CHAPTER 14
COMPOSTING

14.1 INTRODUCTION

The organic content of Municipal Solid Waste (MSW) tends to decompose leading to various smell and odour problems. It also leads to pollution of the environment. To ensure a safe disposal of the MSW it is desirable to reduce its pollution potential and several processing methods are proposed for this purpose. Composting process is quite commonly used and results in production of a stable product - compost which depending upon its quality can be used as a low grade manure and soil conditioner. The process results in conservation of natural resources and is an important processing method, especially in agricultural and horticultural areas.

In the case of individual households, small establishments and colonies, vermi-composting which involves the stabilisation of organic solid waste through earthworm consumption for conversion of the organic material to worm casting is being increasingly preferred. This process is discussed in detail in Chapter 16.

14.2 PRINCIPLES OF COMPOSTING – MANUAL AND MECHANISED METHODS

Decomposition and stabilisation of organic waste matter is a natural phenomenon. Composting is an organised method of producing compost manure by adopting this natural phenomenon. Compost is particularly useful as an organic manure which contains plant nutrients (Nitrogen, Phosphorous and Potassium) as well as micro nutrients which can be utilized for the growth of plants (Gotaas 1956). When used in conjunction with chemical fertilisers optimum results are obtained.

Composting can be carried out in two ways i.e., aerobically and anaerobically. During aerobic composting aerobic micro-organisms oxidise organic compounds to Carbon di oxide, Nitrite and Nitrate. Carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to exothermic reaction, temperature of the mass rises. During anaerobic process, the anaerobic micro organisms, while metabolising the nutrients, break down the organic compounds through a process of reduction. A very small amount of energy is released during the process and the temperature of composting mass does not rise much. The gases evolved are mainly Methane and Carbon di oxide. An anaerobic process is a reduction process and the final product is subjected to some minor oxidation when applied to land.

14.3 INDORE & BANGALORE METHODS OF COMPOSTING

Manual composting was systematised by Howard & his associates. It was further developed by Acharya & Subrahmanyam and the methods are conventionally referred as Indore and Bangalore methods of composting.

14.3.1 Bangalore Method

This is an anaerobic method conventionally carried out in pits. Formerly the waste was anaerobically stabilised in pits where alternate layers of MSW and night soil were laid. The pit is completely filled and a final soil layer is laid to prevent fly breeding, entry of rain water into the pit and for conservation of the released energy. The material is allowed to decompose for 4 to 6 months after which the stabilised material is taken out and used as compost.

14.3.2 Indore Method

This method of composting in pits involves filling of alternate layers of similar thickness as in Bangalore method. However, to ensure aerobic condition the material is turned at specific intervals for which a 60 cm strip on the longitudinal side of the pit is kept vacant (Fig.14.1). For starting the turning operation, the first turn is manually given using long handled rakes 4 to 7 days after filling. The second turn is given after 5 to 10 more days. Further turning is normally not required and the compost is ready in 2 to 4 weeks.

In the urban areas, due to extensive provision of water carriage system of sanitation, night soil is not available. Composting of MSW alone is hence often carried out. Aerobic composting of MSW is commonly carried out in windrows.

14.3.3 Comparison of the Methods

The Bangalore method requires longer time for stablisation of the material & hence needs larger land space, which is in short supply in urban areas. The gases generated in this anaerobic process also pose smell & odour problems.

The Indore method on the other hand stabilises the material in shorter time & needs lesser land space. As no odourous gases are generated in this process, it is environment friendly & hence commonly preferred.

While the organic matter is stabilised during the composting process, the moisture content also changes. The non decomposables are also rejected. Hence the quantity of compost is much lesser than the input & is normally around 50%, and the exact value depends upon the characteristics of the input material.

14.3.4 Windrow Composting

The organic material present in Municipal Waste can be converted into a stable mass by aerobic decomposition. Aerobic micro organisms oxidize organic compounds to Carbon di oxide and oxides of Nitrogen and 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 6^{th} & 11^{th} days outside to the centre to destroy insects larvae and to provide aeration. On 16^{th} 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.

