9.2 Design of Separate Collection System

9.2.1 Examination of Technical Alternatives

Conditions to execute Separate Collection system are as follows:

- Current collection amount (407t/day) shall be assumed to be maintained during F/S study period. In case the volume increased, Collection vehicle shall be procured by the City and this is not included in this F/S.
- The collection efficiency will drop in case the Separate Collection System is introduced. This efficiency drop rate shall be assumed to be 20%and this condition is considered for the required nos. of vehicle in this F/S.
- Container(800lit.) used for Separate Collection System is included in this F/S.
- 30% of the Collection Amount shall be collected by the container as a separated waste.
- Annual collection days shall be assumed to be 350 days.

9.2.2 Preliminary design

a. Planned Waste Collection Amount

Planned waste collection amount for the year 1999 and from the year 2002 until 2005 are shown in Table 9-2

Table 9-2: Waste Generation, Discharge and Collection Amount in MGM

	1998	2002	2003	2004	2005
Generation(ton/day)	446	559	592	625	663
Discharge(ton/day)	425	540	574	607	644
Collection(ton/day)	407	528	563	597	637
Coverage Ratio(%)	96	98	98	98	99

b. Productivity of Collection Vehicles

Productivity of Collection Vehicle(16m^3 compactor truck) is shown in Table 9-3.

Table 9-3: Productivity of Collection Vehicles in MGM

Number of trips per day			
working time	t1	hr	8
Daily inspection and fuelling time before working	t2	hr	0.5
Daily inspection and washing time after working	t3	hr	0.5
Loading time	t4	hr	1.5
Unloading time	t5	hr	0.2
travel distance	D	km	40
Velocity	V	km/hr	40
Number of trips per day	Tr = (t1-(t2+t3))/(D/V+t4+t5)	times	2
Amount of waste carried per day			
Volume capacity of a vehicle	q	m^3	16
Efficiency of lading capacity	e		0.8
Reserve rate of vehicle	r		0.1
AGS of waste	d	t/m^3	0.5
Amount of waste carried per day(ton/day/truck)	Qd=qxexTr/(1+r)xd	t/day/unit	11.6

c. Required Number of Collection Vehicle

Targeted collection amount and Required number of collection vehicle are shown in Table 9-4.

Table 9-4: Required Number of Collection Vehicle in Cimsa

	formula	2002	2003	2004	2005
Collection amount (ton/day)	a	528	563	597	637
Increasing collection amount(ton/day)	b=ax1.2-407	227	269	309	357
	c=bx365/350	237	281	322	372
Required number of vehicle	d =c/Qd	21	25	28	33

b.4 Required Number of Container

Thirty percent of the collection amount shall be collected by the container as a separate waste. The separate waste amount and required number of container are shown in Table 9-5.

Table 9-5: Required Number of Container in Cimsa

	formula	2002	2003	2004	2005
Collection amount(ton/day)	a	528	563	597	637
Increasing collection amount(ton/day)	b=ax30%	158	169	179	191
Increasing collection amount(m^3/day)	c=bxASG	546	582	618	659
required number of container	d=c/0.8x7/n	956	1,019	1,081	1,153

Note: ASG=0.3(ton/m^3)
n: the number of separate collection days in a week=5days

9.3 Design of the Sorting Plant

9.3.1 Basis for Preliminary Design

a. Compositions of Non-compostable Wastes

The composition of non-compostable wastes applied to plant design is assumed as shown in the table below which is based on the JICA study team's data. Underlying assumptions for the establishment of this design waste composition are as follows:

- The waste composition in the AGM and that in the MGM are averaged and applied to the plant design.
- Foreign materials (compostable wastes) mixed in the non-compostable wastes account for 30%.

Table 9-6: Composition for Non-Compostable Wastes in MGM

		Composition	Moisture	Average		Composition			
		Average	Average	Water	Dry Solid	Non-compostable waste	Water	Dry Solid	Dry Base
		%	%	%	%	%	%	%	%
Combustibles	Kitchen Waste	53.7	77.7	41.7	12.0	**30.0**	23.3	6.7	15.1
	Paper	22.8	57.3	13.1	9.7	34.4	19.7	14.7	33.2
	Textile	2.9	50.3	1.5	1.4	4.4	2.2	2.2	5.0
	Grass and Wood	2.0	61.1	1.2	0.8	3.0	1.8	1.2	2.7
	Plastics	8.6	41.1	3.5	5.1	13.0	5.3	7.7	17.4
	Leather and Rubber	0.4	32.2	0.1	0.3	0.6	0.2	0.4	0.9
Incombustibles	Metal	1.8	19.8	0.4	1.4	2.7	0.5	2.2	5.0
	Glass	4.3	11.9	0.5	3.8	6.5	0.8	5.7	12.8
	Ceramic and Stone	1.5	30.4	0.5	1.0	2.2	0.7	1.5	3.4
	Miscellaneous	2.0	37.5	0.8	1.2	3.2	1.2	2.0	4.5
Total				63.3	36.7	100.0	55.7	44.3	100.0

b. Items to be Recovered

The items of wastes that could be recovered from MSW and their specifications are shown in Table 9-7.

Which items are to be recovered at a sorting plant in question is dependent on mainly three factors: the spatial relation between the plant and recycling enterprises, the market demand for the recycled materials, and the amount of recyclables in collected MSW.

Taking these factors into account, the JICA's study revealed that it would be feasible to recycle the following materials at the proposed sorting plant to be located in Cimsa, Mersin city.

- Paper (mainly cardboard)
- Plastics (film and PET bottles)
- Glass (bottles and cullet)
- Ferrous metal
- Non-ferrous metal (mainly aluminium cans)
- Textile

Table 9-7: Typical Materials Specifications that Affect the Selection and Design of Processing Operations for MSW in MGM

Reuse category and materials components	Typical specification items
Aluminium	Particle size; degree of cleanliness; moisture content; density; quantity, shipment means, and delivery point
Paper and cardboard	Source; grade; no magazines; no adhesives; moisture content; quantity; storage; and delivery point
Plastics	Type (e.g., PETE/1, HDPE/2, PVC/3, LDPE/4, PP/5, PS/6, and multilayer/7); degree of cleanliness, moisture content
Glass	Amount of cullet material; colour, no labels or metal; degree of cleanliness; freedom from metallic contamination; noncontainer glass; no broken crockery; quantity, storage and delivery point
Ferrous metals	Source (domestic, industrial, etc.); specific weight; degree of cleanliness; degree of contamination with tin, aluminium, and lead; quantity; shipment means; and delivery point
Non-ferrous metals	Vary with local needs and markets
Rubber (e.g., water tires)	Recapping standards; specifications for other uses not well defined
Textiles	Type of material; degree of cleanliness

Source : Integrated Solid Waste Management, McGraw-Hill

c. Sorting Methods

Sorting can be done either by hands or machine. Manual sorting has less work efficiency in terms of quantity handled per unit time but its output is of better quality compared with mechanical sorting. Further, manual sorting can be applied to any recyclable materials, while mechanical sorting is used only for the recovery of ferrous metal, aluminium, PET bottles and glass.

The use of a magnetic separator considerably facilitates ferrous metal recycling and is widely used. As for aluminium, an efficient method is particularly preferable as its market value is the highest among other recyclable materials. An eddy separator can be used, but the sorting efficiency is not high as the magnetic separator and it requires higher initial investment. Manual sorting, which can result in the aluminium recovery of good purity with a high recovery ratio, will have greater advantage than the eddy separator. Mechanical sorting for glass and PET bottles, which has recently developed to a practical use, utilises technology to segregate glass by colours or bottles by materials. It is only available, however, when glass and PET bottles are completely separated from other wastes beforehand, which is an intensive work. Further, the equipment needs through maintenance to keep work efficiency. Its introduction would not give much benefit.

On the other hand, a common drawback of manual sorting, i.e., the labour intensity, would not be a disadvantage for the sorting plant in Mersin, where labour cost is not high.

Based on the above discussion, the sorting plant is planned to recover ferrous metal by using the magnetic separator and all the other materials by manual sorting on a belt conveyor. In order to raise the work efficiency of manual sorting, a plastic bag breaker will be equipped before the hand-sorting conveyor. Moreover, the possibility to pay the workers at piecework rates should be studied since it could raise workers' motivation and in turn recovery ratio. A sorting plant in Mexico City gives a good example.

Table 9-8: Methods Used for the Processing and the Recovery of Individual Waste Components from MSW

Processing options	Description
Size reduction	Unit operation used for the reduction of both commingled MSW and recovered materials. Typical applications include (1) hammermills for shredding commingled MSW; (2) shear shredders for use with commingled MSW and recycled materials such as aluminium, tires, and plastics; and (3) tub grinders used to process yard wastes.
Size separation	Unit operation in which materials are separated by size and shape characteristics, most commonly by the use of screens. Several types of screens are in common use, including (1) reciprocating screens for sizing shredded yard wastes; (2) trommel screens used for preparing commingled MSW prior to shredding; and (3) disc screens used for removing glass from shredded MSW.
Density separation	Unit operations in which materials are separated by density, Typical applications include (1) air classifiers for the preparation of RDF; (2) inertial separation for the processing of commingled MSW; and (3) flotation for the processing of construction debris.
Electric and magnetic field separation	Unit operations in which materials are separated by their electrostatic charge and magnetic permeability. Typical applications include (1) the separation of plastics from paper and (2) the separation of ferrous from non-ferrous materials (e.g., "tin cans" from aluminium cans).

Source : Integrated Solid Waste Management, McGraw-Hill

d. Proposed Sorting Process

The proposed sorting process diagram for the recovery of recyclable materials is presented in

Figure 9-2.

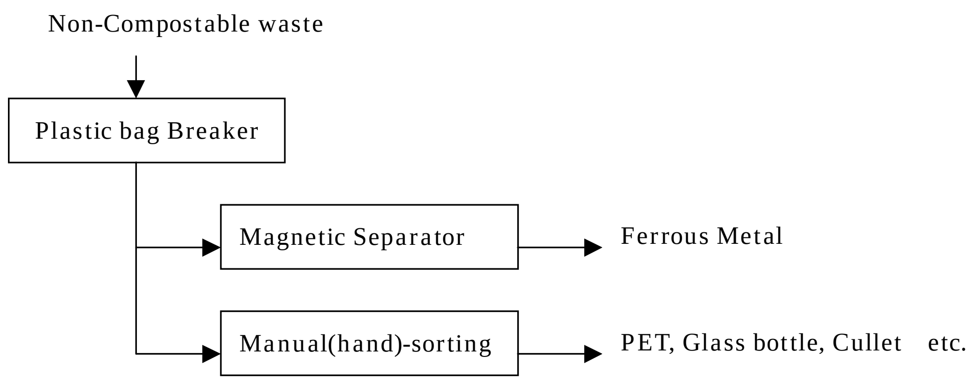


Figure 9-2: Diagram of Sorting Process

9.3.2 Preliminary Design

a. Outline

a.1 Location

The sorting plant is planned to be located within southern section of Cimsa site. The area is about 23 hectares.

a.2 Treatment Capacity

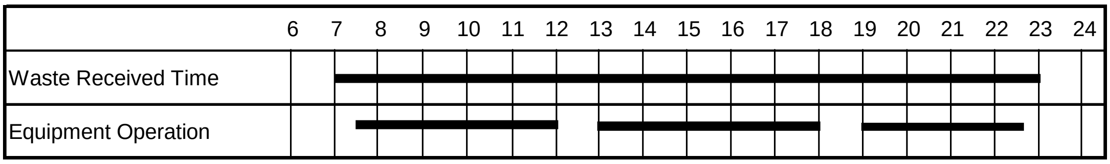
The treatment capacity of the proposed sorting plant is designed to be 100 ton/day as the non-compostable wastes to be handled at this plant in 2005, target year of the F/S, is projected at 32,095 ton/year.

a.3 Working Hours

The work schedule of the plant is as follows.

