

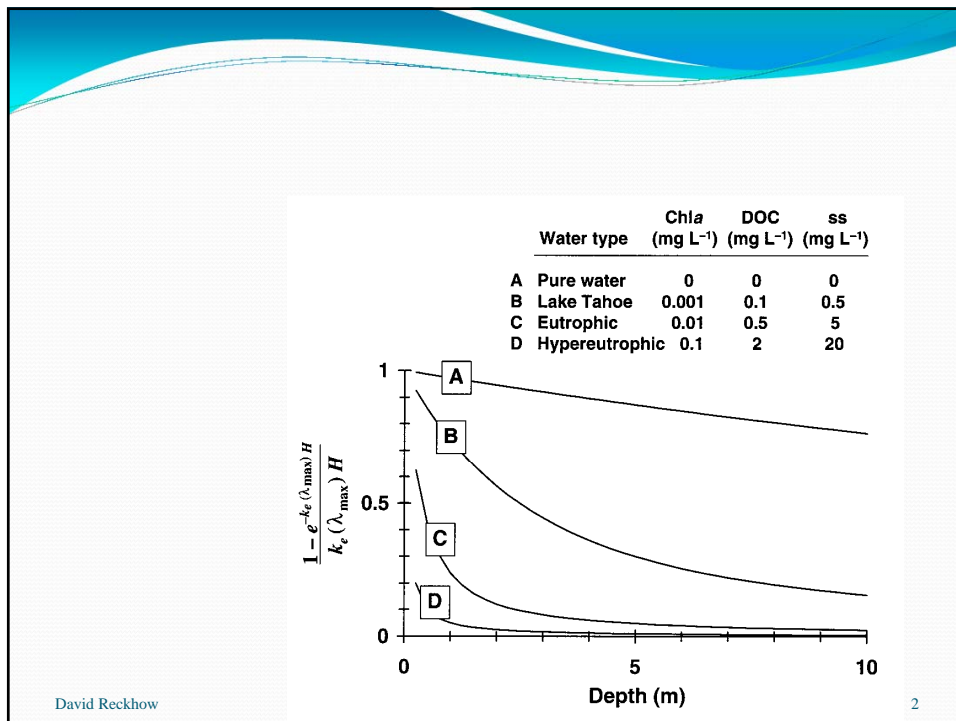
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CEE 577: Surface Water Quality Modeling

Lecture #34

Toxics: Hydrolysis and Biodegradation:
Recapitulation and Simplified Forms
(Chapra, L42, L43 & L44)

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Biotransformation

- Microbially mediated transformation of organic and inorganic contaminants
- Biochemical processes:
 - Metabolism: toxicant is used for synthesis or energy
 - Cometabolism: not “used”, but transformed anyway
- Chemical Effects:
 - Detoxication: Toxic to Non-toxic
 - mineralization
 - Activation: Non-toxic to Toxic

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Bio kinetics

- Michaelis-Menten equation:
 - μ_{\max} = maximum growth rate (yr^{-1})
 - X = microbial biomass (#cells/ m^3)
 - Y = yield coefficient (cells produced per mass toxicant removed, #cells/ μg)
 - k_s = half-saturation constant ($\mu\text{g}/\text{m}^3$)
 - k_b = rate of biotransformation (yr^{-1})
- If $c \ll k_s$, then:

$$k_b = \frac{\mu_{\max} X}{Y(k_s + c)}$$

$$k_b = \frac{\mu_{\max} X}{Yk_s} = k_{b2} X$$

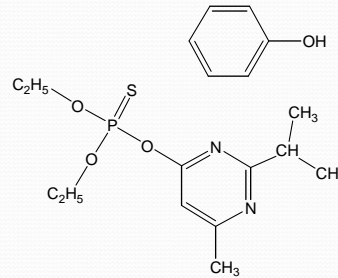
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Bio kinetics (cont.)

- Wide environmental range
 - phenol: $k_b=4.0 \text{ d}^{-1}$
 - diazinon: $k_b=0.016 \text{ d}^{-1}$
- Temperature correction
 - $\theta=1.04-1.095$



$$(k_b)_T = (k_b)_{20} \theta^{T-20}$$

Hydrolysis

- Reaction with water and its constituents

- H_2O $k_h = k_n$

- OH^- $k_h = k_b [\text{OH}^-]$

- H^+ $k_h = k_a [\text{H}^+]$

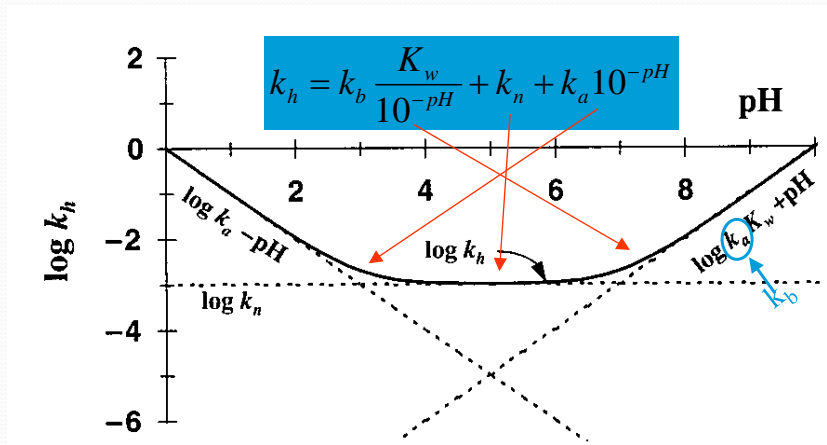
- Autodissociation $K_w = [\text{OH}^-][\text{H}^+]$

- Combining: $k_h = k_b [\text{OH}^-] + k_n + k_a [\text{H}^+]$

- or:

$$k_h = k_b \frac{K_w}{10^{-\text{pH}}} + k_n + k_a 10^{-\text{pH}}$$

Graphic Representation



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Special Considerations for Metals

- In general they are not subject to decomposition
 - e.g., biodegradation, hydrolysis, photolysis
 - exception: radionuclides undergo radioactive decay
- Most do not volatilize (Hg is an exception)
- They speciate into many forms which differ in toxicity and behavior
- Natural background and non-point loadings may be quite high

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- To next lecture

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