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CEE 577: Surface Water Quality Modeling

Lecture #12

BOD and Oxygen Saturation

(Chapra, L19)

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 its 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:

DO saturation formula

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

Overkill !

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:
= $P_o - (0.02667)\Delta H/760$

ΔH = Difference in elevation from the location of interest (at P) to the reference location (at P_o) in feet.

DO (cont.)

P_o = Simultaneous barometric pressure at a nearby reference location

θ = pressure/temperature interactive term

= $0.000975 - (1.426 \times 10^{-5} T) + (6.436 \times 10^{-8} T^2)$

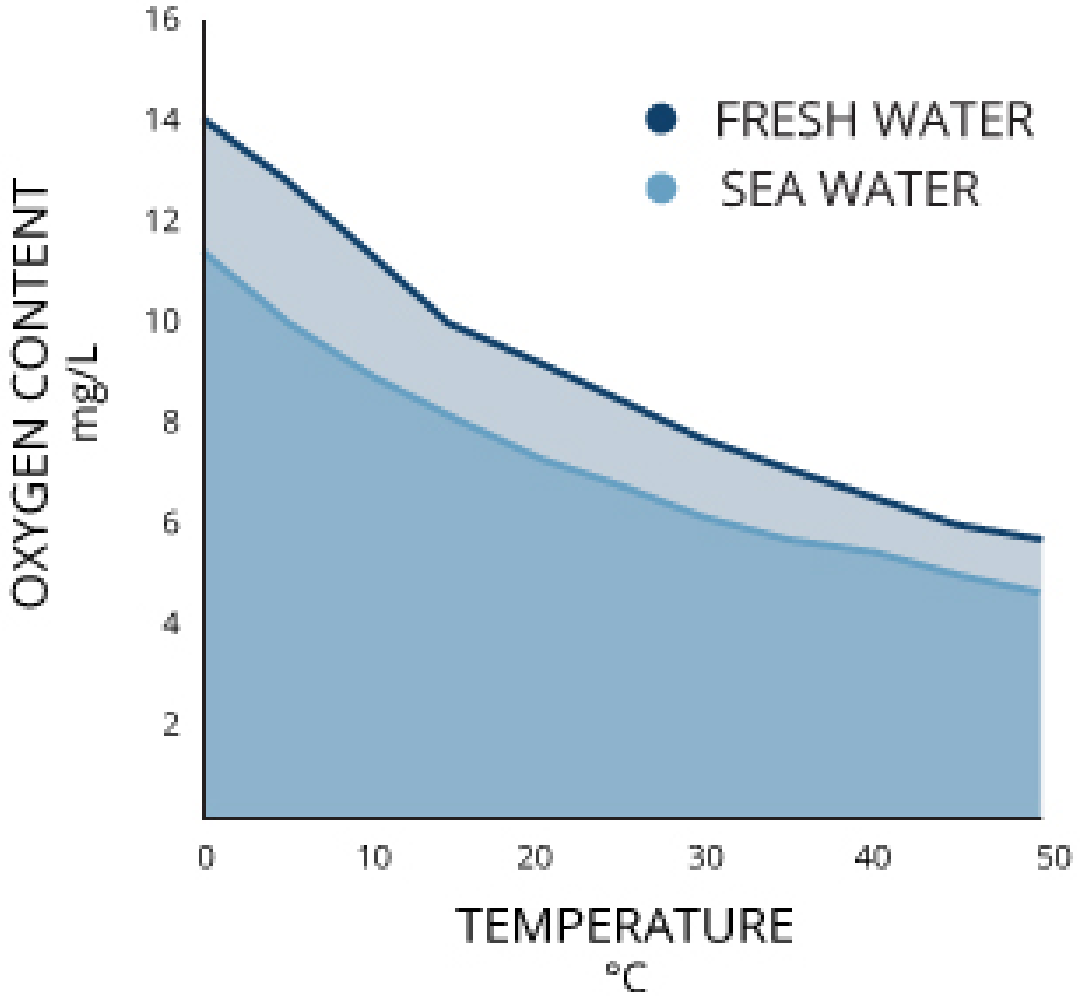
T = Temperature in degrees centigrade

C_{s1} = Saturation concentration of oxygen in distilled water at 1 atmosphere total pressure.

$\ln(C_{s1}) = -139.34411 + (1.575701 \times 10^5 / T_k) - (6.642308 \times 10^7 / T_k^2) + (1.243800 \times 10^{10} / T_k^3) - (8.621949 \times 10^{11} / T_k^4)$.

