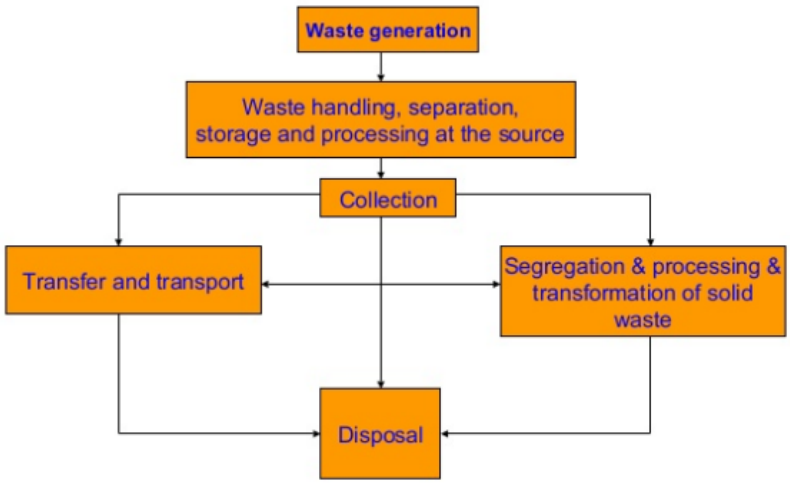
Internal Assessment Test 1 – Sept. 2017
Solution
Solid Waste Management -10CV757

1 (a) Describe about the functional components of a solid waste management system? Explain their relationship with a flowchart.

The activities involved with the management of solid wastes from the point of generation to the final disposal can be grouped into six functional elements as shown in the flowchart.



1. Waste Generation

Includes the activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. Limiting the quantity of waste generated by manifest systems helps in controlling the waste generated.

2. On site handling, storage and processing

Involves those activities associated with management of wastes until they are placed in storage containers for collection. Segregation of waste is an important step here as reuse and recycling can be effectively implemented through this. Processing at source involves activities like compaction and composting.

3. Collection

Activities associated with gathering of solid wastes and hauling of wastes after collection to the location where collection vehicle is emptied. This involves significant economic implications if wastes need to be hauled over long distances in case of large cities.

4. Separation, processing and transformation of solid waste

Transformation processes are used to reduce the volume and weight of wastes requiring disposal and to recover conversion products and energy. Processing includes separation of waste components by size using screens, size reduction by shredding, separation of ferrous materials using magnets, volume reduction by compaction. The organic fraction of wastes can be transformed by biological processes like composting.

Chemical transformation processes like combustion helps in recovery of energy in form of heat.

5. Transfer and transport

The activities associated with (1) transfer of wastes from small collection vehicles to larger transport equipment and (2) the subsequent transport of the wastes usually over long distance to the disposal site. At transfer stations the wastes unloaded from collection vehicles are reloaded into large trucks.

6. Disposal

Activities associated with ultimate disposal of solid wastes. This includes waste transported directly to landfill site, sludge from waste treatment plants, incinerator residue, compost etc.

1. (b) Write a note on quantification of solid waste.

The quantity of solid waste generated is important in the design and operation of SWM systems. Knowing the exact quantities of waste generated will help in effective collection of waste as well proper design of transfer stations and disposal sites. Following methods are recommended in quantification.

i) Load count analysis –

In this method the number of individual loads delivered to transfer station or landfill and the corresponding volume and waste characteristics are noted over a specified period of time. But here estimates regarding wastes recycled or stored in generators premises are not accounted as data collection is made only on the basis of load arriving at transfer stations.

ii)Weight volume analysis –

This method of analysis is similar to the above method with the added feature that mass of each load is also calculated apart from volume of the waste. Hence idea regarding specific weight (mass/volume) of wastes can also be derived here.

iii) Materials mass balance analysis –

The quantities of waste generated and their movement can be analyzed with more reliability using this method. Here a detailed material balance analysis is performed for each generation source (individual home or commercial place or industry).

Steps involved in mass balance analysis are given below.

