Dissolved Oxygen:
Aquatic Life Depends on It

Volunteer Monitoring Factsheet Series 2018

Why are we concerned?

- Both aquatic plants and animals depend on dissolved oxygen (D.O.) for survival.
- D.O. concentrations are influenced by many factors including water temperature, the rate of photosynthesis, the degree of light penetration (turbidity and water depth), the degree of water turbulence or wave action, and the amount of oxygen used by respiration and decay of organic matter.

Time Needed:
40 minutes

Equipment Needed:
- Hip boots
- Hatch dissolved oxygen water test kit
- Thermometer
- Safety Goggles
- Disposable plastic/latex gloves
- Form to record data
- Pen/pencil

When to Measure:
Usually early in the morning. Check with your local coordinator for schedules

Definition of Terms

Cold-blooded: Animals whose body temperatures match that of their surroundings. Fish, invertebrates, snakes, frogs and toads are cold-blooded.

Diel: Involving a 24-hour time period.

Diffusion: The movement of molecules, for example oxygen molecules, from an area of higher concentration (e.g. the air) to an area of lower concentration (e.g. the water).

Endpoint: The completion of a chemical reaction. It is often determined by the change in color of an indicator solution.

Floc: Short for flocculent precipitate. These fine, suspended particles look like heavy snow.

Photosynthesis: The process in which green plants convert carbon dioxide and water, using the sun's energy, into simple sugars and oxygen.

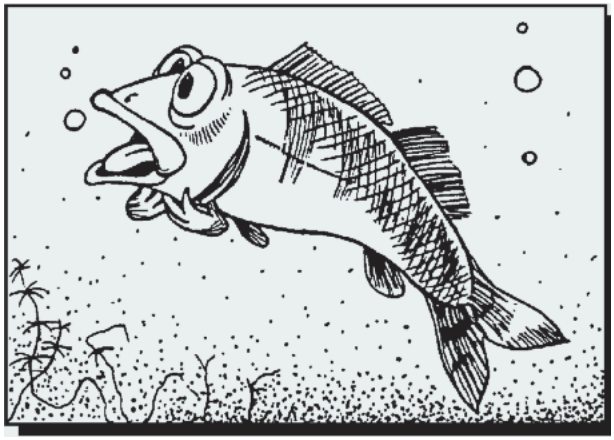
Respiration: The cellular process in which plants and animals use oxygen and release carbon dioxide. Basically, it is the reverse of photosynthesis because carbon dioxide, water and energy are released in the process.

Supersaturation: An indication that more oxygen is dissolved in water than would be in a state of equilibrium. Supersaturation could indicate that some processes are affecting the water's natural balance found in the state of equilibrium.

Titrant: The solution of known strength used for measuring the extent of a chemical reaction, in this case it is sodium thiosulfate.

Background on Dissolved Oxygen

Oxygen is a clear, colorless, odorless, and tasteless gas that dissolves in water. Small but important amounts of it are dissolved in water. It is supplied by diffusion of atmospheric (air) oxygen into the water and by production of oxygen from photosynthesis by aquatic plants. Wind, waves, and tumbling water in fast-moving streams increase the rate of diffusion.



Oxygen: Aquatic Life Depends on it

You will collect a total of three biotic index samples within the same 300' stream section that is used for the Habitat Assessment. Rocky bottom and soft bottom streams support different kinds of organisms, so be sure to choose sites based on your stream type. Your goal is to collect as many different kinds of aquatic macroinvertebrates from as many different habitats as necessary to ensure an accurate site assessment. Be aware that each habitat type has different sampling protocols and some have a greater diversity of organisms than others. If you have many habitats from which to choose, consider sampling from those with the most diversity. If your stream has a rocky bottom, sample at two separate riffle areas and at one other habitat. If your stream has a soft bottom or does not have riffles, collect samples at submerged logs, snags or undercut banks.

