



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2018

Module Number: CE 5254

Module Name: Integrated solid waste management

[Three Hours]

[Answer all questions, each question carries 12 marks]

- Q1. a) Generation of solid waste is the stage at which materials become valueless to the owner and since they have no use for them, they wish to get rid of them.
- (i) Name the factors that may control the solid waste generation rate. [2.0 Marks]
- (ii) Explain briefly the 'public health and aesthetics aspect', which is one of the important factors that should be considered while storing the generated waste at the source. [2.0 Marks]
- b) Three recycling containers are to be provided to each residence in an urban area, and residents will be asked to separate newspaper and cardboard, plastics, glass and metals. The residents will have to place the separated materials in appropriate recycle containers, and then move the containers to the roadside once per week to be picked up by collection vehicles. It is assumed that 80 % of the recyclable material will be separated, and that newspaper represents 20 % of the total paper waste. Table Q1 shows the average composition of the solid waste generated based on 100kg sample in this urban area per week.

Table Q1: Average composition of the solid waste generated in the urban area

Component	Percent by weight, %	Specific weight, kg/m^3
Food wastes	19	288
Paper	30	90
Cardboard	8	50
Plastics	9	66
Textiles	2	66
Rubber	0.5	130
Leather	0.5	160
Yard wastes	15	101
Glass	10	195
Metals	6	90

- (i) Estimate the relative volumetric capacity required for each material in a collection vehicle, if the vehicle volume is $12 m^3$.

[4.0 Marks]

- (ii) Estimate the total weekly volume of separated materials of each category, if the number of homes that will participate in the separation program is estimated to be 70 %. There are 7800 homes in this urban area. Assume 4 residents per home and solid waste generation rate is 0.6 kg/capita. day.

[4.0 Marks]

Q2.

Ultimate analyses of solid waste are used to determine the chemical content of solid waste in terms of C, H, O, N, S and ash.

- a) Name the three other most important chemical properties of solid waste. [1.5 Marks]
- b) Ultimate analyses can also be used to calculate the energy content of solid waste. State one more parameter that can be obtained by ultimate analyses. [1.0 Mark]
- c) Table Q2-a shows the typical data on an ultimate analysis of the combustible components in a municipal solid waste sample. Table Q2-b gives the typical composition of municipal solid waste based on a 100 kg sample.

Table Q2-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 Q2-b: Typical composition of municipal solid waste based on 100 kg sample.

Component	Percent by weight (%)	Typical moisture content (% weight)
Food wastes	26	65
Paper	23	7
Cardboard	8	4
Plastics	14	2
Textiles	3	12
Rubber	2	4
Leather	2	11
Yard wastes	19	55
Wood	3	22

- (i) Estimate the *as-discarded* overall moisture content of this solid waste sample. [2.5 Marks]
- (ii) Determine the chemical formula of this solid waste sample;
 1. without 'water'
 2. with 'water' [2.5 + 2.5 Marks]
- (iii) The energy content (*Btu/lb*) of a solid waste based on the chemical content can also be estimated by the following equation. Determine the energy value based on the dry weight for this solid waste.

$$\text{Energy} = 145C + 610 (H_2 - 0.125O_2) + 40S + 10N$$

[2.0 Marks]

Q3. The 'solid waste management hierarchy concept' developed by the United States Environmental Protection Agency (USEPA) ensures involving almost all the existing environmentally sound strategies of the municipal solid waste management.

- a) Illustrate the solid waste management hierarchy with a diagram. [2.0 Marks]
- b) Develop a sustainable solid waste management system for Bope-Poddala Pradeshiya Sabha (local government) area, based on the solid waste management hierarchy concept. Assume that the current solid waste management practice in this area is to collect waste as a mixed waste, and dispose them on open dumping sites and/or open burning. Use the following guideline for your answer.

-List the types of most important data needed and how to collect them

-Mention clearly any assumption made

-Demonstrate all the key components of the developed solid waste management system based on the hierarchy

-Mention clearly how to use an integrated solid waste management system to handle the waste safely and effectively with the least adverse impacts on the human health and the environment.

[7.0 Marks]

- c) Collection includes not only the gathering or picking up of solid waste from various sources, but also the hauling to the location where the contents of the collection vehicles are emptied. Hauled Container System (HCS) and Stationary Container System (SCS) are two common types of collection systems. Using simple sketches, explain briefly the two systems. Discuss the advantages and disadvantages of HCS and SCS.

[3.0 Marks]

Q4. a) Describe the pyrolysis process and the outputs produced.

[2.0 Marks]

- b) State three composting methods, and discuss the applicability of these methods

based on the resource requirement and time consumption.

[3.0 Marks]

- c) Describe three-unit operations used for segregating and processing of solid waste.
- [3.0 Marks]
- d) Table Q5 gives the characteristics of solid waste generated in a city. Determine the volume reduction of 600 kg of this solid waste after combustion. Assume that the specific weight of the residue is 550 kg/m^3 and the average specific weight of the waste is 150 kg/m^3 .

Table Q5: Characteristics of solid waste.

Type	Percentage composition	Inert residue %
Food waste	48	5
Plastic and polythene	22	3
Yard waste	12	5
Glass	12	90
Tin cans	6	40

[4.0 Marks]

- Q5. a) Describe the composition of landfill gas.
- [2.0 Marks]
- b) Describe the chronological steps of the solid waste decomposition process happening inside sanitary landfills.
- [3.0 Marks]
- c) Propose five strategies to upgrade the solid waste management system in the Faculty of Engineering of University of Ruhuna.
- [3.0 Marks]
- d) Assess the suitability of a low-land lying along a river floodplain to be used as a solid waste disposal site. The land area is adequate for 6 years and away from residential areas.

[4.0 Marks]