

E-waste: According to the guidelines on e-waste management brought by Ministry of Environment and Forests (MOEF), government of India, e-waste is such a waste comprises of waste generated from used electronic devices and household appliances which are not fit for their original intended use and are destined for recovery,

Recycling or Disposal.

- It includes electronic devices such as computers, hand held, Cellular phones, A.C., Refrigerators etc.
- The electronic industry is largest and fastest growing manufacturing industry. All electronic and electrical items on completion of their useful life, are being discarded rapidly and contribute to huge quantum of e-waste.
- The National Safety Council estimates almost 100 million computers and Monitors becomes obsolete annually and generates only 15-20% of total e-waste.
- According to E-waste generation most contributing state list (2012) by CPCB Andhra Pradesh is lead one to generate 11,500 TPD followed by the states Assam, Bihar, Haryana, Jammu & Kashmir, Delhi, Goa, Jharkhand etc.

1) Computer Peripherals

Monitor, Keyboard,  
Mouse, Circuit  
Boards, CDs, Floppies,  
Laptops, Servers,  
etc.

2) Telecommunication  
devices: Phones,  
Cell phones, Fax  
machines, Routers  
RF equipments,  
etc.

Classification  
of  
E-waste

3) Industrial  
electronics:  
Sensors,  
Automobiles  
Electronic Devices  
Medical  
Devices etc.

4) Lighting  
Devices:  
Fluorescent  
Tubes

5) Household  
appliances:  
TV, Fridge,  
washing  
Machines,  
Video,  
Camera etc.

## categories of E-waste :-

As per e-waste [Management and Handling] Rules { 2011 - 2022 } , there are 9 categories of e-waste as shown :-

1. Large household Appliances: Refrigerators & Freezers, washing machine, electric hot plates etc.
2. Small household Appliances: Vacuum cleaners, Carpet Sweepers, Ironing equipment etc.
3. Toys, leisure and sports equipments: Electric Train, Car Racing Sets, Video games etc.
4. Electrical and Electronic Tools: Drills, Saws, Sewing machines, Milling, Grinding etc.
5. Medical Devices: Dialysis, Cardiology, In-vitro Diagonosis etc.
6. Monitoring and control equipments:- Smoke Detector, Thermostats, Bleaching machine etc.
7. Automatic dispenser:- For Beverages, Hot / Cold Bottles or cans etc.
8. IT & Telecommunication equipment:- Mainframes, Minicomputers, Electronic Typewriters etc.
9. Consumer electronics:- Radio sets, TV sets, Video Recorders etc.

Composition of E-waste :- The composition of waste is very diverse and differ in products across different categories. It contain more than 1000 substances which fall under hazardous and Non-hazardous categories.

Broadly It contains ferrous and steel (50%), Non-ferrous Metals (13%), Plastics (21%) & others (16%) [ Glass, woods, plywoods, concrete, ceramics etc. ]

Hazardous Substances : Their Occurrence and

Impact :- The e-waste generated contains various hazardous substances i.e.

- i) PCB : Condenser : Cause cancer etc.
- ii) TBBA : Boards, Covers : Long Term Injury
- iii) Chlorofluorocarbon : Cooling Unit : Toxic emission
- iv) PVC
- v) Arsenic
- vii) Barium
- viii) Cadmium, Chromium, Lithium, Mercury, Nickel
- ix) Rare Earth Metals.
- x) Zinc Sulphide ( $ZnS_2$ )
- xi) Toxic Organic Substances.
- xii) Toner Dust.

Recovery From The Waste:-

Electronic goods are composed of hundreds of different materials, often of high value. Gold, Platinum, Silver etc. are valuable material recover from e-waste.

→ The Best approach to treat the e-waste is to Reduce concentration of Hazardous chemicals and elements during Recycling processes. Recycling and Recovery of e-waste includes the following:-

1 Application of The concept of Reuse, Recycling & Recovery of E-waste:

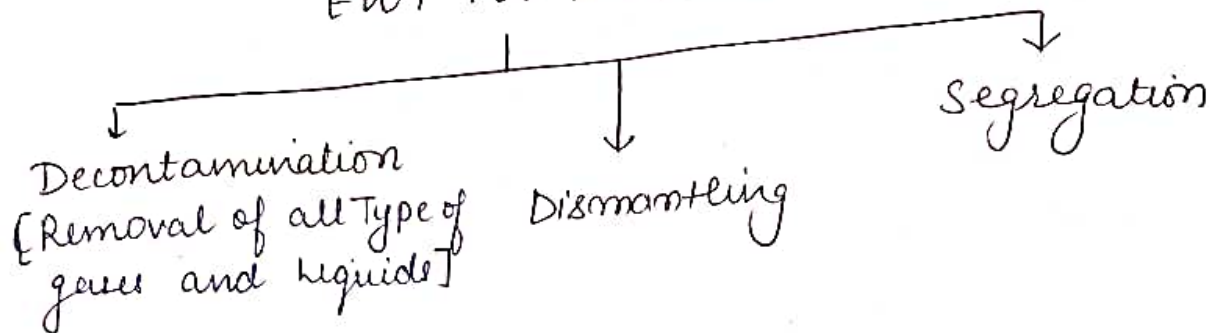
- Dismantling:- Removing of e-waste parts having Hazardous & valuable materials.
- Shredding:- into small pieces.
- Segregation of Ferrous metals, non-ferrous metal & plastic.
- Recovery / Recycling / Reuse of Valuable Material
- Treatment or Disposal of Dangerous material and waste, sent to Hazardous Waste Treatment Storage and Disposal Facility or Incineration is done.

