The impacts of low O$_2$ in water

- Channel catfish mortality due to low dissolved oxygen.
- From: Auburn University, school of fisheries
Dissolved Oxygen (D.O.)

- Oxygen is a rather insoluble gas, and as a result it is often the limiting constituent in the purification of wastes and natural waters. Its solubility ranges from 14.6 mg/l at 0°C to about 7 mg/l at 35°C. In addition to temperature, its solubility varies with barometric pressure and salinity. The saturation concentration of oxygen in distilled water may be calculated from the following empirical expression:

\[
C_s = C_{sl} \left( \frac{1 - P_{vw}/P}{1 - \theta P} \right) \frac{(1 - \theta P)}{(1 - P_{vw})(1 - \theta)}
\]

where:

- \( P_{vw} \) = water vapor partial pressure (atm) 
  = 11.8571 - (3840.70/T_k) + (216,961/T_k^2)
- \( P \) = total atmospheric (barometric) pressure (atm), which may be read directly or calculated from a remote reading at the same time from:
  = \( P_o - (0.02667)\Delta H/760 \)
- \( \Delta H \) = Difference in elevation from the location of interest (at \( P \)) to the reference location (at \( P_o \)) in feet.
DO (cont.)

\[ \text{P}_o = \text{Simultaneous barometric pressure at a nearby reference location} \]
\[ \theta = \text{pressure/temperature interactive term} \]
\[ \theta = 0.000975 - (1.426 \times 10^{-5} T) + (6.436 \times 10^{-8} T^2) \]
\[ T = \text{Temperature in degrees centigrade} \]
\[ C_{s1} = \text{Saturation concentration of oxygen in distilled water at 1 atmosphere total pressure.} \]
\[ \ln(C_{s1}) = -139.34411 + (1.575701 \times 10^5/T_k) - (6.642308 \times 10^7/T_k^2) + (1.243800 \times 10^{10}/T_k^3) - (8.621949 \times 10^{11}/T_k^4) \]
\[ T_k = \text{Temperature in degrees Kelvin (Tk} = T + 273.15) \]

DO temperature profile

DO Temperature Profile

Oxygen and aquatic systems


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DO (cont.)

- Minimum concentration is required for the survival of higher aquatic life
  - larval stages of certain cold-water fishes are quite sensitive
- Significant discharges of organic wastes may depress the D.O. concentrations in receiving waters
  - microbially-mediated oxidation
  - each state has established ambient dissolved oxygen standards
- Another use of D.O. is the assessment of oxidation state in groundwaters and sediments

DO (cont.)

- also a very important parameter in biological treatment processes
  - indicate when aerobic and anaerobic organisms will predominate
  - used to assess the adequacy of oxygen transfer systems
  - indicate the suitability for the growth of such sensitive organisms such as the nitrifying bacteria.
- used in the assessment of the strength of a wastewater through either the Biochemical Oxygen Demand (BOD) or respirometric studies.
Dissolved Oxygen

Solutions

- reduction of BOD by biological WW treatment
- nutrient control

 Ambient Water Quality Criteria

- established by EPA in "Gold Book"
- dependent on type of fish, averaging period

 Ambient Water Quality Standards [enforceable]

- established by states, and other local agencies
- dependent on use classification

Oxygen Demand

- It is a measure of the amount of “reduced” organic and inorganic matter in a water
- Relates to oxygen consumption in a river or lake as a result of a pollution discharge
- Measured in several ways
  - BOD - Biochemical Oxygen Demand
  - COD - Chemical Oxygen Demand
  - ThOD - Theoretical Oxygen Demand
BOD: A Bioassay

Briefly, the BOD test employs a bacterial seed to catalyze the oxidation of 300 mL of full-strength or diluted wastewater. The strength of the un-diluted wastewater is then determined from the dilution factor and the difference between the initial D.O. and the final D.O.

\[ BOD_t = DO_i - DO_f \]

Chapra’s Glucose example

\[ C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O \]
BOD with dilution
When BOD > 8mg/L

\[ \text{BOD}_t = \frac{\text{DO}_i - \text{DO}_f}{\left( \frac{V_s}{V_b} \right)} \]

Where

- \( \text{BOD}_t \) = biochemical oxygen demand at \( t \) days, [mg/L]
- \( \text{DO}_i \) = initial dissolved oxygen in the sample bottle, [mg/L]
- \( \text{DO}_f \) = final dissolved oxygen in the sample bottle, [mg/L]
- \( V_b \) = sample bottle volume, usually 300 or 250 mL, [mL]
- \( V_s \) = sample volume, [mL]

BOD - loss of biodegradable organic matter (oxygen demand)

\[ L_0 - L_t = \text{BOD}_t \]

When \( BOD > 8 \text{mg/L} \)

\[ \text{BOD} - \text{loss of biodegradable organic matter} \]

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The BOD bottle curve

- \( L = \) oxidizable carbonaceous material remaining to be oxidized

\[
BOD_t \equiv y_t = L_o - L_t
\]

- To next lecture