Computer 5

Dissolved Oxygen

INTRODUCTION

Oxygen gas dissolved in water is vital to the existence of most aquatic organisms. Oxygen is a key component in cellular respiration for both aquatic and terrestrial life. The concentration of dissolved oxygen, *DO*, in an aquatic environment is an important indicator of the environment's water quality.

Table 1: Minimum DO Requirements	
Organism	Minimum dissolved oxygen (mg/L)
Trout	6.5
Smallmouth bass	6.5
Caddisfly larvae	4.0
Mayfly larvae	4.0
Catfish	2.5
Carp	2.0
Mosquito larvae	1.0

Some organisms, such as salmon, mayflies, and trout, require high concentrations of dissolved oxygen. Other organisms, such as catfish, mosquito larvae, and carp, can survive in environments with lower concentrations of dissolved oxygen. The diversity of organisms is greatest at higher DO concentrations. Table 1 lists the minimum dissolved oxygen concentrations necessary to sustain selected animals.

Oxygen gas is dissolved in water by a variety of processes—diffusion between the atmosphere and water at its surface, aeration as water flows over rocks and other debris, churning of water by waves and wind, and photosynthesis of aquatic plants. There are many factors that affect the concentration of dissolved oxygen in an aquatic environment. These factors include: temperature, stream flow, air pressure, aquatic plants, decaying organic matter, and human activities.

Sources of DO

- Diffusion from atmosphere
- Aeration as water moves over rocks and debris
- Aeration from wind and waves
- Photosynthesis of aquatic plants

As a result of plant activity, DO levels may fluctuate during the day, rising throughout the morning and reaching a peak in the afternoon. At night photosynthesis ceases, but plants and animals continue to respire, causing a decrease in DO levels. Because large daily fluctuations are possible, DO tests should be performed at the same time each day. Large fluctuations in dissolved oxygen levels over a short period of time may be the result of an algal bloom. While the algae population is growing at a fast rate, dissolved oxygen levels increase. Soon the algae begin to die and are decomposed by aerobic bacteria, which use up the oxygen. As a greater number of algae die, the oxygen requirement of the aerobic decomposers increases, resulting in a sharp drop in dissolved oxygen levels. Following an algal bloom, oxygen levels can be so low that fish and other aquatic organisms suffocate and die.

Factors that affect DO levels

- Temperature
- Aquatic plant populations
- Decaying organic material in water
- Stream flow
- Altitude/atmospheric pressure
- Human activities

Temperature is important to the ability of oxygen to dissolve, because oxygen, like all gases, has different solubilities at different temperatures. Cooler waters have a greater capacity for dissolved oxygen than warmer waters. Human activities, such as the removal of foliage along a stream or the release of warm water used in industrial processes, can cause an increase in water temperature along a given stretch of the stream. This results in a lower dissolved oxygen capacity for the stream.

Expected Levels

The unit mg/L[2] is the quantity of oxygen gas dissolved in one liter of water. When relating DO measurements to minimum levels required by aquatic organisms, mg/L is used. The procedure described in this chapter covers the use of a Dissolved Oxygen Probe to measure the concentration of DO in mg/L. Dissolved oxygen concentrations can range from 0 to 15 mg/L. Cold mountain streams will likely have DO readings from 7 to 15 mg/L, depending on the water temperature and air pressure. In their lower reaches, rivers and streams can have DO readings between 2 and 11 mg/L.

Table 2

DO Level	Percent Saturation of DO
Supersaturation[1]	≥ 101%
Excellent	90 – 100%
Adequate	80 – 89%
Acceptable	60 – 79%
Poor	< 60%

When discussing water quality of a stream or river, it can be helpful to use a different unit than mg/L. The term percent saturation is often used for water quality comparisons. Percent saturation is the dissolved oxygen reading in mg/L divided by the 100% dissolved oxygen value for water (at the same temperature and air pressure). The manner in which percent saturation relates to water quality is displayed in Table 2. In some cases, water can exceed 100% saturation and become supersaturated for short periods of time.

Summary of Methods

Dissolved oxygen can be measured directly at the site or from water samples transported from the site. Measurements can be made at the site by either placing the Dissolved Oxygen Probe directly into the stream away from the shore or by collecting a water sample with a container or cup and then taking measurements with the Dissolved Oxygen Probe back on the shore. Water samples collected from the site in capped bottles and transported back to the lab must be stored in an ice chest or refrigerator until measurements are to be made. Transporting samples is not recommended, because it reduces the accuracy of test results.

1 Supersaturation can be harmful to aquatic organisms. It can result in a disease known as Gas Bubble Disease.
2 The unit of mg/L is numerically equal to parts per million, or ppm.

