ES 200-S2

Module B : Solid Waste Management and Other Aspects of Environmental Management

Professor Anurag Garg
a.garg@iitb.ac.in

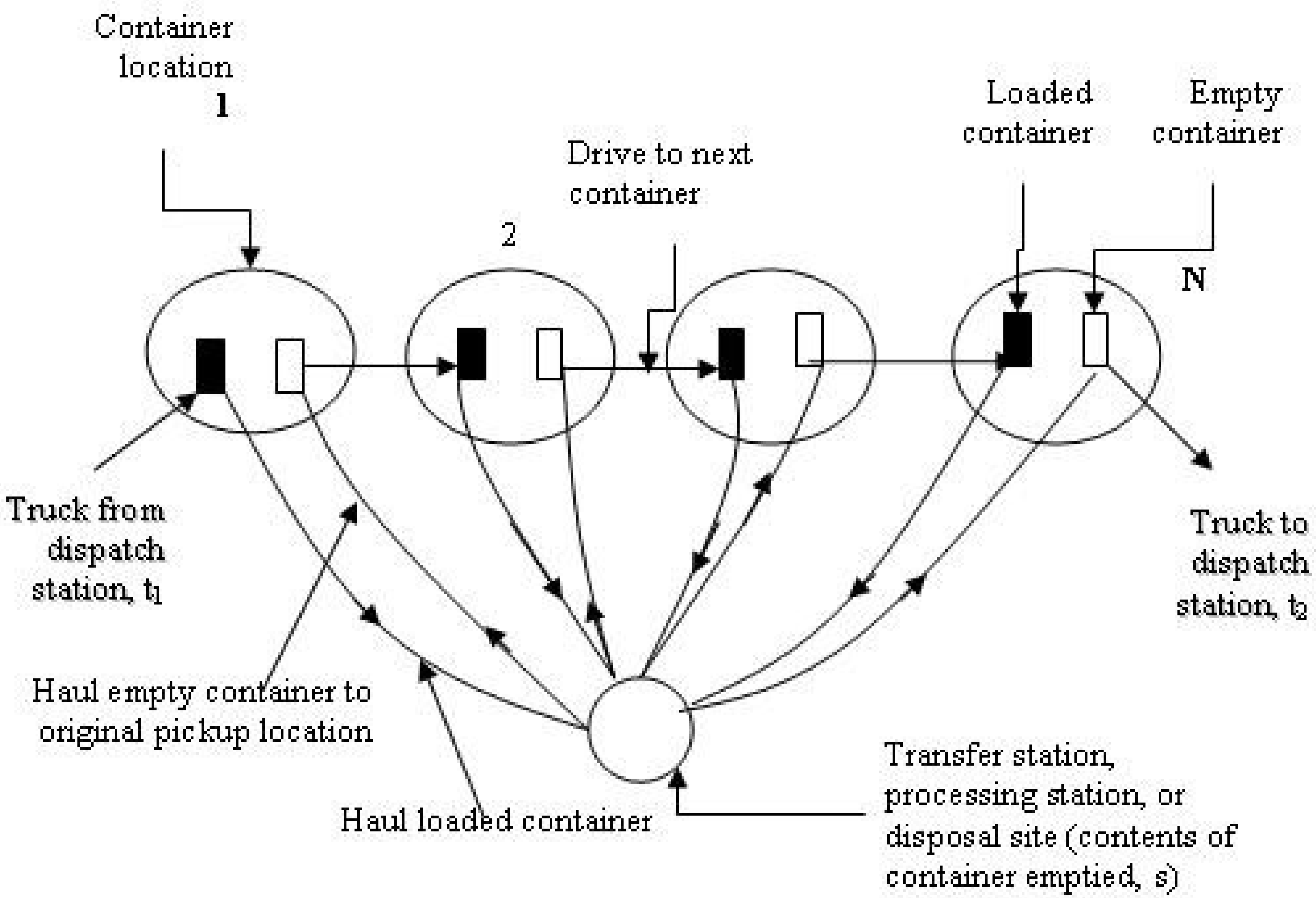
Waste Collection

Waste Collection

Hauled Container System

- Such systems suited for the places where waste generation rate is high because large containers are used.
- The use of large containers reduces handling time as well as unsightly accumulations and unsanitary conditions.
- Hauled container systems have the advantage of requiring one truck and only one driver (and a cleaner if needed only) to complete one cycle, each container picked up requires a round trip to the disposal site.

