Module #2

Calculating Water Quality Index and Dissolved Oxygen

Adapted and excerpted from Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools by Mark M. Mitchell and William B. Stapp

The water quality index is a 100 point scale that summarizes results from a total of nine different measurements:

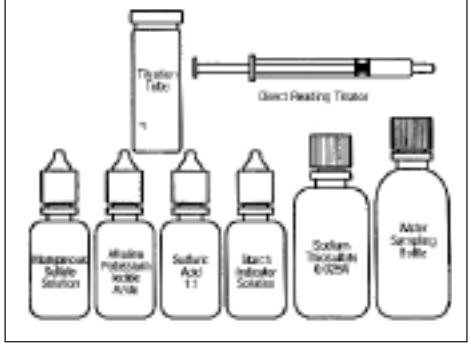
- Dissolved oxygen
- Biochemical oxygen demand
- Nitrates
- Fecal coliform
- Temperature change
- Turbidity
- pH
- Total phosphate
- Total solids

Materials

barometer
small water sample bottle and rod sampler if needed *(constructed from a series of metal rods that can be extended and rubber tubing that holds a sample bottle)*

8 drops of Manganous Sulfate Solution
8 drops of Alkaline Potassium Iodide Azide
8 drops of Sulfuric Acid 1:1 Reagent
Direct Reading Titrator and Titration tube
Sodium Thiosulfate 0.025N Reagent
Starch Indicator Solution

Dissolved Oxygen Test Kit Items



Testing materials can be purchased as individual test kits from Hach or LaMotte. Dissolved oxygen tests also are available in Multiple Water Quality Test kits from these manufacturers as well. The materials and instructions that follow are based on a LaMotte test kit using the Winkler Titration Method. If you use the Hach kit or another titration method, please follow the directions you receive with your test kit.

It is important to exercise care in the way samples are collected for analysis. The sample should be representative of the river or lake being tested. Near-shore samples may not be representative of the river at that location. If possible, water samples should be collected from a bridge spanning the river, from a boat, or off the end of a dock. If that is not practical, the next best option is to extend a rod sampler from shore as far as possible and take a sample beneath the river surface. A rule of thumb for sampling is to sample midway across the river and at various depths below the surface. A simple rod sampler device can be constructed from a series of metal rods that can be extended and rubber tubing attached that holds the sample bottle.

Background Information

from http://www.h2ou.com/h2wtrqual.htm a subsite of hach.com

Dissolved oxygen (DO) is oxygen that is dissolved in water. It gets there by diffusion from the surrounding air; aeration of water that has tumbled over falls and rapids; and as a waste product of photosynthesis. An over simplified formula is given below:

Photosynthesis (in the presence of light and chlorophyll):

Carbon dioxide + Water = Oxygen + Carbon-rich foods
CO_2 H_2O O_2 $C_6H_{12}O_6$

Fish and aquatic animals cannot split oxygen from water (H_2O) or other oxygen-containing compounds. Only green plants and some bacteria can do that through photosynthesis and similar processes. Virtually all the oxygen we breathe is manufactured by green plants. A total of three-fourths of the earth's oxygen supply is produced by phytoplankton in the oceans.

If water is too warm, there may not be enough oxygen in it. When there are too many bacteria or aquatic animal in the area, they may overpopulate, using DO in great amounts.

Oxygen levels also can be reduced through overfertilization of water plants by run-off from farm fields containing phosphates and nitrates (the ingredients in fertilizers). Under these conditions, the numbers and size of water plants increase a great deal. Then, if the weather becomes cloudy for several days, respiring plants will use much of the available DO. When these plants die, they become food for bacteria, which in turn multiply and use large amounts of oxygen.

How much DO an aquatic organism needs depends

upon its species, its physical state, water temperature, pollutants present, and more. Consequently, it's impossible to accurately predict minimum DO levels for specific fish and aquatic animals. For example, at 5°C (41°F), trout use about 50-60 milligrams (mg) of oxygen per hour; at 25°C (77°F), they may need five or six times that amount. Fish are cold-blooded animals, so they use more oxygen at higher temperatures when their metabolic rate increases.

Numerous scientific studies suggest that 4-5 parts per million (ppm) of DO is the minimum amount that will support a large, diverse fish population. The DO level in good fishing waters generally averages about 9.0 parts per million (ppm).

