UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2014

Module Number: CE5316 **Module Name: Solid Waste Management**

[Three Hours]

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

Q1. a) i. Define the term "Recycling".

[2.0 Marks]

ii. List commonly available recyclable materials in your premises.

[2.0 Marks]

b) "Recycling of aluminum makes economic sense to producers". Rationalize this statement.

[2.0 Marks]

c) Explain briefly the advantages of recycling process.

[2.0 Marks]

d) What does the recycling symbol with the three arrows represent?

[2.0 Marks]

e) Explain briefly the objective of a Material Recovery Facility (MRF).

[2.0 Marks]

Q2. a) List the different types of solid waste transfer stations.

[0.5 Mark]

b) In situations where two or more transfer stations and disposal sites are to be used, the waste allocation problem can be analyzed as follows:

- The amount of solid waste (SW) that should be hauled to each disposal site from each transfer station should be determined so as to bring the total haul cost to the minimum possible value.
- The total amount of wastes hauled to all the disposal sites should be equal to the amount delivered to the transfer station (materials-balance requirements).
- Only specified amounts of wastes can be accepted at each disposal site (this constraint could arise as a result of limited road access to a given disposal site)
- The amount of wastes hauled from each transfer station is equal to or greater than zero.

The allocation problem is set up as follows:

- Let the transfer station sites be designated by i.
- Let the disposal sites be designated by j.
- Then let Xij = the amount of wastes hauled from transfer station i to disposal site j.
- Let Cij = the cost of hauling wastes from transfer station i to disposal site j.
- Let Ri = the total amount of wastes delivered to transfer station i.
- Let Dj = the total amount of wastes that can be accepted at disposal site j.

i. A city has four disposal sites and four transfer stations to handle its solid waste. Considering the above waste allocation setup, draw the definition sketch for the allocation of solid waste from the four transfer stations to the four disposal sites.

[2.0 Marks]

ii. If the total haul costs are to be minimized, state an objective function, which is defined based on the above notations.

[1.0 Mark]

iii. State the three problem constraints which the objective function is subjected to by using the given notations.

[1.5 Marks]

c) The city shown in Figure Q2(c) has four disposal sites; D1, D2, D3 and D4 and needs four transfer stations to handle the solid waste. Locations of the transfer stations T1, T2, and T3 have already been selected. The fourth transfer station site has been narrowed to two possibilities, T4 and T5 as shown. Table Q2(c) shows the SW data in the disposal sites and transfer stations per day. On the basis of transport cost alone, determine the more economical location between T4 and T5 to locate the transfer station 4. State any assumptions made.
Assume that the transport time in hours per trip is given by the expression ;
0.25 h/km (x), where 'x' is the round trip haul distance in kilometers per turn, and that the transport cost is Rs.100/= per hour.

Table Q2(c)SW data for the given city in waste tons/day

SW tons/day	D1	D2	D3	D4
T1	4	2	2	5
T2	2	4	4	5
T3	2	2	4	2
T4 OR T5	4	2	4	2

[7.0 Marks]

Q3. a) Explain briefly the C/N (Carbon to Nitrogen) Ratio which is one of the key parameters that affect the efficiency of the composting process.

[2.0 Marks]

b) Explain briefly the different stages of the composting process.

[2.0 Marks]

c) Explain briefly the variation of pH during the composting process using time vs pH graph.

[2.0 Marks]

d) Differentiate the term 'compost maturation' from the term 'stabilization'.

[2.0 Marks]

e) Determine the weight of air required for the complete combustion of one ton (1000 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.

$$C_aH_bO_cN_d + \frac{(4a + b - 2c - 3d)}{4} O_2 \rightarrow aCO_2 + \frac{(b - 3d)}{2} H_2O + dNH_3$$

$$NH_3 + 2O_2 \rightarrow H_2O + HNO_3$$

[4.0 Marks]

Q4. a) i. Explain the terms, 'bioaccumulation' and 'synergistic' as applied to hazardous waste.

[2.0 Marks]

ii. Briefly explain four main characteristics of the hazardous waste.

[2.0 Marks]

b) The Basel Convention is one of the global tools that addresses the hazardous waste management. Explain briefly the key objectives of the convention.

[2.0 Marks]

c) Explain briefly the "Cradle to Grave" management systems.

[2.0 Marks]

d) Discuss the responsibilities of the driver and helper of the vehicle in an incident of spilling out of a liquid-state hazardous waste while being transported.

[2.0 Marks]

e) List common chemical treatment processes of hazardous waste. Explain any one of them giving examples.

[2.0 Marks]

Q5. a) i. "A landfill or land disposal is an integral part of a sound solid waste management strategy." Rationalize this statement.

[2.0 Marks]

ii. Explain briefly the following terms with respect to landfill operations and show them in Figure Q5 wherever appropriate.

