Grey water Harvesting:

Grey water can be defined as any domestic waste water produced, excluding sewage. The main difference between grey water and sewage (or black water) is the organic loading. Sewage has a much larger organic loading compared to grey water.

Reuse options:
Laundry
Toilet flushing
Irrigation of plants

Grey water source and percent of household flow

Source	Percent	Category
Toilet	40	Black water
Kitchen waste	10	
Misc	5	Grey water
Laundry	15	
Bath / Shower	30	

Grey Water Reuse
Subsurface application

- Irrigation

Surface application

- Irrigation
- Toilet flushing
- Cooling water
- Concrete water
- Fire sprinklers, hydrants

Merit

- Saves water
- Less discharge – more ecological sound

De-merit

- More costly

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 f low 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:

$$V = 3t \text{ o } 4.5(g(Ss - 1) d) 1/2$$

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.

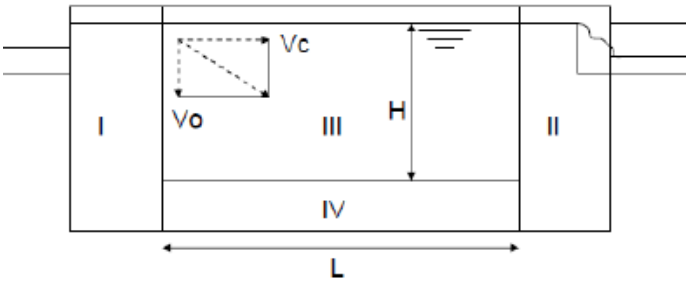


Figure: compartments of Grit chamber

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 period as 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

Operation and maintenance aspects of sewage treatment plant:

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.

PRIMARY SEDIMENTATION TANK:

After grit removal in grit chamber, the wastewater containing mainly lightweight organic matter is settled in the primary sedimentation tank (PST). Due to involvement of many unknown parameters under settling of light weight, sticky, and non regular shaped particles, the classical laws of sedimentation as applicable in grit removal are not valid and this settling is called as flocculant settling. The primary sedimentation tank generally removes 30 to 40% of the total BOD and 50 to 70% of suspended solids from the raw sewage.

The flow through velocity of 1 cm/sec at average flow is used for design with detention period in the range of 90 to 150 minutes. This horizontal velocity will be generally effective for removal of organic

suspended solids of size above 0.1 mm. Effluent weirs are provided at the effluent end of the rectangular tanks, and around the periphery in the circular tanks. Weir loading less than 185m3/m.d is used for designing effluent weir length (125 to 500 m3/m.d). Where primary treatment follows secondary treatment, higher weir loading rates can be used. The sludge collection hopper is provided near the centre in circular tank and near the influent end in rectangular tanks. A baffle is provided ahead of the effluent weir for removal of floating matter. This scum formed on the surface is periodically removed from the tank mechanically or manually.

The efficiency of the sedimentation tank, with respect to suspended solids and BOD removal, is affected by the following:

- Eddy currents formed by the inertia of incoming fluid,
- Wind induced turbulence created at the water surface of the uncovered tanks,
- Thermal convection currents,
- Cold or warm water causing the formation of density currents that moves along the bottom of the basin, and Thermal stratification in hot climates.

Because of the above reasons the removal efficiency of the tank and detention time has correlation $R = t/(a+b.t)$, where ‘a’ and ‘b’ are empirical constants, ‘R’ is expected removal efficiency, and ‘t’ is nominal detention time.

To account for the non optimum conditions encountered in the field, due to continuously wastewater coming in and going out of the sedimentation tank, due to ripples formed on the surface of the water because of wind action, etc., the settling velocity (overflow rate) obtained from the column studies are often multiplied by a factor of 0.65 to 0.85, and the detention time is multiplied by a factor of 1.25 to 1.50. This will give adequate treatment efficiency in the field conditions as obtained under laboratory test.