DISSOLVED OXYGEN

Materials Checklist

___ computer
___ Vernier computer interface
___ Logger *Pro*
___ Vernier Dissolved Oxygen Probe
___ DO Electrode Filling Solution
___ Sodium Sulfite Calibration Solution
___ 250 mL beaker
___ 100% calibration bottle
___ wash bottle with distilled water
___ tissues or paper towels
___ pipet
___ small plastic or paper cup (optional)

Collection and Storage of Samples

1. Before you begin sampling, fill out the site information on the Data & Calculations sheet. Space for observations regarding the site is provided at the bottom of the Data & Calculations sheet. Special things to note about the site are the weather, descriptions of the stream reach (flow, depth, shape), and a description of the riparian zone (density of foliage and width of riparian zone).

2. It is important to sample as far away from the shore as is safe and under the surface of the water. Samplers consisting of a rod and container can be constructed for collection of samples from areas of the stream otherwise unreachable. Refer to page Intro-4 of the Introduction of this book for more details. In slow-moving water, it is necessary to take samples below the water's surface at various depths.

3. When collecting a sample with a cup or container, prevent mixing of the water sample and air by collecting your sample from below the water surface.

4. If you are going to take readings after returning to the laboratory, make sure that there are no air bubbles in the water-sample container and that the container is tightly stoppered. The sample should be stored in an ice chest or refrigerator until measurements are to be made. Storing water samples for later testing decreases sample accuracy and is only recommended in cases where measuring at the site is not possible.

5. When taking readings in cold (0–10°C) or warm (25–35°C) water, allow more time for the dissolved oxygen readings to stabilize. Automatic temperature compensation in the Dissolved Oxygen Probe is not instantaneous and readings may take up to 2 minutes to stabilize depending on the temperature.

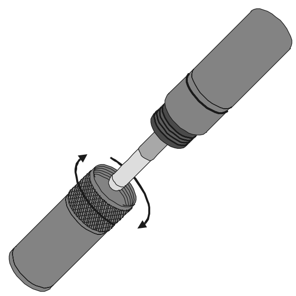
Testing Procedure

1. Position the computer safely away from the water. Keep water away from the computer at all times.

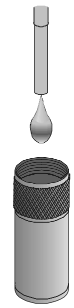
2. Prepare the Dissolved Oxygen Probe for use.

   a. Remove the blue protective cap if it is still on the tip of the probe.
   b. Unscrew the membrane cap from the tip of the probe.
   c. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling Solution.

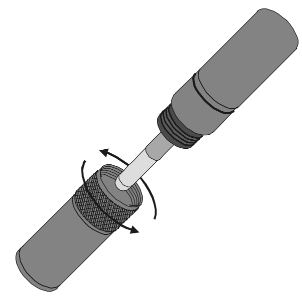
d. Carefully thread the membrane cap back onto the electrode.
e. Place the probe into a container of water.



Remove membrane cap



Add electrode filling solution



Replace membrane cap

3. Plug the Dissolved Oxygen Probe into Channel 1 of the Vernier interface.

4. Prepare the computer for data collection by opening the “05 Dissolved Oxygen” file from the *Water Quality with Vernier* folder of Logger*Pro*.

5. It is necessary to warm up the Dissolved Oxygen Probe for 5–10 minutes before taking readings. To warm up the probe, leave it connected to the interface, with Logger *Pro* running, for 10 minutes. The probe must stay connected at all times to keep it warmed up. If disconnected for a few minutes, it will be necessary to warm up the probe again.

6. You are now ready to calibrate the Dissolved Oxygen Probe.
   - If your instructor directs you to use the calibration stored in the experiment file, then proceed to Step 7.
   - If your instructor directs you to perform a new calibration for the Dissolved Oxygen Probe, follow this procedure.

Zero-Oxygen Calibration Point

a. Choose Calibrate ▸ CH1: Dissolved Oxygen (mg/L) from the Experiment menu and then click Calibrate Now.
b. Remove the probe from the water and place the tip of the probe into the Sodium Sulfite Calibration Solution. **Important:** No air bubbles can be trapped below the tip of the probe or the probe will sense an inaccurate dissolved oxygen level. If the voltage does not rapidly decrease, tap the side of the bottle with the probe to dislodge any bubbles. The readings should be in the 0.2 to 0.5 V range.
c. Type **0** (the known value in mg/L) in the edit box.
d. When the displayed voltage reading for Reading 1 stabilizes, click Keep.