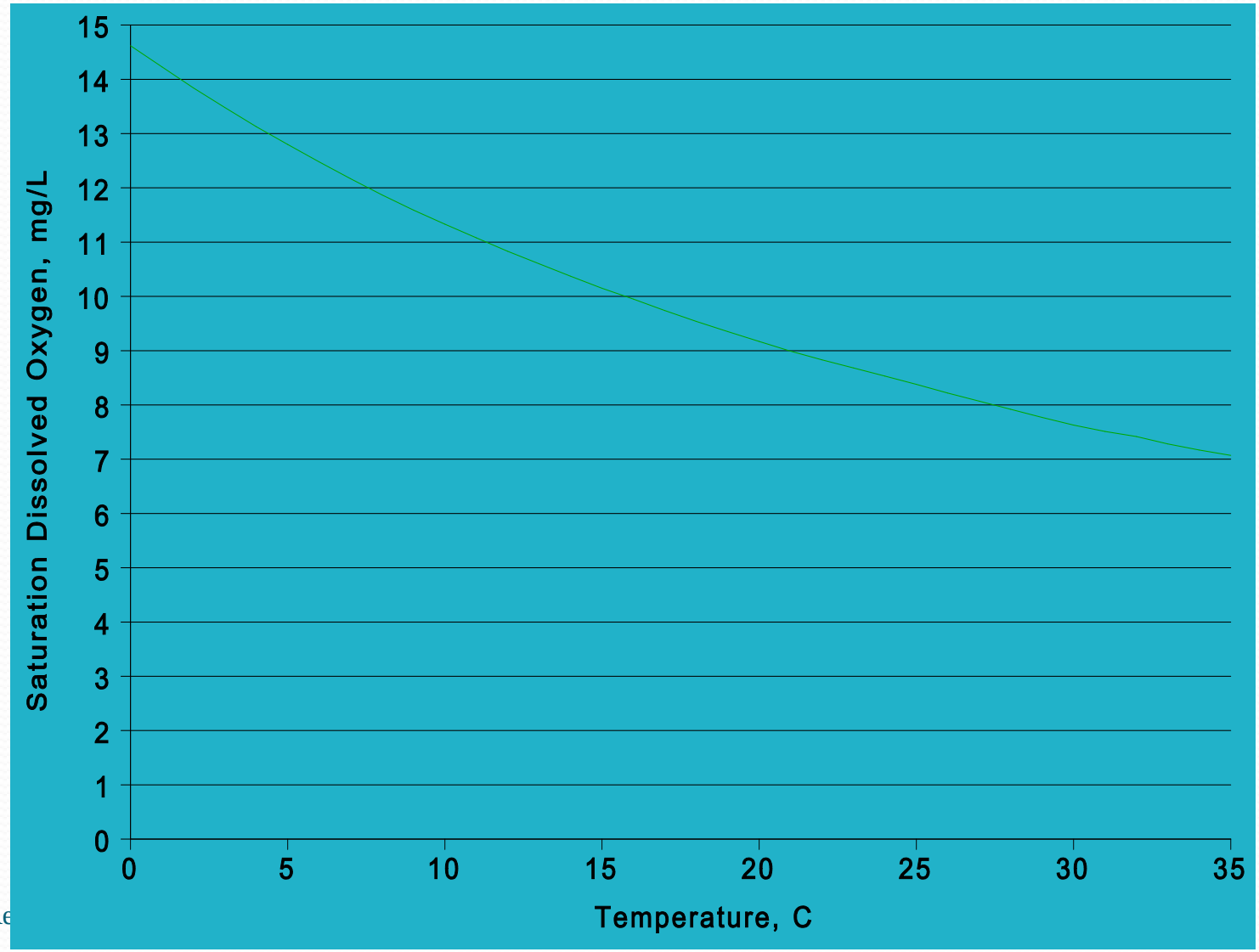
T_k = Temperature in degrees Kelvin ($T_k = T + 273.15$)

