge is collected at the bottom of the digestion tank and is also called ripened stage. Digested sludge is alkaline in nature. The pH value during this stage rises to a little above 7, in n the alkaline range. Large volumes of methane gas (having a considerable fuel value) along with small amount of CO_2 and nitrogen are evolved during this stage. This stage extends for a period of about one month or so. The BOD

of the sludge also rapidly falls down during this stage. It is thus, seen that several months (about 4.5 months or so)are required for the complete process of digestion to take place under natural uncontrolled conditions at about 21°C. This period of digestionis however very much dependent upon the temperature of digestion and other factors.