04-Agric-B11, Principles of Waste Management

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
Any non-communicating calculator is permitted.

3 Answer Question 1 plus any THREE (3) of Questions 2 to 5. Therefore, you should answer a total of FOUR (4) questions. If you answer more than four questions, only Question 1 and the first three of rest questions will be marked.

4. Each question is of equal value at 25 marks.

5. Questions require calculation and/or answer in essay format. Clarity and organization of the answer are important.

QUESTION 1: GENERAL

1) Define or describe briefly each of the following terms: **10**
   i) GHG emission factor
   ii) sodium adsorption ratio (SAR)
   iii) aeration correction factors: alpha (α) and beta (β)
   iv) vegetated filter strips
   v) agricultural waste management system for livestock waste
2) List the main advantages and disadvantages of composting animal manure as compared to direct land application. **5**
3) Sketch the variation of temperature, pH and NH_3-N over different phases of waste composting. **5**
4) A large-scale concentrated swine operation considers the use of earthen waste storage ponds to store liquid manure. List at least three potential facility and/or environmental risks of this waste management component. For each of these risks, briefly discuss at least two mitigation strategies. **5**

ANSWER ANY THREE OF THE FOLLOWING FOUR QUESTIONS.

2. A concentrated animal farm plans to transport its liquid manure using a closed impeller centrifugal pump through 8-inch PVC tube at a flowrate of 0.04 m^3/s into an uncovered earthen circular lagoon. The lagoon is 500m from the animal house and will be designed with a freeboard of 1.0m and a storage capacity of one year. The surface of the lagoon is 3m higher than the tube inlet. The manure friction coefficient "f" and specific gravity are 0.07 and 1.01, respectively. Assuming that the average dry solid production is 2000kg/day, the liquid manure contains 2% by weight of solids and the net precipitation is 500 mm/year, specify:
   1) dimensions of the storage lagoon **10**
   2) total dynamic head of the pump. Ignore the effects of minor headloss **10**
   3) energy demand, assuming that the pump efficiency is 0.4 **5**

3. A large-scale confined swine operation with 10,000 farrow-to-finish pigs, proposes to use anaerobic digestion to treat its manure in order to recover the energy while stabilizing the manure for agricultural land application. The manure is collected in slurry form with a solid content of 5% and will be delivered to heated digester(s) maintained at 35°C. The biogas from these anaerobic digester(s) is used to run an engine generator. Assuming that the dry solid production is 1.0 kg/pig/day:
   1) determine digester volume and dimensions **10**
   2) determine the daily biogas production, assuming the chemical formula of organic fraction is $C_{50}H_{100}O_{35}N$ **10**
   3) list at least two (2) common types of process upsets that anaerobic digesters could experience, and suggest proper mitigation strategies for them. **5**

4. A cattle farm uses an in-vessel aerobic composting process as part of it's integrated waste management system to treat 20 metric tons of agricultural waste. The composition and results of the ultimate analysis of its organic fraction are given in the following table.

Organic Composition					Dry Solids	Residues
C	H	O	N	P	%	%
120	17	100	8	2	25	5%

1) Determine the ash-free empirical chemical formula of the organic fraction. **5**
2) Suggest proper amendment(s), if needed, to satisfy the composting requirements. **10**
3) Estimate total air requirement and maximum volume reduction from composting. **10**

5. A meat processing plant is discharging its lagoon effluent at a flow rate of 10 m^3/h into a nearby river which has a flow rate of 50 m^3/h. Additional information on the lagoon effluent and river water characteristics are listed below:

lagoon effluent: BOD_5 = 50 mg/L, DO = 2 mg/L, T = 15 °C
upstream river: BOD_5 = 3 mg/L, DO = 7 mg/L, T = 10 °C

You may assume a BOD exertion rate constant of k_1 = 0.15 d^{-1} and a reaeration rate constant k_2 = 0.28 d^{-1} (both given at 20 °C and referred to base 10). The saturated DO = 9.2 mg/L after mixing the river water with lagoon effluent. The temperature correction factor (θ) for k_1 and k_2 is 1.135 and 1.056, respectively. Determine whether the dissolved oxygen in the downstream river would fall below 6.0 mg/L as required by a regulatory agency. **25**