LSN 27 In Class—BOD

CEEG 340–Introduction to Environmental Engineering

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BOD Test–From Last Year's Midterm Exam

Methylcyclohexanolmethanol (MCHM, $C_8H_{16}O$) is used to condition coal. An energy company has asked you to design a wastewater treatment plant that will treat MCHM and ammonia (a byproduct of the coal conditioning process). As a first step for the design, you need to conduct a **5-day BOD test** on the wastewater. The wastewater has an MCHM concentration of 2100 mg/L, an ammonia concentration of 30 mg/L NH_3-N (i.e., as N), and a dissolved oxygen (DO) concentration of 4 mg/L. The biodegradability of MCHM is 40 %, and the wastewater has a first order degradation coefficient of 0.06 day^{-1}.

1. What is the theoretical oxygen demand of the wastewater?

GIVEN: $[MCHM] = 2100\ mg/L$; $[NH_4\text{-}N] = 30\ mg/L$

FIND: ThOD

STEP 1: FIND CThOD

$$\underset{128\ g}{C_8H_{16}O} + \underset{368\ g}{11.5\,O_2} \rightarrow 8CO_2 + 8H_2O$$

$$CThOD = 2100\ \frac{mg\ MCHM}{L} \times \frac{368\ g\ oxy.}{128\ g\ MCHM}$$

$$CThOD = 6037\ mg/L$$

STEP 2: FIND NThOD

ALWAYS FOR NThOD

$$NThOD = 30\ \frac{mg\ NH_4\text{-}N}{L} \times \frac{64\ g\ O_2}{14\ g\ NH_4\text{-}N}$$

$$NThOD = 137\ mg/L$$

STEP 3: FIND ThOD

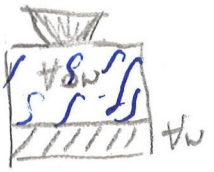
$$ThOD = CThOD + NThOD = 6037 + 137$$

$$ThOD \cong 6100\ mg/L$$

2. If you want the final DO concentration of the test bottle to be 2 mg/L, what volume of wastewater should be added to the BOD bottle. The dilution water has a DO concentration of 9 mg/L, and the test bottle has a volume of 300 mL.

GIVEN: $DO(5) = 2\ mg/L$; BIODEGRADABILITY = 0.4

$D.O._{DW} = 9\ mg/L$; $K = 0.06\ \frac{1}{DAY}$



FIND: $\forall_{WW}$

STEP 1: FIND L_o

L_o = BIODEGRAD. x CTHOO = 0.4×6100

$L_o = 2145\ mg/L$

STEP 2: FIND Y_5 $\quad Y = L_o(1 - e^{-kt})$

$Y_5 = 2145 \times (1 - e^{-0.06 \times 5})$

$Y_5 = 625\ mg/L$

STEP 3: CREATE EXPRESSION FOR DO(0)

$$DO(0) = \frac{DO_W \times \forall_W + DO_{DW} \times \forall_{DW}}{\forall_{BOTTLE}} \quad ; \quad \forall_{DW} = \forall_{BOTTLE} - \forall_W \quad (300\ mL \downarrow)$$

$$DO(0) = \frac{2\ mg/L \times \forall_W + 9\ mg/L \times (300 - \forall_W)}{300}$$

STEP 4: CREATE EXPRESSION FOR DF

$$DF = \frac{\forall_{BOTTLE}}{\forall_W} \quad ; \quad DF = \frac{300}{\forall_W}$$

STEP 5: FIND $\forall_W$

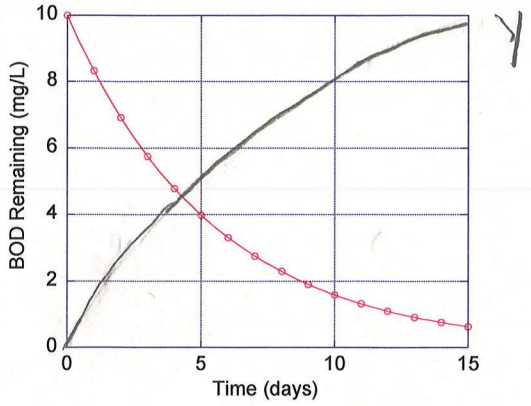
$$Y_5 = BOD_5 = [DO(0) - DO(5)]\,DF$$

$$625\ mg/L = \left[\frac{4\ mg/L \times \forall_W + 9\ mg/L \times (300 - \forall_W)}{300} - 2\ mg/L\right]\frac{300}{\forall_W}$$

$$\frac{625\,\forall_W}{300} = \frac{-5\,\forall_W}{300} + 9 - 2 \quad \{\ 630\,\forall_W = 7 \times 300$$

$$\boxed{\forall_W = 3.3\ mL}$$

The figure below shows data from a BOD test. BOD remaining is plotted versus time for a sample taken from the effluent of a wastewater treatment plant. The BOD test which was run at 20 ^{0}C with a total sample size of 200 mL.



1. What is the ultimate BOD (L_0)?

   $L_0 = 10$ mg/L

2. What is L_5?

   $L_5 = 4$ mg/L

3. What is the BOD exerted at time = 5 days, or Y_5? $Y_5 = L_0 - L_5 = 10 - 4 = 6$ mg/L

4. How much oxygen (in mg/L) was consumed during the first 5 days of the BOD test?

   $DO_{CONSUMED} = Y_5$ (NUMERICALLY); $DO_{CONSUMED} = 6$ mg/L

5. Plot BOD Exerted (Y) versus time on the plot above.