aesthetic acceptability but also for efficient disinfection which is difficult in the presence of suspended and colloidal impurities that serve as hideouts for the microorganisms.

Filters can be classified according to (1) the direction of flow (2) types of filter media and beds (3) the driving force (4) the method of flow rate control and (5) the filtration rate. Depending upon the direction of flow through filters, these are designated as down flow, upflow, biflow, radial flow and horizontal flow filters. Based on filter media and beds, filters have been categorized into (a) granular medium filters and (b) fabric and mat filters and micro-strainers. The granular medium filters include single-medium, dual-media and multi media (usually tri-media) filters. Sand, coal, crushed coconut shell, diatomaceous earth and powdered or granular activated carbon have been used as filter media but sand filters have been most widely used as sand is widely available, cheap and effective in removing impurities. The deriving force to overcome the fractional resistance encountered by the flowing water can be either the force of gravity or applied pressure force. The filters are accordingly referred to as gravity filters and pressure filters. In the fourth category are constant rate and declining or variable rate filters. Lastly dependent upon the flow rates, the filters are classified as slow or rapid sand filters.

9.9 CONSTRUCTION OF SOLID WASTE MANAGEMENT SYSTEMS

Waste management is intended to reduce adverse effects of waste on health, the environment or aesthetics. Waste management is all the activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things, collection, transport, treatment and disposal of waste together with monitoring and regulation. The solid waste can be classified in to two; Bio-degradable and Non-Biodegradable. Biodegradable means any organic material that can be degraded by micro organisms into simpler stable compounds; Non-bio degradable waste includes any waste that cannot be degraded by micro organisms into simpler stable compounds.

9.9.1 Bio Degradable Waste Management

The different types of biodegradable waste management are

9.9.1.1 Vermi composting

Vermi compost is the castings of earthworms. In the present context, vermin composting is the process of composting the biodegradable fraction of SW with the help of earthworms, resulting in the production of vermin compost which can be used in agricultural fields as a soil conditioner and nutrient supplier. Vermi compost is richer in plant nutrients compared with normal compost prepared from similar material; it has some cocoons which develop into worms when put in the soil and continues to do their work of conversion. Vermi compost draws better market price as compared with compost and, in addition, sale of worms can bring in additional revenue. The worms can be further utilised for initiating afresh vermin composting process and also as bait for fishing. The efficiency of vermin composting process depends on selection of proper species of earthworms and their optimal growth.

Vermicomposting is typically suited for managing smaller waste quantities. It is an ideal technology for towns that generate up to 50TPD of SW which is thoroughly segregated either at source or in the plant. Vermi composting involves the stabilisation of organic solid waste through earthworm consumption which converts the material into worm castings. Vermi composting is the result of combined activity of microorganisms and earthworms. Microbial decomposition of biodegradable organic matter occurs through extracellular enzymatic activities (primary decomposition) whereas decomposition in earthworm occurs in alimentary tract by microorganisms inhabiting the gut (secondary decomposition). Microbes such as fungi, actinomycetes, protozoa etc. are reported to inhabit the gut of earthworms. Vermicompostingtakes place at 20-30°C which is the most favourable temperature for ensuring survival of earthworms.

Ingested feed substrates are subjected to grinding in the anterior part of the worms gut (gizzard) resulting in particle size reduction. Vermi technology, a tripartite system which involves biomass, microbes and earthworms in influenced by the abiotic factors such as temperature, moisture, aeration etc. Microbial ecology changes according to change of abiotic factors in the biomass but decomposition never ceases. Conditions unfavourable to aerobic decomposition result in mortality of earthworms and subsequently no vermin composting occurs. Hence, pre-processing of the waste as well as providing favourable environmental condition is necessary for vermin composting.

The vermin compost is relatively more stabilised and harmonises with soil system without any ill effects. Unfavourable conditions such as particle size of biomass and extent of its decomposition, very large temperature increase, anaerobic condition, toxicity of decomposition products etc. influence activity of worms. This technology has been used for agricultural waste and its adoption to municipal solid waste is of recent origin.

9.9.1.1.1 Infrastructure Requirements

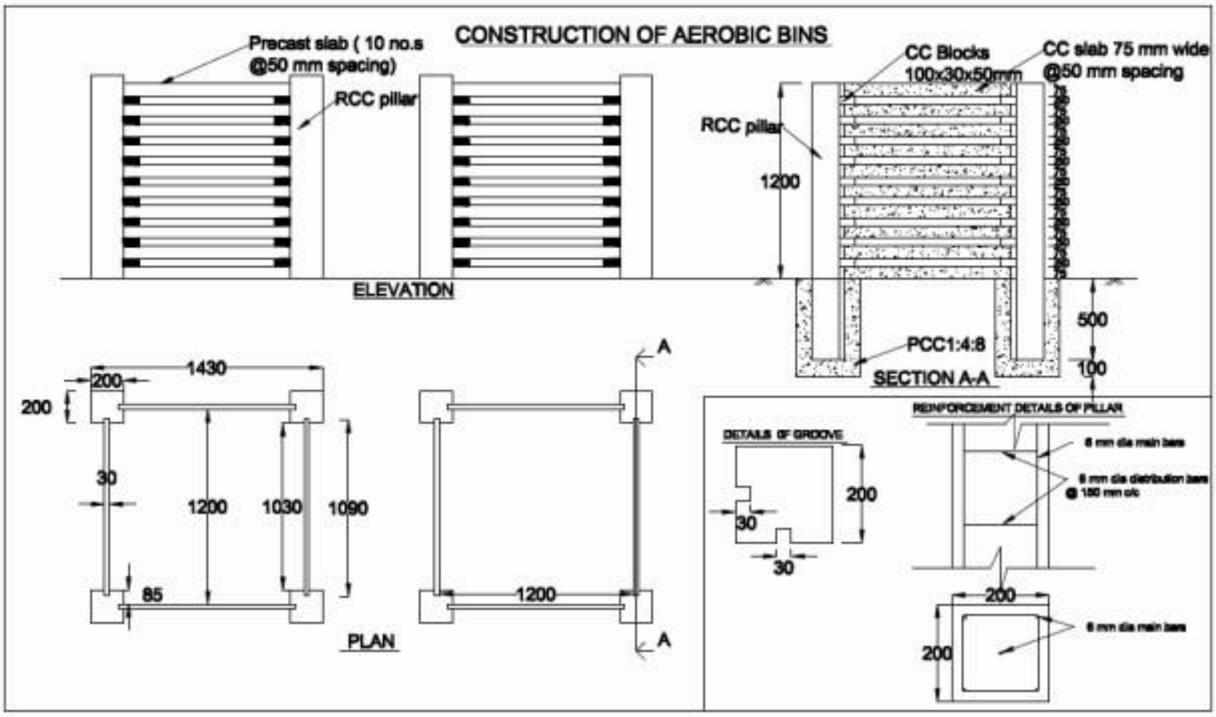
- Base layer with coconut fiber and gravel/sand with cow-dung (5kg) powder.
- Wire-mesh lid covers.
- 200 worms in each tank.
- Holes at the bottom of the basin/pot/tank to drain leachate/vermin wash to a vessel if kept below.
- Arrangements for protecting the basin/pot/tank from mouse, red ants, etc.
- Thick wet cloth or wet sack piece for covering the waste.
- Surgical hand gloves for handling waste & manure.
- Vermi wash collection system is optional.

9.9.1.2 Aerobic Bin Composting Unit

Depending on the quantum of input material, the size of the bin maybe decided. A series of bins may be used to accommodate all incoming waste. The bottom of the bin should be covered with a thick layer (15 cm) of coarse material, such as twigs, broken pieces of stone, or mulch, if available. Over this drainage layer, the feedstock is to be placed in layers. The feedstock should ideally contain a mix of garden or yard waste, kitchen waste, dried leaves, and paper. Water may be sprinkled to keep the heap moist. Care should betaken not to add excess water; the heap should not be wet. Excessively wet conditions can be prevented by placing more dried waste like driedleaves, twigs, and paper. Finished compost may be sprinkled on top to provide the required inoculum and to contain odour. This waste should be turned regularly to hasten the composting process. High temperatures are produced upon turning once every 5–10 days. This also helps tokill larvae and weed seeds, and provides a conducive environment for decomposer organisms. The composting process may take between 45days and 6 months, depending on the feedstock and turning condition.

The composting unit includes a box like structure with Ferro cement floor. Layers of cow dung, carbon source and waste materials are subjected to composting in presence of oxygen. The temperature rises rapidly in the waste to almost 70˚C, the peak temperature with pathogens. An aerobic compost bin, under the correct conditions creates a lot of heat; this can kill all sorts of seeds and pathogens. An efficient aerobic compost bin does not emit foul ammonia like smell. An aerobic compost bin reduces the biomass to usable compost quicker than its anaerobic counterpart Technical Aspects:

Aerobic cluster is an eco-friendly waste management system consisting of two units. Each unit is a 120cm x 120cm x 120cm ferro cement bin with airspace and grooves utilizing bacteria consortium from cow dung and carbon source from dry leaves and paper bits with a roof to prevent rain water during monsoon. 6‘‘ layer of fresh cow dung as the first layer with 6‖ layer of dried leaves provided the carbon source for the bacteria to flourish, above that another six inch layer waste is converted into compost. The core temperature built up in this layering is 70 - 75˚C which prevents the breeding of flies and parasites. Moreover due to aerobic functioning no putrid smell is there. About 2000kg waste can be managed in a bin. We can get compost with carbon nitrogen ratio 20 - 30% after 90 days.



9.9.1.3 Windrow Composting

Windrow composting is the most economical and widely accepted composting process .Windrow composting process consists of placing the pre-sorted feedstock in long narrow piles called windrows that are turned on a regular basis for boosting passive aeration. The turning operation mixes the composting materials and enhances passive aeration. The organic material present in Municipal Waste can be converted into a stable mass by aerobic decomposition. Aerobic microorganisms oxidize organic compounds to Carbon di oxide and oxides of Nitrogen. Carbon from organic compounds is used as a source of energy, while Nitrogen is recycled. Due to exothermic reactions, temperature of mass rises. In areas/regions were higher ambient temperatures are available, composting in open windrows is to be preferred. In this method, refuse is delivered on a paved/unpaved open space but levelled and well drained land in about 20 windrows with each windrow 3m long x 2m wide x 1.5m high, with a total volume not exceeding 9.0 cu.m.

Each windrow would be turned on 6th & 11th days outside to the centre to destroy insect larvae and to provide aeration. On 16th day, windrow would be broken down and passed through manually operated rotary screens of about 25mm square mesh to remove the oversize contrary material. The screened compost is stored for about 30 days in heaps about 2m wide x 1.5m high and up to 20m long to ensure stabilization before sale.

9.9.1.3.1 Control of Composting Process

The composting is normally taken to be complete when the active decomposition stage is over and the C/N ratio is around 20. If the C/N ratio of compost is more than 20, the excess carbon tends to utilise nitrogen in the soil to build cell protoplasm. This results in loss of nitrogen of the soil and is known as robbing of nitrogen in the soil. If on the other hand the C/N ratio is too low the resultant product does not help improve the structure of the soil. It is hence desirable to control the process so that the final C/N ratio is around 20. The decomposing mass remains between 50°-60°C for at least a week. This ensures the destruction of any parasites or pathogens present in the decomposing mass.

During the operation of the process, aerobic conditions should be maintained by controlling the aeration so that smell & odour as well as fly problems do not arise. During turning, care should be taken to avoid dust problem. The windrows should be located over impervious surface so that the surface water from the windrows which may contain entrained particulates & pollutants is properly collected and safely disposed of after processing. Such process leachate can also be reused in composting operation.The rejects from the process should be disposed off at properly designed and operated sanitary landfills. The SW should be diverted to a properly operated sanitary landfill during annual maintenance period as well as during shutdown of the plant. When the composting is carried out by controlling the various factors within the optimum range, proper quality compost will be obtained.

9.9.1.3.2 Windrow Composting Specification and Size

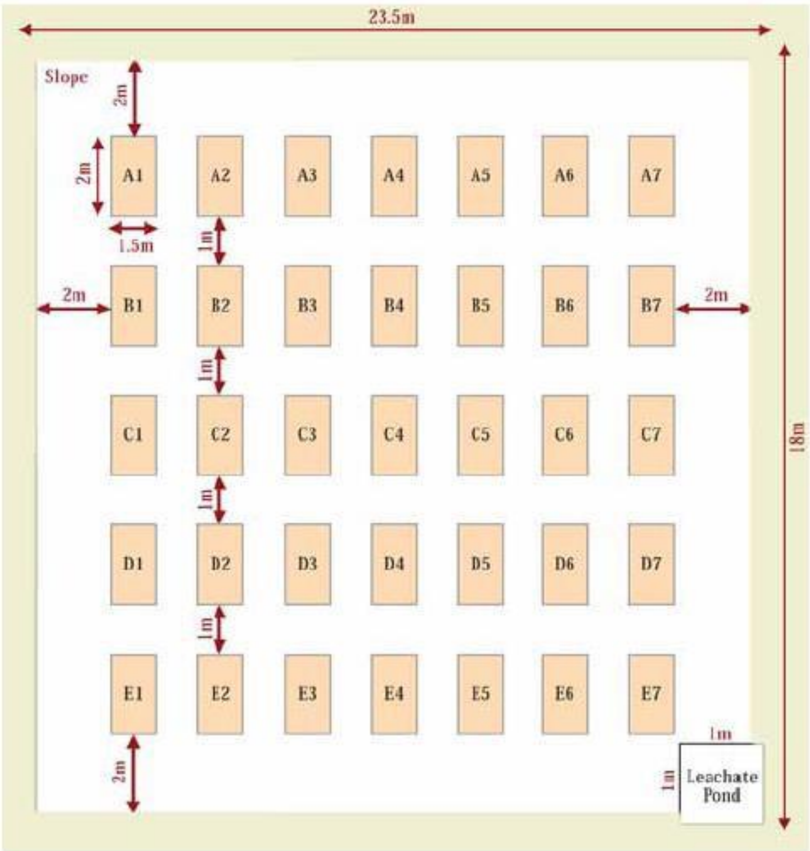
- Windrows are typically trapezoidal in cross section. The average windrow shape is between an oval and trapezoidal. A factor of 0.66 is assumed to estimate windrow volumes (Volume = Height x Width x Length x 0.66)
- Typically windrows can vary from 6 to 10 feet in height and 6 to 10 feet wide at the base.
- The space between windrows should be sufficient for movement of the windrow turning machine to be employed in the plant. Normally it is 1-3 meters.
- Windrow dimensions should allow conservation of heat generated during composting process while also maintaining diffusion of air to the deeper portions of the windrow.

9.9.1.3.3 Infrastructure Requirements

- The compost pad (platform is to be constructed with an appropriately designed combination of RCC and PCC. The compost pad shall have a slope of about 1% to drain the excess water (storm water or leachate) from the windrows into a leachate collection tank. The leachate tank is placed in the lowest corner of the compost pad area. Factors to be considered in the location and design of the composting pad:
  - The base has to provide a barrier to prevent the percolation of leachate and/or nutrients to the sub- soil and groundwater.

- The surface has to facilitate equipment movement even during wet weather conditions.
- The surface area has to accommodate waste for 5 weeks, with sufficient room for equipment to maneuver and an area to establish a static pile for curing compost.

- Loader: Tractor mounted front-end loaders or pay loaders are used to deliver the pre-processed feedstock to form windrows. They can be used for site maintenance, piling the cured compost and loading the finished compost product into trucks or trailers for sale in the market.
- Windrow Turner: Generally, pay loaders (wheel or tracked) or tractors with hydraulic attachments are used to scoop the material from one windrow to make a new pile in an adjacent location on the compost pad, while placing and mixing the material. Other equipment such as front end loaders/ windrows re-shifters may also be used for turning windrows.
- Screener: A trommel screen is desired at the end of the curing process to screen the finished compost for a suitable particle size. This will remove any larger undesirable items and will fluff up the finished product to ensure a suitable compost quality.
- Bagging: Bulk supply of compost is usually through 50 kg bags.



Arrangement and turning of windrows

Unit operations in windrow composting

9.9.1.4 Mechanical Composting

Though manual methods are preferable in countries where labour is comparatively cheap, mechanical processes are preferred where higher labour costs and limitations of space exist. Solid waste collected from various areas reaches the plant site at a variable rate depending upon the distance of collection point. As the compost plant operates at a constant rate, a balancing storage has to be provided to absorb the fluctuations in the waste input to the plant. This is provided in a storage hopper of 8 to 24 hours storage capacity, the exact value depending upon the schedule of incoming trucks, the number of shifts and the number of days the plant and solid waste collection system works.

The waste is then fed to a slowly moving (5metres/minute) conveyor belt and the non-decomposable material such as plastics, glass, metals are manually removed by labourers standing on either side of the conveyor belt. The labourers are provided with hand gloves and manually remove the material from the moving belt (the thickness over the belt is kept less than 15cms) and the removed material is stored separately.

The metals are then removed from the waste by either a suspended magnet system or a magnetic pulley system. Majority of the metals are recycled at the source itself and hence are not contained in the waste. Magnetic removal of metals is not very efficient and therefore not used.

