Solid - Waste Disposal

→ Mixture of solid and semi-solid waste generated due to different activities in the community is termed as solid waste

→ If it is generated due to domestic activity it is termed as domestic solid waste.

→ If it is generated due to industrial activity it is termed as industrial waste.

→ If it is generated from hospital and nursing home it is termed as bio-medical waste [however it is to be disposed off sepraletly.]

→ Domestic solid waste is further being classified as follows:-

(i) Garbage

It includes all the putrescible [bio-degradable] organic waste obtained from kitchens, hotels, resturant that consist of all food waste, vegetable peeling, fruit peeling etc.

→ Its density varies in the range of 450-900 kg/m³.

(ii) Rubbish

→ It includes variety of materials (non-biodegradable) which may either be combustible, eg. paper, plastic or textile

or incombustible . eg. broken glass, crockery, metal, masonry etc.

→ Its density varies between 50-400 kg/m³.

(iii) Ashes

→ residue obtained from house hold earth incombustible in nature in termed as ashes.

→ Its density is in range of 700-850 kg/m³.

(iv) Street Sweeping:

→ Domestic solid waste may also increase the find dust, silt & sand obtained from street.

Note: Domestic solid waste is also termed as Municipal Solid waste (MSW) or refuse.

→ Several other component may also find its way into MSW.

→ Although the amount of municipal solid waste is usually very small (~5%) of total solid waste, but due to its adverse effect its significance is more.

→ Refuse may also be defined as house, street and trade refuse.

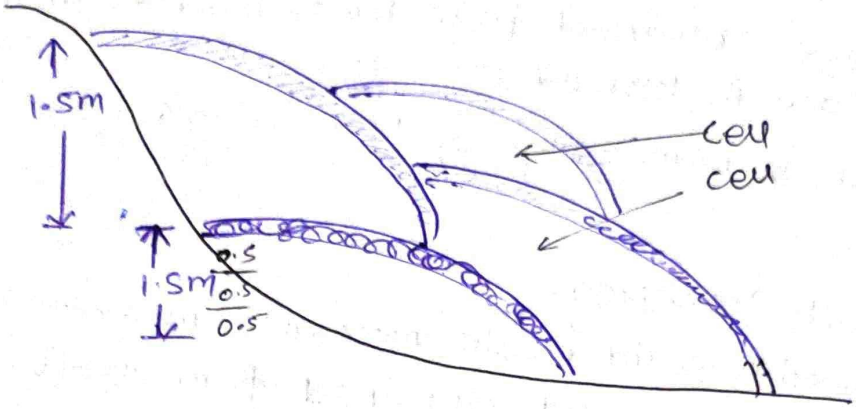
Consituent of refuse	Approximate avg. by wt. at disposal site.
Garbage	45%
Rubbish	15%
Ashes	15%
Street Seepings	25%
Note Density	400 - 600 kg/m³
Calorific value	5000 - 6000 kJ/kg.

Disposal of MSW

Disposal of MSW can be done by any of the following method

(i) Sanitary land filling Method.

leachate = mix of (alcohol + acid + rubbish + water)



→ In this method solid waste is disposed over low lying areas (earmarked as land fill sigate) under an engineered operation, designed and operated in an environmentally sound manner as not to cause any public hazard.

→ In this method the refuse is dumped and compacted in layers of about 0.5m thickness and after the days work when depth of filling becomes about 1.5m it is covered by good earth of about 15cm thickness termed as daily cover.

→ Since refuse is well compacted mechanically and is well covered daily, it does not cause any public nuisance,

→ After filling all the cell (small area unit) with first lift, the second lift is laid in about 1.5m height and is covered with good earth of about ~~1.5m~~ 150mm depth is termed as intermediate cover.

→ After all the cells have been filled with second, third & more lift the process continues till the top most lift is filled up & over which final cover of 0.6m depth is applied.