- The proposed plant operates 350 days a year.
- Mondays - Sundays 7:00 - 23:00 (16 hour/day).
- National Holidays Closed
- Waste received time 16 hour/day
- Equipment operation hours 13 hour/day

Table 9-9: Work Schedule for Sorting Plant in MGM



a.4 Main Process Components of the Plant

The main components of the proposed plant operation are as below:

- waste reception area.
- feed-hopper.
- feeding conveyor.
- hand-sorting conveyor.
- magnetic separator.
- press machine (paper, plastics, ferrous metal, and non-ferrous metal).
- baler machine (paper, plastics and textile).
- discharge equipment.

The auxiliary facilities of the plant comprise the following. Some of them will be commonly used for the operation of the sorting plant, composting plant and landfill.

- weighbridge (for common use).
- air ventilation equipment.
- machine and equipment maintenance workshop (for common use).

- site office and laboratory (for common use).

b. Sorting Plant Design Parameters

b.1 Design Principles

- The treatment capacity of the sorting plant is 100 ton/day, assuming that 30 % of all MSW will be separately collected from the waste sources to the plant, and the plant operates 350 days in a year.
- The sorting plant is planned to start operating in the year 2002.
- The sorting plant will be constructed at southern section of the Cimsa site and next to the compost plant. The site will be surrounded by a buffer zone (green belt).

b.2 Main Design Parameters

b.2.1 Operation Times of Sorting Plant

The operational conditions of the plant are proposed as follows:

- This is the same with the landfill operation hours. Twenty four hour operation could be more advantageous from the viewpoint of lower construction cost and smaller area requirement. On the other hand, however, the difficulty to employ adequate number of workers and the severe work condition would be anticipated. Therefore, twenty four hour operation can not be our option.
- Waste collection is done 16 hours a day and the reception of the non-compostable wastes at the plant will correspond to the collection schedule. Therefore, the plant operation hours is set at 16 hours. Works will be undertaken by 2 shifts.
- Out of 16 hours, 13 hours are spent for facility operation and 3 hours for other miscellaneous works such as routine maintenance of machinery and shift changes.

b.2.2 Summary of Design Parameters

The table below summarises the design parameters based on the above design assumptions.

Table 9-10: Design Parameters of Sorting Plant in Cimsa

Raw Material			
	Amount	32,095 ton/year (2005)	
	Moisture content	55.7 %	*1
	Bulk density	300 kg/m^3	*1
Plant Specification			
	Type	Hand-sorting + a magnetic separator	
	Treatment line	One line	
	Treatment Capacity	100 ton/day	
	Operation	350 day/year	
		16 hour/day by two shifts	
	Recovered Material	(1) Paper (mainly Cardboard)	
		(2) Plastics (Film and PET bottles)	
		(3) Glass (Bottles and Cullet)	
		(4) Ferrous metal	
		(5) Non-ferrous metal (mainly Aluminium cans)	
		(6) Textile	

Source *1:Estimates from the pilot project

c. Plant Process Flow

Figure 9-3 shows the plant process flow.

The key issues in the plant process are as follows.

- The high efficiency of material recovery heavily depends on the extent of non-compostable waste separation at source.
- The waste reception section and the hand-sorting section must be well co-ordinated in order to maintain the appropriate waste flow.
- The shipping of the recyclable materials must be controlled to respond to market demand.
- The waste residues need to be transferred to the landfill without delay to avoid heaps of them.

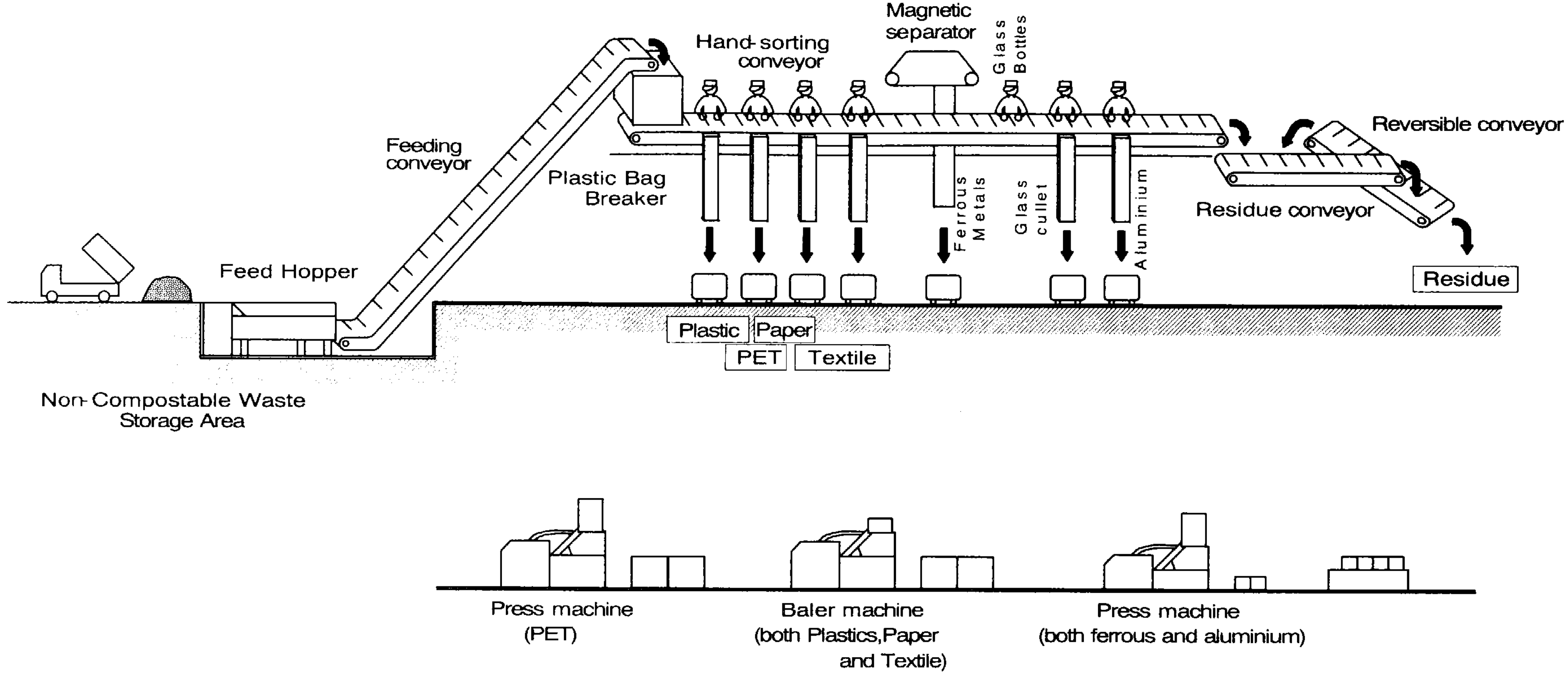


Figure 9-3: Process Flow Diagram of the Sorting Plant in Cimsa

d. Plant Equipment

The equipment of the sorting plant is summarised in the table below.

Table 9-11: Equipment of the Sorting Plant in Cimsa

Items	Descriptions	Remarks
Waste Reception	Storage Capacity : 100 ton (167 m^3) Floor : Concrete pavement	ρ=0.3 height = 2m
Feed Hopper	Type : Wheel loader tipping	---
Feeding Conveyor	Type : Apron conveyor	---
Plastic bag breaker	Type : Conveyor with blade	---
Hand-sorting Conveyor	Type : Flat rubber conveyor	---
Magnetic Separator	Type : Rubber conveyor with permanent magnet	---
Residue Conveyor	Type : Rubber conveyor	---
Reversible Conveyor	Type : Rubber conveyor	
Press Machine for Metal	Type : Oil pressure	---
Press Machine for PET	Type : Oil pressure	
Baler Machine	Type : Oil pressure	

e. Material Balance

The figure below shows the material balance at the proposed sorting plant. The composition ratios of plastic films and PET among plastics and those of bottles and cullet among glass were obtained from the pilot project.

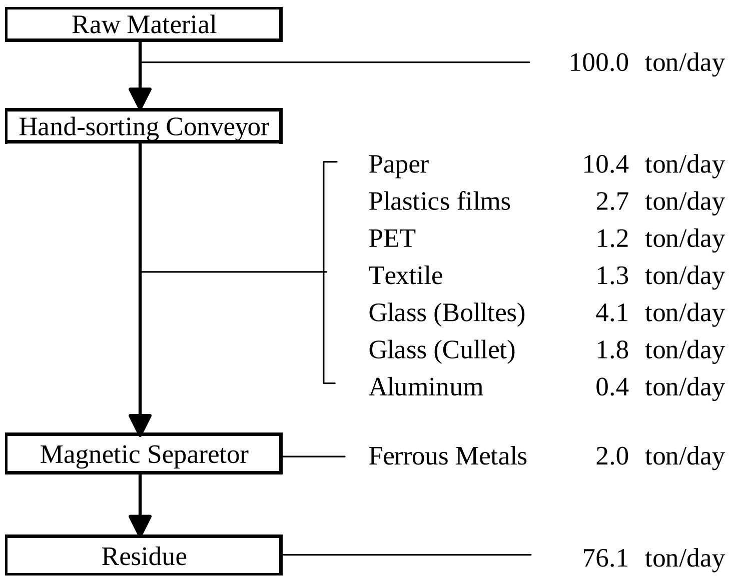


Figure 9-4: Material Balance of the Sorting Plant in Cimsa

f. Layout of Proposed Sorting Plant

The layout of the proposed sorting plant is presented in Figure 9-5.