Hauled Container System (HCS) (Conventional mode)

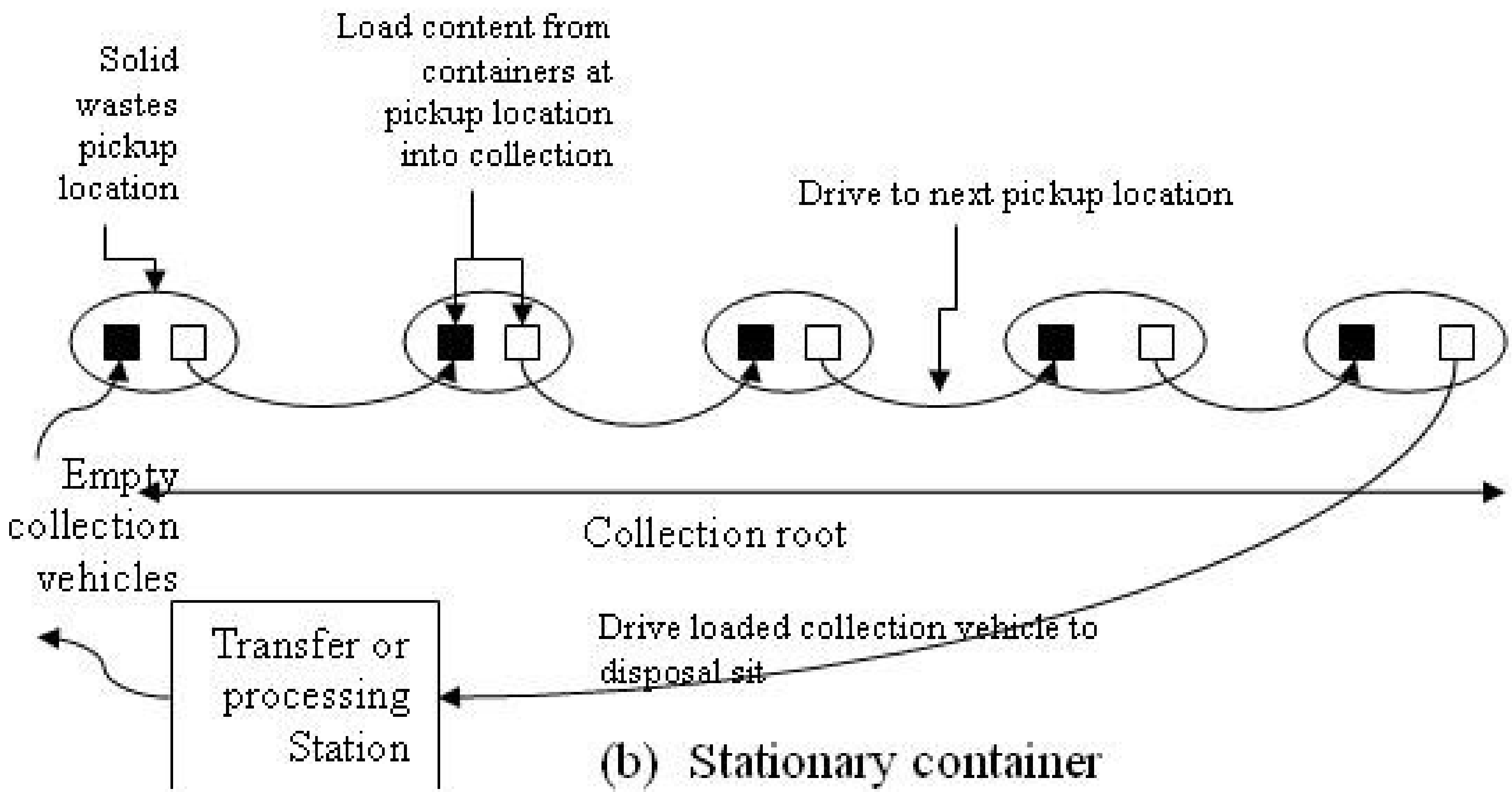


(a) Hauled container.

Stationary Container System (SCS)

- These may be used to collect all types of waste.
- These can be of two types:
  - ✓ Mechanically loaded collection vehicles
  - ✓ Manually loaded collection vehicles
- The personnel requirements for the stationary collection system will vary depending upon the type of system.
- For mechanical systems, a driver and one helper are used. Occasionally, two helpers may be used.
- For manual collection system, 1 – 3 collectors may be used.

