Ref No. –EX/PG/CE/T/113F/2018

M.E. CIVIL ENGINEERING 1st YEAR 1st SEMESTER EXAMINATION, 2018

SOLID WASTE MANAGEMENT (EE)

Time: Three hours

Full Marks 100
(60 marks for part I)

Use a separate Answer-Script for each part

Part-I

Question no. **1** is compulsory

Answer any **two** from the rest

(Assume any data, if required, reasonably)

1.

a) In a metropolitan city numbers of solid waste landfill sites 'u' (indicated by 'k') are located outside the city boundary. Solid wastes are two types, garbage 'g' and silt 's'. Wastes are initially collected in 'm' number of container points (indicated by 'i') located in the city. From container points 'i' [1] garbage 'g' are transported by dedicated trucks to the 'n' number of solid waste processing units (indicated by 'j') for mass reduction by 'R' fraction and then reduced mass transported to the solid waste landfill sites 'k' for final disposal; [2] and/or from container points 'i', garbage 'g' can be transported by dedicated trucks directly to the solid waste landfill sites 'k' for final disposal bypassing the solid waste processing units 'j'. From container points 'i', silt 's' must be transported by dedicated trucks directly to the solid waste landfill sites 'k' for final disposal. Transported costs of per unit weight of garbage and silt are indicated by 'Cg' and 'Cs' respectively. Daily maximum processing capacity of garbage in unit 'j' is 'Capj' and daily maximum landfill capacity of wastes in unit 'k' is 'Capk'. Revenue earning per unit weight of garbage reduction is 'CRg'. Daily processing cost (per unit weight) of waste processing units 'j' is 'Pj' and landfilling cost (per unit weight) of unit 'k' is 'Lk'. Keeping in view the waste generation, capacity limit of different units, transportation costs, processing costs, revenue earning, mass reduction of garbage in the processing units etc. formulate a cost optimization generic LP model of the solid waste management for the city.

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b) In India, why organic content in the solid waste of semi-urban and rural area is higher than a metropolitan city?

Describe the BARC process of biomethanation? How has it become a techno-economically viable option in semi-urban and rural India?

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c) Describe the septage generation and treatment status in India. Describe the process and significance of 'Karnal Technology' in septage management in India.

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2.

a) What is the step by step design procedure of setting up an integrated solid waste management system? 4

b) What are the full form of HELP model and EPACMTP model? What are the utility of these models? 3

c) Write the methane balance equation as a landfill gas. 3

d) Find out the leachate quantity from given data. i) Active waste disposal area = 25000 m^2; ii) Intermediate covered waste disposal area = 50000 m^2; iii) The remaining area is under preparation for landfill = 25000 m^2; iv) Maximum rainfall = 390 mm/month; v) Monthly fraction of annual sun-shine hours = 0.05; vi) Empirical crop and meteorological coefficient = 0.7; vii) Average monthly temperature = 28° C; viii) For evapotranspiration rate use Blaney and Criddle formula. 5

3.

a) Discuss the utility of trigeneration of energy with biofuel w.r.t conventional thermal power station? Give some example of biofuel generating raw materials. 6

b) A local waste management agency has proposed to set up a waste combustion facility next to the existing landfill to maximize the life span of the landfill. Given the following information, determine how much the life span of the landfill is increased by combustion.

(i) Raw garbage generation is 1700 t/d
(ii) Silt generation is 300 t/d having compacted specific weight of 750 kg/m^3
(iii) Estimated landfill capacity remaining is 3,500,000 m^3
(iv) Capacity of combustion facility is 55 t of raw garbage/h
(v) Effective on-line combustion time/day is 22 h
(vi) Residue generation from combustion of 1000t of raw garbage is 248 t
(vii) specific weight of the raw garbage is 170 kg/m^3
(viii) specific weight of compacted raw garbage in landfill is 500 kg/m^3
(ix) specific weight of compacted residue (ash) in landfill is 712 kg/m^3
(x) Yearly maintenance period of the combustion facility is 25%

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4. a) W

b) D

c)

i.

a) With respect to aerobic composting, discuss the significance of C/N ratio in the raw material for 'loss of nitrogen in the form of ammonia'. 3

b) Draw a plan and sectional view of the windrow composting yard showing different components. 5

c) In the 300 t/day of MSW 25% is inert material. The initial composition of the organic fraction is $[C_6H_7O_2(OH)_3]_5$. After 21 days active period of static-pile composting, organic fraction is reduced to 33% having final composition of $[C_6H_7O_2(OH)_3]_2$. Find out the amount of daily air requirement in m^3. 7

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MASTER OF CIVIL ENGINEERING EXAMINATION, 2018

(1st Semester)

SUBJECT: Solid Waste Management

Time: Three hours

Full Marks 100

Use separate Answer-Scripts for each part

No. of Questions	Part II (40 marks for this part)	M
	Answer question number 1 is compulsory and any two from the rest. Assume relevant data if necessary.	
Q1. a)	A municipal area has one compost plant, one biogas plant and one incineration plant for treating 2000 kg of food waste and 1009 kg other organic portion of solid waste. The capacities of each treatment facilities and revenue earned from each facility are presented in the table below. Express the above data in the form of a linear programming problem to optimise the revenue generation from the operations of the three facility sites. Solve the problem by Simplex Method.	

Facility Sites	Waste amount that can be handled (kg)		Revenue Generation (Rs)
	Food Waste	Other Organic Waste	
Compost Plant	10	2	800
Biogas Plant	4	5	600
Incineration Plant	5	4	300
Total Capacity	2000	1009	

b) Write in brief the significances of the following factors in association with the solid waste generation:

i. Source reduction

ii. Waste diversion programme

iii. Public attitude and legislation

iv. Climate and geographical factors

v. Collection frequency

Q2. Discuss the advantages and disadvantages of different primary waste collection methods present in India considering advantages of municipal authority and residents. What is the basic difference between proximate analysis and ultimate analysis in association with taking decision about solid waste treatment? Why determination of specific density is very important in association with solid waste management?

Q3.a) The solid waste generated per week in a residential complex is 700 kg. There are two containers each with a capacity of 4 kg at the rear of each house. The solid wastes are collected by a two person crew using a 35 kg manually loaded compactor vehicle once a week. Determine the time per trip and the weekly labour requirements in person-days. The disposal site is located 15 km away, haul constants a and b are 0.022h/trip and 0.022h/km respectively, the container utilization factor is 0.7 and the compaction ratio is 2. Assume the collection is based on 8-h day. The average pick up time per container is 6 min, the average drive time between the containers are 6 min, the average time to empty the truck at the disposal site is 15 minutes time from garage to first container is 20 minutes and disposal site to garage is 15 minutes.

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	No. of Questions	Part II (40 marks for this part)	Marks
	Q3.b)	Describe the methodology to determine the necessity of constructing a transfer station in association with solid waste management system with a neat sketch	3
	Q4.a)	Discuss the advantages and disadvantages of 'material balance analysis' for solid waste quantification.	3
	b)	After plotting the weekly solid waste production for a half calendar of operation for a residential area in a probability paper it was obtained that the plotting position of 30, 35, 40, 45 and 50 m3/week waste generations are 30%, 65%, 90%, 98.4% and 99.9% respectively. Using these waste generation data, determine the most cost effective container size to make extra pickup trips, on call, instead of using a larger sized container. Consider the following data given below.	7

Container Vol (m3)	Capital cost (Rs)	Annual O & M cost (Rs/yr)
30	3000	150
35	3500	175
40	4000	225
45	5000	300
50	6500	400

Cost per trip = Rs 500/trip

Useful life of container = 10 years

Discount rate =12%