National Examinations, May 2002

98-Env-B7, Agricultural 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 clean statement of any assumptions made.
2. This is an open-book exam.
3. Any non-communicating calculator is permitted
4. Do 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 the first four of them will be marked.
5. All the questions are of equal value (25% of the total mark for each question).

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## QUESTION 1: GENERAL

a) Define or describe briefly each of the following terms: 10

i) eutrophication
ii) breakpoint chlorination
iii) denitrification
iv) autothermal aerobic digestion
v) buffer strip practice

2) The BOD test is accomplished by determining oxygen consumed during microorganism growth on a substrate. Sketch the dissolved oxygen utilization rate versus time under the following conditions: 6

ii) normal food processing wastewater
iii) toxic material in raw domestic sewage
iv) the use of unacclimated seeds

3) Which criterion would you use to determine whether the sources of contamination results from human feces or animal feces? 2

4) For the discrete settling in an ideal sedimentation tank, what will be the effect on particle removal efficiency by using different tank depths? 2

5) From the energy requirement for cell synthesis, explain why anaerobic processes are usually well suitable for manure digestion as compared to aerobic processes. 2

6) A completed mixed activated sludge bioreactor with a volume of 1000 L receives a flow of 100 L/hr. 90% of the effluent exits through a biomass separator which removes all particulate material and returns all the settled sludge to the bioreactor. The remaining 10% exits directly from the bioreactor. What is the mean cell residence time? 3

## QUESTION 2

A 1,000 capacity grower-finisher pig farm plans to store its liquid manure into an uncovered earthen circular lagoon with a freeboard of 0.7m and a storage capacity of one year. The stored liquid manure is then transferred 2-km from the lagoon to the crop field for land application using a closed impeller centrifugal pump through 8-inch PVC pipes at a flowrate of 0.02 $m^3/s$. Pivot nozzles are located 3m above the field surface. The elevation of the lagoon surface is 520.00m, while the elevation of the field is 550.00m. 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, the liquid manure contains 5% by weight of solids and the net precipitation is 500 mm/year, specify:

1) the volume of liquid manure per year,

2) the dimensions of the storage lagoon, and

3) the total dynamic head of the pump to achieve the discharge pressure at the end of pivot nozzle of 550 kPa. Ignore the effects of minor headloss.

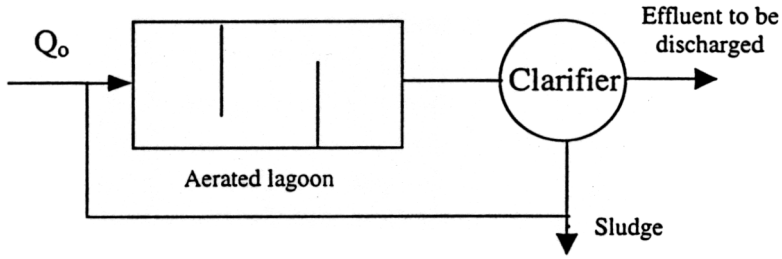
## QUESTION 3

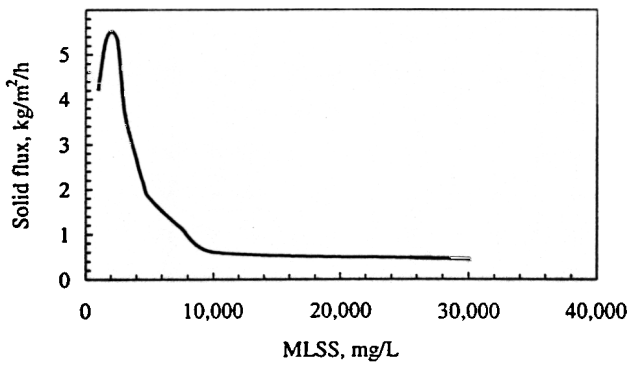
A poultry processing plant plans to treat its wastewater using a three-stage aerated lagoon, followed by a settling basin for the removal of solids as shown below. Assume the following conditions and requirements apply:

Plant wastewater treatment capacity = 10,000 $m^3/d$
Lagoon influent soluble $BOD_5$ = 250 mg/L
Lagoon influent SS = 250 mg/L, of which 65% is biodegradable
Lagoon effluent $BOD_5$ = 20 mg/L or less after settling
Lagoon effluent SS = 20 mg/L or less after settling
$BOD_5$ removal rate = 0.3 $d^{-1}$
Mixed liquor volatile suspended solids/Mixed liquor suspended solids = 0.8
60% of mixed liquor suspended solids is biodegradable

1) Determine the total volume of the aeration lagoon, daily sludge production, and oxygen uptake rate required in the aerated lagoon.

2) If the underflow concentration of suspended solids is required to be 12,000 mg/L and a scale-up factor of 1.5 is to be used for the solids flux value, determine the clarifier area. Use the attached solid flux curve from a series of batch tests.




## QUESTION 4

A dairy producer plans to surface apply 2000 $m^3$ 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 180 kg/ha-year and is to be limited by accumulative zinc addition of 30 kg Zn/ha for the length of application time so that the site can be used. Assuming the following conditions,

Manure fertilizer values: organic N = 0.25 kg/m$^3$, $NH_4$ = 1.0 kg/m$^3$, $NO_3^-$ = 0 kg/m$^3$
$P_2O_5$ = 1.5 kg/m$^3$
Ammonia volatilization factor after field application = 30%
Nitrogen uptake for corn = 120 kg/ha

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/m$^3$.

For the simplicity, all your calculations may be based only on the second-year application rate.

## QUESTION 5

As a consulting engineer, you are hired to determine the effluent treatment efficiency for a large-scale hog farm whose lagoon effluent is currently discharged continuously into a nearby river. The river has a minimum flowrate of 100 m$^3$/h while the lagoon effluent flow is 10 m$^3$/h. Other characteristics of the river stream and lagoon effluent are:

upstream river: ultimate $BOD_L$=3 mg/L, actual DO=8 mg/L
lagoon effluent: ultimate $BOD_L$ =200 mg/L, actual DO=2 mg/L

You may also assume that after confluence, the river temperature remains 20°C and saturated dissolved oxygen is 10 mg/L. The BOD exertion rate constant K and reaeration rate constant $K_2$ are 0.15 d$^{-1}$ and 0.20 d$^{-1}$ (e-based), respectively.

Provide the efficiency required in a treatment process required to meet an anticipated regulatory requirement of minimum dissolved oxygen (DO) in the downstream river of 6.0 mg/L.