Stationary Container System



(b) Stationary container

Commonly Used Unit Operations for Separation of MSW

Item	Function	Equipment
Shredding	Size reduction and to obtain a uniform product	e.g. Hammer mills
Screening	• Separation of over- and under-sized material • Waste segregation into light combustibles and heavy non-combustibles	e.g. vibrating screens, trommel or rotary screens and disc screens
Density separation (air classification)	Separation of light fraction (paper, plastic) from heavier materials (such as metals)	Air classifiers
Magnetic separation	Separation of ferrous metals	Magnetic separator
Densification	Compaction into bales or flattening or increase the density of waste materials	Balers or Can crushers

Composting Process

- It is aerobic biological process
- In this process, readily biodegradable organic fraction of MSW is decomposed by microbes under controlled aerobic conditions.
- A stabilized product (compost) is produced that can be used as soil cover at landfills or conditioner.
- MSW volume is reduced by around 50% after the process.
- Three systems for composting process are: Windrow, forced aeration and in-vessel.

Composting Process…

- **Sometimes, sewage sludge or agricultural residues are also added with MSW. This is called 'co-composting'.**

- **Composting can also have negative impacts:**

✓ **Water pollution may exist if moisture content is very high (> 65%)**

✓ **Odor is another major problem from composting sites using open windrow method.**

Design Considerations for Composting Process

Parameter	Comment/ range
Particle size	25 – 75 mm
C/N ratio	20 – 40
Blending and seeding	Partially decomposed waste or sewage sludge can be added
Moisture content	50 – 60%
Temperature	Should be maintained in thermophilic range during the active composting period.
pH control	7.0 – 7.5

Aerobic Biological Transformations

- **General aerobic transformation of solid waste is described by the following equation:**

✓ **Organic matter + O_2 + nutrients → New cells + resistant organic matter + CO_2 + H_2O + NH_3 + SO_4^{2-} +…..+ heat**

- **If resistant matter is also formed (neglecting production of new cells and sulfate), the oxygen requirement would be:**

✓ **$C_aH_bO_cN_d + 0.5(ny+2s+r-c)O_2 \rightarrow nC_wH_xO_yN_z + sCO_2 + rH_2O + (d-nx)NH_3$**

where $r = 0.5(b - nx - 3(d-nx))$, $s = a - nw$

- **In case of complete conversion**

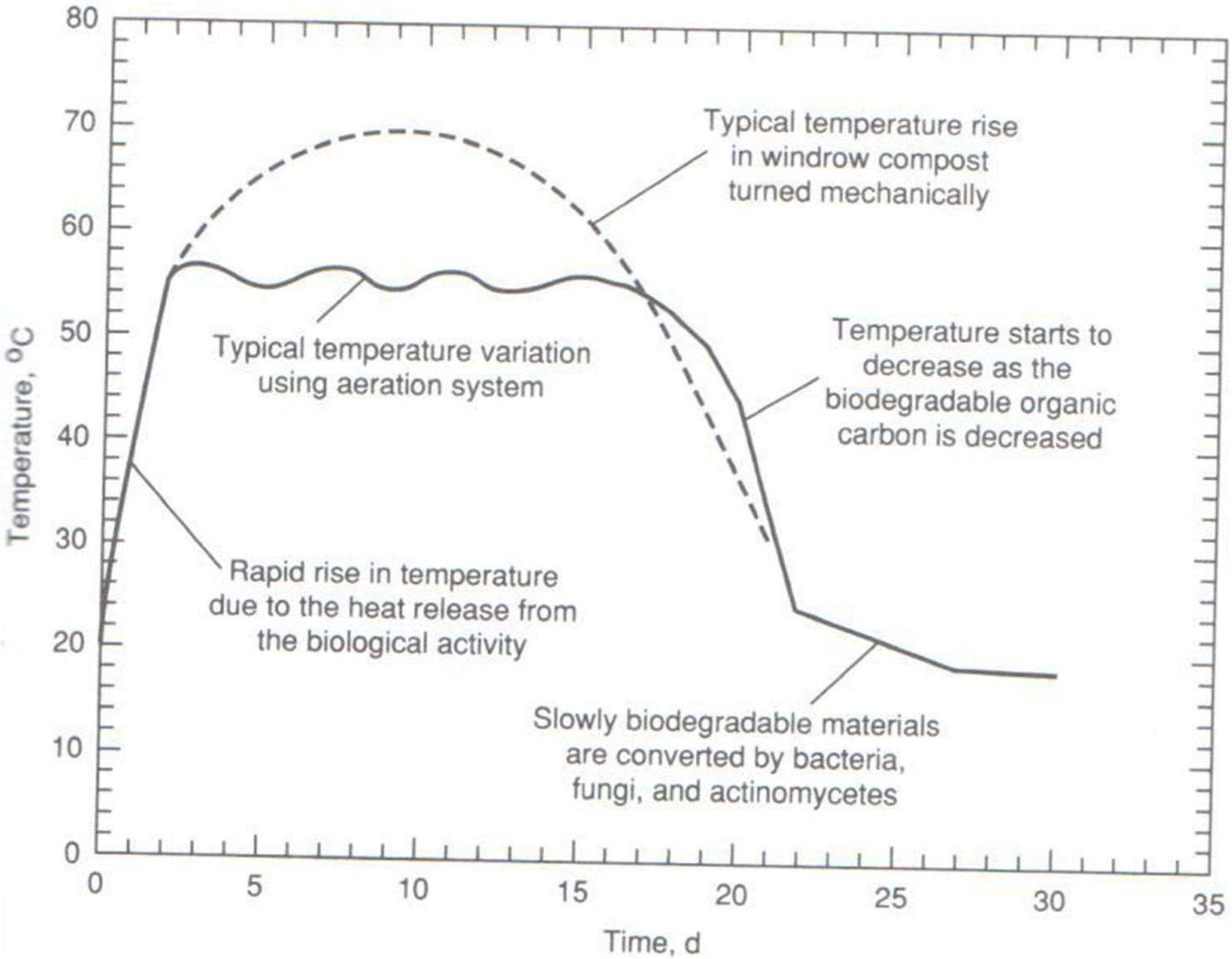
✓ **$C_aH_bO_cN_d + [(4a+b-2c-3d)/4]O_2 \rightarrow aCO_2 + [(b-3d)/2]H_2O + dNH_3$**

