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Master's Comprehensive Exam
CEE 211B: Environmental Biological Processes
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TreesToPoles Industries is a company that produces telephone poles and generates significant amounts of hazardous waste containing pentachlorophenol (PCP, an agent used as a wood preservative on the poles). This company sends the major portion of the spent PCP to be incinerated in Utah but is left with wastewater containing dilute amounts of the toxic material. As the resident environmental engineer, you have decided to treat the wastewater containing 15 mg/l PCP by aerobic biodegradation in a two stage reactor, a CMFR followed by a PFR. The first stage and second stage have detention times of 6 hours and 2 hours respectively. The first stage is aerated to promote oxygen transfer into solution for degradation of the PCP. An unfortunate side effect of the aeration is stripping of the PCP from the CMFR which occurs at a rate of:

$$r_{st} = -k_{st}(C - C_g^*)$$

Where C and C_g^* represent the PCP concentrations in the liquid and equilibrium gas phases respectively. The degradation rate of PCP in both reactors can be expressed by:

$$r_d = -k_m \frac{XC}{K_s}$$

Since PCP can be used as a primary substrate by the microbial population, the microbial growth rate can be expressed as:

$$r_X = -r_d Y - bX$$

Assume that the air movement above the CMFR is fast enough to set $C_g^* = 0$, and that although there are no cells in the influent flow, cell growth has reached steady-state within the reactors (think about why this is possible). Given the following parameters:

$$\begin{aligned} k_{st} &= 10 \text{ d}^{-1} \\ k_m &= 2 \text{ d}^{-1} \\ K_s &= 0.25 \text{ mg/l} \\ Y &= 0.8 \text{ g/g} \\ b &= 0.1 \text{ d}^{-1} \end{aligned}$$

- a) Calculate the PCP concentration in the CMFR effluent liquid.
- b) Calculate the cell concentration within the CMFR.
- c) Making the conservative assumption that the cell concentration remains constant in the PFR (i.e., degradation occurs with no cell growth or decay), calculate the PFR effluent PCP concentration (remember there is no stripping in the second stage).
- d) What are two major advantages of placing the CMFR before the PFR?