EVE 290L
INTRODUCTION TO ENVIRONMENTAL ENGINEERING LABORATORY
EXPERIMENT #2

GAS TRANSFER TEST

Purpose:
To measure the rate of gas-liquid mass transfer in a diffused bubble system and to examine variables that influence the rate of mass transfer.

Background:
Mass transfer between gas and liquid phases is commonly encountered in the environmental sector. Oxygen supply to biological wastewater treatment reactors and stripping of trihalomethanes from drinking water are common examples. This experiment focuses on the former mechanism. Recall that there are two major types of aeration systems: diffused aeration and mechanical or surface aerators. This experiment will focus on a diffused aeration system.

Gas transfer is a vital unit operation in many environmental engineering processes. It may involve either the adsorption or desorption of gas. The transfer of oxygen to liquid systems is particularly important in the biological treatment of wastewaters.

Aeration kinetics may be expressed as;

$$\frac{dC}{dt} = K_L a \, (C_S - C) \tag{1}$$

where:

C_S = saturation level of oxygen (M/L^3)
C = actual oxygen concentration (M/L^3)
$K_L a$ = over-all transfer coefficient (T^{-1}).

Upon integration, this equation becomes

$$K_L a = 2.303 \, \frac{1}{t_1 - t_0} \, \log \frac{C_S - C_0}{C_S - C_1} \tag{2}$$

Since the over-all transfer coefficient, K_{La}, is a characteristic of a particular system, it would be expected to change with changes in physical or chemical properties, which may be described by the α and β coefficients. The α coefficient is defined as the ratio of K_{La} value for waste to the K_{La} value for water, or

$$\alpha = \frac{\left(K_{La}\right)_{waste}}{\left(K_{La}\right)_{water}} \tag{3}$$

This coefficient may be less than or greater than one, but should change during treatment and approach unity for treated wastewater, since the substances affecting the transfer rate are

being removed in the process.

The coefficient β is defined as the ratio of oxygen saturation level for studied wastewater to the oxygen saturation level for tap water, or

$$\beta = \frac{C_s(waste)}{C_s(water)} \qquad\qquad (4)$$

Including the α and β coefficients in Equation 2 will yield Equation 5:

$$\frac{dC}{dt} = \alpha K_{La}(\beta C_s - C) \qquad\qquad (5)$$

During the steady-state operations, dC/dt equals zero, and

$$C = \beta C_s \qquad\qquad (6)$$

Materials:
1. Completely-mixed reactor.
2. Dissolved oxygen analyzer.
3. Saturated solution of Na_2SO_3.
4. $CoCl_2 \bullet 6H_2O$ solution, 1%.
5. Stopwatch.

Procedure: Oxygen Transfer under Non-Steady-State Conditions
1. Fill a completely-mixed, batch reactor with tap water

2. Determine the maximum and minimum flow rates for your system set up.

3. Perform your experiment at the ~~following~~ max and min flow rates:
   - ~~5.0 L/hr~~
   - ~~7.5 L/hr~~
   - ~~10.0 L/hr~~
   - ~~12.5 L/hr~~
   - ~~15.0 L/hr~~

4. Deoxygenate the water with sodium sulfite and a cobalt catalyst. This may be accomplished by adding:

   a. 8 mg of Na_2SO_3 per liter of water per mg/l of dissolved oxygen and 2 mg/l of $CoCl_2$ or

   b. 0.25 ml of a saturated Na_2SO_3 solution per liter of liquid and 0.4 ml of a 1% $CoCl_2 \bullet 6$ H_2O solution per liter.

5. Determine the dissolved oxygen concentration with time, using DO probe and meter. Continuous readings should be taken until DO_{SAT} is reached.

6. Determine and record the temperature of the water.

7. Drain the batch reactor used above and refill it with clean tap water. Be sure the volume, temperature, and mixing speed are the same. Repeat experiment at ~~a new~~ the other flow rate.

Analysis:
(make sure you discuss/include the following in your report)
1. Calculate the over-all transfer coefficient, K_{La}, for each of the tests conducted.
2. Plot K_{La} versus gas flow rate. What do you think is responsible for the change in K_La with each of the following variables? a) Mixing speed, b) Gas flow rate, c) Temperature.
3. Would you expect K_{La} to vary with different sizes and types of impellers? Why?
4. Estimate the saturation concentration of oxygen in water (C_s) for each experiment by plotting the measured concentrations versus time and extrapolating the results to a horizontal line. Compare the measured C_s values to tabulated values.