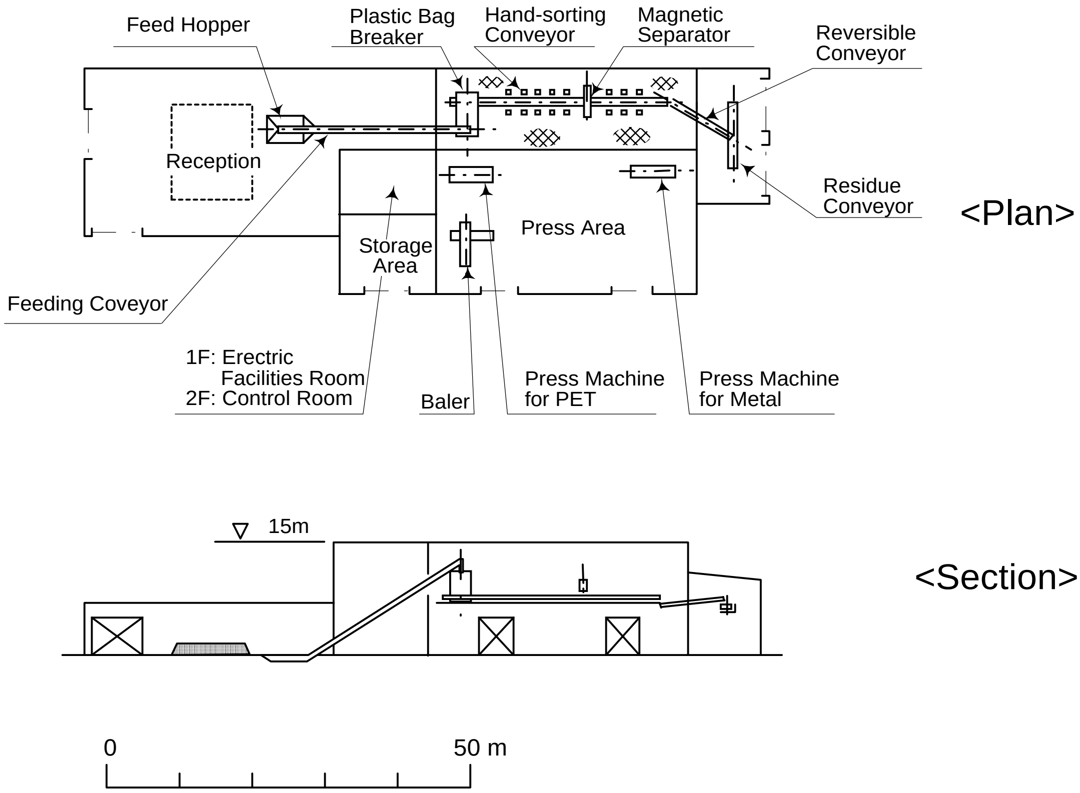


Figure 9-5: Layout of the Sorting Plant in Cimsa

g. Design Concept Summary of a Sorting Plant

The process flow diagram and the plant layout presented in Figure 9-3 and Figure 9-5, respectively, are designed for mechanical sorting of ferrous metal and hand sorting of the other materials. The reasons for choosing such sorting methods are as follows.

- Theoretically it is possible to design a fully mechanised sorting plant but it is expensive both in construction, and operation and maintenance (O&M).
- In addition mechanical sorting is less efficient in terms of recovery quality than manual sorting except for ferrous metal recovery.
- On contrary to mechanical sorting, the operation of manual sorting is flexible to the fluctuation of incoming wastes in terms of quantity as well as quality.
- The labour cost in the Mersin GM is relatively cheap, thus labour intensity of manual sorting is not necessarily disadvantage.

h. Construction Schedule

The construction schedule of the sorting plant will be as below.

- Detailed design in 2000.

- Construction of the plant in 2001.
- Equipment procurement in 2001.
- Operation commencement in 2002.

i. Operation Plan

The proposed operation plan is as follows.

i.1 Weighbridge

It is used to weigh wastes or recovered materials.

- Wastes delivered to the site is weighed by the weighbridge on arrival.
- After being weighed, wastes are transferred to the sorting plant, compost plant or landfill site depending on their types.

i.2 Waste Reception and Storage Area

The non-compostable wastes are received in and fed to the sorting line from this area.

- The non-compostable wastes, after weighed, are unloaded in this area.
- The wheel loader supplies the unloaded wastes to the feed hopper.
- When the delivered wastes is beyond the plant capacity, the excess will be moved to the storage area by the wheel loader.

i.3 Hand Sorting Section

This section segregate recyclable materials from the non-compostable waste.

- After fed by the feed hopper and the feeding conveyor, plastic bags are torn and opened by the plastic bag breaker and wastes are put on the hand-sorting conveyor.
- The magnetic separator equipped above the hand-sorting conveyor recovers ferrous metal. For the other items, the workers on the both sides of the conveyor pick up specific items pre-assigned to each of them.
- The items will be picked up in a following manner.
  - Items of relatively large size, such as paper, plastic film and textile, are picked up in the first stage to facilitate sorting in the following stage.
  - Ferrous metal is sorted by the mechanical equipment in the next stage.
  - Glass bottles and cullet are sorted in the third stage.
  - Finally non-ferrous metals is picked up.
- The sorted recyclable materials are collected through the shoots into the specific boxes downstairs except for the glass bottles which will be collected in boxes provided near the workers to prevent them being broken.

i.4 Product Section

The recovered materials are pressed or baled in this section.

- The boxes for recovered material collection under the shoots have to be replaced when full. The boxes full of materials is moved to the proper place for further processing.
- The press machine handles ferrous metal, aluminium cans and PET bottles while the baler machine handles plastic film, paper and textile.
- The press machine and the baler machine are planned to have large handling capacity for high machine efficiency. They are, thus, used for plural items by turns.

i.5 Stock Yard and Transport Section

Recovered materials would be stored temporally in the stock yard. It will be divided into several sub-sections for the following items.

  - Ferrous metal (pressed product)
  - Aluminium (pressed product)
  - PET bottles (pressed product)
  - Paper (baled product)
  - Plastic film (baled product)
  - Textile (baled product)
  - Glass (cullet and bottles)

- Each item is moved to the pre-determined sub-section of the stock yard by the workers.
- The recovered materials are shipped by recycling dealers who are supposed to come to the plant. The plant workers will load the materials on the dealers' trucks by a forklift. The trucks must be weighed on leaving.
- Waste residue remained after sorting recyclable materials are loaded on the dump trucks by the residue conveyor, and disposed of at the landfill site.

j. Staff Allocation Schedule

Table 9-12 is the staff allocation schedule for the proposed sorting plant. The number of operators and manual workers is derived from the volume of materials to be processed and facility operation capacity.

Table 9-12: Staff Allocation Schedule for Sorting Plant in Cimsa

Position	Shift 1	Shift 2	total
ADMINISTRATION			
Sub-manager	1	---	1
Accountant	1	---	1
Secretary	1	---	1
sub-total	3	---	3
OPERATION			
Pre-treated section			
Supervisor	1	1	2
Facility operate section			
Machine operator	2	2	4
Reception section			
Loader operator	1	1	2
Labourer	1	1	2
Hand-sorting section			
Hand-sorting supervisor	1	1	2
Hand-sorting labourer	12	12	24
Product section			
Supervisor	1	1	2
Labourer	7	7	14
Press machine operator	2	2	4
Baler machine operator	1	1	2
Fork lift driver	1	1	2
Transport section			
Truck driver	1	1	2
Labourer	1	1	2
sub-total	32	32	64
Total	35	32	67

9.4 Design of a Compost Plant

9.4.1 Examination of Technical Alternative

a. Composition of Compostable Waste

Composition of compostable waste applied to the plant design is assumed as shown in the table below, based on JICA study team data. The design waste composition is assumed as follows:

- The waste composition in the AGM and that in the MGM are averaged and applied to the plant design.
- Foreign materials (non-compostable wastes) in the compostable wastes account for 10%.
- The average moisture content of compostable waste is 74.5% by calculation, while the moisture content of the waste separately collected by the pilot project was 68%. It is assumed to be 70% for the design purpose.

- The delivered compostable wastes will be dewatered by its own weight while they are in the reception area and the feed hopper. As a result, the moisture content will drop to about 65%. The figure was obtained from the data of the JICA study team.

Table 9-13: Composition of the Compostable Waste in MGM

		Composition Average	Moisture Average	Average		Composition			
				Water	Dry Solid	Compostable waste	Water	Dry Solid	Dry Base
		%	%	%	%	%	%	%	%
Combustibles	Kitchen Waste	53.7	77.7	41.7	12.0	**90.0**	69.9	20.1	78.8
	Paper	22.8	57.3	13.1	9.7	4.9	2.8	2.1	8.2
	Textile	2.9	50.3	1.5	1.4	0.6	0.3	0.3	1.2
	Grass and Wood	2.0	61.1	1.2	0.8	0.4	0.2	0.2	0.8
	Plastics	8.6	41.1	3.5	5.1	1.9	0.8	1.1	4.3
	Leather and Rubber	0.4	32.2	0.1	0.3	0.1	0.0	0.1	0.4
Incombustibles	Metal	1.8	19.8	0.4	1.4	0.4	0.1	0.3	1.2
	Glass	4.3	11.9	0.5	3.8	0.9	0.1	0.8	3.1
	Ceramic and Stone	1.5	30.4	0.5	1.0	0.3	0.1	0.2	0.8
	Miscellaneous	2.0	37.5	0.8	1.2	0.5	0.2	0.3	1.2
Total				63.3	36.7	100.0	74.5	25.5	100.0

b. Definition of Terms

Prior to the examination of technical alternatives the terms used in this report are defined for good understanding.

- **Raw materials**: the materials to be fed into the compost plant. They are supposed to be compostable and separated at source.
- **Pre-treated materials**: the materials after the removal of non-compostable materials from the raw materials and size reduction by crushing.
- **Composting**: the controlled biological decomposition of compostable waste materials under aerobic conditions. The product of this process is defined as **raw compost**.
- **Composting period**: the period of decomposition of the raw material. For this preliminary design it is assumed to be **28 days**.
- **Turning**: action of agitating the static piles in order to maintain aerobic conditions inside them.
- **Maturation (Curing)**: time for stabilisation of raw compost. The product of this process is defined as **mature compost**.
- **Maturation Period**: time required for maturation. For this preliminary design the maturation period is assumed to be **60 days**.
- **Primary Screening**: the process of removing large-size particles, non-compostables (e.g., plastics, glass, cans, metal, etc.) and materials which needs longer time for decomposition (e.g., paper and wood) from the raw

compost using a trommel. Its mesh size is 25mm. The product of this process is defined as **screened raw compost**.

- **Final Screening**: the process of removing large-size particles (over 12 mm). Mature compost is passed through a trommel (mesh size : 12 mm), then ferrous metal is removed with a magnetic separator. The output of the final screening is called **fine compost** and the remained oversize material are **coarse compost**.
- **Compost Product**: the end product resulting from the composting, maturation, and screening processes.
- **Compost Product Storage Areas**: the area to store compost products while there is no market demand. The storage period is 90 days as maximum.

c. Examination of Technical Alternative

c.1 Composting Process

There are basically two types of composting process for organic fraction of municipal solid wastes: "aerobic process" (so-called composting plant) and "anaerobic process" (in general term biogas plant). Table 9-14 shows the comparison of the two processes.