Dissolved oxygen (D.O.) is reported as milligrams of oxygen per liter of water (mg/L) which can be called parts per million by weight (ppm). Different aquatic organisms have different oxygen needs. Trout and stoneflies, for example, require high dissolved oxygen levels. Trout need water with at least 6 mg/L D.O. Warm water fish like bass and bluegills survive nicely at 5 mg/L D.O. and some organisms like carp and bloodworms can survive on less than 1 mg/L D.O. Based on this, there are stream classifications in Wisconsin that define the minimum amount of oxygen allowed at a site (see Table 1).

The oxygen demand of aquatic plants and cold-blooded animals also varies with water temperature. A trout uses five times more oxygen while resting at 80° F (26.7° C) than at 40° F (4.4° C).

TABLE 1: *Minimum dissolved oxygen levels allowed for waters with varied classification in Wisconsin.*

Stream Classification	Minimum Dissolved Oxygen Allowed
Trout Waters	6 mg/L (out of spawning season) and 7mg/L (during spring/fall spawning season)
Fish or aquatic life-designated waters	5 mg/L
Limited forage fish waters	3 ml/L
Limited aquatic life waters	1 mg/L

Factors Affecting Oxygen Levels

There are many factors that affect the amount of dissolved oxygen in the water (see inset boxes). A major one is photosynthesis. Aquatic plants produce oxygen by photosynthesis during daylight hours but they also use oxygen for respiration. High day-time levels of D.O. are often countered with low night-time levels (see a sample diel cycle for dissolved oxygen in Figure 1). This is due to respiration of living organ-isms, including fish, bacteria, fungi and protozoans, as well as the cessation of photosynthesis. Wide daily fluctuations of D.O. stress fish and other aquatic animals. Oxygen depletion can occur because of heavy plant growth. Complete depletion of D.O. can some-times be detected with your nose. Anaerobic decay results in a rotten egg smell (hydrogen sulfide gas). However, good management practices such as planting or maintaining vegetation that filters rainwater runoff and shades the water, cooler water temperatures and protecting the stream channel in other ways to maintain or increase turbulence all promote good dissolved oxygen levels.

Factors that could INCREASE the amount of dissolved oxygen in water	Factors that could DECREASE the amount of dissolved oxygen in water
• High atmospheric pressure • Clear water • Photosynthesis • A lot of turbulence/wave action • Cold water • Presence of excessive amounts of plants (during daytime)	• Respiration of animals and plants living in the water • Chemical reactions of the decaying process • Low atmosphere pressure • High levels of turbidity (such as from erosion) • Warm water • Very colored water • Presence of excessive amounts of plants (at nighttime) • Excessive organic materials (such as sewage, manure, or fertilizers)

Percent Saturation

Recording dissolved oxygen differs from other tests in that it requires two distinct calculations. We are interested in both the absolute amount of D.O. (mg/L or ppm) and how close the value is to the equilibrium value for that temperature and air pres-sure -which is the percentage of saturation. Values between 90% and 110% of saturation are excellent (see Figure at right). Supersaturated (over 100%) values may sound good but they can also indicate problems, such as excessive plant growth. You can assess the range of dissolved oxygen levels that aquatic plants and animals at your stream site must withstand by monitoring twice in one day – early in the morning, just before sunrise, and later in the afternoon when plants have been exposed to the most direct sunlight for an extended period.

Dissolved Oxygen Levels (% saturation)
Excellent: 91 - 110
Good: 71 - 90
Fair: 51 - 70

SOURCE: Field Manual for Water Quality Monitoring (13th Edition)

