KATHMANDU UNIVERSITY
End Semester Examination
09 January 2024

Marks Scored:

Level : B.Tech.
Year : IV
Course : ENVS 431
Semester : I

Exam Roll No. :
Time: 30 mins.
F. M. : 20

Registration No.:
Date :

SECTION "A"
[20Q. × 1 =20 marks]

Choose and encircle the most appropriate answers from the given choices

1. Which of the following is **NOT** a landfilling method?
   a. Bangalore method
   b. Area method
   c. Depression method
   d. Trench method

2. Which of the following waste can be decomposed by bacteria?
   a. Radioactive substances
   b. Ashes
   c. Food waste
   d. Rubbish

3. ..... is the cutting and tearing of municipal solid waste.
   a. Landfills
   b. Shredding
   c. Pulverization
   d. composting

4. What plan should we make for the disposal of solid waste?
   a. Integrated waste management plan
   b. Recycling of waste management plan
   c. Reducing of waste management plan
   d. Use of waste management plan

5. Which of the following can be recycled many times?
   a. Plastic
   b. Wood
   c. Organic materials
   d. Aluminum

6. The density of ash produced in the municipal solid waste is .....
   a. 700 kg/m^3
   b. 1000 kg/m^3
   c. 550 kg/m^3
   d. 200 kg/m^3

7. In solid waste management, waste utilization is achieved by .....
   a. Recover, Reclamation and Reproduce
   b. Reuse, Reclamation and Recycling
   c. Recover, Reuse and Recycle
   d. Reuse, Recycle and Reproduce

8. MSW is composed of ..... organic waste.
   a. 50-60%
   b. 10-15%
   c. 1-5%
   d. 100%

9. The maximum C/N ratio in a Municipal Solid Waste compost is .....
   a. 20:1
   b. 40:1
   c. 60:1
   d. 80:1

10. The phase I German SWM project was held in .....
    a. 1983-85
    b. 1980-1983
    c. 1980-1982
    d. 1982-1985

11. MARPOL 73/78 Convention was for the .....
    a. Prevention of pollution from aircrafts
    b. Prevention of pollution from ships
    c. Prevention of pollution from rail transport
    d. Prevention of pollution from vehicles

12. Field capacity of solid waste varies with .....
    a. the degree of moisture
    b. State of decomposition of waste
    c. Nature of field
    d. Area of field

13. The moisture content of solid waste ranges from ..... in developing countries, depending on the location.
    a. 10%-20% b. 10%-30% c. 30%-50% d. 30%-60%

14. Landfill gas (LFG) is produced by the ..... of organic material present in solid waste.
    a. Anaerobic degradation
    b. Aerobic degradation
    c. Combustion
    d. Emission

15. To avoid compaction, the height of the windrow should not exceed .....
    a. 0.3 m b. 1.3 m c. 2.3 m d. 3.3 m

16. Which of the following does not affect Permeability?
    a. Pore size distribution
    b. Porosity
    c. Surface area
    d. Weather condition

17. The process of burning municipal solid waste at high temperature is called .....
    a. Incineration b. Composting c. Grinding d. Landfilling

18. ..... is the separation of biodegradable waste from non-biodegradable waste for proper disposal and recycling.
    a. Removal b. Separation c. Segregation d. Composition

19. Stockholm Convention on Persistent Organic Pollutants was signed in ..... and effective from May
    a. 2001 and 2003 b. 2001 and 2004 c. 2000 and 2003 d. 2000 and 2004

20. The 'Municipal Solid Waste' is .....
    a. Hazardous b. Non-hazardous c. Toxic d. Non-toxic

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SECTION "B"

Attempt *ALL* questions. Assume necessary data with explanation.

1. Find the stoichiometric equation of the given waste sample without water. Find the heat value and overall density of the waste sample. [8]

components	mass (kg)	MC%	MC	dry mass	density vol.	% by mass (dry basis)				
						C	H	O	N	S
Food waste	15.00	70.00	10.50	4.50	290.00	48.00	6.40	37.60	2.00	0.40
paper	34.00	6.00	2.04	31.96	85.00	43.50	6.00	44.00	0.30	0.20
cardboard	6.00	5.00	0.30	5.70	50.00	44.00	5.90	44.60	0.30	0.20
plastic	10.00	2.00	0.20	9.80	65.00	60.00	7.20	22.80	0.00	0.00
garden trimmings	18.50	60.00	11.10	7.40	105.00	47.80	6.00	38.00	3.40	0.30
wood	5.50	20.00	1.10	4.40	240.00	49.50	6.00	42.70	0.20	0.10
inorganic	11.00	3.00	0.33	10.67	480.00	26.30	3.00	2.00	0.50	0.20
			25.57							

