**Vision of the institute**

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

**Mission of the institute**

To keep pace with advancements in knowledge and make the students competitive and capable at the global level.

To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations to shine as torch bearer of tomorrow’s society.

To strive to attain ever-higher benchmarks of educational excellence.

**Vision of the Department**

The department will be recognised for its value based teaching, associated activities pertaining to research and entrepreneurship.

**Mission of the Department**

* To provide quality education through faculty and state of art infrastructure
* To identify the current problems in society pertaining to Civil Engineering disciplines and to address them effectively and efficiently
* To inculcate the habit of research and entrepreneurship in our graduates to address current infrastructure needs of society

**PEO’s**

**Graduates who complete their UG through our institute will be,**

**PEO 1**- Engaged in professional practices, such as construction, environmental, geotechnical, structural, transportation, water resource engineering by using technical, communication and management skills.

**PEO 2**- Engaged in higher studies and research activities in various civil engineering fields and life time commitment to learn ever changing technologies to satisfy increasing demand of sustainable infrastructural facilities.

**PEO 3**- Serve in a leadership position in any professional or community organization or local or state engineering board

**PEO 4**- Registered as professional engineer or developed a strong ability leading to professional licensure being an entrepreneur.

**PSO’s**

**PSO 1** – To apply science, mathematics and mechanics to solve problems in engineering realm

**PSO 2** – To analyse the techniques, skills and modern engineering tools necessary for engineering practices

**PSO 3** – To develop ability to function as a leader and a team player in multidisciplinary teams

**PSO 4** – To recognize of the need for and an ability to engage in research and life-long learning for developing sustainable construction practices

**PSO 5** – To design and conduct experiments as well as to analyse and interpret data

**Unit – 1**

**Introduction**

**Structure**

1.0 Introduction

1.1 Objectives

1.2 Functional elements

1.3 Classification

1.4 Solid Waste Characteristics

1.5 Solid Waste Quantification:

1.6 Assignment questions

1.7 Outcomes

1.8 Further reading

**1.0 Introduction:**

The planning and delivery of waste management in Newfoundland is the direct responsibility of municipalities and communities.

The Province holds overall responsibility for the development and enforcement of policies, regulations and standards related to the municipal management of waste.

**1.1 Objectives**

1. Classify solid wastes
2. Explain the functional elements of SWM
3. Assess the current situation of SWM in India
4. Discuss the physical and chemical characteristics of solid wastes.

**Definitions:**

**Solid waste:**

Solid wastes are the wastes arising from human activities and are normally solid as opposed to liquid or gaseous and are discarded as useless or unwanted.

**Solid Waste Management:**

The systematic administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of solid waste.

**Scope of solid waste management:**

* To protect environmental health
* To promote the quality of the urban environment
* To support the efficiency and productivity of the economy
* To generate employment and income

**Objectives of solid waste management:**

* To minimize the rate of waste generation through education and source reduction.
* To encourage and facilitate the recovery, reuse and recycling of material within the waste stream.
* To decrease the volume of residual waste, this must be managed.
* Provide efficient and economical recycling and disposal services.
* To provide for adequate facilities and programs to achieve these goals, for a ten-year planning period and beyond.

**Importance of solid waste management: (Jan 10/Dec12)**

Integrated Solid Waste Management (ISWM) is the term applied to all the activities associated with the management of society's wastes.

In medieval times, wastes discarded in the streets led to the breeding of rats and the associated fleas which carried the bubonic plague. The lack of management of solid wastes thus led to the Black Plague which killed half of 14th century Europe.

USPHS has traced 22 human diseases to improper solid waste management. Solid wastes also have a great potential to pollute the air and water.

Materials Flow - The best way to reduce solid wastes is not to treate them in the first place.

Others methods include: decrease consumption of raw material and increase the rate of recovery of waste materials. Technological advances - Increased use of plastics and fast, pre-prepared foods.