14.4 FACTORS AFFECTING THE COMPOSTING PROCESS

14.4.1 Organisms

Aerobic composting is a dynamic system wherein bacteria, actinomycetes, fungi and other biological forms are actively involved. The relative preponderance of one species over another depends upon the constantly changing food supply, temperature and substrate conditions. Facultative and obligate forms of bacteria, actinomycetes and fungi are most active in this process. In the initial stages mesophilic forms predominate and thermophilic bacteria and fungi soon take over except in the final stage of composting. Except when the temperature drops, actinomycetes and fungi are confined to 5 to 15 cm outer surface layer. If the turning is not carried out frequently the actinomycetes and fungi in these layers register increased growth imparting it typical greyish white colour. Thermophilic actinomycetes and fungi are known to grow well in the range of 45 to 60^{o} C.

Different organisms are known to play predominant role in breaking down different constituents of municipal solid waste. Thermophilic bacteria are mainly responsible for the breakdown of proteins and other readily biodegradable organic matter. Fungi and actinomycetes play an important role in the decomposition of cellulose and lignin. The actinomycetes common in compost are Streptomyces sp. and Micromonospora sp. the latter being more prevalent. The common fungi in compost are Thermonomyces sp., Penicillium dupontii and Asperigallus fumigatus. Majority of these organisms responsible for composting are already present in municipal solid waste. Not much information is available regarding the organisms active in anaerobic composting, though many of the organisms responsible for anaerobic decomposition of sewage sludge will be active here also, and differences are expected due to the concentration of nutrients present and the temperature conditions.

14.4.2 Use of Cultures

During the development of composting process various innovators came forward with **inoculum, enzymes** etc., claimed to **hasten the composting process. Investigations carried out by various workers have shown that they are not necessary.** The required forms of bacteria, actinomycetes and fungi are indigenous to MSW. Under proper environmental conditions the indigenous bacteria adapted to MSW rapidly multiply, as compared to the added cultures which are more attuned to controlled laboratory conditions and carry out decomposition. The process is dynamic and as any specific organism can survive over a specific range of environmental conditions, as one group starts diminishing, another group of organisms starts flourishing. Thus, in such a mixed system appropriate life forms develop and multiply to keep pace with the available nutrients and environmental conditions. Hence, addition of similar and extraneous organisms in the form of inoculum is unnecessary. However, such inoculum will be required during composting of industrial and agricultural solid waste which do not have the large mix of indigenous bacterial population.

14.4.3 Moisture

The moisture tends to occupy the free air space between the particles. Hence, when the moisture content is very high, anaerobic conditions set in. However, the composting mass should have a certain minimum moisture content in it for the organisms to survive. The optimum moisture content is known to be between 50 to 60 % . Higher moisture content may be required while composting straw and strong fibrous material which soften the fibre and fills the large pore spaces. Higher moisture content can also be used in mechanically aerated digesters. In anaerobic composting the moisture content used will depend upon the method of handling and whether it is carried out in the open or in closed container.

14.4.4 Temperature

The aerobic decomposition of a gram mole of glucose releases 484 to 674 kilo calories (kcal) energy under controlled conditions, while only 26 kcal are released when it is decomposed anaerobically. Municipal solid waste is known to have good insulation properties and hence the released heat results in increase in temperature of the decomposing mass. As some of the heat loss occurs from the exposed surface, the actual rise in temperature will be slightly less. When the decomposing mass is disturbed, as during turning of windrows, the resultant heat loss results in drop in temperatures. Under properly controlled conditions temperatures are known to rise beyond 70^{o}C in aerobic composting. Under properly controlled conditions temperatures are known to rise beyond 70^{o}C in aerobic composting. During anaerobic composting as the released heat is quite small and as part of it is lost from the surface only a marginal rise in temperature occurs.