→ A "CAP ~~cover~~ system" is also installed over the top of final cover.

→ over the period of time decomposition of OM in refuse takes place biologically in following stages:-

(i) Action by Aerobic M/O.
(ii) Action by acid former.
(iii) Action by methane former.

→ for optimum decomposition moisture conlent must be greater than 60%

→ The refuse in land fill is stabilised with in a period of 2-4 months (upto 12 month) & settle down by 20-40%.

→ This method of refuse disposal is very suitable to heavier type of refuse, (about 90% of Indian refuse is disposed by this method).

→ It is most simple economical and biological method.

→ Sepration of different kinds of diffuse as required in other method is not needed here.

→ There is no residue or by product left out in this method and no further disposal is required.

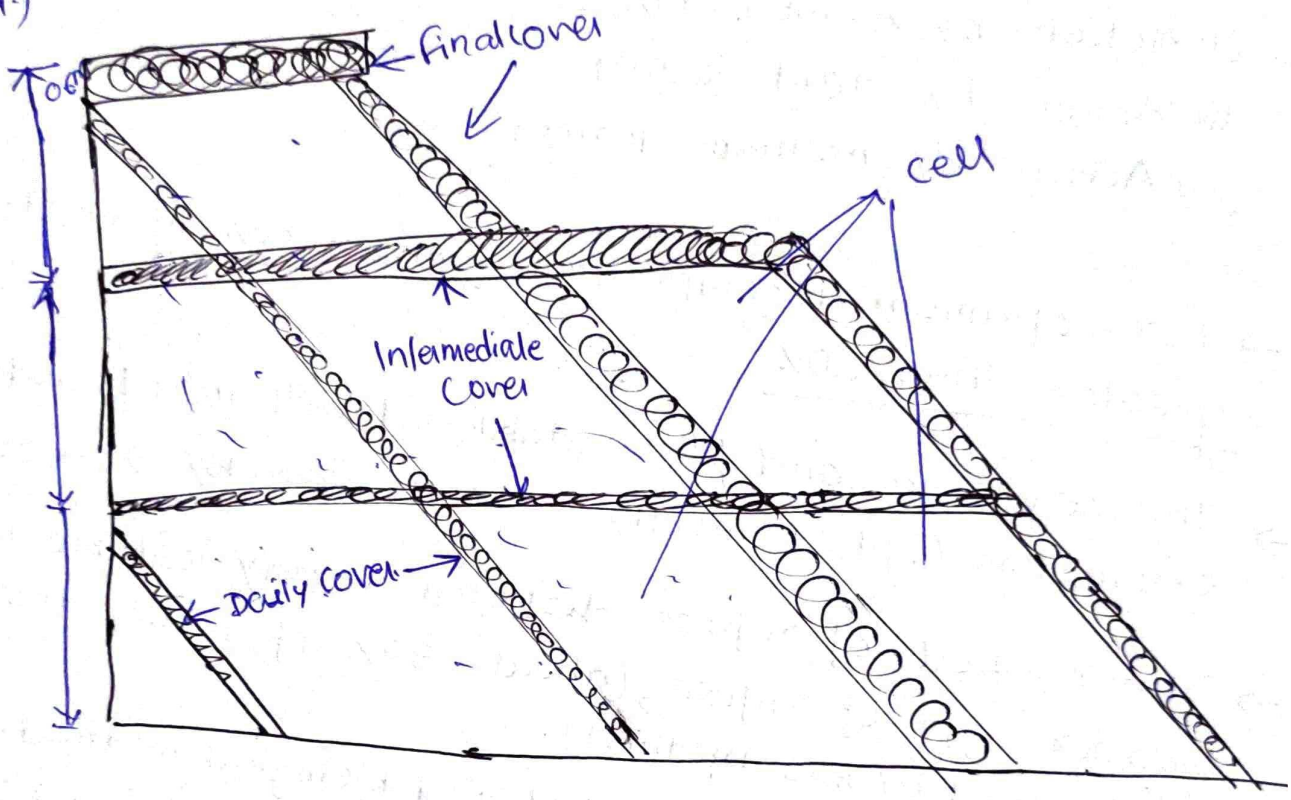
→ Low lying water logged area can be easily used in this method.

