

CE 641 FATE AND TRANSPORT MODELING OF ECOSYSTEMS

Eutrophication Analysis

1. A waste source with a flow of $10^5 \text{ m}^3/\text{day}$, a dissolved phosphorus concentration of 0.1 mg/L , and a dissolved nitrogen concentration of 10 mg/L discharges into a river with an upstream flow of $10^6 \text{ m}^3/\text{day}$ and upstream concentration of 0.002 mg P/L and 0.3 mg N/L . The uptake rate of the phosphorus in the river is 0.1 day^{-1} and of the nitrogen is 0.3 day^{-1} . Assume that the half-saturation constant for phosphorus is 0.002 mg P/L and for nitrogen is 0.01 mg N/L . Which nutrient is controlling the growth rate of phytoplankton at a travel time of 10 days?

2. Given the following stream:

Flow	
Upstream	12 cfs
Wastewater Treatment Plant	0.3 MGD
Stream	
Depth	2.2 ft
Velocity	0.4 ft/s
Temperature	25°C
Sunlight – daily radiation	600 langley/day
Photoperiod	0.5
Light extinction coefficient in stream	0.33 ft^{-1}
Chlorophyll <i>a</i> - upstream @ $x = 0$	26 $\mu\text{g/L}$
Net settling velocity	0.33 ft/day
Inorganic phosphorus concentration	
Upstream of $x = 0$	0.02 mg/L
Phytoplankton Growth/Death	
Phytoplankton maximum growth rate	1.8 day^{-1}
Temperature effect of growth rate, θ	1.066
Phytoplankton light saturation level	300 langley/day
Phytoplankton respiration rate	0.1 day^{-1}
Temperature effect of respiration rate, θ	1.08

- (a) Calculate the net phytoplankton growth rate (day^{-1}) assuming no nutrient limitation
- (b) Calculate the maximum possible phytoplankton concentration (in $\mu\text{g/L}$ of chlorophyll *a*) in the tributary @ $x = 20$ miles downstream [assuming no nutrient limitation]
- (c) For an inorganic phosphorus in the wastewater treatment plant effluent of 1 mg/L , check if phosphorus will limit the algal growth in this 20-mile tributary and if so, what the phytoplankton concentration (in $\mu\text{g/L}$ of chlorophyll *a*) would be in the that case? The phosphorus to chlorophyll *a* ratio in the algal biomass is $1 \mu\text{g P}/\mu\text{g Chl}a$. When the inorganic phosphorus concentration drops below $25 \mu\text{g/L}$ in the 20-mile tributary, the algal growth would be limited.