Recommendation for Design of Primary Sedimentation Tank

Primary sedimentation tanks can be circular or rectangular tanks designed using average dry weather flow and checked for peak flow condition. The numbers of tanks are determined by limitation of tank size. Two tanks in parallel are normally used to facilitate maintenance of any tank. The diameter of circular tank may range from 3 to 60 m (up to 45 m typical) and it is governed by structural requirements of the trusses which supports scrapper in case of mechanically cleaned tank. Rectangular tank with length 90 m are in use, but usually length more than 40 m is not preferred. Width of the tank is governed by the size of the scrappers available for mechanically cleaned tank. The depth of mechanically cleaned tank should be as shallow as possible, with minimum 2.15 m. The average depth of the tank used in practice is about 3.5 m. In addition, 0.25 m for sludge zone and 0.3 to 0.5 m free board is provided. The floor of the tank is provided with slope 6 to 16 % (8 to 12 % typical) for circular tank and 2 to 8% for rectangular tanks. The scrappers are attached to rotating arms in case of circular tanks and to endless chain in case of rectangular tanks. These scrappers collect the solids in a central sump and the solids are withdrawn regularly in circular tanks. In rectangular tanks, the solids are collected in the sludge hoppers at the influent end, and are withdrawn at fixed time intervals.

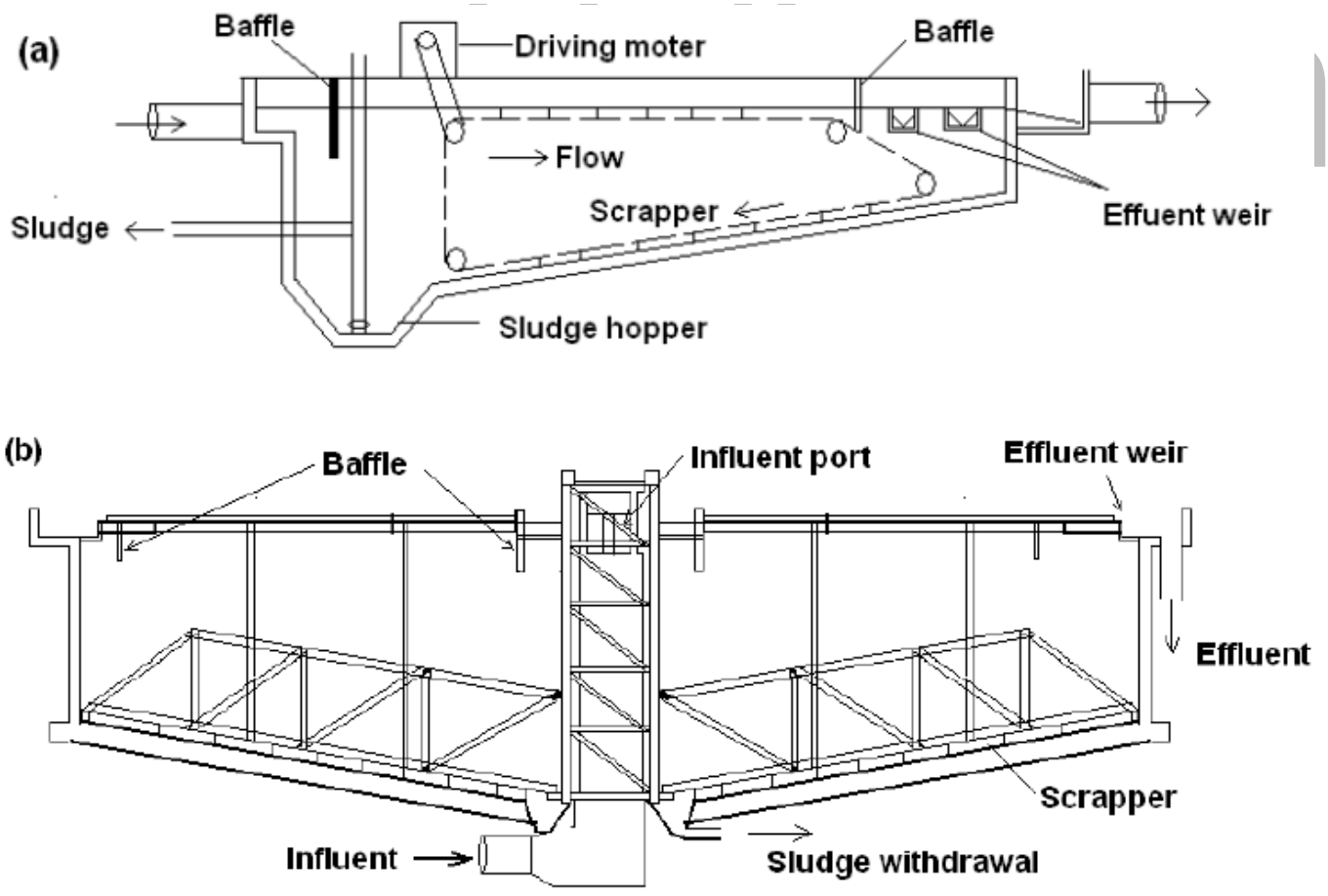


Figure (a) Rectangular and (b) Circular primary sedimentation tank

The scrapper velocity of 0.6 to 1.2 m/min (0.9 m/min typical) is used in rectangular tank and flight speed of 0.02 to 0.05 rpm (0.03 typical) is used in circular tank.
