ECO2 SuperOxygenation System Design: Literary References

Amount of Dissolved Oxygen Required to Oxidize Dissolved Sulfide

In biochemical oxidation of organic matter, free oxygen as dissolved oxygen (D.O.) is the preferred electron acceptor [1]. Dissolved sulfides (D.S.) are oxidized to sulfur and sulfate according to the following reactions[2][3]:

$$2\ H_2S + O_2 \rightarrow 2\ H_2O + 2\ S$$
$$H_2S + 2\ O_2 \rightarrow 2\ H + SO_4$$

Per these equations, it takes 2 mg/L of D.O. for every 1 mg/L of dissolved sulfide present in the wastewater. ECO_2 SuperOxygenation systems are designed to add this ratio of D.O. to D.S. to ensure that the D.S. are fully oxidized. It is important to note that this 2:1 oxygen to dissolved sulfide requirement has been verified by ECO_2 in the field numerous times in operating systems across the country.

Amount of Time Required to Oxidize Dissolved Sulfide

When H_2S is in the presence of D.O., biochemical oxidation occurs and dissolved sulfides are metabolized within 15-30 minutes. Figure 1[7] represents the first order reaction of sulfide oxidation as derived through numerous wastewater tests conducted by Alan Plummer and Associates, Inc.

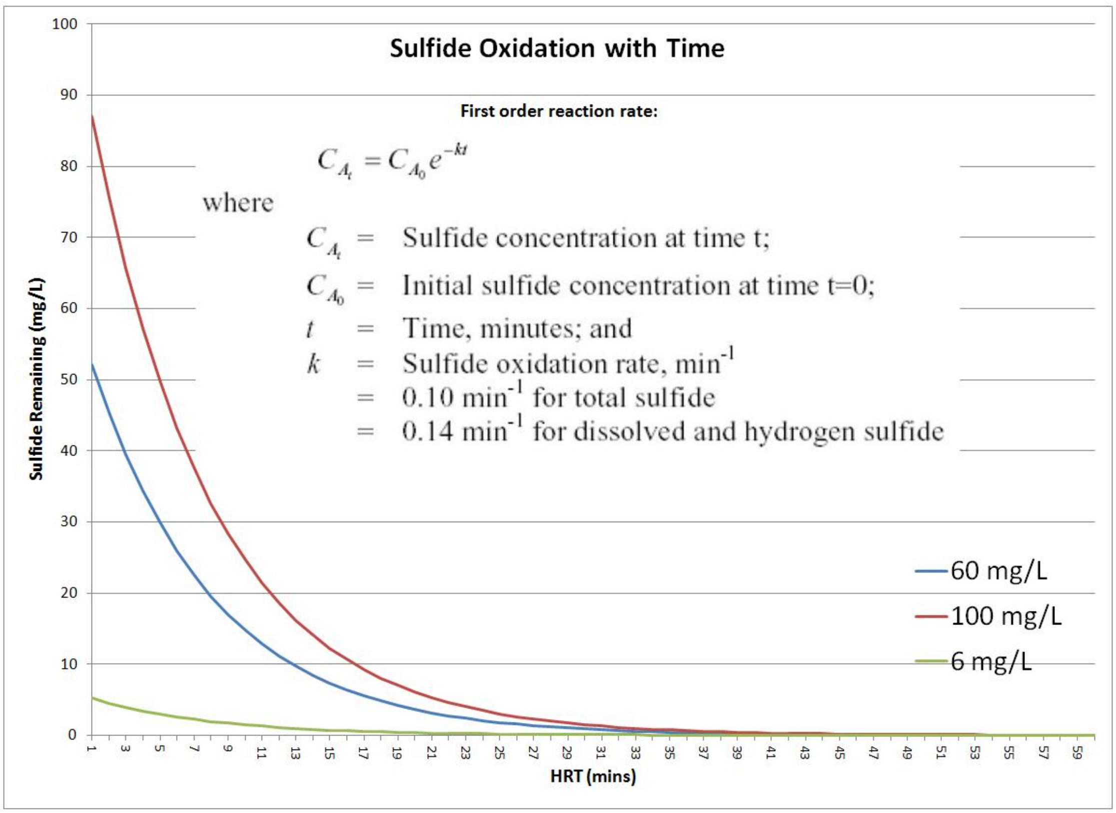


Figure 1.

ECO_2 systems are designed to be installed at least 30 minutes of Hydraulic Retention Time (HRT) upstream of the area requiring odor control. This ensures that there is a sufficient amount of time for the D.S. to be oxidized in the wastewater before it can be released.

Amount of Dissolved Oxygen Required to Maintain Aerobic Conditions
The oxygen uptake rate of wastewater is a function of several wastewater parameters, most importantly temperature, BOD level and HRT. It has been well documented in a number of U.S. EPA references that the oxygen uptake rate of wastewater ranges between 5-15 mg/L per hour[1][2]. ECO_2, through extensive field testing across its installation base, has validated this range and has developed tools to accurately predict the oxygen uptake rate in different systems.

Solubility of Pure Oxygen Related to Pressure
Oxygen saturation tables listed by temperature and atmospheric pressure are contained in numerous textbooks and other publications. Typically, these tables are valid for water in contact with air. The WEF Manual of Practice 25 contains a graph of how the oxygen saturation of water changes with pressure when water is in contact with pure oxygen rather than air.

