Onsite Sanitation

Rural areas and the outskirts of the urban areas may have insufficient population and infrastructure to support the sewer system and central treatment plant. Hence, onsite sanitation becomes necessary to maintain hygienic living conditions. For environmentally safe onsite sanitation, satisfactory wastewater management techniques should ensure that:

- water body used for water supplies are notcontaminated;
- flies and vermin have no access toexcreta;
- surface water bodies are not polluted by runoff;and
- nuisance conditions such as odour areminimized.

Acceptable onsite sanitation systems, depending on circumstances, include septic tanks and surface percolation; extended aeration, alone or following a septic tank; and in some area without running water the pit privy is still used.

24.1 SepticTanks

This is basically a sedimentation tank with some degree of solid destruction due to sedimentation and subsequent anaerobic digestion. Septic tanks are ordinarily designed for 24 h liquid retention time at average daily flow. Considering the volume required forsludge andscumaccumulation,theseptictankmaybedesignedforwastewaterretentiontimeof1to 2 days. The flow and characteristics of the wastewater that can be considered for design of septic tank is presented in the Table 24.1. Septic tanks can be made from concrete, masonry or fiberglass. Prior two are of rectangular shape and later is generally of circular shape. The inlet and outlet are baffled so that the floating matter and grease will be retained in the tank. Heavy solids settle at the bottom of the tank, where the organic fraction will decompose followinganaerobicpathway.Theproductionofbiogasmayinterferewiththesedimentation of the solids. Every septic tank should be provided with the ventilation pipe with the top of the pipe covered with suitable mosquito proof wire mesh. The top of the pipe should extend to at least 2 m above the highest building height present in the vicinity of 20 m from the septictank.

The ratio of peak flow to average flow may be very high for the small septic tanks, and can disturbthefunctioningofthetankduetoflowsurges,leadingtowashoutofthesettledsolids. Theliquiddepthofthetankis1to2mandthelengthtothewidthratioisintherangeof2:1 to 4:1 (Figure 24.1). The sludge accumulated in the tank is cleaned at the frequency of once in2to3years.Minimumof300mmoffreeboardshouldbeprovidedinthetank.The effluent of the septic tank is offensive and potentially dangerous. Hence, further treatment for septic tank effluent is necessary to protect the receiving environment. Due to inadequate treatmentofferedtothesewage,septictanksarerecommendedforindividualhousesandfor clusterofhousesorinstituteswherecontributingpopulationisnotexceeding300persons.

Table 24.1 Characteristics of household wastewater to be considered for septic tank design

Average flow per capita	100 - 160 L/day
Peak flow per capita	170 - 270 L/day
BOD per capita	0.045 kg/day
Suspended solids per capita	0.070 – 0.090 kg/day
Soluble solids per capita	0.035 kg/day
Sludge accumulation per capita	0.073 m^3/year

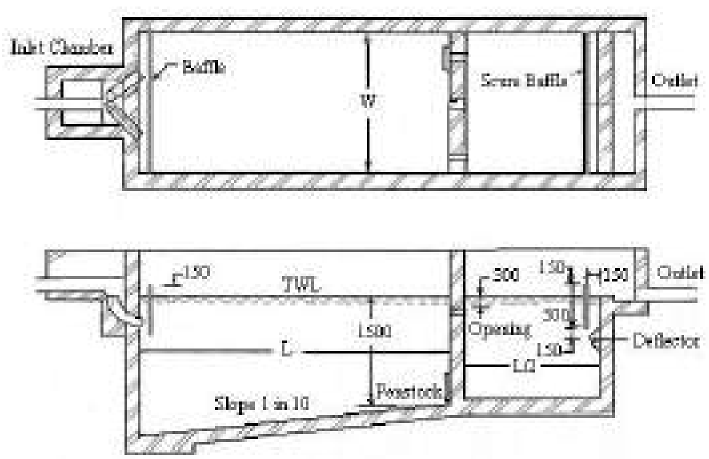


Figure 24.1 Construction Details of the Septic Tank

Post treatment can be achieved by aerobic treatment or subsurface disposal. Diffused air aeration with solids recycling (extended aeration), sand filter or synthetic media filter (attached growth process) can be used for treatment of septic tank effluent. Filter bag equipment and hypochlorite addition will also be suitable for treatment. However, frequent replacement of filter bag and hypochlorite addition makes it costly.

24.1.1 Design Features of SepticTank

The tank should be large enough to provide space for sedimentation of solids, digestion of settled sludge, and storage of sludge and scum accumulated between successive cleaning.

