NATIONAL EXAMINATIONS

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. General (answer the following questions CONCISELY)
   a) Explain why pH is a very important factor in predicting the toxic effects of ammonia when the effluents are discharged into water streams. 3

   b) What will the impacts of decreasing temperature be on SRT selection, aeration requirement and sludge production when a conventional activated sludge process is used to treat wastewater? 3

   c) List at least three advantages and disadvantages between aerobic and anaerobic digestion in animal manure management. 3

   d) What are the rationale(s) imposed on the lower and upper limits of flow velocity in pumping liquid manure slurry? 3

   e) List at least three potential concerns when the animal manure is applied on agricultural land. 3

   f) Sketch a typical integrated management system for the generation of animal manure to utilization. For each major component of the system, briefly describe its functions and potential concerns of environmental contamination. 3

   g) Identify at least three types of odour compounds generated from anaerobic digestion of swine manure. For each type of odour compounds, describe at least two mitigation strategies commonly used in practice. 3

   h) Suggest at least two on-farm disposal approaches to properly manage the deadstock from a large-scale concentrated poultry operation. For each approach, list three potential environmental risks and briefly discuss two mitigation strategies. 4

ANSWER ANY THREE OF THE FOLLOWING FOUR QUESTIONS.

2. A concentrated swine operation with 5,000 farrow-to-finish pigs proposes co-anaerobic digestion of its manure with on-farm organic wastes to maximize the energy recovery while stabilizing the manure for agricultural land application. The manure is collected in slurry form with a solid content of 3%. The organic wastes include straw, roughages, food wastes, etc. with a total production of 2,000kg/day. After physical pretreatment and thermal hydrolysis, the organic waste mixture contains 40% total solids, 80% of which is volatile solids. Based on the previous studies, the anaerobic digestors will be operated at 35°C. The biogas from these anaerobic digester(s) is used to run an engine generator. Assume that the dry solid production from the pigs is 1.0 kg/day/pig. As an environmental engineer, you are asked to:
   1) select a proper type of anaerobic digester(s) and provide your justification briefly. 5
   2) determine digester volume and daily biogas production, 15
   3) estimate the volume of digested biomass if it is further concentrated to a total solids content of 50%. 5

3. A food processing plant employs the completely mixed activated sludge process to treat its wastewater. Following data applies:

Feed wastewater to the bioreactor:	
Design flow rate:	10,000 m^3/d
BOD_5:	300 mg/L
TSS:	100 mg/L
VSS:	0 mg/L (simplified for this exam)
NH_4+-N:	40 mg/L
TP	5 mg/L
Temperature:	20 °C
Treated effluent:	
SS:	10 mg/L (85% biodegradable)

Previous pilot testing recommended SRT to be 6 days. Given yield coefficient Y = 0.60 mg VSS/mg BOD_5, maximum substrate utilization rate coefficient k = 5.0 d-1, saturation coefficient K_s = 50 mg/L of BOD_5, decay rate constant b = 0.06 d-1, f_d = 0.15 and other information in the textbook,

1) Calculate effluent BOD_5, 10
2) Determine aeration tank dimension (length. width and depth), daily sludge production rate and oxygen utilization rate, and 10
3) What major facility upgrades would you suggest if ammonia must be removed by at least 95% prior to discharge. 5

4. An agricultural facility produces 10,000 m^3 of liquid manure per year at a solids content of 4 wt%. Recommendation was made to construct uncovered circular concrete tank(s) to store this liquid manure with a maximum storage duration of one year. The diameter of the tanks should be no more than 15 m due to the geological condition. The liquid manure is pumped from the barn to the storage tanks 200m away using a closed impeller centrifugal pump through 8-inch PVC pipes. The elevation of the tank surface is 320.00 m, while the elevation of the manure collection pits at the barn is 330.00 m. The stored manure will be subsurface applied in the late spring to a nearby corn field. At the beginning of planting, 10 kg per hectare of starter nitrogen will be added to enhance early seedling vigour. The following conditions apply for manure land application:

- manure fertilizer values: organic N=1.2 kg/m^3, NH_4=0.3 kg/m^3, NO_3^-=0 kg/m^3
- organic nitrogen 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) Determine the number and dimensions of the storage tanks, 5
2) Calculate total dynamic head of the pump, assuming that the manure friction coefficient f and specific gravity are 0.07 and 1.01, respectively. 10
3) 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. 10

5. A large-scale farm 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 and a temperature of 20°C in the summer.

lagoon effluent: BOD_u = 50 mg/L, DO = 2 mg/L, T = 20°C
upstream river: BOD_u = 2 mg/L, DO = 7 mg/L, T = 20°C
mixed flow: BOD reaction rate coefficient k = 0.15 d^{-1},
reaeration coefficient k_2 = 0.20 d^{-1}(e-based),
saturated DO = 9.1 mg/L.

1) Using Streeter-Phelps equation, determine whether the dissolved oxygen in the downstream river would fall below 5.0 mg/L as required by a regulatory agency. 20
2) What are the basic assumptions underlying this equation in your calculation? 5