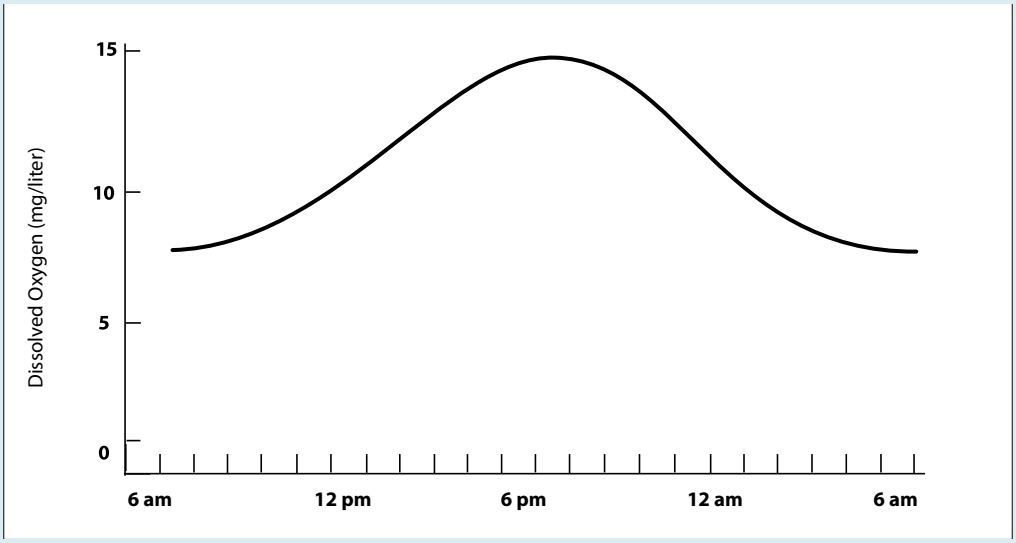


FIGURE 1: Diel Fluctuation in dissolved oxygen

Temperature Conversion Chart

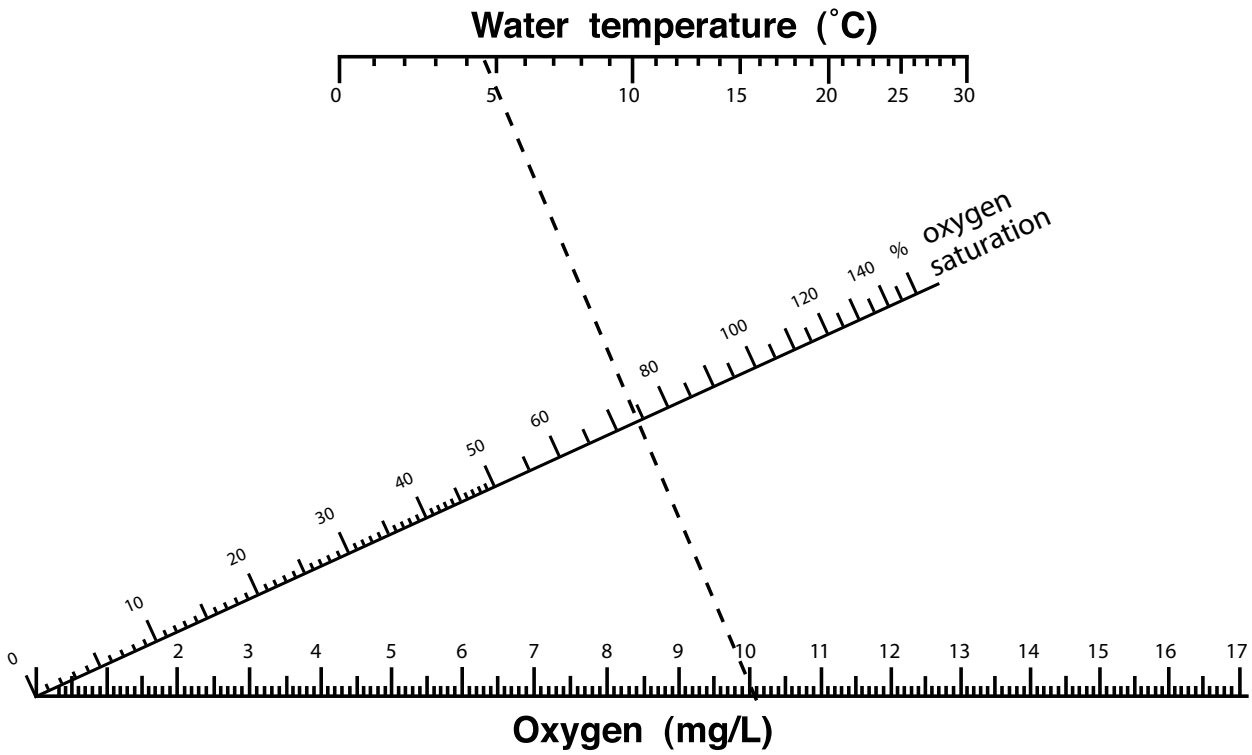
Fahrenheit	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Celsius	.6	1.1	1.7	2.2	2.8	3.3	3.9	4.4	5	5.6	6.1	6.7	7.2	7.8	8.3	8.9	9.4	10	10.6