Sewage flow: The flow of sewage is considered to be proportional to the number of fixture units discharging simultaneously. One fixture unit is treated as equivalent to the flow of 10 L/min. This is equivalent to the discharge generated from one water closet (WC) when flushed. The number of fixtures discharging simultaneously depends on the population served. For example for the population of 5 persons, number of fixtures will be one and probablepeakdischargewillbe10L/min.Similarlyforpopulationof10,20,and30numbers of fixtures will be 2, 3, and 4, and probable peak discharge will be 20 L/min, 30 L/min, and 40 L/min,respectively.

Detention time: The detention time of 24 to 48 h is provided for average flow conditions. However,theflowvariationissubstantialfromtanktotankdependinguponwaterusage;and it is not important designcriteria.

Sludge withdrawal: The sludge is withdrawn at a frequency of 6 months to year in large tank. For small tank it can be 2 to 3 years.

Capacity of the Tank: The total capacity of the septic tank is worked out using following considerations.

1. Sedimentation: An area of 0.92 m^2 is required for every 10 L/min peak flow rate to supportadequatesedimentationofsuspendedsolids.Thiswillfavoursedimentationofsolids with0.05mmsizeandsp.gravityof1.2.Aminimumof0.25to0.30mdepthisnecessaryfor sedimentation.

2. Sludge digestion: The SS per capita may be considered as 70 g/day. It is assumed that that 60% of the solids will be removed in the tank, out of which 70% solids will be volatile, with 5% solid content i.e., 95% water content. The volume of fresh sludge = 0. 84L/Capita-day.Consideringthat2/3ofthevolatilematterisdestroyedofwhich¼ismineralizedduring digestion and solids content of 13 % in digested sludge, the volume of total digestedsludge, i.e.,mineralizedsludgewith13%solidsplusundigestedsludgewith5%solids,willbe0.234 L/Capita-day. The digestion zone contains both the fresh sludge (which is simultaneously getting destroyed by 2/3 of its volume) and digested sludge; hence volume of both of these will work out to be (0.848*1/3+0.234) = 0.516 L/Capita-day. At 25 ^{o}C the typical time required for digestion will be 63 days. Hence, capacity of digestion zone works out to be63 * 0.0005 = 0.032 m^3/capita.

3. Volumerequiredforsludgeandscumstorage:Forintervalof1yearofsludgecleaning, a sludge storage capacity of 0.0002*365 = 0.073 m^3/cap is required. The 25 to 50 mm of seedvolumeshouldbeconsidered,andcareshouldbetakenwhilewithdrawingthesludgeto leavethisvolumeofsludgetoactasseed.Noseparatedepthisprovidedforthis.

TotalCapacity: Hencethetotalcapacityoftheseptictankwillbeequaltosumoftheabove three requirements, plus a minimum free board of 0.3 m should be provided. Therefore for 20 persons the total capacity of the septic tank willbe

1. *Sedimentation:* Considering peak flow of 30 L/min for 20 persons, the area required = 0.92*30/10 = 2.76 m^2. Keeping depth of min. 0.3 m for sedimentation, the volume = 2.76*0.3 = 0.828m^3
2. *Digestion:* 0.032 * 20 = 0.64 m^3
3. Sludge storage: 0.073 * 20 = 1.46 m^3 for one year. For 2 year cleaning frequency sludge storage volume required = 1.46 * 2 = 2.92m^3
4. Free board = 2.76 * 0.3 = 0.828 m^3.

Hence, total volume of septic tank for 20 person = 0.828 + 0.64 + 2.92 + 0.828 = 5.216 m^3. Height of the septic tank = 0.3 + 0.231 + 1.05 + 0.3 m = 1.881 m, and provide length to the width ratio of 3; hence L = 2.88 m and W = 0.96 m

24.1.2 Other details of SepticTank

1. Septic tanks are provided with water tight cover, along with ventilation pipe extendingupto2.0mabovethehighestbuildinginthe20mradius.
2. Inletandoutletpipesarelocatedonoppositewallswithbaffletoavoidexitoffloating matter.