This increased temperature results in increased rate of biological activity and hence results in faster stabilisation of the material. However, if the temperature rise is very high, due to inactivation of the organisms & enzymes the rate of activity may decrease. The studies carried out have shown that the activity of cellulose enzyme reduces above 70^{o}C and the optimum temperature range for nitrification is 30^{o} to 50^{o}C beyond which nitrogen loss is known to occur. The temperature range of 50^{o} to 60^{o}C is thus optimum for nitrification and cellulose degradation.

The high temperature also helps in destruction of some common pathogens and parasites (Table 14.1). According to Scott, during aerobic composting when the material is turned twice in 12 days ***Entamoeba histolytica*** is killed and the eggs of ***Ascaris lumbricoides*** are killed in 36 days when turned thrice. The studies carried out at NEERI have shown that the destruction of these organisms is not ensured under anaerobic conditions.

Knoll has proved that the high temperature and long retention during aerobic composting along with the antibiotic effect results in destruction of parasites and pathogens.

Thus, if the process is so controlled that the temperature is kept between 50^{o} to 60^{o} C for 5 to 7 days, destruction of pathogens and parasites can be ensured.

14.4.5 Carbon/Nitrogen (C/N) Ratio

The organisms involved in stabilisation of organic matter utilise about 30 parts of carbon for each part of nitrogen and hence an initial C/N ratio of 30 is most favourable for composting. Research workers have reported the optimum value to range between 26-31 depending upon other environmental conditions. The C/N ratio considers the available carbon as well as the available nitrogen while the available carbon and nitrogen in the MSW may vary from sample to sample. Whenever the C/N ratio is less than the optimum, carbon source such as straw, sawdust, paper are added while if the ratio is too high, the sewage sludge, slaughter house waste, blood etc. are added as a source of nitrogen.

Table 14.1 : Temperature and Time of Exposure Needed for Destruction of some Common Parasites and Pathogens.

Organisms	Time and Temperature for destruction
1. S.typhosa	No growth beyond 46^{O}C, death in 30 minutes at 55-60^{O}C and 20 minutes at 60^{O}C,destroyed in a short time in compost environment.
2. Salmonella sp.	In 1 hour at 55^{O}C and in 15-20 minutes at 60^{o}C
3. Shigella sp.	In 1 hour at 55^{O}C .
4. E. Coli	In 1 hour at 55^{O}C and in 15-20 minutes at 60^{o}C
5. E.histolytica cysts	In few minutes at 45^{O}C and in a few seconds at 55^{O}C.
6. Taenia saginata	In a few minutes at 55^{O}C.
7. Trichinella spiralis larvae	Quickly killed at 55^{O}C, instantly at 60^{O}C.
8. Br.abortus or Br.suis	In 3 minutes at 62-63^{O}C and in 1 hour at 55^{o}C
9. Micrococcus pyogenes var. aureus	In 10 minutes at 54^{O}C.
10. Streptococcus pyogenes	In 10 minutes at 54^{O}C.
14. Mycobactercum tuber-culosis var. hominis	In 15-20 minutes at 66^{O}C or after momentary heating at 67^{O}C.
12. Corynebacterium diptheriae	In 45 minutes at 55^{O}C.
13. Necator americanus	In 50 minutes at 45^{O}C .
14. A.lumbricoides eggs	In 1 hour at 50^{O}C.

14.4.6 Aeration

It is necessary to ensure that oxygen is supplied throughout the mass and aerobic activity is maintained. During the decomposition, the oxygen gets depleted and has to be continuously replenished. This can be achieved either by turning of windrows or by supplying compressed air. During the turning, it is necessary to bring inner mass to the outer surface and to transfer the outer waste to the inner portion. (Fig. 14.2) . In case of artificial air supply the quantity of air supply is normally maintained at 1-2 cu.m./day/kg of volatile solids.

Artificial air supply requires enclosing decomposing mass in containers which is quite costly. Hence in Indian conditions the decomposition is commonly carried out in open windrows. Studies at NEERI have shown that the optimum turning interval which will reduce the cost and simultaneously maintain aerobic conditions is 5 days.