A. DISSOLVED OXYGEN Calculating Percent Saturation

The percent saturation of water with dissolved oxygen at a given temperature is determined by pairing temperature of the water with the dissolved oxygen value (after first correcting your dissolved oxygen measurement for the effects of atmospheric pressure). This is done with the use of the correction table (right) and the percent saturation chart (below). Using either your atmospheric pressure (as read from a barometer) or your local altitude (if a barometer is not available), read across to the right hand column to find the correction factor. Multiply your dissolved oxygen measurement by this factor to obtain a corrected value.

Now look at the percent saturation chart (next page). Draw a straight line between the water temperature at the test site and the corrected dissolved oxygen measurement, and read the saturation percentage at the intercept on the sloping scale.

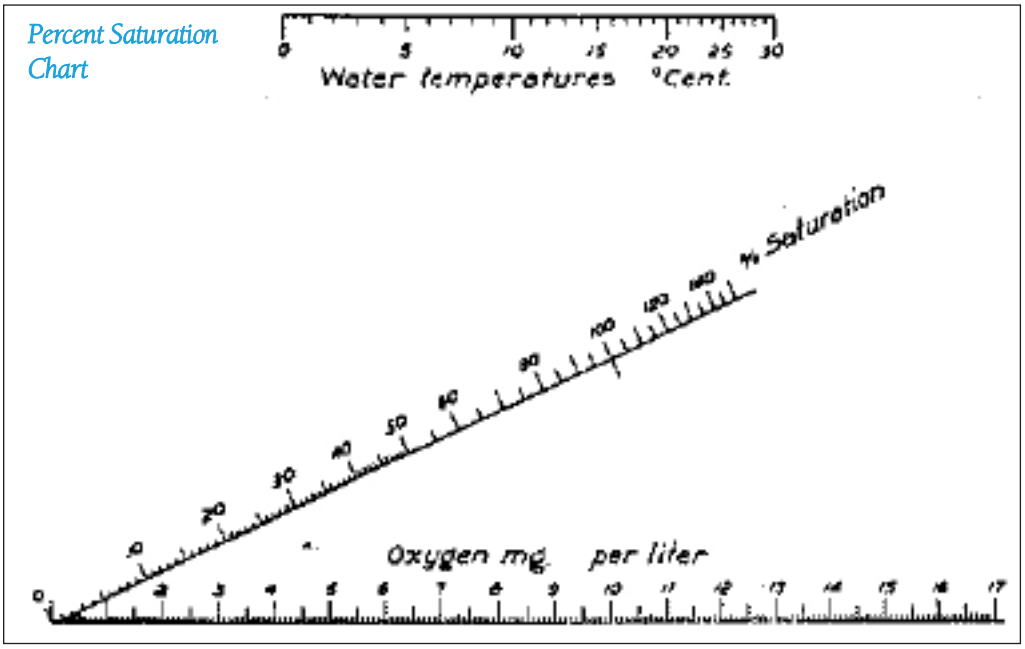
Correction Table for Dissolved Oxygen Measurements

Atmospheric Pressure (mmHg)	Equivalent Altitude (ft.)	Correction Factor
775	-540	1.02
760	0	1.00
745	542	.98
730	1094	.96
714	1688	.94
699	2274	.92
684	2864	.90
669	3466	.88
654	4082	.86
638	4756	.84
623	5403	.82
608	6065	.80
593	6744	.78
578	7440	.76
562	8204	.74
547	8939	.72
532	9694	.70
517	10,472	.68

EXAMPLE: Let's say that your dissolved oxygen value was 10 mg/L, the measured water temperature was 15°C, and the atmospheric pressure at the time of sampling was 608 mmHg. From the table above, the correction factor is 80 percent, which multiplied by 10 mg/L gives a corrected dissolved oxygen value of 8 mg/L. Drawing a straight line between this value and 15°C gives a percent saturation of about 80 percent.

How might you interpret these results? At the relatively cool temperature of 15°C, one would expect a river to have a dissolved oxygen value higher than 80 percent. It would appear that something is using up oxygen in the water.

Percent Saturation Chart



B. DISSOLVED OXYGEN Sampling Procedures

The extended rod sampler with an elastic strap or wire basket can be used to hold a dissolved

oxygen bottle. Remember that the dissolved oxygen test should be run immediately after sampling.