The stabilisation is carried out in open windrows provided over flagstone paved or cement concrete paved ground. These windrows are turned every 5 days to ensure aerobic decomposition. Various types of equipment such as front end loaders/windrows reshifters are used for turning of windrows.

At the end of the 3 to 4 weeks period, the material is known as green or fresh compost wherein the cellulose has not been fully stabilised. It is hence stored in large sized windrows for 1-2 months either at the plant or the farms. At the end of the storage period, it is known as ripe compost. It may be sometimes subjected to size reduction to suit kitchen garden and horticulture requirements.

9.9.1.5 Anaerobic Methods/ Biomethanation

Biomethanation is the anaerobic (in the absence of free oxygen) fermentation of biodegradable matter in an enclosed space under controlled conditions of temperature, moisture, pH, etc. The waste mass undergoes decomposition due to microbial activity, thereby generating biogas comprising mainly of methane and carbon dioxide (CO2), and also digested sludge, which is almost stabilised but may contain some pathogen. Due to the anaerobic environment, hydrogen sulphide (H_2S) is generated with varying percentage depending on the sulphur content in the system (in the form of protein, sulphate, etc.). Like composting, biomethanation is one of the most technically viable options for solid waste (SW) due to the presence of high organic and moisture content.

9.9.1.5.1 Advantages

- Energy generation
- Reduction in land requirement for MSW disposal
- Reduction of environmental impacts from landfilling by avoiding contamination of land and water sources from leachate
- Biomethanation of biodegradable organic material would ultimately result in stabilized sludge which can be used as a soil conditioner.

9.9.1.5.2 Disadvantages

- In case of digesters operated under mesophilic temperatures, destruction of pathogenic organisms may be less than that in aerobic composting.
- It is more capital intensive compared to composting and landfill
- Not suitable for wastes containing less biodegradable matter.

Biomethanation is the anaerobic digestion of biodegradable organic waste in an enclosed space under controlled conditions of temperature, moisture, pH, etc. It is a human engineered decomposing system wherein - depending on the waste characteristics – the waste mass undergoes decomposition thereby generating biogas comprising mainly of methane and carbon dioxide. Biomethanation could be considered as one of the most technically viable options for the solid waste due to the presence of high organic and moisture content. Generally the overall process can be divided into four stages:

i. **Pre-treatment**: Most digestion systems require pre-treatment of waste to obtain homogeneous feedstock. The pre-processing involves separation of non-digestible materials either through segregation at source or through mechanical sorting; the former leads to less contaminated sludge compost. This segregation ensures the removal of undesirable or recyclable materials such as glass, metals, stones etc. The waste is shredded before it is fed into the digestor.
ii. **Waste Digestion:** Inside the digester, the feed is diluted to achieve desired solids content and remains in the digester for a designated retention time. For dilution, a varying range of water sources can be used such as clean water, sewage sludge, or re-circulated liquid from the digester effluent.
iii. **Gas Recovery and Usage:** The biogas obtained is scrubbed to ensure pipeline quality gas. Biogas may also be further used for generating electricity.
iv. **Residue Treatment:** In case of residue treatment, the effluent from the digester is dewatered and the liquid recycled for use in the dilution of incoming feed. The bio solids are dewatered to 50-55% Total Solids (TS) with a screw press, filter press or other types of dewatering systems and aerobically cured to obtain a compost product.

9.9.1.5.3 Important Operating Parameters for Biomethanation

a. **Temperature:** Temperature affects bacterial growth and hence the amount of biogas produced. Treatment of waste in anaerobic reactors is normally carried out within two ranges - around 25-40°C known as mesophilic range and higher than 45°C known as thermophilic range. At higher temperatures, the rate of digestion is faster, and thus shorter retention times are required – smaller reactor volumes are required for treating the same amount of waste – higher rate and efficiency of particulate matter hydrolysis – more efficient destruction of pathogens (CHECK)
b. **pH:** The anaerobic digestion process is limited to a relatively narrow pH interval from approximately 6.0 to 8.5 pH.
c. **Moisture:** The moisture content of waste should not be less than 15% as it can prevent decomposition of waste.
d. **Toxicity:** A number of compounds are toxic to anaerobic microorganisms. Methanogens are commonly considered to be the most sensitive to toxicity.
e. **C/N Ratio:** Optimum C/N ratio in anaerobic digesters is between 20–30. A high C/N ratio is an indication of rapid consumption of nitrogen by methanogens and results in lower gas production. On the other hand, a lower C/N ratio causes ammonia accumulation and pH values exceeding 8.5, which is toxic to methanogenic bacteria. Optimum C/N ratios of the digester materials can be achieved by mixing materials of high and low C/N ratios, such as organic solid waste (high in Carbon) and sewage or animal manure (high in Nitrogen).

f. **Organic Loading Rate:** Organic loading rate is the frequency and speed at which the substrate is added to the digester. For each plant of a particular size, there is an optimal rate at which the substrate should be loaded. Beyond this optimal rate, further increases in the feeding rate will not lead to a higher rate of gas production. Agitation or consistent stirring of the contents in the digester also plays an important role in determining the amount of biogas produced.

g. **Retention Time:** The required retention time for completion of the reactions varies with differing technologies, process temperature, and waste composition. The retention time for wastes treated in a mesophilic digester range from 10 to 40 days. Lower retention times are required in digesters operated in the thermophilic range. A high solids reactor operating in the thermophilic range has a retention time of 14 days.

9.9.1.6 Biogas Plant

When municipal solid wastes with a large proportion of organic matter is subjected to anaerobic decomposition, a gaseous mixture of Methane & Carbon di-oxide (CH_4& CO_2) known as biogas could be produced under favourable conditions. The process is quite stable and upsets do not easily occur. The gas production ranges from 0.29 m^3/kg of VS added/day to 0.16 m^3/kilogram of VS added/day in different seasons. The pH (Hydrogen Ion Concentration) of the digesting mixture remains around 6.8 + 0.20.

The volatile solids destruction ranges from 40 to 55%. The sludge has good manurial value of Nitrogen, Phosphorous, Potassium (NPK :: 1.6 : 0.85 : 0.93) and is observed to drain easily. The process gives a good performance at a detention time of 25 days.

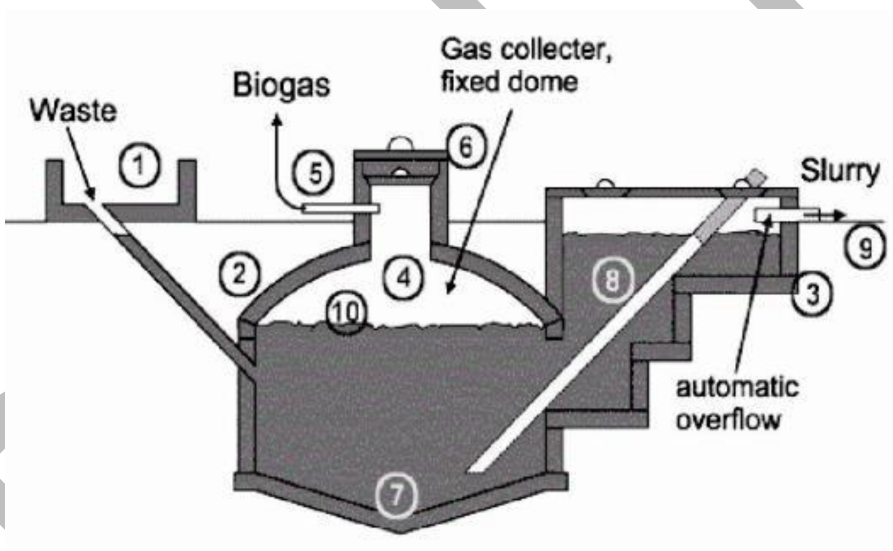
9.9.1.6.1 Infrastructure Requirements

- Unit without water jacket: PVC/LLDPE/HDPE tanks with circular shape as digester and floating gas holder
- Unit with water jacket: PVC/LLDPE/HDPE tanks with water jacket in between the digester and the gas holder.
- Inlet device with PVC pipe of diameter 110mm
- Inlet chamber with a plastic/FRP mug having circular shape and with a lid.
- Outlet device wit PVC pipe of 63 mm.
- A plastic can of 10 litre capacity to be used for collecting slurry/effluent for safe disposal.
- Rubber hose of 25 mm diameter for conveyance of biogas for use with maximum length of 10m.
- Stove wit single burner.
- Control valve for regulating gas.

9.9.1.6.2 Types of Biogas Plants

9.9.1.6.2.1 Fixed-Dome Plants

A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank. The costs of a fixed-dome biogas plant are relatively low. It is simple as no moving parts exist. There are also no rusting steel parts and hence a long life of the plant (20 years or more) can be expected. The plant is constructed underground, protecting it from physical damage and saving space. While the underground digester is protected from low temperatures at night and during cold seasons, sunshine and warm seasons take longer to heat up the digester. No day/night fluctuations of temperature in the digester positively influence the bacteriological processes. The construction of fixed dome plants is labor-intensive, thus creating local employment. Fixed-dome plants are not easy to build. They should only be built where construction can be supervised by experienced biogas technicians. Otherwise plants may not be gas-tight (porosity and cracks).



1. Mixing tank with inlet pipe and sand trap. 2. Digester. 3. Compensation and removal tank. 4. Gasholder. 5. Gas pipe. 6. Entry hatch, with gastight seal. 7. Accumulation of thick sludge. 8. Outlet pipe. 9. Reference level. 10. Supernatant scum, broken up by varying level.

Function - A fixed-dome plant comprises of a closed, dome-shaped digester with an immovable, rigid gas-holder and a displacement pit, also named 'compensation tank'. The gas is stored in the upper part of the digester. If there is little gas in the gas-holder, the gas pressure is low.

Digester - The digesters of fixed-dome plants are usually masonry structures, structures of cement and ferro-cement also exist.Main parameters for the choice of material are:

- Technical suitability (stability, gas - and liquid tightness);
- Cost - effectiveness;

- Availability in the region and transport costs;
- Availability of local skills for working with the particular building material.

Fixed dome plants produce just as much gas as floating-drum plants, if they are gas-tight. However, utilization of the gas is less effective as the gas pressure fluctuates substantially. Burners and other simple appliances cannot be set in an optimal way. If the gas is required at constant pressure (e.g., forengines), a gas pressure regulator or a floating gas-holder is necessary.

Gas Holder - The top part of a fixed-dome plant (the gas space) must be gas-tight. Concrete, masonry and cement rendering are not gas-tight. The gas space must therefore be painted with a gas-tight layer (e.g. 'Water-proofer', Latex or synthetic paints). A possibility to reduce the risk of cracking of the gas-holder consists in the construction of a weak-ring in the masonry of the digester. This "ring" is a flexible joint between the lower (water-proof) and the upper (gas-proof) part of the hemispherical structure. It prevents cracks that develop due to the hydrostatic pressure in the lower parts to move into the upper parts of the gas-holder.

Climate and Size - Fixed-dome plants must be covered with earth up to the top of the gas-filled space to counteract the internal pressure (up to 0,15 bar). The earth cover insulation and the option for internal heating makes them suitable for colder climates. Due to economic parameters, the recommended minimum size of a fixed-dome plant is 5 m . Digester volumes up to 200 m are known and possible.

9.9.1.6.2.1.1 Advantages

- Low initial costs and long useful life-span
- No moving or rusting parts involved
- Basic design is compact, saves space and is well insulated
- Construction creates local employment
- Relatively low construction costs
- Absence of moving parts and rusting steel parts. If well-constructed, fixed dome plants have a long life span. The underground construction saves space and protects the digester from temperature changes.

9.9.1.6.2.1.2 Disadvantages

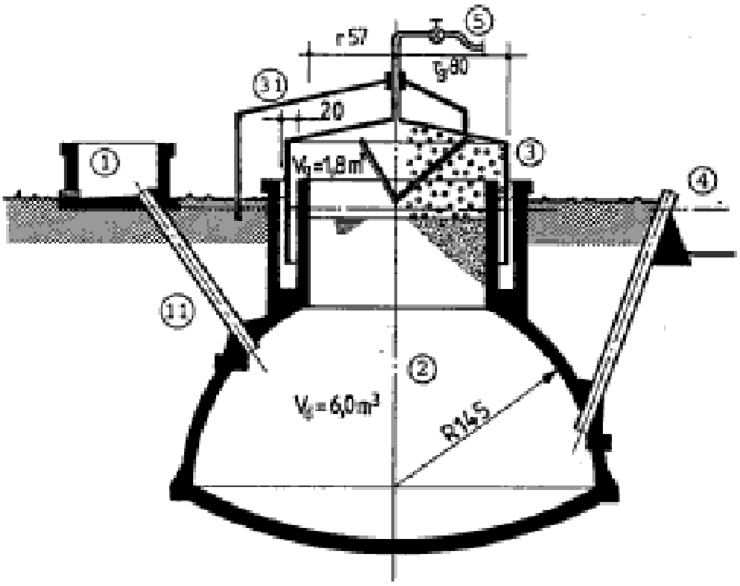
- Masonry gas-holders require special sealants and high technical skills for gas-tight construction
- Gas leaks occur quite frequently, a small crack in the upper brickwork can cause heavy losses of biogas
- Fluctuating gas pressure complicates gas utilization
- Amount of gas produced is not immediately visible, plant operation not readily understandable

- Fixed dome plants need exact planning of levels
- Excavation can be difficult and expensive in bedrock.

Fixed-dome plants are, therefore, recommended only where construction can be supervised by experienced biogas technicians. The gas pressure fluctuates substantially depending on the volume of the stored gas. Even though the underground construction buffers temperature extremes, digester temperatures are generally low.

9.9.1.6.2.2 Floating Drum Plants

Floating-drum plants consist of an underground digester and a moving gas-holder. The gas-holder floats either directly on the fermentation slurry or in a water jacket of its own. The gas is collected in the gas drum, which rises or moves down, according to the amount of gas stored. The gas drum is prevented from tilting by a guiding frame. If the drum floats in a water jacket, it cannot get stuck, even in substrate with high solid content.



Drum - In the past, floating-drum plants were mainly built in India. A floating-drum plant consists of a cylindrical or dome-shaped digester and a moving, floating gas-holder, or drum. The gas-holder floats either directly in the fermenting slurry or in a separate water jacket. The drum in which the biogascollects has an internal and/or external guide frame that provides stability and keeps the drum upright. If biogas is produced, the drum moves up, if gas is consumed, the gas-holder sinks back. Size - Floating-drum plants are used chiefly for digesting animal and human feces on a continuous- feed mode of operation, i.e. with daily input. They are used most frequently by small- to middle-sized 3 farms (digester size: 5-15m) or in institutions and larger agro-industrial estates (digester size: 20- 3 100m).

Disadvantages: The steel drum is relatively expensive and maintenance-intensive. Removing rust and painting has to be carried out regularly. The life-time of the drum is short (up to 15 years; in tropical coastal regions about five years). If fibrous substrates are used, the gas-holder shows a tendency to get "stuck" in the resultant floating scum.

9.9.1.6.2.3 Water Jacket Floating Drum Plant

Water-jacket plants are universally applicable and easy to maintain. The drum cannot get stuck in a scum layer, even if the substrate has a high solids content. Water-jacket plants are characterized by a long useful life and a more aesthetic appearance (no dirty gas-holder). Due to their superior sealing of the substrate (hygiene!), they are recommended for use in the fermentation of night soil. The extra cost of the masonry water jacket is relatively modest. Material of Digester and Drum The digester is usually made of brick, concrete or quarry-stone masonry with plaster. The gas drum normally consists of 2.5 mm steel sheets for the sides and 2 mm sheets for the top. It has welded-inbraces which break up surface scum when the drum rotates. The drum must be protected against corrosion. Suitable coating products are oil paints, synthetic paints and bitumen paints. Correct priming is important. There must be at least two preliminary coats and one topcoat. Coatings of used oil are cheap. They must be renewed monthly. Plastic sheeting stuck to bitumen sealant has not given good results. In coastal regions, repainting is necessary at least once a year, and in dry uplands at least every other year. Gas production will be higher if the drum is painted black or red rather than blue or white, because the digester temperature is increased by solar radiation. Gas drums made of 2 cm wire- mesh-reinforced concrete or fiber-cement must receive a gas-tight internal coating.

The gas drum should have a slightly sloping roof, otherwise rainwater will be trapped on it, leading to rust damage. An excessively steep-pitched roof is unnecessarily expensive and the gas in the tip cannot be used because when the drum is resting on the bottom, the gas is no longer under pressure. Floating-drums made of glass-fiber reinforced plastic and high-density polyethylene have been used successfully, but the construction costs are higher compared to using steel. Floating-drums made of wire-mesh-reinforced concrete are liable to hairline cracking and are intrinsically porous. They require a gas-tight, elastic internal coating. PVC drums are unsuitable because they are not resistant to UV.

Guide Frame - The side wall of the gas drum should be just as high as the wall above the support ledge. The floating- drum must not touch the outer walls. It must not tilt, otherwise the coating will be damaged or it will get stuck. For this reason, a floating-drum always requires a guide. This guide frame must be designed in a way that allows the gas drum to be removed for repair. The drum can only be removed if air can flow into it, either by opening the gas outlet or by emptying the water jacket. The floating gas drum can be replaced by a balloon above the digester. This reduces construction costs but in practice problems always arise with the attachment of the balloon to the digester and with the high susceptibility to physical damage.