## Treatment and Disposal of waste:-

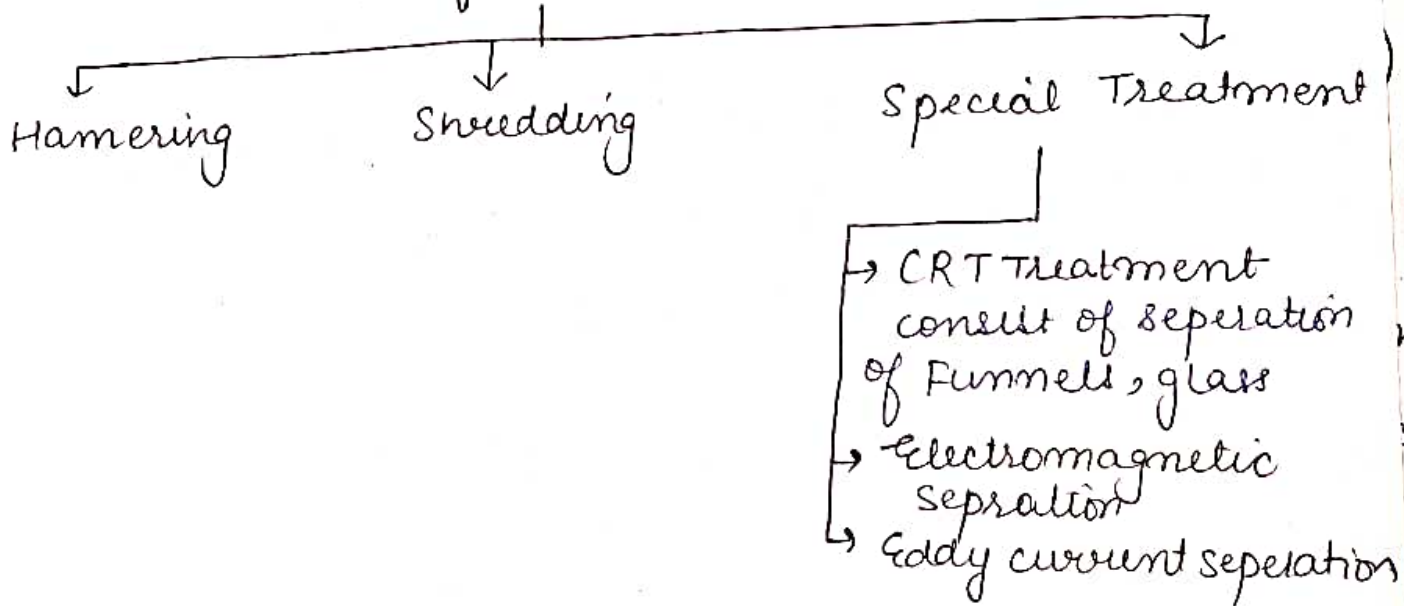
The e-waste Treatment is generally carried out in unregulated env., where there is insufficient monitoring and control of emissions.

EWT (E-waste Treatment) technologies have been identified at three levels.

### EWT For 1st level



### EWT for 2nd level



EWT for 3rd level:- Carried to Recover Items mainly to ferrous, non-ferrous metal, plastic and other item to economic value like Raw material, Pelletisation or Alternative fuel etc.

# E-waste Management and Handling Rules [2011] :-

It has been notified in May 2011 and are effective in 01-05-2012.

**Applicability:-** This Rule shall apply to every producer, consumer or Bulk Consumer, Collection Centre, Dismantler, Recycler of e-waste involved in manufacture, sale, purchase & processing of EEE's as specified in Schedule-I By SPCBs/PCCs.

**Producer's Responsibility:-** Should take authorization only in place where their manufacturing facilities and corporate head offices are located.

Authorization By SPCB/PCC and inform the CPCB, to CPCB would maintain centralized database on their website.

**Collection Centre Role:-** i) Obtain authorization from concerned SPCBs/PCCs.

- ii) ensure that the e-waste collected by them is sent to registered dismantler/recycler in secured manner.
- iii) To maintain record of e-waste handled in form-2
- iv) To file annual return in Form-3
- v) To make records available for scrutiny by SPCBs/PCCs.

**Responsibility of Dismantler:-** The additional is to ensure that dismantled e-waste is segregated, sent to recycling facilities.

→ They should not process without registration with SPCB/PCC.

Responsibility of Recycler:- To ensure That Disinfectant materials are sent to registered or Bonafide Industries for use of Recycled Materials .