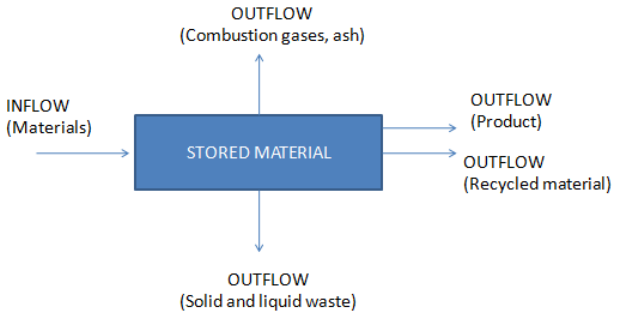
1) Identify boundary of the system or source for which mass balance is to be performed

2) Identify all activities within the system or across it that affects waste generation

3) Identify rate of waste generation associated with each of these activities

4) Use following mathematical relationship between quantity of waste generated, collected, stored and moved from the system for performing mass balance

Material Stored = Inflow – Outflow - Waste Generation



2 (a) Explain hauled container and exchange container system.

The systems solid waste collection may be classified based on mode of operation, equipment used and types of wastes collected. The most common classification is the one based on mode of operation.Based on mode of operation collection systems may be classified as **1) Hauled container system 2) Stationary container system**

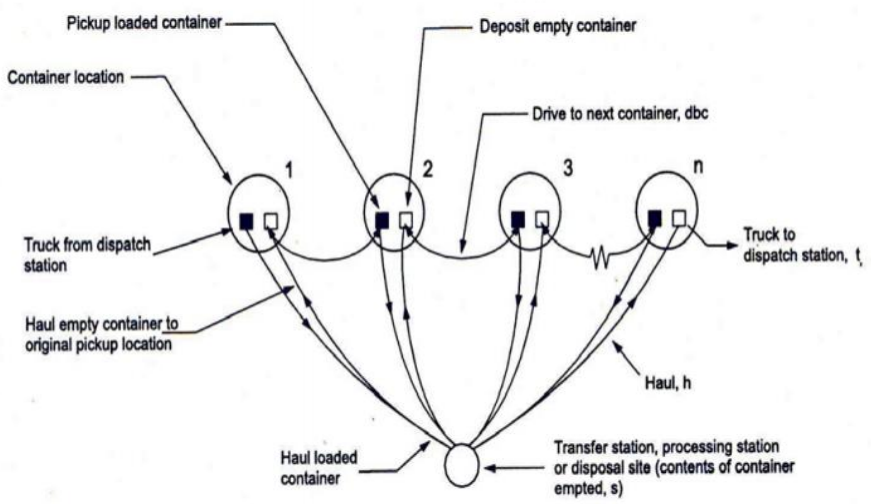
1) Hauled container system

Here the containers used for storage of wastes are hauled to the disposal site/transfer station emptied and returned to their original location or some other location.

Advantages:

- Ideally suited for removal of wastes from sources where generation rate is high as relatively large containers are used here.
- Reduces handling time, unsightly accumulations and unsanitary conditions associated with numerous large containers.
- Requires only one truck and one driver

But manual filling of these large containers may often lead to low utilization rate, hence these must be equipped with mechanical loading aids.



Hauled container system

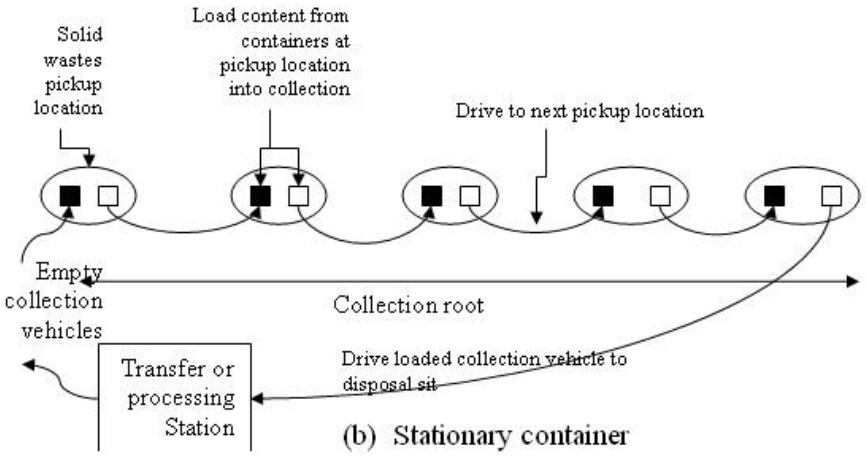
Hoist truck, Tilt frame container and trash trailer containers are used for hauled container systems. Tilt-frame

hauled container system has become widespread because of large volume that can be hauled but trash trailer is better for the collection of especially heavy rubbish. The application of both tilt -frame container and trash-trailer are similar, where the collector is responsible for driving the vehicles, loading full containers, and unloading empty containers, and emptying the contents of the container at the disposal site.