9.9.1.6.2.3.1 Advantages:

- Simple, easily understood operation - the volume of stored gas is directly visible.
- The gas pressure is constant, determined by the weight of the gas holder.
- The construction is relatively easy, construction mistakes do not lead to major problems in operation and gas yield.

9.9.1.6.2.3.2 Disadvantages:

- High material costs of the steel drum, the susceptibility of steel parts to corrosion. Because of this, floating drum plants have a shorter life span than fixed-dome plants and regular maintenance costs for the painting of the drum.

9.9.1.6.3 Bottling of Biogas

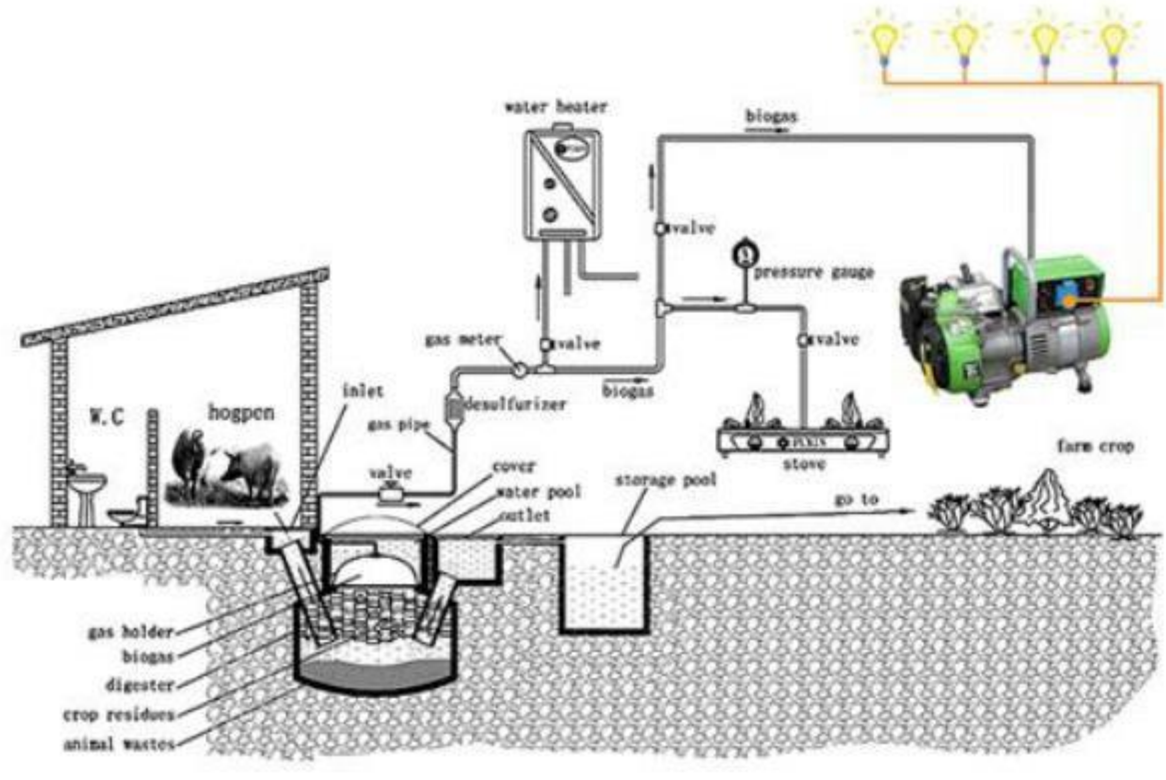
Biogas comprises of 60-65% methane, 35-40% carbon dioxide, 0.5-1.0% hydrogen sulphide, rests of water vapors etc. Biogas is non-toxic, color less and flammable gas. It has an ignition temperature of 650 - 7500C. Its density is 1.214kg/ m3 (assuming about 60% Methane and 40% CO2). Its calorific value is 20 MJ/m3 (or 4700 kcal.). It is almost 20% lighter than air. Biogas, like Liquefied Petroleum Gas (LPG) cannot be converted into liquid state under normal temperature and pressure. It liquefies at a pressure of about 47.4 Kg/cm2 at a critical temperature of -82.10 c. Removing carbon dioxide, Hydrogen Sulphide, moisture and compressing it into cylinders makes it easily usable for transport applications & also for stationary applications. Already CNG technology has become easily available and therefore, bio-methane (purified biogas) which is nearly same as CNG, can be used for all applications for which CNG are used.

Purified biogas (bio-methane) has a high calorific value in comparison to raw biogas. The purified biogas is filled in CNG cylinder and supplied to mid-day meal scheme, mess, Hotel, industries etc. for various purposes such as cooking & heating etc.. Calorific value of purified biogas is equivalent / similar to CNG. As a matter of fact, the biogas bottling plants are one of the most potent tools for mitigating climatic change by preventing black carbon emission from biomass chulha since biogas is used as a cooking fuel and methane emissions from untreated cattle dung and biomass wastes are also avoided. The purified biogas can be bottled in CNG cylinders and wherever CNG is currently used, compressed biogas (CBG) can be used as an alternative.

The slurry which comes out of the biogas plant is directly or after drying used as bio/organic manure for improving soil-fertility and reducing use of chemical fertilizers. It is also non-pollutant because it is free from weed-seeds, foul smell and pathogens. The slurry is rich in main nutrients such as Nitrogen, Potassium and Sodium (NPK) alongwith micronutrients - Iron & Zinc etc. As such there is no pollution from biogas plant. The slurry/manure of biogas plant is being sold to the farmers and used in liquid/solid form by them in agricultural crops. In addition to the energy production, biogas plants also provide bio-manure and are helpful in dealing with the problems of waste management, providing clean environment and mitigating pollution in urban, industrial and rural areas. Biogas is also a prominent alternative to petroleum fuel like LPG, CNG and diesel.

9.9.1.6.4 Electricity from Biogas

Various technologies to generate electricity from biogas on a household level are available. In principle, the chemical energy of the combustible gases is converted to mechanical energy in a controlled combustion system by a heat engine. This mechanical energy then activates a generator to produce electrical power. In most cases, biogas is used as fuel for combustion engines, which convert it tomechanical energy, powering an electric generator to produce electricity. The most common heat engines used in for biogas energy conversion are gas turbines and combustion engines. Combustion engines can be either internal combustion engine (e.g. reciprocating engine) or external combustion engine (e.g. Stirling engine). The average calorific value of biogas is about 21-23.5 MJ/m³, so that 1 m³ of biogas corresponds to 0.5-0.6 l diesel fuel or about 6 kWh (FNR, 2009). Normally, after conversion loses, 1.5 kilo watt electricity can be produced from 1 m³ of biogas.



9.9.1.6.5 Advantages

1. Generation of renewable, green electricity
2. Low operating costs
3. Underground construction minimizes land use
4. Long life span
5. Reduces greenhouse gases
6. Increases family income by selling back electric energy to the electric power grid
7. On site use of heat

9.9.1.6.6 Disadvantages

1. Requires expert design
2. Skilled construction and expert maintenance required
3. Biogas production below 15°C, is no longer economically feasible
4. High capital costs

9.9.2 Non-Bio Degradable Waste Management

Non-biodegradable waste is a type of waste that cannot be broken down into its base compounds by micro-organisms, air, moisture or soil in a reasonable amount of time. It includes items like plastic, rubber, Styrofoam, fiberglass and metals. Because non-biodegradable waste cannot be broken down, recycling is the best option for managing it.

9.9.2.1 Material Recovery Facility

A Material Recovery Facility (MRF) accepts mixtures of waste fractions for the purpose of separating and diverting recyclable materials and transferring the remaining waste for disposal. The configuration of an MRF processing line is critical to the overall quality of the segregated material. It depends upon numerous factors including the types and quantities of materials to be processed, quality and quantity of incoming waste, desired processing rates, and required specifications for the end products. While no two MRFs are identical, they generally employ common design principles and sequencing in the configuration of equipment and labour.

Material recovery starts at the primary level, by households which segregate recyclables like newspapers, cardboard, plastics, bottles etc. from waste, to sell such material to local recyclers/ scrap dealers / haulers or kabali system. Well segregated recyclables can directly be transferred to a processing site or to the recyclable market depending on local conditions. The dry fraction of the waste can be segregated at the ward level, where waste from one or more wards is collected and segregated. Different recyclables are sent either directly to locally available recycling facilities or are sold to wholesale dealers. Dry waste fraction may also be transported to the waste transfer station, where it is further segregated. Segregation at the transfer station is through manual and or mechanized segregation. Depending on the scale of the operations employed and the level of mechanization in the facility, MRFs may be classified as manual or mechanized facilities. Manual MRFs are usually small scale units, typically owned, managed and operated by the informal sector and largely employ manual sorting practices. Material is segregated based on the types of wastes (paper, plastic, metal, glass etc.) and gradation of material within each waste type (paper: news print, office paper, packaging paper, printed books etc.).Segregated material is then sold on to intermediaries, who supply material in bulk to the recycling industry. Mechanized facilities are large scale units where recyclables are sorted by using automated machines when quantities to be handled are large.

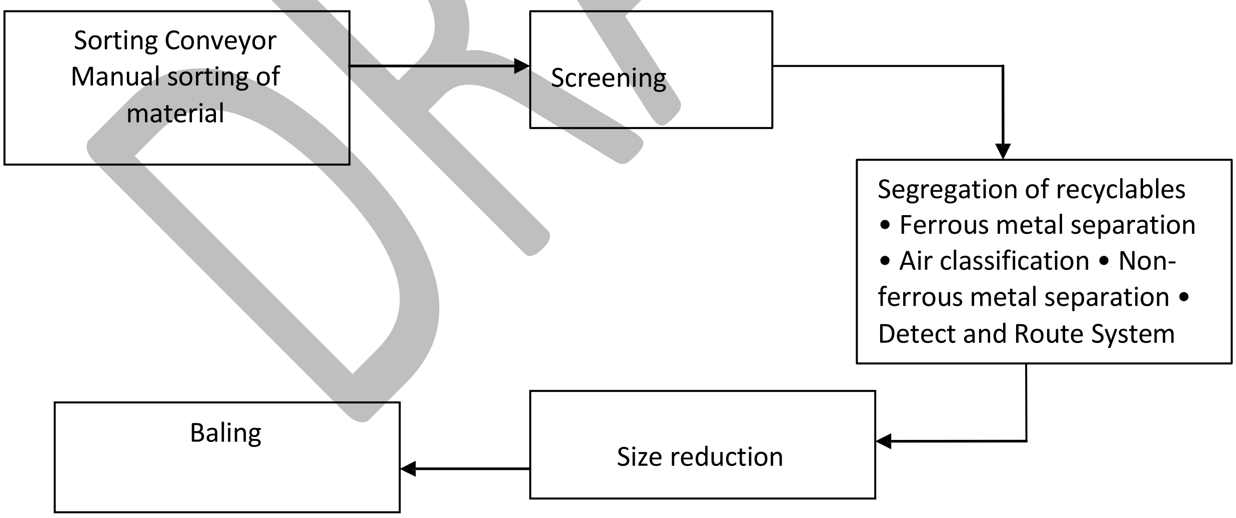
MRF Unit Processes :MRF units employ varying combinations of manual and mechanical processes, based on the type of facility, easy availability of equipment, labour availability and associated cost implications. MRF units employing manual labour for sorting operations have relatively lower costs, but may also operate at lower efficiencies compared to mechanical sensor based sorting facilities

Pre-Sorting: Bulky and contaminated wastes hamper further sorting/processing in the facility; mechanical or manual pre-sorting is essential to separate out these wastes.

Mechanical Sorting: Mechanical processes based on principles of electro-magnetic fluid mechanics, pneumatics etc. are used to segregate the different waste streams in the pre-sorted waste. Mechanical processes require specialized equipment for segregation of co-mingled municipal waste. Mechanical sorting typically employs the following processes:

- Screening
- Ferrous Metal separation
- Air Classification
- Non-ferrous metal separation
- Detect and Route system
- Size reduction
- Baling

The unit processes in a MRF is schematically shown in the figure



Indicative Unit Process in a Material Recovery Facility :A MRF facility is also equipped with suitable environmental pollution control and monitoring equipment. At a minimum a waste recycling facility should consist of the following equipment:

- Dust Collection System
- Noise Suppression Devices

- Odour Control System
- Heating, Ventilating& Air Conditioning

Note: The plastic waste management is dealt in the‖ Plastic Waste (Management and Handling) Rules 2011‖.

A small model of MRF

9.9.2.2 Recycling

Non-bio degradable waste is divided into two types

Recyclable: Waste having economic values but destined for disposal can be recovered and used along with their energy value. e.g. plastic, paper, old cloth etc

Non-recyclable: Waste which do not have economic value of recovery e.g. tetra packs, carbon paper, thermocol etc.

Because non-biodegradable waste cannot be broken down, recycling is the best option for managing it. Recycling is the process by which materials that are otherwise destined for disposal are collected, processed and remanufactured or reused. Recycling diverts a significant fraction of municipal, institutional and business waste away from disposal and, thereby, saves scarce resources as well as reduces environmental impacts and the burden of waste management on public authorities. If appropriate market mechanisms are established, recycling can generate revenues, contributing to the overall cost recovery for municipal solid waste service provision. According to the integrated solid waste management hierarchy, recycling is a preferred waste management strategy and recycling systems should be adopted before planning for any waste processing/treatment facilities. Recyclables mainly consist of paper, plastic, metal, and glass.

Material recycling can occur through sorting of waste into different streams at the source or at a centralised facility. Sorting at source is more economical than sorting at a centralised facility. Recycling is the process by which materials that are otherwise destined for disposal are collected, processed and remanufactured or reused. Recycling diverts a significant fraction of municipal, institutional and business waste away from disposal and, thereby, saves scarce resources as well as reduces environmental impacts and the burden of waste management on public authorities. If appropriate market mechanisms are established, recycling can generate revenues, contributing to the overall cost recovery for municipal solid waste service provision. According to the integrated solid waste management hierarchy, recycling is a preferred waste management strategy and recycling systems should be adopted before planning for any waste processing/treatment facilities. Recyclables mainly consist of paper, plastic, metal, and glass.

9.9.2.2.1 Centralised Sorting

Centralised sorting is needed wherever recyclable materials are collected in a commingled (mixed) state. Hand sorting from a raised picking belt is mostly adopted. Mechanised sorting facilities using magnetic and electric field separation, density separation, pneumatic separation, size separation and other techniques are used in some developed countries. Such facilities are usually prohibitively expensive in comparison to hand sorting.

9.9.2.2.2 Sorting Prior to Waste Processing or Land filling

Home sorting and centralised sorting processes normally recover most of the recyclable materials for reuse. However, a small fraction of such materials may escape the sorting process. Sorting is also undertaken just prior to waste processing, waste transformation or land filling to recover recyclable materials. In a landfill, sorting may be carried out by rag pickers immediately after spreading of a layer of waste. In waste processing or transformation centres, manual sorting or size separation is usually undertaken. Wherever manual sorting is adopted, care must be taken to ensure that sorters are protected from all disease pathways and work in hygienic conditions.

9.9.2.3 Incineration

It is the process of direct burning of wastes in the presence of excess air (oxygen) at temperatures of about 8000C and above, liberating heat energy, inert gases and ash. Net energy yield depends upon the density and composition of the waste; relative percentage of moisture and inert materials, which add to the heat loss; ignition temperature; size and shape of the constituents; design of the combustion system (fixed bed/ fluidised bed), etc. In practice, about 65 to 80 % of the energy content of the organic matter can be recovered as heat energy, which can be utilized either for direct thermal applications, or for producing power via steam turbine generators (with typical conversion efficiency of about 30%).

Wastes burned solely for volume reduction may not need any auxiliary fuel except for start-up. When the objective is steam production, supplementary fuel may have to be used with the pulverized refuse, because of the variable energy content of the waste or in the event that the quantity of waste available is insufficient.

While Incineration is extensively used as an important method of waste disposal, it is associated with some polluting discharges which are of environmental concern, although in varying degrees of severity. These can fortunately be effectively controlled by installing suitable pollution control devices and by suitable furnace construction and control of the combustion process.

Besides the established techniques such as composting, incineration, etc. , various new methods are being developed for processing of municipal solid waste. All these methods reduce the pollution potential & quantity of solid waste requiring to be disposed off and also sometimes result in recovery of some by products having potential use. These processes commonly follow either the biological or the thermal route.The following general description of an incineration plant includes the crucial processing steps and aspects:

a. Siting of an Incineration Plant
b. Waste reception and handling (storage, on site pre-treatment facilities)
c. Combustion and steam generation system
d. Flue gas cleaning system
e. Energy generation system (steam turbine and generator in case the unit is equipped for waste to energy recovery)
f. Residual hauling and disposal system
g. Monitoring and controlling incineration conditions

9.9.2.3.1 Advantages

- Most suitable for high Calorific Value waste, pathological wastes, etc.
- Thermal Energy recovery for direct heating or power generation.

9.9.2.3.2 Environmental Impacts

1. Municipal solid waste incineration produces a range of volatile and gaseous emissions, which, if untreated released to the atmosphere, can compromise environment quality.
2. Concern for toxic metals that may concentrate in ash, emission of particulates, SOx, NOx, chlorinated compounds, ranging from HCl to Dioxins.