24.2 Subsurface disposal of Septic TankEffluent

The subsurface disposal field can serve as a further treatment system and for disposal of treated wastewater, which has undergone some reduction in SS and grease content. Many natural soils are suitable for such systems. The design is based on the long term capacity of the soil to percolate the water and it is decided upon the standard percolation test. The subsidence rate of water in the test bore hole (100 mm dia.) with the test depth of proposed disposalfield(min.500mm)isrecorded.Afterremovingtheloosesoil50mmoffinegravel or coarse sand is placed at the bottom. The hole is then filled with the water to the depth of 300 mm, and the depth is maintained overnight (at least 4 h) by adding water. The depth is thenadjustedto150mmabovegravelandthedropinwaterlevelisrecordedat30min interval for next 4 h. If the hole does not hold the water in the morning, it is filled with the water (150 mm above gravel) and the drop in water level is recorded. The drop recorded in the last 30 min is used for the determination of percolation rate. The flow rate which can be appliedperunitareaasafunctionofpercolationrateiscalculatedasQ=204/($t^{0.5}$),where,Q flow (L/m^2.d), t = time in min, required for the water to fall 25 mm. [Q = 130/ ($t^{0.5}$) as per CPHEEO(1993)].

If the subsidence rate is over 0.5 mm/min, then a septic tank and the disposal system will work satisfactorily. The disposal field is constructed by using short length open joined pipe (100 mm dia.) or perforated plastic or fiber pipe. The length of individual pipe is up to 30m and laid with the slope of 0.017 to 0.33%. The pipe is placed in a ditch (300 to 900 mm width) and minimum 500 mm depth (or it has been excavated to the depth of permeable stratum). The ditch is backfilled with gravel for a depth of 300 to 400 mm and over which pipes are placed. An additional 50 mm gravel cover is given to the pipe before the soil backfillingmaterialisplaced.Thetotallengthofpipedependsonthetrenchwidth,sincethe product of this, i.e., the plan area of the trench, should be equal to the area required to be provided as per the percolation test. Laterals (pipes) are placed about 2 mc/c.

Example: Determinethesizeoftheseptictankandpercolationfieldforhostelwhichhas200 residents. The average percolation rate has been determined to be 5 mm/min. Consider rate of wastewater generation 120L/capita.day.

Solution:

Total wastewater volume per day = 120 x 200 x 10^{-3}= 24 m^3

Hence, for 24 hr HRT the volume of Septic tank = 24 m^3 + volume for sludge accumulation

@ 0.073 m^3/capita.year = 24 + 0.073 * 200 = 38.6m^3

(Theexactvolumerequirementfortheseptictankcanbeworkedoutusingpeakdischargeof 480 L/min for 200persons)

The percolation rate (time to fall water to the depth of 25 mm) is = 25/5 = 5 min.

Hydraulic loading applicable = Q = 130/ ($t^{0.5}$) = 58 L/m^2.day

Therefore, total trench area = 24/ 0.058 = 413.8 m^2

Ifwidthoftrenchis900mm,lengthoftrench=414/0.9=460m

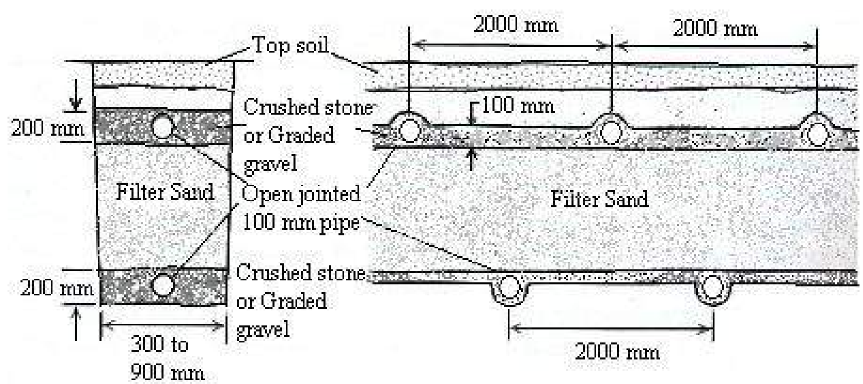
Provide15lateralsof30.7mlengtheach,placedat2mc/c.

The area dedicated to the field would be = 30 x 30.7 = 921 m^2.

Mounds may be constructed above the surface of the ground where the parent soil permeability is poor by bringing pervious material. The area of mounds depends on evapo-transpiration rate for disposal of the bulk liquid. The remainder may be able to percolate below. Grass cover and proper shaping of the mound are important to ensure that rainfall will run-off and that evapo-transpiration of wastewater will be maximized.

Sand filters or buried filters or intermittent sand filters may be provided when soils are relativelyimpermeable.Loadingratesonintermittentsandfilterstreatingseptictankeffluent ranged from 0.16 to 0.20m^3/m^2.day.

Subsurface sand filters are installed in place of permeable material in a suitable excavation (Figure 24.2). Loading rate of about 0.04 m^3/m^2.day can be applied, when relatively coarse sand (1 mm) and uniform size is used (McGhee, 1991). The effluent from either filtration process must be collected and discharged after disinfection as per the requirements.