Fahrenheit	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
Celsius	11.1	11.7	12.2	12.8	13.3	13.9	14.4	15	15.6	16.1	16.7	17.2	17.8	18.3	18.9	19.4	20	20.6	21.1

Fahrenheit	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
Celsius	21.7	22.2	22.8	23.3	23.9	24.4	25	25.6	26.1	26.7	27.2	27.8	28.3	28.9	29.4	30	30.6	31.1	31.7

How to Find Percent Saturation:

Using a straight edge, find your water temperature (convert from Fahrenheit if necessary using above chart). Align with the oxygen (mg/L) scale. The measured percent saturation is on the point where the line connecting those two points crosses the oxygen saturation line. For example, 5˚C with 10 mg/L of oxygen aligns with 75% saturation, which is your answer.



Collecting the Sample

Remember that photosynthesis and respiration will continue after a sample is collected, so water can gain or lose oxygen while sitting in the sample bottle. Therefore, you should begin D.O. testing immediately upon reaching the shore after you have collected the sample.

You should measure water temperature at the same time and location that you collect the D.O. sample.

Think Like a Scientist!

Follow the directions VERY CAREFULLY! Accuracy is a must for valid data comparisons.

1. Use bottle with the stopper included in the Hach or LaMotte kit.
2. Collect your sample in roughly one-foot deep, normally moving water.
3. Facing upstream, slowly lower the bottle so opening of the bottle faces away from you and water current is entering the bottle.
4. Allow the bottle to fill with water gradually turning it to allow air bubbles to float out.
5. Cap bottle while still submerged and leave extra water in the neck of the bottle.
6. When lifting the bottle out of the water, look for bubbles. If you see any, take another sample using the same procedure.

Testing for Dissolved Oxygen

Using the Hach Model 146900

Note: If you see any air bubbles trapped in the sample bottle during steps 2-4 below, discard the sample and start over.

1. Put on protective gloves and safety goggles. If your skin comes in contact with any powder or titrant, rinse the area liberally with water.
2. Remove the stopper and add the contents of D.O. powder pillow #1 (manganous sulfate powder) and D.O. powder pillow #2 (alkaline iodide azide powder) to the sample.
3. Insert the stopper, being careful not to trap an air bubble and shake vigorously, holding on to the top. If oxygen is present, a brownish-orange floc will form.
4. Allow the sample to stand until the floc settles halfway. Shake the bottle a second time and allow the floc to settle halfway again.
5. Remove the stopper and slowly add the contents of D.O. powder pillow #3 (sulfamic acid).
6. Stopper and shake vigorously until the acid is dissolved. The yellow color is from iodine. This is called the prepared sample. Prepared samples can be stored in the dark for a short time if it is more convenient or comfortable to return to your home/school to complete the analysis.
7. Transfer two plastic measuring tubes full of prepared sample to the square glass mixing bottle (your Hach kit instructions probably say one measuring tube full). Using two measuring tubes allows you to determine D.O. to the nearest 0.5 mg/L instead of 1 mg/L .
8. ***a)*** Holding the dropper vertically, add one drop at a time of sodium thiosulfate standard solution titrant to the square mixing bottle, and count each drop. ***b.)*** Swirl the solution after each drop. ***c.)*** Continue adding sodium thiosulfate drops until the sample is a very light yellow. ***d.)*** Add 3 to 4 drops of starch solution. The prepared sample will turn blue from the added starch solution. If you do not have starch solution, proceed with the next step but be aware that your sample will turn from yellow to colorless instead of blue to colorless. ***e.)*** Continue adding drops, mixing and counting until the prepared sample turns from blue (or yellow) to colorless (the end point). Often this is just one or two more drops, so be careful.
9. The dissolved oxygen content of the water in mg/L is the total number of drops of titrant used to get to the endpoint divided by two if two measuring tubes of prepared sample were used. If only one measuring tube of prepared sample was used, the dissolved oxygen content is equal to the number of drops of titrant. Example: If you used two tubes of sample, you need to divide by two (13 drops divided by two tubes = 6.5 mg/L). If you only used one tube of sample, it's the actual number of drops of titrant used (6 drops with one tube = 6 mg/L)
10. Report dissolved oxygen (mg/L) and temperature on the recording form.
11. Use instructions and chart below to convert D.O. to %saturation. Report % saturation on the recording form.