9.9.2.4 Waste to Energy

Where material recovery from waste is not possible, energy recovery from waste through production of heat, electricity, or fuel is preferred. Biomethanation, waste incineration, production of refuse derived fuel (RDF), co-processing of combustible non-biodegradable dry fraction from MSW in cement kilns and pyrolysisor gasification are some waste-to-energy technologies.

Gasification and pyrolysis are similar processes; both decompose organic waste by exposing it to high temperatures. Both processes limit the amount of oxygen present during decomposition; gasification allows a small amount of oxygen, pyrolysis allows none. In other words, gasification and pyrolysis limit or prevent oxidation. Plasma arc gasification uses electrically generated plasma torches to converting waste material into gas and a slag byproduct.

9.9.2.4.1 Pyrolysis

Pyrolysis involves an irreversible chemical change brought about by the action of heat in an atmosphere devoid of oxygen. Synonymous terms are thermal decomposition, destructive distillation and carbonisation. Pyrolysis, unlike incineration is an endothermic reaction and heat must be applied to the waste to distil volatile components. Process of converting plastic to fuels through pyrolysis is possible, but yet to be proven to be a commercially viable venture. Pyrolysis is carried out at temperature between 500 and 1000°C and produces three component streams such as gas(mixture of combustible gases such as hydrogen, carbon monoxide, methane, carbon dioxide and some hydrocarbons), liquid (consisting of tar, pitch,acetic acid, acetone, methanol) and Char (Consisting of elemental carbon along with the inert materials in the waste feed). The char, liquids and gas are useful because of their high calorific value.

MSW Pyrolysis Process Sorted and pre-treated feed stock is supplied to pyrolysis reactor where partial combustion of material occurs at temperatures as high as $500-800^{0}$ C. As a result of combustion of organic matter in an oxygen deficient environment various products such as char (ash), pyrolysis oil and syngas are produced. Production of these biproducts is dependent on the organic component of SW, temperature, pressure and time of retention in the reactor. Char is a combination of non-combustible materials and carbon.

The syngas is a mixture of gases (combustible constituents include carbon monoxide, hydrogen, methane and a broad range of other volatile organic compounds). Syngas is further refined to remove particulates, hydrocarbons, and soluble matter, and is then combusted to generate electricity. If required, the condensable fraction can be collected by cooling the syngas, potentially for use as a liquid fuel (oils, waxes and tars).

9.9.2.4.2 Gasification

Gasification is a partial combustion of organic or fossil based carbonaceous materials, plastics etc. into carbon monoxide, hydrogen, carbon dioxide and methane. This is achieved at high temperatures (650°C and above), with a controlled amount of air/oxygen and/ or steam. The process is largely exothermic but some heat may be required to initialise and sustain the gasification process. The main product is syngas, which contains carbon monoxide, hydrogen and methane. The other main product produced by gasification is a solid residue of non-combustible materials (ash) which contains a relatively low level of carbon. Gasification of SW in the waste gasification plant is accomplished in two chambers: the primary is operated at below the stoichiometric air requirement and the second operated under excess air conditions.

The waste is fed into the primary chamber and semi-pyrolysed, releasing moisture and volatile components. The heat is provided by the controlled combustion of fixed carbon within the waste. The syngas that is driven off contains a high calorific value and can act as a feedstock for the secondary chamber. Importantly, combustion air is then added to the syngas making it highly combustible and prone to self-ignition. The secondary chamber is equipped with a conventional burner to maintain operating temperature at all times. The combined gases are combusted in the secondary chamber.

9.9.2.4.2.1 Advantages

- Syngas has a calorific value, so it can be used as a fuel to generate electricity or steam or as a basic chemical feedstock in the petrochemical and refining industries.
- Reduced flue gas volumes after combustion.

9.9.2.4.2.2 Environmental Impacts.

1. The ash which remains after gasification is toxic and presents special problems because of the acidic, or low pH, conditions in landfills.
2. Leaching of toxic metals cadmium, lead , and mercury occurs more rapidly at low pH, resulting in contaminated groundwater.

9.9.2.5 Landfills

The term 'landfill' is used herein to describe a unit operation for final disposal of 'Municipal Solid Waste' on land, designed and constructed with the objective of minimum impact to the environment. The term 'landfill' can be treated as synonymous to 'sanitary landfill' of Municipal Solid Waste, only if the latter is designed on the principle of waste containment and is characterised by the presence of a liner and leachate collection system to prevent ground water contamination. A landfill site with low environmental impact, high social acceptance and low costs is the most desirable. Landfills may have different types of sections depending on the topography of the area. The landfills may take the following forms:

i. above ground landfills (area landfills);
ii. below ground landfill (trench landfills);
iii. slope landfills;
iv. valley landfills (canyon landfills); and
v. a combination of the above.

Above Ground Landfill (Area Landfill): The area landfill is used when the terrain is unsuitable for the excavation of trenches in which to place the solid waste. High-groundwater conditions necessitate the use of area-type landfills. Site preparation includes the installation of a liner and leachate control system. Cover material must be hauled in by truck or earthmoving equipment from adjacent land or from borrow-pit areas.

Below Ground Landfill (Trench Landfill): The trench method of landfilling is ideally suited to areas where an adequate depth of cover material is available at the site and where the water table is not near the surface. Typically, solid wastes are placed in trenches excavated in the soil. The soil excavated from the site is used for daily and final cover. The excavated trenches are lined with low-permeability liners to limit the movement of both landfill gases and leachate.Trenches vary from 100 to 300 m in length, 1 to 3 m in depth, and 5 to 15 m in width with side slopes of 2:1.

Slope Landfill: In hilly regions it is usually not possible to find flat ground for landfilling. Slope landfills and valley landfills have to be adopted. In a slope landfill, waste is placed along the sides of existing hill slope. Control of inflowing water from hillside slopes is a critical factor in design of such landfills.

Valley Landfill: Depressions, low-lying areas, valleys, canyons, ravines, dry borrow pits etc. have been used for landfills. The techniques to place and compact solid wastes in such landfills vary with the geometry of the site, the characteristics of the available cover material, the hydrology and geology of the site, the type of leachate and gas control facilities to be used, and the access to the site. Control of surface drainage is often a critical factor in the development of canyon/depression sites.

It is recommended that the landfill section be arrived at keeping in view the topography, depth to water table and availability of daily cover material.

Sanitary landfills are facilities for final disposal of Municipal Solid Waste on land, designed and constructed with the objective of minimizing impacts to the environment. Landfilling will be done for the following types of waste:

- Comingled waste (mixed waste) not found suitable for waste processing
- Pre-processing and post-processing rejects from waste processing plants
- Non-hazardous waste not being processed or recycled

Sanitary landfilling is not allowed for the following waste streams in the municipal solid waste:

- Bio-degradable waste/garden waste (it should preferably be composted)
- Dry recyclables (it should preferably be recycled)
- Hazardous wastes (needs hazardous waste sites with special equipment)

9.9.2.5.1 Environmental Impact and its Minimization

The impact of dumping municipal solid waste on land without any containment cause the following problems:

a. Groundwater contamination through leachate
b. Surface water contamination through runoff
c. Air contamination due to gases, litter, dust, bad odour

d. Other problems due to rodents, pests, fire, bird menace, slope failure, erosion etc.

Landfills minimise the harmful impact of solid waste on the environment by the following mechanisms

a. isolation of waste through containment;
b. elimination of polluting pathways;
c. controlled collection and treatment of products of physical, chemical and biological changes within a waste dump – both liquids and gases; and
d. Environmental monitoring till the waste becomes stable.

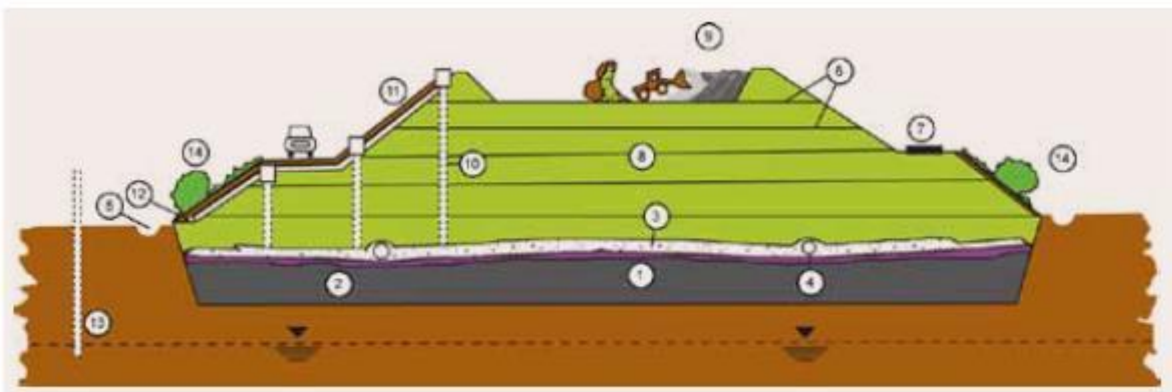
The urban local body shall adhere to the following compliance criteria in the matter of solid waste disposal of solid waste, (1)land filling or dumping of mixed waste shall be stopped soon after the timeline as specified in Rule 10 for setting up and operationalization of sanitary landfill is over; (2) landfill shall only be permitted for non-usable, non-recyclable, non-biodegradable, non- combustible and non-reactive inert waste and other wastes such as residues of waste processing facilities as well as preprocessing rejects from waste processing facilities and the landfill sites shall meet the specifications as given in Schedule–I of Solid Waste Management Rules, 2015, however every effort shall be made to recycle or reuse the rejects to achieve the desired objective of zero waste going to landfill; (3) landfill site shall provide an appropriate facility for sorting, storing and transportation of recyclable material to the processing facility and ensure that such wastes do not get land filled; (4) all old open dumpsites and existing operational dumpsites shall be carefully investigated and analyzed about their potential of bio-mining and bio-remediation and actions shall be taken accordingly in cases where such course of action is found feasible; and (5) in absence of potential of bio-mining and bio-remediation of dumpsite, it shall be scientifically capped as per landfill capping norms to prevent further damage to the environment.

9.9.2.5.2 Essential Components of Sanitary Landfill

The seven essential components of a MSW landfill are:

1. A liner system at the base and sides of the landfill which prevents migration of leachate or gas to the surrounding soil.
2. A leachate collection and control facility which collects and extracts leachate from within and from the base of the landfill and then treats the leachate.
3. A gas collection and control facility (optional for small landfills) which collects and extracts gas from within and from the top of the landfill and then treats it or uses it for energy recovery.
4. A final cover system at the top of the landfill which enhances surface drainage, prevents infiltrating water and supports surface vegetation.
5. A surface water drainage system which collects and removes all surface runoff from the landfill site.
6. An environmental monitoring system which periodically collects and analyses air, surface water, soil- gas and ground water samples around the landfill site.

7. A closure and post-closure plan which lists the steps that must be taken to close and secure a landfill site once the filling operation has been completed and the activities for long-term monitoring, operation and maintenance of the completed landfill. The components of sanitary landfill is represented in the figure



1. Geological barrier
2. Impermeable base liner
3. Drainage layer
4. Leachate collection system
5. Storm - water drain ditch
6. Bordering dams
7. Circulation roads
8. Landfill body
9. Filling and compacting in layers
10. Gas venting system
11. Protective cover system
12. Gas collectors
13. Groundwater control
14. Re-planting

9.9.2.5.3 Landfill Capping

Landfill capping is a containment technology that forms a barrier between the contaminated media and the surface, thereby shielding humans and the environment from the harmful effects of its contents and perhaps limiting the migration of the contents. The main objectives in designing a capping system are to:

- minimize infiltration of water into the waste;
- promote surface drainage and maximize run off;
- control gas migration; and
- provide a physical separation between waste and plant and animal life.

The components of a landfill capping system may include: topsoil; subsoil; drainage layer; barrier (infiltration) layer; gas drainage layer; and system for leachate recirculation

Limitations of the landfills are

- Landfill caps are most effective where most of the underlying waste is above the water table.

- Landfill caps have a limited life span. They are estimated to last from 50 to 100 years. In areas with high rates of subsidence and regions prone to earthquakes, the cap and its foundation should be designed appropriately.

Dumping yard

After scientific closure

9.9.2.6 E-Waste Management

"Electronic waste" may be defined as discarded computers, office electronic equipment, entertainment device electronics, phones, television sets, and refrigerators. This includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal. Others are re-usables (working and repairable electronics) and secondary scrap (copper, steel, plastic, etc.) to be "commodities", and reserve the term "waste" for residue or material which is dumped by the buyer rather than recycled, including residue from reuse and recycling operations. Because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable), several public policy advocates apply the term "e-waste" broadly to all surplus electronics. The processes of dismantling and disposing of electronic waste in the third world lead to a number of environmental impacts. Liquid and atmospheric releases end up in bodies of water, groundwater, soil, and air and therefore in land and sea animals – both domesticated and wild, in crops eaten by both animals and human, and in drinking water. Some computer components can be reused in assembling new computer products, while others are reduced to metals that can be reused in applications as varied as construction, flatware, and jewellery.

9.9.2.7 Hazardous Waste Management

Hazardous waste is waste that possesses substantial or potential threats to public health or the environment. Many types of businesses generate hazardous waste. For example, dry cleaners, automobile repair shops, hospitals, exterminators, and photo processing centres may all generate hazardous waste. Some hazardous waste generators are larger companies such as chemical manufacturers, electroplating companies, and oil refineries. These wastes may be found in different physical states such as gaseous, liquids, or solids. A hazardous waste is a special type of waste because it cannot be disposed of by common means like other by-products of our everyday lives. Depending on the physical state of the waste, treatment and solidification processes might be required.

9.9.2.7.1 Disposal of Hazardous Waste

Historically, some hazardous wastes were disposed of in regular landfills. This resulted in unfavorable amounts of hazardous materials seeping into the ground. These chemicals eventually entered natural hydrologic systems. Many landfills now require countermeasures against groundwater contamination, an example being installing a barrier along the foundation of the landfill to contain the hazardous substances that may remain in the disposed waste. Currently, hazardous wastes must often be stabilized and solidified in order to enter a landfill and many hazardous wastes undergo different treatments in order to stabilize and dispose of them. Most flammable materials can be recycled. One example they can be recycled into is industrial fuel. Some materials with hazardous constituents can be recycled, lead acid batteries are one example.

A. Recycling : Many hazardous wastes can be recycled into new products. Examples might include lead-acid batteries or electronic circuit boards. Where the heavy metals these types of ashes go through the proper treatment, they could bind to other pollutants and convert them into easier-to-dispose solids, or they could be used as pavement filling. Such treatments reduce the level of threat of harmful chemicals, like fly and bottom ash, while also recycling the safe product.

B. Incineration, destruction and waste-to-energy : A HW may be "destroyed" for example by incinerating it at a high temperature, flammable wastes can sometimes be burned as energy sources. For example, many cement kilns burn HWs like used oils or solvents. Today, incineration treatments not only reduce the amount of hazardous waste, but also they generate energy from the gases released in the process. It is known that this particular waste treatment releases toxic gases produced by the combustion of byproduct or other materials, and this can affect the environment. However, current technology has developed more efficient incinerator units that control these emissions to a point where this treatment is considered a more beneficial option. There are different types of incinerators and they vary depending on the characteristics of the waste. Starved air incineration is another method used to treat hazardous wastes. Just like in common incineration, burning occurs, however controlling the amount of oxygen allowed proves to be significant to reduce the amount of harmful byproducts produced. Starved air incineration is an improvement of the traditional incinerators in terms of air pollution. Using this technology, it is possible to control the combustion rate of the waste and therefore reduce the air pollutants produced in the process.

C. Hazardous waste landfill (sequestering, isolation, etc.) A HW may be sequestered in a HW landfill or permanent disposal facility. "In terms of hazardous waste, a landfill is defined as a disposal facility or part of a facility where hazardous waste is placed or on land and which is not a pile, a land treatment facility, a surface impoundment, an underground injection well, a salt dome formation, a salt bed formation, an underground mine, a cave, or a corrective action management unit."

9.9.2.8 Biomedical Waste Management

Biomedical waste is generated from biological and medical sources and activities, such as the diagnosis, prevention, or treatment of diseases. Biomedical waste is waste that is either putrescible or potentially infectious. Biomedical waste may also include waste associated with the generation of biomedical waste that visually appears to be of medical or laboratory origin (e.g., packaging, unused bandages, infusion kits, etc.), as well research laboratory waste containing biomolecules or organisms that are restricted from environmental release.

Biomedical waste is a type of biowaste. Biomedical waste may be solid or liquid. Examples of infectious waste include discarded blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts, other human or animal tissue, used bandages and dressings, discarded gloves, other medical supplies that may have been in contact with blood and body fluids, and laboratory waste that exhibits the characteristics described above. Waste sharps include potentially contaminated used (and unused discarded) needles, scalpels, lancets and other devices capable of penetrating skin. Biomedical waste must be properly managed and disposed of to protect the environment, general public and workers, especially healthcare and sanitation workers who are at risk of exposure to biomedical waste as an occupational hazard. Steps in the management of biomedical waste include generation, accumulation, handling, storage, treatment, transport and disposal.

