problems related to ...

* odour
* pathogen content
* salt concentratn
* Ammonia productn

Module-2

Waste Generation

It includes those activities in which materials are identified no longer being of value and are either thrown away or gathered together for disposal. The generation rate of house hould waste are usualy expressed in kg/per capita/day.

Factors affecting generation rate

* Geographic location
It can influence both the amount of certain types of solid wastes generated and the collection operation

* season
It have implications for the quantities and composition of certain types of solid waste
moisture content also varies

* collection frequencies
A general observatn is that in localeties where there are ultimate collectn services more wastes are collected but it doesn't mean that more wastes are generated

* population diversities
The characteristics of populatn influence the quantity and composition of waste generated. The amount of waste generated is more in low income area compared to high income area

* Extent of salvaging and Recycling

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* Public attitude

Significant reduction in the quantity of solid waste is possible if people are willing to change on their on volition, their habits and life style to conserve natural resoarces & to reduce economic burden accosiated with management of solid waste.

* Legislation

This refers to existence of local and state regulation concerning the use and disposal of specific material.

Characteristics of MSW

1. composition of identifiable items
2. Moisture content
3. particle size
4. chemical composition
5. Heat value
6. Density
7. Mechanical properties
8. Biodegradabelety

1. composition by identifiable items

The readely identifiable items in solid waste are paper, plastic, foodwaste, glass items, leather, textile, e-waste

* The waste composition can be estimated by using either i/p method or o/p method. The i/p method of estimating solidwaste generatn is applicable where the i/p fig. can be obtained from specialised agencies which routinely collect and publish industry wide data whereas o/p method followed by sampling study is the most releable method.

i/p → i/p fig.
o/p → sampling study

The composition of waste can be found by manual sampling or photogrametry.

* waste compositn can be found out by material flow methodology and source specific approach

Material Flow Methodology:

Here the mass of material entering the waste stream are estimated from the amount of materials predected to be discarded based on the amount of materials produced. Thus the magnitude of waste can be estimated by production statistics.

Source specific Approach:

Here the mass of waste is estimated from the actual waste that has been produced.

CMPC HD MB

Moisture content

$$M = \frac{\text{wet} - \text{dry}}{\text{wet}} \times 100$$

- Moisture content of solid waste is the weight lose expressed as % when a sample of solid waste is dried to a constant weight @ a temp. of 100-105°c.
- Moisture content has greater influence on heat of combustion as well as in the biological process of organic matter.
- Moisture content depends upon the organic matter, the type of source, weather or climatic condition etc.

Q1 A residential waste has the following component:

Paper 50%
Glass 20%
Food 20%
Yard waste 10%

Estimate its moisture content assume the wet wt of given sample as 100 kg.

Component	Percent	Moisture (per)	Dry wt
Paper	50	6	(100-6) x 0.50 = 47
Glass	20	2	(100-2) x 0.2 = 19.6
Food	20	70	(100-70) x 0.2 = 6
Yardwaste	10	60	40 x 0.1 = 4
			Σd = 76.6 (Ans)

$$\frac{M-d}{w} \times 100 = \frac{100-76.6}{100} \times 100$$

$$= 23.4\ \%$$

Moisture content of uncompacted refuse compound

Residential	Typical value (%)
⇒ Al can, steel can	3
⇒ cardboard	5
⇒ Fines (dust)	8
⇒ Foodwaste	70
⇒ Glass	2
⇒ Grass, Yardwaste	60
⇒ Leaves	30
⇒ Leather, Textiles	10
⇒ Paper	6
⇒ Plastic, rubber	2
⇒ wood	20

Commercial	
⇒ Foodwaste	70
⇒ constructn (mixed)	8
⇒ Mixed commercial	15
⇒ wood crates, pallets	20

3 Particle size

The size distribution of solid waste component is important for improving the rate of chemical reaction and for the recovery of materials. It is difficult to characterise because of waste heterogeneity.
- the size of waste component may be defined by following equations.

$$S_c = l$$

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

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

$$S_c = (lw)^{1/2}$$

$$S_c = (lwh)^{1/3}$$

S_c → size of component
l → length
w → width
h → height

When the mixture of particle is non-uniform, the particle size is often expressed in terms of mean particle dia