✓ **$NH_3 + 2O_2 \rightarrow H_2O + HNO_3$**

Problem

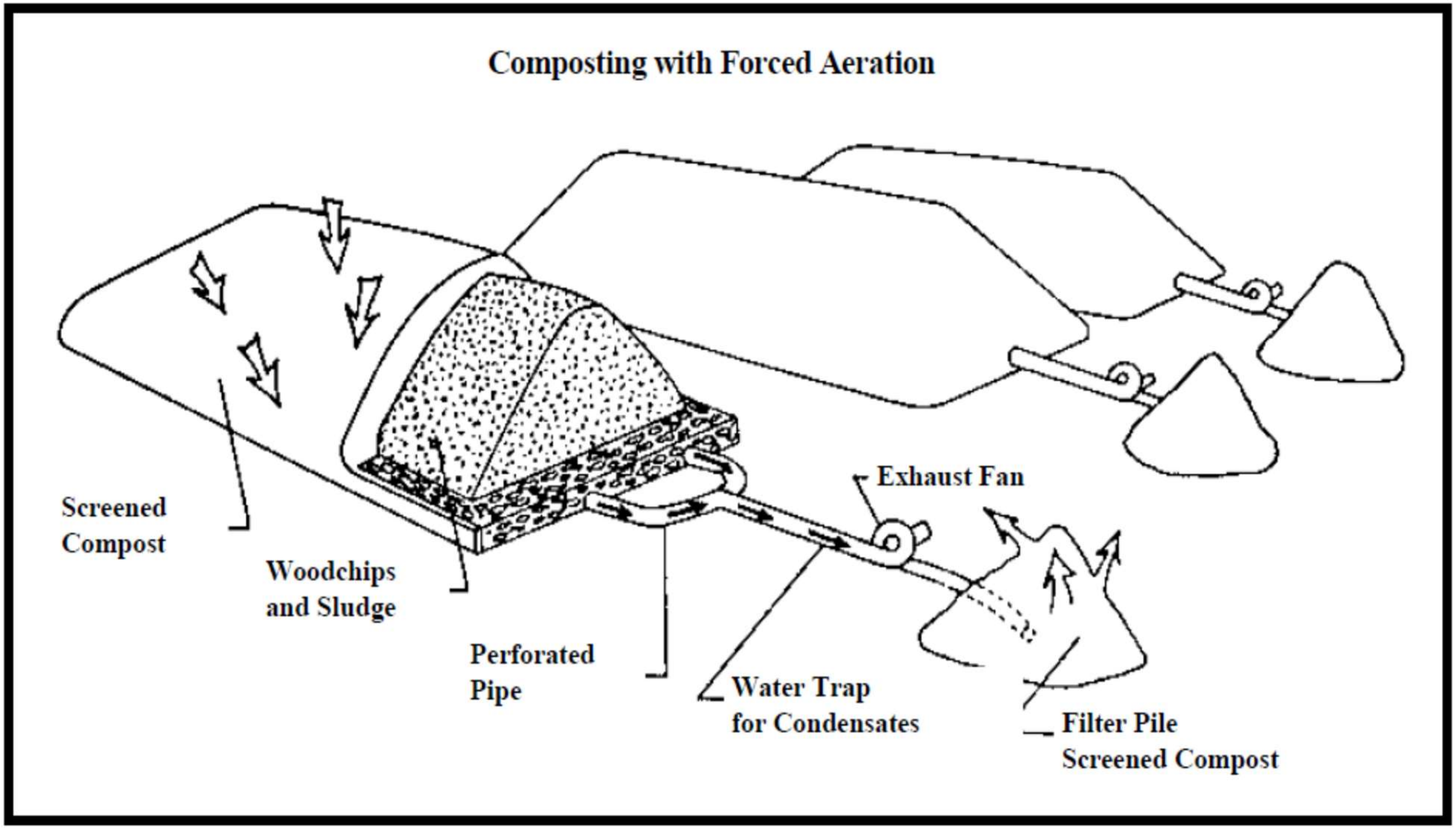
- **Estimate the total theoretical amount of air that would be required under aerobic conditions to oxidize completely an organic waste (mass = 1 ton) with a chemical formula of $C_{120}H_{180}O_{80}N_2$.**