Drawbacks

→ Low lying or depression may not always be available.

→ There is continuous evolution of foul gases, near the fill site (these are termed as land fill gases).

→ Since the dumped garbage may content harmful, caucinogenic substance, it mix with acid alcohol and water there by leads to formation of LEACHATE (this is highly poisnous coloured cancer causing liquid.)



Acids + Alcohol + water + Rubbish = Leachate.

Note: The cap system or cap which is usually provided at the top of landfill after filling it to full height to avoid formation of leachate, consist of following layers

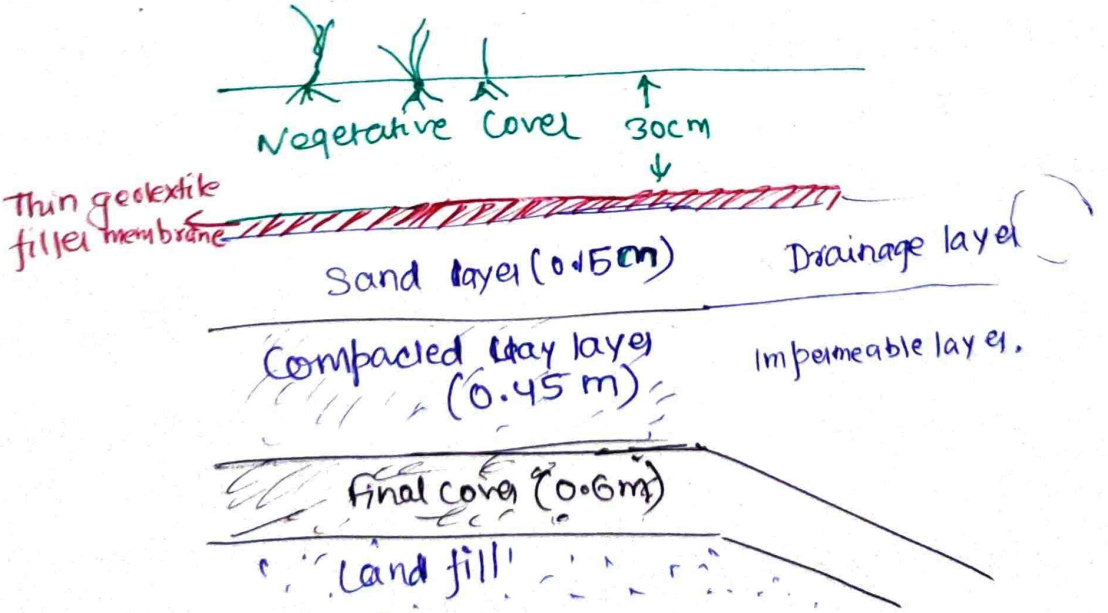
(i) 45cm thick compacted clay layer. is provided at the bottom which is overlain

(ii) By a 15cm thick drainage layer consisting of sand

(iii) Above the second layer of sand is laid a geolextile fibre membrane to protect the drainage layer from being clogged.

(iv) Finally 30cm thick soil ~~cover~~ layer is laid at the top to promote the vegetative cover and grasing. This topmost layer is called vegetative layer.

(v) This entire arrangement is termed as CAP system and is provided over the final cover of 0.6m thickness.



