UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: December 2020

Module Number: CE5204 **Module Name: Integrated Solid Waste Management**

[Three Hours]

[Answer **all questions**, each question carries **Twelve marks**]

Q1. Determination of characteristics of municipal solid waste helps in planning how to reduce waste, set up recycling programs, and conserve money and resources.

a) Explain briefly the 'Grid-and-pull method', which is one of the standard methods used to collect a representative sample to analyze the composition of municipal solid waste.

[2.0 Marks]

b) Ultimate analysis of solid waste components involves the determination of the percent C, H, O, N, S and ash. Typical data on the ultimate analysis of the combustible components in municipal solid waste are given in Table Q1-a. Table Q1-b shows the typical composition of municipal solid waste based on a 50 kg sample.

Table Q1-a: Typical data on the ultimate analysis of the combustible components in municipal solid waste

Component	Percent by weight (dry basis)					
	C	H	O	N	S	Ash
Food wastes	48.0	6.4	37.6	2.6	0.4	5.0
Paper	43.5	6.0	44.0	0.3	0.2	6.0
Cardboard	44.0	5.9	44.6	0.3	0.2	5.0
Plastics	60.0	7.2	22.8	-	-	10.0
Textiles	55.0	6.6	31.2	4.6	0.15	2.5
Rubber	78.0	10.0	-	2.0	-	10.0
Leather	60.0	8.0	11.6	10.0	0.4	10.0
Yard wastes	47.8	6.0	38.0	3.4	0.3	4.5
Wood	49.5	6.0	42.7	0.2	0.1	1.5

Table Q1-b: Typical composition of municipal solid waste based on a 50 kg sample

Component	Percent by weight (%)	Typical moisture content (% weight)
Food wastes	12	70
Paper	41	6
Cardboard	9	5
Plastics	8	2
Textiles	3	10
Rubber	2.5	2
Leather	1.5	10
Yard wastes	18.5	60
Wood	4.5	20

i) Estimate the overall moisture content of this solid waste sample 'as discarded' with the typical composition given in the Table Q2-b.

[3.0 Marks]

ii) Determine the chemical formula of this solid waste sample;
(i) without "water"

[3.0 Marks]

(ii) with "water"

[4.0 Marks]

Q2. Table Q2 shows the characteristics of a 100 kg municipal solid waste sample collected from the Southern province in Sri Lanka.

Table Q2: Characteristics of a municipal solid waste sample

Component	Percent by weight (%)	Typical moisture content (%) (On wet weight basis)	Typical energy (*kJ/kg*)
Food wastes	33	70	4650
Paper	19.5	6	16750
Cardboard	9	5	16280
Plastics	8	2	32560
Textiles	3	10	17440
Rubber	2.5	2	23260
Leather	1.5	10	17310
Yard wastes	16	60	6510
Wood	3.5	20	18620
Glass	2.5	2	145
Tin cans	1.5	3	720

a) Calculate the dry mass of the solid waste sample.

[2.0 Marks]

b) Estimate the overall moisture content of it.

[2.0 Marks]

c) Determine the 'as discarded' energy value of the solid waste sample.

[4.0 Marks]

d) Estimate the 'dry basis' energy value of it.

[2.0 Marks]

e) In this municipality, there is a proposal to separate 75% of the paper, 80% of the cardboard and 80% of plastics by the homeowners. Using the data in Table Q2, estimate the new 'as discarded' energy content of the remaining solid wastes.

[2.0 Marks]

Q3. An integrated solid waste management system refers to a combination of various functional elements associated with the management of solid waste.

a) Draw a simplified diagram showing the interrelationships between the functional elements of a solid waste management system.

[2.0 Marks]

b) Assume you are asked to develop a solid waste management system for a local authority in Sri Lanka. At the moment, there is no proper solid waste management system and current practice in this area is to collect waste as mixed waste and dispose them as open dumping and/or open burning.

i) Given that the area is mostly comprised of domestic units, propose a suitable waste separation system for the area. State the assumptions made.