Arithmetic Mean:

$$AM = D_A = \frac{D_1 + D_2 + D_3 \ldots D_n}{n}$$

Geometric Mean:

$$GM = D_G = \sqrt[n]{D_1 D_2 D_3 \ldots D_n}$$

Weighted Mean:

$$WM = D_W = \frac{W_1D_1 + W_2D_2}{W_1+W_2 \ldots W_n}$$

Number Mean

$$NM = D_N = \frac{N_1D_1 + N_2}{N_1+N_2 \ldots N_n}$$

where

$n \rightarrow$ no. of discrete classification (sieves)

$W \rightarrow$ wt in each "

$M \rightarrow$ No. of particle "

Q2. consider non spherical particle that are uniformly sized as length = 2

width = 0.5

Ht = 0.5

calculate particle diameter by the various defenition

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

$= \frac{2+1}{3} = \underline{\underline{1}}$

* $S_c = l$

$= 2$

* $S_c = \frac{l+w}{2} = \frac{2+0.5}{2} = 1.25$

* $S_c = (lw)^{1/2} = (2 \times 0.5)^{1/2} = \text{ditto } 1$

* $S_c = (lwh)^{1/3} = (2 \times 0.5 \times 0.5)^{1/3} = 0.79$

Surface Area Mean

$$D_S = \frac{M_1 D_1^3 + M_2 D_2^3 \dots}{M_1 D_1^2 + M_2 D_2^2 \dots}$$

volume mean

$$D_V = \frac{M_1 D_1^4 + M_2 D_2^4 + \dots}{M_1 D_1^3 + M_2 D_2^3 \dots}$$

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Q8 Given the following analysis

Particle Dia (mm) D	60	40	20	5
wt of each fractn (kg) W	2	10	5	4
No. of particle H	140	300	1000	2000

a) calculate AM, GM, WM, NM, Ds, Dv

Ans $AM = \frac{D_1 + D_2}{n}$

$= \frac{60 + 40 + 20 + 5}{4} = 31.25$ mm

$GM = \sqrt[n]{D_1 D_2 \ldots} = \sqrt[4]{60 \times 40 \times 20 \times 5}$ = ~~39.35~~ 22.13 mm

$WM = \frac{W_1 D_1 + W_2 D_2}{W}$

$= \frac{(2 \times 60) + (10 \times 40) + (5 \times 20) + (5 \times 4)}{2 + 10 + 5 + 4} = 30.47$

$= 30.47$ mm

$NM = \frac{H_1 D_1 + H_2 D_2}{H} = \frac{(140 \times 60) + (300 \times 40) + (1000 \times 20) + (2000 \times 5)}{140 + 300 + 1000 + 2000}$

$= 14.65$ mm

$Ds = \frac{H_1 D_1^3 + H_2 D^3 \ldots}{H_1 D_1^2 + H_2 D_1^2 \ldots}$

$= \frac{140 \times 60^3 + 300 \times 40^3 + (1000 \times 20)^3 + (2000 \times 5^3)}{(140 \times 60^2) + (300 \times 40^2) + (1000 \times 20^2) + (2000 \times 5^2)}$

$= 40$ mm

$Dv = \frac{H_1 D_1^4 + H_2 D_2^4 \ldots}{H_1 D_1^3 + H_2 D_2^3 \ldots} = 47.4$ mm

4 chemical composition

- chemical properties are imp for improving the leach properties and ground water contamination
- Evaluating alternating solid waste processing and recovery options
- ~~Evalu~~ Information about trace element
- Acessing the feasibility of MSW combustn

Analysis → Proximate Analysis; → ultimate Analysis

a) **Proximate Analysis:**

It is imp for ~~analysis~~ combustn properties of waste or refuse derived fuel (?)

Proximate Analysis → Moisture content; → Ash; → volatile matter; → Fixed carbon

* Moisture content :- Add wt to the waste without increasing its heating value and Evaporatn of water reduces the heat released from the fuel.