- Biomedical waste should be collected in containers that are leak-proof and sufficiently strong to prevent breakage during handling. Containers of biomedical waste are marked with a biohazard symbol.
- Workers who handle biomedical waste should observe standard precautions.
- The goals of biomedical waste treatment are to reduce or eliminate the waste's hazards, and usually to make the waste unrecognizable. Treatment should render the waste safe for subsequent handling and disposal. There are several treatment methods that can accomplish these goals.
- Biomedical waste is often incinerated. An efficient incinerator will destroy pathogens and sharps. Source materials are not recognizable in the resulting ash.
- An autoclave may also be used to treat biomedical waste. An autoclave uses steam and pressure to sterilize the waste or reduce its microbiological load to a level at which it may be safely disposed of.
- For liquids in small quantities, a 1–10% solution of bleach can be used to disinfect biomedical waste. Solutions of sodium hydroxide and other chemical disinfectants may also be used, depending on the waste's characteristics.
- Other treatment methods include heat, alkaline digesters and the use of microwaves.

9.9.2.9 Construction and Demolition Waste Management

Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges, flyover, subway, remodelling etc. It consists mostly of inert and non- biodegradable material such as concrete, plaster, metal, wood, plastics etc. These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container. Waste from small generators like individual house construction or demolition, find its way into the nearby municipal bin/vat/waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. Often it finds its way into surface drains, choking them.

While retrievable items such as bricks, wood, metal, titles are recycled, the concrete and masonry waste, accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India. Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled aggregate can be used to make concrete for road construction and building material. The major components of C & D wastes are Cement concrete, Bricks, Cement plaster, Steel, Rubble, Stone, and Timber/wood. The minor components of C & D wastes are Conduits (iron, plastic). Pipes (GI, iron, plastic), Electrical fixtures, Panels (wooden, laminated) and others (glazed tiles, glass panes).

All construction/demolition waste should be stored within the site itself. A proper screen should be provided so that the waste does not get scattered and does not become an eyesore. - Attempts should be made to keep the waste segregated into different heaps as far as possible so that their further gradation and reuse is facilitated. Material, which can be reused at the same site for the purpose of construction, leveling, making road/pavement etc. should also be kept in separate heaps from those, which are to be sold or send to landfill.

The use of these materials basically depends on their separation and condition of the separated material. A majority of these materials are durable and therefore, have a high potential of reuse. It would, however, be desirable to have quality standards for the recycled materials. Construction and demolition waste can be used in the following manner:

- Reuse (at site) of bricks, stone slabs, timber, conduits, piping railings etc. to the extent possible and depending upon their condition.
- Sale/auction of material which cannot be used at the site due to design constraint or change in design.
- Plastics, broken glass, scrap metal etc. can be used by recycling industries.
- Rubble, brick bats, broken plaster/concrete pieces etc. can be used for building activity, such as, leveling, under coat of lanes where the traffic does not constitute of heavy moving loads.
- Larger unusable pieces can be sent for filling up low-lying areas.
- Fine material, such as, sand, dust etc. can be used as cover material over sanitary landfill.

Being predominantly inert in nature, construction and demolition waste does not create chemical or biochemical pollution. Hence maximum effort should be made to reuse and recycle them. The material can be used for filling/leveling of low-lying areas. In the industrialized countries, special landfills are sometimes created for inert waste, which are normally located in abandoned mines and quarries. The same can be attempted in our country also for cities, which are located near open mining quarries or mines where normally sand is used as the filling material.

9.9.2.10 Waste Minimisation

Waste minimisation or reduction at source is the most desirable activity, because the community does not incur expenditure for waste handling, recycling and disposal of waste that is never created and delivered to the waste management system. However, it is an unfamiliar activity as it has not been included in earlier waste management systems.

To reduce the amount of waste generated at the source, the most practical and promising methods appear to be (i) the adoption of industry standards for product manufacturing and packaging that use less material, (ii) the passing of laws that minimise the use of virgin materials in consumer products, and (iii) the levying (by communities) of cess/fees for waste management services that penalise generators in case of increase in waste quantities. Modifications in product packaging standards can result in reduction of waste packaging material or use of recyclable materials. Minimisation of use of virgin raw materials by the manufacturing industry promotes substitution by recycled materials. Sorting at source, recycling at source and processing at source (e.g. yard composting) help in waste minimisation.

One waste management strategy used in some communities in developed countries is to charge a variable rate per can (or ton) of waste, which gives generators a financial incentive to reduce the amount of waste set out for collection. Issues related to the use of variable rates include the ability to generate the revenues required to pay the costs of facilities, the administration of a complex monitoring and reporting network for service, and the extent to which wastes are being put in another place by the generator and not reduced at source.

Waste prevention helps to reduce handling, treatment, and disposal costs and various environmental impacts such as leachate, air emissions, and generation of greenhouse gases(GHG). Minimisation of waste generation at source and reuse of products are the most preferred waste prevention strategies. Waste minimisation results in reducing the amount and toxicity of the wastes produced. Minimisation is the most preferred waste management strategy in the hierarchy as it reduces the quantity of waste to be handled, the cost associated with its handling, and its environmental impacts.

9.9.3 Gas Crematorium

Gas Crematorium should be designed to have a cremation of one body at a time and the time taken for the completion of one cremation is approximately one to one and half-hour time.

Cremation Process: After the rituals the body is kept in a moveable trolley and finally places the body in the cremation platform in cremation furnace. Combustion blowers and air blowers are switched on and then the primary and secondary burners in the cremation chambers switched on to get the furnace temperature at about 9000 C. By the moveable trolley the body will be placed upon the cremation platform in the cremation chamber. The cremation door would then keep closed. The body would incinerate in the primary and in the secondary chamber between the temperature 800 and 11000 C and the cremation get completed in about 60 to 90 minutes maximum depend upon the body size and other biological reasons.

The hazardous gas and other substances are piped out from cremation chamber and cleaned by ventury scrubber with water treatment and finally the hot air is being discharged in to the 130m height chimney. ETP system takes care of treated water. The system has the ash removal system to collect the ash and remains for further custom. The system has necessary controls, auto on-off, cutoff switches and other necessary controls for a safety LPG Gas Crematorium.

Cremation is the process of reducing dead bodies to basic chemical compounds in the form of gases and bone fragments. This is accomplished through burning at high temperatures, vaporization and oxidation.

9.9.3.1 Furnace Components

Furnace System comprises of

1. **Primary Combustion Chamber:** Primary Combustion Chamber is for the incineration of Human dead Body. The Incineration is achieved by maintaining the temperature of the Chamber and also supplying air for combustion. The moment the body is introduced it catches fire and incineration process starts
2. **Body Loading Trolley:** For loading and transferring the body to furnace a trolley moves on rails is provided.
3. **Hot Duct:** The Duct connecting the Primary Combustion Chamber to Secondary Combustion chamber will always be hot during operation enabling the hot air to enter inside the Secondary Combustion chamber during the cremations process.
4. **Secondary Combustion Chamber**: Secondary combustion chamber to incinerate the emissions of gas again during cremation process. Secondary burning helps in converting Hydrocarbons to compound forms, removal of foul odor, conversion of certain gaseous elements to soluble emission gases.
5. **Cloud Chamber**: The chamber enables the removal of sub-micron particulates from emissions so that the fine particulates are not thrown to atmosphere along with the treated emission gases.
6. **Ventury Wet Scrubber**: Ventury wet Scrubber system is for the removal of soluble emissions, particulate matter and also for the removal of emissions of acid in nature.
7. **Mist Separator**: Mist separator takes care of the removal of carried over mist from emissions prior to entrance of the emissions to the Chimney
8. **Dilution System:** Dilution System provides will dilute the emissions so that the concentration of emissions is brought down prior to letting out to atmosphere.
9. **Stack**: Stack having a height of 30 Meters from the ground level is for the safe disposal of treated emissions to atmosphere
10. **Ash Chamber**: The burnt out ashes from the primary burning chamber will fall to the chamber provided beneath the primary chamber from where the ash is collected by opening the ash door by means of the scrapper provided.

9.9.3.2 Technical Specification

Chamber width : 6ft (180cm)
Chamber Length : 9ft (270cm)
Chamber Height : 5ft (150cm)
Maximum Temperature : 11000C
Fuel : L.P. Gas

Door : Front Opening
Burner System : Full length Burners on either side (3ft x 4nos.)
Gas Pipe Line : Unit made out of Copper/Ms with pressure gauge.
Insulation Kit : Withstanding 11000C with Special Cement Coating for durability
Operation : Manual operation
Chimney/Flue Gas : 30 Meter height
Lighting Arrestor : Yes.
Filtering System : Water Impingent
Emission Standard : As per KSPCB Norms
Power : 5.2 KW, 3 phase power connection
Cylinder : 8 Nos Minimum
Exhaust Pipe : Sufficient length with heat resistant insulated pipe.
Control Panel : Manual with sufficient features including temperature with monitoring device
Bed : Stainless Steel with additional M.S, Hospital trolley.
Structure : Heavy duty steel fabrication with required thickness of steel materials with additional re-enforcement and supports, front door with eye piece, Body covered with CRCA sheet and inside filled with ISI insulation bricks with Trolley to lay the body inside the chamber.

9.9.3.3 The following are the basic requirements;

- Furnace structure fabricated using heat resistant structural steel plates.
- Front door provided with view port.
- Chamber totally covered.
- Fire resistant coating over firebricks.
- Emission with in PCB's norms.
- Chimney : 30 meters.
- Burner : Full length Burners on either side.
- Process Duration : 50 ± 5 minutes
- LPG consumption : 12 ± 2 kg.

The unit is to be placed in North south basis where door to be on North.

- Combustion chamber : 800±500 C
- Post combustion chamber : 1050±500 C
- Temperature control and Indication AC : Solid state Digital type temperature indicating controller 0 - 12000˚C in each chamber.
- Safety to control activity : Solid state non indicating controller 0 - 12000˚C in each chamber.
- Temperature sensor : Cr / Al Thermocouple – 1No. in each chamber.

- Combustion air supply :1 No Blower for the supply of Oxygen for incineration of the body in combustion chamber and supply of excess air to post combustion chamber for re-incineration of emissions.
- Casing :Mild steel construction – outer with glazed tiles.
- Thermal Insulation :Ceramic board backed with energy efficient ceramic fibers of various grades on sides and top and refractory high alumina tiles backed up with ceramic fibers at the bottom of the Furnace Chamber.
- Primary Door :Vertical sliding type, counter weight balanced, motorized movement.
- Trolley: Modern stretcher type trolley with rollers moving on ball bearings for the easy sliding in of the body for cremation inside the chamber. The stretcher is having wheels and can be kept anywhere after loading.
- Ash removal : Rear side of the combustion chamber scraping by manual operation.
- Ash door : hinged type manual operated.
- Control panel : A floor mounting control cubical fabricated out of mild steel sheets and angle frame, housing indicating lamps, ON – OFF switches, contractors, HRC fuses temperature indicating controllers, safety controllers, Ammeter with selector switch, volt meter with selector switch, push button etc. will be provided. The control panel will be neatly wired and ferruled as per standard norms. The electrical components used for panel will be of reputable make.
- Secondary combustion chamber: for re-incineration of Emissions – conversion of emissions to compound soluble forms.
- Excess air purging system : for achieving cent percent combustion efficiency.
- Wet scrubber Ventury type : to remove carried over particulates and soluble emissions such as HCl, NOX etc. as over mist from the Scrubber.
- Dilution systems :to bring down further the concentration of detrimental emissions prior to letting out to atmosphere. Negative pressure creation system :for efficient drawing of emissions from the combustion chamber formed during incineration of body.

9.9.3.4 Safety Measures

- Safety Controller - To take care of control activity in case of failure of main controllers.
- Thermocouple failure safety device - Incorporated in the controllers to cut off the power supply to the Burners in case of failure of Thermocouple.
- Earthing – Proper earthing will be provided for electrical circuits as per the norms of Electricity Board.

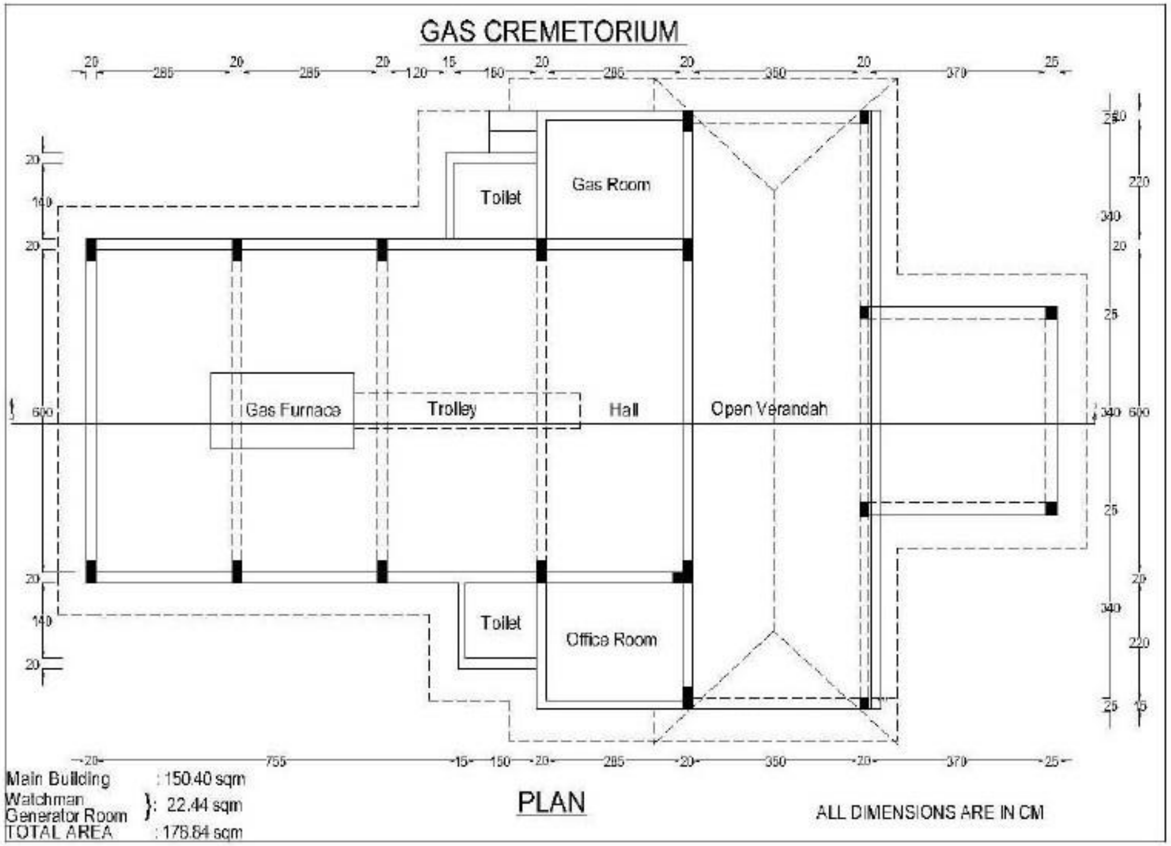
9.9.3.5 Painting: The system steel items will be painted with attractive enamel paint. The control panel will be painted with attractive enamel painted after making surface operation. The chimney will be painted as per the colour code requirement as per ICAO regulations with enamel.