Variation of Temperature During Composting Process (Tchobangolous, 1993)

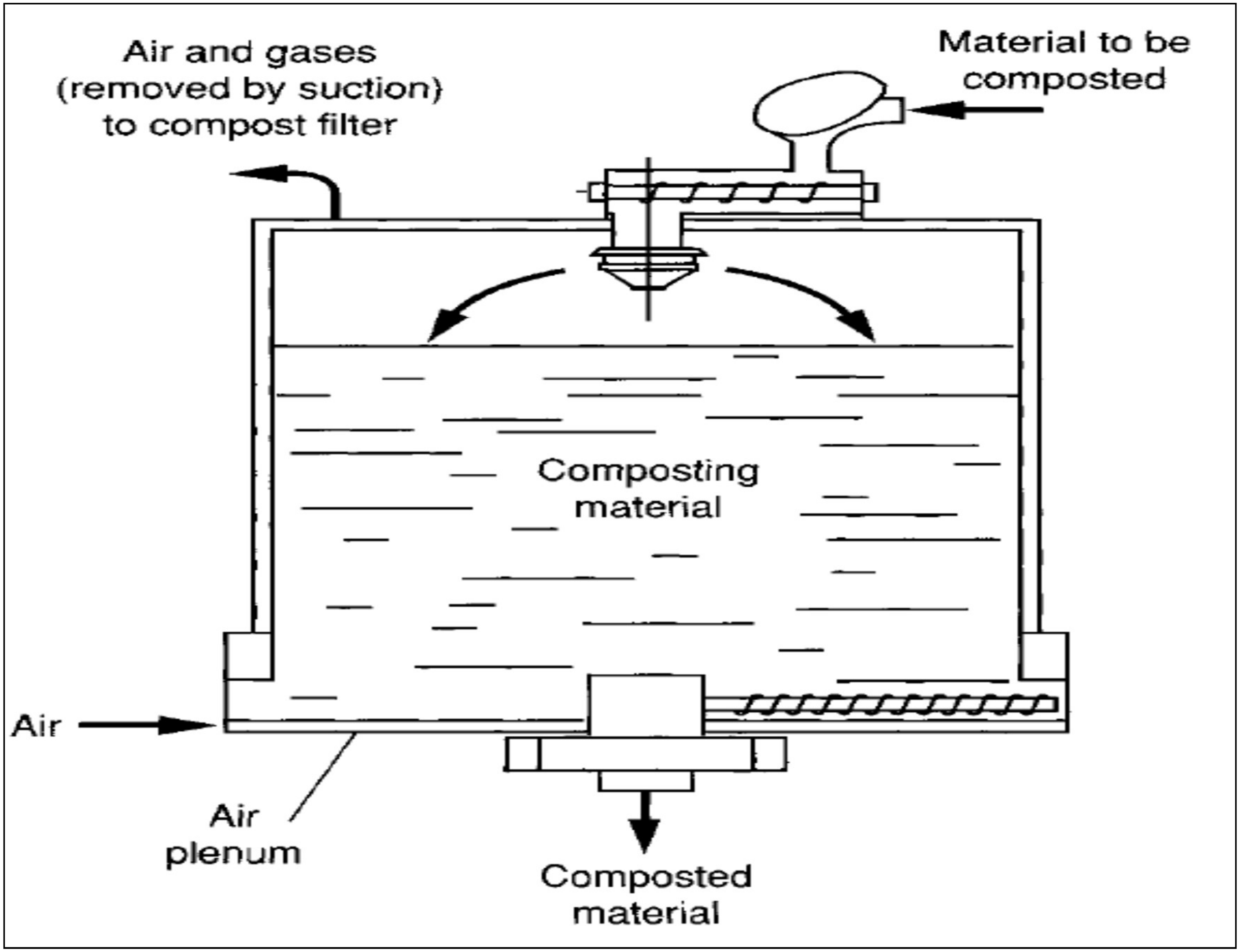


Windrow Composting

Static Aerated Windrows



In-Vessel System



Specifications of Composting Systems

Composting type	Dimensions	Turning frequency	Time to obtain finished product
Windrow	5 – 8 ft (h), 12 – 18 ft (W)	Weekly	4 – 6 weeks
Aerated static piles	8 – 10 ft (h), 16 – 20 ft (W)	-	3 – 4 weeks
In-vessel composting system	-	-	2 – 2.5 weeks followed by curing in open windrows

EPA Requirements for Pathogen Control in Compost Processes (Tchobanoglous et al., 1993)

Requirement	Remarks
Processes for significantly reduce pathogens	The solid waste is maintained at minimum operating conditions of 40°C for 5 days. For 4 h during this period, the temperature exceeds 55°C.
Processes for further reduce pathogens	Using the in-vessel and aerated static pile composting methods, the solid waste is maintained at operating conditions of 55°C or greater for 3 days. In windrow composting, the solid waste is maintained at operating conditions of 55°C or greater for at least 15 days during the composting period. During this period, there will be minimum of 5 turnings of the windrow.

Land Requirements

- For windrow composting plant of 50 tons/ day, typically about 2.5 acre of land would be required. Of this, ~ 1.5 acre would be devoted to buildings, plant equipment and roads.
- For each additional 50 tons, 1 acre would be needed for the composting operation and 0.25 acre for buildings and roads.
- For larger plants, the unit area requirements would be less. e.g., a plant processing 500 t/d can be built on 18 acre land.

Anaerobic digestion (Biomethanation)

