




ENVE 330
SOLID WASTE ENGINEERING

Prof. Dr. Barış ÇALLI
<http://mebig.marmara.edu.tr>



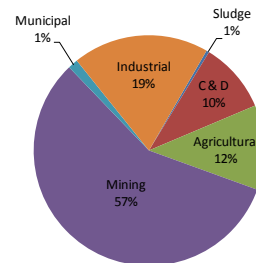
Lecture 1

**Evolution of Solid Waste
Management**



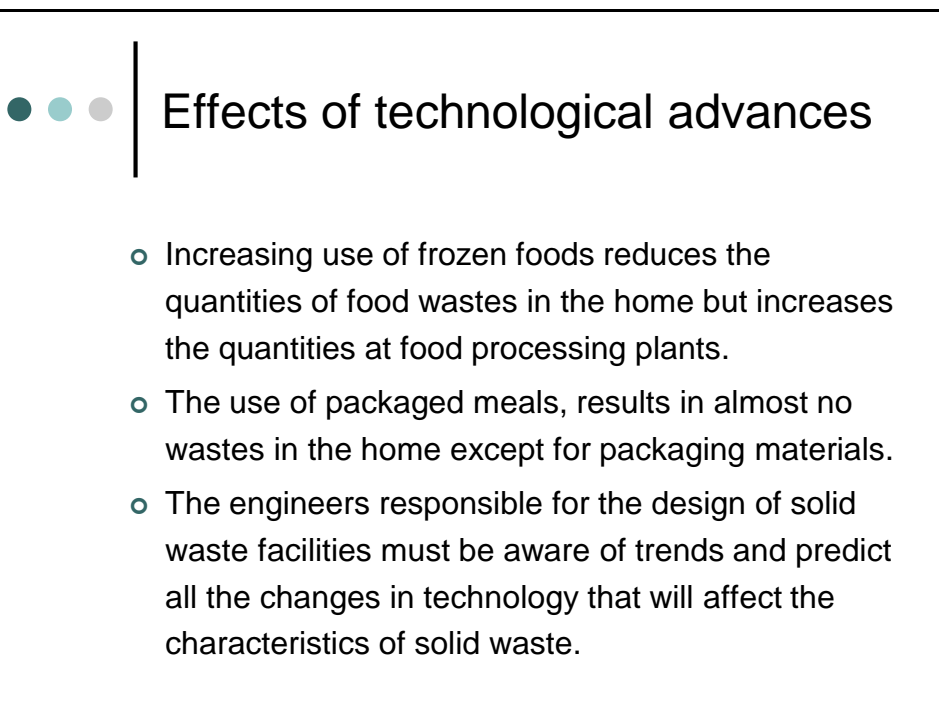
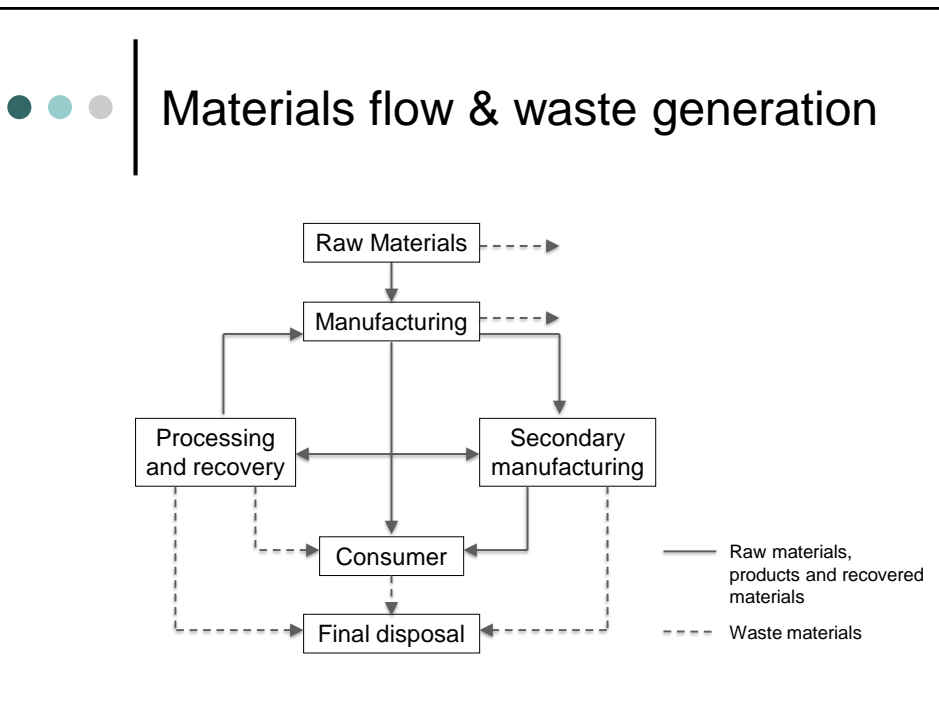
What is Solid Waste?