**1.2 Functional elements of solid waste management: (Dec 12/Jan 13)**

The functional elements that constitute the system are:

1. Waste generation
2. On-site handling, storing and processing
3. Collection
4. Transfer and transport
5. Processing and recovery
6. Disposal

(i) **Waste generation:** Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. The source of waste generation, determines quantity, composition and waste characteristics. For example, wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services. The most important aspect of this part of the SWM system is the identification of waste.

(ii) **Waste storage:** Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. The heterogeneous wastes generated in residential areas must be removed within 8 days due to shortage of storage space and presence of biodegradable material. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved. Some of the options for storage are plastic containers, conventional dustbins, used oil drums, large storage bins etc. Obviously, these vary greatly in size, form and material.

(iii) **Waste collection:** This includes gathering of wastes and hauling them to the location, where the collection vehicle is emptied, which may be a transfer station, a processing plant or a disposal site. Collection depends on the number of containers, frequency of collection, types of collection services and routes. Typically, collection is provided under various management arrangements, ranging from municipal services to franchised services, and under various forms of contracts.

(iv) **Transfer and transport:** This functional element involves:

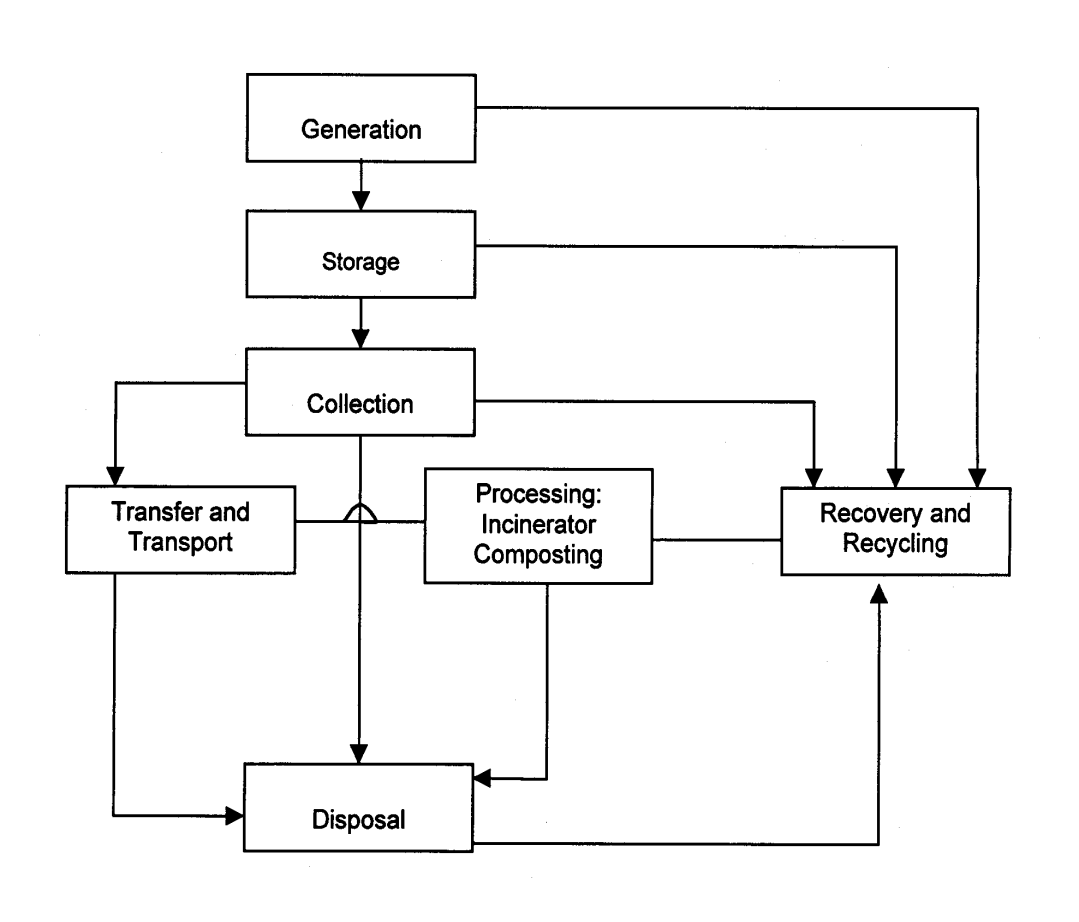
* The transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations;
* The subsequent transport of the wastes, usually over long distances, to disposal sites.

