G. S. Mandal's Maharashtra Institute of Technology, Aurangabad An Autonomous Institute, NAAC GRADE-A



Department of Civil Engineering, Academic Year (2024-25) Semester-VI

Course Title : Solid Waste Management (CED-391)

Open Elective-III CED Third Year B. Tech.

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Structures of Syllabus

Objective



"To get introduced to the generation, collection and management of the various types of solid waste and different solid waste management techniques".

Unit 1 Introduction to Solid Waste Management (SWM)

Need and Objectives, Waste Management Hierarchy, Functional elements, Environmental impact of mismanagement. Solid waste: Sources, types, Composition, Quantities, Physical, chemical and Biological properties.

Unit 2 Generation of Solid Waste

Factors affecting. Storage and collection: General considerations for waste storage at source, Types of collection systems., Transfer station: Meaning, Necessity, Transportation of solid waste: Means and Methods, Routing of vehicles.

Unit 3 Segregation & Material Recovery

Objectives, Stages of segregation, sorting operations, Guidelines for sorting for materials recovery, E waste management, Biomedical waste management.

Unit 4 Waste Processing

Processing technologies: Composting, thermal conversion technologies incineration, treatment of biomedical wastes. Energy recovery from solid waste: Parameters affecting energy recovery, Bio-methanation, Fundamentals of thermal processing, Pyrolysis, Incineration, Advantages and disadvantages of various technological options.

Unit 5 Disposal

Landfills and its introduction, Definition, Essential components, Site selection, Land filling methods, Leachate analysis and landfill gas management, treatment & disposal, Determination of capacity of landfill disposal site.

Unit 6 Hazardous Waste Management (HWM)

Types of hazardous waste (such as nuclear, biomedical and industrial waste), problems and issues related to HWM, Need for HWM, Legislations on management and handling of HW, Hazardous Characteristics, reduction of wastes at source, Recycling and reuse, labeling and handling of hazardous wastes, incineration, solidification & stabilization of hazardous waste.

REFERENCES

- Hilary Theisen and Samuel A, Vigil, George Tchobanoglous, Integrated Solid Waste Management, McGraw-Hill, New York, 1993
- 2. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000
- 3. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and Environmental
- 4. Resources Management, Hazardous waste Management, Mc-Graw Hill International edition, New York, 2001.
- 5. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.
- 6. Charles A. Wentz, Hazardous Waste Management, Second Edition, Pub: McGraw Hill International Edition, New York, 1995..

1. Introduction:

Waste:

Waste are unwanted or unusable materials. Waste is any substance which is discarded after primary use, or is worthless, defective and of no use.

Depending on their physical state they are classified as: Liquid wastes

Gaseous wastes

Solid wastes.

Solid waste: Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area.

Solid Waste Management:

Solid waste management is the process of collection, transportation and disposal of solid waste in a systematic, economic and hygienic manner.

'Or'

Solid-waste management is the process of the collecting, treating, and disposing of solid material that is discarded because it is of no longer use.

What are Solid Wastes

- All the wastes arising from human and animal activities that are normally solid, Are discarded as useless or unwanted .
- Are the heterogeneous mass of throwaways from residences and commercial activities as well as more homogeneous accumulations of a single industrial activity.
- It could be semi-solid, semi-liquid, liquid or gaseous forms also Called as refuse, rubbish, garbage, trash etc.

Why do need to properly manage solid waste?

It can

- Cause bad odour,
- Make us sick
- Spread epidemics through cockroaches, mice, stray animals etc
- Attract birds and hence cause bird menace to air flights
- Cause fires
- Can release green house gases
- Cause contamination of surrounding soil
- Lead to ground water pollution due to waste dumps
- Cause surface water contamination by the run off from the waste dump
- Make city landscape unattractive

The main objectives of waste management are

- For the protection of environment through effective waste management techniques.
- To protect health, well being and environment.
- To prevent <u>pollution</u>.
- To reduce and reuse of waste.
- Safe disposal of waste.
- To minimize the production of waste.
- To create awareness among the people about the impact of waste.
- To maintain sustainable development and <u>ecosystem.</u>
- Encourage waste to energy development.
- Ensure and promote proper solid waste management.