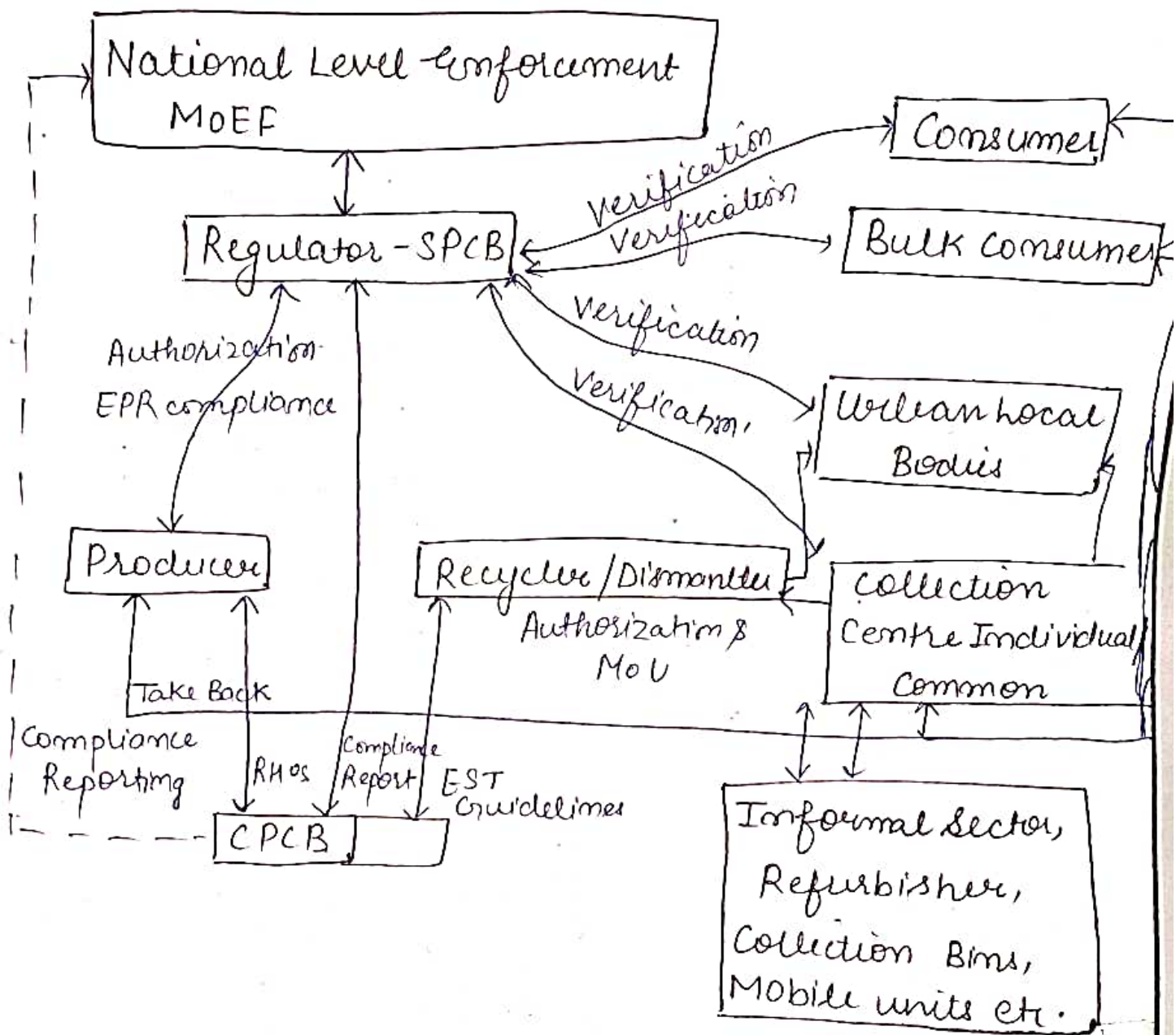
Role of Bulk Consumers:- To ensure That e-waste generated by them have to be channeled to authorized collection centres or registered dismantler or recycler or is returned to Producer through its pick up or Take Back service

Role of SPCB/ PCC:- To ensure That Producer, Collection Centre, Dismantler, Recycler Have State obtain authorization.

- shall ensure that The Fill of annual return to be submitted in stipulated time.
- The condition imposed on entities are strictly met by facility concerned.



# Implementation of E-waste 2011.



## E-waste Management and Handling Rule (2016)

- Come into force on 1st October, 2016
- Shall apply to every manufacturer, producer, consumer, Bulk consumer, collection centres, dealers, e-retailer, refurbisher, dismantler and Recycler.
- Only cover 21 types of EEs categorized.
- Require authorization from CPCB by Producer while Manufacturer, Refurbisher, Recycler, Refurbisher require authorization from SPCB or O.P.C.C.
- Do not include any provisions regarding these specific responsibility

## Amendments in E-waste Management & Handling Rule (2016) & (2022)

- E-waste Management and Handling Rule (2022)
- Come into force on April 1, 2023.
- Shall apply to manufacturer, producer, Refurbisher, Dismantler, Recycler
- Cover 100 Types of EEs, newly added equipment includes Tablets, GPS, modems, Solar PV cells.
- It Require all entity To Register on CPCB's online portal, without authorization they can't operate without registration.
- Outlines specific obligation for Individuals or entities manufacturing or producing solar PV modules, Panels, cells.
- Also Submit Online Report.

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Assignment :

Solid Waste Management  
[2023-2024] (July-Dec)

Material Recovery  
(Composting)

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## Material Recovery Facility (MRF) in SWM Rules 2016 :-

As per the SWM Rules, 2016 "Material Recovery Facility" (MRF) means a facility where non compostable solid waste can be temporarily stored by local Body or any person or agency authorized by any of them to facilitate segregation, sorting and recovery of recyclables from various component of waste by authorized informal sector of waste pickers, informal recyclers or any other work force engaged by local body for purpose of waste delivered or taken up for processing or disposal.

→ Material Recovery starts at 1<sup>o</sup> level by households who segregate recyclables like newspapers, cardboard etc. from waste to sell such material to Kalandiwalas, scrap dealers.

Need :-  
→ Material Recovery Facility (MRF) is an infrastructure to receive, sort, process and store recyclable / non-recyclable and inert material with aim to maximize the Quantity of Recyclable waste

→ MRF accepts the waste materials, whether source Segregated or mixed, and further separates, processes and stores them for later use as raw material for Remanufacturing, Reusing & Reprocessing.

→ MRF is also known as Material Reclamation Facility or Material Recycling Facility.

Function of MRFs :- The main function of MRF is to maximize the quantity of Recyclables processed, while segregating materials that will generate the highest possible Revenue from Recycling market.

→ Also Helps in Segregating Combustible fraction (RDF) [Refused Derived Fuel], non recyclables & Inert from Dry waste streams.

