The Design of Wastewater-fed Fishponds: A Summary

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Design procedure

1. Design an anaerobic pond and a secondary facultative pond in the usual way.[1] The fac. pond effluent feeds the fishpond.

2. Determine the total nitrogen concentration in the fac. pond effluent (C_{TNfe}, mg/l) using Reed's equation[2] and assuming there is no TN removal in the anaerobic pond:

$$C_{TNe} = C_{TNi}\, e^{-[0.0064(1.039)^{T-20}][\theta_f + 60.6(pH-6.6)]}$$

3. Design the fishpond to receive a TN surface loading of 4 kg/ha day:

$$A_{fp} = \frac{10 C_{TNfe} Q}{4} \text{ m}^2$$

where Q is the wastewater flow, m^3/day.

$$\theta_{fp} = \frac{2 A_{fp} D_{fp}}{2Q - 0.001 e A_{fp}}$$

where D_{fp} is the fishpond depth (usually 1 m), and e is the net evaporation (= evaporation − rainfall), mm/day.

4. Check the *E. coli* count in the fishpond (N_{fp}, per 100 ml):

$$N_{fp} = \frac{N_{fp}}{(1 + K_{B(T)}\theta_a)(1 + K_{B(T)}\theta_f)(1 + K_{B(T)}\theta_{fp})}$$

where $K_{B(T)} = 2.6(1.19)^{T-20}$

- N_{fp} must be ≤1000 per 100 ml.[3]

5. Check the concentration of free ammonia (i.e., dissolved NH_3 gas) in the fishpond:

(a) Calculate the total ammonia (i.e., $NH_3 + NH_4^+$) concentration in the fac. pond effluent (C_{TAf}, mg/l), assuming that the anaerobic pond effluent has a "worst case" total ammonia concentration equal to 75% of the TN concentration in the raw wastewater (because of

ammonification − conversion of organic N to ammonia − in the anaerobic pond), using the Pano and Middlebrooks equation:[4]

$$C_e = \frac{C_i}{1 + [5.035 \times 10^{-3}(A_f / Q)e^{1.54(pH - 6.6)}]}$$

(b) Using the same equation determine the total ammonia concentration in the fishpond, C_{TAfp} (mg/l).

(c) Determine the percentage *p* of total ammonia present as free ammonia, using the equations:[5]

$$p = \frac{100}{10^{(pK_a - pH)} + 1}$$

where $pK_a = 0.09018 + \frac{2729.92}{T}$

T = absolute temperature in degrees Kelvin (K = °C + 273)

(d) Determine the concentration of free ammonia in the fishpond:

$$C_{NH_3fp} = \left(\frac{p}{100}\right) C_{TAfp}$$

- C_{NH_3fp} must be ≤0.5 mg N/l to avoid ammonia toxicity to the fish.

References

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4. Pano, A. and Middlebrooks, E. J. (1982). Ammonia nitrogen removal in facultative waste stabilization ponds. *Journal of the Water Pollution Control Federation* **54** (4), 344–351.
5. Emerson, K., Russo, R. C., Lund, R. E. and Thurston, R. T. (1975). Aqueous ammonia equilibrium calculations: effect of pH and temperature. *Journal of the Fisheries Research Board of Canada* **32** (12), 2379–2383.