How Waste is Generated

- Everyone in your family produces about half kg of garbage everyday
- The activities that produce garbage are :
- Preparation, cooking and serving food
- Sweeping of house
- Discarding waste papers, packaging ,metal cans, glass and plastic bottles etc.
- Discarding broken articles, furniture etc.
- Cleaning of lawn and gardens
- Construction and demolition activities
- Markets, commercial sources, community halls, hotels, water and wastewater treatment plant also generate these waste as a part of community.

2. Classification of Solid Waste:

 \checkmark Based on their sources of origin:

- Residential wastes
- Commercial wastes
- Institutional waste
- Municipal wastes
- Industrial wastes
- Agricultural wastes

✓ Based on physical nature:

- Garbage
- Ashes
- Combustible and non-combustible wastes
- Demolition and construction wastes
- Hazardous wastes

Classification of Materials comprising SW

- Food wastes
- Rubbish
- Ashes and residues
- Demolition and construction wastes
- Special wastes
- Treatment plant wastes.

Introduction to solid waste

As per the Municipal Solid Waste (Management &Handling) Rule, 2000 garbage is define as Municipal Solid Waste which includes commercial and residential wastes generated in a municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes.

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes.

Classification of solid waste

It is based on Sources, types of solid waste, composition of solid waste and the rate at which it is generated, discarded or disposed.

- **1. Residentia**l– it refers to wastes generated from dwelling, apartment, town houses. It consists of left over food, vegetables, peeled material, plastic, clothes, wood, ashes, etc.
- 2. Commercial– Waste from stores, hotels, markets, restaurants, shopping malls, etc. It consists of grocery material, leftover food, metals, E-waste, etc.
- **3. Institutional** waste generated from schools, colleges, offices. It consists of paper, plastic, glass, E-waste.

Classification of solid waste

Municipal waste- waste generated from house holds, commercials buildings, street sweeping, hotels and restaurants, clinics and dispensaries, construction and demolition, horticulture and sludge.

- 5. Industrial consists of process waste, ashes, demolition and construction waste, hazardous waste from various industrial processes.
- 6. Agricultural– Includes spoiled food grains and vegetables, agricultural remains, litter generated from fields, farms, vineyards etc.

It is based on the physical, chemical and biological characteristics of waste.

- **1. Refuse-** This is all putrescible and non putrescible waste except body waste. It consists of **rubbish and garbage.**
- 2. **Rubbish** Portion of refuse which is non putrescible solid waste. (packaging material)
- **3. Garbage** consists of putrescible component of solid waste. Includes vegetable, animal waste resulting from handling, sale, storage, preparation, cooking and serving of food.

Garbage consist of four broad categories of waste

- 1. Organic waste: kitchen waste, vegetables, flowers, leaves, fruits.
- 2. **Toxic waste:** old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.
- 3. **Recyclable:** paper, glass, metals, plastics.
- 4. Soiled: hospital waste such as cloth soiled with blood and other body fluids.

- 1. Ashes and residues Total inorganic includes remains from burning of wood, coal, charcoal and other combustible material for cooking and heating in houses. When produced in large amount in factories and power plants it is classified as industrial waste.
- 2. Combustible and non combustible waste- Generated from household and institutions excluding food waste.
- Combustible paper, textile, cardboard , rubber, garden trimmings.
- Non combustible material glass, crockery, cans, ferrous and non ferrous material.

- 3. Bulky waste– Household waste which cannot be accommodated in the normal storage containers and need special collection mechanism. (refrigerators, washing machines, furniture etc.)
- 4. **Street Waste** waste collected from streets, walkways, parks, playgrounds. Include paper, cardboard, plastic, dirt leaves in large quantities.
- 5. Biodegradable and non biodegradable waste- Organics are biodegradable waste and inorganic and recyclable material is non biodegradable such as Plastic, metal, glass, etc.

