THEORETICAL OXYGEN DEMAND

(BASED ON SIMPLE STOICHIOMETRY)

GLUCOSE IN WATER

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + CH_2O$$

↑ FW = 180 ↑ FW = 32

SUPPOSE A DILUTE WASTEWATER FROM A FOOD PLANT

GLUCOSE = 1 mg/L

$$\frac{1\ \frac{mg}{L}}{180\ \frac{mg}{mol}} = 0.0055\ mM$$

↓ REACTS w/ 6 O_2's

$0.0055\ mM \times 6 = 0.033\ mM\ O_2$ CONSUMED

$0.033 \times 32\ \frac{mg}{mmol} = 1.1\ mg\text{-}O_2/L$

BOD = 1.1 mg/L

BOD

① PURE SAMPLE IN BOTTLE

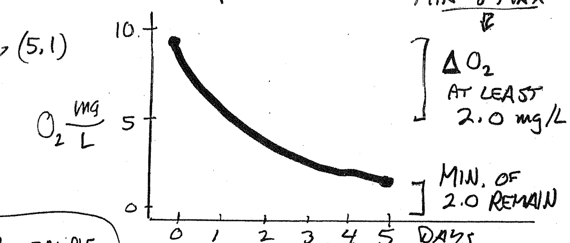
$$BOD_5 = DO_i - DO_5$$

② Dilution usually needed

$$P = \frac{\text{Volume of Wastewater}}{\text{Vol. of WW + Vol. Diln Water}}$$

$$BOD_5 = \frac{DO_i - DO_5}{P}$$

EXAMPLE (5.1)



MIN & MAX

] ΔO_2 AT LEAST 2.0 mg/L

] MIN. OF 2.0 REMAIN

10 mL SAMPLE
300 mL BOTTLE

$$\text{MIN. } BOD_5 = \frac{\Delta DO}{P} = \frac{2.0\ mg/L}{10/300} = 60\ mg/L$$

$$\text{MAX BOD} = \frac{9.0 - 2.0}{10/300} = 210\ mg/L$$

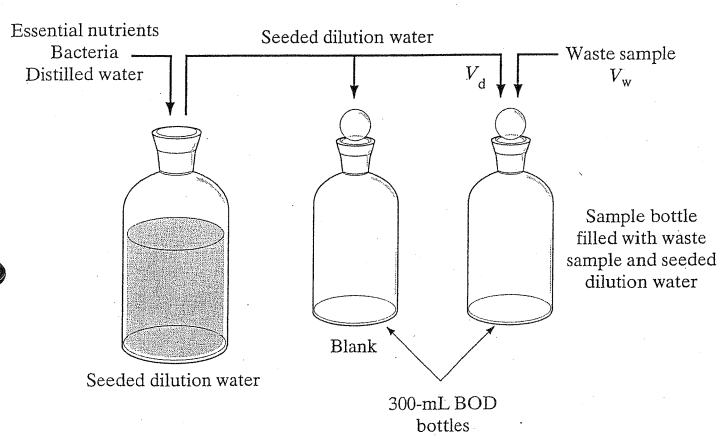


FIGURE 5.9 Laboratory test for BOD using seeded dilution water.

SEEDED BOD TEST

"w" = waste "d" = dil'n water "m" = mixture

$$BOD_m V_m = BOD_w V_w + BOD_d V_d$$

$$BOD_w = BOD_m \left(\frac{V_m}{V_w}\right) - BOD_d \left(\frac{V_d}{V_w}\right)\left(\frac{V_m}{V_m}\right)$$

$$BOD_w = \frac{BOD_m}{V_w/V_m} - BOD_d \frac{V_d/V_m}{V_w/V_m}$$

V_d/V_m ← $1 - P$

↑ $P = V_w/V_m$

$$BOD_w = \frac{BOD_m - BOD_d(1-P)}{P}$$

OR

$$BOD_w = \frac{(DO_i - DO_f) - (B_i - B_f)(1-P)}{P}$$

EXAMPLE 3

15 mL SAMPLE IN 300 mL BOTTLE } $P = \frac{15}{300} = 0.05$

$\Delta DO_B = 1.0\ mg/L$ $\Delta DO_{SAMPLE} = 7.2\ mg/L$

$$BOD_5 = \frac{7.2 - 1.0(1 - 0.05)}{0.05} = 125\ mg/L$$

BOD MODEL: 1st ORDER DECAY

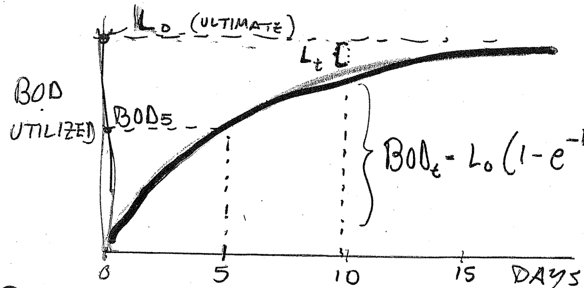
L_t = oxygen demand remaining @ t
L_0 = ultimate (100%) oxygen demand (carbonaceous)