These fractions may be utilized/reused as -

- Recyclables - Reuse/Reprocessed
- Non Recyclables - Road making/plastic to oil
- Inert - C&D plant

Duty of ULB [Urban Local Bodies] to set up MRF as per SWM Rules 2016 : As per SWM Rules 2016, It is duty and Responsibility of ULB to setup material Recovery facilities (MRFs) or 2<sup>o</sup> storage facilities with sufficient space for sorting of Recyclable material to enable informal or authorized waste pickers and waste collectors to separate Recyclables from waste & provide easy access to waste pickers and Recyclers for collection of segregated Recyclable waste such as paper, plastic, metal, glass from the Source of generation or from MRFs.

Types  
2

## Types of Material Recovery Facility by Ownership and Operations :-

MRF can be publicly owned and operated, publicly owned and privately operated or privately owned and operated.

### (I) On Basis of Type of Waste Received



i) **Mixed MRFs**:- Unsegregated, mixed waste with Biodegradable and non-Biodegradable material is collected and sent to MRF processing facility.

→ At mixed MRF, mixed waste stream may be segregated manually / mechanically to separate recyclable material from compostable & Inert waste.

→ Recyclable material are processed separately & Residual Inert are sent to Landfill.

→ MRF unit can use a combination of manual, hybrid and Machine based Sorting.

ii) **Dry/Clean MRF**:- It receives source segregated or commingled Recyclable materials (Recyclable material that are already separated from other main solid waste stream).

→ Clean MRF Reduce material contamination & can Recycle more material than Mixed MRFs.

→ It consist of combination of Paper, cardboard, etc and commingled containers (plastic, glass, metal etc).

→ These Recyclables are also sorted By using automated machines when Quantities to be Handled are large.

## (II) On Basis of Type of Operation

Manual      Semi-Automated      Automatic/Mechanized

i) Manual MRFs:- Sorting process is carried out manually. Suitable for small quantities of MSW like 5-10 TPD unit. Sometimes these MRFs are also known as SRLM (Solid Liquid Resource Management) centre.  
→ Receives waste either in mixed form or in wet/dry stream.

ii) Semi-Automated MRFs :- This type of MRF has combination of manual & mechanized operation.  
→ It can cater for 10-100/200 plus TPD of Segregated waste.  
→ It also work as 2<sup>o</sup> collection points in which after Segregation of wet & Dry streams, further Transportation of MSW is carried out in compacted manner to save on Transportation cost.

iii) Automatic MRFs :- They are fully mechanized/automated facilities for Material Recovery in large quantities (>100 TPD) with least Human Intervention.  
→ These are best suitable for Segregation of Recyclables/Non-Recyclables/Inert, when only source segregated Dry waste is coming to facility.  
→ These mechanized plants have limitations to Segregate mix MSW if wet/mix waste is more than 20% of total Received waste.

selection of MRF :- It largely depends on ULBs capabilities - its financial conditions and linkage to markets / Industries for Sale of Byproducts.

ULB have to adopt type of MRF as per their specific requirement depending on following aspects :-

- Waste Quantity
- Waste characterization
- Availability of Land
- Capital & Operational cost of facility
- Type and linkage of final Treatment.