Table 9-14: Comparison of Aerobic and Anaerobic Composting for Organic Fraction of Municipal SW

Characteristic	Aerobic process	Anaerobic process
Energy use	Net energy consumer	Net energy producer
End products	Humus, CO_2, H_2O	Sludge, CO_2, CH_4
Volume reduction	Up to 50%	Up to 50%
Processing time	20 to 30 days	20 to 40 days
Curing time	30 to 90 days	30 to 90 days
Primary goal	Volume reduction	Energy production
Secondary goal	Compost production	Volume reduction, waste stabilisation

source : Integrated Solid Waste Management, McGraw-Hill

As the compost plant is selected as one of the priority projects in the Study with the prime objective of "recovery of organic waste, especially kitchen waste", the aerobic process is selected for the design of this project.

Aerobic composting can be operated by either windrow composting, static pile composting or in-vessel composting. Furthermore, the windrow composting has two types: minimal technology windrow and high-rate windrow. Table 9-15 shows comparison of these composting methods.

Table 9-15: Comparison of Composting Method

	Window		Static pile	In-vessel
	Minimal Technology	High-rate windrow		
Outline	The minimal windrow technology approach involves forming large windrows (e.g., around 3.5m height by 7.3m width) that are turned only once a year with a front-end loader.	A high-rate windrow composting system employs windrow with smaller cross section, typically 1.5 to 2.0 m height by 4 to 5m width. The dimensions of the windrows depend on the type of equipment that will be used to turn the composting waste. Waste is turned twice per week while the temperature is maintained at around 55 Centigrade.	An aerated static pile system consists of a grid of aeration or exhaust piping over which the processed organic fraction of municipal solid waste is placed. Typical pile heights are 2 to 2.5 m. A layer of screened compost is often placed on top of the newly formed pile for insulation and odour control.	In-vessel composting contains an enclosed container vessel inside. The system can be divided into two major categories: plug flow and dynamic (agitated bed). In the plug flow system, the relationship between particles in the composting mass stays the same throughout the process, and system operates on first-in, first-out principle. In the dynamic system, the composting material is mixed mechanically during the processing.
Odours	Probably emit objectionable odours	Often release offensive odours (accompanied turning)	Controllable	Less than static pile and controllable
Roof	No	No	Yes	Yes
Degradation period	Three to five years	Three to four weeks (composting) Three to four months (curing)	Three to four weeks (composting) Three to four months (curing)	One to two weeks (composting) Four to twelve weeks (curing)
Required area	Very large	Large	Large	Small
Construction cost	Very cheap	Cheap	Intermediate	High
O & M cost	Very cheap	Cheap	Intermediate	High

source : Integrated Solid Waste Management, McGraw-Hill

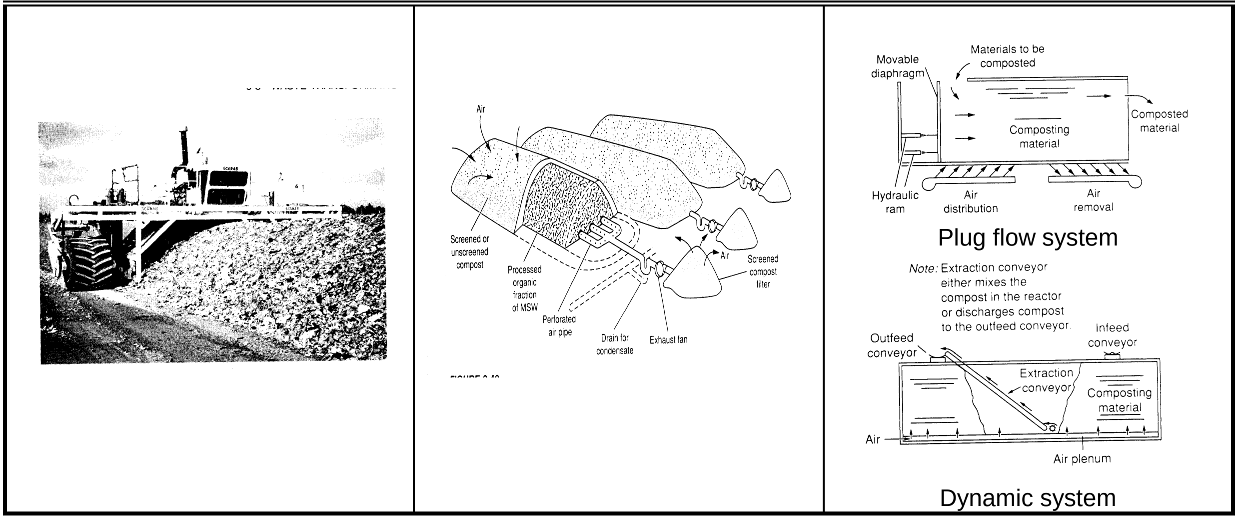


Figure 9-6: Major Composting Systems

c.2 Selection of Composting System

Although the Mersin composting plant was originally designed as a composting container (a kind of static pile according to the above table), the current plant operation employs a windrow system of minimal technology. Based on the above comparison table and past experience of the plant the team recommends to apply the static pile system as composting method for the new plant. The reasons are:

- Taking proximity to the residential area (about one km or less) into consideration, it is indispensable to have an odour control facility.
- For operation in rainy season (winter) it is necessary to have a roof for the composting process in order to avoid leachate generation by rain water.
- The windrow system can neither control odours nor leachate.
- The in-vessel system is expensive both in investment and O&M (operation and maintenance).
- The static system is relatively cheap both in investment and O&M. It can control both odours and leachate.

c.3 Pre-treatment Process

The proposed composting plant needs the pre-treatment process for the following reasons.

- The raw materials separated at source as compostable can still contain non-compostable materials. To prevent product quality deterioration, they should be removed. The removal method may allow material recovery from the removed materials.
- Size reduction will result in the enlarged surface area of waste fractions. The larger the surface area is, the more oxygen can be supplied, and aerobic decomposition is facilitated.

The methods applicable for pre-treatment are listed in Table 9-16.

Table 9-16: Methods Used for the Processing and the Recovery of Individual Waste Components from MSW

Processing options	Description
Size reduction	Unit operation used for the reduction of both commingled MSW and recovered materials. Typical applications include (1) hammermills for shredding commingled MSW; (2) shear shredders for use with commingled MSW and recycled materials such as aluminium, tires, and plastics; and (3) tub grinders used to process yard wastes.
Size separation	Unit operation in which materials are separated by size and shape characteristics, most commonly by the use of screens. Several types of screens are in common use, including (1) reciprocating screens for sizing shredded yard wastes; (2) trommel screens used for preparing commingled MSW prior to shredding; and (3) disc screens used for removing glass from shredded MSW.
Density separation	Unit operations in which materials are separated by density, Typical applications include (1) air classifiers for the preparation of RDF; (2) inertial separation for the processing of commingled MSW; and (3) flotation for the processing of construction debris.

Processing options	Description
Electric and magnetic field separation	Unit operations in which materials are separated by their electrostatic charge and magnetic permeability. Typical applications include (1) the separation of plastics from paper and (2) the separation of ferrous from nonferrous materials (e.g., “tin cans” from aluminium cans).

Source : Integrated Solid Waste Management, McGraw-Hill

c.3.1 Non-compostable Material Mixed in the Raw Materials

There are in general two ways to segregate recyclable materials and other materials unsuitable for composting from the raw materials: manual sorting and mechanical sorting.

The JICA study team conducted a pilot project of separate waste collection. The compostable wastes separated in this project was found to contain farther more organic components and thus more decomposable than wastes currently fed to the existing Mersin compost plant.

Therefore, when manual sorting is applied, the work environment will be highly unhygienic. Furthermore, the pilot project revealed that there were little incentives for the workers to sort recyclable materials. The team, therefore, planned not to apply manual sorting to the proposed plant.

c.3.2 Size Reduction

The size reduction of the raw materials down to the size suitable for composting, i.e., 50mm, is worth for process time reduction and product quality improvement. The use of hammer mills, as in the existing compost plant in Mersin, is the most common. The units of this type, however, crush all materials fed to them including plastics, metals and glass, which could be easily rejected if they were not crushed.

The figure below illustrates the typical structure of the hammer mill.

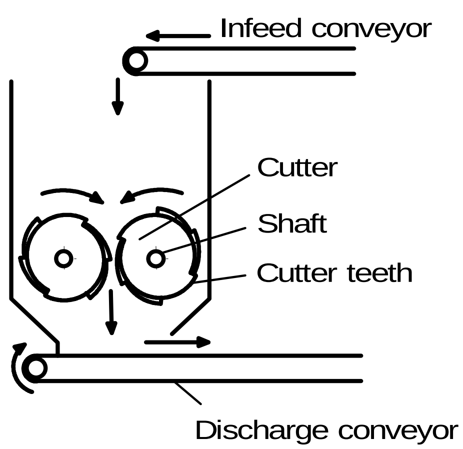


Figure 9-7: Hammer Mill

A new crushing technique innovated a selective crushing separator (SCS). This is able to crush only fragile wastes such as food waste and wet paper and separate robust or flexible wastes such as cans, plastic sheet and fibres without crushing. It consists of a rotary drum screen with holes and a turning scraper within it.

The features of the SCS are as follows.

- Its functions include crushing and separating.
- Although the compostable wastes received by this plant has high moisture content, the SCS will face less troubles of screen blockage which is often caused by such wastes
- It reduces the size of kitchen waste to 50mm.
- It tears plastic bags.

The SCS was applied to the design by the JICA study team, by which size reduction and the rejection of unsuitable materials can be achieved. As shown in Figure 9-8, the SCS consists of a perforated rotating drum screen and a rotating scraper at different speed within the drum screen.

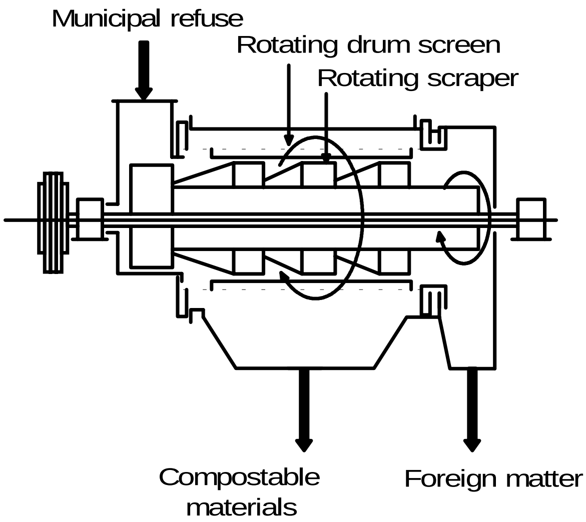


Figure 9-8: Selective Crushing Separator

c.4 Screening Section

It is highly effective to remove impurities from the raw compost and the mature compost for compost production of good quality.

The following methods are available for compost purification.

