CE 7114 - Municipal Solid Waste Management

Unit - I

Sources and Types of Municipal Solid wastes

Solid waste - definition:

Solid waste comprises all the waste arising from human and animal waste that are solid and are discarded as useless and unwanted.

* Homogeneous SW
* Heterogeneous SW.

Sources of Solid waste:

* Residential
* commercial
* Institutional
* Construction and demolished
* Industrial
* Agricultural
* Municipal services
* Treatment plant

Municipal Solid waste (MSW) is assumed to include all community wastes with the exception of industrial and agricultural wastes.

Residential and commercial:

* Organic waste → kitchen (food waste), paper, wood, leather, yard waste, rubber, plastic, textiles.

* Inorganic waste → Glass, tin cans, aluminium, ferrous materials, dirt.

Wastes that will decompose rapidly especially food wastes are known as putrescible wastes. This will lead to the development of offensive odors and breeding of flies.

Paper waste in MSW → newspaper, books, office paper, paper board, tissue paper, card board.

Plastic waste in MSW fall into 7 categories

1. Polyethylene terephthalate (PETE)
2. High density polyethylene (HDPE)
3. Polyvinyl chloride (PVC)
4. Low density polyethylene (LDPE)
5. Polypropylene (PP)
6. Polystyrene (PS)
7. Other multilayered plastic material

Special wastes → bulky items, consumer electronics, yard wastes, batteries, oils and tyres.

Bulky items - furniture, lamps, cabinets, etc.

consumer electronics - radio, television, etc.

Batteries - households, automobile and other vehicle servicing facilities

Oil waste - automobile servicing

Institutional waste:

Institutional sources include government centers, schools, prisons and hospitals.

Except hospital, the wastes generated at these facilities are quite similar to residential SW.

In most hospitals medical wastes are handled and processed separately.

Construction and Demolition:

construction waste - construction, remodeling, repairing of residencies and commercial buildings.

It may composed of dirt, stones, concrete, brick etc.

waste from razed buildings, broken out streets, sidewalks, bridges and other structures are known as demolition wastes.

Municipal Services:

Street sweepings, road side litter, waste from municipal litter containers, land scape and tree trimings, catch - basin debris, dead animals and abandoned vehicles.

Treatment Plant waste:

The solid and semisolid wastes from water, wastewater and industrial water treatment facilities are called treatment plant waste.

The characteristics of waste vary, depending on the nature of treatment process.

Treatment plant sludges are commonly co-disposed with MSW to landfills.

Agricultural wastes:

residues from planting, harvesting of row, field, tree, vine crops, production of milk, production of animals for slaughter.

Industrial wastes:

Sources and types of SW generated at industrial sites grouped, according to Standard Industrial Classification (SIC).

code	Group classification	waste generating process	Expected waste
22	Textile mill products	weaving, processing, dying, shipping	cloths and fibre residues
28	chemical and related products	manufacture and preparation of inorganic (soap, paint, varnishe, and explosives)	inorganic solid material
31	Leather and leather products	curing, tanning, finishing	scrap leather, thread and skins

Importance of Quantity :

* Quantity is used to asses the load capacity of the collection equipment.
* It is used to asses the no. of vehicles required for collection and transportation.
* Total volume and weight of solid waste, quantity play a vital role in planning and design.
* Per capita rate generation is the statistic indicating the consumption.
* In India, production rate is 0.22 - 0.6 kg / cap / day.

Factors affecting the generation of solid waste :

- Socio - economic
- Migration of population
- Industrialization
- Seasonal variation
- Cultural & regional events

Socio - Economic :

The quantity of waste generated depends on the income level, a higher income produces more solid waste than a lower income group.

Higher income groups discards more than the lower income group.

Migration of population:

The larger employment in the cities brings the rural youth to the cities. So the population of cities get increased. Hence the solid waste generation also gets increased.

Industrialization:

Industries in a city demands raw materials for processing, packaging, washing which in turn increases the solid waste.

They also need more power to run the industry.

Seasonal variation:

During summer, the waste become denser. Due to rainfall, tonnage increases. Also the growth of plants is much higher, during rainfall.

Dry leaves set the plants and becomes the significant proportion of street sweepings and house waste.

Cultural and Regional Events:

During cultural and regional events, the people buys new cloths and celebrate events. In that time waste generated is high.

Cultural events like pongal, holi and regional events like deepavali, christmas, ramzan time, municipal workers has to work around minimum 4 days to clear solid waste.

