Water Supply & Sanitary Engineering (DI05006021)

Unit 11: Recycling of wastewater and Solid Waste

Lecture 44: Solid Waste Management: Sources, Classification, and Collection

GTU Diploma Engineering

Agenda

- Introduction to Solid Waste Management (SWM)
- Sources of Solid Waste
- Classification of Solid Waste
- Physical and Chemical Characteristics
- Functional Elements of SWM
- Waste Segregation at Source
- Collection Systems and Equipment
- Transfer Stations and Transportation

Introduction to Solid Waste Management

- Solid Waste: Any discarded or abandoned materials (non-liquid) arising from domestic, commercial, industrial, and agricultural activities.
- Municipal Solid Waste (MSW): Primarily household waste (garbage and rubbish) alongside commercial and institutional waste collected by municipalities.
- Impact of Poor SWM: Clogged drains leading to flooding, proliferation of disease vectors (rats, mosquitoes), groundwater contamination (leachate), and air pollution.
- Objective of SWM: To control generation, storage, collection, transfer, processing, and disposal in a manner compliant with public health and environmental principles.

Sources of Solid Waste

- Residential: Single and multifamily dwellings (food waste, paper, plastics, glass).
- Commercial: Stores, hotels, restaurants, markets (corrugated cardboard, food waste, plastics, e-waste).
- Institutional: Schools, hospitals, government centers (paper, hazardous biomedical waste, cafeteria waste).
- Construction and Demolition (C&D): Road repair, building construction (wood, steel, concrete, dirt).
- Municipal Services: Street sweeping, landscaping, park maintenance (leaves, street dirt, branches).

Classification of Solid Waste

- Garbage: Putrescible (biodegradable) organic waste from the preparation, cooking, and serving of food. Decomposes rapidly and produces odors.
- Rubbish: Non-putrescible solid waste, both combustible (paper, wood, plastics) and non-combustible (glass, metals, ceramics).
- Ashes: Residue from the combustion of solid fuels for heating and cooking.
- Hazardous Waste: Wastes that pose a substantial danger immediately or over time (toxic, ignitable, corrosive, reactive). Requires specialized handling.

Physical Characteristics of MSW

- Density/Specific Weight: Crucial for assessing total mass and volume. Dictates the size and type of collection vehicles (e.g., use of compactor trucks).
- Moisture Content: Important for evaluating processing options like composting or incineration. Food waste typically has a high moisture content (50-70%).
- Particle Size and Distribution: Affects the porosity and permeability of compacted waste, influencing the design of mechanical separators and landfill gas/leachate movement.
- Field Capacity: The total amount of moisture that can be retained in a waste sample subject to the downward pull of gravity. Important for leachate generation calculations.

Chemical Characteristics of MSW

- Proximate Analysis: Determines moisture, volatile combustible matter, fixed carbon, and ash. Essential for evaluating combustion properties.
- Fusing Point of Ash: The temperature at which ash forms clinkers. Critical for incinerator design to prevent blockages.
- Ultimate Analysis (Elemental): Determines Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur, and halogens. Used to calculate the carbon-to-nitrogen (C/N) ratio for composting.
- Energy Content (Calorific Value): Measured in kJ/kg using a bomb calorimeter. Determines the viability of waste-to-energy (WTE) projects.

Functional Elements of SWM

- 1. Waste Generation
- 2. Waste Handling and Segregation at Source
- 3. Collection
- 4. Separation, Processing, and Transformation
- 5. Transfer and Transport
- 6. Final Disposal

Waste Segregation at Source

- The most critical step for effective recycling and processing.
- Wet Waste (Biodegradable): Kitchen waste, vegetable peels, leftover food. Sent for composting or biomethanation.
- Dry Waste (Recyclable/Non-biodegradable): Paper, plastics, metal, glass. Sent for material recovery and recycling.
- Domestic Hazardous & E-waste: Batteries, paints, expired medicines, electronics. Require specialized safe disposal.
- Color-coded Bins: Green (Wet/Organic), Blue (Dry/Recyclables), Red/Black (Hazardous).

Waste Collection Systems

Concept 1	Concept 2

Hauled Container Systems (HCS): The containers used for storage are hauled to the processing/disposal site, emptied, and returned. Suitable for high waste generation points (markets, construction sites).

Stationary Container Systems (SCS): The containers used for storage remain at the point of generation. Waste is transferred into collection vehicles (e.g., compactor trucks). Used for residential and commercial collection.

Routing: Heuristic routing optimization is used to minimize travel distance, avoid dead-heading, and reduce fuel consumption.

Collection Equipment and Vehicles

- Handcarts and Tricycles: Used for door-to-door primary collection in narrow streets and dense urban areas.
- Light Commercial Vehicles (LCVs): Used for secondary collection and transport to transfer stations.
- Compactor Trucks: Hydraulically compact the waste inside the vehicle, increasing payload capacity by up to 3 times. Ideal for low-density MSW.
- Roll-on/Roll-off (Ro-Ro) Trucks: Used to haul large demountable containers from commercial areas or transfer stations.

Transfer Stations and Transportation

- Transfer Station: A centralized facility where waste is unloaded from smaller collection vehicles and re-loaded into larger, long-haul vehicles (trailers, trains).
- Purpose: Reduces transport costs when the disposal site is far (¿15-20 km) from the collection area.
- Operations: Often includes further compaction, baling, or preliminary material recovery to maximize the payload of the long-haul transport.
- Environmental Controls: Must be enclosed and equipped with odor control, dust suppression, and leachate collection systems.

Summary

- Solid Waste Management encompasses generation to final disposal, aiming to protect public health and the environment.
- Understanding waste sources and physical/chemical characteristics (density, moisture, C/N ratio, calorific value) is crucial for selecting processing methods.
- Source segregation (wet vs. dry) is the most critical step for effective waste recycling.
- Collection is the most expensive phase; optimizing vehicle types (HCS vs SCS) and routing is essential.
- Transfer stations consolidate waste for cost-effective long-haul transport to distant disposal sites.