DO temperature profile

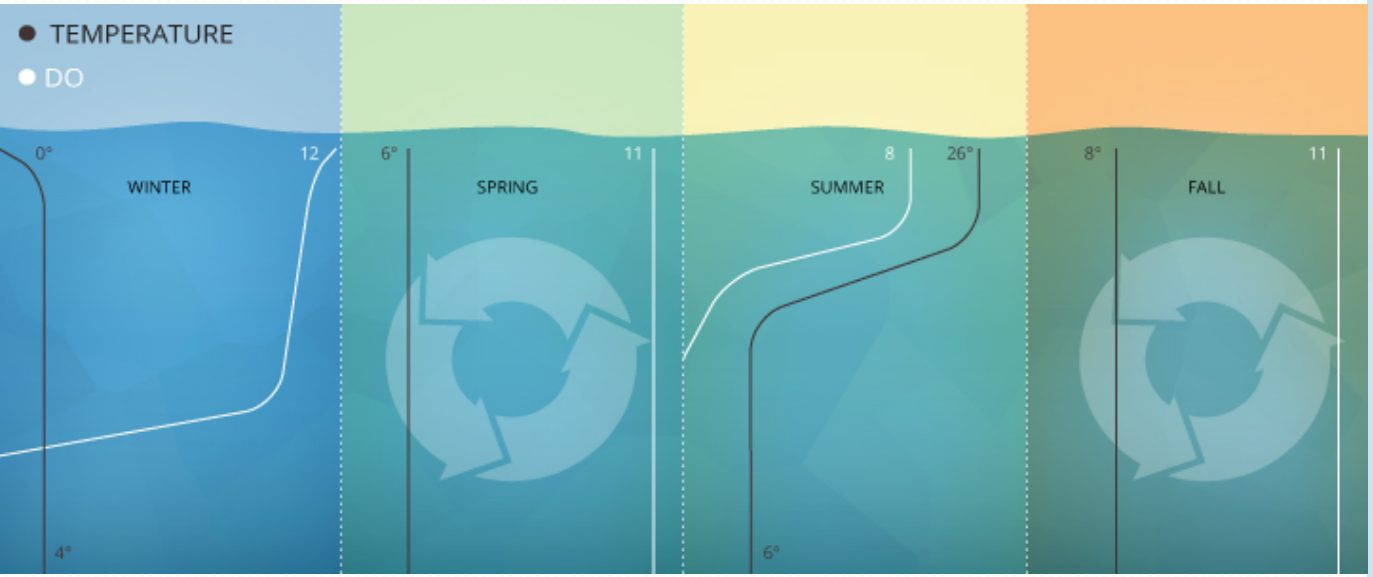


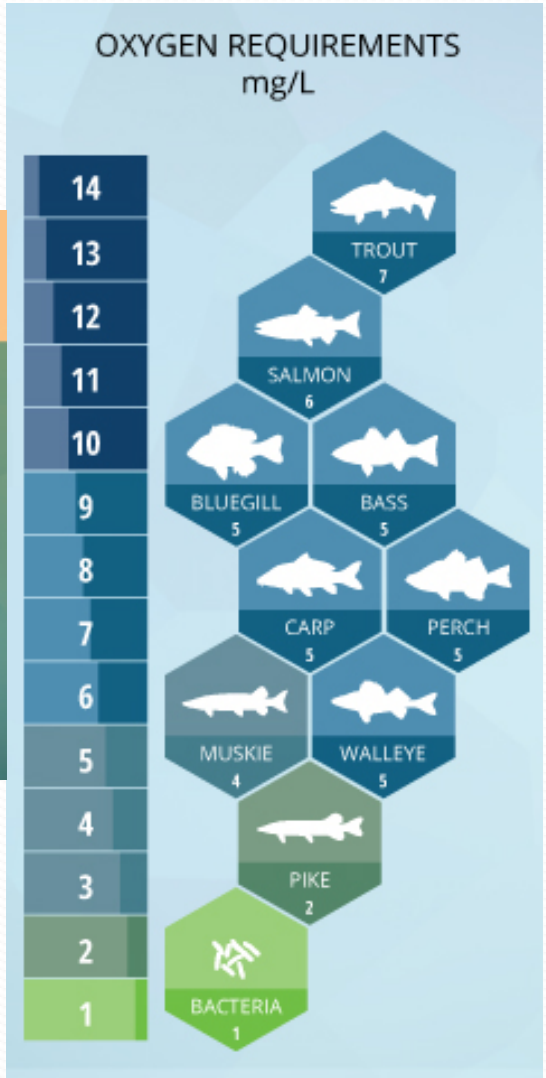
http://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/