- **Solid waste** comprise all the wastes from human and animal activities that are normally solid and that are discarded as useless or unwanted.
- **Solid waste** may arise from *urban communities, agricultural and industrial activities* or they may be *mining wastes*.



Solid Waste: A consequence of Life

- Humans and animals have used the resources of the earth to support life and to dispose of waste.
- In early times, the disposal of wastes did not pose a significant problem.
- Because, the population was small and the amount of land available for assimilation of waste was large.
- Problems with the disposal of wastes started when humans first began to congregate in tribes, villages and communities.



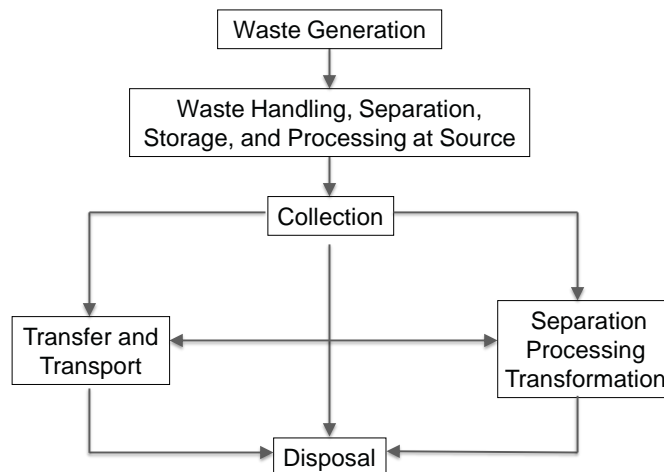


Solid Waste Management

- May be defined as the discipline associated with the *control, generation, storage, collection, transfer and transport, processing and disposal* of solid waste.
- Has to be in accord with the best principles of *public health, economics, engineering, conservation, aesthetics* and that has to be also responsive to *public attitudes*.
- Includes all *administrative, financial, legal, planning* and *engineering* functions involved in solution of all problems of solid waste.



Functional elements of a solid waste management system



http://www.manisa.bel.tr/s350_copun-hikayesi.aspx

Waste generation

- Encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered for disposal.
- At present, not very controllable, more control will be exercised in the future.
- Source reduction is now included in system evaluations as a method of limiting the quantity of waste generated.



Waste handling and separation, storage and processing at the source

- *Waste handling* and *separation* involves the activities associated with management of wastes until they are placed in *storage* containers for collection.
- *Processing at source* involves activities such as compaction and yard waste composting





Collection

- Includes gathering of solid wastes and recyclable materials, and transport of collected materials, to location where collection vehicle is emptied.
- This location may be a materials processing facility, a transfer station or a landfill disposal site.
- Collection accounts for almost **50%** of the total annual cost of urban solid waste management.

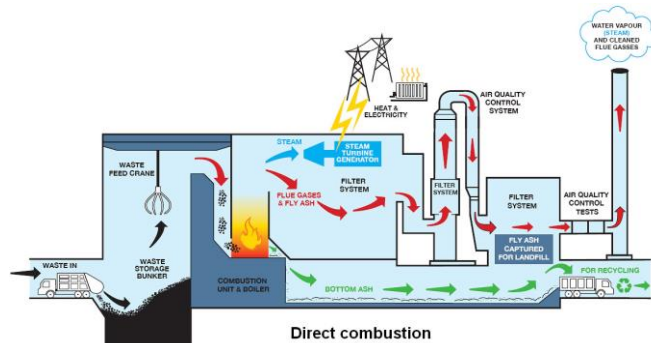


Separation, processing and transformation

- **Separation** of commingled wastes and processing of wastes that have been separated at source usually occur at a materials recovery facility (MRF), transfer station or combustion facility.
- **Processing** often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, size reduction by shredding, separation of ferrous metals using magnets, volume reduction by compaction.

