UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: October 2019

Module Number: CE5254 **Module Name: Integrated Solid Waste Management**

[Three Hours]

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

[Use **separate books** to answer **Section-A** and **Section-B**]

SECTION – A

Q1. Growing concerns regarding shrinking natural resources, contribution of improper waste management to global warming and shortage of power generation have triggered discussions regarding waste as an energy resource. However, the feasibility of combustion depends on several chemical properties of the solid waste.

a) "Proximate analysis" one of the important chemical properties of solid waste. Briefly describe on "Proximate analysis" of solid waste.

[2.0 Marks]

b) Data on the energy content of each components of municipal solid waste (MSW) (100 kg sample), based on the results of bomb calorimeter tests, are shown in the Table Q1.

Table Q1: Energy content of MSW based on bomb calorimeter test

Component	Mass, kg	Energy Content (kJ/Kg)
Food wastes	14	4650
Paper	34.5	16750
Cardboard	14	16280
Plastics	10.5	32560
Textiles	2.5	17440
Rubber	1.2	23260
Leather	0.3	17310
Yard wastes	12	6510
Wood	7	18620
Glass	4	140

i) Determine the energy content "as discarded" for this MSW.

[5.0 Marks]

ii) What is the "dry basis" energy content, if the moister content was 25%?

[2.0 Marks]

iii) This municipality implemented new reuse/recycle program among homeowners of the municipality. Estimate the as discarded energy content of the remaining

solid wastes if 80% of the food wastes and yard wastes are separated for composting by the homeowners of this municipality.

[3.0 Marks]

Q2. a) "Field Capacity" is considered as one of the useful "physical properties" of municipal solid waste. Name 3 more "physical properties" of municipal solid waste. Briefly describe about the "Field Capacity" and its importance for solid waste management.

[3.0 Marks]

b) In a small urban community, there are 3 types of vehicle used for collecting municipal solid waste. From the following data, estimate the daily per capita waste generation rate for above community consisting of 900 homes. The observation location is a local transfer station that receives all the wastes collected for disposal. The observation period was one week. Assume that each household is comprised of 4 people. There are 3 type of waste collecting vehicles;

Vehicle Type 1:

- *Volume of the "Tractor with Tailor" = 2 m^3*
- *Typical specific weight of municipal SW for "Tractor with Tailor" = 110 kg/m^3*
- *Number of loads per week = 6*

Vehicle Type 2:

- *Volume of the "Compactor Truck" = 15 m^3*
- *Typical specific weight of municipal SW for "Compactor Truck" = 300 kg/m^3*
- *Number of loads per week = 3*

Vehicle Type 3:

- *Volume of the "Individual domestic vehicle" = 0.25 m^3*
- *Typical specific weight of municipal SW for "Individual domestic vehicle" =90 kg/m^3*
- *Number of loads per week = 10*

[4.5 Marks]

c) A new residential area is composed of 250 low-rise detached housing units. This community administrates plans to have a proper solid waste collection system with following data;

- *Occupants per housing units* = 3.5
- *Solid waste collection rate* = 1.6 kg/ person/day
- *Type of collection service* = Curb
- *Moisture Content of waste* = 23%
- *Collection vehicle capacity* = 10.7 m^3
- *Compacted specific weight of solid waste* = 320 kg/m^3

i) Determine the compacted volume of solid waste to be collected per month.

[1.5 Marks]

ii) Determine the number of trips required per week.

[2.0 Marks]

iii) Determine the average number of occupants from which wastes are to be collected on each collection trip.

[1.0 Mark]

Q3. The "solid waste management hierarchy" is a concept that promotes waste avoidance ahead of recycling and disposal.

a) List the hierarchy ranking according to the order of preference for action to manage solid waste and present them in diagrammatically.

[2.0 Marks]

b) Assume you are the municipal engineer in a small city in Sri Lanka. At the moment, there is no proper solid waste management system and current practice in this city area is to collect waste as mixed waste and dispose them as open dumping and open burning.

i) Uncontrolled dumping and improper waste handling may cause a variety of problems. List 8 such environmental issues due to improper waste handling.

[2.0 Marks]

ii) You have been asked to plan a sustainable solid waste management system for this city. You may need to combine of various functional elements associated with the management of solid wastes. As the first step you may need to find the composition of solid waste that is the individual components that make up a solid waste stream and their relative distribution, usually based on percent by weight. There are two standard methods to collect a representative sample from a truckload. Name these two methods and briefly explain one of the methods.

[2.0 Marks]

iii) Briefly explain your plan to design such a system based on "Solid waste management hierarchy concept". The system, when put in place, facilitates the collection and disposal of solid wastes in the community at minimal costs, while preserving public health and ensuring little or minimal adverse impact on the environment. You may use following guideline to prepare your answer.

- *Population in the city is 35,000*
- *There is a school, one market and 3 religious places in the city*
- *There are no big industries or agricultural areas in this city*
- *List out the most important data you may need*
- *The methods to obtain these data*
- *Clearly mention any other assumption you made*
- *Demonstrate all the key components of your new solid waste management system based on the hierarchy*
- *Clearly mention how to use integrated management system to safely and effectively handle the waste in this city.*

[6.0 Marks]

Q4. Open dumping of solid waste results many environmental and social problems in Sri Lanka. The Ministry of Megapolis and Western Development of Sri Lanka launched the Aruwakkalu solid waste management project that has been set up to facilitate the disposal of 600 metric tons of municipal waste from Colombo city in an environmentally friendly and hygienic manner.

a) Discuss the negative social impacts to the neighbor community due to an open dumping site.

[2.0 Marks]

b) Aruwakkalu sanitary landfill is located about 170 km from the Colombo City. Briefly discuss the issues due to the location of the sanitary land fill is such a distance away from the waste generation sources.

[2.0 Marks]

c) Based on your field visit experience to Aruwakkalu landfill area, briefly explain two techniques used to minimize the groundwater pollution in Aruwakkalu sanitary landfill.

[2.0 Marks]

d) The municipal council of a city in Sri Lanka is searching for a landfill site that is useable for a period of 5 years beginning from year 2020. Prove that 200 acres land can fulfill this requirement. Applicable conditions are given in Table Q4.

Table Q4: Waste generation rate in the city

Year	End of year population (× 1000)	Waste quantity (m^3/ *capita. d*)
2020	12	0.02
2021	13	0.02
2022	15	0.019
2023	17	0.019
2024	19	0.019
2025	20	0.019
2026	21	0.017
2027	22	0.017

The maximum height allowed for the landfill is 8 m.
Cover: waste ratio=1:5
Slope =1:3
Cover material will be obtained from the landfill site and can go for a maximum of 2.0 m deep excavation.
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 $= \left(\frac{h}{3}\right) \times (A1 + A2 + \sqrt{(A1 \times A2)})$
Where, h = height of the frustum
A1 =area of upper base
A2 =area of lower base

[6.0 Marks]

Q5. a) Volume reduction is an important requirement in a proper solid waste management process.

(i) Name two-unit operations that can be used for volume reduction.

[1.0 Mark]

(ii) Briefly discuss advantages of volume reduction in solid waste management.

[2.0 Marks]

b) A coastal city is planning to have a waste incineration plant located 500 m away from the coast. There are arguments about this decision within community and professionals. Provide your opinion on this decision and justify your opinion.

[3.0 Marks]

c) Contrast the outputs generated by the 'open burning of solid waste' and 'combustion of solid waste in an incinerator'.

[3.0 Marks]

d) An incinerator converts waste to energy. Elaborate this statement with examples.

[3.0 Marks]