2) Stationary container system

Here containers used for storage of wastes remain at the point of generation and the wastes are transferred to the collecting vehicles.

There are two types of stationary container systems: 1) self-loading collection vehicles equipped with compactors. 2) Manually loaded vehicles.
Trips to the disposal site, transfer station or processing station are made after the content of the collection vehicle is full.



Operational tasks in Stationary container system

2 (b What are the chemical characteristics of solid waste?

Information on the chemical composition of the components of MSW is important in evaluating alternative processing and recovery options. For example the feasibility of combustion depends on the chemical composition of solid wastes. If solid wastes are to be used as fuel the four most important properties to be known are the following:

1. Proximate Analysis

Proximate analysis for the combustible components of MSW includes the following tests.

i) Moisture - Loss of moisture when heated to 105^0 C for 1h

ii) Volatile combustible matter - Additional loss of weight when on ignition at 950^0 C in a covered crucible)

iii) Fixed Carbon – Combustible residue left after volatile matter is removed

iv)Ash – Weight of residue after combustion in an open crucible.

2. Fusing point of Ash

Fusing point of ash is defined as the temperature at which the ash resulting from the burning of solid waste will form a solid called clinker by fusion and agglomeration. It usually lies in the range 1100 -1200^0 C.

3. Ultimate analysis

The ultimate analysis of a waste component involves the determination of the percentage Carbon (C), percentage Hydrogen (H), percentage Oxygen (O), percentage Nitrogen (N), percentage Sulphur (S) and percentage ash. The results of this analysis can be used characterize the chemical composition of the organic matter in solid waste. Based on C/N ratio the feasibility of biological conversion processes can also be understood.

4. Energy content

Energy content or energy value of solid waste can be defined as the total energy produced per unit mass of solid waste. Energy content of solid waste calculated on dry basis will be more than that calculated on as - discarded basis (waste in the form in which it is discarded from generators and will contain moisture). Similarly energy content calculated on ash free dry basis will be more than that calculated on dry basis).

Energy Content **as discarded** (KJ/kg) = $\frac{Total\ \ Energy\ \ pro\,duced\ \ from\ \ solid\ \ waste}{Total\ \ mass\ \ of\ \ solid\ \ waste}$

Bomb calorimeters capable of measuring the heat of combustion of reactions are used to measure energy value of solid wastes.

3 (a) Explain the different sources and types of solid waste.

The knowledge on the sources, types, composition and rate of generation is basic to design the functional elements of solid waste management system.

The sources of solid wastes in a community are related to land use and zoning. It may be listed as given below.

1. Residential
2. Commercial
3. Institutional
4. Construction and Demolition
5. Municipal services
6. Treatment plant sites
7. Industrial
8. Agricultural
9. Open areas

SOURCE	LOCATION WHERE GENERATED	TYPES
Residential	Houses, Apartments	Food waste, Rubbish, Ashes
Commercial	Restaurants, Offices, Markets, service stations	Food waste, Rubbish, Hazardous wastes
Institutional	Schools, Hospitals	Same as commercial
Construction and Demolition	New sites, Renovation sites, Razing of buildings	Wood, Steel, Concrete
Municipal services	Street cleaning, Landscaping, Parks	Special wastes, Debris, Tree Trimmings
Treatment plant sites	Sewage treatment, Industrial Treatment	Residual Sludges
Industrial	Manufacturing, Refineries, Chemical plants, Power plants	Hazardous wastes, Scraps, Rubbish, Ashes
Agricultural	Crops, Orchards, Wine yards. Diaries, Farms	Spoiled food wastes, hazardous, rubbish
Open areas	Streets, beaches, highways	Special wastes, rubbish

1.5 Classification of SWM – Municipal, Industrial and Hazardous

Municipal wastes – Waste type consisting of everyday items discarded by public. It consists of organic and inorganic solid waste from residential and commercial establishments. Classification of materials comprising municipal solid waste is shown below.