Using the LaMotte Test Kit Model 7414 or 5860

A) Fix your sample

1. Put on protective gloves and safety goggles. If your skin comes in contact with any powder or titrant rinse the area liberally with water.
2. Holding the reagent bottle completely upside down, add 8 drops of Manganous Sulfate solution (labeled "1" on bottle).
3. Holding the reagent bottle completely upside down, add 8 drops of Alkaline Potassium Iodide Azide (labeled "2" on bottle).
4. Cap and shake the bottle for 30 seconds. A white to brownish orange floc will cloud the sample bottle. Let the floc settle until the top half of the bottle is clear.
5. Shake the bottle again. Allow the floc to settle again.
6. Add 8 drops of Sulfuric Acid 1:1 (red cap on bottle) and shake for 30 seconds. The solution will turn from cloudy to clear in color (If you still see some dark "pepper specks" in the solution add 1 more drop). Your sample is now "fixed".
7. Pour your fixed sample into the graduated cylinder to the 20 ml mark and then pour it into the titration vial (glass vial labeled code 0299).

B) Prepare to titrate

1. Pick up the plastic titrator syringe (labeled code 1649) and push in the plunger to expel air.
2. Put the tip of the titrator syringe into the hole in the top of the titrating solution (bottle labeled Sodium Thiosulfate 0.025N). Fill the syringe by turning the bottle upside down and slowly pull back on the syringe plunger until the tip on the bottom of the plunger is well past the zero mark on the scale on the titrator. You may have to push the plunger in and out a few times to get rid of any air bubbles in the syringe.
3. Turn everything right side up.
4. Slowly push the plunger until the large ring on the plunger of the plastic titrator syringe is right at the zero mark on the titrator.
5. Remove the titrator from the sodium thiosulfate bottle.

C) Titrate the sample

1. Put the tip of the titrator into the opening on the plastic cap of the titration vial (code 0299) that contains your fixed sample.
2. Add the titrating solution one drop at a time by gently pushing the plunger. Swirl the solution between drops until the sample has turned pale yellow. If your solution is already pale yellow skip this step. If your solution is colorless you have zero mg/l dissolved oxygen (if this is the case you can proceed to step 24 for confirmation, if you like).
3. Pop off the plastic cap from the titration vial with the titrator still in the hole without moving the plunger in the syringe.
4. Add 8 drops of starch indicator solution to the pale yellow sample in the titration vial. The sample should now turn deep blue or black.
5. Put the cap back on the titration vial.
6. Swirl to mix the contents.
7. Continue to add sodium thiosulfate one drop at a time, swirling the solution between each drop Observe the color change from dark blue to light blue.
8. Stop when the solution turns from pale blue to colorless. (If no color change occurs by the time the plunger tip reaches the bottom of the scale on the titrator, refill the titrator by filling with titrant to the zero mark and continue the titration. Include both titration amounts in the final test results.)
9. Read the test result directly from where the scale intersects the ring of the plunger for plastic titrator. The titrator is marked at 0.2 ppm increments. So if the titrator ring is touching the third line below the line marked "7" the result would be 7.6 mg/l dissolved oxygen. (If the titrator has been refilled once before, the result would be 17.6 mg/l dissolved oxygen.)
10. Report dissolved oxygen (mg/L) and temperature on the recording form.
11. Use instructions and chart below to convert D.O. to % saturation. Report % saturation on the recording form.

-Modified from URI Watershed Watch

Water Action Volunteers is a cooperative program between the University of Wisconsin-Madison Division of Extension and the Wisconsin Department of Natural Resources. For more information, go to https://wateractionvolunteers.org/