DO Temperature Profile



Oxygen and aquatic systems





http://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/

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

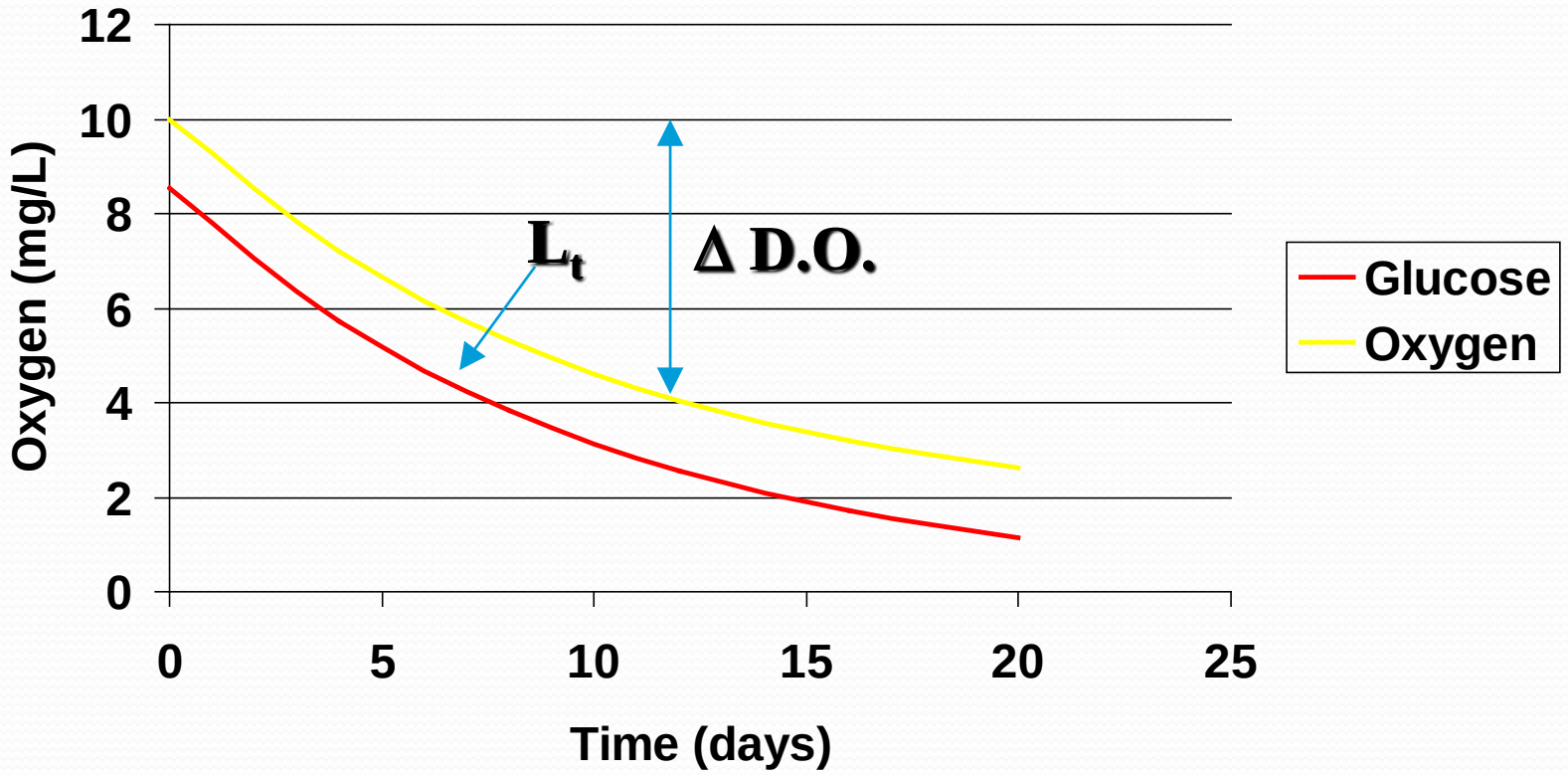
BOD: A Bioassay

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.

$$BOD_t \equiv DO_i - DO_f$$

Chapra's Glucose example

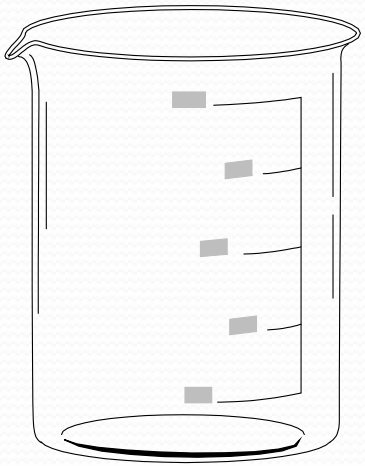
$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$$