The factors that contribute to the designing of a transfer station include the type of transfer operation, capacity, equipment, accessories and environmental requirements.

(v) **Processing:** Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, and manual separation of waste components, incineration and composting.

(vi) **Recovery and recycling:** This includes various techniques, equipment and facilities used to improve both the efficiency of disposal system and recovery of usable material and energy. Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass. The selection of any recovery process is a function of economics, i.e., costs of separation versus the recovered-material products. Certain recovered materials like glass, plastics, paper, etc., can be recycled as they have economic value.

(vii) **Waste disposal:** Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment plants, incinerator residues, composts or other substances that have no further use to the society. Thus, land use planning becomes a primary determinant in the selection, design and operation of landfill operations. A modern sanitary landfill is a method of disposing solid waste without creating a nuisance and hazard to public health. Generally, engineering principles are followed to confine the wastes to the smallest possible area, reduce them to the lowest particle volume by compaction at the site and cover them after each day’s operation to reduce exposure to vermin. One of the most important functional elements of SWM, therefore, relates to the final use of the reclaimed land.



**1.3 Classification of solid wastes:**

Solid wastes are classified on the basis of source of generation and type.

**Source-based classification: (Dec12/Jan13)**

1. **Residential:** This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.
2. **Commercial:** This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.
3. **Institutional:** This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.
4. **Municipal:** This includes dust, leafy matter, building debris, treatment plant residual sludge, etc., generated from various municipal activities like construction and demolition, street cleaning, landscaping, etc. (Note, however, in India municipal can typically include items at (i) to (iii) above).
5. **Industrial:** This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.
6. **Agricultural:** This mainly consists of spoiled food grains and vegetables, agricultural remains, litter, etc., generated from fields, orchards, vineyards, farms, etc.
7. **Open areas:** this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.

**Type-based classification:**

(i) **Garbage:** This refers to animal and vegetable wastes resulting from the handling, sale, and storage, preparation, cooking and serving of food. Garbage comprising these wastes contains putrescible organic matter, which produces an obnoxious odour and attracts rats and other vermin. It, therefore, requires special attention in storage, handling and disposal.

(ii) **Ashes and residues:**

These are substances remaining from the burning of wood, coal, charcoal and other combustible materials for cooking and heating in houses, institutions and small industrial establishments.

When produced in large quantities, as in power-generation plants and factories, these are classified as industrial wastes.

(iii) **Combustible and non-combustible wastes:**

These consist of wastes generated from households, institutions, commercial activities, etc.,

Combustible material consists of paper, cardboard, textile, rubber, garden trimmings, etc.,

Non-combustible material consists of such items as glass, crockery, tin and aluminium cans, ferrous and non-ferrous material and dirt.

**(iv) Bulky wastes:**

These include large household appliances such as refrigerators, washing machines, furniture, crates, vehicle parts, tyres, wood, trees and branches.

**(v) Street wastes:**

These refer to wastes that are collected from streets, walkways, alleys, parks and vacant plots, and include paper, cardboard, plastics, dirt, leaves and other vegetable matter.

(vi) **Biodegradable and non-biodegradable wastes:**

Biodegradable wastes mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., generated from various household and industrial activities.

