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 of Questions 2 to 5. Therefore, you should answer a total of FOUR 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) Water quality guideline vs. criteria
   ii) non-point source pollution
   iii) self-purification capacity
   iv) sludge retention time
   v) engineered wet land
2) Describe at least three potential transformation pathways of nitrogen after applying swine manure to a crop field? 5
3) List at least three advantages and disadvantages between windrow and static pile composting methods. 5
4) A large-scale concentrated poultry operation considers fuel-assisted incineration process to dispose of its deadstock on-site. List two potential environmental risks of this process. For each of these risks, briefly discuss at least two mitigation strategies. 5

ANSWER ANY THREE OF THE FOLLOWING FOUR QUESTIONS.

2. As part of an integrated manure management system, 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, determine:
   1) digester volume and dimensions,
   2) daily biogas production,
   3) digester heating requirements, and
   4) whether the amount of waste heat would be enough to satisfy the digester heating requirements?

3. A dairy farmer wishes to compost the bio-waste generated from the herd in the barn. The 200-cow Holstein herd is in the barn for an average of 6 hours. The average weight of a cow is 1,200 pounds with an average milk production of 75 pounds per day. The waste is scraped daily from the barn and contains straw as a bedding material because it is the cheapest and most abundant source of a high C:N ratio amendment on the farm. Ten 60-pound bales of straw (chopped) are added daily for bedding. No bulking agent and extra water is necessary to improve the compost porosity or structure. The following supporting information is given:

   Wheat straw:
   Moisture content = 15% (estimated)
   C:N ratio = 80
   Percent N = 0.67%

   Manure:
   Number of cows = 200
   Size of cows = 1,200 lb
   Number of AU = 100 × 1,200/1,000 = 120
   Moisture content = 87%

Manure production = 108 lb/d/1,000 lb
Nitrogen production = 0.71 lb/1,000 lb/d
Volatile solids = 11 lb/1,000 lb/d
Fraction in barn = 6 h/24 h = 0.25

1) What amendment(s) would you suggest to satisfy the composting requirements?
2) Calculate the amount of amendment(s) needed per kilogram of manure for a moisture content of the mixture?

4. A meat processing plant intends to use an aerated lagoon to treat its waste water. The wastewater flow is 5 MLD with an average BOD_5 of 400 mg/L. The temperature extremes expected for the lagoon contents range from 10°C in winter to 25°C in summer. Minimum BOD_5 reduction through the lagoon should be 80%. During the laboratory treatability studies, the wastewater was shown to have the following characteristics: BOD_5-removal-rate constant, $k_{20}{}^{\circ}c$=, 0.68 per day, θ = temperature coefficient = 1.037. Determine:

1) volume and dimension of aerated lagoons,
2) amount of oxygen required per hour; and
3) amount and frequency of sludge that must be removed.

5. A swine operation produces 10,000 m^3 of liquid manure at a solids content of 4 wt%. It was recommended that the stored manure is to be subsurface applied in the late spring to a nearby corn field. At the beginning of planting, 15 kilogram per hectare of starter nitrogen must be added to enhance early seedling vigour. Assume the following conditions:
   - Manure fertilizer values: organic N=1.0 kg/m^3, NH_4=0.3 kg/m^3, NO_3^-=0 kg/m^3
   - Organic nitrogen mineralization rate of 40% for the first year, 20% for the second year, 5% for the third and subsequent years.
   - Ammonia volatilization factor after field application = 30%
   - Nitrogen uptake for corn = 120 kg/ha

1) Using the total nitrogen in year 2 as a steady-state value, determine the annual application rate and the land area requirement to satisfy the plant nitrogen requirements.
2) Discuss the potential environmental impacts from the land application of tis manure?