* Ash :- Add wt without generating heat during combustion

* **volatile matter :** - It is that portion of waste which is converted to gases before and during combustion ~~Fixed carbon represents the~~ carbon

* Fixed carbon : represent the carbon remaining on surface as charchol. A waste with high proportion of fixed carbon require a longer retention time on the furnace to achieve complete combustion ~~or~~ than a waste with low proportion of fixed carbon

b) Ultimate Analysis

It is defined as total elemental analysis to determine the percentage of element (C, H, O, N, S,)

5. Heat Value

$$U = \frac{C_V \Delta T}{M}$$

ΔT = Rise in temp (°C)

C_V = Heat capacity of calorimeter (cal/°C)

M - Mass of unknown material

It have importance in resource recovery

Q. A 15g sample of mixed muncipal solid waste (MSW) is combusted in a calorimeter having the heat capacity of 8750 cal/°C. The temp increase on combustion is 2.75°C calculate the heat value of the substance

Ans

M = 15g

C_V = 8750 cal/°C

ΔT = 2.75°C

$$U = \frac{C_V \Delta T}{M} = \frac{8750 \times 2.75}{15} = 1604.16 \text{ cal/g}$$

Refuse can be characterised as being made up of organic materials, inorganic materials and water. It can be expressed as moisture free or moisture and ash free

* Heat value in dry basis (kJ/kg)

$$= \text{Heat value as discarded (kJ/kg)} \times \frac{100}{100 - \%\text{ moisture}}$$

* Heat value in ashfree dry basis kJ/kg

$$\text{Heat value as discarded kJ/kg} \times \frac{100}{100 - \%\text{moisture} - \%\text{ash}}$$

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ans. $H = \frac{C_v \Delta T}{M}$

$C_v = 8750$ cal/°C

$\Delta T = 2.75$°C

$M = 15g$

$= \frac{8750 \times 2.75}{15}$

$= 1604.167$ cal/g

Refuse can be characterised as being made up of organic materials, inorganic materials & water. It can be expressed as either moisture free or moisture and ash free.

(1) Heat value in dry basis (KJ/kg)

$= \text{Heat value as discarded (KJ/kg)} \times \left(\frac{100}{100 - \%\,\text{moisture}}\right)$

(2) Heat value in ash free dry basis (KJ/kg)

$= \text{Heat value as discarded (KJ/kg)} \times \left(\frac{100}{100 - \%\,\text{moisture} - \%\,\text{ash}}\right)$

Q. A sample of refuse is analysed and found to contain 10% of water. The Btu (british thermal unit) of the entire mixture is measured in a calorimeter and is found to be 4000 Btu/lb (lb = pound). 1g sample is placed in the calorimeter and 0.2g ash remains in the samples cup after combustion. What is the comparable moisture free Btu and moisture and ash free heat value.

ans. dry basis $= 4000 \times \left(\frac{100}{100 - 10}\right)$

$= 4444$ Btu/lb

ash free dry basis $= 4000 \times \left(\frac{100}{100 - 10 - 20}\right)$ (0.2g = 20%)

$= 5714$ Btu/lb

1/12/20

6. Density:

Density varies depending on the composition of waste and it will be higher in organic wastes & lower in commercial wastes containing mainly paper & cardboard. It is important for selection of waste collection equipment. Usually it will increase by amount 20-25% during transportation.

eg:

House owner garbage - 90-150 kg/m³

Pushed into a can - 180 kg/m³

collection truck - 350 - 420 kg/m³

Landfill → machine compaction → 700 kg/m³

→ If each layer of refuse is compacted - 1000 kg/m³

Q. Determine the avg. density & moisture content of MSW for a typical intensity

Description	% by wt.	typical density kg/m³	Moisture content %
Food waste	39.5	290	70
Yard waste	3.8	240	60
Paper	0.85	85	6
Plastic	0.7	65	2
Glass/ceramics	0.5	195	2
Metal	0.65	160	2
Textile	2	65	8
Leather	0.5	160	10
Stones/brick	40.5	480	10
miscellaneous	9	240	8

Dry wgt.	Density of msw
	typical density x %
(100-70)x.395 = 11.85	$(290 \times \frac{39.5}{100}) = 114.55$
1.52	240x0.038 = 9.12
0.799	0.7225
0.686	0.455
0.49	0.975
0.637	1.04
1.84	1.3
2.25	4
36.45	194.4