(a) (b)

Figure 24.2 Subsurface filter (a) Sand filter trench (b) sand filter

Onsite wastewater treatment systems have a potential to provide excellent effluent qualityif they are properly designed and operated. Constructed Wetland system can also be used for removalofnitrogenalongwithothercontaminantsuchasheavymetalremoval.

Onsite Sanitation

24.3 PitPrivy

Pit privies still exist in large number in rural areas particularly in developing countries and underdeveloped countries. A typical privy consists of a pit of about 1.0 m^2 by 1.25 m deep, linedwithroughboardsonthesidesandcoveredwithareinforcedconcreteslab.Aconcrete risersupportstheseatandventilatorpipeconveysodoursthroughtheroof.Theslabrestson the concrete curb to which the house is bolted. Earth is banked around the curb to prevent surface runoff from entering the pit. For average family size such privy will serve for about 10 years. Cleaning is not practical and new privy should be dug once the old is full. The house, slab, and the curb can be moved to the new location. Pit privies with heavy use are often lines with concrete and have an access door at the rear of the unit. This permits the contentstoberemovedandhauledtoamunicipaltreatmentplantorsuitabledisposalsite.

24.4 Aquaprivy

In an aqua privy, urine and faeces are dropped into a water-tight tank which stores and decomposes the excreta in the absence of oxygen (i.e. anaerobically) as in a septic tank (Figure 24.3). It differs from the septic tank as regards the method of entry of the contents, andfromthepitlatrineinthatthesludgeiseasiertoremove.Theaquaprivymaybelocated above ground level or partly above and partlybelow.

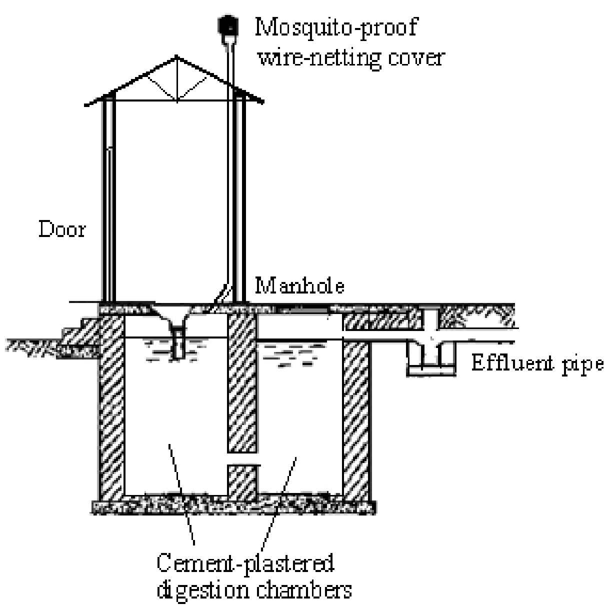


Figure 24.3 Aqua privies

The contents of the tank have no contact with the ground. Unlike the septic tank, the aqua privy does not require much water; but each day a quantity equivalent to that of the added cleansing water has to be evacuated from it, and therefore provision must be made for a means of draining off effluent. This effluent should not be allowed to run into open fieldsor gardens. Aqua privies may be recommended whenever the supply of water is limited, although they do not always work satisfactorily. Mosquitoes (for instance *Culex*species, which is responsible for the transmission of filariasis) have been known to breed in the vicinity of this type oflatrine.

24.5 Bore HoleLatrine

A bored-hole latrine is a hole drilled in the ground to receive and store the excreta. It is similar to a basic pit latrine, but pit is a hole bored in a soil auger, either manually or mechanically(Figure24.4).Itissuitableforstable,permeablesoil,freeofstones,andwhere thegroundwaterisdeepbeneaththesurface.However,bore-holelatrinesdopresentsanitary andhealthhazards,andexpertadviceshouldbesoughtbeforetheyareconstructed.

