National Examinations December 2008

04-Agric-B11, Principles of Waste Management

<u>3 hours Duration</u>

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.
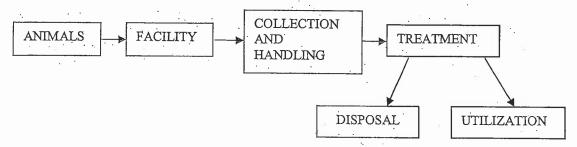
4. Each question is of equal value.

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QUESTION 1: GENERAL

1) Define or describe briefly each of the following terms: 10
   i) TMDL
   ii) buffer strip zone
   iii) BMP
   iv) F/M ratio
   v) SRT

2) The BOD test is accomplished by determining oxygen consumed during microorganism growth on a substrate. List at least three functions of dilution water in the test. 3

3) Identify at least two groups of microorganisms as an indicator of fecal contamination in water and explain why they are selected. 4

4) For each type of aerobic, anoxic and anaerobic processes, list the electron acceptor, important end products, energy source and carbon source for cell synthesis. 4

QUESTION 2 20

An integrated system approach to an animal production and waste management can be described by the following blocks:

You are asked to propose an integrated manure management system for a confined animal operation that has 5000 grower-finisher pigs. The manure is collected in slurry form with a solid content of 5%. Assuming that the dry solid production is 1.2 kg/pig/day,

1) Design a manure storage system with a storage capacity for one year.
2) Proposed and briefly describe at least two integrated systems by incorporating both treatment technologies and disposal/utilization components, and
3) Discuss briefly the potential concerns of environmental contamination from each of two of the proposed management schemes.

QUESTION 3 20

A dairy producer plans to surface apply 1000 m^3 of liquid manure at a solids content of 10 wt% in the spring to a nearby corn field. 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 the nitrogen needs of the corn crop of 160 kg/ha/year. The number of application years is to be limited by accumulative addition of 20 kg Zn/ha so that the site can be reclaimed. Assuming the following conditions,

Manure fertilizer values: organic N = 0.25 kg/m³, NH₄ = 2.0 kg/m³, NO₃⁻ = 0 kg/m³
$$P_2O_5 = 1.0 \text{ kg/m}^3$$
Ammonia volatilization factor after field application = 30%

determine:

1)   the residual nitrogen available from two previous years of manure application. Use an organic nitrogen mineralization rate of 40% for the first year and 20% for the second year.
2)   the annual application rate and the land area requirement, and
3)   the useful life of the site for land application if the manure contains 300 mg Zn/kg of dry solids. Specific gravity of manure = 1000 kg/m³.

For the simplicity, your calculations for questions 2) and 3) may be based only on the second-year application rate.
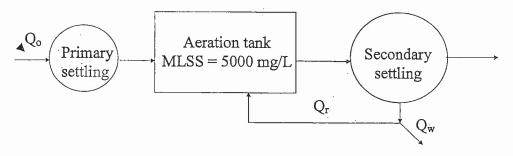

QUESTION 4   20

A cattle farm produces solid manure with a moisture content of 80% and rich in nitrogen (6%). Because of the high moisture and the nitrogen content, it was suggested to add sawdust to reduce the moisture content. The sawdust has a moisture content of 35%, a carbon-to-nitrogen (C/N) ratio of 400:1, and a nitrogen content of 0.10%. If the C/N ratio of the cattle manure is 20:1, calculate

1)   the amount of sawdust needed per kilogram of manure for a moisture content of the mixture to be 60%
2)   what is the corresponding C/N ratio of the mixture?
3)   Comment on the suitability of sawdust-manure mixture for optimum composting.

QUESTION 5   20

Design a single stage, completely mixed activated sludge facility to treat an animal slaughter wastewater of 1,000 m³/d. The influent BOD₅ to the aeration tank is 300 mg/L. Based on previous pilot testing, the sludge retention time was chosen to be 10 d and the MLSS in the aeration tank 5000 mg/L. Assume yield coefficient Y = 0.60 mg VSS/mg BOD, decay rate constant k_d = 0.06 d⁻¹, saturation coefficient K_s = 60 mg/L of BOD₅, maximum substrate utilization rate coefficient k = 5.0 d⁻¹, maximum specific growth rate coefficient μ_m = 3.0 d⁻¹, MLVSS/MLSS = 0.8, total suspended solids in secondary clarifier underflow X_u = 2.0%.

Determine effluent BOD$_5$, aeration tank size, daily sludge production and oxygen utilization rate.

QUESTION 6   20

A large-scale hog farm proposes to discharge its lagoon effluent into a nearby river. The main characteristics of the river water and lagoon effluent are:

upstream river: ultimate BOD$_L$=2 mg/L, actual DO=8 mg/L, flow rate = 100 m^3/h

lagoon effluent: ultimate BOD$_L$ =200 mg/L, actual DO=1 mg/L, flow rate = 10 m^3/h

You may also assume that after discharge, the saturated dissolved oxygen in the river is 9 mg/L and the temperature remains 20°C. The BOD exertion rate constant K and the reaeration rate constant K$_2$ are 0.15 d^{-1} and 0.20 d^{-1} (e-based), respectively.

1)   Determine the location of the critical point on the oxygen sag curve and the minimum DO in the river.

2)   If the photosynthesis from algae growth occurs at the critical point, qualitatively describe the diurnal variation in term of dissolved and pH.