Effect of improper disposal of solid waste:

* It causes ground water contamination by leachate generated in waste dump.
* It causes surface water contamination by run off from waste dump
* It causes bad odour, breeding of mosquitoes, pests and rodents.
* The litter spreads around the dumps when the wind blows and causes ugly appearence, nuisance, etc.
* It generates inflammable methane gas with in the waste dump.
* In some cases, it fires with in dump.
* It causes bird menace, above the waste dump and affects flight of aircraft.
* It causes erosion and stability problems relating to slope of waste dumps.
* It releases green house gases.
* It causes acidity to surrounding soil.

Public Health Effects:

* It causes air, water, land and noise pollution and related diseases.
* It causes gastro intestinal disorders, respiratory diseases, skin infections, etc.
* It produces poisonous gases, dust allergy.
* It acts as a breeding place of mosquitoes, pests and rodents which communicates related diseases like malaria, dengue fever, swine flu etc.
* It creates bad odour, ugly appearence, etc.
* It is possible to create explosive hazards.
* It may creates physical injury from waste disposal like glass, metal pieces, etc.

Composition of MSW:

Individual source that makeup solid waste (MSW) should be measured interms by weight.

Source	Typical MSW composition (%)
Residential and commercial	62
Hazardous	5
Institutional	0.1
Construction and demolishion	3-4
Municipal services	14
Treatment plant	6

Physical, Chemical and Biological properties of MSW:

Physical property:

Important physical characteristics of MSW include specific weight, moisture content, particle size and size distribution, field capacity and compacted waste porosity.

Specific weight:

Specific weight is defined as the weight of material per unit volume.

MSW have been vary from 300 - 700 lb/yd^3, a typical value is about 500 lb/yd^3.

Moisture content:

The wet weight method is used most commonly in the field of solid waste management.

The wet weight moisture content is expressed as

$$M = \left(\frac{w - d}{w}\right) \times 100$$

M - moisture content, %

w - initial weight of sample

d - weight of sample after drying at 105°C.

Particle size and size distribution:

The size and size distribution of component materials in SW are an important consideration in material recovery especially with mechanical means

such as trommel screens and magnetic separators.

The size of waste component may be defined by one or more following measures

$$S_c = l$$

$$S_c = \frac{l + w}{2}$$

$$S_c = \frac{l + w + h}{3}$$

$$S_c = (l \times w)^{1/2}$$

$$S_c = (l \times w \times h)^{1/3}$$

Field capacity :

Field capacity is the ability of material to retain water. This property is usually associated with soil. The field capacity of uncompacted commingled wastes from residential and commercial sources is in the range of 50 - 60%. Low field capacity waste produces more amount of leachate.

Permeability of compacted waste :

The hydraulic conductivity of compacted waste is an important physical property which governs the movement of liquids and gases in landfill.

The co-efficient of permeability is written as

$$K = Cd^2 \frac{\gamma}{\mu}.$$

K - coefficient of permeability

C - dimensionless constant

d - average size of pores

γ - specific weight of water

μ - dynamic viscosity of water.

Chemical Properties of MSW:

If solid wastes are used to be as fuel, the four most important properties are

* Proximate analysis
* Fusing point of ash
* Ultimate analysis
* Energy content.

Proximate Analysis:

Proximate analysis of MSW includes moisture, volatile combustible matter, fixed carbon and ash.

Fusing point of ash:

It is defined as that temperature at which the ash resulting from the burning of waste will form a solid by fusion.

Ultimate analysis:

The ultimate analysis of waste component typically involves the determination of percent 'C', 'H', oxygen, nitrogen, sulfur and ash and halogen.

They are used to define the proper mix of waste materials to achieve suitable C/N ratio.

Energy content :

The energy content of organics in MSW can be determined by using full scale boiler as a calorimeter, laboratory bomb calorimeter and calculation.

Biological properties of MSW:

Excluding plastic, rubber and leather components, the organic fraction of MSW can be classified as: water soluble constituents such as sugars, starches, amino acids and organic acids; Hemicellulose, cellulose, fats, oils and waxes, lignin, lignocellulose and proteins.

Almost all the listed compounds are degraded, depends on the nature of substance.

Biodegradability :

Volatile solids (VS) content is used as a measure of biodegradability of organic fraction in MSW. The principal organic waste in MSW are often classified as rapidly and slowly decomposable materials.

Production of odors :

Odors can develop when solid wastes are stored for long periods of time. The development of odors is more significant in warm conditions.

The formation of odourless compound can be illustrated as

$$2CH_3CHOHCOOH + SO_4^{2-} \longrightarrow 2CH_3COOH + S^{2-} + H_2O + CO_2$$

lactate sulfate

$$2H_2 + SO_4^{2-} \longrightarrow S^{2-} + 4H_2O$$

$$S^{2-} + 2H^+ \longrightarrow H_2S.$$

Sulfide ion can also combine with metal salts such as iron to form metal sulfides.

$$S^{2-} + Fe^{2+} \longrightarrow FeS.$$

Breeding of flies:

Fly breeding is an important consideration in on-site storage of wastes. It happens mainly in residential wastes.

