Updated: 30 October 2017

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CEE 577: Surface Water Quality Modeling

Lecture #19
Streeter-Phelps: Nitrogen, Photosynthesis/Respiration
(Chapra, L23, L24)

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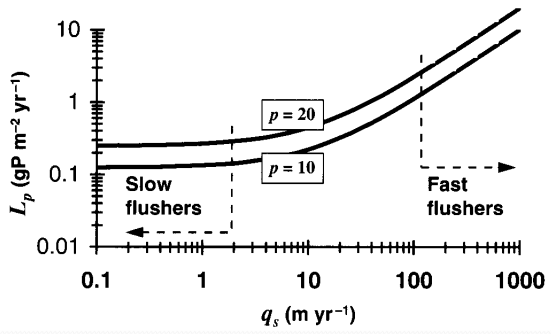
Loading & Overflow Model

$$P = \frac{L}{11.6 + 1.2q_s}$$



From Chapra (pg 538)

Extended Streeter Phelps

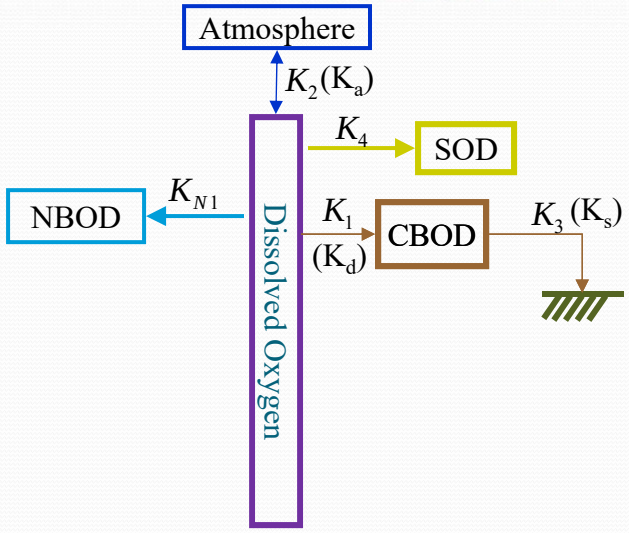
$$D = \underbrace{D_o e^{-k_a t}}_{\#1} + \underbrace{\frac{k_d L_o}{k_a - k_r}\left(e^{-k_r t} - e^{-k_a t}\right)}_{\#2} + \underbrace{\frac{k_n L_{No}}{k_a - k_n}\left(e^{-k_n t} - e^{-k_a t}\right)}_{\#3}$$

$$\#4 \quad + \frac{-P + R + \left(S_B^{'}/H\right)}{k_a}\left(1 - e^{-k_a t}\right)$$

$$\#5 \quad + \frac{k_d S_d}{k_r k_a}\left(1 - e^{-k_a t}\right) - \frac{k_d S_d}{k_r\left(k_a - k_r\right)}\left(e^{-k_r t} - e^{-k_a t}\right)$$

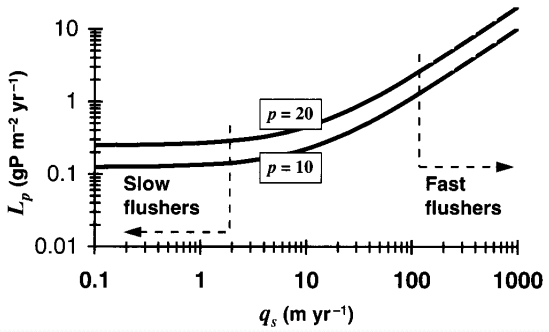
$$\#6 \quad + \frac{k_n S_{Nd}}{k_n k_a}\left(1 - e^{-k_a t}\right) - \frac{k_n S_{Nd}}{k_n\left(k_a - k_n\right)}\left(e^{-k_n t} - e^{-k_a t}\right)$$

