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Gas Transfer

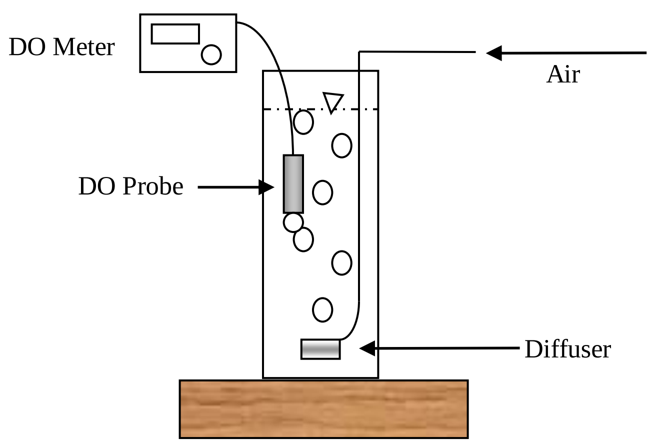
Background

Gas transfer is a vital unit operation in many environmental engineering processes. It involves either the desorption or adsorption of gas. The transfer of oxygen to liquid systems is particularly important in oxidation of iron and manganese in water treatment and in the biological treatment of wastewaters. Air stripping to remove toxic volatile organics is another wastewater application. Students will also be exposed to the fundamentals of gas transfer through an oxygen transfer experiment in water.

Aeration systems are designed to promote turbulence and break the water into smaller volumes of droplets, increasing the surface area for mass transfer. Gravity or pressurized flow systems are typically used.

Determination of the Overall Gas Transfer Coefficient

Gas transfer means simply the process of allowing any gas to dissolve in a fluid or the opposite of that, promoting the release of a dissolved gas from a fluid. The figure below shows a system where air is forced through a tube and a porous diffuser, creating very small bubbles that rise through clean water.



The transfer of oxygen takes place through the bubble gas-liquid interface. If the gas inside the bubble is air, and an oxygen deficit exists in the water, the oxygen transfers from the bubble into the water. Most gases are only slightly soluble in water; among these are hydrogen, oxygen and nitrogen. Solubility is influenced by many variables such as the presence of impurities and temperature.

Aeration kinetics can be expressed as :

$$\frac{dC}{dt} = K_L a(C^* - C)$$

where C* = saturation concentration of oxygen in water (mg/L), K_La = overall gas transfer coefficient (sec^{-1}), t = time (sec) and C = actual concentration of oxygen (mg/L). Rearranging for integration yields

$$\int_{Co}^{Ct} \frac{-dC}{C^{*}-C} = K_L a \int_{0}^{t} -dt$$

Integrating and rearranging gives

$$\ln(C^{*} - C_t) = \ln(C^{*} - C_o) - K_L at$$

The above equation is of the straight line form y = mx+c; thus $\ln(C^{*} - C_t)$ versus time, t, gives a line with slope K_La.

Apparatus: Dissolved Oxygen Probe and Meter, Air Pump, Air Diffuser

Procedure:

1. Record temperature so that you can determine C* (saturation concentration).
2. Add 4 mL (2000 mg/L) of cobalt chloride and then 15 mL (10,000 mg/L) of sodium sulfite to the water in the aeration reactors. ***Make sure that the diffuser is turned OFF and the stirrer is ON!!!***
3. Keep observing the (DO) dissolved oxygen concentration in the DO meter. Keep adding sodium sulfite till a steady DO value of 2-3 mg/L is obtained.
4. Record the temperature.
5. Now turn the stirrer OFF and the air sparger ON.
6. Start recording DO values every 10 seconds for the first couple of minutes and then record readings every minute.
7. Stop the experiment after 20 minutes.
8. **Plot the data to obtain the value of the overall mass transfer coefficient K_La.**

Results

Report your results in a tabular form as shown below.

Temperature	C* mg/L	Time	C_t mg/L	$\ln(C^{*} - Ct)$ mg/L	$\ln(C^{*} - Co)$ mg/L

Plot your data and report the value of K_La with appropriate units.

$\ln(C^{*}-Ct)$

LABEL GRAPH CORRECTLY WITH APPROPRIATE UNITS.

Time

Topics that need to be discussed in the lab report:

1. What is the objective of this laboratory?
2. What processes of water and wastewater treatment include some form of gas transfer?
3. What are the factors affecting gas transfer?
4. What is the role of cobalt chloride and sodium sulfite in this experiment? Write chemical reactions.
5. What is the impact of detergents during gas transfer?
6. What kind of Dissolved Oxygen concentrations should be maintained in activated sludge tanks and aerobic digestion processes during wastewater treatment?

References:

Davis, Mackenzie L., and Masten, Susan J., Principles of Environmental Engineering and Science. McGraw Hill, 2004.

Mihelcic, James R., Fundamentals of Environmental Engineering. J. Wiley & Sons Inc., 1999.

APHA, AWWA, WPCF, Standard Methods for the Examination of Water and Wastewater, APHA, 2004.