The detention time in PST could be as low as 1 h to maximum of 2.5 h. providing detention time of 1.5 to 2.5 h at average flow is a common practice. To avoid resuspension (scouring) of settled particles, horizontal velocities through the PST should be kept sufficiently low.

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.

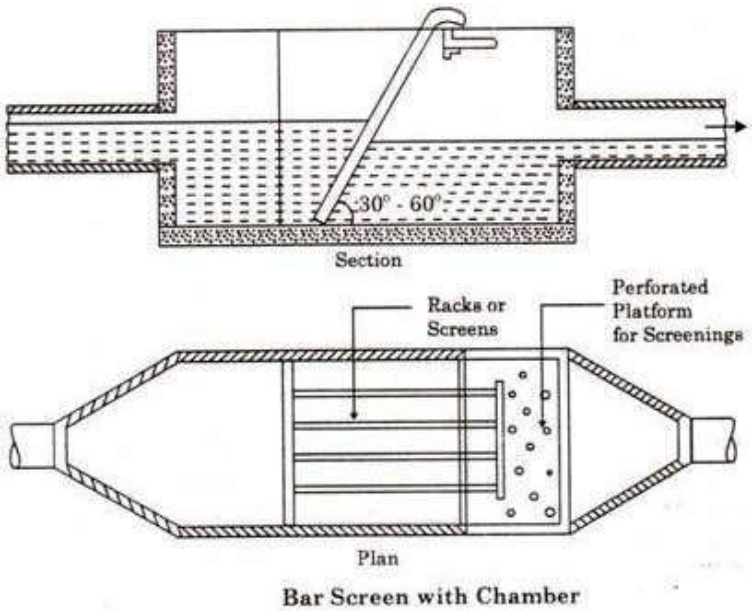
Hand cleaned racks are set usually at an angle of 45 °to the horizontal to increase the effective cleaning surface and also facilitate the raking operations. Mechanical cleaned racks are generally erected almost vertically. Such bar screens have openings 25% in excess of the cross section of the sewage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

SEPTIC TANK:

A septic tank is an underwater sedimentation tank used for waste water treatment through the process of biological decomposition and drainage. A septic tank makes use of natural processes & proven technology to treat wastewater from household plumbing produced by bathrooms, kitchen drains, and laundry.

A septic tank system has a relatively simple design. It is an underground watertight container (mostly rectangular or round) made of fiber glass, plastic or concrete.The Compartments in a septic tank and normally a T-shaped outlet prevent the sludge and scum from leaving the tank and travelling into the drain field area. Septic tank systems are a type of simple onsite sewage facility and only provide a basic treatment.

For homes that have poor drainage or are not connected to the mains sewage network septic tanks allow a safe disposal of wastewater.

They work by collecting the excreta and wastewater in one big underground tank, they are predominantly used in rural areas. Septic tanks are installed underground normally 50 meters away from the household. They are usually made up of two chambers or compartments and one tank that receives wastewater from an inlet pipe.

