Solution Manual for Solid Waste Engineering A Global Perspective SI Edition 3rd Edition Worrell Vesilind Ludwig 1305638603 9781305638600

Chapter 2

2-1 *Assume*: From table 2-2, $1.07 \frac{kg}{capita/day}$;

20,000 people x $\left(1.07 \frac{kg}{capita/day}\right) = 21.4 \frac{tons}{day}$;

landfill capacity = $\left(21.4 \frac{tonnes}{day}\right)$; x 365 days x 10 years = 78,110 tonnes

industrial waste = 900 tonnes per day, so $921.4 \frac{tonnes}{day}$ is generated.

Therefore, capacity will be reached in approximately 85 days instead of 10 years.

2-3 2 *tracks*(0.5 *ft*)(3 *ft*) = $3m^2$; $\frac{8\ tonnes}{3m^2} = 2667\ kg/m^2$

2-5 Moisture transfer is the movement of water from wet materials such as food waste to dry absorbent materials like paper.

2-9 *Assume*: $\frac{2.2\ kg}{capita/day}$ of waste collection; 220,000 kg/day generated waste;

Assume: loose refuse (no compaction); density $= 120 \frac{kg}{m^3}$;

140,000 m^3 capacity $\left(120 \frac{kg}{m^3}\right) = 1.68 \times 10^7$ kg capacity;

Then, the expected life is:

$1.68 \times 10^7\ kg$ capacity $\left(\frac{1 day}{220,000\ kg}\right) = 76$ days;

However, if it assumed that the refuse is compacted to a density of $450 \frac{kg}{m^3}$,

$450 \frac{kg}{m^3} (140,000\ m^3) = 6.3 \times 10^7\ kg$ capacity;

Then the expected life is:

$$6.3\times10^{7}\ kg\left(\frac{1\,day}{220,000\ kg}\right)=286\ \text{days}$$

2-10 *As-received Heat Value* – includes organic materials, inorganic materials and water. The heat value depends on mass of the sample and the heat generated by its combustion.

Calculated by: Heat value as measured by a calorimeter (*Btu/lb*)

Moisture-Free Heat Value – the heat value of the object excluding the water component from the denominator

Calculated by: $$Heat\,Value\left(\frac{kJ}{kg}\right)\times\left(\frac{Total\ Sample\ Mass}{Total\ Sample\ Mass-Mass\ of\ Water}\right)$$

Moisture- and Ash-Free Heat Value – the heat value excluding both water and inorganic material, or ash.

Calculated by:

$$Heat\,Value\left(\frac{kJ}{kg}\right)\times\left(\frac{Total\ Sample\ Mass}{Total\ Sample\ Mass-Mass\ of\ Water-Mass\ of\ Ash}\right)$$

2-11 The objective of diversion is to increase the life of a landfill or to reduce the cost of disposal.

The following equation is used to attain high diversion rates:

$$\left(\frac{Solid\ waste\ not\ going\ to\ landfill}{Total\ Municiple\ solid\ waste\ generated}\right)$$

If the more honest calculation is used, we do not begin to achieve 75% diversion:

$$\left(\frac{\text{Re}\,cyclables}{Mixed\ household\ and\ commercial\ waste+recyclable\,s}\right)$$

For example, suppose we assume that the purpose of the program is to recycle more. Then 450 *kg* are either diverting or recycling it and compare the different amounts of diversion obtained by the equations above.