Determination of MSW composition:

Because of the heterogeneous nature of solid wastes determination of composition is not an easy task. Here generalized field procedures, based on common sense and random sampling techniques have evolved for determining composition.

Residential MSW:

The procedure for residential MSW involves unloading and analyzing a quantity of residential waste in a controlled area of disposal site that is isolated

from winds and separate from other operations.

To obtain a sample for analysis, the load is first quartered. One part is then selected for additional quartering until a sample size is obtained. It is important to maintain the integrity of each selected quarter, regardless of odor or physical decay, and to make sure that all the components are measured. Only in this way some degree of randomness and unbiased selection be maintained.

Commercial and Industrial MSW:

The field procedure for component identification for commercial and nonprocess industrial solid waste involves the analysis of representative waste samples taken directly from source.

Because commercial and industrial sources are so variable, statistically valid sampling is seldom possible. Estimation of distribution of waste components and quantities remains an art.

Solid waste Management:

Solid waste management may be defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid waste in a manner that is in accord with the best principles of public health, economics, engg, conservation and other environmental considerations.

Elements of waste management system:

Management of solid wastes have been grouped into six functional elements.

1. waste generation
2. waste handling and separation, storage and processing at source
3. collection
4. Separation and processing and transformation
5. transfer and transport
6. disposal.

Waste Generation:

Waste materials are identified as no longer being of value and are either thrown away or gathered together for disposal.

Waste generation is an activity that is not controllable.

Waste Handling and separation, Storage and processing at source:

Waste handling and separation involves the activities associated with management of wastes until they are placed in storage containers for collection.

Handling encompasses the movement of loaded containers to the point of collection.

Separation is an important step in handling and storage of solid waste at source.

Collection:

Collection includes not only gathering of solid wastes and recyclables, but also the transport of these materials, after collection, to location where the collection vehicle is emptied.

Separation, Processing and Transformation:

Separation includes the separation of bulky items, separation of waste by size using screens, manual separation etc

Processing includes size reduction by shredding, separation of ferrous materials using magnets, etc

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

Transfer and Transport:

The functional element of transfer and transport involves two steps

* the transfer of waste from smaller collection vehicle to larger transport equipment
* the subsequent transport of wastes usually over long distances.

Disposal:

The final element in solid waste management system is disposal. Land filling is the ultimate disposal method.

Integrated Solid Waste Management :

ISWM can be defined as the selection and application of suitable techniques, technologies and management programs to achieve specific waste management objectives and goals.

A hierarchy in waste management is

* Source reduction
* recycling
* waste transformation
* Land filling

Role of NGO :

* NGO's may be encouraged to participate in SWM.
* NGO's may be allowed to collect both degradeable and recyclable waste from resident and commercial complexes.
* NGO's may be utilized for public awareness programme.
* NGO's may collect waste from door to door and with the help of rag pickers.
* NGO's may be given necessary support and encouragement to do so.
* NGO's shall be trained on MSWM to carry forward the essence to public.

Major Legislation :

Environmental legislation has become increasingly restrictive as public health agencies, conservationists and concerned citizens have pressured legislatures to take action.

The earliest legislation was passed in nineteenth century.

In 1899, Rivers and Harbors Act directed the to regulate the dumping of debris in navigable waters and adjacent lands.

Solid Waste Disposal Act, 1965 :

* Promote demonstration, construction and application of solid waste management
* Provide technical and financial assistance to state and local governments
* Promote national research and development programs for improved techniques

National Environmental Policy Act, 1969 :

The act specified the creation of the council on Environmental Quality in the office of president. This body has the authority to force every federal agency to submit to the council an Environmental Impact Statement (EIS) on every project.

Resources Recovery Act, 1970:

This act directed that the emphasis of national solid waste management program to recycling and reuse of recoverable materials in solid waste.

Resource conservation and Recovery Act, 1976:

This legislation gave the legal basis for implementation of guidelines and standards for solid waste storage, treatment and disposal.

Compensation and Liability Act, 1980:

It was enacted to provide a means of directly responding and funding the activities of response to problems at uncontrolled hazardous waste disposal site.

Public Utility Regulation and Policy Act, 1981:

It is a congressional law that among its statutes, directs public and private utilities to purchase power from waste to energy facilities. The legislation has been very effective in advancing the use of solid waste as a fuel in generating electricity.