Experiment GB-3: Water Quality

Background

The acidity, salinity, conductivity, and many other properties of natural water systems depend on the conditions of the environment that surround the water systems. These properties determine the organisms that can live in the water system.

To maintain aquatic life in a water system, the properties of water quality need to be within a narrow range of values. For example, if the water system is too acidic (pH <4) or too basic (pH >9), it usually cannot sustain aquatic organisms. Other properties, like salinity, affect the species of organisms that can live within a water system; some species of fish only live in water with low or no salinity, while other species can only live in seawater.

The water that fills natural water systems may begin as rain that is slightly acidic, and becomes more acidic as it seeps through the leaves littering the forest floor. As the water percolates through the soil, it reverts to being less acidic and becomes basic as it moves through deposits of minerals, like limestone. These compounds in the ground usually balance each other, so that natural water systems have a pH between 4 and 9.

The interactions of humans with the environment can alter the quality of water dramatically and affect the survival of aquatic life. Many natural water systems are surrounded by agricultural land. Nutrients in the soil and fertilizers applied to the land can alter the abundance of aquatic life in the water system. When these chemicals reach the water system, they can stimulate the growth of organisms, like algae, that actually deplete the water system of dissolved oxygen and affect the survival of fish in that water.

In this experiment, students will collect water samples from a variety of sources, like streams and ponds, around their community. They can also collect samples of tap water, water from swimming pools and drinking fountains, and deionized or distilled water for testing. Students will measure the temperature of the water at the site where it is collected. When the water samples are brought back to the laboratory, the students will measure the pH, dissolved oxygen concentration, and specific gravity of their samples. The values of these four parameters for each sample will be entered into a table for comparison.

Equipment Required

PC Computer

IWX/214 data acquisition unit

USB cable

IWX/214 power supply

ISE-730 Dissolved oxygen electrode

DO2-100 Current to voltage adapter

ISE-100 combination pH electrode

Magnetic stirrer

Stir bars

200 ml flasks (4)

Nalgene plastic water sample bottles with caps

1000 ml beaker

Roll of plastic wrap

pH 4 and pH 7 buffer solutions

Thermometer

Hydrometer and cylinder

Deionized water

Zero-percent oxygen calibration solution

Collect Water Samples

1. Your instructor will organize the collection of water samples for your lab session. Sampling may be part of the regular lab session or may need to be completed before the lab session in which the samples are analyzed.
2. When going sampling, wear appropriate clothing for doing outdoor activities. Wear personal flotation devices where and when water safety precautions should be taken.
3. Check the contents of the water sampling kit to make it sure contains the appropriate number of clean and capped water sample bottles, sampling container and retrieval devices, thermometer, indelible marking pen, and protective gear like goggles and gloves.
4. Make sure the set of sample bottles have been cleaned and rinsed with distilled water. Attach a label to each bottle.
5. Proceed to the first collection site and collect a sample of water according to the directions for using the sampling equipment provided by your instructor.
6. Use the thermometer to measure the temperature of the water at the site where the sample was taken.
7. Fill the sample bottles as high as possible to insure there is no air in the bottle. Quickly and tightly cap the bottle.
8. Using the indelible marking pen, label the bottle with information about the following parameters: the date and time of the collection; the name and location of the collection site; the weather conditions at the collection site; and, the temperature of the water at the collection site.
9. Repeat Steps 5 through 8 at other collection sites. Then, return to the lab for analysis of your water samples.

IWX/214 Setup

1. Place the IWX/214 on the bench, close to the computer.
2. Check Figure 1-1 in Chapter 1 for the location of the USB port and the power socket on the IWX/214.
3. Use the USB cable to connect the computer to the USB port on the rear panel of the IWX/214.
4. Plug the power supply for the IWX/214 into the electrical outlet. Insert the plug on the end of the power supply cable into the labeled socket on the rear of the IWX/214. Use the power switch to turn on the unit. Confirm that the red power light is on.

Start the Software

1. Click the Windows **Start menu**, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the LabScribe **icon** on the Desktop
2. When the program opens, select **Load Group** from the **Settings menu**.
3. From the dialog box, select **AddedLabs.iws**. Click **Load**.
4. Click on the **Settings menu** again and select the **Water Quality** settings file.
5. After a short time, LabScribe will appear on the computer screen as configured by the **WaterQuality** settings.
6. If you want a digital display of the current dissolved oxygen concentration and pH level to appear on the **Main window** during the recording, open the **View menu** and select **Voltmeter**.