- 6. **Dead animals** those who die naturally or accidently killed on the road. It does not include waste from slaughter house.
- 7. Construction and demolition waste– Include stones, concrete, bricks, roofing and plumbing material, electric wires etc.
- 8. **Farm waste** results from diverse agricultural activities like planting, harvesting, rearing of animals, poultry waste.
- **9. Hazardous waste** Include the waste from institutions, and industries which have characteristics of Ignitability, corrosively, reactivity, toxicity.

- **10. Sewage waste-** These are the solid by products of sewage treatment. Mostly organic derived from treated organic sludge separated from raw and treated sewage. Waste is sticky and rich in pathogens.
- 11. E waste- these are the electronic products nearing the end of their useful life. It include discarded computers, televisions, fax machines, copiers, cell phones, batteries.

Impacts of solid waste on health

- Chemical poisoning through chemical inhalation
- Uncollected waste can obstruct the storm water runoff resulting in flood
- Low birth weight
- Cancer
- Congenital malformations
- Neurological disease
- Nausea and vomiting
- Increase in hospitalization of diabetic residents living near hazard waste sites.

Effects of Solid Waste on Animals and Aquatics life

- Increase in mercury level in fish due to disposal of mercury in the rivers.
- Plastic found in oceans ingested by birds, resulted in high algal population in rivers and sea.
- It degrades water and soil quality.

Impacts of solid waste on Environment

- Waste breaks down in landfills to form methane, a potent greenhouse gas.
- Change in climate and destruction of ozone layer due to waste biodegradable.
- Due to waste pollutions, illegal dumping, Leaching: is a process by which solid waste enter soil and ground water and contaminating them.





Characteristics of Solid Waste



Presented By:

Aditya Jain



The term solid waste means : Material such as household garbage, food wastes, yard wastes, and demolition or construction debris.

MUNKULANN

Solid waste are wastes that are not liquid or gaseous. Solid wastes are all the discarded solid materials from What municipal, industrial, and is Solid agricultural Waste activities.



E-Wastes



Bio-medical wastes

Agricultural wastes



Industrial wastes



Physical Characteristics
 Chemical Characteristics
 Biological Characteristics

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Physical Characteristics

Information and data on the physical composition of solid wastes.

These are important in the selection and operation of equipment and facilities, and in the analysis and design of disposal facilities.

Major Physical Characteristics:
Density
Moisture Content
Waste Particle Size

Other Physical Characteristics

- Colour
- Shape of components
- Optical property
- Magnetic properties

Density

Density of waste, i.e. its mass per unit volume (kg/m3).

It is a critical factor in the design of a SWM system i.e. the design of sanitary landfills, storage, types of collection and transport vehicles etc.

For an efficient operation of landfill, compaction of wastes to optimum density is essential.



Any normal compaction equipment can achieve reduction in volume of wastes by 75%, which increases an initial density from 100 kg/m3 to 400 kg/m3.

Municipal solid wastes as delivered in compaction vehicles have been found to have a average density of about 300 kg/m3.

A waste collection vehicle can drag four times the weight of waste in its compacted state than when it is un-compacted.

Moisture Content

Moisture content is defined as the ratio of the weight of
 water to the total weight of the wet waste.

Moisture content(%) =
$$\frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} * 100$$

☐ Moisture increases the weight of solid wastes and thereby, the cost of collection and transport.

□ It is a critical determinant in the economic feasibility of waste treatment by incineration because wet waste consumes energy for evaporation of water and in raising the temperature of water vapour.

□ A typical range of moisture content is 20 to 40%. However, values greater than 40% are not uncommon.

Particle Size

The size distribution of solid wastes are important in the recovery of materials especially with mechanical means such as trommel screens and magnetic separators.

It plays a significant role in the design of mechanical separators and shredders.





☐ The major means of controlling particle size is through shredding.

Shredding increases homogeneity, increases the surface area/volume ratio and reduces the potential of liquid flow paths through the waste.

Particle size will also influence waste packing densities.

Particle size reduction could increase biogas production through the increased surface area available to degradation by bacteria.

Other Properties

Optical property can be used to separate opaque materials from transparent substances which majorly contains glass and plastic.

Shape can be used for segregation as flaky substance will behave differently compared to non-flaky substance.