WARNING: *Please wear protective gloves. If your skin comes into contact with any reagent, rinse this area liberally with water. First aid directions are included on the reagent containers. SAFETY GOGGLES SHOULD BE WORN WHILE SHAKING THE DISSOLVED OXYGEN BOTTLE.*

C. DISSOLVED OXYGEN Testing Procedure

1. If you have a barometer, record the atmospheric pressure. Remove the cap and immerse the DO bottle beneath the river's surface. Use gloves to avoid contact with the river.
2. Allow the water to overflow for two to three minutes. (This will ensure the elimination of air bubbles.)
3. Make sure no air bubbles are present when you take the bottle from the river.
4. Add 8 drops of Manganous Sulfate Solution and 8 drops of Alkaline Potassium Iodide Azide.
5. Cap the bottle, making sure no air is trapped inside, and invert repeatedly to fully mix. Be very careful not to splash the chemical-laden water. Wash your hands if you contact this water. If oxygen is present in the sample, a brownish-orange precipitate will form (floc). The first two reagents "fix" the available oxygen.
6. Allow the sample to stand until the precipitate settles halfway. When the top half of the sample turns clear, shake again, and wait for the same changes.
7. Add 8 drops of Sulfuric Acid 1:1 Reagent. Cap and invert repeatedly until the reagent and the precipitate have dissolved. A clear yellow to brown-orange color will develop depending on the oxygen content of the sample.

Note: Following completion of step 7, contact between the water sample and the atmosphere will not affect the test result. Once the sample has been "fixed" in this manner, it is not necessary to perform the actual test procedure immediately. Several samples can be collected and "fixed" in the field, and then carried back to a testing station or laboratory where the titration procedure is to be performed.

8. Fill the titration tube to the 20 ml line with the "fixed" sample and cap.
9. Fill the Direct Reading Titrator with Sodium Thiosulfate 0.025N Reagent. Insert the Titrator into the center hole of the titration tube cap. While gently swirling the tube, slowly press the plunger to titrate until the yellow-brown color is reduced to a very faint yellow.

Note: If the color of the fixed sample is already a very faint yellow, skip to step 10.

10. Remove the cap and Titrator. Be careful not to disturb the Titrator plunger, as the titration begun in step 8 will continue in step 11. Add 8 drops of Starch Indicator Solution. The sample should turn blue.
11. Replace the cap and Titrator. Continue titrating until the sample changes from blue to a colorless solution. Read the test result where the plunger tip meets the scale. Record as mg/L (ppm) dissolved oxygen.

Note: Each minor division on the Titrator scale equals 0.2 mg/L (0.2 ppm). Note: If the plunger tip reaches the bottom line on the Titrator scale (10) before the endpoint color change occurs, refill the Titrator and continue the titration. When recording the test result, be sure to include the value of the original amount of titrant dispensed.

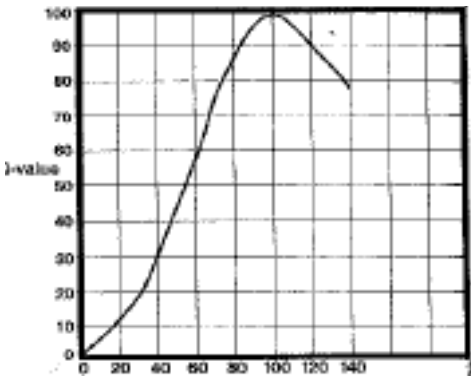
D. DISSOLVED OXYGEN Calculating the Results

To compute the Q-value for the dissolved oxygen test, follow these steps:

1. Find the weighting curve chart (below);
2. Locate your test result on the bottom (horizontal or "x" axis) of the chart;
3. Interpolate the Q-value for your test result using the following steps;
4. From your test result value on the horizontal ("x") axis of the chart, draw a vertical line up until it intersects the weighting curve line;
5. From this point of intersection, draw a horizontal line to the left hand side (the vertical or "y" axis) of the chart.
6. Where this horizontal line intersects the vertical ("y") axis of the chart, read off the value. This is the Q-value for this test; it should be recorded in Column B on the WQI chart on the Calculating Water Quality Index page 13.

The Q-value for each test should then be multiplied by the weighting factor listed in the chart on the Water Quality Index page. Record the product of this calculation in Column D of the chart.

Dissolved Oxygen Weighting Curve Chart



Nitrate: mg/L Note: If NO-3>100.0, Q=1.0