Freshman Engineering Clinic

ROWAN UNIVERSITY
College of Engineering

GAS TRANSFER

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GAS TRANSFER

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 **water-to-air** method is designed to produce small drops of water that fall through the air.

The **air-to-water** method creates small bubbles of air that are injected into the water stream.

All aerators are designed to create a greater amount of contact (**surface area**) between the air and water to enhance gas transfer.

GAS TRANSFER

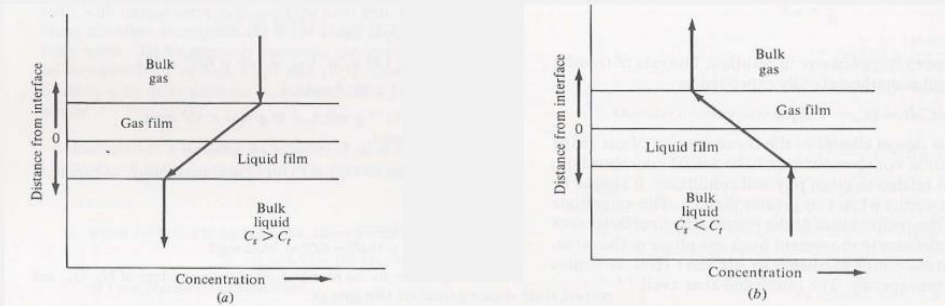
When disequilibrium conditions exist for a gas between its gaseous phase and aqueous concentration, gas transfer occurs. The concentration gradient (difference in concentration) drives a gas flux according to the equation proposed by Lewis and Whitman in 1924.

Lewis and W.G. Whitman, Principles of Gas Absorption Ind. Eng. Chem. 16, 1215 (1924).

TWO FILM THEORY (Lewis – Whitman)

The resistance to movement between the phases can be explained by TWO-FILM THEORY (Lewis-Whitman)

Acc. to this theory, transfer of a gas must occur across the two films that are assumed to exist at the gas-liquid interface.



Applications

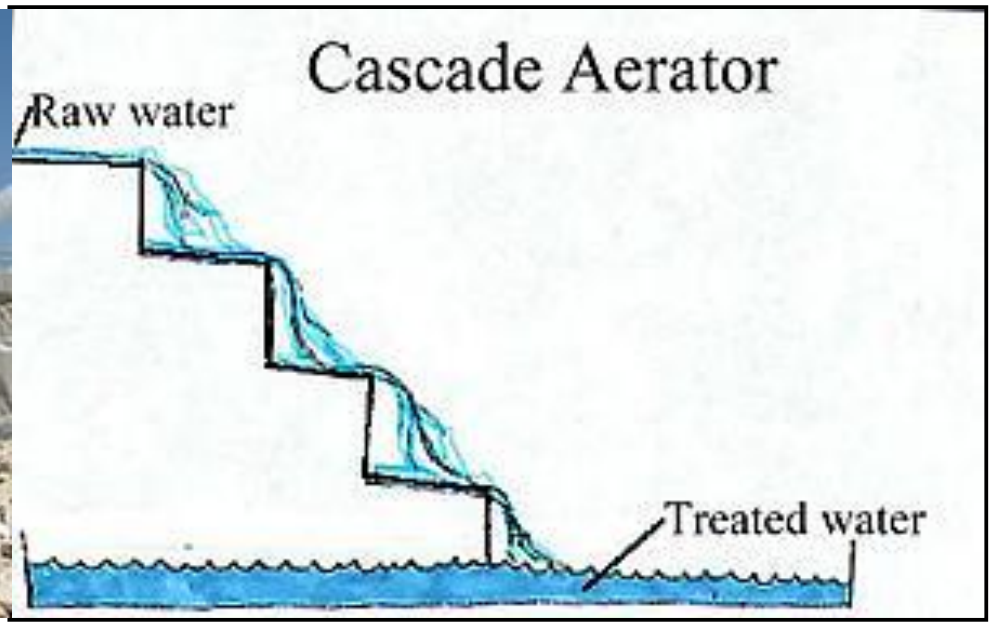
- Addition of gases

  Oxygen Transfer

  - Aeration of surface water bodies
  - Drinking Water Treatment
  - Wastewater Treatment
- Chemical Industries
- Removal of Gases

Aeration of Surface Water Bodies

Help maintain DO levels for supporting aquatic life and prevent anaerobic conditions



Increase dissolved oxygen in water

Drinking Water Treatment

Oxygen is injected into water through aeration to remove iron and manganese (ferrous and manganous form) as they cause color and taste in water.