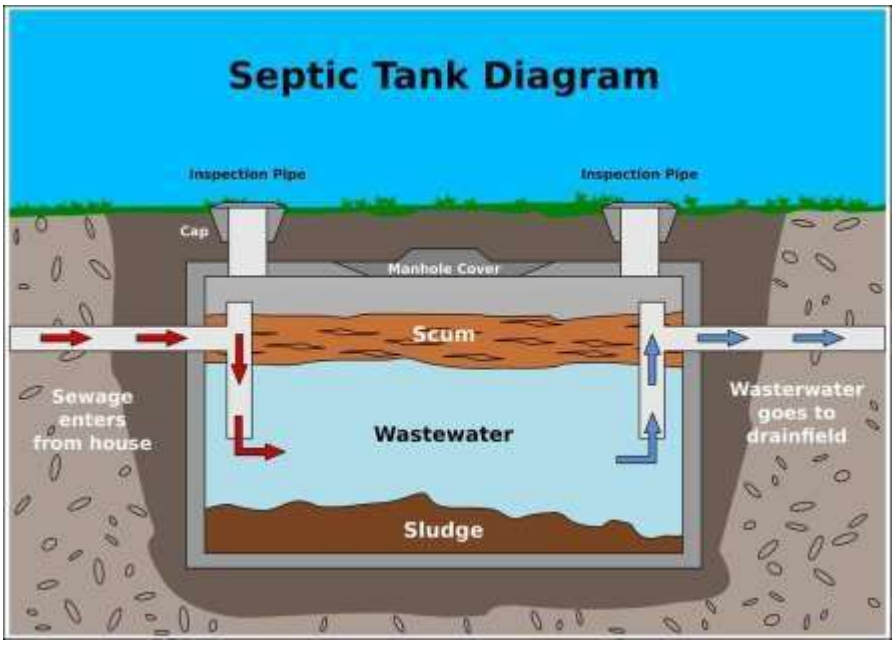
For those that live in cities and towns septic tanks are not needed as waste water will be transported and dealt with their sewage system. A local water company will maintain & manage this. A septic system will allow any house to use water facilities as normal.

However, there are additional precautions that need to be adhered to. Regular maintenance of the septic tank will also be required. Home owners with a septic tank have an additional duty to ensure their tank does not impact the local environment. For example, If the drain field is overloaded with too much liquid, it can flood, causing sewage to flow to the ground surface or create backups in toilets and sinks.

How Does a Septic Tank Work?

A septic tank will digest organic matter and separate float able matter (e.g., oils and grease) and solids from the wastewater. A septic tank will be connected with two pipes (for inlet and outlet). The inlet pipe is used to transport the water waste from the house and collect it in the septic tank. It is kept here long enough so that the solid and liquid waste is separated from each other.

The second pipe is the outlet pipe. It can also call the drain field. This pipe moves out the pre-processed wastewater from the septic tank and spreads it evenly in the soil and watercourses.



When waste water has been collected after a while it will begin to, separate into 3 layers. (as shown in the image above) The top layer is oils and grease and floats above all the waste. This commonly referred to as "scum". The middle layer contains wastewater along with waste particles.

The third and bottom layer consists of particles that are heavier than water and form a layer of sludge. Bacteria inside the tank does it's best to break down the solid waste, which then allows liquids to separate and drain away easily.

What is left at the bottom of the tank is what needs to be periodically removed as part of general maintenance. This is one of the reasons why a septic tank is only a basic form of sewage treatment.

The Step-by-step Process of How a Septic Tank Works

1. Water from your kitchen, bathroom etc runs through one main drainage pipe leading to your septic tank.

2. Underground the septic tank starts the process of holding the waste water. It needs to hold this long enough so the solids settle down to the bottom, while oil and grease floats to the top.

3. After this process the liquid wastewater (effluent) will then be able to exit the tank into the drain field.

4. This wastewater is discharged through pipes on to porous surfaces. These allow wastewater to filter though the soil.

5. The soil accepts, treats, and disperses wastewater as it percolates through the soil, ultimately discharging to groundwater.

6. Finally, the wastewater percolates into the soil, naturally removing harmful coliform bacteria, viruses and nutrients.

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