Q A city with the population of 2 lakh produces 400gm per capita per day of refuse, 20% of which is recycled. and 80% goes on land-fill site. compute the area of land fill for disposal of solid waste of 25 years. of avg. density 250 kg/m³. Assume compaction ratio to be 4. and height of each lift to be 1.5m.. site condition indicate max^m of 3 lift can be provided.

$$V = \frac{400 \times 2 \times 10^5 \times 10^{-3} \times 365 \times 25}{250} \quad (\text{kg/25 years})$$

$$\text{Compacted} = \frac{292 \times 10^4}{4}$$

$$\text{Volume compacted} = 73 \times 10^4 \ m^3$$

$$80\% \text{ goes} = \frac{73 \times 10^4 \times 0.8}{} = 584000$$

$$\text{Area} = \frac{584000}{(1.5 \times 3)} = 129777.m^2$$

$$= 12.97 \text{ hectare.}$$

GAS Production and its Control in land fill method.

→ The rate of decomposition of solid waste in land fill is measured by gas production., which reaches at its peak within first two year and then tappers off continuing in many year (upto 25 year) or more.

→ The total volueme of gases produced during anerobic decomposition can be estimated as follow:-

(i) If all the organic consistvent in the refuse is generalised in form of $C_aH_bO_cN_d$ then total volume of gases produced by complele decomposition of solid waste ~~tore~~ is given by

$$C_aH_bO_cN_d + \left(a - \frac{b}{4} - \frac{c}{2} + \frac{3}{4}d\right) H_2O \longrightarrow \left(\frac{a}{2} + \frac{b}{8} - \frac{c}{4} - \frac{3d}{8}\right) CH_4 \uparrow$$

$$+ \left(\frac{a}{2} - \frac{b}{8} + \frac{c}{4} + \frac{3d}{8}\right) CO_2 \uparrow + d\,NH_3 \uparrow$$

→ Over 90% of gas volome produced from decomposition of solid waste consist of methane and carbon dioxide

→ Although most of these gases escape into atmosphere but about 40% of these gases is found at the lateral distance upto 120m from edges of the land fill.

→ Methane being a very light gas rises around the land fill area & increases the chances of explosion in nearby area.

→ CO_2 being heavier (1.5 times than air & approximately 2.8 times than CH_4). remains in high concentration in lower region of land feel area, seeps into the ground along with the water meets the ground water table level and increases its acidity over the period of time.

→ The movement of these gases is controlled by provision of different types of vent and barriers. (generally cell vent, trench vent and well vent are provided around the cell.

→ The movement of landfill gases through adjacent soil formation can be controlled by providing vertical well barriers of landfill sealents which is generally an impermeable material.

→ Commonly used sealents includes.

Classification	Representation	Significance.
→ compacted soil	soil	should contain some silt and clay
→ compacted clay	Bentonile, Illile, Kaolnile,	Most commonly used sealent.
→ Inorganic material	Sodium carbonate, silicate	Use depend upon local characteristic.
→ Synthetic material	Polymer, rubber, latex	Use for experimental work.
→ Synthetic membrane liner	Polyvinile chloride, Nylone, Butyle rubber	expensive for use.
→ Asphalt	Asphalt concrete	Used in case of differential settlement.

Q 150gm of municipal solid waste after being disposed over the land fill produces 60gm of CO_2, 130gm of methane and 10gm of ammonia & 2gm of H_2S during its decomposition over a period of 25 years. Compute the rate of green house gas production in (gm/c/day). from the total solid waste of 200T obtained from the community of population of 25 lakh.

green house gas = CO_2 + Methane,

150gm of MSW produces = (60 + 130) gm = 190gm of

$$200T \longrightarrow \frac{\frac{190}{150} \times 200 \times 10^6 \text{ (gm)}}{\underbrace{25 \times 10^5}_{\text{population}} \times (25 \times 365)}$$

$$= 0.0111 \text{ gm/c/day.}$$

Q Raw municipal solid waste collected from a city contains 70% decomposible material that can be converted to methane ~~the~~ analysis ~~of decomposible material yield the following~~

~~Mass (%)~~

C : H : O : N : other = 44 : 6 : 43 : 0.8 : 6.2

The methane production of decomposible material is govern by the following relationship.

$$C_aH_bO_cN_d + \eta H_2O \rightarrow mCH_4 + sCO_2 + dNH_3$$

Compute mass of methane produced in gm/kg of MSW.