$$4Fe(HCO_3)_2 + O_2 + 2H_2O = 4Fe(OH)_3^- + 8CO_2$$

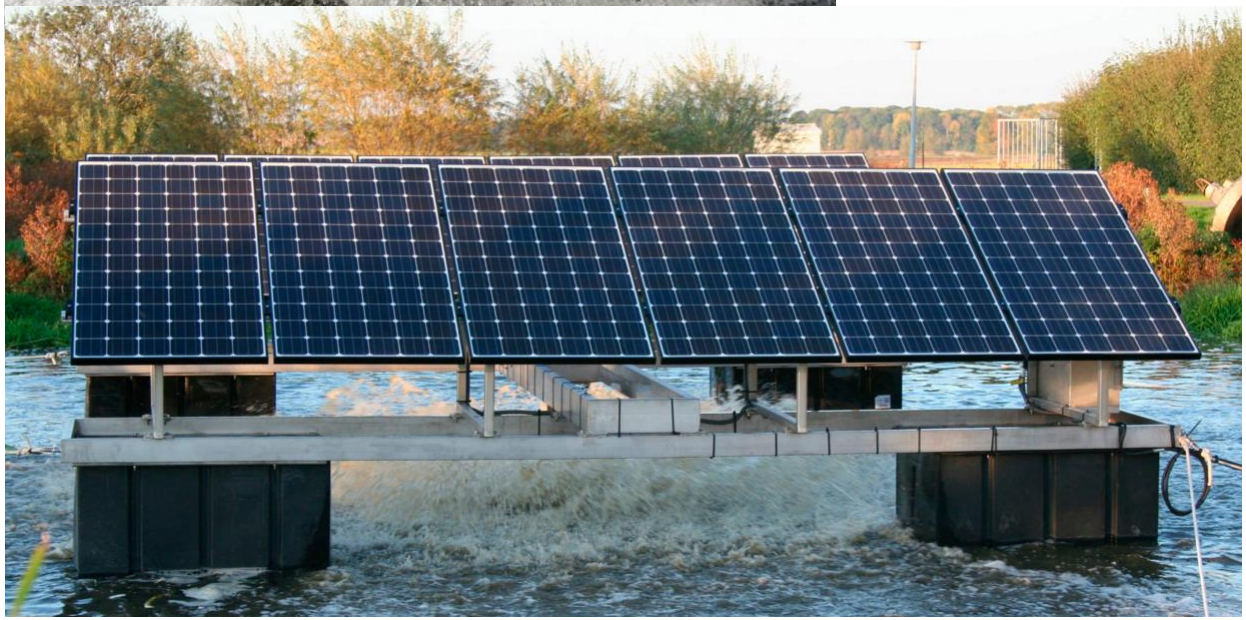
$$2Mn(HCO_3)_2 + O_2 = 2MnO_2 + 4CO_2^- + 2H_2O$$

Aeration is also effective in removing tastes and odors that are caused by volatile chemicals as VOCs

Wastewater Treatment

Mechanical Aerators

Membrane Aerators



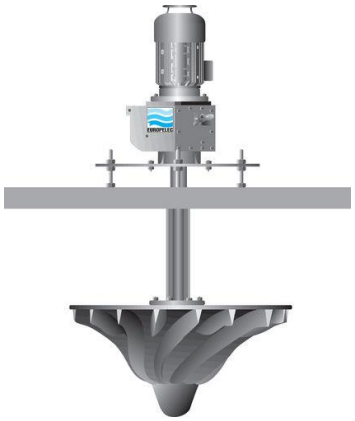
Provide oxygen for microorganisms

Remove VOCs (Volatile Organic Compounds)

AIR DIFFUSERS

Type of Aerators

MECHANICAL: surface and turbine



Surface aerators consist of submerged or partially submerged impellers or paddle wheels, which are centrally mounted in the aeration tank. Surface aerators agitate the water vigorously.

Turbine aerators are usually upflow types that rely on violent agitation of the surface and air entrainment for their efficiency.

MEMBRANE:

Bubbleless gas transfer enhances efficiency.