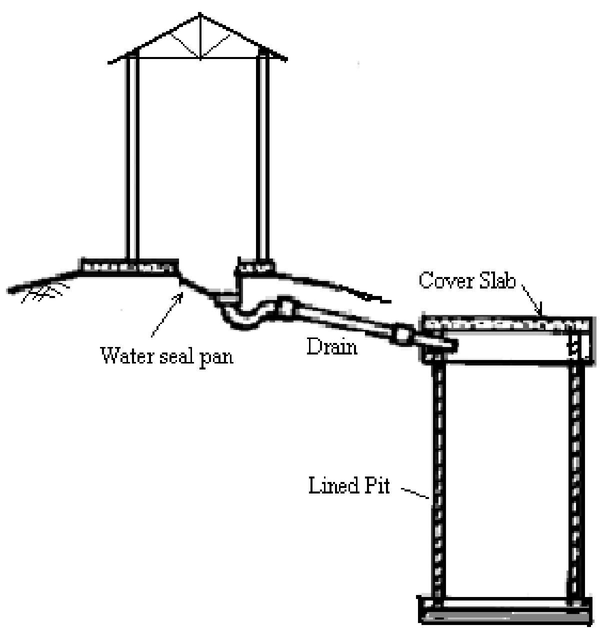


Figure 24.4 Bore hole latrine

Itconsistsofaholecoveredbyaoneseatlatrinebox.Boreholelatrineshaveanauguredhole insteadofadugpitandmaybesunktoadepthof10mormore,althoughadepthof4-6m isusual.Auguredholes,300-500mmindiameter,maybedugquicklybyhandormachinein areas where the soil is firm, stable and free from rocks or large stones. While a small diameter is easier to bore, the life of the pit is very short. For example a 300-mm diameter holewith5mdeepwillserveafamilyoffivepeopleforabouttwoyears.

Thesmalldiameteroftheholeincreasesthelikelihoodofblockage,andthedepthofaugured hole increases the danger of groundwater contamination. Even if the hole does not become blocked, the sides of the hole become soiled near the top, making fly infestation probable. However,boreholelatrinesareconvenientforemergencyorshort-termuse,becausetheycan bepreparedrapidlyingreatnumbers,andlightportableslabsmaybeused.

The holes should be lined for at least the top half-meter or so with an impervious material such as concrete or baked clay, but the pit is not lined all the way at the bottom. Because of the small diameter and short life, the full depth is not usually lined. Improved type of borehole latrine will also avoid fly nuisance and odour.

24.6 Dug wellLatrine

Itissimilartothatofbored-holelatrinebutonlydifferenceisinthediameterofthewhole.In dug well privy 75 cm x 75 cm x 360 cm pit is excavated, which is lined with honey comb brickworkorstonework,toabsorbtheliquidwaste(Figure24.5).Inconservancysystemthe humanexcretafromunseweredareaarecollectedindugwelltypelatrine.

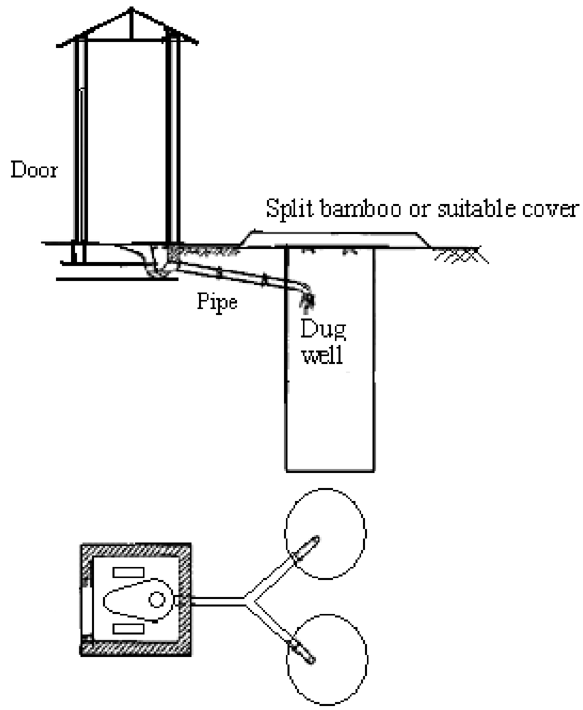


Figure 24.5 Dug well latrine

Questions

1. Explaintheprecautionstobetakenforenvironmentallysafeonsitesanitation.
2. Designaseptictankforthegrouphousingschemeoftotalpopulationof300persons. Theprobablepeakdischargewillbe720L/min.Alsodesignasoilabsorptionsystem for the disposal of septic tank effluent considering the average percolation rate of 6 mm/min.
3. Describe septic tank. State advantages and disadvantages of the septictank.
4. Describepitprivyandaquaprivy.Underwhatcircumstancestheywillbeused?
5. Whereboreholelatrineswillbeused?Explaintheconstructionfeaturesofthesetypes oflatrines.

Answer:

Q. 2. For one year sludge storage, height of the septic tank = 1.08 m, and for length to the width ratio of 3; L = 14.1 m and W = 4.7 m.

Forpercapitasewagegenerationof120L/day,totaltrencharea=36/0.064=562.5m^2

Provide20lateralsof31.25mlengtheach,placedat2mc/c.

The area dedicated to the field would be = 40 x 31.25 = 1250 m^2.