For 1 kg of MSW decomposible material = 0.7 × 1 = 0.7 kg.

~~Solid = 0.85 × 0.7 = 0.455 kg.~~

Carbon $12a = 0.44 \times 0.7 \times 10^3$ (M.W. ratio)

$$a = 0.0256 \times 10^3 = 25.6 \text{ moles}$$

~~Hydrogen~~ $b = 0.06 \times 0.7$

$$b = 0.042 \times 10^3 = 42$$

Oxygen, $16C = 0.43 \times 0.7 \times 10^3$

$C = 0.0188 \times 10^3 = 18.8$.

Nitrogen $14d = 0.008 \times 0.7 \times 10^3$

$d = 0.4$

From boom balance eqn,

$a = m + 5$ —(i)

$b + 2n = 4m + 3d$ —(ii)

$c + n = 2$ —(iii)

$a = d$

~~methane produced = 13.19~~ $m = 13.19$

methane produced $= 13.19 \times 16 = 211.29m$.

(ii) Disposal of Refuse by Schedding & Pullve-risation.

→ In real terms it is not method of disposal of solid waste, it is only used to convert the heavier solid into lighter ones so as to carry out their effective disposal by any other method.

→ Shredding refers to action of cutting & tearing where as pulverisation refers to action of crushing and griding

→ These method may help in reducing the overall volume of original MSW by as much as 40%. but also help in changing the physical characles of the waste which becomes practically odour less and unattractive to the insects.

→ Pulverisation is carried out in the units termed as hammer mill.

→ In order to further reduce the waste volume and facilitate handling of the pulverised MSW it is usually compacted to form rectangular blocks or bails (and the procen is termed as bailing)

→ Pulverisation and bailing together can reduce the volume upto 90%.

(iii) Composting

→ Composting of refuse is also biological method of decomposing solid waste → This decomposition can be carried out either aerobically or anerobically.

→ The final end product is termed as manure, compost or humus.

→ Composting is considered to be an aerobic process as it involve piling up of refuse and its regular turning either manually or mechanically. to ensure sufficient supply of air and oxygen during decomposition.

→ Initially the process starts with Mesophilic bacteria which oxidise the organic matter to carbon dioxide and liberate heat that rises the temperature to about 45%. and at this point thermophilic bacteria takes over and continues the decomposition and raises the temp. to about 60°C.

→ for optimum decomposition temp. most be in range of 55 to 60°C beyond which decomposition slows down.

→ Once decomposition is complete temp. start falling.

→ ~~If compos~~ Aerobic composting is also termed as Indore Process. which is compleled in 3 to 4 months.

→ If composting is done anerobically it is termed as Banglore procen in which mixing of refuse is not done hence this method is cleaner / sanitary than Indore process. but time required in this case is more. (4-5) months.

→ After stabilisation the refuge changes into a brown coloured odourless, powdery mam called as "humus."

→ for optimum composting $\frac{C}{N} = 30-50$

$$\frac{C}{N} = \frac{\text{Carbon / food / energy}}{\text{Nitrogen / Nutrient / growth.}}$$

→ The above range is on basis of fact that MO utilises Carbon, 30-50 times faster than nitrogen,

→ If $\frac{C}{N}$ is more nitrogen is exhausted prior to the carbon leaving growth of M/o incomple. that intern carries out incomplete decomposition.

→ If $\frac{C}{N}$ is less, carbon is exhausted prior to that of N & left over nitrogen combine with hydrogen & form ammonia which is disables for methane formers.