8.28

$\Sigma d = 64.802$

21.6

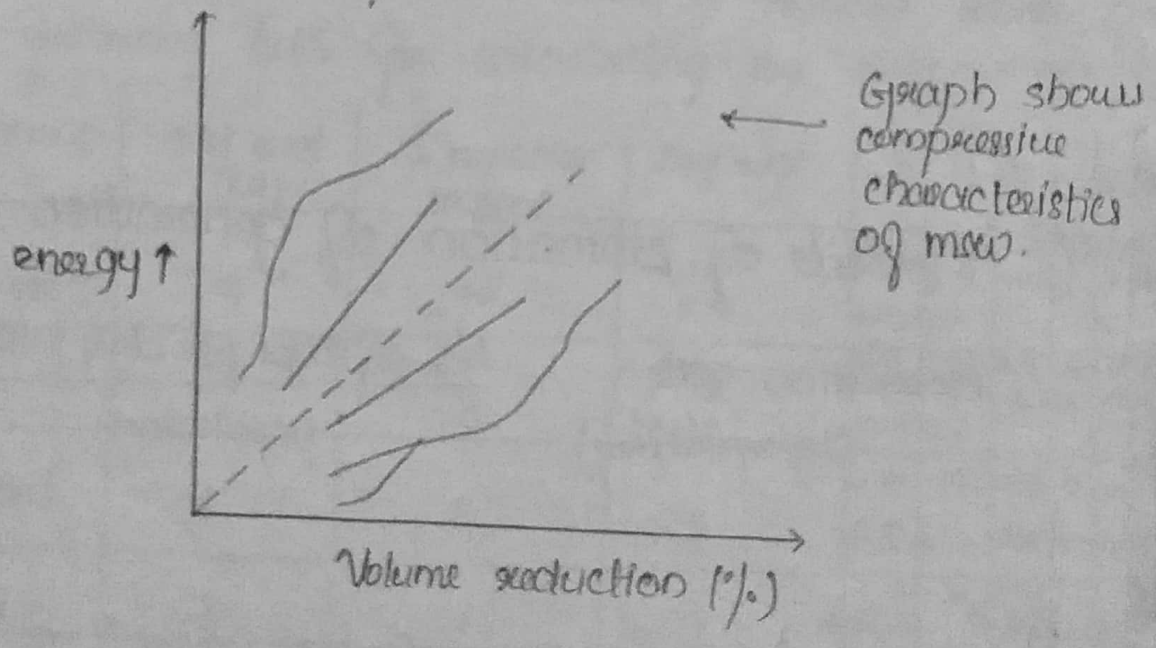
$\Sigma density = 348.162$

Moisture content $= \frac{w-d}{w} \times 100 = \frac{100-64.802}{100} \times 100$

$= 35.198\ \%$

Avg. density of MSW = 348.1625 kg/m^3

7. Mechanical properties:



The curves tends to be mostly linear indicating that substantial vol. reduction can be achieved by extending greater energy in compaction.

8.

3/2/20 Methods of estimation of generation rate:

$$\text{Generation rate (kg/capita/day)} = \frac{\text{No. of trips per day} \times \text{vol}(m^3) \times \text{density}(kg/m^3)}{\text{population}}$$

Q. The student population of high school is 881 the school has 30 std. class rooms. Assuming a 5day school week with solid waste pickups on wednesday & friday before school starts in morning. Determine the size of storage containers required. Assuming the waste generation rate 0.11 kg/capita/day & 3.6 kg/m² Density of waste 120kg/m³ & the standard containers are 1.5m³, 2.3m³, 3m³ & 4.6m³.

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ans. Total waste production = $(0.11 \times 881) + (3.6 \times 30)$

$= 204.91$ kg/day

Total volume of waste $= \frac{204.91}{120} = 1.71\ m^3/day$

Since, the max. storage period is 3days (fri, mon, tue)

∴ Total vol. of waste $= 1.71 \times 3 = 5.13 m^3$

One soln to this would be 1 containers of $2.3m^3$ & $3m^3$.

Q.