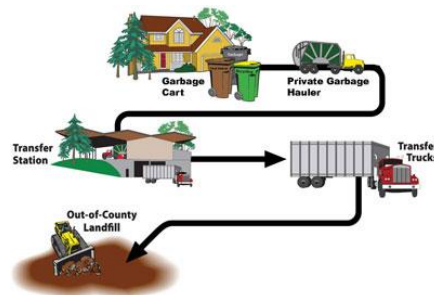
Separation, processing and transformation

- **Transformation** processes are used to reduce the volume and weight of waste requiring disposal and to recover conversion products and energy.



Transfer and transport

- **Transfer** of wastes from the smaller collection vehicle to the larger transport equipment
- Subsequent **transport** of wastes, usually over long distances, to a processing or disposal site





Transfer and transport

- In Istanbul, the collection vehicles, which are relatively small because of the need to give service within the city, haul their loads to one of the 7 transfer stations.
- At the transfer stations, solid wastes unloaded from collection vehicles are reloaded into large truck trailers.
- The loaded trucks are then driven to Şile-Kömürcüoda or Kemerburgaz-Odayeri Landfill sites.



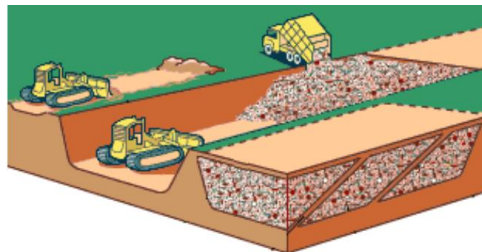
Disposal

- Today the disposal of wastes by landfilling is the ultimate fate of all solid wastes whether they are;
 - residential wastes collected and transported directly to a landfill site,
 - residual materials from materials recovery facilities (MRFs),
 - residue from the combustion of solid waste, or
 - other substances from various solid waste processing facilities.



Disposal

- A modern landfill is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health or safety, such as the breeding of rats and insects and the contamination of groundwater.



Example

Question

- Imagine a town where 10,000 households each generate 50 L of MSW per day. What would this MSW occupy in a landfill? Assume that 10% of the volume is occupied by the final cover.
- Solve the problem using a mass balance assuming that the landfill is a black box and the MSW generated (MSW_{loose}) goes from the households to the landfill ($MSW_{compacted}$).

Assumptions:

- $Density_{loose-MSW} = 120 \text{ kg/m}^3$
- $Density_{compacted-MSW} = 600 \text{ kg/m}^3$