2. The space for the construction of landfill sites for Suryabinayak Municipality, Bhaktapur District, Bagmati Province in (L * B) is 200 m * 120 m. Calculate the design parameters of LFS to satisfy the above mention area of LFS. Use the following information to calculate other required parameters: [8]
   - Present population of the LFS = 4, 50,000
   - Population increment = 2 %
   - Design period = 10 years
   - Density of waste = 550 kg/m^3
   - Per capita waste generation = 220 gm

3. Solid waste from Bhadrapur Municipality, Jhapa is collected in HCS basis using hoist truck. Time taken to reach the first container site from the garage is 30 min. and to the garage from the last location is 45 min. If the average time required to drive between containers is 5 min. and one way distance to the disposal site is 20 km (speed limit 40 kmph); determine number of containers that can be emptied per day based on 8 hr/d working schedule. What would be the amount of waste that can be collected in a day by this truck if the 4 m^3 containers are in an average 3/4th full? Use annex to solve this numerical. [8]

4. Determine landfill gas generation distribution over time for a landfill with a useful life of five years based on following data: [8]
   - Landfill life = 5 years
   - Assume complete decomposition takes place
   - Readily biodegradable and slowly biodegradable wastes are 29.27%and 4.1% of total waste respectively
   - The sum of gas generated from annual readily biodegradable and slowly biodegradable wastes are 0.95 m3/kg and 1.16 m3/kg within the period of 5 and 15 years respectively
   - The gas production starts after one year of deposition
   - Use triangular gas production model
   - The amount of waste landfill is 100 ton everyday

5. Explain about the production of landfill gas with equations? Estimate the volume and mass of the methane gas generated in the landfill site for per ton wastes where the wastes from the Nepalgunj Sub-Metropolitan city is disposed. The composition of the waste in LFS is $C_aH_bO_cN_d$ where a=80, b=180, c=42 and d=1 [2+6]

6. What will be the breakeven haul distance between a direct haul system and a transfer station operation with the following properties? [8]
   - Direct haul system uses 4 m^3 skips
   - Cost of operation of skip vehicles = Rs. 9/m^3-km
   - The transfer station (TS) uses 20 m^3 transfer trailer
   - The cost of operation of tractor trailer = Rs. 3.50/m3-km
   - Initial investment in TS = Rs. 35000000 (for buildings, equipment, facilities, etc.)
   - Useful life of TS = 20 years
   - Interest rate = 10%
   - Cost of operation and maintenance of TS = Rs. 500000/yr
   - Volume of waste handled = 400000 m^3/yr

OR

Draw material flow and waste generation diagram. Explain the different methods of estimation of solid waste quantities?

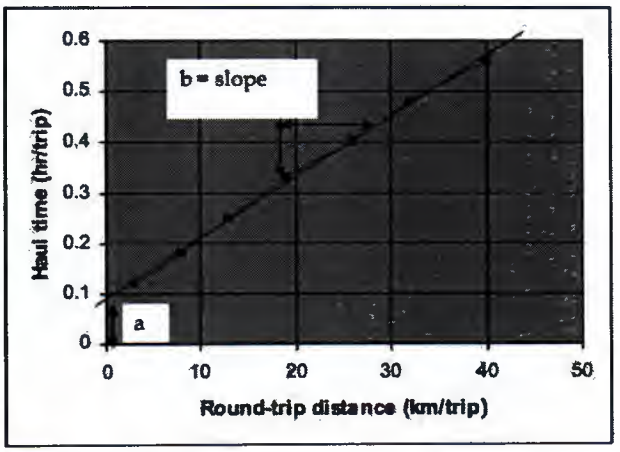
7. Attempt *ANY TWO* questions of the following. [2Q × 3.5 = 7]
   a. What is hazardous waste? Describe characteristics of hazardous waste.
   b. What are the design considerations for the transfer station?
   c. How rapid assessment of a landfill could be conducted?
   d. Describe about the types of composting used in Nepal.

Annex

Determining the haul speed constants a and b.

Following are the observation of average speed and respective round-trip haul distance.