[2.0 Marks]

ii) The local government considers the option of having a transfer station in their solid waste management system. Evaluate the applicability of that considering the functions of a transfer station.

[2.0 Marks]

c) 'A sustainable integrated solid waste management plan' is proposed to implement at the Faculty of Allied Health Sciences, University of Ruhuna, which is to be established in Walahanduwa area. The faculty is expected to serve 1000 undergraduates and 200 staff will be attached to the faculty.
Formulate sustainable integrated solid waste management plan' based on the 'solid waste management hierarchy concept', highlighting the key components.
You must use following guidelines (but not limited) to prepare your answer.

- *List out the most important data needed*
- *The methods to obtain these data*
- *Clearly mention assumptions*
- *Demonstrate all the key components of proposed solid waste management system based on the hierarchy*
- *Clearly mention how to use integrated management system to safely and effectively handle the waste.*

[6.0 Marks]

Q4. The most common solid waste disposal method in Sri Lanka is open dumping. However, open dumping of solid waste results many environmental and social problems.

a) Discuss three possible environmental and public health problems due to open dumping of solid waste.

[2.0 Marks]

b) Sanitary landfills are the environmental friendly alternative for solid waste disposal over open dumping.

i) Briefly explain two techniques used to minimize the environmental pollution in a sanitary landfill.

[2.0 Marks]

ii) Describe the stages of solid waste decomposition process in a landfill.

[2.0 Marks]

c) The municipal council of city A has a 175 acre land. They are willing to use that land for a landfill site if the useable period is more than 5 years, beginning from year 2021. Determine whether the land can fulfill the requirement of the municipal council.
Applicable conditions are given in Table Q4.

Table Q4: Waste generation rate in the city

Year	End of year population (× 10000)	Waste quantity ($m^3/capita.\ d$)
2020	11	0.019
2021	12	0.019
2022	14	0.018
2023	18	0.018
2024	19	0.018
2025	20	0.017
2026	21	0.017
2027	22	0.017

The maximum height allowed for the landfill on the given land is 8 m.
Cover : waste ratio=1:5
Slope =1:3 (v:h)
Cover material will be imported.
Length to width ratio of the land can be assumed to be 2:1.
1 acre=4046.86 m^2
Volume of a frustum of a pyramid $=\left(\frac{h}{3}\right) * (A1 + A2 + \sqrt{(A1 * A2)})$ *with usual notations.*
Where, h= height of the frustum
A1=area of upper base
A2=Area of lower base

[6.0 Marks]

Q5. a) Biodegradation is nature's way of recycling wastes, or breaking down organic matter into nutrients that can be used and reused by other organisms. Composting is the most common biodegradation method applied in Sri Lanka.

(i) Compare and contrast in-vessel composting and windrow composting methods.

[2.0 Marks]

(ii) Explain two common problems that may arise in compost piles and suggest the possible solution for each problem.

[2.0 Marks]

b) Determine the reduction in volume after combustion of a municipal solid waste with characteristics shown in Table Q5.

Table Q5: Characteristics of waste

Type	Percent by weight (%)	Inert residue (%)
Food waste	45	5
Plastic	25	3
Polythene	10	2
Yard waste	10	5
Tin cans	5	40
Glass bottles	5	90

Assume that the specific weight of the residue is 500 kg/m^3 and the average specific weight of the waste is 160 kg/m^3. Proceed the calculations considering 100 kg waste sample before combustion.

[2.0 Marks]

c) Evaluate the advantages of thermal conversion of solid waste over sending them directly into a sanitary landfill.

[2.0 Marks]

d) We can frequently see the public opposition in siting any kind of solid waste disposal facility. However, they must be located on somewhere minimizing environmental and public health issues. Hence, discuss your major concerns in selecting a land for siting an incineration plant considering possible public health issues arise and the outputs produced by incineration process.

[4.0 Marks]