→ Hence in either of the case composting is incomplete.

eg $\frac{C}{\text{Energy}} = 30 - 5\frac{N}{\text{Growth}}$ [1N, 30.5C]

(i) $\frac{C}{N}\uparrow = 80$ [1N, 80C], left (50-30) C, N ✗ growth of microorganism ✗

(ii) $\frac{C}{N}\downarrow = 10$ [1N, 10C], left $\left(\frac{1}{3} - \frac{1}{5}\right)$ N, C ✗

$N + H \rightarrow NH_3$ (Ammonia) $\xrightarrow{\text{Distinctorous methane forcer.}} CH_4$

* Nitrogen govern

Q A waste Activated sludge is to be blended with green waste the carbon and Nitrogen content per kg of WAS and green waste on dry basis are given in the table.

Parameter	WAS	GW (green waste)
Carbon(g)	54	360
Nitrogen(g)	10	6
ratio	5.4:1	60:1

$\frac{54x + 360}{x} = 35$

The ratio of waste activated sludge to green waste required achieve a blended $\frac{C}{N}$ ratio of 35.

$a + b = 1$

$\frac{WAS}{GW} = \frac{x}{1}$

$\frac{C}{N} = \frac{54x + 360 \times 1}{10x + 6 \times 1} = 35$

$\frac{54a + 360b}{10a + 6b} = 35$

$54a + 360b = 350a + 210b$

$150b = 296a$

$x = 0.506$

$\frac{a}{b} = 0.506$

$\frac{a}{b} = 0.506$

$\boxed{WAS = 0.5 \times GW}$

Note:

VERMI-COMPOSTING

→ Vermi-composting uses the natural composting process of decomposition of bio-degrable organic matter by soil bacteria as in ordinary composting technique but takes the assistance of cultured [artificially produced] earth worms like red wiggler or tiger worm, European night crawler, Blue worms, etc.

→ These worms do help in quicker decomposition of organic matter

→ This method helps in adopting the composting technique in individual household. by following process:-

(i) Dig a small pit of $0.5m^2$ and 1m deep.
(ii) Line the pit with straw or dried leaves.
(iii) Organise the disposal of domestic waste into the pit as when generated.
(iv) Introduce culture of worms.
(v) Cover the pit content daily., by spreading dried leaves and soil
(vi) Water the pit once or twice a week
(vii) Turn over the content every 15 days.
(viii) In about 45 days the waste will be decomposed by action of MO.
(ix) The produced humus in the pit can be used as manure

(iv) Disposal by incineration and thermal Pyrolysis.

→ In this method disposal of the refuse is carried out by burning it at high temperature in furnaces termed as incinerators.

→ Only combustible matter such as garbage, rubbish and dead animal are burnt and incombustible matter like broken glass, china ware, metal etc are either unburnt or are separated out for recycling and reuse. before burning the solid waste.

→ The heat produced during the burning of refuels is used in the form of steam power to run the turbine to generate electricity

→ In Incineration burning of ~~refuels~~ refuse is carried out in the presence of oxygen.

→ In pyrolysis principle is same for disposal but mechanism is different in the sense that heating is carried out is closed container. in O_2 free atmosphere.

→ Most of the organic matter of solid waste can be split through a combination of thermal cracking and condensation reaction. into gaseous, liquids and solid fraction

→ In contrast to the combustion process which is highly exothermic (releasing heat on burning in presence of O_2) the pyrolosis is highly endothermic, (consuming heat). that is why it is also known as DESTRUCTIVE DISTILLATION.

→ When the organic solid waste is pyrolysed following three types of products are obtained.

(i) A gas stream (consisting of H_2, CH_4, CO, CO_2) which can be used again as ~~use~~ fuel.

(ii) A liquid fraction (consisting of tar or oil) which is liquid at room temperature.

(iii) A solid fraction (consist of char coal) that can also be used as fuel.

→ Pyrolysis may be used for reducing quantity of sludge produce in waste water plant.

→ This is the most sanitary method of refuse disposal.