Non-biodegradable wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals, etc.

|  |  |  |
| --- | --- | --- |
| **Category** | **Type of waste** | **Approximate time taken to degenerate** |
| Biodegradable | Organic waste such as leftover food, vegetable and fruit peels, etc., | A week or two |
| Paper | 10-30 days |
| Cotton cloth | 2-5 months |
| Woollen items | 1 year |
| Wood | 10-15 years |
| Non-Biodegradable | Tin, aluminium and other metal items such as cans | 100-500 years |
| Plastic bags | 1 million years |
| Glass bottles | Undetermined |

(vii) **Dead animals:**

Dead animals are divided into two groups – large and small. Among the large animals are horses, cows, goats, sheep, pigs, etc., and among the small ones are dogs, cats, rabbits, rats, etc.

The reason for this differentiation is that large animals require special equipment for lifting and handling when they are removed.

If not collected promptly, dead animals pose a threat to public health since they attract flies and other vermin as they decay.

(viii) **Abandoned vehicles:**

This category includes automobiles, trucks and trailers that are abandoned on streets and other public places. However, abandoned vehicles have significant scrap value for their metal, and their value to collectors is highly variable.

(ix) **Construction and demolition wastes:** These are wastes generated as a result of construction, renovation, repair and demolition of houses, commercial buildings and other structures.

They consist mainly of earth, stones, and concrete, bricks, lumber, roofing and plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream.

(x) **Hazardous wastes:**

Hazardous wastes are those defined as wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment.

This is due to their physical, chemical and biological or radioactive characteristics like ignitability, corrosively, reactivity and toxicity.

Certain hazardous wastes may cause explosions in incinerators and fires at landfill sites. Others such as pathological wastes from hospitals and radioactive wastes also require special handling.

(xi) **Sewage wastes:**

The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derived from the treatment of organic sludge separated from both raw and treated sewages.

**1.4 Solid Waste Characteristics: (Jan 10/Jan13)**

In order to identify the exact characteristics of municipal wastes, it is necessary that we analyse them using physical and chemical parameters

**Physical characteristics:**

Information and data on the physical characteristics of solid wastes are important for the selection and operation of equipment and for the analysis and design of disposal facilities.

(i) **Density:** Density of waste, i.e., its mass per unit volume (kg/m3), is a critical factor in the design of a SWM system, e.g., the design of sanitary landfills, storage, types of collection and transport vehicles, etc. To explain, an efficient operation of a landfill demands compaction of wastes to optimum density**.**

(ii) **Moisture content:** Moisture content is defined as the ratio of the weight of water (wet weight - dry weight) to the total weight of the wet waste. Moisture increases the weight of solid wastes, and thereby, the cost of collection and transport.

(iii) **Size:** Measurement of size distribution of particles in waste stream is important because of its significance in the design of mechanical separators.

(iv) **Permeability of compacted wastes:** The hydraulic conductivity of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill.

(v) **Compressibility of MSW:** Degree of physical changes of the suspended solids when subjected to pressure.

**Chemical characteristics:** 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.

(i) **Lipids:** This class of compounds includes fats, oils and grease, and the principal sources of lipids are garbage, cooking oils and fats. They are biodegradable, the rate of biodegradation is relatively slow because lipids have a low solubility in water.

(ii) **Carbohydrates:** These are found primarily in food and yard wastes, which encompass sugar and polymer of sugars. Decomposing carbohydrates attract flies and rats, and therefore, should not be left exposed for long duration.

(iii) **Proteins:** These are compounds containing carbon, hydrogen, oxygen and nitrogen, and consist of an organic acid. 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.

(iv) **Natural fibres:** These are found in paper products, food and yard wastes and include the natural compounds, cellulose and lignin, that are resistant to biodegradation. Because they are highly combustible solid waste, having a high proportion of paper and wood products, they are suitable for incineration.

(v) **Synthetic organic material (Plastics):** Accounting for 1 – 10%, plastics have become a significant component of solid waste in recent years.

They are highly resistant to biodegradation and therefore, are objectionable and of special concern in SWM.