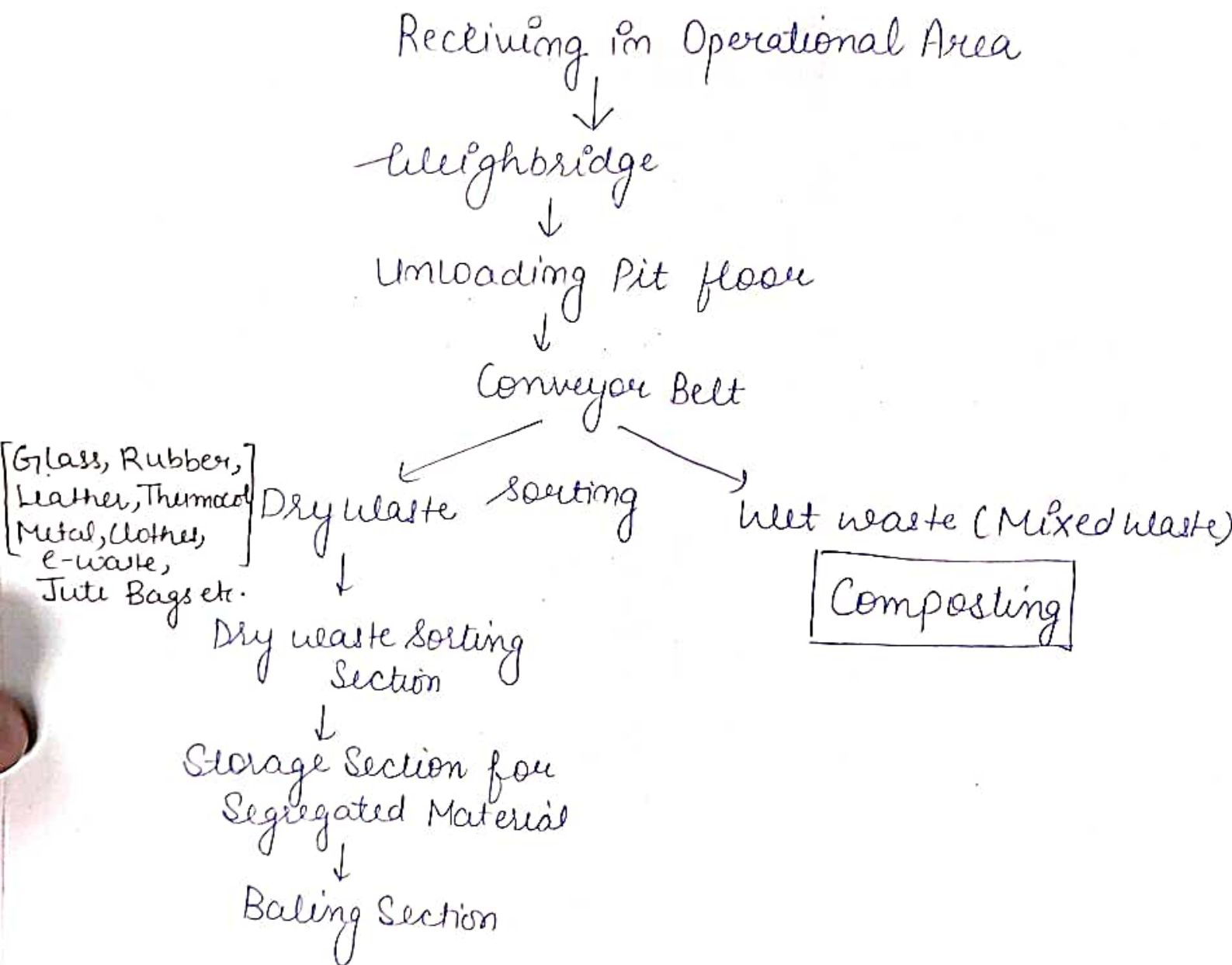
Siting Criteria for MRF :-

- MRFs need to be located close to existing roads, But traffic Blocks resulting from movement of waste collection Trucks should be avoided.
- These facilities must be near or within urban areas that generates inputs to be processed for recyclable.
- MRFs should be sited, considering local geographical features in a safe manner.
- Flood prone area should not be selected.
- If Development area is zoned, MRFs are preferably located in Industrial zone or close to sanitary landfill to facilitate efficient movement of waste from various generator & Disposal of Residual waste.



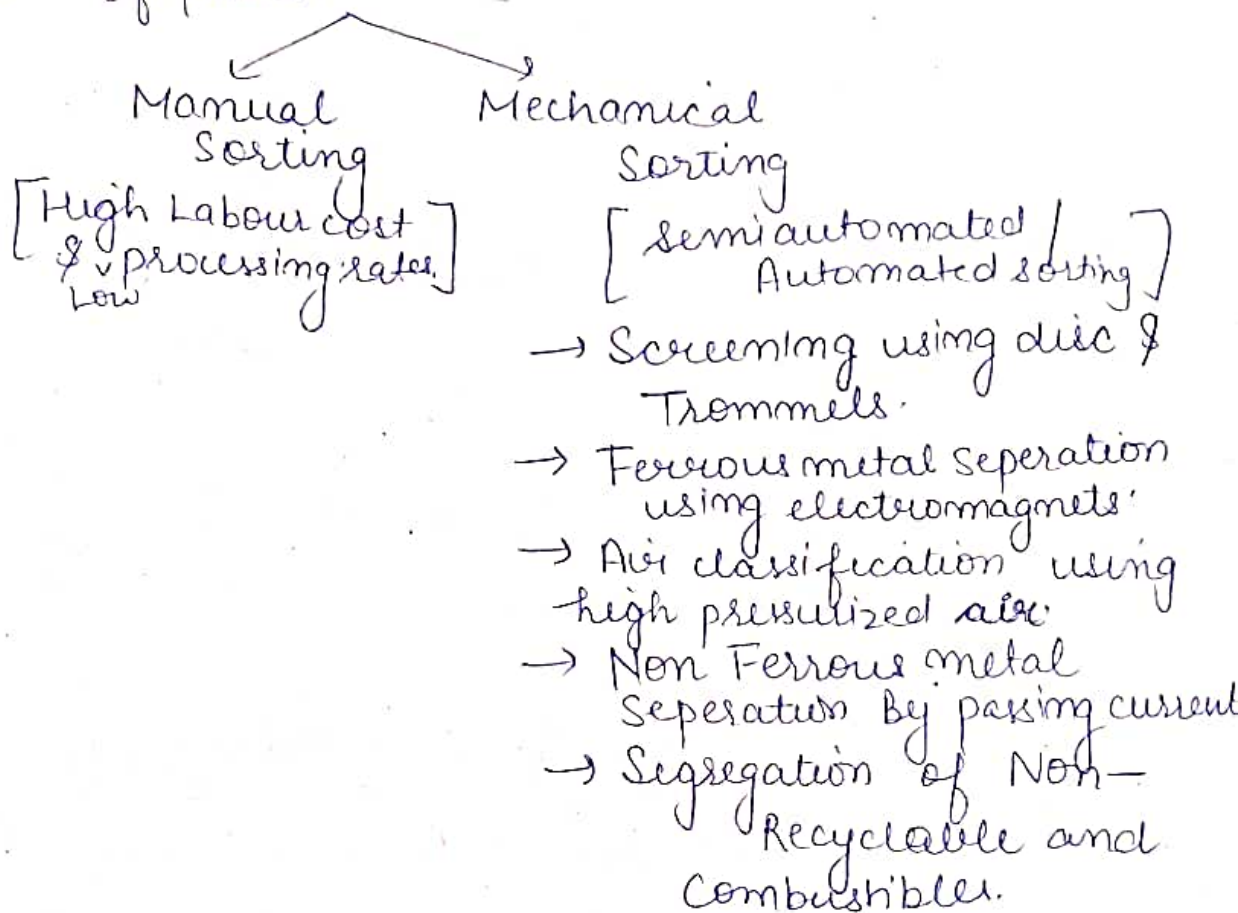
Authorizations / Permissions Required To Setup MRF  
 The permissions have to be sought from SPCB  
 [State Pollution Control Board] in the form of  
 Consent to establish, consent to operate etc.  
 Later, an annual report needs to be given to SPCB/  
 Pollution Control Committee (PCC).