COMPONENT	DESCRIPTION
Food wastes	Fruit, vegetable or meat residues (garbage) resulting from preparation, cooking and eating of food. They decomposes easily in warm weather (putrescible)
Rubbish	**Combustible** rubbish consists of paper, cardboard, plastics, textiles, rubber, leather, wood, garden trimmings **Noncombustible** rubbish consists of glass, crockery, tin cans, aluminium cans, ferrous and non ferrous materials, dirt
Ashes and residue	Materials remaining from burning of wood, coal,

	coke etc
Demolition and Construction wastes	Demolition – Waste from razed buildings Construction – Wastes from construction, remodeling and repairing of structures. Includes dirt, stones, concrete, bricks, plaster, plumbing and electrical parts
Special Wastes	Includes bulky items, consumer electronics, yard wastes, batteries, oil and tyres
Treatment plant wastes	Solid and semi solid wastes from waste water and industrial waste water treatment plants. Includes sludge, grit, grease etc

Industrial wastes – Those waste arising from industrial activities like manufacturing, assembling, processing, packaging, dyeing etc. This includes rubbish, ashes, demolition and construction wastes, and special wastes but excludes hazardous wastes.

Hazardous waste – A waste is classified as hazardous if it exhibits any of the following characteristics: 1) Ignitable 2) Corrosive 3) Reactive 4) Toxic. This includes batteries, pesticides, drugs etc.

3. (b) Write a note on transfer stations.

Transfer station is a centralized facility where waste is unloaded from smaller collection vehicles and reloaded into large vehicles for transport to a disposal or processing site. To determine whether a transfer system is viable for a particular community, the decision-makers should compare the costs and savings associated with the construction and operation of a transfer facility. The use of transfer station is a sound practice when there is a need for vehicles servicing a collection route to travel a shorter distance, unload and return quickly to their primary task of collecting the waste.

Depending upon the method used to load the transport vehicles transfer stations are classified as follows. **1) Direct discharge 2) Storage discharge 3) Combined**

1. Direct discharge

Wastes from collection vehicles are emptied directly into the vehicle to be used to transport them to disposal site. To accomplish this transfer stations are constructed in a two level arrangement as shown below.

2. Storage discharge

Wastes from collection vehicles are emptied into storage pit or platform first from where they are loaded to

trucks using auxiliary equipments.

3. Combined direct and storage discharge

These are multipurpose facilities designed to service a broader range of users than a single purpose facility. These also houses materials salvage operation.

4 (a) Define solid waste. Explain importance of solid waste management.

The discipline associated with the **control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes** in a manner that is in accord with the best principles of public health, environment, economics, engineering, conservation and aesthetics.

It includes all engineering, administrative, financial, planning and legal functions involved in solving solid waste problems. The problem is interdisciplinary and requires idea in the areas of regional planning, geography, demography, economics.

In earlier days solid waste did not possess significant problem as the population was less and the land available for the assimilation of waste was large. The nature has the capacity to dilute, disperse, degrade or reduce the impact of unwanted residues in air, water and soil till its natural assimilative capacity. With an increase in urban population of the country from 20% to 40% over past 10 years, the municipal waste production by urban community today is 1.5lakh metric tonnes per day. Improper and unscientific handling of this poses serious threats to public health, environment and aesthetics.

Public health – The decomposition of organic solid waste leads to the spread of infectious pathogens. Improper dumping in open spaces leads to the breeding of rodents and flies which serves as vectors of diseases like plague. Also hazardous and biomedical wastes if not handled properly can pose serious threat to public health.

Environment – The leaching of solid wastes from unscientifically dumped sites will lead to land pollution and water pollution. The leachate may contain pathogens as well as toxic chemicals and heavy metals. Green house gas emission due to anaerobic decomposition of waste is also a serious threat.

Aesthetics - Improper solid waste management affects the aesthetics of streets and living environment. It will also create odour problems. Disposing in open drains leads to the blocking of drains as well.

In this context an Integrated Solid waste Management is needed which includes the selection and application of suitable technologies and management programs to achieve proper solid waste management.

4 (b) What is energy value of solid waste? Explain its significance.