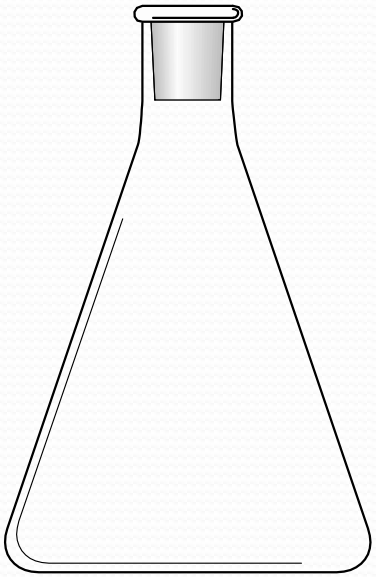


BOD with dilution

When BOD>8mg/L

$$BOD_t = \frac{DO_i - DO_f}{\left(\frac{V_s}{V_b}\right)}$$





Where

BOD_t = biochemical oxygen demand at t days, [mg/L]

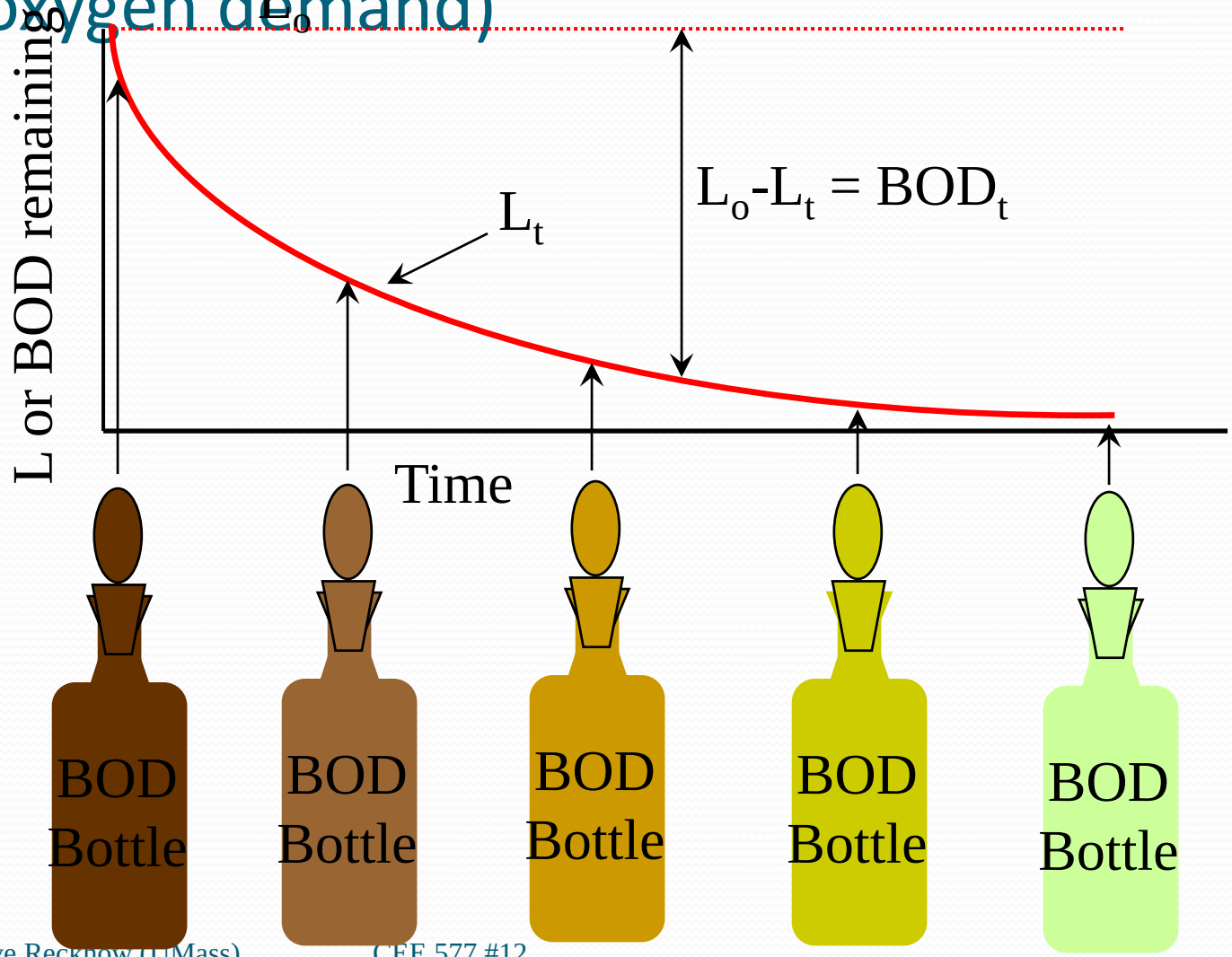
DO_i = initial dissolved oxygen in the sample bottle, [mg/L]