14.4.7 Addition of Sewage and Sewage Sludge

The optimum C/N ratio for composting is 25-30. MSW in developed countries has a C/N ratio of nearly 80. To bring it down to the optimum value and to reduce the cost of sewage sludge treatment, it is mixed with sewage sludge (C/N = 5 to 8). MSW in India, on the other hand has an initial C/N ratio of around 30 which does not need blending. If such a mixing is done, C/N value may reduce below 20, when a loss of nitrogen in the form of ammonia occurs. (Table 14.2)

Tables 14.2 : Nitrogen Conservation in relation to C/N Ratio

Initial C/N Ratio	Final % of Nitrogen (N) (dry weight basis)	% N loss
20	1.44	38.8
20.5	1.04	48.1
22	1.63	14.8
30	1.21	0.5
35	1.32	0.5
76	0.86	-

Addition of sewage sludge increases smell and odour problems. It will also increase handling and transportation cost. Even if sewage is used as a source of moisture, bulk of sewage will still have to be treated. The sewage often contains waste waters from industries which contain hazardous constituents which will pose problems in the composting process and compost quality. In view of the above, addition of sewage and sludge is not desirable in India.

14.5 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 composting process should also be so controlled that the temperature of the decomposing mass remains between 50^{o}-60 ^{o}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 MSW 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.

14.5.1 Properties of Compost

The compost prepared from MSW should be black brown or at least black in colour. It should be crumbly in nature with an earthy odour. The pH should be neutral though slightly acidic or alkaline pH within the range of 6.5 to 7.5 can be tolerated.

The compost should neither be completely dry nor it be lumpy and water should not come out of the mass when squeezed.

The Nitrogen, Phosphorous and Potassium (NPK) contents should be more than one percent each. The Nitrogen should be in the form of Nitrates for proper utilisation by the plants. The C/N ratio should be between 15 to 20.

In order to ensure safe application of compost, the standards laid down in the Draft on Municipal Waste (Management & Handling) Rules, 1999, notified on 27th September, 1999 by the Ministry of Environment & Forests, Government of India, for production of compost given as per table 14.3 must be adhered to:-

Table 14.3 Standards for Compost

Parameter	Maximum acceptable concentration parts per million (ppm)
Arsenic	20
Cadmium	20
Chromium	300
Copper	500
Lead	500
Mercury	10
Nickel	100
Zinc	2500

14.6 MECHANICAL COMPOSTING

Though manual methods are preferable in countries where labour is comparatively cheap, mechanical processes are preferred (Gotaas 1956) where higher labour costs and limitations of space exist. In 1922, Becari in Italy patented a process using a combination of aerobic and anaerobic decomposition in enclosed containers. The first full scale plant was established in 1932 in the Netherlands by a non profit utility company-VAM using Van Maanen Process in which raw refuse is composted in large windrows, which are turned at intervals by mobile cranes moving on rails. The Dano Process was developed in Denmark in 1930. Several other processes were subsequently developed using different methods of processing of solid waste using different designs of digester.

14.6.1 Unit Processes

A mechanical composting plant is a combination of various units which perform specific functions. Fig.14.3 gives a general flowchart of a mechanical compost plant.

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(Fig.14.4a) or a magnetic pulley system (Fig.14.4b). Majority of the metals are recycled at the source itself and hence are not contained in the waste. Magnetic removal of metals hence is not very efficient and therefore not used is India.

In developed countries glass and metals are present in larger concentration and are removed by using ballistic separators. In these units, the waste is thrown with a large force when different constituents take different tragectories and get separated (Fig.14.5). This unit is energy intensive and due to smaller content of glass and metals in Indian municipal solid waste, it is not used in India.

The waste is thus subjected to size reduction when the surface area per unit weight is increased for faster biological decomposition. Size reduction also helps in reducing fly breeding in the decomposing mass. This is commonly carried out either in Hammermills or Rasp mills. Hammermills are high speed (600-1200 revolutions per minute) compact machines but consume large energy (Fig.14.6). Rasp mills are slow moving large units that require lesser energy (Fig.14.7). The capital cost of a hammer mill is less but its operating cost is more than that of a rasp mill mainly due to the larger energy requirement as well as more frequent replacement / retipping of hammers.