Example

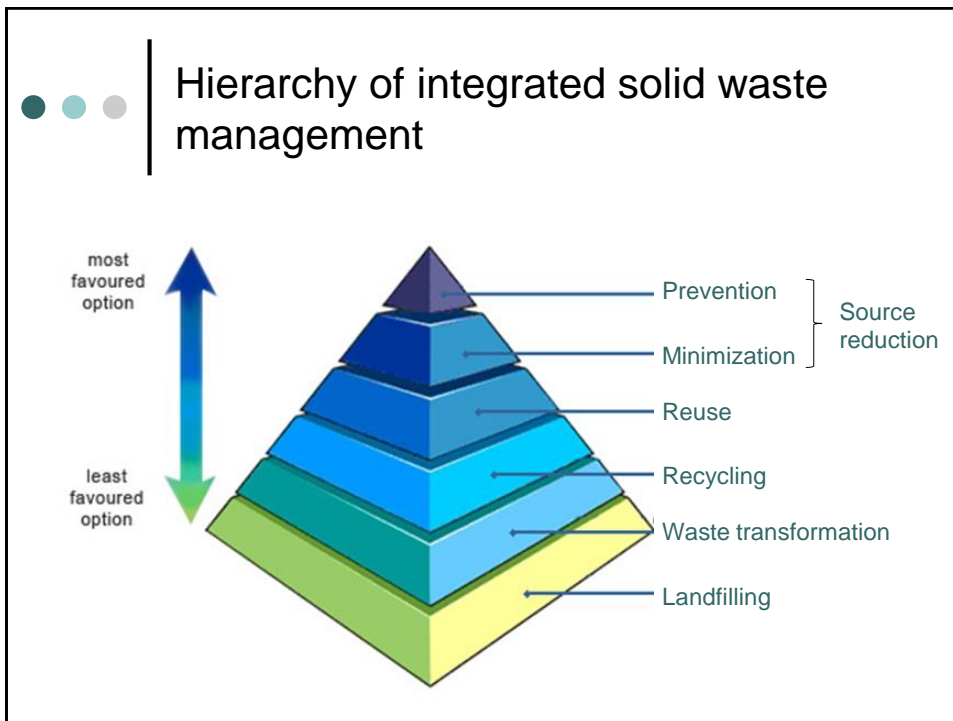
Solution

- $Mass_{loose} = Mass_{compacted}$
- $V_{loose-MSW} * D_{loose-MSW} = V_{compacted-MSW} * D_{compacted-MSW}$
- $V_{loose-MSW} = 10000 \text{ ca} * 50 \text{ L/ca.day} * m^3 / 1000 \text{ L}$
- $V_{loose-MSW} = 500 \text{ m}^3/\text{day}$
- $V_{compacted-MSW} = (500 \text{ m}^3/\text{day} * 120 \text{ kg/m}^3) / 600 \text{ kg/m}^3$
- $V_{compacted-MSW} = 100 \text{ m}^3/\text{day}$
- $V_{landfill} = V_{compacted-MSW} * (1+10\%)$
- $V_{landfill} = 110 \text{ m}^3/\text{day}$



Integrated Solid Waste Management

- When all the functional elements have been evaluated for use and all of the interfaces and connections between elements have been matched for effectiveness and economy, the community has developed an ISWM system.
- ISWM can be defined as the selection and application of suitable techniques, technologies and management programs to achieve specific waste management objectives and goals.



Future challenges and opportunities

- The cost of solid waste management can be supported only by the public, which is responsible for the generation of the vast amount of wastes.
 - Changing consumption habits in society
 - Reducing the volume of waste at the source
 - Making landfills safer (reduce the toxicity of wastes, understand how to manage the landfilled wastes)
 - Development of new technologies (cost effective and conservative of natural sources)



Problem 1

- To maximize the life span of the landfill, local waste management agency has proposed to set up a waste combustion facility next to the existing landfill which has 1.500.000 m³ remaining capacity.
- Determine how many days the life span of the landfill is increased by combusting the MSW instead of landfilling it directly.
 - 2000 tons/day MSW will be combusted assuming 82% weight reduction and the combustion residue (ash) will be landfilled.
 - Specific weights of combustion residue and compacted MSW in the landfill are 600 and 800 kg/m³, respectively.



Solution

Remaining landfill capacity =	1500000 m ³
Incinerator capacity =	2000 tons/day
Weight reduction with incineration =	82%
Specific weight of MSW =	800 kg/m ³
Specific weight of ash =	600 kg/m ³
Volume of MSW generated =	2500 m ³ /day
Lifespan without combustion =	600 days
Volume of ash generated =	600 m ³ /day
Lifespan with combustion =	2500 days
Increase in the lifespan of landfill =	1900 days



Problem 2

- Estimate (a) the annual landfill volume required for a city with population of 1 million where 40% of the MSW is diverted to produce compost that is to be used as intermediate cover.
- What would be (b) the annual landfill volume if all MSW is directly landfilled and covered with intermediate soil cover?
- Assume that soil occupies 20% of the landfill volume.
- The following data and information are applicable.
 - Weight reduction achieved in composting = 50%
 - MSW generation rate = 1 kg/ca.day
 - Specific weight of compacted MSW in landfill = 800 kg/m³



Solution

Weight reduction achieved in composting process	50%
MSW generation rate	1 kg/ca.day
Specific weight of compacted MSW in landfill	800 kg/m ³
Population	1.000.000
MSW diverted to produce compost	40%
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a) Vol. of soil / Vol. of landfill	25%
MSW	1000 tons/day
Composted	400 tons/day
Compost product used as intermediate cover	200 tons/day
Landfilled	600 tons/day
Tot. (MSW + compost cover)	800 tons/day
	292000 tons/year
	365000 m ³
b) Landfilled	365000 tons/year
	456250 m ³
Soil cover	114063 m ³
Tot. (MSW + soil cover)	570313 m ³



Problem 3

- Calculate (a) the required 5-year landfill capacity (m^3) for the city ABC which is projected to have a population increase of 0.2% per year.
- Assume that the current 10% recycling efficiency will increase by 20% per year.
- The MSW generation rate is expected not to change during this period.
 - MSW generation rate = 1.2 kg/ca.day
 - Current population = 2 million
 - Sp. weight of compacted MSW (in landfill) = 900 kg/ m^3



Solution

Year	Population	MSW gen., tons/year	Recycling rate, %	Recycled, tons/year	Landfilled, tons/year	Landfilled, m^3 /year
2019	2004000	877752	12,0%	105330	772422	858246
2020	2008008	879508	14,4%	126649	752858	836509
2021	2012024	881267	17,3%	152283	728984	809982
2022	2016048	883029	20,7%	183105	699924	777693
2023	2020080	884795	24,9%	220165	664630	738478

5-year landfill capacity, m^3 4020909