### Standard Process Flow of MRF:



RF Depending on level of complexity, will consist of combination of processing units in varying degree of mechanisation :-

i) Pre-Sorting: Sorting of waste to separate out bulky/large pieces of packets



ii) Size Reduction

iii) Bailing

# Composting :- It is aerobic, Biological process which uses naturally occurring microorganisms to convert biodegradable organic matter into humus-like product (Compost).

Composting is Biological reclamation of organic materials by natural decomposition process.

Optimal Conditions for Composting :-

C : N = 35 : 1

O<sub>2</sub> = > 10 %

Moisture = 45-60% By weight

Temperature = 55-75°C (Thermophile Range)

pH = 6.8 - 8.5

Factors Involved in Composting :-

Feed stock & Nutrient Balance: Requires proper Balance of "green" organic materials and "Brown" organic material.

Particle Size: Grinding, chipping & shredding material increases surface area on which micro org. can feed.

Moisture Content: Need enough Moisture Content.

O<sub>2</sub> Flow:

Temperature: Sp. Range of Temp. Needed.

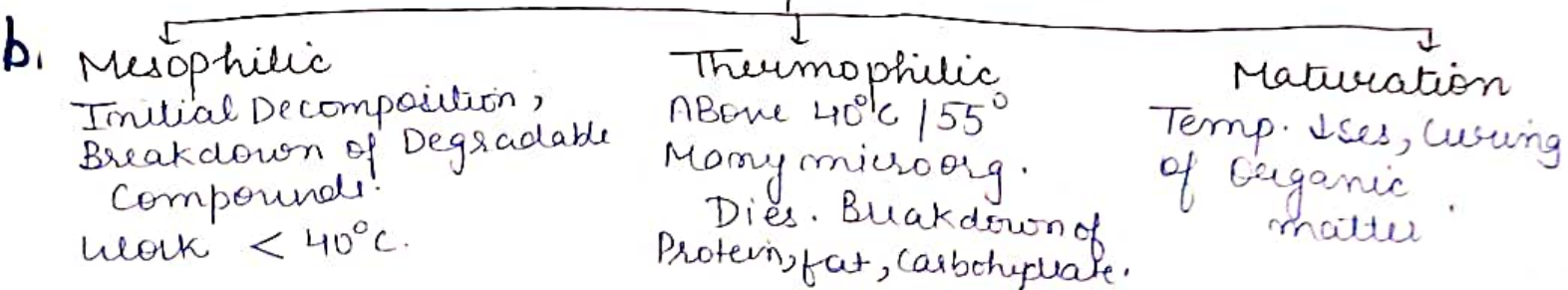
Food / Household Items that are Compost friendly :-  
Crushed eggshells, Coffee grounds, Plant & Flower  
Clipping, Fruit scraps, straw, Tea leaves etc.

Items that should not be composted: Meat, Bones,  
Banana peels, Orange rinds, corn cobs, Pesticides,  
Onion & Garlic, Dairy products etc.

How To Compost :-

- 1) Find an Appropriate Spot, find a patch of bare earth, Outdoor part of yard.
- 2) Lay Down Straw / Twigs : For proper drainage, lay down straw / twigs as base of your pile.
- 3) Add in Compost :- Alternate layer of wet waste with Dry waste i.e. Fruit scraps → shredded Newspaper
- 4) Add Manure :- For super-efficient compost, add some grass / plant clippings, wheat grass etc. as green.
- 5) Water your Compost :
- 6) Cover :- wood / Plastic sheet to create its own moisture.
- 7) O<sub>2</sub> flow :- O<sub>2</sub> given for Break Down of contents.

### Phases of Composting.



## Microorganism in Composting

Aerobes

In presence of  $O_2$

Org. matter is Degraded

Anaerobes

In absence of  $O_2$

Vermicomposting:- Use of worm to Recycle food scraps & other matter into valuable soil amendment.

Mesophilic process (earthworms active at  $10-32^\circ C$ )

Two Methods

Bed Method

Bed of Organic Matter is prepared.

→ earthworm is Eisenia fetida

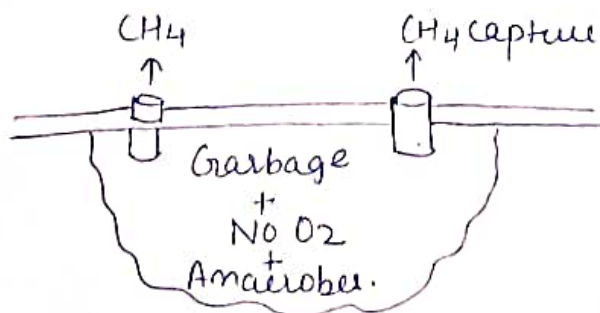
Pit Method.

Org. matter collected in cemented pits. Not efficient Bcz of poor aeration.

Biogas Production:- Anaerobic digestion (AD) of Organic Matter produces Biogas. consist Methane (50-70%),  $CO_2$  & small amount of Mixed gases including  $H_2S$ .