Energy content or energy value of solid waste can be defined as the total energy produced per unit mass of solid waste. Energy content of solid waste calculated on dry basis will be more than that calculated on as -

discarded basis (waste in the form in which it is discarded from generators and will contain moisture). Similarly energy content calculated on ash free dry basis will be more than that calculated on dry basis).

i. Energy Content **as discarded** (KJ/kg) = $\frac{Total\ \ Energy\ \ pro\,duced\ \ from\ \ solid\ \ waste}{Total\ \ mass\ \ of\ \ solid\ \ waste}$

ii. Energy Content on **dry basis** (KJ/kg) = Energy Content **as discarded** (KJ/kg) $\times \frac{100}{100 - \%\ moisture}$

iii. Energy Content on **ash free dry basis** (KJ/kg) =

$$\text{Energy Content as discarded (KJ/kg)} \times \frac{100}{100 - \%ash - \%\ moisture}$$

If energy content values are not available, approximate values may be determined using **modified Dulong formula**.

iv. Energy content (KJ/kg) = $337\mathbf{C} + 1419\ (\boldsymbol{H} - \boldsymbol{O}/8) + 93\mathbf{S} + 23\ \mathbf{N}$

$\mathbf{C}$ = Percentage Carbon; $\mathbf{H}$ = Percentage Hydrogen; $\mathbf{O}$ = Percentage Oxygen

$\mathbf{S}$ = Percentage Sulphur; $\mathbf{N}$ = Percentage Nitrogen

Bomb calorimeters capable of measuring the heat of combustion of reactions are used to measure energy value of solid wastes.

Municipal solid wastes are one of the important renewable energy resources. Recovering energy from municipal solid waste is feasible by means of a number of energy generation processes such as combustion, pyrolysis and gasification. Design and operation of the mentioned energy systems based on municipal solid waste are highly related to energy value of the used municipal solid waste materials. Thus, determining energy value of municipal solid waste is a key work to perform the efficient design and operation of the waste to energy conversion based technologies.

5 (a) Estimate energy content of solid waste sample with following composition. Assume ash content of 5% and moisture content of 21%. What is the energy content on dry basis and on ash free dry basis?

Compo-nent	Food waste	Paper	Card board	Plastic	Garden Trimmi-ngs	Wood	Tin cans	
% by mass	15	45	10	10	10	5	5	
Energy content (KJ/Kg)	4650	16750	16300	32600	6500	18600	700	

Component	Mass by %	Energy content(KJ/ kg)	Mass of each component (kg)	Total energy(KJ)
Food waste	15	4650	150	697500
Paper	45	16750	450	7537500
Cardboard	10	16300	100	1630000
Plastic	10	32600	100	3260000
Garden waste	10	6500	100	650000
Wood	5	18600	50	930000
Tincans	5	700	50	35000
			Total	14740000

Since total mass not given, assume total waste mass of 1000kg

Mass of each component **= Total mass of waste ×Mass %**

= 1000×15/100

= **150kg**

Total energy produced by each component **= Mass of component × Energy value**

=150×4650

=**697500KJ**

Energy content of solid waste **=Total energy/total mass**

=14740000/1000

=14740KJ/kg

Energy Content on **dry basis** (KJ/kg) = Energy Content **as discarded** (KJ/kg) $\times \frac{100}{100 - \%\ moisture}$

=14740×100/(100-21)

=**18658.2KJ/kg**

Energy Content on **ash free dry basis** (KJ/kg) =

Energy Content **as discarded** (KJ/kg) $\times \frac{100}{100 - \%ash - \%\ moisture}$

=14740×100/(100-21-5)

=19918.9KJ/kg

6 (a) An area consisting of 400 houses contributes solid waste. Estimate the solid waste generation rate, if the observation is a local transfer station and period of generation

is one week. The waste is carried out in two types of vehicles, compactor truck and flat bed trucks.

No. of compactor truck load – 10; No of flat bed truck load – 20

Volume of each compactor truck – 15m$^{3;}$ Volume of each flat bed truck – 1.25m^{3}

Density of waste compactor truck – 295kg/m$^{3;}$ Density of flat bed – 110 kg/m^{3}

No of persons in each house- 6

Load	Volume (m3)	No	Density (kg/m^3)	Total volume(m^3)	Total mass (kg)
Compactor truck	15	10	295	150	44250
Flat bed truck	1.25	20	110	25	2750
					47000

Total volume = No of trucks × volume of each

Total mass = Total volume × density

Waste generation rate = Total solid waste mass/(No. of persons ×no. of days)

= 47000/(400×6×7)

=2.8 kg/person. day