Round-trip distance (x) Km/trip	Average haul speed (y) Km/hr	Total haulage time (h = x/y) hr.
3	25	0.12
8	44	0.18
13	52	0.25
19	58	0.33
26	65	0.4
32	67	0.48
40	71	0.56



Vehicle type	Loading method	Comp-action ratio r	Time required to pickup + deposit empty container Pc + Uc (hr/trip)	Time required to empty contents of loaded container (hr/container)	At site time s (hr/trip)
Haul Container System					
Hoist truck	Mechanical	-	0.067	-	0.053
Tilt frame	Mechanical	-	0.4	-	0.127
Tilt frame with compactor	Mechanical	2~4	0.4	-	0.133
Stationary Container System					
Compactor	Mechanical	2~2.5	-	0.08~0.05	0.1
Manual	Manual	2~2.5	-	-	0.1

Pickup time per trip (hr/trip)

$$P_{hcs} = Pc + Uc + dbc$$

Here, Pc = time required to pickup loaded container; hr/trip
Uc = time required for unloading empty container; hr/trip
dbc = time required to drive betn. two container locations; hr/trip

Total time required per trip (hr/trip)

$$T_{hcs} = P_{hcs} + s + h$$

s = at site time; hr/trip
h = round trip haul time in hr/trip = a + bx

The number of trips per day N_d

$$N_d * T_{hcs} = [\ (1\text{-}W)H - (t_1 + t_2)]$$

$$N_d = [\ (1\text{-}W)H - (t_1 + t_2)]/T_{hcs}$$

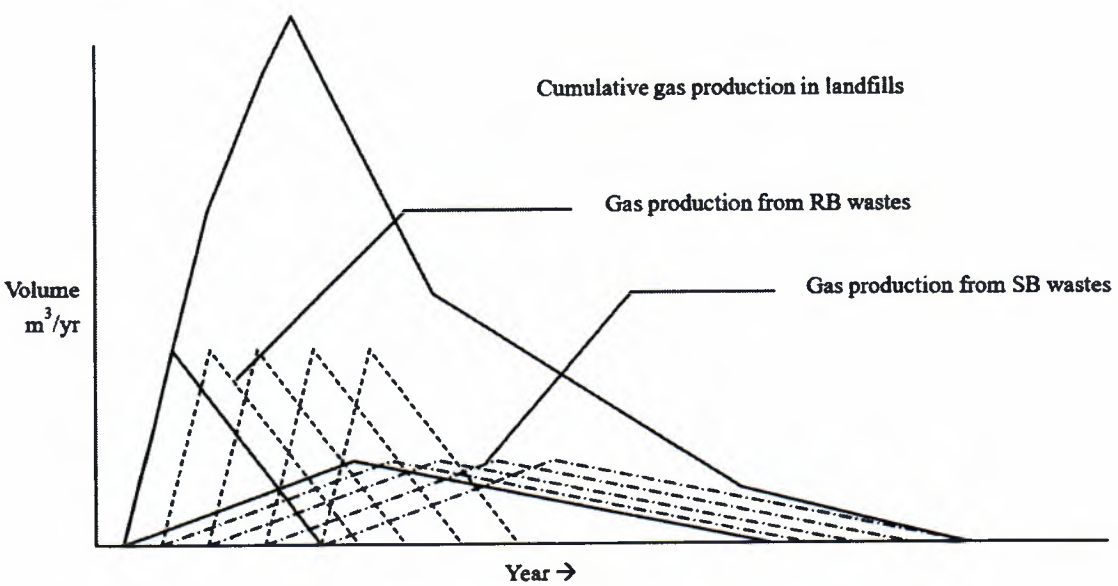
W = off route factor (expressed as a fraction; 0.1~0.25, normally 0.15 is taken)
H = length of the work days; hr/d
t_1 = time for garage to first container location; hr
t_2 = time for last container location to garage; hr

From waste generation relation,

$$N_d = (V_d / c*f)]$$

Where V_d = Average daily quantity of waste collected (m^3/d)
c = Average container size, m^3/trip
f = weighted average container utilization factor (volume actually filled/volume of container)

Annuity of future value of the investment (A) = $P(\frac{i\,(1+i)^n}{(1+i)^n-1})$,
Volume of LFS = P*E*C/§ ,
Ratio of cover to compacted fill (E) = $(V_{SW}+ V_C)/V_{SW}$,



Triangular model for overall gas production in Landfills