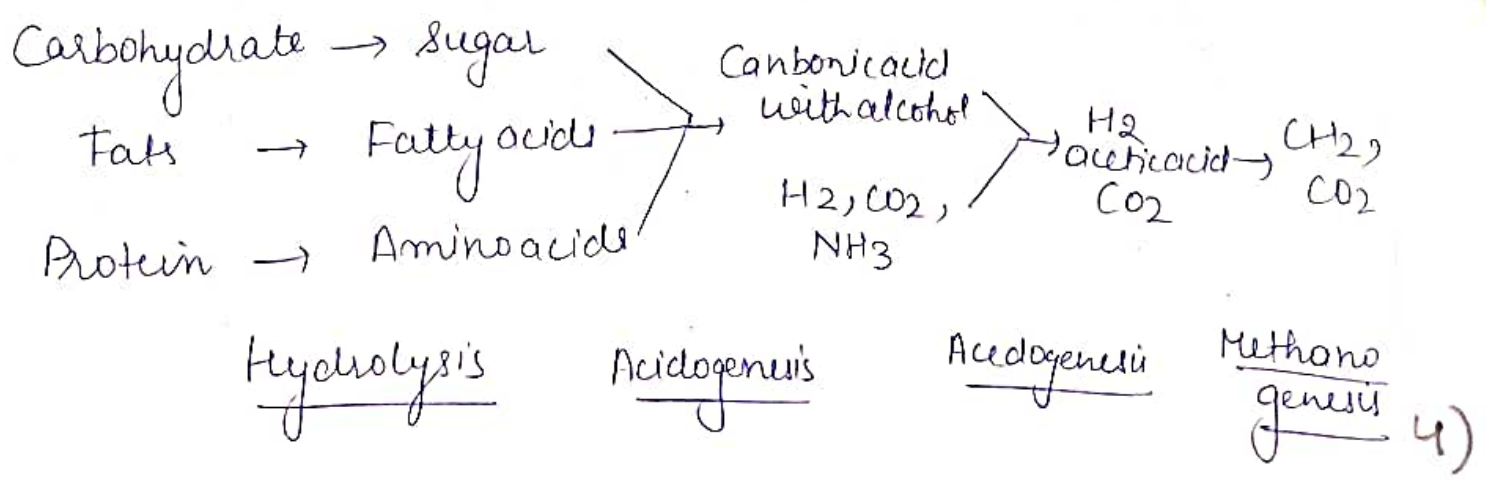
Biogas Production process

1) Landfill gas (LFG), By Break Down of Biodegradable waste inside landfill due to chemical Reaction and Microbes.

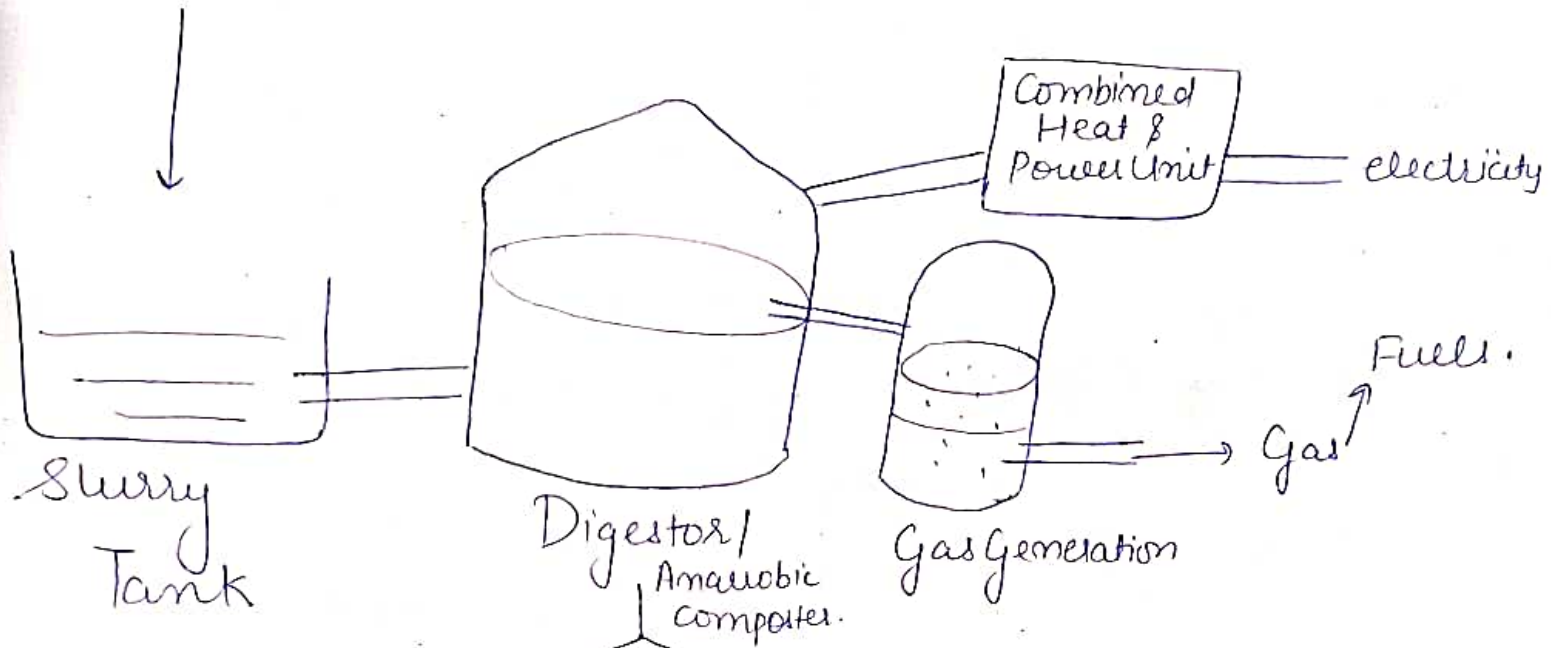


2) Gas Formed Inside Anaerobic Digester, process commonly named Anaerobic Digestion. (Pseudomonas)  
 ↓ 4 steps