→ There is no odour nusiance.

→ some cost can be recovered by used of end product.

→ It requires very less space.

→ It is very costly method and requires technical supervision.

→ Solid waste of only high calorific value can be burned

→ Pollution created by this method is more.

Q A waste to energy plant burnt dry solid waste of composition

C = 35%
Oxygen = 26%.
Hydrogen = 10%
Sulphur = 6%.
Nitrogen = 3%.
Inerts = 20% (does not react)

Burning rate is 1000 ton/day.
Oxygen in air by weight = 23%.
assume comple conversion of carbon → CO_2

Hydrogen ⟶ H_2O
Sulphur ⟶ SO_2
Nitrogen → NO_2

The amount of air (tonnes/day) required for complete burning of this waste would be.

Sol^n

$C + O_2 \longrightarrow CO_2$
1 mole 1 mole 1 mole.
12gm 32gm

$S + O_2 \longrightarrow SO_2$
1 mole 1 mole,
32gm. 32gm

$N + O_2 \rightarrow NO_2$
1 mole 1 mole
14gm. 32gm

~~$2H + O_2 \rightarrow H_2O$~~

$2H + 0.5\,O_2 \rightarrow H_2O$
1 mole 0.5 mole.
2gm 16gm.

$\frac{2}{16}$ 1gm
3.25% 26%.

(Remain hydrogen = 10 − 3.25 = 6.75%.

Carbon Sulphur Hydrogen

Amount of air required = $\left[\frac{32}{12} \times 0.35 + \frac{32}{32} \times 0.06 + \frac{32}{14} \times 0.03 + \frac{16}{2} \times \left(0.10 - 0.26 \times \frac{2}{16}\right)\right] \times \frac{1}{100}$

$\times \frac{1000}{0.23}$

$= 6964.80$ tonnes/day.

$O_2 \rightarrow$ Air (23%)

x gm

$y \times 0.23 = x$

$y = \frac{x}{0.23}$

V Bagging/Dumping into the Sea.

→ In this method disposal of solid wasle is carried out by throwing it away into the sea.

→ Disposal of refuse in the sea must be done far away from the shore/coast (15-20km), below the water surface level. (30-50)m and at the time of low tides so as to avoide flow back of solid wasle on the to the shore.

→ This method proves to be quite cheap and simple but posses several drawbacks.

→ The bulky and lighter part of refuse do not settle down and remains floating and return to the shore.

→ This method require ship for taking the refuse into the sea, movement of which is difficult during monsoon or stormy wheather.

→ Even inspite best care is taken, some refuse in this method come back to the shore.

→ The dumping of refuse causes sea pollution and effects the marine life.

VI Autoclaving

→ It is a low heat thermal process which is used for disposal of bio-medical waste in which steam under under controlled temperature, and pressure is passed over the waste to carry out its disinfection.

Q The composition of MSW is given, compute the difference between energy content of waste sample calculated on dry basis & as discarded basis. in KJ/kg.

Component	% BY Mass	Moisture content (%)	Energy content (KJ/kg) on discarded basis
Food waste	20	70	2500
Paper	10	4	~~10000~~ 15000
Cardboard	10	4	8000
Plastic	10	1	14000
Plants	40	60	3500
Woods	5	20	14000
Tin can	5	2	100

Sol

Dry content (%) (100 − moisture cont.)	total dry mass (%) (dry content % × % mass)	Energy on discarded basis (% mass × energy)
30 %	6	500
96 %	9.6	1000
96	9.6	800
99	9.9	1400
~~40~~ 80	16	1400
80	4	700
98	4.9 %	5
60%		5805 KJ/kg.

Energy on discarded basis (when 60% dry) = 5805 KJ/kg.

Energy on dry basis (when it is 100% dry) = $\frac{5805}{0.6}$ = 9675 KJ/kg

Difference = (9675 − 5805) = 3870 KJ/kg.