- **If the organic waste is buried in pits under anaerobic conditions, it will be decomposed by anaerobic bacteria.**
- **Thermophilic digestion is much faster and leads to the energy recovery through biogas generation.**
- **Biogas contains 55 – 60% CH_4 and 35 – 40% CO_2.**
- **There is a little experience in treatment of solid organic waste in India.**

Low Solids Anaerobic Digestion Process

- **In this process, organic wastes are fermented at solids concentrations equal to or less than 4 – 8%**
- **Temperature between 30 - 38°C for mesophilic and 55 - 60°C for thermophilic reactor**
- **60 – 80% VS destruction can be achieved**
- **40 – 60% TS can be destroyed depending upon the inert material**
- **Gas production = 0.5 – 0.75 m^3/kg of BVS destroyed** **(CH_4 = 55%; CO_2 = 45%)**
- **<u>Disadvantages</u>**

✓ **Considerable water must be added**

✓ **The diluted digested sludge must be dewatered prior to disposal**

✓ **Liquid stream generate after dewatering step should be disposed properly**

High Solids Anaerobic Digestion

- In this process, organic wastes are fermented at solids concentrations of 20 – 35%
- Temperature same as for Low solids process
- 90 – 98% BVS destruction
- Gas production: 0.625 to 1 m^3/kg of BVS destroyed (CH_4 = CO_2 = 50%)
- <u>Advantages</u>

✓ Low water requirement and

✓ Higher gas production per unit volume of reactor size

✓ Less effort is required to dewater and dispose of the digested sludge

- <u>Disadvantages</u>

✓ Heavy metal toxicity and ammonia toxicity are common

✓ Not commercialized for energy recovery

Comparison of Composting and Anaerobic Digestion Process

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