- Size separation : trommel screen, vibrating screen, disc screen, etc.
- Density separation : air classifier, stoner, ballistic inertial separator, etc.
- Magnetic and electric field separation

  : magnetic separator, eddy current separator, etc.

In general, a compost plant has one or more separators shown above. A trommel screen for size separation is especially popular due to its high separation efficiency and easy operation. A magnetic separator is also commonly used to reject ferrous metal from screened compost after size separation. A ballistic inertial separator, although it is not widely used, is effective to reject glass or gravel of small size. The structure is simple with less movable devices and its separation efficiency is relatively high.

The proposed compost plant is planned to be equipped with the following separators.

- trommel screen (size separation for raw compost and mature compost)
- ballistic inertial separator (density separation for small glass cullet and gravel)
- magnetic separator (ferrous metals)

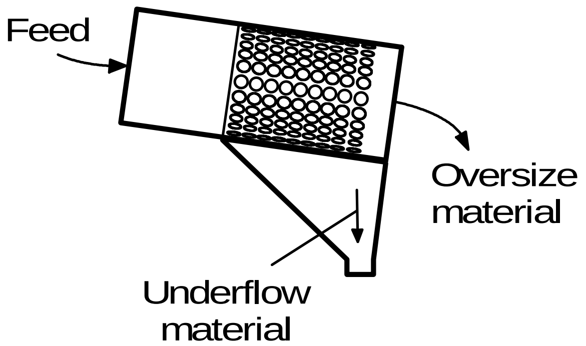


Figure 9-9: Trommel Screen

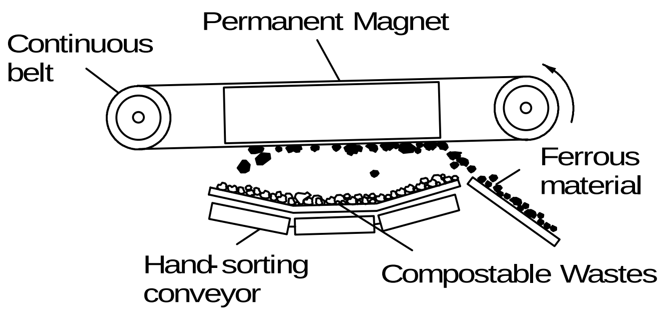


Figure 9-10: Magnetic Separator

9.4.2 Preliminary Design

a. Outline

a.1 Location

The compost plant is planned to be located within southern section of Cimsa site. The area is about 23 hectares.

a.2 Treatment Capacity

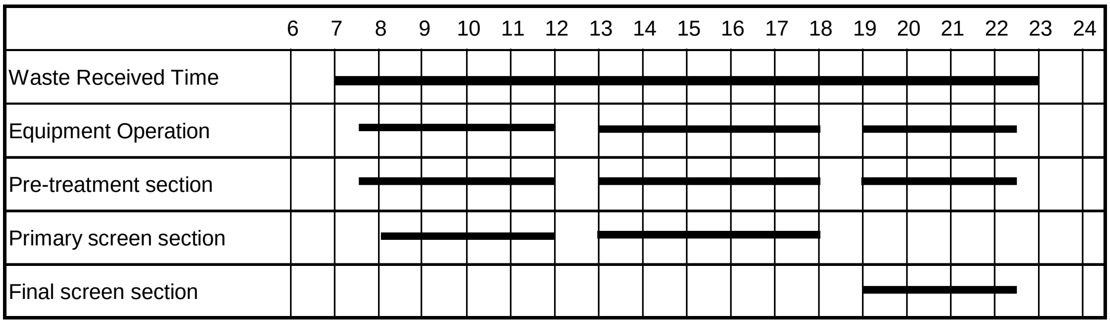
The treatment capacity of the proposed compost plant is designed to be 110 ton/day as the compostable wastes to be processed at this plant in 2005, target year of the F/S, is projected at 37,677 ton/year.

a.3 Working Hours

The work schedule of the plant is as follows.

- the proposed plant operates 350 days a year.
- Mondays - Sundays 7:00 - 23:00 (16 hour/day).
- National Holidays Closed.
- Waste received time 16 hour/day
- Equipment operation hours 13 hour/day

Table 9-17: Work Schedule for Compost Plant in Cimsa



a.4 Main Process Components of the Plant

The main components of the proposed plant operation are as below.

- pre-treatment process.
- composting process.
- maturating process.
- screening process.

The process times are assumed for the purpose of preliminary design to be 28 days for composting and 60 days for maturation. Auxiliary facilities of the plant comprise the following.

- weighbridge (for common use).
- waste reception areas.
- temporary storage areas.
- compost product storage areas.
- air supply facility.
- water supply facility.
- drainage facility.
- machine/equipment maintenance workshop (for common use).
- site office and laboratory (for common use).

b. Compost plant Design Parameters

b.1 Design Principals

- The plant capacity is calculated to be 110 ton/day by assuming that 30% of MSW will be separately collected and that the plant operates 350 days in a year.
- It is planned that the compost plant starts operating in the year 2002.
- The compost plant will be constructed at southern section of the Cimsa site and next to the sorting plant. The site will be surrounded by a buffer zone (green belt).

b.2 Main Design Parameters

b.2.1 Operation Times of Compost Plant

Operational conditions of the facility are proposed as follows:

- This is the same with the landfill operation hours. Twenty four hour operation could be more advantageous from the viewpoint of lower construction cost and smaller area requirement. On the other hand, however, the difficulty to employ adequate number of workers and the severe work condition would be anticipated. Therefore, twenty four hour operation can not be our option.
- Waste collection is done 16 hours a day and the reception of the non-compostable wastes at the plant will correspond to the collection schedule. Therefore, the plant operation hours is set at 16 hours. Works will be undertaken by 2 shifts.
- Out of 16 hours, 13 hours are spent for facility operation and 3 hours for other miscellaneous works such as routine maintenance of machinery and shift changes.

b.2.2 Design Assumptions

Design assumptions for the preliminary design are described below.

- **Composting Period**: In general practice, the composting period is in the order of 20 to 30 days. This preliminary design proposes a period of 28 days including a margin of safety that allows adjustment for variations in moisture content of the raw materials.
- **Turning Frequency**: It is assumed to carry out 5 turnings in total during the 28-day composting period, with an interval between turnings of 5 or 6 days. Transferring the raw compost to the maturation area on the 28th day is counted as the 5th turning. The initial temperature of the static piles should be maintained at 55-60 ºC, which is the determinant of the timing of turning.
- **Maturation Period**: This is generally in the order of 30 to 90 days. The preliminary design assumes a 60 day period in order to provide sufficient maturation time.
- **Bulk Density and C/N ratio**: Bulk density and the C/N ratio obtained by the WACS by the JICA study team are employed as the figures for the raw material.

Meanwhile, the corresponding figures for the raw compost and mature compost are derived from empirical values obtained in Japan.

- **Moisture Content**: The moisture content of the raw material was calculated to be 70% based on the WACS by the JICA study team. The moisture content of the waste separately collected by their pilot project was 68%. In plant design, 70% moisture content of the raw materials was assumed considering the release of substantial amount of water at waste generation and collection stages. Design moisture contents for raw compost and mature compost are derived from empirical values recorded in Japan.

- **Compostable Content**: Based on the result obtained from the separate collection pilot project by the JICA study team, the team assumed foreign materials (non-compostable waste) in the compostable wastes to account for 10%.

b.2.3 Summary of Design Parameters

The table below summarises design parameters based on the design assumptions established above.

Table 9-18: Design Parameters of Compost Plant in Cimsa

Composting section				
	Type	Aerated Static Pile		
	Raw Material	Amount	110 ton/day	
	(Compostable Waste)	Compostable Content	20.3 % by Dry weight	*1
		Moisture Content	70 %	
		Apparent Specific Gravity (ASG)	500 kg/m^3	*2
	Operation		350 day/year 16 hour/day	
	Treatment Capacity		110 ton/day	
	Composting Period		28 days	
	Pile Temperature		>55^{o}C	
Maturation (Curing) section				
	Operation		350 day/year 16 hour/day	
	Treatment Capacity	Mature compost product	~ 20.0 ton/day	
		Moisture Content	~ 40 %	
		Apparent Specific Gravity (ASG)	500 kg/m^3	*2
	Maturation Period		60 day	
Final Separation section				
	Type	Trommel screen		
	Operation Time		350 day/year 16 hour/day	
	Treatment Capacity	Fine compost product	~ 16.2 ton/day	
		Coarse compost product	~ 3.8 ton/day	
		Moisture Content	~ 40 %	
		Apparent Specific Gravity (ASG)	500 kg/m^3	*2

*1 : Obtained from Table 9-13 (composite of kitchen waste, grass and wood)
*2 : Estimates from the pilot project.

c. Quantity and Quality of Compost Product

Table 9-19 shows the target quality and quantity of the compost product in the preliminary design.

- Moisture content of the compost product is kept as low as possible (approximately 40%), for the purpose to mitigate the odour effect on the surrounding environment.
- A water truck is included in the plant machinery plan to be used to adjust the moisture level of the final product. There is a possibility of having market demand for compost product with a higher moisture content. The water truck is also utilised for moistening the static piles.

Table 9-19: Quantity and Quality of Compost Product in Cimsa

Quantity	Fine Compost	~ 16.2 ton/day ~ 5,670 ton/year
Quality	Moisture Content	40 %
	Apparent Specific Gravity (ASG)	500-700 kg/m^3
	C/N ratio	< 25

d. Flow of Compost Plant Process

Figure 9-11 shows the flow of the proposed compost plant process.

The key issues in the plant process are as follows.

- The pre-treatment process must be well managed in order to secure good product quality.
- The environment favourable for organics decomposition in the static piles must be maintained by air supply control, turning and moisture adjustment.
- The compost product must be shipped responding market demand.