Dissolved Oxygen and pH Electrodes Setup

1. Plug one end of the DIN-DIN cable into Channel 3 on the iWorx unit. Plug the other end of this cable into the DIN connector on the DO2-100 current to voltage adapter (Figure GB-3-1 on page 2).
2. Attach the cable from the ISE-730 dissolved oxygen electrode to the BNC connector on the current to voltage adapter.
3. Plug the DIN connector on the end of the cable of the ISE-100 pH electrode into Channel 4 on the iWorx unit.

Calibration of the Dissolved Oxygen Electrode

Aim: To calibrate the dissolved oxygen electrode.

The standard used for calibrating the dissolved oxygen electrode is the known concentration of oxygen in air-saturated deionized water. The amount of oxygen that is dissolved in water is known as its solubility (S) and it is dependent upon the temperature, oxygen pressure in the air, and the concentrations of dissolved solutes in the water. Solubility (S) can be determined by using the following equation:

$$S = (\alpha/22.414)\ ((P-p)/P)\ (r\%/100).$$

In this equation, α is the absorption coefficient of O_2 at the temperature, **p** is the vapor pressure of water at the temperature, **P** is the barometric pressure, and **r%** is the percent oxygen in the air. For example, at 26°C and 760mmHg and a concentration of oxygen in air of 21%, S equals:

$$(0.02783/22.414\text{L/mole})(734.91\text{mmHg}/760\text{mmHg})(0.21) = 252\mu MO_2$$

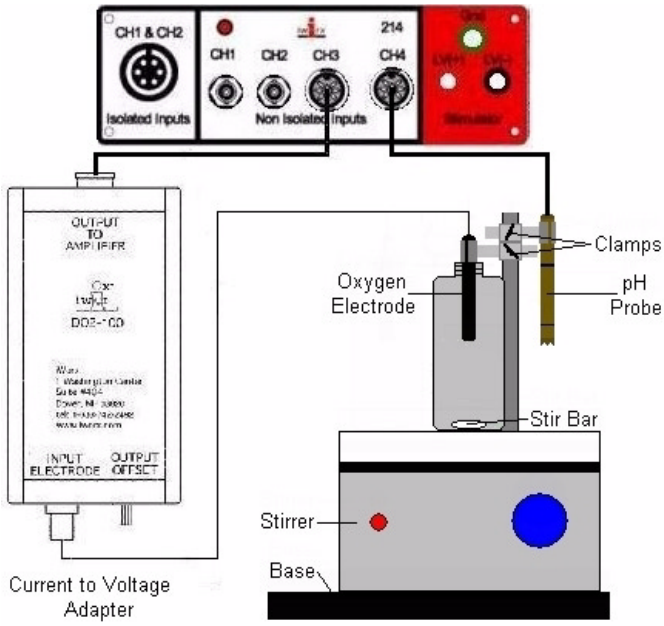

Figure GB-3-1: The setup for recording oxygen concentration levels and pH in a small closed ecosystem using the iWorx/214.

Procedure

1. Place the oxygen electrode in a 250 ml beaker containing room temperature deionized water. There needs to be enough water in the beaker to submerge the tip of the oxygen electrode, and keep its tip away from the stir bar in the beaker. Place the beaker on a magnetic stirrer. Adjust the speed of the stirrer so the stir bar is rotating quickly and evenly.
2. Click **Start** on the LabScribe **Main window** to begin recording. The trace will eventually reach a stable baseline towards the top of the recording channel. Type the words **Saturation-DI Water** on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the stable baseline of the recording. This comment marks the output of the oxygen electrode in room temperature deionized water that is saturated with as much oxygen as it can hold.
3. Obtain a beaker containing zero-percent oxygen calibration solution at room temperature. Make sure there is enough solution in the beaker to keep the tip of the electrode clear of the stir bar.Continue to record as you remove the oxygen electrode from the deionized water and place it in the beaker with the zero-percent oxygen calibration solution.

4 Turn off the magnetic stirrer. Remove the beaker of deionized water from the stirrer, and place the beaker containing zero-percent oxygen calibration solution on the stirrer. Turn on the stirrer and adjust the speed of the stirrer so the stir bar is rotating quickly and evenly.

5 The trace will move towards the bottom of the recording channel. Type the words **No Oxygen** on the comment line. Eventually, the trace will reach a stable baseline at the bottom of the recording channel. Press the **Enter key** on the keyboard to mark this new baseline. This comment marks the output of the oxygen electrode in a room temperature solution that is depleted of oxygen.

6 Click **Stop** to halt the recording.

7 Select **Save As** in the **File menu**, type a name for the file. Choose a destination on the computer in which to save the file (e.g., a class folder). Click the **Save button** to save the file (as an ***.iwd** file).

8 Turn off the stirrer. Remove the electrode from the beaker of calibration solution. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode and place it in a beaker of deionized water.