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.

14.6.2 Experience in India

Ten mechanical compost plants were set up in India during 1975-80 under the Central Scheme of Solid Waste Disposal. These plants used different flowsheets. NEERI evaluated the performance of 7 of these mechanical composting plants during 1980-82. The studies revealed :-

- Large storage hoppers are not needed.
- The waste characteristics indicated that magnetic separators were inefficient at the concentration of metals in Indian municipal solid waste & need not be provided.
- Revolving drum mixers were counter productive and need not be provided.
- Covering of windrow area is not required as the plants are normally shut down during monsoon for annual repairs.
- Artificial aeration under Indian conditions does not reduce composting time and hence need not be provided.
- It is preferable to first stabilise the raw material and then subject it to picking and size reduction. This will require same windrow area, and improve efficiency of picking and size reduction.
- Composting should not be considered as a commercial venture but should be treated as a processing method and the sale price of compost fixed accordingly.
- In case the plants have to be set up by private agency, this aspect should be kept in view while entering into agreement.

14.6.3 Composting Plants for Indian Municipal Solid Waste

The Municipal Solid Waste in Indian urban centres has a favourable C/N ratio of around 30 and is amenable to composting. The farmers and horticulturists are also accustomed to the use of farmyard manure and hence may adopt compost prepared from municipal solid waste. While setting up a municipal scale mechanical compost plant the following steps need to be taken.

14.6.3.1 Assessment & Development of Market

The size and location of market for the sale of compost needs to be assessed through a market survey. The survey should assess the price which the consumer would be willing to pay and the transportation distance to the potential market. The demand of compost is seasonal and is dependent upon the crops being grown. Hence, the marketing and distribution system should include location of supply depots close to the bulk consumers.

14.6.3.2 Selection of Site

The site should be flat and should not be liable to flooding. It should be readily approachable but slightly away from a main road to avoid any nuisance to the traffic in the event of the plant not operating properly. The approach road should be sufficiently wide so that the traffic is not obstructed in the event of break down of incoming Municipal Solid Waste trucks. The areas where compost is to be supplied should be near the site and should be easily accessible. A site for disposal of non compostables should be available near the compost plant site.

Trees planted along the periphery of the site will serve partly as a barrier against the noise and odour from the plant and also help in litter control by reducing the wind speed . The trees will also protect the plant from dust and pollutants due to the highway.

14.6.3.3 Pilot Studies

The design and construction of a full scale compost plant needs at least 1.5 to 2 years. Before the plant becomes operational, pilot scale studies be carried out using a small quantity of the raw waste that will be used in the final plant. The raw waste as well as finished compost should also be analysed for heavy metal content. The output of the plant should be widely advertised to the consumers. The pilot studies will help determine the proportion of non-compostables that need disposal, the compost output per tonne of input and its nutrient contents.

The input to composting process should be carefully chosen to be mainly organic & should not contain any hazardous material. Wastes originating from industrial areas should have to be carefully selected to ensure that it does not contain any hazardous components.

The site should be properly paved and the run off from the area collected by a peripheral drain and taken to a sump from where it can be pumped and reused for tree plantation.

14.6.3.4 Flowsheet

In the pre-fermentation type of plant which are preferred, in a majority of Indian urban centres, the incoming trucks can directly discharge their contents in the windrow area.

During composting, the temperature of the mass has to be continuously monitored. This can be done by using probes. The optimum moisture content for composting is between 50-60%, while that in the incoming waste is much lower. The addition of moisture can hence be done through a hose connected to a fire hydrant. During composting, the moisture content tends to reduce and necessary moisture can be similarly added during turning.

After 20 days, the organic matter would be stabilised and the waste can then be taken for further processing.