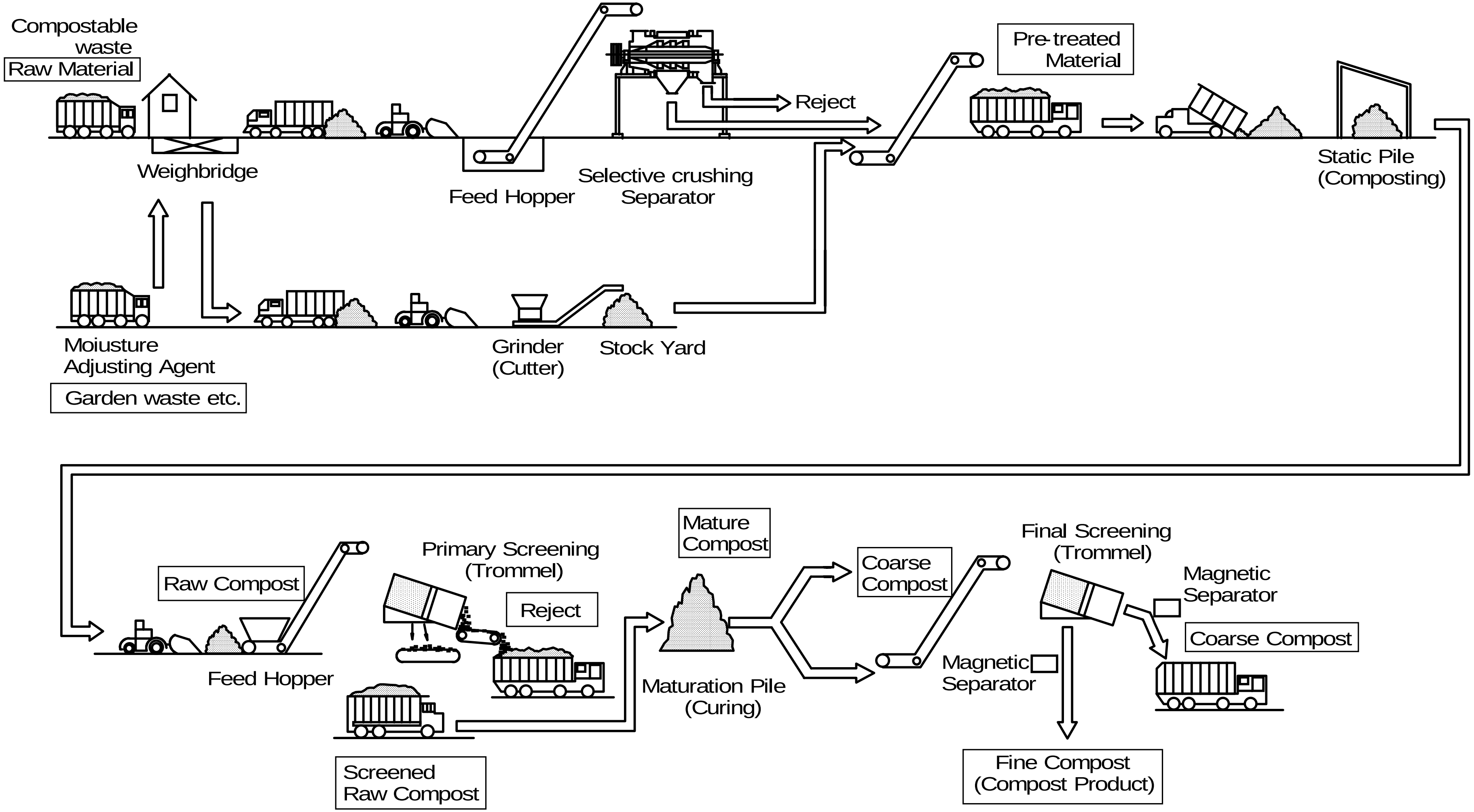


Figure 9-11: Process Flow Diagram of the Compost Plant in Cimsa

e. Material Balance

The figure below shows the material balance in the proposed plant process in the case of 70% moisture content.

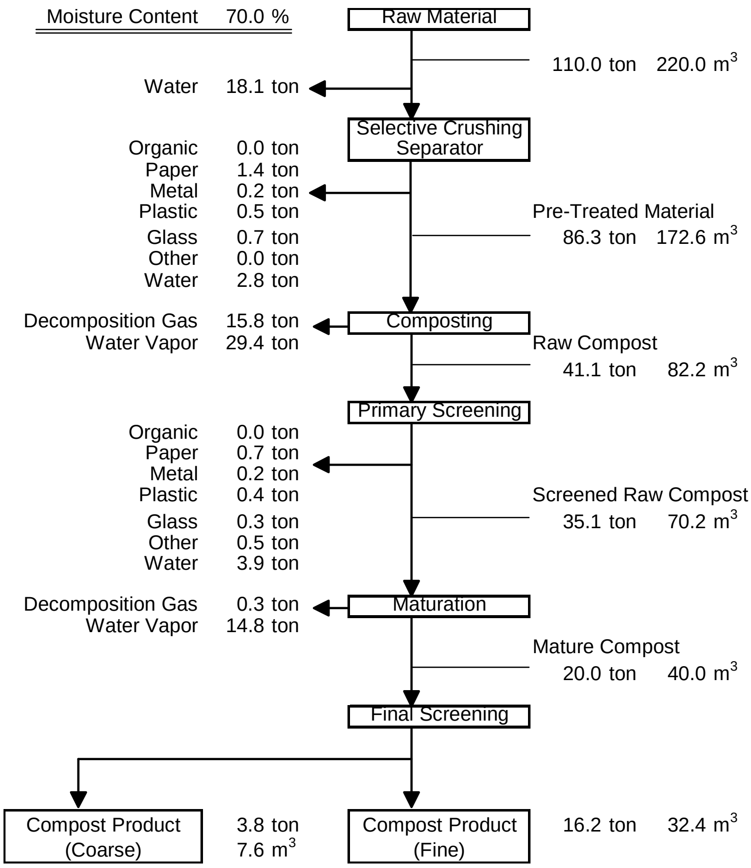


Figure 9-12: Material Balance of the Compost Plant in Cimsa

f. Layout of Proposed Compost Plant

Figure 9-13 shows the proposed layout of the compost plant.

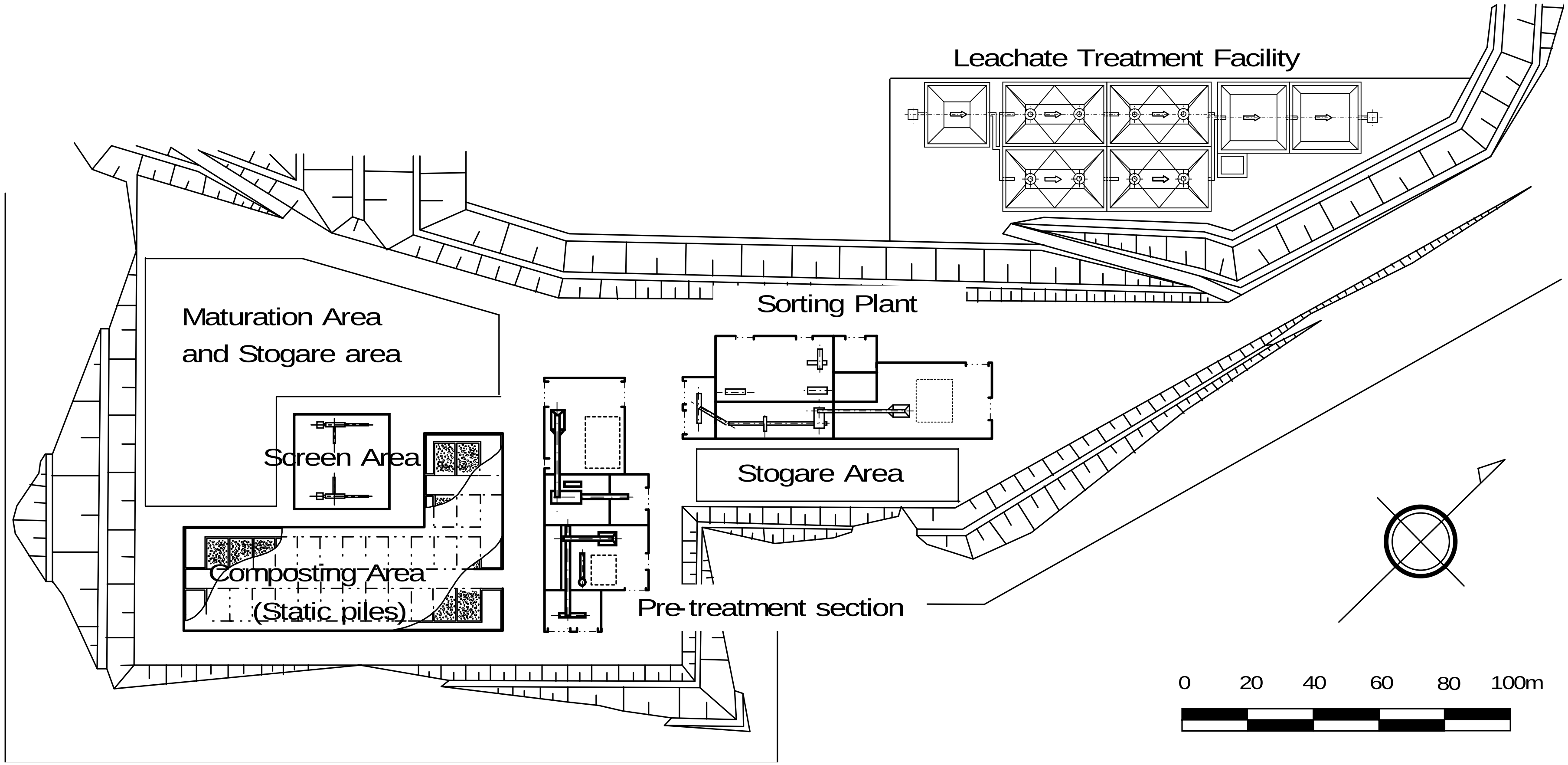


Figure 9-13: Layout of Proposed Compost Plant in Cimsa

g. Construction Schedule of the Compost Plant

The construction schedule will be as follows.

- Detailed design in 2000.
- Construction of the plant in 2001.
- Equipment procurement in 2001.
- Operation commencement in 2002.

h. Operation Plan

The proposed operation plan is as follows.

h.1 Weighbridge

It is used to weigh waste or recovered materials.

- Wastes delivered to the site is weighed by the weighbridge on arrival.
- After being weighed, wastes are transferred to the sorting plant, compost plant or landfill site depending on their types.

h.2 Waste Reception and Storage Area

The compostable wastes are received in and proceed to the pre-treatment process from this area.

- The compostable wastes, after weighed, are unloaded in this area.
- A wheel loader supplies the unloaded waste to a feed hopper.
- When the delivered wastes is beyond the plant capacity, the excess will be moved to the storage area by the wheel loader.

h.3 Pre-treatment Section

The raw materials are selectively crushed and materials unsuitable for composting such as plastics and metals are rejected in this section.

- The key facility is the SCS, which can divided the raw materials into two groups: fragile wastes including kitchen wastes and wet paper, and the other robust or flexible wastes such as plastic sheets, fibres and cans. The former group proceeds to the composting section as pre-treated materials. The latter is called rejects.
- While the raw materials are processed by the SCS, plastic bags are torn and the compostable materials are crushed into pieces.
- The crushed raw materials are sieved and moved to the stock yard by the conveyor equipped with the magnetic separator.
- In the stock yard, the pre-treated materials are loaded onto the dump trucks by the wheel loader and transferred to the composting area.
- Recovered ferrous metal is delivered to the sorting plant.

- The rejects are loaded on the dump trucks by the wheel loader and transported to the sorting plant for material recovery.
- This is the facility for adding moisture adjusting agent to watery compostable wastes to be fed to the pre-treated material conveyor. Garden wastes including saw dusts, wood chips, grass and pruned wood are used as the agent. It is stored in a stock yard, and ground into fragments before used. Therefore, the facility consists of the reception area of garden wastes, stock yard and grinder with a conveyor. Raw compost shall be used as a moisture adjusting agent.