DO_f = final dissolved oxygen in the sample bottle, [mg/L]

V_b = sample bottle volume, usually 300 or 250 mL, [mL]

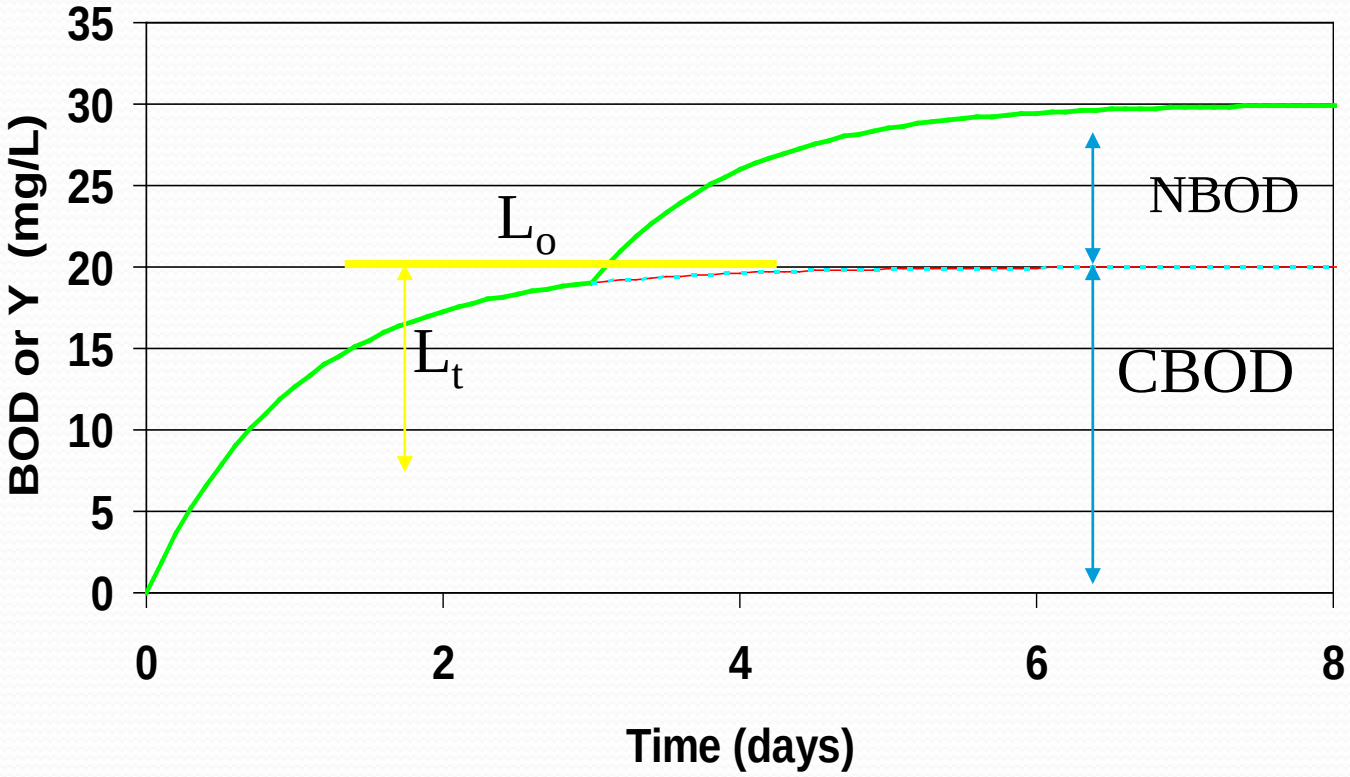
V_s = sample volume, [mL]

BOD - loss of biodegradable organic matter (oxygen demand)



The BOD bottle curve

- L=oxidizable carbonaceous material remaining to be oxidized



$$BOD_t \equiv y_t = L_o - L_t$$

- To next lecture