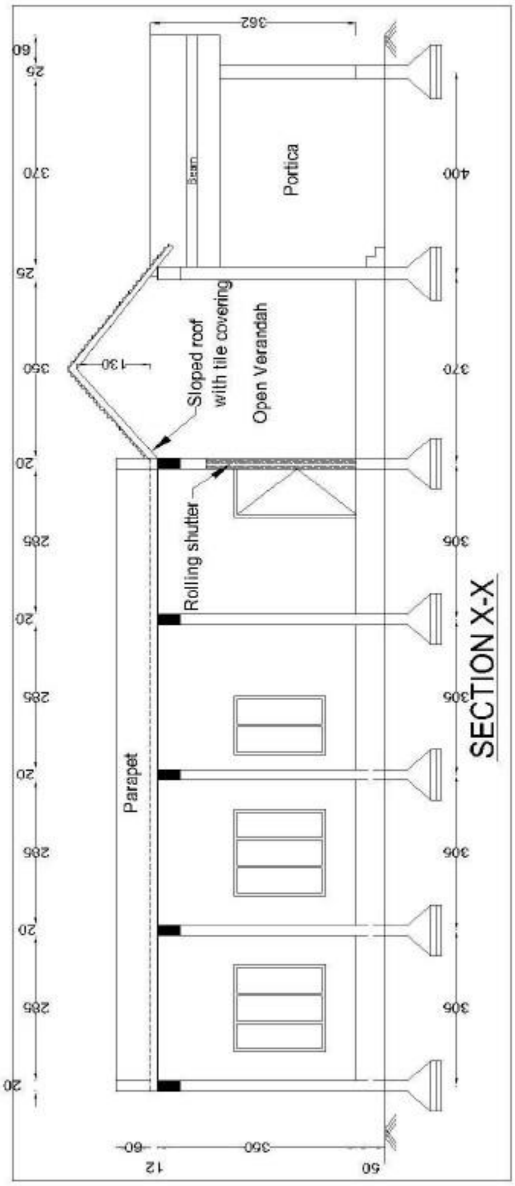
9.9.3.6 Other Requirements

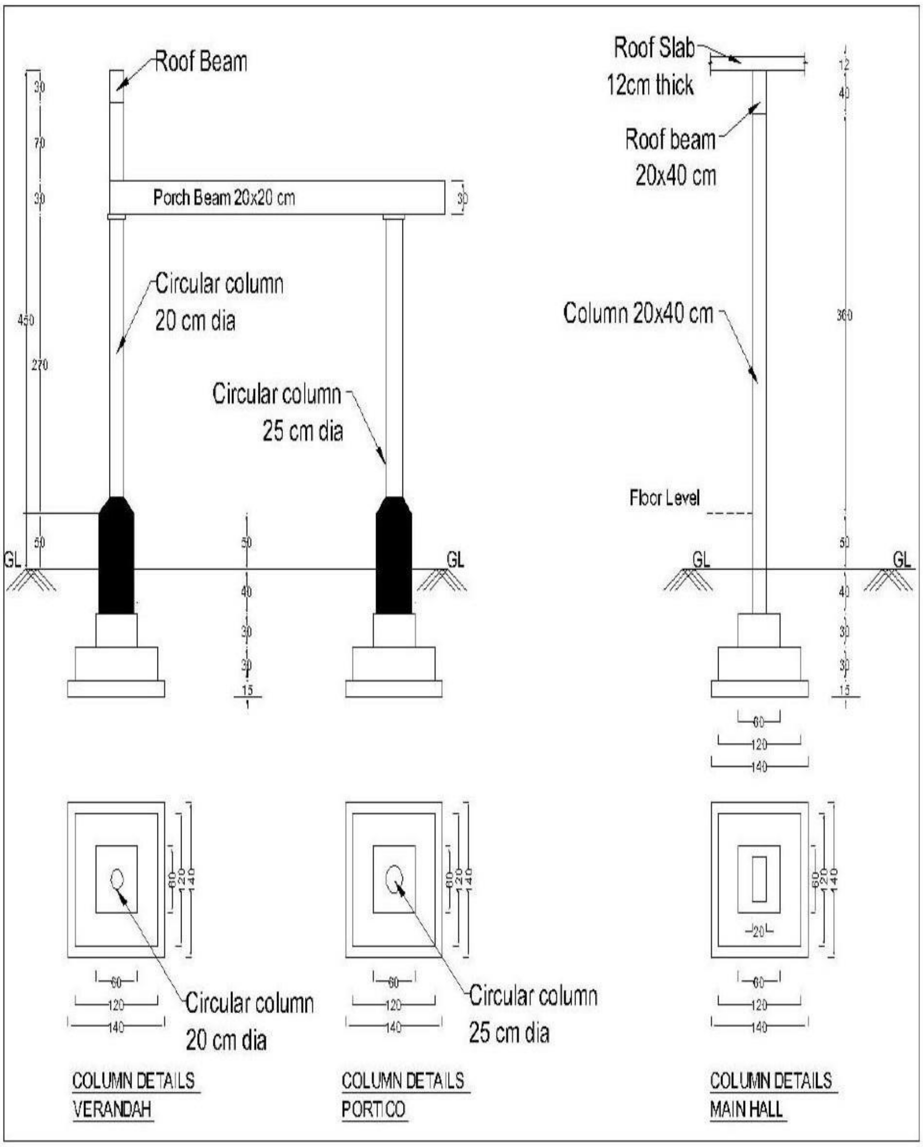
1. Required numbers of LPG cylinders
2. Obtaining explosive certificate if required.
3. Storage facility for materials.
4. Pollution Control Board approval.
5. Light, fan, exhaust for the building.
6. Land

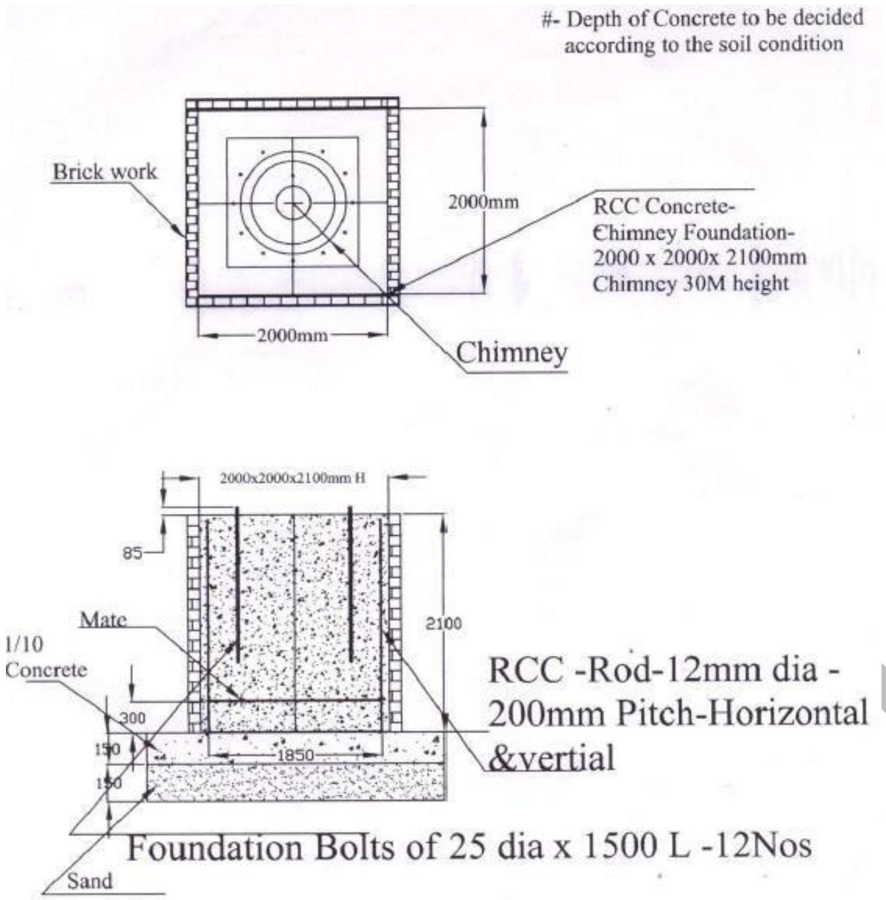
Minimum of 50 cents of land is the basic requirement for Gas Crematorium. The Plant should be established at the center portion of the land. A garden or lawn may be developed in the front portion. A minimum of 50m distance may be maintained with nearest house in order to minimize nuisance to nearby inhabitants.

Operation and Maintenance: The selected agency should be given six months free Operation and Maintenance of the facility including training to local body engaged personnel within the period. The agency should also provide AMC for a period of 3 years after the six months trial run period. Supply of electricity and Gas for Crematorium should be provided by the Local Body. Man power for operation of the facility after trial run period should be provided by the Local Body.

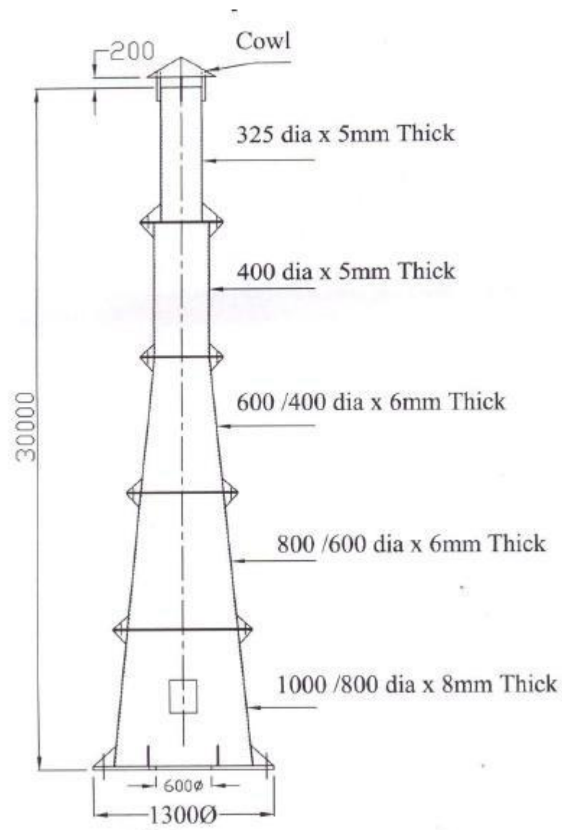

GAS CREMETORIUM
Gas Room
Toilet
Toilet
Office Room
Gas Furnace
Trolley
Hall
Open Verandah
Main Building : 150.40 sqm
Watchman
Generator Room }: 22.44 sqm
TOTAL AREA : 176.84 sqm
PLAN
ALL DIMENSIONS ARE IN CM


SECTION X-X
Parapet
Rolling shutter
Sloped roof
with tile covering
Open Verandah
Portica
Beam


Roof Beam
Porch Beam 20x20 cm
Circular column
20 cm dia
Circular column
25 cm dia
Roof Slab
12cm thick
Roof beam
20x40 cm
Column 20x40 cm
Floor Level
GL
GL
GL
GL
Circular column
20 cm dia
Circular column
25 cm dia
COLUMN DETAILS
VERANDAH
COLUMN DETAILS
PORTICO
COLUMN DETAILS
MAIN HALL



Chimney Foundation details -003



Chimney

9.9.4 Slaughter House

Modern slaughter house is required to be established in all Local Self Government Institutions (LSGIs) for ensuring slaughtering of animals in a scientific way, for producing hygienic meat and ensuring recovery of resources. Layout of slaughter house should enable that resource can be segregated and recovered at appropriate stages. The model slaughter house should comply with all statutory provisions and guidelines. Modern slaughter houses functioning outside the State at some places have all facilities in order to perform slaughtering in most hygienic way, but those slaughter houses are functioning in a factory mode. In Kerala, there is no need for highly mechanised automated slaughter houses in LSGIs since it requires high capital and operating costs. Hence, mini or tiny type of slaughter house with minimum mechanisation required to be established in Kerala.

Scientific slaughtering, maintenance of hygienic conditions in slaughter houses and maximum utilization of byproducts are the three most important requirements for sustaining our meat industry. Quality and hygiene levels in slaughter house are low due to imperfect bleeding, primitive and crude slaughtering, lack of infrastructure facilities for water, electricity and facilities for hanging carcass / flaying. This has resulted in increase of waste contamination / deterioration of meat. Qualitative and quantitative capacities of abattoirs need to be upgraded and these are required to be linked with commercial processing of meat, both for domestic consumption and exports. It will ultimately results in discouraging unauthorized slaughtering.

9.9.4.1 Resource Recovery

There is dynamic scope of by-products utilization from abattoirs/livestock and its multifarious benefits are generally not realized by industries, govt. agencies, farmers and the public. Now a major part of such by-products are considered as waste, which cause environmental pollution, and its potential to enhance the financial viability of such projects are neglected. By-products from livestock should therefore be considered as wealth. India is considered as the largest producer of milk in the world and the major producer of buffalo meat in the world. The scope and potential of by-products utilisation comprises of newer industries, employment generation, increased revenue generation, better returns to the farmer and environmental protection and safety. Some of the probable by - products and its scope on resource recovery is given in the Table

Slaughter House by-products and end products

By-product	End Product
Blood	Pharmaceutical products, leather finishing agent, plywood adhesive, feed and fertilizer
Bone Gellatine	Hotographic, pharmaceutical, explosives, printing and food
Tallow	Soap, cosmetics, food and feed
Hide/Skin	Leather, collagen, cosmetics, glue and gelatin.
Intestine	Food, surgical sutures, musical strings, sports guts, Prosthetic materials-collagen sheets, burn dressing, heparin and feed.
Horn & Hoof	Horn meal, manure, neats foot oil, fire extinguishers and protein hydrolysate
Hair/Wool	Carpets, felt,upholstery, amino acid and brushes
Stomach	Rennin for dairy industry
Fat	Fatty acids, Tallow, pharmaceuticals, feed, food, cosmetics greese, lubricants and soaps
Vitreous humour intestinal content & Stomach contents	Biogas and manure

9.9.4.2 Waste Management

Effective waste management can reduce environmental problems associated with slaughter house. The strategy followed is to reduce waste by segregating resources from different types of wastes generated in the slaughter houses. Solid waste is the main waste product from a slaughter house. Solid waste from slaughter house can be divided into two main groups, namely edible & inedible. Organs such as brain, liver, heart are the examples of edible by-products. Hooves, horns, hair, gall bladder, ears, skin, bones etc. are the inedible by-products. The components left unrecovered forms are the solid wastes.

In a modern slaughter house most of the solid wastes can be recovered as by-products. Success of material recovery depends on how slaughtering is done and how the facilities are provided in the slaughter house. Solid waste generation from slaughter house is given in the Table

9.9.4.3 Solid Waste Generation from Slaughter House

Sl. No.	Animal	Quantity of solid waste	
		kg/head	% of animal wastes
1.	Bovine	83.00	27.50
2.	Goat	2.50	17.00
3.	Pig	2.30	4.00

9.9.4.4 Solid Waste Management

Most of the solid wastes can be utilized as by-products. Composting and biomethanisation are the widely used technologies for the processing of solid waste. Solid waste from a slaughter house can be broadly classified into two for processing, Type I waste & Type II waste and it is given in theTable.

Classification of Solid Waste from Slaughter House

Category	Constituents of waste
Type I	Vegetable matter such as rumen, stomach and intestine contents, dung, agricultural residues etc.
Type II	Animal matter such as inedible offals, tissues, meat trimmings, waste and condemned meat etc.

(a) Composting

Aerobic composting is the best option for processing of type I and type II wastes. Dung from lairage, ruminal and intestinal contents, blood, meat cuttings, floor sweepings, hair etc. can be stabilized in the compost pile. Carbon to nitrogen ratio, can be balanced by depositing alternate layers of type I waste and type II waste. Maximum heap height of 1.5 m with a width of 2m shall be made use. It is advisable to put flushy matter mixed with earth in the centre of compost pit for avoiding bad odour and for generating high temperature within pit. Aeration of heap can be done once in a week by rotation of materials and within 60-90 days compost can be received. About 200 kg of solid waste can be treated in the composting system. A shed of 20 m^2 area is required for the purpose.

(b) Biogas plant

` Dung from lairage and other wastes in slurry form can be treated in biogas plant. Slaughter house having a capacity to slaughter 5 large and 20 small animals generates about

250 kg of solid waste per day. About 150 kg of solid waste can be treated in biogas plant. Specification, operation and maintenance protocol for biogas plant is given below in the Table.

Specification for Biogas Plant

Sl.No.	Particulars	Specification
1	Type	Fixed dome type
2	Volume of digester including gas holder	22m^3
3	Digester	RCC or brick masonry with RCC lining with pressure release valve, scum breaker mechanism / mixing having agitator or mixer of propeller type or anchor type, bottom slope 1 in 8 for easy withdrawal of sludge, pumps of screw type of submersible type or external chemical process type pumps for pumping water, slurry and sludge
4	Units for increasing the efficiency of digestion / plant	Pre digester tank for increasing the efficiency of main digester, homogenizer / mixer / pulper / shredder for size reduction and to make the solid waste into uniform composition before putting it to pre-digester tank. Waste to be converted into slurry form by mixing it with equal volume of water to feed in tothe digestion for easy and clog free digestion, solar water heater for making hot water, for mixing the waste with hot water, to maintain the temperature in the range of 55-60^{o}C in the digester for the growth of thermophilic microbes, Biogas holder / balloon storage facility for storage of atleast one day biogas generated, Control pane for monitoring / operation of plant
5	Inlet device	PVC pipe of diameter 250mm
6	Inlet chamber with lid	Made of cement concrete/ ferro cement, circular shape withbrickmasonry/cement concrete of 120cm diameter
7	Outlet tank	Cement concrete/brick masonry having a freeboard of 30 cm and liquid volume of 4.5 m^3.
8	Outlet opening	150 mm x 150 mm
9	Septic Tank & Soak Pit	For treatment and disposal of effluent from biogasplants. Septic tank of at least 2 compartments with maximum of 1.7 m depth and L: B: H ratio of 7.5: 2.25:1.The soak pit has to be concreted at bottom, honey- comb or perforated ring inside wall and 45–100 cm thick 2 mm sand envelop around. Vent pipe is not

		necessary. Septic tank with size of 1.5m^3.
10	Biogas	Biogas should be utilized for heating purpose for dewatering blood, melting of fat and hot water making.

- All metal parts to be coated with epoxy primer and epoxy enamel for avoiding corrosion.
- All masonry tanks to be coated with epoxy or other corrosion resistant coating.
- Skilled Manpower for Operation of the Plant.
- AMC with the consultant / supplier for a period of 2 years after installation.
- Plant to be established in a place fully exposed to sunlight and away from drinking water source.

9.9.4.4.1 Additional Facilities Include

- Facility for utilizing the gas generated for drying of blood or smelling of fat in the slaughter house.
- Facility for flaring of excess gas with automatic or semi automatic flame ignition.
- Facility for Biogas cleaning for removal of water vapour and H2S concentration to 100 ppm or less.