2-13 Using representative values for bulk density (Table 2-5);

Component	Loose Density (kg/m^3)	Baled Density (kg/m^3)
Newsprint	12	430
Office Paper	240	420
Cardboard	210	210
Glass	300	1080
HDPE	14	40
PETE	18	240
Steel Cans	90	510
Yard Waste	30	300
Aluminum Cans	37	150
Misc.	180	600

Assuming: 450 *kg* combined waste:

Loose Density = (taking weighted average of loose densities)

$$\frac{0.21(12)+0.15(240)+0.08(210)+0.12(300)+0.03(14)+0.03(18)+0.05(90)+0.18(50)+0.04(37)+0.11(180)}{1.00}=127\ \frac{kg}{m^3}$$

Volume occupied by 450 kg of loose refuse:

$$450\text{ kg}\left(\frac{1\ m^3}{127\text{ kg}}\right)=3.54m^3$$

Baled Density = (taking weighted average of baled densities)

$$\frac{0.21(430)+0.15(420)+0.08(210)+0.12(1080)+0.03(40)+0.03(240)+0.05(510)+0.18(300)+0.04(150)+0.11(600)}{1.00}=460\ \frac{kg}{m^3}$$

Volume occupied by 450 kg of baled refuse:

$$450kg\left(\frac{1m^3}{460kg}\right)=0.98m^3$$

Therefore, the loose volume is approximately 3.6 times as much as the baled refuse volume.

2-14 Taking a weighted average of moisture contents, the overall moisture content is (assuming 45 *kg* of waste):

$$\frac{45}{100}\;\frac{10kg(70\%)+33kg(6\%)+8kg(5\%)+5kg(2\%)+4kg(10\%)+3kg(2\%)+18kg(60\%)+10kg(3\%)+9kg(6\%)}{45kg\times 100\%}=21.6\%\,water$$

2-15 *On wet basis*: *M* = 21.6% water (calculated in 2-14)

Therefore;

$$0.216=\frac{45-d}{45};d=35.28kg$$

Final dry weight of sample = 35.38 *kg*

On dry basis:

$$M_d=\frac{45kg-35.28kg}{35.28kg}(100\%)=27.5\%$$

Wet basis is a fraction of wet weight of the sample. Dry basis is a fraction of the dry weight of the sample. Typically, mass is expressed on a wet basis.

2-16 Composition of waste = 82% Other Waste, 18% Yard Waste

Component	% Water	% of Weight
Food	70	12.2
Paper	6	40.2
Cardboard	5	9.8
Plastics	2	6.1
Textiles	10	4.9
Rubber	2	3.7
Metals	3	12.2
Misc.	6	11.0

Moisture Content (weighted average):

$$\frac{45}{100}\;\frac{12.2kg(70\%)+40.2kg(6\%)+9.8kg(5\%)+6.1kg(2\%)+4.9kg(10\%)+3.7kg(2\%)+12.2kg(3\%)+11kg(6\%)}{45kg\times 100\%}=13.1\%\,water$$

2-17 Overall Energy Content of Waste (weighted average assuming 40 kg):

$$\frac{40}{100}\frac{10kg(4650)+33kg(16750)+8kg(16300)+5kg(32500)+3kg(17500)+4kg(23250)+18kg(6500)+10kg(700)+9kg(3000)}{40\,kg}=11547\frac{kJ}{kg}$$

2-18 Composition of Waste (assuming 40 *kg*):

Component	Weight (*kg*)	% (by Weight)
Food	4.5	12.7
Paper	7.25	20.5
Cardboard (wood)	3.25	9.2
Plastics	1.7	4.8
Textile	1.35	3.8
Rubber	1.8	5.1
Yard Waste	8.2	23.2
Metals	3.2	9.1
Misc.	4.1	11.6

Overall Energy Content:

$$\frac{12.7\%(4650)+20.5\%(16750)+9.2\%(16300)+4.8\%(32500)+3.8\%(7500)+5.10\%(23250)+23.2\%(6500)+9.1\%(700)+11.6\%(3000)}{100\%}=10438\frac{kJ}{kg}$$

(note: wood waste is assumed to be the cardboard)

2-19 The answer is 13.2 *J*, (see figure 2-13).

2-20 The answer to this problem depends on the current year. Students should get the current generation and diversion numbers from the USEPA website and then compare those numbers to what is shown in Chapter 2 (2012 information).