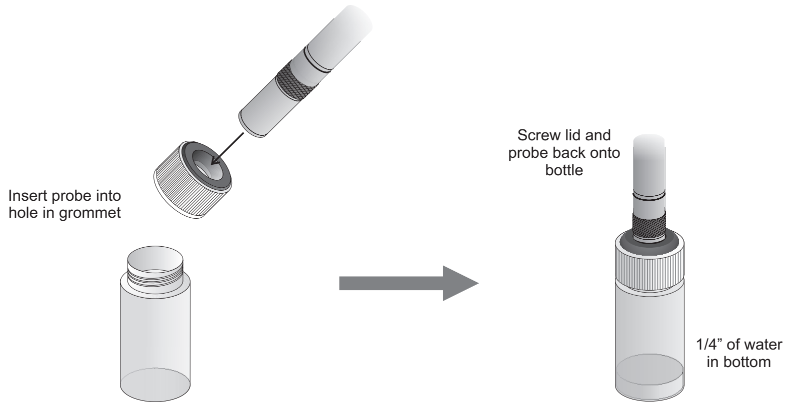
Insert probe at an angle

Submerge probe tip 1-2 cm

Saturated DO Calibration Point

e. Rinse the probe with distilled water.

f. Unscrew the lid of the calibration bottle provided with the probe. Slide the lid and the grommet about 1/2 inch onto the probe body.

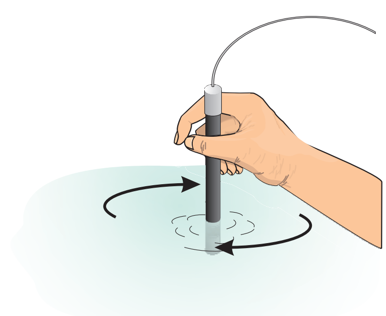


g. Add water to the bottle to a depth of about 1/4 inch and screw the bottle into the cap, as shown. **Important:** Do not touch the membrane or get it wet during this step. Keep the probe in this position for about a minute.

h. Type the correct saturated dissolved-oxygen value (in mg/L) from Table 3 (for example, **8.66**) using the current barometric pressure and air temperature values. If you do not have the current air pressure, use Table 4 to estimate the air pressure at your altitude.

i. When the displayed voltage reading for Reading 2 stabilizes (readings should be above 2.0 V), click Keep and then click Done.

7. You are now ready to collect dissolved oxygen concentration data.



a. Rinse the tip of the probe with sample water.

b. Place the tip of the probe into the stream at Site 1, or into a cup with sample water from the stream. Submerge the probe tip to a depth of 4-6 cm.

c. Click Collect to begin data collection.

d. Gently stir the probe in the water sample. Click Keep to begin a 10 s sampling run. **Important:** Leave the probe tip submerged for the 10 seconds that data is being collected.

e. When the sampling run is complete, stop data collection and record the mean dissolved oxygen concentration value on the Data & Calculations sheet.

8. Return to Step 7 to obtain a second reading. When both readings have been taken, rinse the tip of the probe and secure it in the calibration bottle filled with water.