General Model Kinetics



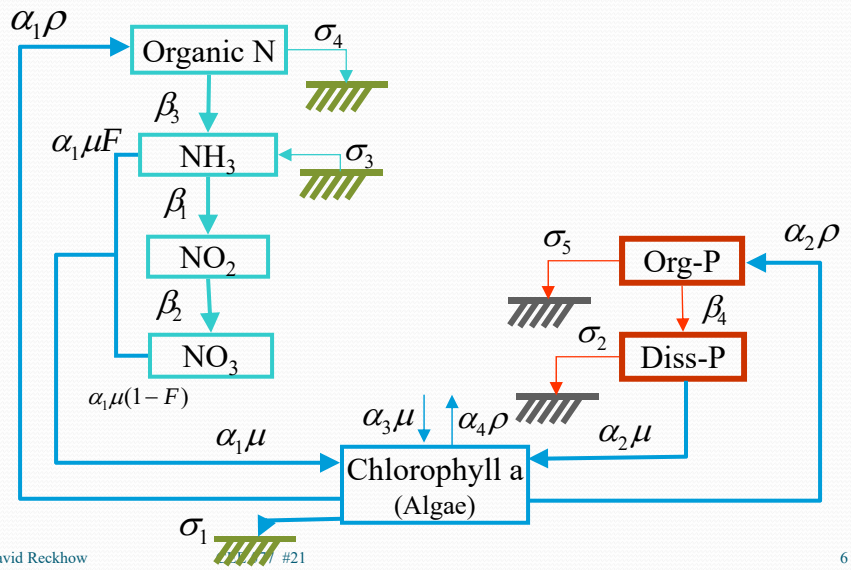
Loading & Overflow Model

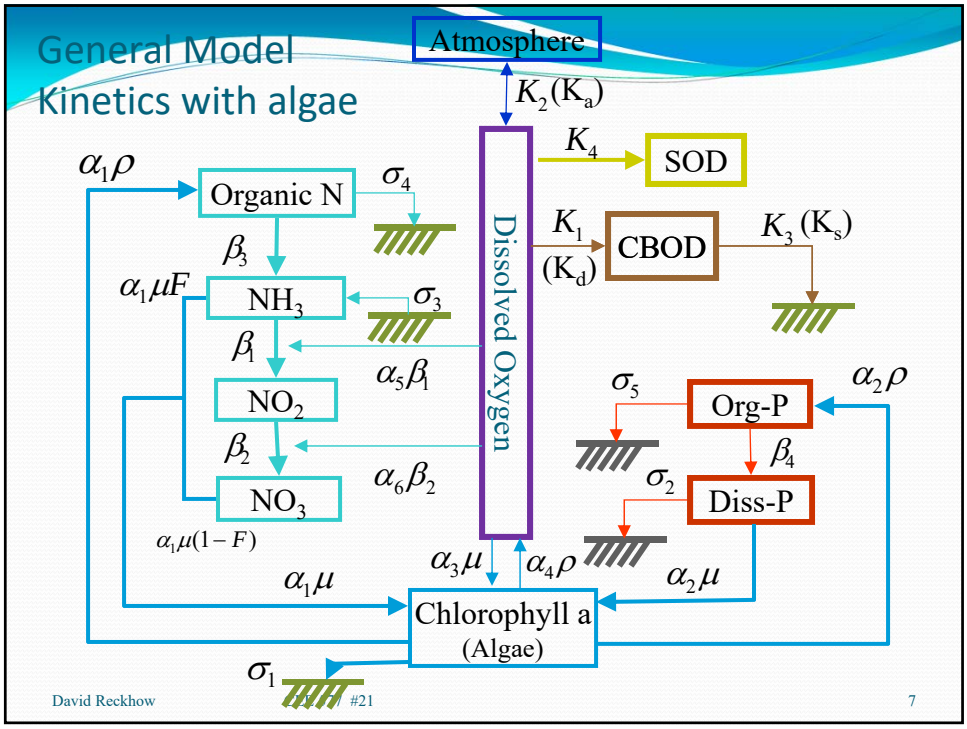
$$P = \frac{L}{11.6 + 1.2q_s}$$



From Chapra (pg 538)