9.9.4.4.2 Standards

1. Minimum 45 days waste retention time.
2. Particle size of waste not to exceed 20 mm
3. Rubber hose of ¾ to $1^1/_2$inch diameter with maximum length of 40 m forconveyance of biogas
4. Rubber hose, stove and control valve with ISI mark.
5. The capacity of the biogas plant to bementioned in terms of the loading rate (ie, maximum quantity of waste to be fed in kg per day)

9.9.4.4.3 O&M Protocols

Start up by adding cow dung and equal quantity of water W

1. Waste feeding after chopping and mixed with water in the ratio 1:1
2. Daily feeding of easily degradable waste in slurry form or solid waste mixed with equal quantity of water
3. Limit the quantity of daily waste feed below the designed capacity
4. Maximum particle size of waste shall be 20 mm
5. Daily removal of slurry in to Septic Tank - Soak Pit system
6. Clean the inlet chamber after each feeding and keep it closed
7. Prohibited to feed wastes of slow degrading nature like straw, soil, egg shells, fibrous materials like banana leaves, coconut shells, coconut coir, pseudo stem etc. Feeding of toxic substances like fungicides, insecticides, pesticides, detergents, and disinfectants like phenyl, dettol etc. are prohibited.

8. Mix the substrate or rotate the drum at least weekly for preventing scum formation

9.9.4.5 Liquid Waste Management

Septic tank with soak pit system shall be utilised for tiny slaughter house having a capacity to slaughter 5 - 10 large animals and 20 small animals.. Waste water generation and typical waste water characteristics of slaughter house waste are given in the following tables.

Waste Water Generation

Sl. No.	Type of Animal	Waste Generation (in litre)
1.	Cattle	250
2.	Sheep	60
3.	Pig	400
4.	Poultry	15

Typical Waste Water Characteristics of Slaughter House Effluent

Sl. No.	Parameter	Unit	Concentration
1.	Biological oxygen demand (BOD), 27^{0}C at 3 days	mg/L	1750
2.	Chemical oxygen demand (COD)	mg/L	3550
3.	Total suspended solids (SSS)	mg/L	875
4.	Oil & grease	mg/L	220

The strategy adopted here is to reduce pollution load by recovering by-products and use of less quantity of water for washing purpose. Wastewater mainly consists of wash water and can be treated in a septic tank and soak pit system established in the site of slaughter house.

9.9.4.5.1 Treatment

Septic tank and soak pit should be provided for treatment of sewage generated from toilets in the slaughter house. A septic tank of 2.5 m x 1.2 m x 1.5 m size with soak pit shall be provided for the purpose.

9.9.4.6 Basic Facilities for a Slaughter House

The basic facilities required for a tiny slaughter house having a capacity of 5-10 big animals & 20 small animals, are given below

a. Reception area for animals
b. Lairage (Resting place for animals)
c. Room for Veterinary Doctor for performing anti-mortem and post– mortem examination.
d. Place for isolated resting place for diseased animals.
e. Stunning place / Halal slaughtering place

f. Bleeding place (for removal of blood)
g. Removal of skin and washing place
h. Evisceration place (removal of contents from stomach)
i. Meat removal and examination place.
j. Storage facilities for skin, bones, blood, fat etc.

9.9.4.6.1 Ancillary Facilities

a. Biogas plant with septic tank and soak pit system for treatment and disposal of solid waste.
b. Septic tank and Soak pit for toilet waste (sewage) treatment and disposal.
c. Aerobic composting system for disposal of undigested food from stomach of animals including dung.
d. Other facilities such as compound wall/fence with gate, internal road, water storage facility, wash room for workers, toilet etc.
e. Planting of trees/green belt in the boundary of the land.
f. Solar water heater of 500 litre capacity
g. DG set of 10 KVA

9.9.4.5.4 Optional Items

a. Meat cutter
b. Waste shredder
c. Meat stall
d. False ceiling for slaughter halls

9.9.4.6.2 Power Requirement

Slaughtering is normally commenced early morning hence a standby Diesel Generator Set of 10 KVA is essential for ensuring continuous supply of electricity for proper functioning of equipment and lighting.It is estimated that 10 KW power connected load is required in the slaughter house. A three phase power supply is required for the purpose.

9.9.4.6.3 Water Requirement

The slaughter house requires sufficient quantity and good quality water round the year. Water is required for consumption of animals, its washing before slaughtering, washing of meat, washing of floor and other areas. If public water supply is available, water connection can be taken. An over head PVC water tank can be provided for water storage purpose. Otherwise a bore well can be constructed, and it shall be provided with water pump. Sufficient number of leg operated water taps are also to be provided. A solar water heater with capacity of 500 litre capacity shall be installed for the purpose of hot water in the slaughter house. Hot water shall be used for washing slaughter hall and for sterilizing tools and other requirements. General requirements of water supply to slaughter house are given below.

- Safe, potable and constant supply of fresh water at adequate pressure
- Floor washing with water jet of 200 to 330 kPa pressure
- A constant supply of clean hot water shall be available in the slaughter hall and work rooms during the working hours
- Hot water not less than 82^0C for sterilizing of equipment and secondaryfloor washing
- Suitable facilities for washing of hands (including adequate supplies of hot and cold running water, nail brushes, soap or other detergents)
- Non-potable water for fire fighting purpose
- PVC water tank of 5000 litre capacity.

9.9.4.6.4 Lairage

Lairage is for keeping the animals indented for slaughter, well in advance for rest, observation and convenience. The size of lairage for large animals is 10 m x 2 m and that for small animals is 8.5 m x 1.5 m. Provision for water and feed to the animals shall be provided in the lairage. The lairage should have antimortem examination facility to check each animal for physical disease or pregnancy. Specification for lairage is given below.

- As per IS code a minimum area of 2.8 m^2 should be provided for large animals and 1.6 m^2 for small animals
- Animals should be kept separately depending upon type and class
- Lairage should be constituted to protect the animal from heat, cold and rain
- Floor slope should be of 20mm per metre, and 'U' Shape drain leading to biogas plant.
- Separate isolation pen should be provided with water and feeding arrangement for diseased animals (IS.4393)

Specification for Lairage

Sl. No.	Particulars	Specification
1	Foundation	Rubble masonry
2	Super structure	GI pipe upto roof level and brick wall upto 1.5 m height, preferably lean to roof to compound wall
3	Roof	Lean to roof with GI sheet preferably supported to compound wall
4	Floor	10cm thick rough PCC finish with suitable slope.
5	Entrance	Grill with locking arrangement
6	Access	Through ramp of suitable dimension

9.9.4.6.5 Slaughter Hall

Separate provision should be made for slaughtering large and small animals. Separate space should be provided for stunning, bleeding and dressing of carcass. Animals should not be slaughtered in sight of other animals. There should be two areas in the slaughter hall, the dirty area and clean area and there should not be material movement from clean area to dirty area. Dirty area consists of bleeding & dressing section and clean area for meat cutting inspection and despatch. The size of the slaughter hall specified in the type design 10 m x 3.7 m for the large animals and 11 m x 3.6 m for small animals.

Pedal operated water taps and wash basin should be provided in the slaughter hall. At the bleeding area, the blood is to be collected in stainless steel basin for further processing/ disposal. The collected blood is to be stored in tank for heating and drying. Stainless steel wheel barrow is to be provided in the slaughter hall for collecting and removing waste items like large bones, tail, intestine etc into the tripery outside. Disposal of waste should be done every day on completing the slaughter of the day. Following specification shall be adopted.

- Internal wall with smooth and flat and constructed by impervious materials with washable surface upto a height of 2.1 m
- Window sill with 1200 mm above the floor level
- Ceiling with a height of 5 m or more
- Door and doorway –1500 mm wide and 3000 mm height
- Doors of rust resistant materials
- As a general rule, one drainage inlet shall be provided for each 37 m^2 floor space.
- Floor with non absorbent and non slippery with rough finish with gradient 20 mm per metre to drainage inlets
- Slaughter hall divided into three portions – stunning place/halal place, dirty area and clean area
- Drains with a longitudinal slope of 33mm per metre length

Table 11: Specification for Slaughter Hall

Sl. No.	Components	Specification
1	Foundation	Rubble Masonry
2	Floor height (slaughter hall)	60cm above ground level
3	Floor	• Non-absorbent and non-slippery with roughfinish with suitable gradient for drainage (20mm per meter) • No breaks or cracks on the floor • Should have sufficient opening for drainage • Unpolished granite slab for flooring
4	Dadoing	White ceramic glazed tiles upto 2.1 m height in both slaughter halls
5	Doors	Stainless steel (Two door system with air curtain)
6	Windows	• Glass panel with fly proof shutters on both sides and non-transparent plane glass

		• Opening is sliding or swing facing outside • Proper net / screen for preventing insects and flies
7	Roof	• Truss work supported on column above top level lintel • Steel truss and GI sheet (powder coated) for slaughter hall • lean to roof with GI sheet (powder coated) for small animal slaughter hall
8	Access	Through ramp with GI pipe barricade of suitable length on either side with locking arrangement

The following ancillary facilities should be provided in the slaughter hall.

(a) **Screens and insect control :** All windows, doorways and other openings that may admit flies should be equipped with effective insect and rodent screens, 'Fly chaser' fans and ducts or air curtains shall be provided over doorways in outside wall of food handling areas that are used for despatch or receiving.

(b) **Rodent proofing :** Except in the case of solid masonry walls constructed of glazed brick, and the like, expanded metal or wire mesh, not exceeding 12.5 mm mesh, shall be embedded in walls and floors at their junctions. This mesh should extend vertically and horizontally to a sufficient distance to exclude the entrance of rats and other rodents.

9.9.4.6.6 Stunning Box / Cubicles in the Slaughter Hall for Large Animals

As per PCA Rules a stunning box is to be provided for large animals. Floor level of stunning box need be in an elevated plane than that of the bleeding area. One side of the stunning box shall have hinged plate. Immediately after stunning, the animal falls on the side wall of the stunning box, and the hinged plate will open and the animal slips on to the bleeding area. The bleeding area need be positioned in such a way that, an animal in the stunning box will not see the bleeding animal.

In the case of halal slaughtering, separate cubicles made up of RCC wall and with ceramic tile in walls should be utilised. Sufficient drains and floor slope should be provided for easy drainage of blood from the cubicles. Bleeding is done by hoisting the animal to a height of 5 m rail system and blood collection vessel with funnel should be used for collection of blood. Blood collected should be dewatered by heating in a vessel using stove of LPG and methane from biogas plant. Dried blood mixed with rice branshall be disposed of as fish feed / cattle feed or as manure. The following points may be noted while constructing killing place for animals.

- Stunning place separated with a cross wall
- An animal shall not be slaughtered in sight of other animals
- Stunning box manually operated for large animals (statutory requirement)
- Electric stunning box for small animals (statutory requirement)

9.9.4.6.6 Continuous Rail Arrangement in the Slaughter Hall

A continuous rail arrangement should be provided on the top of the large animal slaughter hall. The rail arrangement should be at a height as specified in the following **Table** below and is fixed on to the roof slab with supporting structures. The rail arrangement should be strong enough to carry and run 10 large animals at a time in the slaughter hall. The rail arrangement covers the bleeding area and hanging area for the smooth and convenient movement of the carcass for processing.

- Continuous rail system with 1SMB 250 with supporting structures and its fabrication bending etc in large animal slaughter halls.
- The rails should be fixed with a slope of 10 mm per 1 metre from stunning/halal place to clean area for gravity rails.

Specification:

a. Material - ISMB 250

b. Height and length - As given below

Height and Length of Bleeding and Dressing Rails

Sl.No	Operation	Height		Length	
		Large Animal	**Small Animal**	**Large Animal**	**Small Animal**
1	Bleeding	4500-5000 mm	3000-2200 mm	600 mm	450 mm
2	Dressing	3200 mm	2000-2200 mm	1800 mm for legging &dehiding and 2400 mm for evisceration and further	900 mm
3	Slope	10mm per meter for gravity rails			

9.9.4.6.7 Electric Hoist

There should be an electric hoist on each rail for lifting of large animals. Primary objective of electric hoist is to bring the animal to a height of 5 m for bleeding purpose. The hoist should have a capacity of one tone. In addition to electric hoist there should be atleast one unit of manual operated moving hoist. After bleeding the carcass shall be lowered to 3 m high rail, where movement is done using shackles. There shall be atleast5 shackles for movement of carcass and movement shall be done manually. The hoist will be of reputed brand. The hoist can operate with the pendant switch hanging by the side.

A ladder arrangement should also be provided there to access to the hoist and rail for maintenance. The electric hoist is running on through a three phase power supply. The carcass can be lifted conveniently with the hoist for processing at different stages. After hoisting carcass can be horizontally and vertically moved manually. The throat is cut and the blood is to be collected in stainless steel trough, in hanging position with the help of this hoist. The manually operated moving hoist shall be of reputed brand and it could be used at the time of power failure and during busy hours of working of slaughter house. Specification for electric hoist is given in the following Table.

Electric Hoist – Specification

Sl. No.	Components	Specification
1	Material	Indef/ Brady/ Morris or equivalent having ISI certification
2	Capacity	1 tonne
3	Type	Wire rope hoist
4	Operation	1.50 HP, 3 phase power supply withbuilt in control panel and hanging type pendant switch
5	Method of mounting	On specially built steel bracket structure
6	Electric motor capacity	1.5 HP
7	Lifting speed	4m/minute (app)
8	Lifting rope	Upto 18 mm gauge
9	Hook	Forged steel with locking arrangement
10	Hoist body	Metal body with anticorrosive powder Coated finish
11	No. of electric hoist	1no.

Specification for manually operated moving hoist is given in the following Table

Manually Operated Moving Hoist - Specification

Sl. No.	Components	Specification
1	Material	Indef / Brady or equivalent having ISI certification
2	Capacity	1 tonne
3	Type	4 wheel type traveling trolley
4	Wheel material	Cast steel IS:1030
5	Trolley operation	Manually with anti corrosive type chain
6	Lift of hoist	5 m
7	Lifting chain	S. S. chain
8	Long travel chain	S. S. chain
9	Lifting hook	Forged steel with locking arrangement
10	Hoist brake	Self sustaining, maintenance free, friction type break
11	Hoist body	Metal body with anticorrosive powder coated finish
12	No. of hoist	1 no.

Specification for shackle and chain is given in Table 15

Shackles &Chain - Specification

Sl. No.	Item	Specification
1	Material	Stainless steel – 304 Grade
2	Capacity	- 1 tonne (for large animals) - 500 kg (for small animals)
3	Quantity	5 sets (for large animals)
4	Length of chain	2 m (for large animals)

Specification for slink is given in Table

Slink - Specification:

Sl. No.	Item	Specification
1	Material	10mm dia 90cm length G.I. wire rope both side bend with brazing
2	No. of slink	15 nos.

9.9.4.6.8 Dressing

Dressing is carried out in rails fitted at a height of 3 m. Transferring of animal from 5 m bleeding rails to 3 m dressing rail can be done using the electric hoist. Adequate means and tools for dehiding or belting of the animals should be provided. Hides or skins should be transported either in a closed wheel barrow or by a chute provided with a self - closing door. Immediate disposal of legs, horns, hooves etc. should be done through side wall doors or closed wheel barrows. Care should be taken while using wheel barrows or trucks that at no point wheel barrow or truck has to ply under the dressing rails and a clear passage is provided for movement of the trucks. Care should be taken to comply with the following;

- Dressing of carcasses should not be done on floor
- Hides or skin removed should be transported immediately in a closedwheel barrow
- No hides or skin should be spread on slaughter floor for inspection
- Floor wash point and adequate number of hand wash basins with sterilizer should be provided.

9.9.4.6.9 Evisceration

Adequate space and suitable and properly located facilities should be provided for inspection of the viscera of the various types of animals slaughtered. This department should have adequate facilities for hand washing, tool sterilization, floor washing, contrivances for immediate separation and disposal of condemned material. Adequate arrangements may be made for identification, inspection and correlation of carcass, viscera and head of slaughtered animal.

9.9.4.6.10 Captive Bolt Pistol

As per PCA rules, a captive bolt pistol should be provided for stunning the animal inside the box. The pistol should be specially made for stunning of animals. It is a trouble free pistol and is in use in slaughter houses in India and abroad. As it is a statutory requirement it is to be procured, even though in most of the slaughter houses in Kerala practices halal type of slaughtering.

Captive bolt pistol and bullets

9.9.4.6.11 Stainless Steel Chute

Stainless steel chute are to be provided on the side wall of the slaughter hall for transferring waste to tripery. Through this chute, waste can be deposited to the tripery situated outside. When the slaughter of the day is over, waste can be collected from tripery. The chute should be made of stainless steel, so that it will last long and easy to keep it in clean and tidy.

9.9.4.6.12 Hanging of Goat

Stainless steel pipe should be fixed at convenient height (2 m) and having length from one end to the other end of the hall for hanging and processing the small animals. Chain with hook is provided on the pipe for hanging of carcass. The size of the stainless steel pipe shall be of 3”.

Small animals are slaughtered by halal cut. After this operation, it is manually hanged with chain and hook over the pipe. After removing the skin, intestine etc it is put on trolley having stainless steel top and can be moved to the despatch area.