Hence the increasing attention being paid to the recycling of plastics to reduce the proportion of this waste component at disposal sites.

(vi) **Non-combustibles:** This class includes glass, ceramics, metals, dust and ashes, and accounts for 12 – 25% of dry solids.

(vii) **Heating value:** An evaluation of the potential of waste material for use as 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.

1 kJ/kg – 4.19 gram / calorie

1 kJ/kg – 0.238 calorie / gram

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Component** | **Heating Value (kJ/kg)** | |
| **Range** | **Typical** |
| 1 | Food Waste | 3500-7000 | 4500 |
| 2 | Paper | 11500-18500 | 16500 |
| 3 | Cardboard | 14000-17500 | 16000 |
| 4 | Plastics | 28000-37000 | 32500 |
| 5 | Textiles | 15000-20000 | 17500 |
| 6 | Rubber | 21000-28000 | 18500 |
| 7 | Leather | 15000-20000 | 17500 |
| 8 | Garden trimming | 2300-18500 | 6500 |
| 9 | Wood | 17500-20000 | 18500 |
| 10 | Glass | 120-240 | 140 |
| 11 | Tin cans | - | - |
| 12 | Nonferrous metals | 240-1200 | 700 |
| 13 | Ferrous metals | 240-1200 | 700 |
| 14 | Dirt, ash, bricks, etc. | 2300-11500 | 7000 |
| 15 | Municipal solid waste | 9500-13000 | 10500 |

(viii) **Ultimate analysis:** This refers to an analysis of waste to determine the proportion of carbon, hydrogen, oxygen, nitrogen and sulphur, and the analysis is done to make mass balance calculation for a chemical or thermal process.

|  |  |
| --- | --- |
| **Element** | **Range (% dry weight)** |
| Carbon | 25-30 |
| Hydrogen | 2.5-6.0 |
| Oxygen | 15-30 |
| Nitrogen | 0.25-1.2 |
| Sulphur | 0.02-0.12 |
| Ash | 12-30 |

(ix) **Proximate analysis:** This is important in evaluating the combustion properties of wastes or a waste or refuse derived fuel. The fractions of interest are:

**Moisture content:** This adds weight to the waste without increasing its heating value.

**Ash:** This adds weight without generating any heat during combustion.

**Volatile matter:** the portion of the waste that is converted to gases before and during combustion.

|  |  |  |
| --- | --- | --- |
| **Components** | **Value, percent** | |
| **Range** | **Typical** |
| Moisture | 15-40 | 20 |
| Volatile matter | 40-60 | 53 |
| Fixed carbon | 5-12 | 7 |
| Glass, metal, ash | 15-30 | 20 |

**1.5 Solid Waste Quantification:**

The most important aspect of solid waste management is the quantity of waste to be managed. The quantity determines the size and number of functional units and equipments required for managing the waste.

The quantities are measured in terms of weight and volume. The weight is fairly constant for a given set of discarded objects whereas volume is highly variable.

Waste quantities are usually estimated on the basis of past records of waste generation. The methods commonly used to assess the quantities are

1. Load count analysis
2. Weight volume analysis
3. Material balance analysis.

**1.6 Recommended Questions**

1. Briefly explain the functional elements of SWM with schematic diagram.
2. Explain the different types of solid waste.
3. Explain the different source of solid waste.
4. List the physical and chemical characteristics of solid waste.

**1.7 Outcomes**

1. An understanding of the nature and characteristics of municipal solid wastes and the regulatory requirements regarding municipal solid waste management
2. Characterization of solid waste

**1.8 Further Reading**

1. http://www.yourarticlelibrary.com/solid-waste/16-major-classification-of-solid-waste-solid-waste-management/27415/
2. https://2ch458npc.files.wordpress.com/2014/12/3-properties-of-solid-waste.pdf
3. http://www.yourarticlelibrary.com/waste-management/solid-waste-management-types-sources-effects-and-methods-of-solid-waste-management/9949/