Description	wt (%)	Typical density kg/m³	Moisture content (%)	Vol = wgt / density
Food waste	39.5	290	70	0.136
Yard waste	3.8	240	60	0.158
Paper	0.85	85	6	0.01
Plastic	0.7	65	2	0.011
Glass	0.5	195	2	2.564×10^{-3}
Metal	0.65	160	2	4.062×10^{-3}
Textiles	2	65	8	0.031
Leather	2.5	16	10	0.156
Stones	40.5	480	10	0.084
Miscellaneous	9	240	8	0.037
	$\Sigma w = 100$			$\Sigma V = 0.3477$

what is the bulk density of the waste mixture prior to compaction. Assume that the compaction in the cell is 600 kg/m³ Estimate the vol reduction as percentage during compaction in the land fill. If food & yard waste are diverted for composting what is the uncompact bulk density of the remaining waste.

ans Bulk density prior to compaction $= \frac{wt}{vol} = \frac{100}{0.3477}$

$= 287.604\ kg/m^3$

The % volume reduction due to compaction

$= \frac{287.6}{600} \times 100 = 47.93\%$

when food & yard wastes are removed the uncompacted bulk density $= \frac{[100-(39.5+3.6)]}{[0.3477-(.136+.160)]}$

Storage of muncipal solid waste:

Container volume:

1) Ash : 80 - 188 l
2) Rubbish : 200 l
3) mixed refuse : 120 - 128 l
4) Kitchen waste : 40 l
5) Garbage : 48 - 80 l.

4/2/20 Public health & economic aspects of open storage:

* Wastes gets scattered at the bins
* Some wastes cannot be recycle
* Toxic or hazardous waste does not properly collected.

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* Recycling in sewage condition.

Changes needed:

* Recycling laws for specific types of wastes are to be implemented.
* Presorting of waste
* Organize colony wise collection system have to be promoted.
* Investment in recycling sectors.

Q. Determine the chemical composition of the organic fraction of the waste described below with & without water. Use the following table for calculating the composition.

Component	wet wgt (kg)	% moisture content	Dry wgt	C	H	O	N	S	Ash
Food waste	9	70	9×.3 = 2.7	1.3 ~~2.7×.48~~ ~~1.296~~	.17	1.01 ~~.173~~	.07	.01 ~~1.0~~	.
Paper	34	6	34×(100−6)/100 31.96	13.9 ~~31.96×.435~~ ~~13.9026~~	1.92	14.06 ~~1.918~~	.095	.06 ~~14~~	1
Cardboard	6	5	5.7	2.51 ~~2.508~~	.34	2.54 ~~.3363~~	.02	.011	-
Plastics	7	1	6.93	4.16 ~~4.158~~	.5	1.68 ~~0.499~~		~~1.5~~	0
Textiles	2	10	1.8	0.99	.12	.56	.08	.004	
Rubber	0.5	0	0.5	.39	0.05		0.01		.
Leather	0.5	20	0.4	0.24	0.03	0.05	0.04	.07	
Yard waste	18.5	65	6.475	3.09	.39	2.46	.22	.02	
Wood	2	20	1.6	.792	.096	.683	.0032	.0036	

Component	C	H	O	N	S	Ash
Food waste	0.48	0.064	0.376	0.026	0.004	0.05
wood	0.435	0.06	0.44	0.003	0.002	0.06
cardboard	0.44	0.059	0.446	0.003	0.002	0.05
Plastics	0.60	0.072	0.228			0.10
Textile	0.55	0.066	0.312	0.046	0.002	0.025
Rubber	0.78	0.10		0.02		0.10
Leather	0.6	0.08	0.116	0.10	0.004	0.10
Yardwaste	0.478	0.06	0.38	0.034	0.003	0.045
wood	0.495	0.06	0.427	0.002	0.001	0.015

Total wet wgt = 79.5kg
Total dry wt = 58.065kg
wt of water = 79-5-58.065 = 21.435kg

Total C = 27.37 N = 0.539
H = 3.616 S = 0.11144
O = 22.95 Ash = 3.483

Chemical composition of organic fraction:

Element	Atomic wgt	Molar composition	
		without water	with water
C	12	$(27.37/12) = 2.281$	2.281
H	1	$(3.611/1) = 3.611$	5.993
O	16	$(22.95/16) = 1.434$	2.625
N	14	0.039	0.039
S	32	0.003	0.003

$$\frac{(8.411 + 2.382)}{1}$$

$$\frac{(20.95 + 19.053)}{16}$$

wt of hydrogen = $21.435 \times \frac{2}{18} = 2.382$ kg

wt of O_2 present = $21.435 \times 16/18 = \underline{19.053 \text{ kg}}$