9.9.4.6.13 Wheel Barrows

Minimum of 10 numbers of wheel barrows is required for 5 - 10 large & 20 small animals (tiny slaughter house). It shall be made use in the large animal slaughter hall for movement of waste and materials. It can also be used for conveying dung, waste etc to the compost unit / biogas plant. Specification for wheel barrow is given in Table.

Specification for the Wheel Barrow

Sl. No.	Item	Specification
1	Type	Stainless steel, 2 wheeled, single axle, top side 20mm dia SS pipe, bottom and vertical corner 20mm x 20mm of 3mm thick

		SSangle, 3” x 8” TOT wheel with MS axle
2	Capacity	75kg (size 70cm x 50cm x 40cm approximate)
3	Body	Fabricated body with steel per IS : 2062
4	Wheel	Pneumatic tires with ball bearing TOT wheel assembly
5	Quantity	10 nos. (min)

9.9.4.6.14 Diesel Generator Set

A diesel generator set having capacity of 10 KVA, 3 phase power supply is required for the electric hoists, lighting purpose etc for tiny slaughter house. It shall be included in the project proposal. Since slaughtering of animals commences in the early morning, electric power is essential for lighting. In addition to lighting power is essential for operation of the hoists. Therefore, a DG Set should be installed in the slaughter house.

9.9.4.6.15 Waste Grinder / Homogeniser

The waste generated is to be grinded / shredded into small pieces before putting in to the biogas plant. For this a motorized waste grinder is needed. Hence it has been included as an optional item in the project proposal.

9.9.4.6.16 Meat Cutter and Scissor Type Cutter

A motorized meat cutter and scissor type cutter should be included as an optional item in the project proposal. A scissor type meat cutter is ideal for cutting the carcass of large animals in to convenient pieces before dispatch. This can also be used for removing horn, head and hoof. This will ease the work of butchers in slaughter house. The motorized meat cutter is imported equipment. It is trouble free and is used in modern slaughter houses.

9.9.4.6.17 Compound Wall

Construction of compound wall should be included in the project. It is to be constructed with rubble basement and super structure with hollow bricks. The slaughter house and its surrounding should not be visible to the public easily. Also it helps to keep away from stray dogs. A steel fabricated gate having sufficient width according to the approach road should be included in the project. The gate can be made and fix in such a way that stray dogs cannot enter in to slaughter house premise.

9.9.4.6.18 Electrification of the Slaughter House

Electrification of the slaughter house should be done in order to get sufficient light in the slaughter hall and inspection area. Sufficient number of electric lamp inside and out side the slaughter house is to be provided. Fan and light is to be provided in the room for veterinary surgeon and health inspector’s office. Electrification for hoist and other equipments should also be provided.

9.9.4.6.19 Lighting and Ventilation

Unrefrigerated work rooms should be provided with adequate direct natural light and ventilation or ample artificial light and ventilation by mechanical means. Uncoloured glass having a high transmissibility of light may be used in skylights and windows. The glass area should be approximately one-fourth the floor area of a workroom. This ratio should be increased where there are obstructions, such as adjacent buildings, overhead catwalks, and hoists, which interfere with the admittance of direct natural light. Well distributed artificial lighting of good quality should be provided at all places where adequate natural light is not available or is insufficient. The following points should be followed while constructing slaughter house.

a. Every abattoir should be so constructed that meat inspection may be carried out in daylight. Sockets for the use of inspection lamps shall be provided at convenient places.
b. Every abattoir should be provided with well distributed artificial light of an overall intensity of not less than 200 lux throughout the slaughter hall and workrooms and at places where meat inspection is carried out, the overall intensity of artificial lights shall be not less than 500 lux.
c. Every abattoir should be provided with suitable and sufficient means of ventilation to the outside air. The construction of the slaughter hall should be so arranged that the dressed carcasses are not exposed to direct sunlight.

9.9.4.6.20 Green Belt

A green belt of sufficient width and with suitable species of trees should be developed around the compound in order to have a better environment around the slaughter house.

9.9.4.6.21 Rooms : An office for the veterinary doctor and health inspector and rest room for the workers should also be included in the project. A provision is to be made for dress changing of workers and cup boards for keeping their dress and belongings. Toilets are to be provided for the use of workers and for office staff in the slaughterhouse. It should be provided with flush, wash basins, floor with tiles, light fittings etc.

9.9.4.6.22 Plumbing Work

The slaughter house should be provided with sufficient number of water taps, wash basin, pedal operated water taps etc. Also flexible hose arrangement should be provided for easy cleaning of the slaughter hall. Water jet pressure cleaner should be provided for efficient washing of carcass and slaughter hall with minimum quantity of water. This will ensure less use of water for cleaning purpose and helps in reducing the quantity of waste water.

9.9.4.6.23 Unloading Platform with Ramp

An unloading platform with ramp which is suitable for unloading of animals from truck or other small vehicles should be provided in the project.

Specification for unloading platform

Sl. No.	Particulars	Specification
1	Size of platform	4m x 3m x 0.9m
2	Foundation	Rubble Masonry
3	Floor	Rough PCC

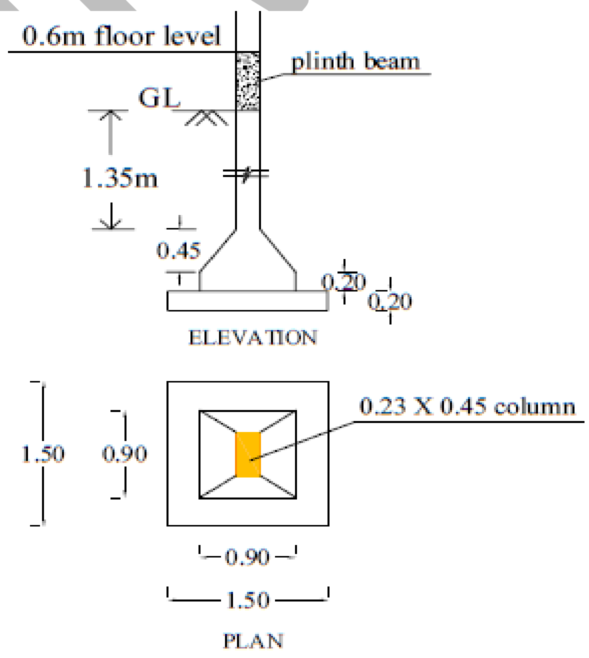
9.9.4.6.24 Guideline for Non Acceptable Materials

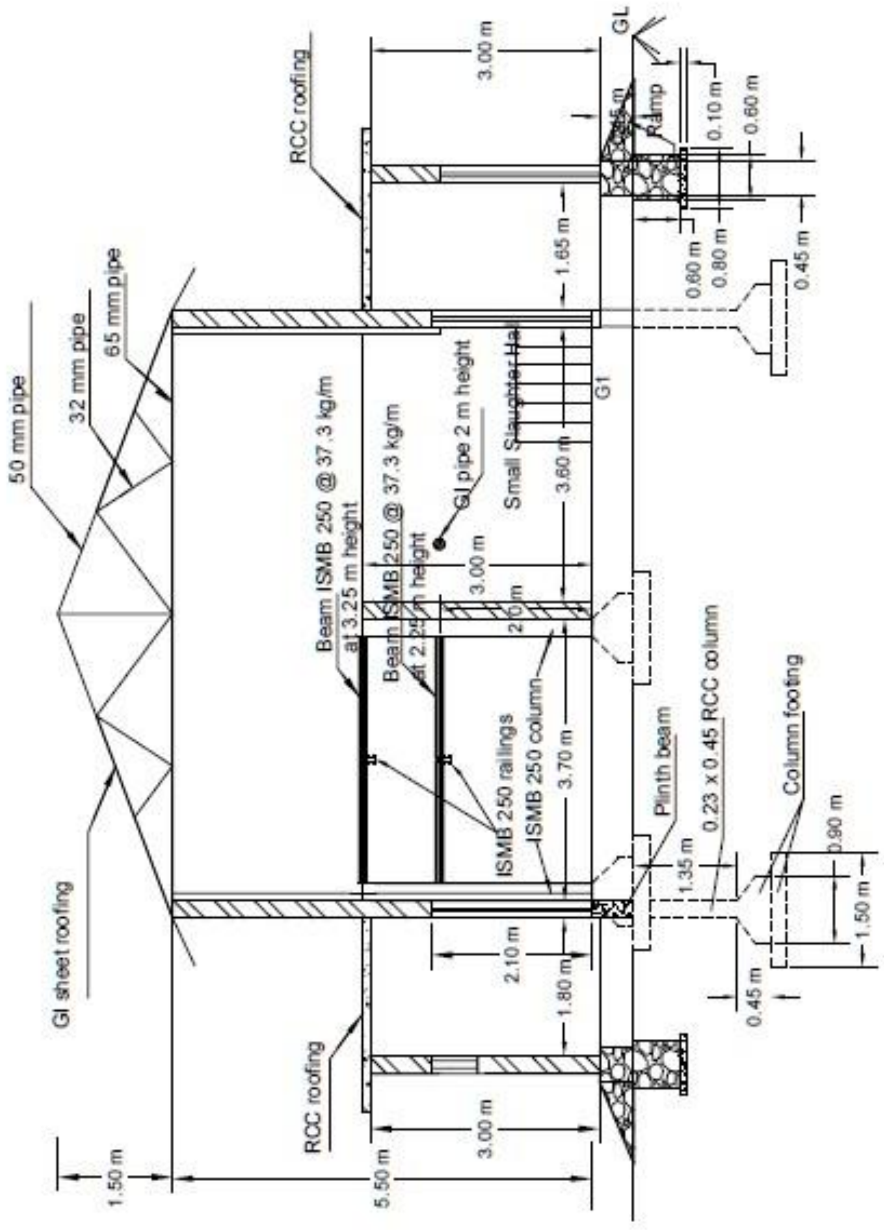
The following materials should be avoided in slaughter house construction as it has toxic potential and thereby meat gets contaminated.

- Copper and its alloys in equipment used for edible products
- Cadmium in any form in equipment handling edible products
- Equipment with painted surface in product zone
- Enamel containers or equipment is not desirable
- Lead

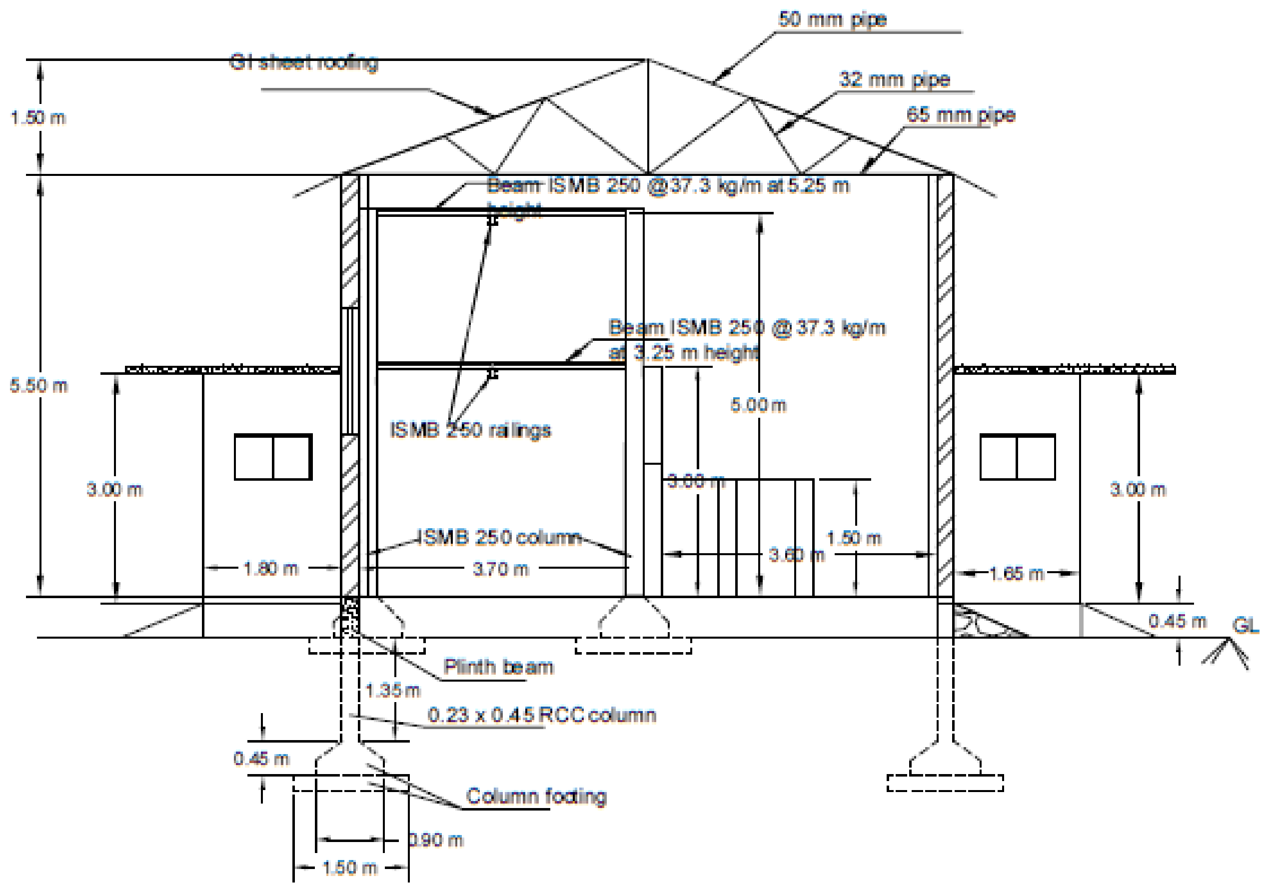
9.9.4.6.25 Working Platform

For elimination of fatigue and comfortable working for labourers the working table should be at waist height of the worker to work in standing position. If the table is at more height (that is 800 mm to 860 mm) it should have a platform incorporated for the balance height above 860mm. Working platform for on-the rail operations should be of such height that the slaughter man has neither to stoop too low nor stretch himself to his operation zone, and he should be able to reach operation zone in his natural standing position.

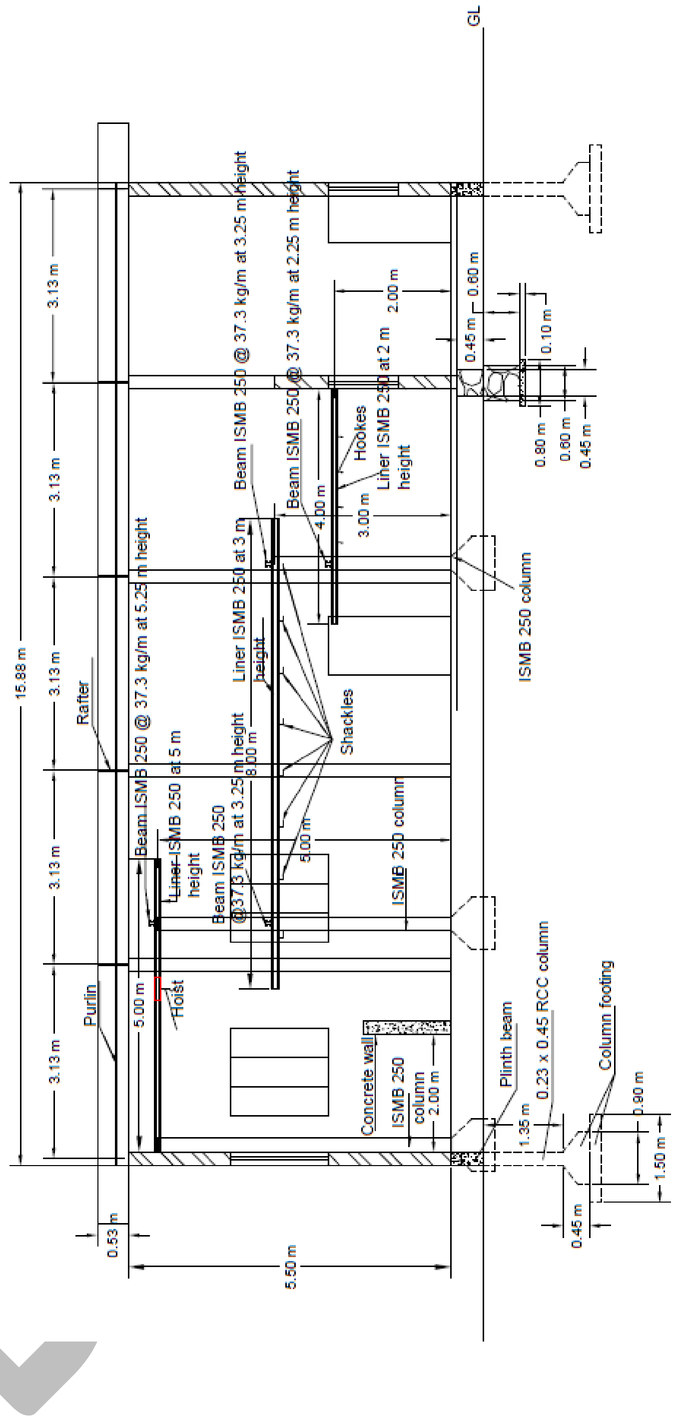




TINY TYPE SLAUGHTER HOUSE - SECTION AA



TINY TYPE SLAUGHTER HOUSE - SECTION BB



TINY TYPE SLAUGHTER HOUSE - SECTION CC