Table 3: 100% Dissolved Oxygen Capacity (mg/L)												
	770 mm	**760 mm**	**750 mm**	**740 mm**	**730 mm**	**720 mm**	**710 mm**	**700 mm**	**690 mm**	**680 mm**	**670 mm**	**660 mm**
0°C	14.76	14.57	14.38	14.19	13.99	13.80	13.61	13.42	13.23	13.04	12.84	12.65
1°C	14.38	14.19	14.00	13.82	13.63	13.44	13.26	13.07	12.88	12.70	12.51	12.32
2°C	14.01	13.82	13.64	13.46	13.28	13.10	12.92	12.73	12.55	12.37	12.19	12.01
3°C	13.65	13.47	13.29	13.12	12.94	12.76	12.59	12.41	12.23	12.05	11.88	11.70
4°C	13.31	13.13	12.96	12.79	12.61	12.44	12.27	12.10	11.92	11.75	11.58	11.40
5°C	12.97	12.81	12.64	12.47	12.30	12.13	11.96	11.80	11.63	11.46	11.29	11.12
6°C	12.66	12.49	12.33	12.16	12.00	11.83	11.67	11.51	11.34	11.18	11.01	10.85
7°C	12.35	12.19	12.03	11.87	11.71	11.55	11.39	11.23	11.07	10.91	10.75	10.59
8°C	12.05	11.90	11.74	11.58	11.43	11.27	11.11	10.96	10.80	10.65	10.49	10.33
9°C	11.77	11.62	11.46	11.31	11.16	11.01	10.85	10.70	10.55	10.39	10.24	10.09
10°C	11.50	11.35	11.20	11.05	10.90	10.75	10.60	10.45	10.30	10.15	10.00	9.86
11°C	11.24	11.09	10.94	10.80	10.65	10.51	10.36	10.21	10.07	9.92	9.78	9.63
12°C	10.98	10.84	10.70	10.56	10.41	10.27	10.13	9.99	9.84	9.70	9.56	9.41
13°C	10.74	10.60	10.46	10.32	10.18	10.04	9.90	9.77	9.63	9.49	9.35	9.21
14°C	10.51	10.37	10.24	10.10	9.96	9.83	9.69	9.55	9.42	9.28	9.14	9.01
15°C	10.29	10.15	10.02	9.88	9.75	9.62	9.48	9.35	9.22	9.08	8.95	8.82
16°C	10.07	9.94	9.81	9.68	9.55	9.42	9.29	9.15	9.02	8.89	8.76	8.63
17°C	9.86	9.74	9.61	9.48	9.35	9.22	9.10	8.97	8.84	8.71	8.58	8.45
18°C	9.67	9.54	9.41	9.29	9.16	9.04	8.91	8.79	8.66	8.54	8.41	8.28
19°C	9.47	9.35	9.23	9.11	8.98	8.86	8.74	8.61	8.49	8.37	8.24	8.12
20°C	9.29	9.17	9.05	8.93	8.81	8.69	8.57	8.45	8.33	8.20	8.08	7.96
21°C	9.11	9.00	8.88	8.76	8.64	8.52	8.40	8.28	8.17	8.05	7.93	7.81
22°C	8.94	8.83	8.71	8.59	8.48	8.36	8.25	8.13	8.01	7.90	7.78	7.67
23°C	8.78	8.66	8.55	8.44	8.32	8.21	8.09	7.98	7.87	7.75	7.64	7.52
24°C	8.62	8.51	8.40	8.28	8.17	8.06	7.95	7.84	7.72	7.61	7.50	7.39
25°C	8.47	8.36	8.25	8.14	8.03	7.92	7.81	7.70	7.59	7.48	7.37	7.26
26°C	8.32	8.21	8.10	7.99	7.89	7.78	7.67	7.56	7.45	7.35	7.24	7.13
27°C	8.17	8.07	7.96	7.86	7.75	7.64	7.54	7.43	7.33	7.22	7.11	7.01
28°C	8.04	7.93	7.83	7.72	7.62	7.51	7.41	7.30	7.20	7.10	6.99	6.89
29°C	7.90	7.80	7.69	7.59	7.49	7.39	7.28	7.18	7.08	6.98	6.87	6.77
30°C	7.77	7.67	7.57	7.47	7.36	7.26	7.16	7.06	6.96	6.86	6.76	6.66
31°C	7.64	7.54	7.44	7.34	7.24	7.14	7.04	6.94	6.85	6.75	6.65	6.55

Table 4: Approximate Barometric Pressure at Different Elevations					
Elevation (feet)	**Pressure (mm Hg)**	**Elevation (feet)**	**Pressure (mm Hg)**	**Elevation (feet)**	**Pressure (mm Hg)**
0	760	2000	708	4000	659
250	753	2250	702	4250	653
500	746	2500	695	4500	647
750	739	2750	689	4750	641
1000	733	3000	683	5000	635
1250	727	3250	677	5250	629
1500	720	3500	671	5500	624
1750	714	3750	665	5750	618

DATA & CALCULATIONS

Dissolved Oxygen

Stream or lake: ______________________________ Time of day: ______________________________

Site name: ______________________________ Student name: ______________________________

Site number: ______________________________ Student name: ______________________________

Date: ______________________________ Student name: ______________________________

Column	A	B	C	D	E
Reading	Dissolved oxygen (mg/L)	Water temperature (°C)	Atmospheric pressure (mmHg)	100% dissolved oxygen (mg/L)	Percent saturation (%)
Example	8.2 mg/L	18.4°C	760 mmHg	9.5 mg/L	86 %
1					
2					
				Average %	

Column Procedure:

A. Record the dissolved oxygen reading from computer.
B. Record the water temperature from a Temperature Probe or thermometer (Test 1).
C. Record the atmospheric pressure from a barometer or by using known altitude (see Table 4).
D. From Table 3, record the 100% dissolved oxygen value using measured temperature and atmospheric pressure.
E. Percent saturation = A / D x 100

Field Observations (e.g., weather, geography, vegetation along stream) ______________________________

____

____

____

Test Completed: ________________ Date: ______

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Water Quality with Vernier* lab manual includes 16 water quality tests and essential teacher information. The full lab book is available for purchase at: http://www.vernier.com/cmat/wqv.html

Vernier Software & Technology

Vernier Software & Technology
13979 S.W. Millikan Way • Beaverton, OR 97005-2886
Toll Free (888) 837-6437 • (503) 277-2299 • FAX (503) 277-2440
info@vernier.com • www.vernier.com