AERATION KINETICS

Aeration kinetics can be expressed as :

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

The gas transfer per unit time through the surface can be described by the following differential equation:

$$dc/dt = K_L(A/V)(C^* - C_0)$$

where:

- dc/dt = change in concentration per unit time (mg/(l h))
- K_L = coefficient for gas transfer (cm/h)
- A/V = contact area of the gas–liquid interface (cm^2) in relation to the total liquid volume (cm^3)
- C^* = saturation concentration for the gas in the liquid (mg/l)
- C_0 = starting concentration of the gas in the liquid (mg/l).

where

C^* = saturation concentration of oxygen in water (mg/L)

K_La = overall gas transfer coefficient (sec^{-1})

t = time (sec)

C = actual concentration of oxygen (mg/L)

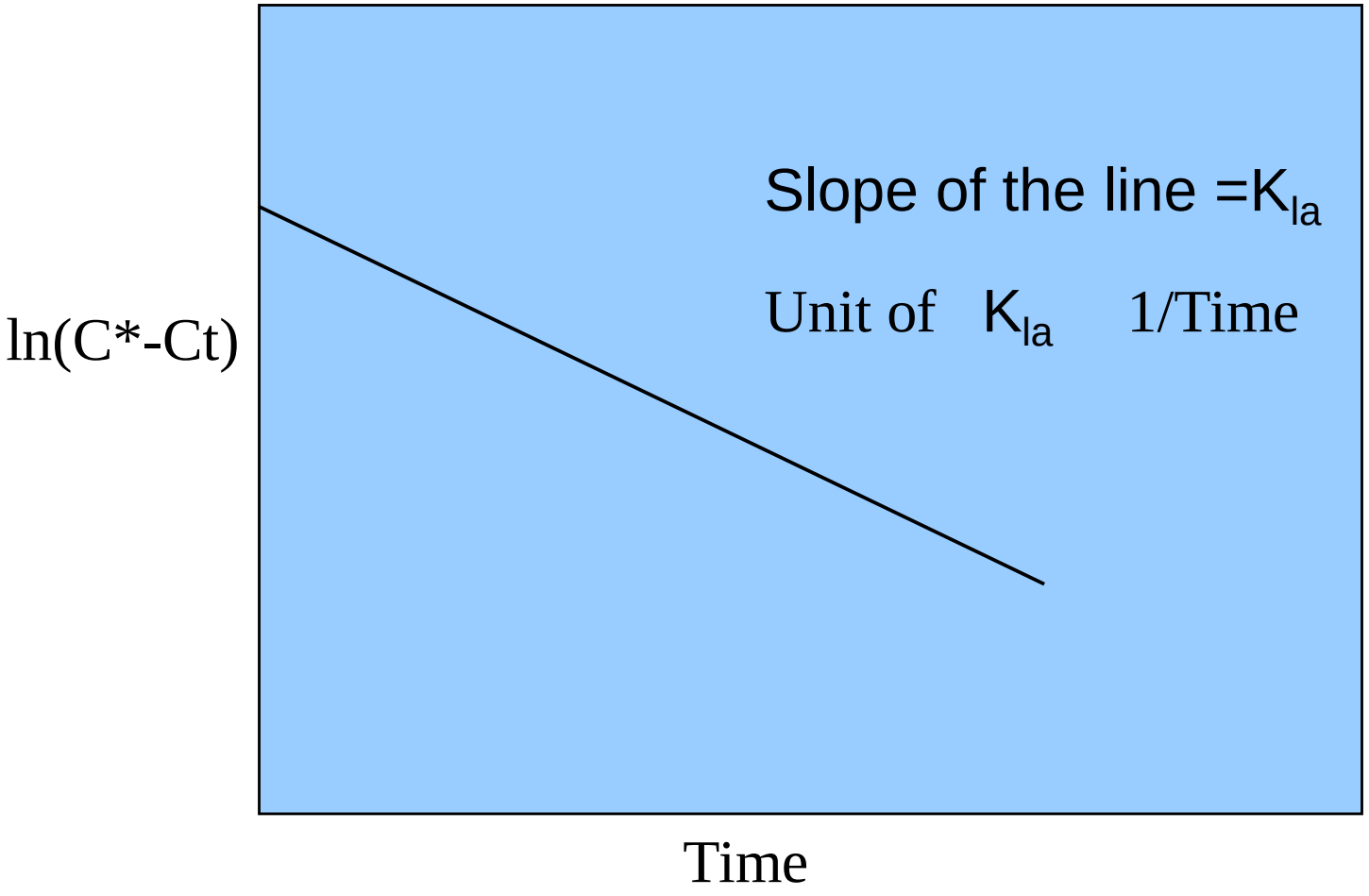
$$\int_{Co}^{Ct} \frac{-dC}{C^* - C} = K_L a \int_{0}^{t} -dt$$

