UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: July 2016

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

[Three Hours]

[Answer all questions, each question carries 12 marks]

Q1. a) List five management issues related to the operation of integrated solid waste management systems.

[2.5 Marks]

b) Discuss briefly 'future challenges' to be faced by municipal solid waste management systems.

[3.0 Marks]

c) A municipal council has been practicing a solid waste recycling program. Under this program, each residence has been provided with three containers to store separately the source-segregated recyclable solid wastes of the following three types: Type 1 - paper and cardboard, Type 2-plastics and pet bottles, and Type 3- glasses and metals. About 750 residences participate in this program. These containers are usually collected by the municipal council once in every 3 days using a special garbage truck designed to collect recyclable solid wastes separately. Table Q1 shows the typical composition and component-densities of a 100 *kg* solid waste sample collected from this area. Assume followings;

1. Only 75 % (on weight basis) from each of type 1 and type 2 recyclables, and 90 % (on weight basis) from type 3 recyclables are separated.
2. Waste generation rate is 0.9 *kg / capita. day* and there are 4 residents per residence.

Table Q1 Composition of solid wastes with their typical densities.

Component	Total solid waste, *kg*	Typical density, *kg/m³*
Food wastes	9.5	280
Paper	35	90
Cardboard	6.0	55
Plastics and pet bottles	7.5	65
Textiles	2.0	65
Rubber	0.5	130
Leather	0.5	160
Yard wastes	12.0	105
Wood	2.5	240
Glass	9.5	195
Metals	7.0	220
Others (Dirt, Ash, etc)	8.0	480

i) Estimate the total volume of each type of recyclable solid wastes collected within one collection day.

[3.0 Marks]

ii) If the total capacity of the special garbage truck is 8 m^3, determine the number of trips it should make on one collection day.

[3.5 Marks]

Q2. a) Waste generation is an important functional element of an integrated solid waste management system. List **five** factors that may affect the waste generation in a community.

[2.5 Marks]

b) A survey conducted for one week on waste collection vehicles along the Galle-Wackwella road reveals the following information:
- Number of Compactor Vehicle loads = 16
- Average size of a Compactor = 5 m^3
- Number of Open Truck loads = 8
- Average Open Truck volume = 1.5 m^3
- Number of loads from Tractor Trailers = 30
- Estimated volume per Tractor Trailers = 1 m^3

Calculate the waste generation rate per capita per day for this road consisting of 1,750 residences. Assume that each residence comprises 4 residents. Typical specific weights of waste collection vehicles are as follows:
- Compactor Vehicle = 300 kg/m^3
- Open Truck = 125 kg/m^3
- Tractor Trailer = 80 kg/m^3

[4.0 Marks]

c) Discuss briefly how different types of storage methods and location of the containers of solid waste affect the waste composition and public health.

[2.5 Marks]

d) Name two methods used to collect a representative sample to analyze the composition of municipal solid waste? Explain one method briefly.

[3.0 Marks]

Q3. a) It is planned to establish an incineration plant in the Hambantota new township area to manage the municipal solid waste as well as to generate the electricity using the incineration plant. In order to have successful outcomes from an incineration plant, total 'as-discarded calorific value' of the waste must be greater than 7 MJ/kg. The projected population of the Hambantota new township area is 12,000. Table Q3 depicts the as-discarded calorific value of each component of the municipal solid waste collected from the area, based on 75 kg sample and the results of bomb calorimeter tests.

i) Discuss whether it is effective to invest on the planned incineration

[2.0 Marks]

ii) What will be the daily energy production in *MJ*, if the waste generation rate is 0.6 *kg/capita.day*. Assume all the waste generated in the city will be collected.

[2.0 Marks]

iii) If 80 % (on weight basis) from each of 'food waste' and 'yard waste' are separated to produce compost, what will be the new rate of energy production?

[2.0 Marks]

Table Q3 As-discarded calorific value of the municipal solid waste.

Component	Mass, *kg*	As - discarded calorific value, *kJ/kg*
Food wastes	7.6	4,650
Paper	31.0	16,750
Cardboard	12.0	16,280
Plastics	7.0	32,560
Textiles	1.9	17,440
Rubber	0.7	23,260
Leather	0.3	17,310
Yard wastes	7.5	6,510
Wood	3.0	18,620
Glass	4.0	140

b) In order to manage the municipal solid waste safely and effectively with the least adverse impacts on the human health and the environment, an 'integrated solid waste management plan' can be introduced to the Hambantota township. Explain how to apply 'solid waste management hierarchy concept' in developing such an 'integrated solid waste management plan'.

[6.0 Marks]

Q4. a) Explain the environmental pollution controlling measures applied in a sanitary landfill of municipal solid waste.

[3.0 Marks]

b) Compare and contrast the characteristics of the leachate produced in the different phases of biological transformation of solid waste in a sanitary landfill.

[3.0 Marks]

c) Discuss the environmental pollution caused by the semi-controlled municipal solid waste dumpsite managed by the Galle municipality.

[2.0 Marks]

d) The existing capacity of a sanitary landfill in a city is 550,000 m^3. Table Q4 depicts the waste generation rates of the city. Calculate the lifespan of the landfill. Assume that the cover material is imported to the site, and the

cover: waste ratio (on volume basis) is 1:5. State any assumption/s.

[4.0 Marks]

Table Q4 Per capita waste generation rates in the city.

Year	End of year population (× 1000)	Waste generation rate (L/capita. d)
2013	12	19
2014	13	19
2015	15	18
2016	17	19
2017	19	19
2018	20	18
2019	21	17
2020	22	17

Q5.　a)　State advantages and disadvantages of 'windrow' and 'vessel' methods of composting.

[2.0 Marks]

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

[3.0 Marks]

　　c)　Determine the volume of air required for the complete combustion of 2,000 kg of an organic solid waste having the composition, $C_{120}H_{180}O_{80}N_2$. The molecular weights of C, H, O and N are 12, 1, 16 and 14, respectively. Assume that the air contains 23.15 % oxygen by weight and that the density of air is 1.3 kg/m^3.

[4.0 Marks]

　　d)　Describe **three** unit operations used for separating and processing of solid waste in waste separation and processing plants.

[3.0 Marks]