National Exams

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. Do Questions 1 and 2 **plus** any three of Questions 3 to 6. Therefore, you should answer a total of five questions. If you answer more than five questions, only Questions 1, 2 and the first three of rest questions will be marked.

4. Each question is of equal value.

5. Most questions require an 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) available nitrogen
   ii) indicator organisms
   iii) eutrophication
   iv) vegetative filter strip
   v) engineered wetland

2) Describe three steps of the anaerobic processes involving in the oxidation of agricultural wastes. 3

3) Why are anaerobic processes usually more advantageous to treat high strength wastes when compared to aerobic processes? 3

4) Identify the main short-term and long-term air emissions when animal manure is utilized in land application? 3

5) Draw a general waste management system from production to utilization for a daily farm with a total of 1,000 cows. Briefly describe the functions of each component of the management system and potential environmental concerns. 4

QUESTION 2 20

A pig farm having 1,500 grower-finisher pigs, plans to construct uncovered circular concrete tank(s) to store the liquid manure (95% moisture content) for one year. The diameter of the tanks should be no more than 10 m. The stored liquid manure is then transferred up to 500m from the tank to the field for land application using a closed impeller centrifugal pump through 8-inch PVC pipes at a flow rate of 0.02 m^3/s. Pivot nozzles are located 2 m above the field surface. The discharge pressure required at the end of pivot nozzle is 550 kPa. The elevation of the tank surface is 320.00 m, while the elevation of the field is 330.00 m. Both engine and pump efficiency is 75%. The manure friction coefficient f and specific gravity are 0.07 and 1.01, respectively. Assuming that the average dry solid production is 1.2 kg/pig/day and the precipitation less evaporation is 250 mm/year, specify:

1) number and dimensions of the storage tanks,
2) total dynamic head of the pump, and
3) engine size. (1 inch = 2.54 cm)

QUESTION 3 20

A dairy farm wishes to compost the waste generated from the herd in the barn. The farm holds a 500-cow Holstein herd is in the barn for an average of 8 h/d and uses fifty 60-pound bales of straw daily as bedding material. The waste is scraped daily from the barn without extra water addition. Given:

Wheat straw:		**Manure:**	
Moisture content:	15%	Manure production:	60 kg/day/cow
C:N ratio:	80	Moisture content:	85%

Percent nitrogen: 0.67% Nitrogen production: 0.40 kg/day/cow

1) Calculate the moisture content of the mixture.
2) Estimate the C/N ratio of the mixture.
3) Determine the total air requirement for the composting process
4) Comment on the suitability of manure mixture for optimum composting.

QUESTION 4

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A swine CAFO plans to surface apply its liquid manure at a solids content of 5 wt% in the spring to a nearby corn field. The total manure production is 3,000 m^3. At planting time, the field will have been added 20 kg/ha of starter nitrogen to enhance early seedling vigour. The design is to be based on satisfying the nitrogen needs of 160 kg/ha/year for corn crop. The number of application years is to be limited through accumulative addition of 50 kg Zn/ha so that the site can be reclaimed. The following conditions apply:

- manure fertilizer values (kg/ kg-dry solids):
  - organic N = 0.02
  - NH_4 = 0.12
  - NO_3^- = 0
  - P_2O_5 = 0.04
- ammonia volatilization factor after field application = 30%
- organic nitrogen mineralization rate = 40% for 1st year; 20% for 2nd year and subsequent years
- specific gravity of manure = 1000 kg/m^3

Determine:

1) annual application rate per ha,
2) total land area requirement, and
3) useful life of the site for land application if the manure contains 500 mg Zn/kg of dry solids.

For the simplicity, your calculations for questions 1) and 2) may be based only on the second-year manure application rate.

QUESTION 5

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A food processing plant discharges 0.30 mgd wastewater with an average BOD_5 of 500 mg/L. An aerated lagoon is proposed to achieve a minimum BOD_5 reduction by 75%. From completed laboratory biodegradation kinetic studies, the wastewater was shown to have the following characteristics: BOD_5-removal-rate constant, k_{20oC}, = 0.68 per day, θ = temperature correction coefficient = 1.047. The temperature expected in the lagoon ranges from 10°C in winter to 25°C in summer. The surface aerators to be installed carry a manufacturer's specification to transfer 2.5 lb of oxygen/hp-hr under standard conditions.

1) Specify the number, volume and configuration of the aerated lagoons.
2) Calculate the amount of excessive sludge produced and oxygen supply needed per day.
3) Determine the number of 10-hp surface aerators required.

QUESTION 6

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Odour has become one of main complaints from the stakeholders in managing and utilizing animal manures. In particular, composting facilities and land application have become an environmental target by people who have moved from cities to rural areas.

1) List main compounds that cause odour problems.
2) Explain how these odourous compounds are generated.
3) Suggest at least three methods to reduce odour emissions from composting and land application plants. Explain why they work.