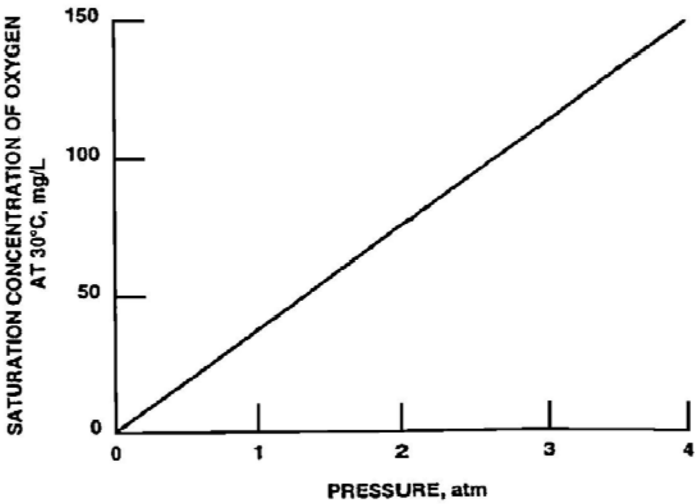


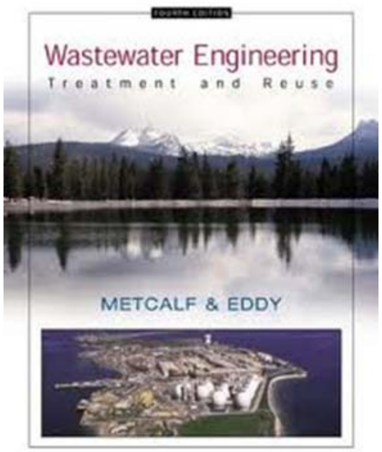
Figure 2.

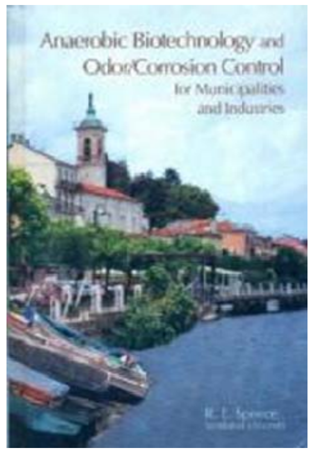
Considering Henry's Law where $p=k_H c$, if the partial pressure of oxygen in air is increased from 0.21 atm to 0.93 atm using high purity oxygen, the saturation of oxygen in water at 20°C at sea level will increase from 9.1 mg/L to 40.3 mg/L.

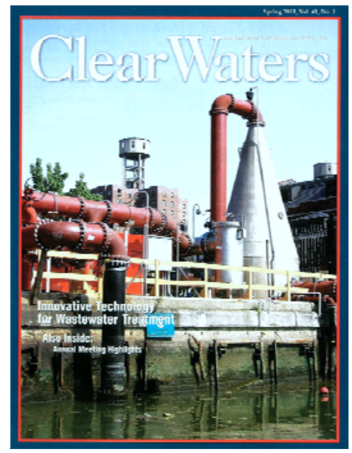
ECO_2 has developed analytical tools which utilize the Benson and Krause equations[4] for calculating the solubility of oxygen in water. The pressure factor portion of the equation considers temperature, barometric pressure, water vapor pressure and the second virial coefficient of oxygen to correct for non-ideal gas behavior. The result is in proportion to the graph in Figure 2. and is approximately 1 mg/L increase in D.O. for every 1 foot of head pressure increase at typical wastewater temperatures of 20-25 °C.

The ECO_2 SuperOxygenation Concept and Installations in Print

The ECO_2 SuperOxygenation concept and projects have been well documented in a number of academic books, engineering journals and trade publications. The Metcalf and Eddy Wastewater Engineering Treatment and Reuse [5] text as well as Dr. Richard Speece's Anaerobic Biotechnology and Odor/Corrosion Control for Municipalities and Industries[6] both describe the use of oxygen in conjunction with the ECO_2 SuperOxygenation systems. Other references are readily available upon request.







References:

(1) U.S. Environmental Protection Agency (1985) *Design Manual, Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants;* EPA-625/1-85-018, U.S. Environmental Protection Agency: Washington, D.C., page 4.

(2) U.S. Environmental Protection Agency (1974) *Process Design Manual for Sulfide Control in Sanitary Sewerage Systems;* U.S. Environmental Protection Agency: Washington, D.C., page 3-19, 3-22, 5-4.

(3) Water Environment Federation (2004) *Control of Odors and Emissions from Wastewater Treatment Plants;* WEF Manual of Practice 25, Water Environment Federation; Alexandria, VA, page 258, 262.

(4) Benson, B.B., and Daniel Krause, Jr (1984) The concentration and isotopic fractionation of oxygen dissolved in freshwater and seawater in equilibrium with the atmosphere: *Limnology and Oceanography*, vol. 29, no. 3, p. 620-632.

(5) Tchobanoglous, George (2003) *Wastewater Engineering Treatment and Reuse, 4^{th} ed.* Metcalf & Eddy, Inc. New York, NY.

(6) Richard Speece, (2008) *Anaerobic Biotechnology and Odor/Corrosion Control*, Archae Press, Nashville, TN.

(7) Alan Plummer and Associates, Inc. derived formula through wastewater testing.