Mechanistic Algal Model




General Model
Kinetics with algae
Atmosphere
$K_2(K_a)$
Dissolved Oxygen
K_4
SOD
K_1
(K_d)
CBOD
$K_3(K_s)$
$\alpha_1\rho$
Organic N
σ_4
β_3
$\alpha_1\mu F$
NH_3
σ_3
β_1
$\alpha_5\beta_1$
NO_2
β_2
$\alpha_6\beta_2$
NO_3
$\alpha_1\mu(1-F)$
σ_5
Org-P
$\alpha_2\rho$
β_4
σ_2
Diss-P
$\alpha_3\mu$
$\alpha_4\rho$
$\alpha_2\mu$
$\alpha_1\mu$
Chlorophyll a
(Algae)
σ_1
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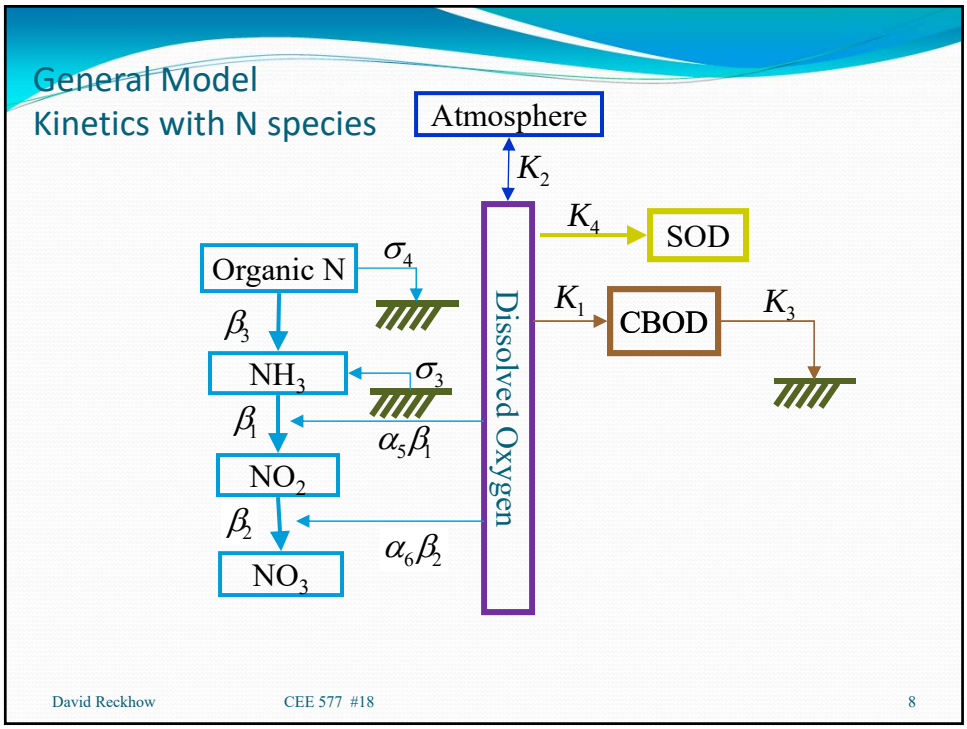
General Model
Kinetics with N species
Atmosphere
K_2
Dissolved Oxygen
K_4
SOD
K_1
CBOD
K_3
Organic N
σ_4
β_3
NH_3
σ_3
β_1
$\alpha_5\beta_1$
NO_2
β_2
$\alpha_6\beta_2$
NO_3
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Nitrogen Modeling

- Organic Nitrogen (N_4)

$$\frac{dN_4}{dt} = \alpha_1 \rho A - \beta_3 N_4 - \sigma_4 N_4$$

Org-N settling rate (d^{-1})

Fraction of algal biomass which is nitrogen (mg-N/mg-A)

Algal respiration rate (d^{-1})

Algal biomass (mg/L)

Org-N hydrolysis rate (d^{-1})

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Nitrogen Modeling (cont.)