Integrating and rearranging gives

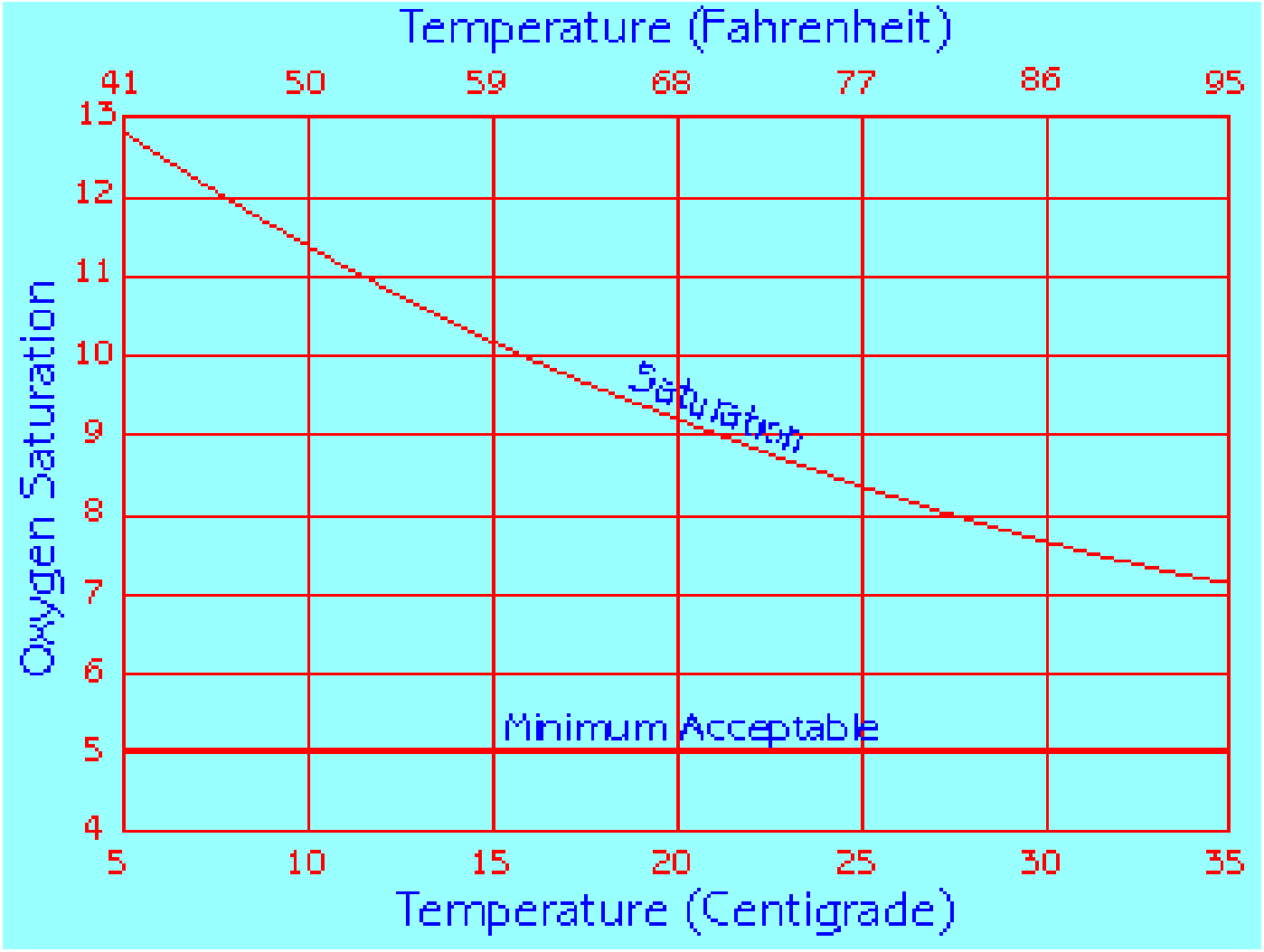
$$\ln(C^* - C_t) = \ln(C^* - C_o) - K_l a t$$

A plot of $\ln(C^* - C_t)$ versus time, t, gives a line with slope $K_L a$.