A. Cell
B. Daily cover
C. Lift
D. Bench (Terrace)

[4.0 Marks]

b) What is meant by "NIMBY" syndrome? Explain how to overcome this situation in a solid waste management program of a community.

[2.0 Marks]

c) List land disposal methods of hazardous waste and explain briefly one of them.

[2.0 Marks]

d) Explain briefly the use of Material Safety Data Sheets (MSDS) complying to the laboratory.

[2.0 Marks]

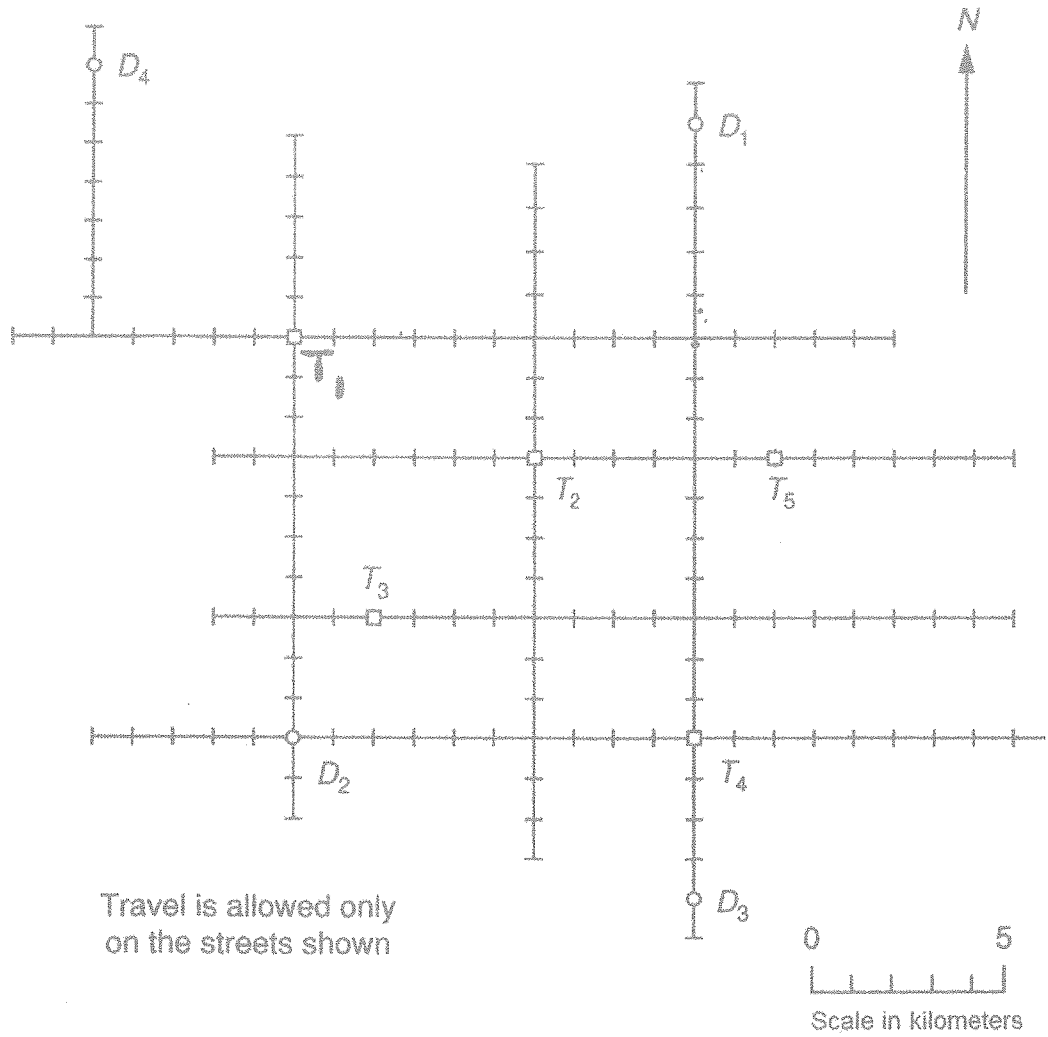

Figure Q2(c) : Proposed solid waste transferring setup for the given city

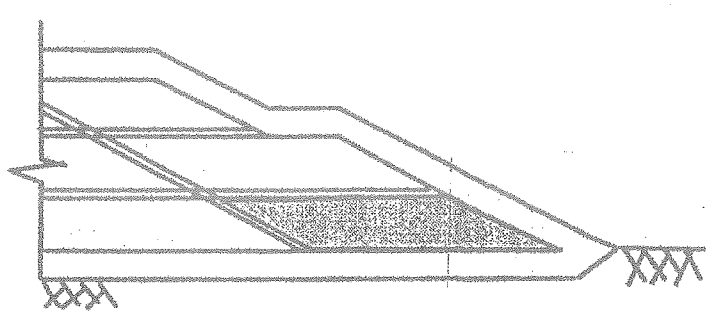

Figure Q5 Cross section of a sanitary landfill