The pre-treatment section layout is presented in Figure 9-14.

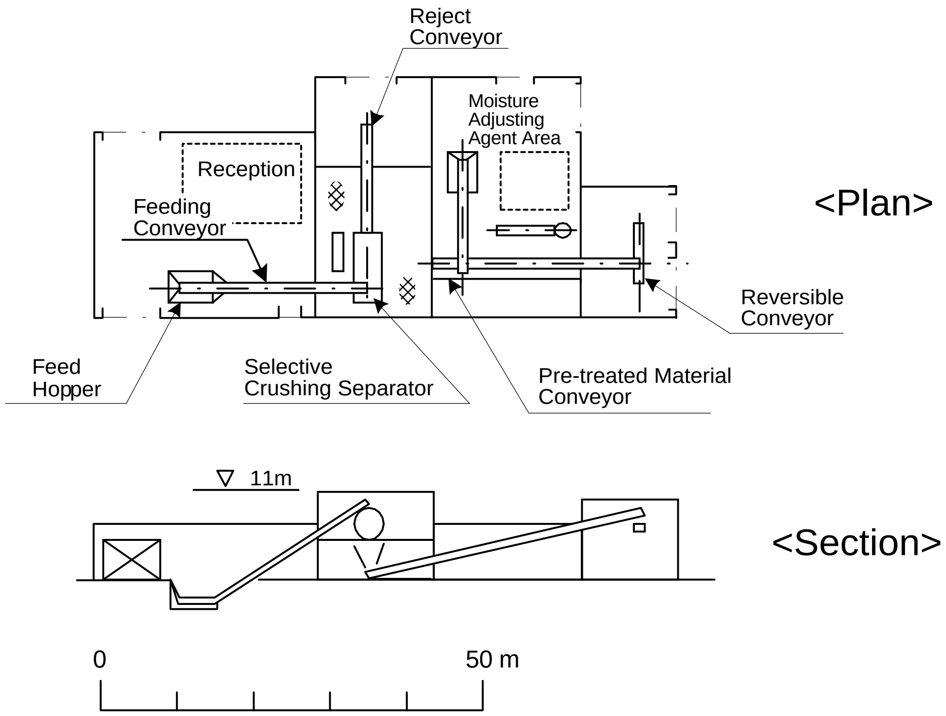


Figure 9-14: Layout of the Pre-treatment Section in Cimsa

h.4 Composting Area (Static piles)

The pre-treated materials undergoes composting in this are which is divided into 28 sections to form 28 static piles.

- The pre-treated materials are unloaded in one section and formed into a pile by a wheel loader.
- After pile formation, the materials require air control in the early stage, turning by the wheel loader, and moistening by the water truck.
- After 28 days of composting period, the raw compost is loaded on the dump trucks by the wheel loader and proceeds to the primary screen process.

The Composting area (Static piles) layout is presented in Figure 9-15.

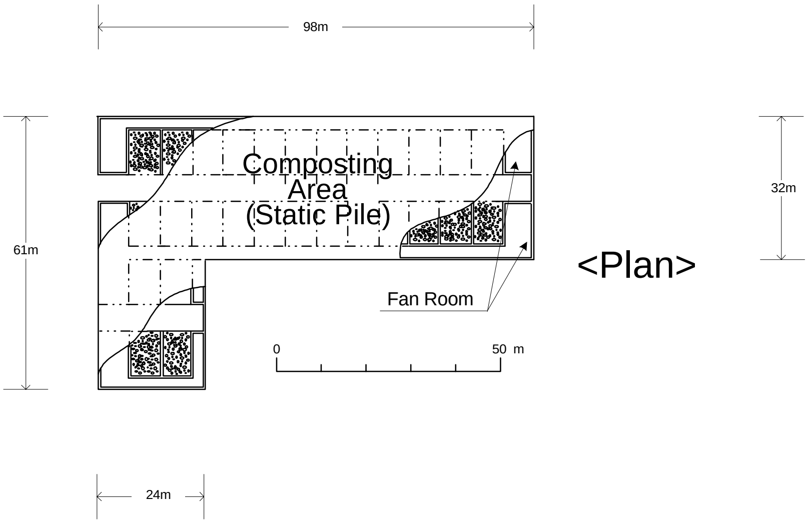


Figure 9-15: Layout of the Composting Area (Static Piles) in Cimsa

h.5 Primary Screen Equipment

The primary screen equipment comprises a supplying conveyor, trommel, product conveyor with a magnetic separator, residue conveyor and ballistic inertial separator. The sieve size of the trommel is 25mm. The underflow is the material for further processing and the oversize material is the rejects.

- The raw compost is unloaded in the supply are of the primary screen section.
- The unloaded raw compost is placed on the supplying conveyor by the wheel loader and fed to the trommel.
- The trommel screen sieves the raw compost.
- The underflow materials will be conveyed to their stock yard. Meanwhile, ferrous metal is removed by the magnetic separator and glass and gravel by the ballistic inertial separator.
- The underflow raw compost is loaded on the dump trucks by the wheel loader and delivered to the maturation area.
- The oversize materials remained on the sieves are the rejects to be disposed of at the landfill site.

The primary screen equipment layout is presented in Figure 9-16.

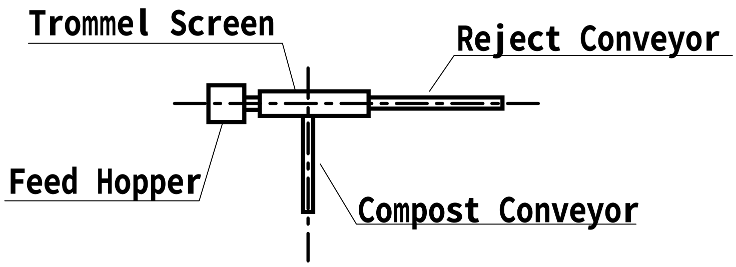


Figure 9-16: Layout of the Primary Screen Equipment in Cimsa

h.6 Maturation Area

The maturation of the screened raw compost takes place in this area. A roof is not necessary. Unlike the composting area, this area is not physically divided into sections but the area should be clearly marked whenever the mature pile is formed. Although the maturation period is to be 60 days, the planned area size is enough to store compost produced in 90 days to allow the adjustment of product shipping in response to the market demand.

The floor of the maturation area will be equipped with pipes so that the area will serve as odour removal facility.

- The screened raw compost is unloaded from the dump trucks and formed into maturation piles by the wheel loader. The pile formation does not require particular skills.
- After the maturation period, the materials are loaded on the dump trucks by the wheel loader and delivered for final screen processing.

h.7 Final Screening Equipment

The final screen equipment is primarily similar to the primary screen equipment but the mesh size of the trommel screen is 12mm, instead of 25mm. The screen should be removable so that the mesh size can be changed depending on market demand.

- The mature compost is unloaded in the supply are of the primary screen section.
- The unloaded mature compost is placed on the supplying conveyor by the wheel loader and fed to the trommel.
- The trommel screen sieves the mature compost.
- The underflow materials will be conveyed to their stock yard. Meanwhile, ferrous metal is removed by the magnetic separator and glass and gravel by the ballistic inertial separator.
- The mature compost can be shipped as it is, or be packed in plastic bags with net weight of 20 kg.
- The compost, if shipped without packed, is loaded on the dump trucks by the wheel loader. For the packed compost, a forklift is used.
- The oversize material on the sieves are the rejects to be disposed of at the landfill site.

i. Staff Allocation Schedule

Table 9-20 is the staff allocation schedule for the proposed compost plant. The number of operators and manual workers is derived from the volume of materials to be processed and facility operation capacity.

Table 9-20: Staff Allocation Schedule

Position	Shift 1	Shift 2	total
ADMINISTRATION			
Sub-manager	1	---	1
Accountant	1	---	1
Secretary	1	---	1
sub-total	3	---	3
OPERATION			
Pre-treated section			
Supervisor	1	1	2
Facility operate section			
Machine operator	2	2	4
Reception section			
Loader operator	1	1	2
Labourer	1	1	2
Transport section			
Labourer	2	2	4
Truck driver	1	1	2
sub-total	8	8	16
Composting section			
Supervisor	1	1	2
Static pile section			
Loader operator	1	1	2
Labourer	2	2	4
Transport section			
Loader operator	---	---	---
Labourer	---	---	---
Truck driver	1	1	2
Separate section			
Operator	1	1	2
Loader operator	1	1	2
Labourer	2	2	4
Curing section			
Loader operator	1	1	2
Labourer	2	2	4
sub-total	12	12	24
Total	23	20	43

9.5 Design of a Final Disposal Site

9.5.1 Examination of Technical Alternatives

The concept described below is applied to the design of a Cimsa disposal site. Although the team proposed to design new landfill (Phase 2 & 3) without liner, it was not approved by the MoE. Then, the team changed the phase 2 and 3 originally proposed due to the durability of the liner.

a. Phased Site Development and Landfill Operation

The Cimsa disposal site will be developed and operated in 3 phases as described below (refer to Figure 9-17).

Phase 1:

In this phase as shown in Figure 9-17 will be reclaimed by waste. The landfill operation will be completed when the height of it reaches to the ultimate use of the landfill. In addition, the surface soil can be used for covering soil for phase 1 landfill operation.

Phase 2:

In this phase as shown in Figure 9-17 will be reclaimed by waste. The landfill operation will be completed when the height of it reaches to the ultimate use of the landfill. In addition, the surface soil can be used for covering soil for phase 2 landfill operation.

Phase 3:

The landfill operation area of the phase 3 is the uppermost section upstream of the catchment area. Since rain water fallen in this area will generate leachate by passing the current dump site, it is considered much better to fill up the area by waste than to remain as it is (like a reservoir in shape).