Magnetic separators are designed based on the magnetic characteristics of the waste.



Field Capacity:

The field capacity of waste is the total amount of moisture which can be retained in a waste sample subject to gravitational pull.

It is used to determine the formation of leachate in landfills.

It is a critical measure because excess water in field capacity will form leachate.

Leachate is the fluid percolating through the landfills and is generated from liquids present in the waste and from outside water, including rainwater, percolating though the waste.



CHEMICAL PROPERTIES

- Knowledge of the classification of chemical compounds and their characteristics is essential for the proper understanding of the behaviour of waste, as it moves through the waste management system.
- To use solid wastes as fuel, or for any other purpose, their chemical characteristics should be known.

CHEMICAL PROPERTIES INCLUDES...

- Lipids
- Carbohydrates
- Proteins
- Natural fibres
- Synthetic organic material (plastics)

- Non-combustibles
- Heating value
- Ultimate analysis
- Proximate analysis

LIPIDS

- A Lipid is any of various organic compounds that are insoluble in water.
- This class of compounds includes fats, oils and grease and the principal sources of lipids are garbage, cooking oils and fats.
- Lipids have high heating values, about 38,000 KJ/Kg, which makes them suitable for energy recovery.
- Since lipids become liquid at temperatures slightly above ambient, they add to the liquid content during waste decomposition.

- Though they are biodegradable, the rate of biodegradation is relatively slow because lipids have a low solubility in water.
- Solubility is defined as the maximum amount of a substance that will dissolve in a given amount of solvent at a specified temperature.

CARBOHYDRATES

- These are found primarily in food and yard wastes, which encompass sugar and polymer of sugars (e.g., Starch, cellulose, etc.) With general formula (CH2O)X.
- Carbohydrates are easily biodegraded to products such as carbon dioxide, water and methane.
- Decomposing carbohydrates attract flies and rats and therefore,
- should not be left exposed for long duration.

PROTEINS

- These are compounds containing carbon, hydrogen, oxygen and nitrogen and consist of an organic acid with a substituted amine group (NH2).
- They are mainly found in food and garden wastes. The partial decomposition of these compounds can result in the production of amines that have unpleasant odours.

NATURAL FIBRES

- These are found in paper products, food and yard wastes that are resistant to biodegradation.
- They are a highly combustible solid waste, having a high proportion of paper and wood products, they are suitable for incineration.
- **Incineration** -The destruction of something, especially waste material, by burning.

HEATING VALUE

- The heating value (or energy value or calorific value) of a substance, usually a fuel or food is the amount of heat released during the combustion of a specified amount of it.
- An evaluation of the potential of waste as a fuel for incineration, requires a determination of its heating value expressed as kilojoules per kilogram (kj/kg).
- The heating value is determined experimentally using the bomb calorimeter test, in which the waste of specified quantity is heated at constant temperature of 25C.

SYNTHETIC ORGANIC MATERIAL (PLASTICS)

- They are highly resistant to biodegradation and therefore, are objectionable and of special concern in SWM.
- Plastics have a high heating value, about 32,000 KJ/KG, which makes them very suitable for incineration.

 But, polyvinyl chloride (PVC), when burnt, produces dioxin and acid gas. This increases corrosion in the combustion system and is responsible for acid rain.

BIOLOGICAL PROPERTIES

- It includes:
 - Biodegradability of Organic Waste
 - Odours
 - Breeding of flies

BIODEGRADABILITY OF ORGANIC WASTE COMPONENTS

- Volatile solids (VS) content, determined by ignition at 550C, is often used as a measure of the biodegradability of the organic components.
- The use of VS in describing the biodegradability of the organic components is misleading, as some of the organic constituents are highly volatile but low in biodegradability(e.g., Newsprint and certain plant trimmings).

- Lignin -a complex organic polymer deposited in the cell walls of many plants, making them rigid and woody.
- Alternatively, the lignin content of a waste can be used to estimate the biodegradable fraction, using the following relationship:

BF = 0.83 - 0.028 LC

• Wastes with high lignin contents are significantly less biodegradable.

Thank You