- Ammonia Nitrogen (N_1)

$$\frac{dN_1}{dt} = \beta_3 N_4 - \beta_1 N_1 + \sigma_3 / z - F_1 \alpha_1 \mu A$$

Benthos release rate (g-N/m^2/d)

Specific Algal growth rate (d^{-1})

Org-N hydrolysis rate (d^{-1})

Rate of biological oxidation of ammonia (d^{-1})

Fraction of algal-N uptake from ammonia

Fraction of algal biomass which is nitrogen (mg-N/mg-A)

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Nitrogen Modeling (cont.)

- Nitrite (N_2)

$$\frac{dN_2}{dt} = \beta_1 N_1 - \beta_2 N_2$$

Rate of biological oxidation of ammonia (d^{-1})

Rate of biological oxidation of nitrite (d^{-1})

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Nitrogen Modeling (cont.)

- Nitrate (N_3)

$$\frac{dN_3}{dt} = \beta_2 N_2 - (1 - F_1)\alpha_1 \mu A$$

Specific Algal growth rate (d^{-1})

Rate of biological oxidation of nitrite (d^{-1})

Fraction of algal-N uptake from ammonia

Fraction of algal biomass which is nitrogen (mg-N/mg-A)

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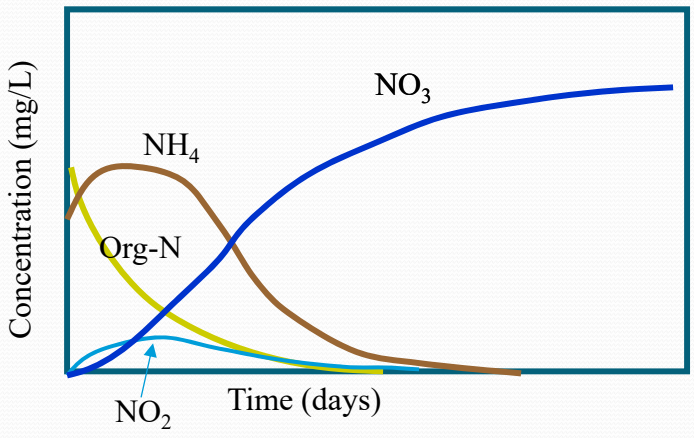
Nitrogen Modeling (cont.)



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Nitrogen Modeling (cont.)

- Inhibition of Nitrification at low D.O.

$$CORDO = 1 - e^{-KNITRF*D.O.}$$ EPA

Nitrification correction factor

Nitrification inhibition coefficient (0.6-0.7 L/mg)

$$f_{nitr} = 1 - e^{-k_{nitr}o}$$ Chapra

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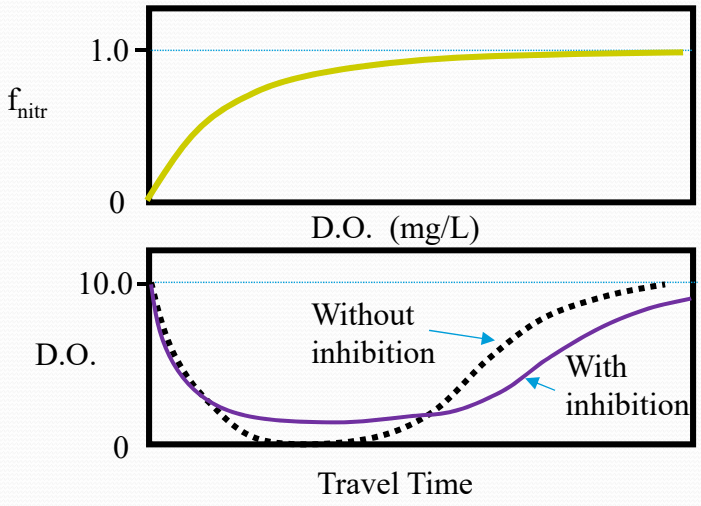
Impact of nitrification inhibition



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- To next lecture

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