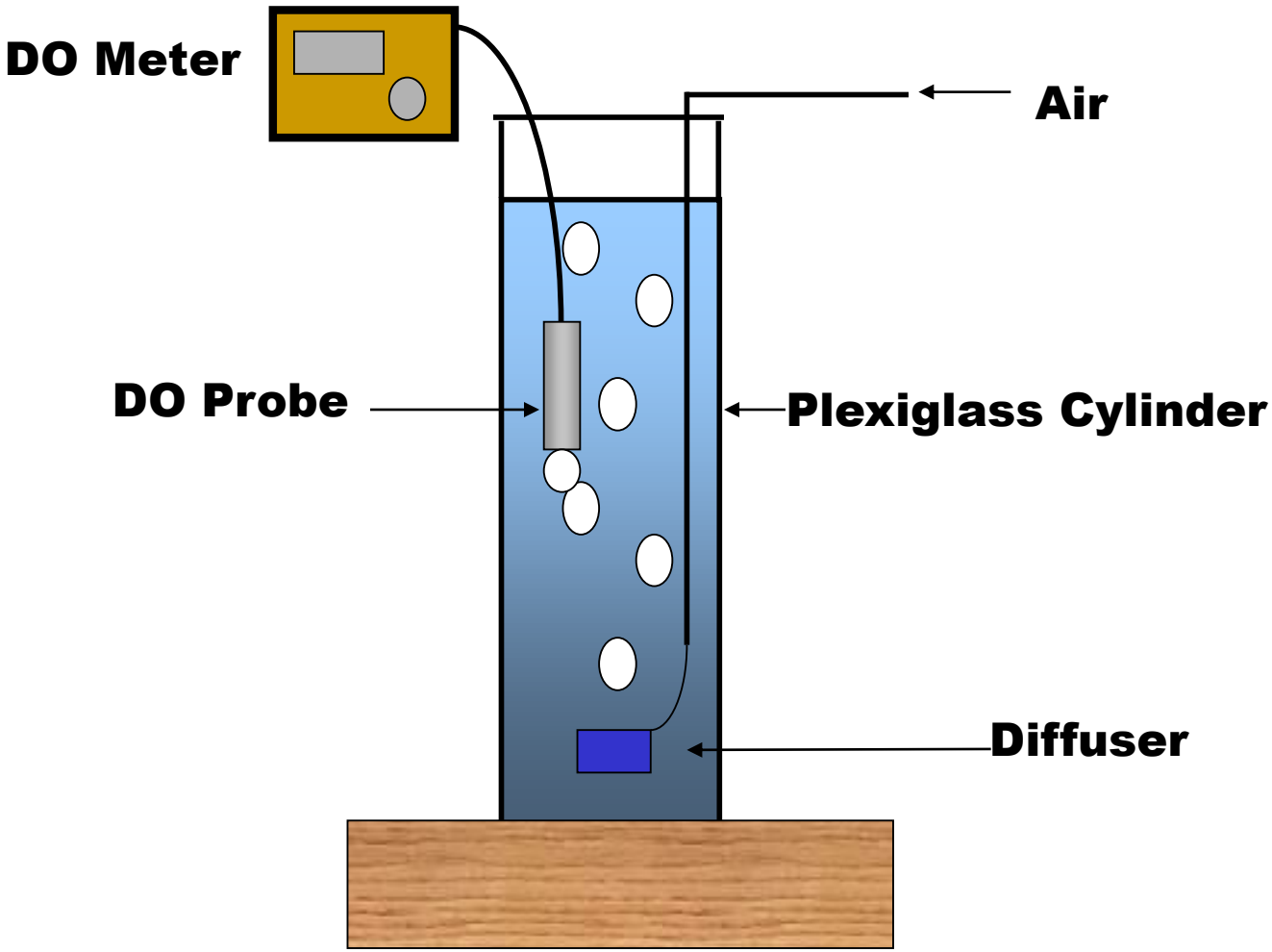
Data Analysis



Oxygen Saturation vs Temperature



Experimental Setup



The transfer of oxygen in this experiment 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. In this experiment we are measuring the rate of oxygen transfer.

The water is first stripped of oxygen by chemical means. The air is then turned on and the dissolved oxygen concentration is measured with time using a dissolved oxygen meter.

Oxygen Removal

Sulfite is a strong reductant that will reduce dissolved oxygen in the presence of a catalyst.

$$O_2 + 2SO_3^{-2} \xrightarrow{\text{cobalt}} 2SO_4^{-2}$$

Cobalt chloride ($CoCl_2$) is used as the catalyst.

Data Collection

- Record Time and Dissolved Oxygen Concentration with Time (C_t)
- Record temperature of water
- Look up C* from a standard table

Time (minutes)	Dissolved Oxygen C_t (mg/L)
0	0
1	2.2
2	3.85
3	5.05
4	6
5	6.65
6	7.1
8	7.85
10	8.25
12	8.55
15	8.6
20	8.7
25	8.75
30	8.75

Factors Impacting Gas Transfer

- Temperature
- Salinity
- Pressure
- Presence of Chemicals

- The amount of oxygen that the water can hold is dependent on the temperature.

- The colder the water, the more oxygen the water can hold.

- Water that contains excessive amounts of oxygen can become very corrosive.