# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 5 Examination in Engineering: July 2017

**Module Number: CE 5254** **Module Name: Integrated solid waste management**

**[Three Hours]**

[Answer **all questions**, each question carries 12 marks]

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Q1. a) Table Q1 depicts the details of the solid waste (SW) collection vehicles used in a ward of a municipality. The ward consists of 1250 homes. Estimate the daily per capita waste generation in this ward using 'Load -count analysis` method if each household is comprised of 4 persons on average.

**Table Q1 :Details of solid waste collection vehicles in a ward of a municipality**

| Vehicle Type | Average capacity of each vehicle, $m^3$ | Typical specific weight of municipal SW in each vehicle, $kg/m^3$ | Number of loads during the month of June-2017 |
|---|---|---|---|
| Compactor Vehicle | 5 | 300 | 45 |
| Open Truck | 1.5 | 120 | 24 |
| Tractor with Trailers | 1.2 | 85 | 86 |

[5.0 Marks]

b) Name two other methods used to estimate waste quantities. Explain briefly one of them.

[2.0 Marks]

c) 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.
Name another standard method for collecting a representative solid waste sample to analyze the composition.

[3.0 Marks]

d) Explain briefly the 'field capacity', which is an important 'physical property' of the municipal solid waste.

[2.0 Marks]

Q2. Table Q2 shows the characteristics of a 50 kg municipal solid waste sample collected from the Western 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 | 13 | 70 | 4650 |
| Paper | 39.5 | 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) Hence, 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) Hence, 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, 90% of the cardboard and 60% 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. a) An integrated solid waste management system refers to a combination of various functional elements associated with the management of solid wastes. Draw a simplified diagram showing the interrelationships between the functional elements in such a system.

[2.0 Marks]

b) 'Solid waste management hierarchy concept' is a well-accepted guide for prioritizing waste management practices to manage municipal solid waste.

i) Present the 'solid waste management hierarchy concept' diagrammatically.

[2.0 Marks]

ii) 'A sustainable integrated solid waste management plan' is proposed to be implemented at the Faculty of Technology, University of Ruhuna,

Kamburupitiya, which has been established recently. The aim of the proposal is to convert the premises into a 'zero waste faculty', which will minimize the wastes dumped on landfills and combusted in incinerators. Formulate such a solid waste management plan based on the 'solid waste management hierarchy concept', highlighting the key components. State any assumptions made.

[8.0 Marks]

Q4. a) List three primary functions of the final cover of a sanitary landfill.

[3.0 Marks]

b) Discuss the environmental pollution caused by open dumping of solid waste in Sri Lanka.

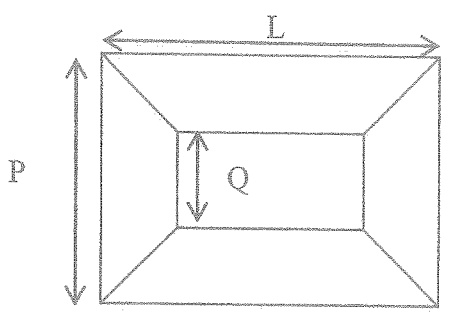
[3.0 Marks]

c) The municipal council of a city is searching for a landfill site that is useable for a period of 6 years beginning from year 2018. Calculate the minimum land area requirement. Applicable conditions are given in Table Q4. (State any assumptions made.)

**Table Q4: Waste generation rate in the city**

| Year | End of year population (× 1000) | Waste quantity ($m^3$/ *capita. d* ) |
|---|---|---|
| 2018 | 120 | 0.002 |
| 2019 | 130 | 0.002 |
| 2020 | 150 | 0.0019 |
| 2021 | 170 | 0.0019 |
| 2022 | 190 | 0.0019 |
| 2023 | 200 | 0.0019 |
| 2024 | 210 | 0.0017 |
| 2025 | 220 | 0.0017 |

Volume of a trapezoid =h x L x (P+Q)/2
Where h=10 *m* and it is the maximum height allowed for the landfill.
Cover : waste ratio=1:5
Slope =1:3
Q= 150 *m*
Clearance from the boundary line to the landfill base = 5 *m*




[6.0 Marks]

Q5. a) Discuss the role of a 'transfer station' in an integrated solid waste management facility.

[2.0 Marks]

b) It has been observed that a composting pile does not seem to be heating up at all. Analyze the possible causes for this situation, and propose remedies.

[3.0 Marks]

c) Calculate the volume reduction after burning 700 *kg* of solid waste having the composition indicated by Table Q5. The specific weights of waste in the pit and ash are 175 $kg/m^3$ and 500 $kg/m^3$, respectively.

**Table Q5: Waste composition and percentage of inert residue**

| Type | Percentage by weight | Inert residue (%) |
|---|---|---|
| Organic | 50 | 30 |
| Glass | 5 | 98 |
| Metals | 10 | 96 |
| Polythene | 20 | 5 |
| Plastics | 10 | 10 |
| Other | 5 | 20 |

[3.0 Marks]

d) List four components of the flue gas (output) of an incineration plant, and explain the cleaning process of this gas before discharging into the environment.

[4.0 Marks]