- 1) Hydrolysis :- Break Down of complex molecule to simpler molecules in presence of hydrolyzing enzymes.
- 2) Acidolysis :- product of hydrolysis (soluble organic monomers of sugars & amino acids) are degraded by acidogenic bacteria to produce alcohols, aldehyde, volatile fatty acids (VFAs).
- 3) Acetogenesis :- Formation of Acetic acid with help of acetogens. Rxn produces  $\text{CH}_4$  &  $\text{CO}_2$  &  $\text{H}_2$  as main by product.
- 4) Methanogenesis :- Final step, pH sensitive (6.5-8). Methane is produced by the bacteria Methanogens. (Methanococcus)



Mamure &  
Agricultural  
Waste

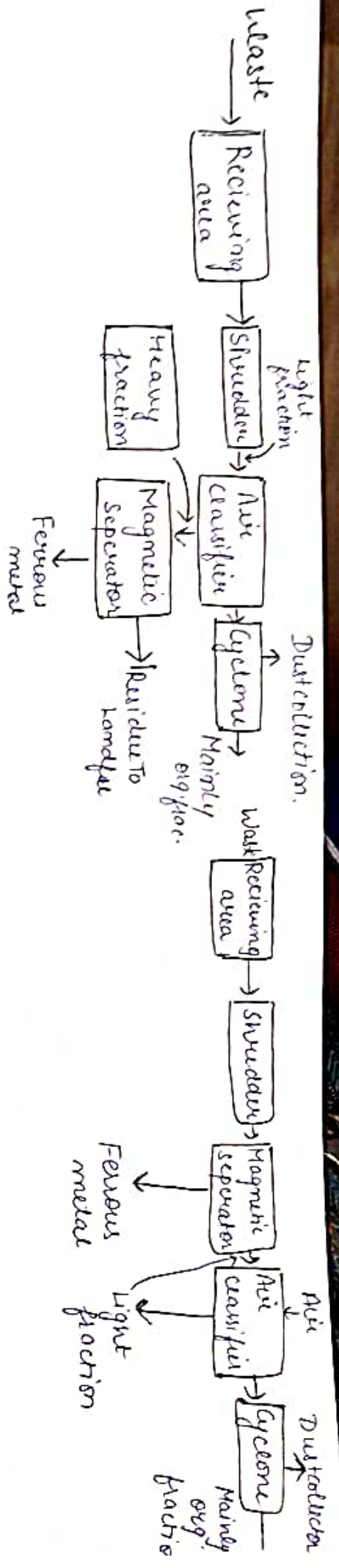


Continuous Digester

↓  
Substrate continuously added & Methane is removed frequent to Homogenous composition  
30-38°C work Temp.

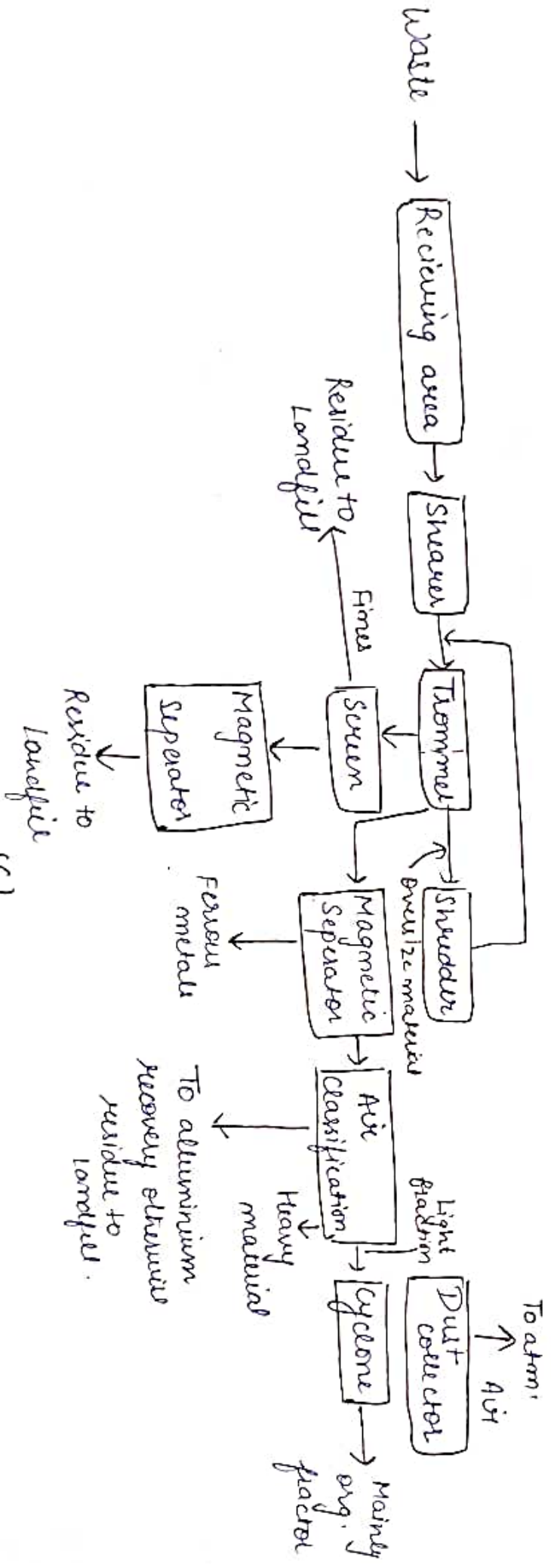
Batch Digester

↓  
Sludge act as substrate & Only feed when the Rx<sup>n</sup> starts & when Rx<sup>n</sup> completed, Product is removed.



(a)

(b)



(c)

Fig. Flow sheet of material Recovery of waste component from solid waste

- a) conventional
- b) conventional with shredder
- c) Trommel used to replace shredder.