The Indian waste characteristics indicate a low content of metals and glass. Further, when the recommendations of the committee appointed by Hon'ble Supreme Court regarding source separation are implemented, this proportion will be very small. Magnetic separators hence need not be provided. The glass, plastics and other inorganics can easily be removed using the manual separation process and ballistic separators will not be required. After pre-fermentation, the waste is transferred to a hopper using tractor trailor system. A conveyor at the bottom of the hopper transfers it to the sorting area where workers standing on either side of the conveyor belt remove the contraries and deposit them in bins placed alongside. As majority of Indian urban centres are not completely sewered, human excreta and cowdung are often mixed with the waste. After prefermentation, the material is no more offensive and hence does not pose any problem during manual separation.

The compost thus prepared can be sold directly to the farmers as raw or green compost. However, as the lignin content of the waste has not yet been stabilised, it should not be applied to the farms for at least two more months. In case adequate space is available at the plant, the material should be stored in large size maturation windrows for 2-3 months. During this period, lignin and other resistant material is stabilised and the product can then be sold as ripe compost.

In case the ripe compost is to be sold in bulk it can be sold as it is. Sometimes it is sold in small packets. In such cases, from marketing point of view, size reduction using a simple hammer mill is carried out and the material is bagged and sold. As the material is already stabilised, the required Horse Power of the hammer mill is less, thus reducing the energy consumption and maintenance problem.

In the North East Indian states, to protect the windrows from heavy rainfall, the windrow area will have to be covered. For urban centres in Kashmir and Himachal Pradesh covering of windrows will be necessary to protect the plant from low external temperatures.

14.6.3.5 Environmental Control

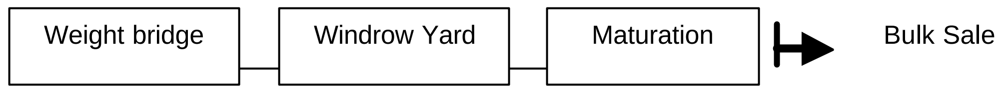
- All uncovered windrow areas should be provided with an impermeable base. Such a base may be made of concrete or of compacted clay, 50 centimetres thick, having permeability less than 10 centimetres/second. The base must be provided with 1 to 2 percent slope and must be encircled by lined drains for collection of leachate/surface water runoff. All lined drains should be connected to a lined settling pond, where tests for quality of waste-water are to be performed on a weekly basis. A treatment unit will be provided to ensure that the waste-water is discharged to open drains only after it meets the regulatory standards.

- On such days when the waste cannot be accepted at the compost plant or if shutdown occurs for extended period due to rains/cold climate/major breakdown or annual maintenance, the waste should be diverted to a properly designed and operated MSW landfill.

- The process rejects are to be removed from the compost plant on a daily basis. The recyclables should be diverted to appropriate vendors. The non-recyclables should be sent to a properly designed and operated MSW landfill. Temporary storage of rejects should be done in a covered area. If temporary storage is done in an open area, it must be done only for 1 or 2 days, at an area having an impermeable base and lined drains for collection of leachate/surface water runoff. The height of stockpiled waste should not exceed 3 metres and the storage area must have provision for odour control, litter control, fire control and birds control.

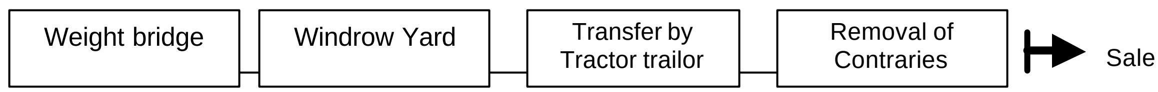
The general flowsheets for different population ranges are as given below :

I. Less than 1 Lakh population



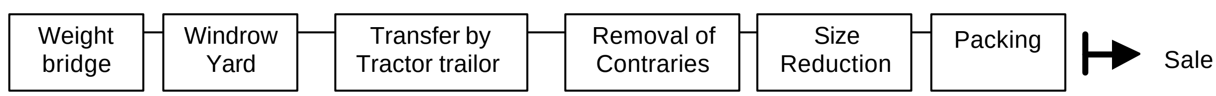
Manual Turning
every 5 days

II. Between 1,00,000 to 5,00,000 population



Turning by Front End Loader
every 5 days

III. More than 5,00,000 population



Turning by Front End Loader
every 5 days