Sea Grant
ILLINOIS - INDIANA

Water Issues And Concerns Fact Sheet Series

Dissolved Oxygen

by Leslie Dorworth

The air we breathe contains about 20 percent oxygen. Fish and other aquatic organisms require oxygen as well. The term dissolved oxygen (DO) refers to the amount of free oxygen dissolved in water which is readily available to respiring aquatic organisms. State water quality standards often express minimum concentrations of dissolved oxygen which must be maintained in order to support life as well as be of beneficial use. Levels of dissolved oxygen below 4-5 milligrams per liter affect fish health and levels below 2 milligrams per liter can be lethal to fish.

Biochemical oxygen demand (BOD) is commonly used with reference to effluent discharges and is a common, environmental procedure for determining the extent to which oxygen within a sample can support microbial life. The test for BOD is especially important in waste water treatment, food manufacturing, and filtration facilities where the concentration is crucial to the overall process and end products. High concentrations of DO predict that oxygen uptake by microorganisms is low along with the required break down of nutrient sources in the medium.

How does oxygen get into the water?

Oxygen from the atmosphere is mixed into the water through diffusion. However, more oxygen is mixed into the water with the help of winds, rain, waves, and currents. The faster the water moves, the more dissolved oxygen the water will contain since it has more contact time with the air. The process of photosynthesis (underwater plants and algae) occurring in the water affects the number and kinds of animals found there. Healthy streams are saturated with oxygen (90 to 110% saturation) during most of the year.

What processes affect the oxygen content in water?

Dissolved oxygen is affected by weather, temperature and even salinity. Cold, fresh water holds more oxygen than warm or salty water. When the weather conditions are dry and hot, the water temperature increases which may result in evaporation. Dissolved oxygen concentrations may decrease under these conditions.

Seasons will also have an impact on the oxygen concentrations in the water. When the water temperature increases during the day, the oxygen level decreases by late afternoon. Algal photosynthesis, particularly during periods of high growth may increase the oxygen level during the day however, algae are also responsible for oxygen depletions in the water. Loss of oxygen at this time usually occurs when the plants respire as well as when the plants die and begin to degrade. Animal and plant respiration in the water may decrease the overall oxygen levels during the night. Dissolved oxygen concentrations are typically lowest at dawn.

How can oxygen levels in streams be increased safely?

Planting stream bank vegetation helps to increase oxygen levels in streams. Foliage provides shade for the water which tends to cool the water. Building structures in streams will also help to aerate the water.

Measuring biochemical oxygen demand

The BOD test requires a commitment of five days from initial sample collection to the end of the analysis. During this time, samples are initially seeded with microorganisms and supplied with a carbon nutrient source of glucose-glutamic acid. The sample is then introduced to an environment suitable for bacterial growth at reproducible temperatures, nutrient sources and light within a

20°C incubator such that oxygen will be consumed. Quality controls, standards and dilutions are also run for accuracy and precision. Determination of the dissolved oxygen within the samples can be determined through Winkler titration. The difference in initial DO readings (prior to incubation) and final DO readings (after a five-day incubation period) predicts the BOD of the sample. A suitable detection limit as per environmental quality control is 1 milligram per liter (1mg l-1). The main details of this method are taken from Standard Methods for the Examination of Water and Wastewater (Method 507; 1985, p531).

BOD calculations

The following steps should be used to calculate BOD and are based on the addition of a nutrient source (carbon - glucose-glutamic acid) and no nutrient source.

A. The BOD of the blanks (no nutrient source) = DO(final) - DO (initial)

B. The BOD of the nutrient added samples = (DO(final) - DO(initial)) X dilution factor per 300ml

-300 ml is based on the volume contained in BOD bottles

The BOD of the sample and standards are calculated by subtracting the final DO from the initial DO and multiplying this factor by the dilution factor. The final value is determined by subtracting out the BOD for the blank from the BOD that has been nutrient enriched.

Measuring dissolved oxygen in your stream

This test is performed using a Hach (dissolved oxygen kit). If possible collect water samples with the Hach test kit when you record the afternoon water temperature. Otherwise, do the test at the same time and in the same location as the temperature measurement.

Instructions for using the kit:

Step 1 Collect a water sample in a BOD bottle by totally submerging the bottle in the water.
- remember to stopper the bottle tightly before bringing the bottle to the surface
- make sure there are no air bubbles in the bottle

Step 2 Add the contents of Hach powder pillows #1 (manganous sulfate) and #2 (alkaline iodide azide) to the bottle
- shake the bottle, again making sure there are no air bubbles in the bottle
- if oxygen is present in the water, a brownish floc (precipitate) will form

Step 3 Allow the sample to stand until the precipitate settles halfway
- shake the bottle again to see if more floc forms
- again wait for the precipitate to settle

Step 4 Add the contents of powder pillow #3 (sulfamic acid)
- shake the bottle again and this time the floc should dissolve and the water will turn yellow

Step 5 From the kit, fill the measuring tube with the yellow DO sample
- pour the contents into a mixing bottle
- pour a second full measuring tube full of the same sample into the mixing bottle
- add sodium thiosulfate titrant, one drop at a time to the sample in the mixing bottle
- as the sodium thiosulfate titrant is being added, swirl the sample
- count the number of drops added
- stop when the color changes from yellow to clear

Step 6 Divide the number of drops added to the sample by two
- this will give you the dissolved oxygen concentration in mg l-1

Perform the test carefully or the results will not be valid. The results obtained from the analysis will be in mg l-1. Milligrams per liter is the same as parts per million. Temperature will influence the amount of dissolved oxygen in the water sample. If percent saturation is the desired end result, then convert the mg l-1 to percent saturation using Figure 1.

As an example, the water temperature was 12°C and the dissolved oxygen was measured at 10 mg l-1. Use the chart below to determine the percent saturation. Use a ruler to connect the oxygen and temperature readings. Read the percent saturation value where the ruler crosses the middle line. For the example, the percent saturation is 78.

Temperature C ________________________.

Dissolved Oxygen (mg l-1)________________.

Percent Saturation of Oxygen _____________.

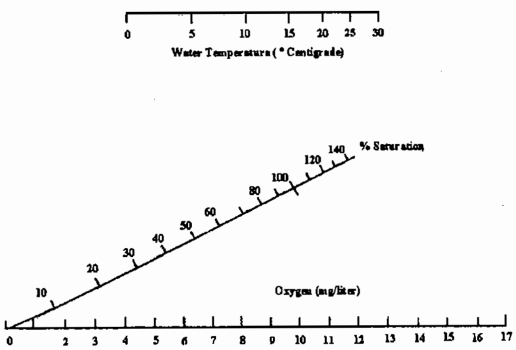

Figure 1. Oxygen saturation curve

Recommended Resources

Dissolved Oxygen and Biochemical Oxygen Demand. 1996. Proceedings from the fourth National Conference (Know Your Environment). (Web Site). The Academy of Natural Sciences.

Mitchell, Mark K. and William B. Stapp. Field **Manual for Water Quality Monitoring**. 1996. Kendall Hunt Publishers, 304 p.

Standard Methods for the Examination of Water and Wastewater. Method 507: 1985, p.531.

Water Quality Issues and Concerns is an ongoing series addressing relevant water quality issues. For water quality information, contact Leslie Dorworth, Sea Grant aquatic ecology specialist, at 219 989-2726; dorworth@calumet.purdue.edu

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