$$L_t = L_0 e^{-kt}$$

$$L_0 = BOD_t + L_t$$

↑ ULTIMATE DEMAND (L_0); ↑ DEMAND "USED UP" BY t (BOD_t); ↑ DEMAND REMAINING AT t (L_t)

$$BOD_t = L_0 - L_0 e^{-kt} = L_0(1 - e^{-kt})$$



ALSO: $BOD_t = L_0(1 - 10^{-Kt})$ $\quad k = K \ln 10 = 2.303K$

TEMP. DEPENDENCE of BOD

At 20°C

	k (d^{-1})
RAW SEWAGE	0.35 - 0.70
TREATED SEWAGE	0.12 - 0.23
POLL. RIVER	0.12 - 0.23

$$k_T = k_{20}\,\theta^{(T-20)}$$

$\theta = 1.047$ typical

EX: At 20°C BOD_0 = 300 mg/L
BOD_5 = 200 mg/L
$k = 0.22\ d^{-1}$

BOD_5 @ 25° ?

$$k_{25} = k_{20}\theta^{T-20} = 0.22(1.047)^{(25-20)} = 0.277\ d^{-1}$$

$$BOD_5 = L_0(1 - e^{-kt}) = 300(1 - e^{-0.277 \times 5}) = 225\ \text{mg/L}$$

NITRIFICATION

Org-N → NH_3

$$2NH_3 + 3O_2 \xrightarrow{\text{Nitrosomonas}} 2NO_2^- + 2H^+ + 2H_2O$$

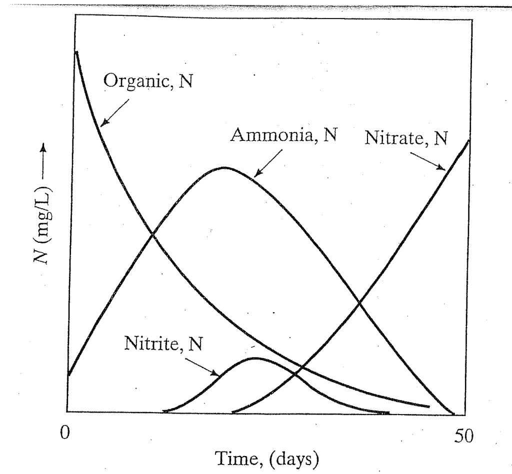
$$2NO_2^- + O_2 \xrightarrow{\text{Nitrobacter}} 2NO_3^-$$

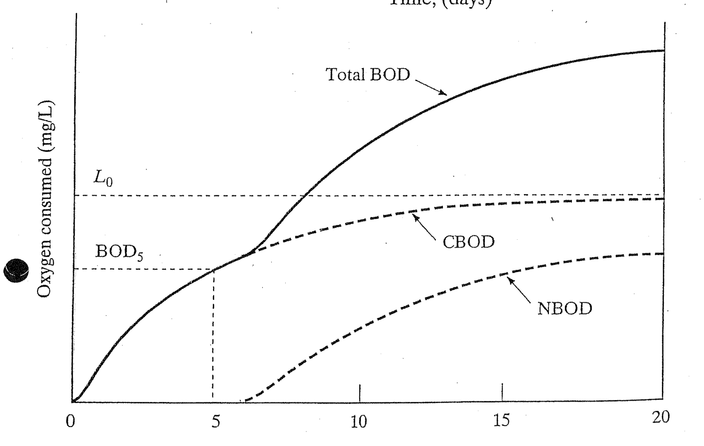
"NBOD"

Usually we try to NOT measure this in standard BOD_5

(Hence 5-day limit)

NBOD Tends not to be a serious problem in many rivers unless is very high or river has very high loading.





E 5.13 Illustrating the carbonaceous and nitrogenous biochemical oxygen demand. Total BOD n of the two.