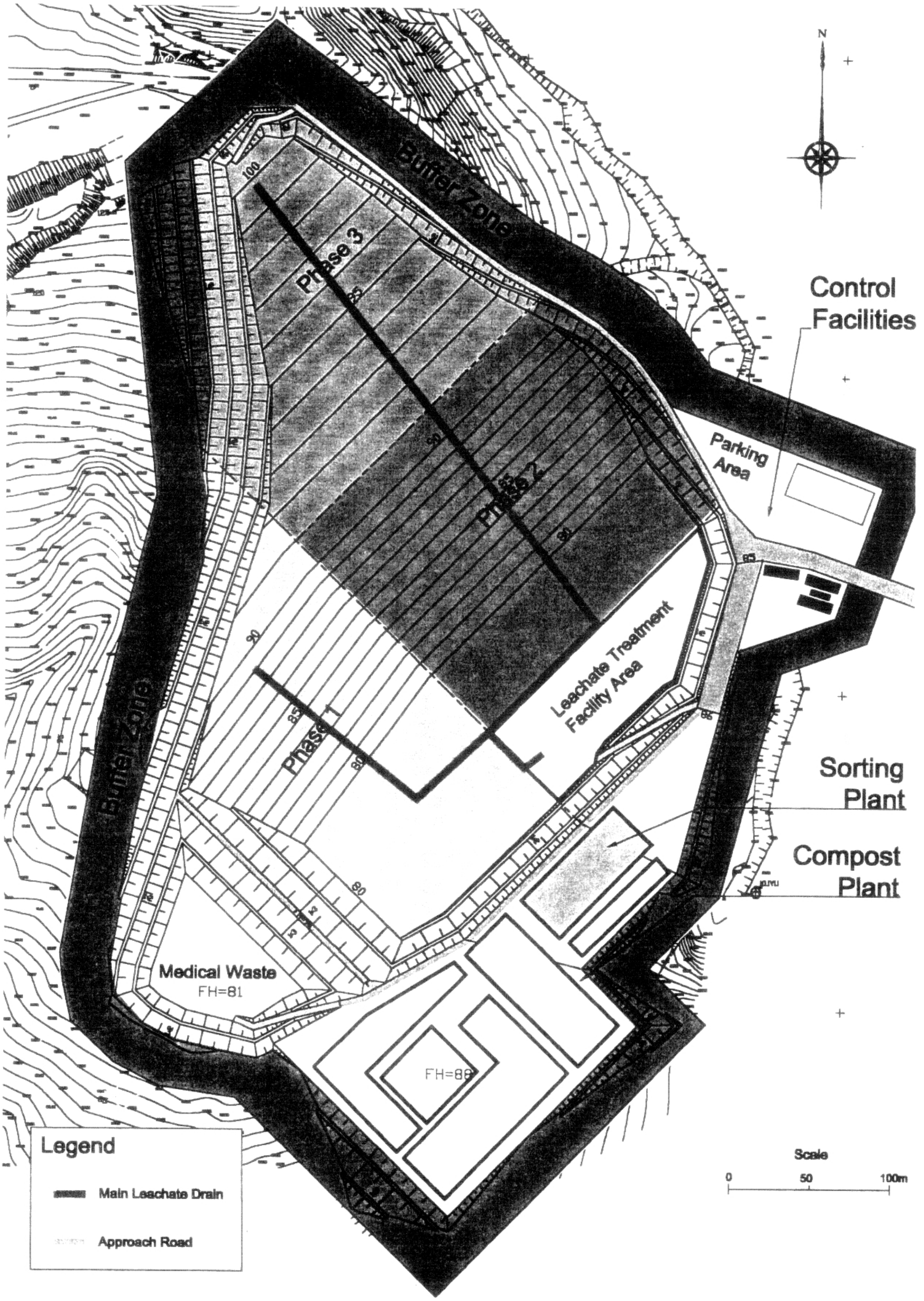


Figure 9-17: Design of the Cimsa Disposal Site

b. Appropriate Sanitary Level of the Disposal Site

Turkish Solid Waste Regulation requires a 2 mm, high density polyethylene (HDPE) liner at the slope surface of disposal site if there is impermeable layer at the bottom; the disposal site shall be lined accordingly.

- Leachate shall be treated accordingly at Leached Treatment Facility and discharged to the down stream.

9.5.2 Preliminary design

a. Outline of the Cimsa Disposal Site

Outline of the Cimsa Disposal site is shown on Table 9-21

Table 9-21: Outline of the Cimsa Disposal Site

Items	Description
Land Area and Proposed Land Use	Total Area :24ha Phase1:Landfill Area :5ha Phase2:Landfill Area :4ha Phase3:Landfill Area :4ha Plant :Area :3ha Medical waste Landfill Area :2ha Buffer zone :Area :6ha
Landfill Volume	Phase / Capacity / Disposal Period Phase 1 463,000m^3 2002-2003 Phase 2 397,000m^3 2004-2004 Phase 3 297,000m^3 2005-2005
Road	Approach road(Asphalt paved) :width15.0m,lenght170m Access road(Asphalt paved) : width4.0m,lenght490m Operation road
Control facilities and approach road	Entrance area(Asphalt paved) :1,000m^2 Site office :300m^2 Weigh bridge : 2set Tire washing pit : 1set Gate : 1set Power supply :1set water supply :1set Weighbridge and washing area(conc. paved) :1,000m^2 Parking for heavy vehicle(gravel) :1,000m^2
	Leachate collection pipe φ100mm:2,255m Main leachate drain φ200mm:650m Leachate treatment facility:1set
Drain for runoff water	Open concrete drain :725m Pipe drain for rain fall :650m
Environmental protection facilities	Fence :2,040m Buffer zone :2,040m Gas removal facility(Vertical) :780m Gas removal facility(Horizon) :2,255m Monitoring borehole :3set

Purpose and outline of the individual facilities will be explained as follows.

b. Final Disposal Site

Final disposal site shall be constructed for treating the municipal solid waste from Mersin city.

b.1 Capacity of Final Disposal Site and Disposal Period

Disposal period for Cimsa Disposal Site shall be planned considering both final municipal solid waste disposal volume from Mersin Greater Municipality and remaining capacity of Cimsa Disposal Site. According to the above consideration, disposal period for Cimsa Disposal Site shall be from year 2002 until year 2005. Final municipal solid waste disposal volume from Mersin Greater Municipality is shown in Table 9-22 and Volume of each Phases, year of construction and disposal period are shown in Table 9-23.

Table 9-22: Final Disposal Amount in Cimsa

Item	unit	formula	2002	2003	2004	2005
Final Waste Disposal Amount	ton/day	a	440	473	503	593
	ton/year	b=ax365	160,799	172,780	183,736	196,729
Waste +Cover soil	m^3/year	c=bx1.2/0.8	241,199	259,170	275,604	295,094
Total	m^3/year	Σ d	241,199	500,369	775,973	1,071,067

Table 9-23: Disposal Capacity by Phase in Cimsa

Phase No.	Capacity of Phase(m^3)	Year of Construction	Disposal Period
Phase 1	463,000m^3	2001	2002-2003
Phase 2	397,000m^3		2004-2004
Phase 3	297,000m^3	2004	2005-2005

Structure of the final disposal site is as follows.

b.2 Bottom and Slope of Final Disposal Site

According to the SWM regulation, a liner will be laid at bottom and slope of the final disposal site to prevent leachate from seeping into the ground. The structure of Bottom and slope are as follows;

- Bottom: Impermeable clay layer (K = 10^{-8} to 10^{-9} m/sec) should be kept as the liner.
- Slope: 60cm impermeable clay layer (K = 10^{-8} to 10^{-9} m/sec) should be kept as the liner. And a 2 mm, high density polyethylene (HDPE) liner should be laid on top of it.

The structure of the bottom of final disposal site is shown on the following figure

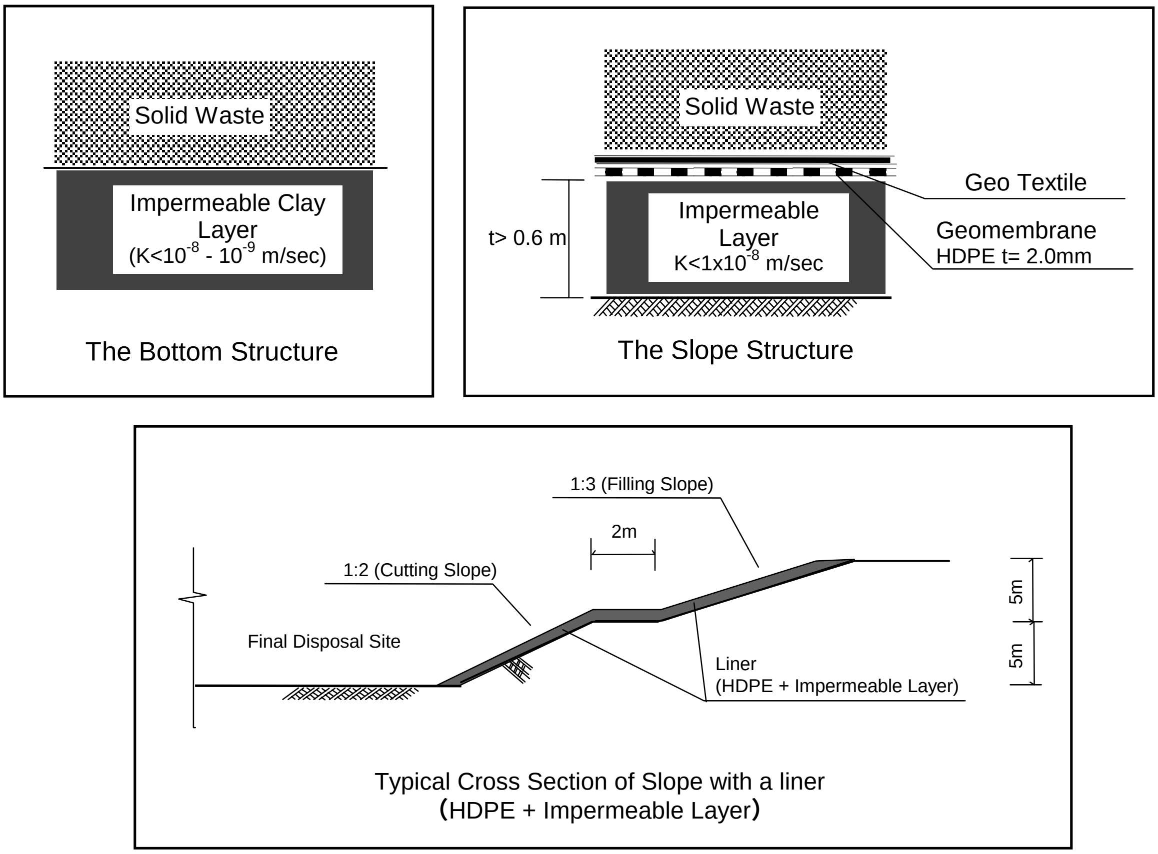


Figure 9-18: Diagrams of the Landfill's Impermeable Strata (Bottom and Slope)

b.3 Slope of Final Disposal Site

The structure of the slope of final disposal site is same as bottom of it. The slope will be 1:2 for cutting and 1:3 for filling and has 2m wide bench at every 5m height after consideration of construction of clayey liner.

b.4 Approach Road

For the refuse collection vehicles reaching the working face(waste disposal site), sorting plant and compost plant, this approach road should be constructed. Its width should be 8.0m and 780m long, paved with asphalt. Open concrete drain will be constructed along approach road in order to prevent rainfall water to flow into landfill area.

b.5 Access Road

For the refuse collection vehicles reaching the working face(current landfill operation area) , this approach road should be constructed. Its width should be 4.0m and 490m long, paved with asphalt. Open concrete drain will be constructed along access road in order to prevent rainfall water to flow into landfill area.

b.6 Operation Road

Operation road for the refuse collection vehicles will be constructed at the working face(current landfill operation area). This is a temporary road which will shift location according to the location of the working face.