Units Conversion-Dissolved Oxygen

1 Measure the temperature (^{o}C) in the lab room. Assume the barometric pressure in the lab room is one atmosphere (760mmHg) and the concentration of oxygen in the air is 21%. Look up the concentration of oxygen in deionized water for the temperature in the lab room on Table GB-3-1 on page 3. This value will be used in Step 4 of this units conversion.

Table GB-3-1: Concentration of Oxygen [O2] in Air-Saturated Deionized Water at 1 Atmosphere.

Temp (^{o}C)	O_2 Abs Coeff (a)	H_2O Vapor Press (p in mmHg)	[O2] (µM)
20	.03102	17.54	284
21	.03044	18.65	278
22	.02988	19.83	273
23	.02934	21.07	267
24	.02881	22.38	262
25	.02831	23.76	257
26	.02783	25.09	252
27	.02736	26.74	247
28	.02691	28.35	243
29	.02649	30.04	238
30	.02608	31.82	234

2 Select the section of the recording before and after the oxygen is removed from the deionized water in the chamber. To view this section of the recording in its entirety on the same window, it may be necessary to click either of the **Display Time icons** in the LabScribe **toolbar** (Figure GB-3-2 on page 3).

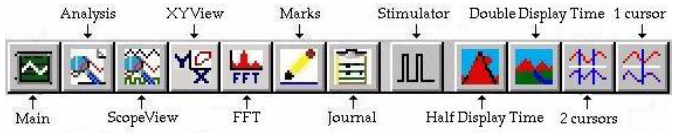

Figure GB-3-2: The LabScribe toolbar.

3 Click the **2-Cursor icon** (Figure GB-3-2 on page 3) so that two blue vertical lines appear over the recording window. Place one cursor on the left side of the plateau corresponding to the oxygen concentration in air-saturated deionized water. Place the other cursor on the right side of the plateau corresponding to the oxygen concentration in the zero-percent oxygen calibration solution (Figure GB-3-3 on page 3).

4 **Right-click** on the Channel 3 window to open the **right-click menu**. Select **Units** from the **right-click menu**. Note that the voltage values for the positions of Cursors 1 and 2 are already entered in the **units conversion window**.

- Next to the voltage value for **Cursor1**, enter **0**.
- Next to the voltage value for **Cursor2**, enter the concentration of oxygen dissolved in deionized water at room temperature found on Table GB-3-1 on page 3.
- Next to the **unit name**, enter **µMolarO_2**.
- Click **OK**. The units on the Y-axis are equal to the **µmoles of oxygen in a liter of deionized water**.

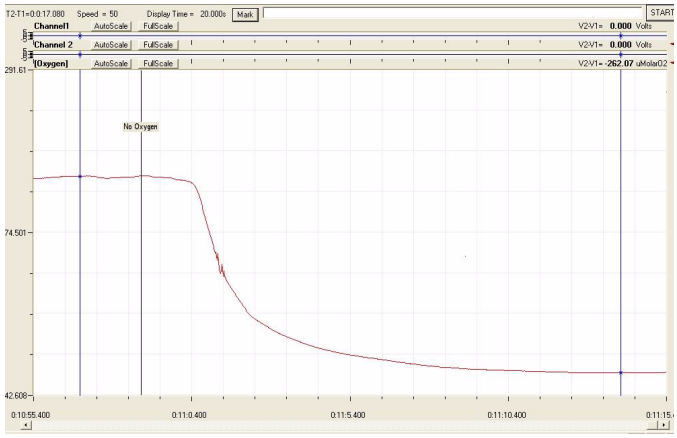

Figure GB-3-3: Recording used to convert units of the Y-axis from voltage to O_2 concentration (µMolar).

Calibration of the pH Electrode

1 If the pH electrode is still stored in its bottle of buffer, remove the electrode from the bottle. Rinse the electrode with deionized water while holding the electrode over a 1000 ml beaker used for the collection of waste liquids.

2 Place the tip of the pH electrode in a 250 ml beaker containing enough room temperature deionized water to submerge the tip. Keep the electrode in deionized water for at least ten minutes.

3 Prepare two 100 ml beakers filled with the pH buffers used for calibrating the pH electrode. The buffers should be a room temperature. One beaker is filled with pH 7 buffer; and the other is filled with pH 4 buffer. Each beaker should be filled with enough buffer to cover the tip of the pH electrode, and also allow the stir bar in the beaker to spin without touching the pH electrode.

4 Place the beaker containing the pH 7 buffer on the magnetic stirrer. Carefully place a stir bar in the beaker. Remove the pH electrode from the deionized water and blot any drops of water from the electrode. Position the tip of the electrode in the beaker of pH 7 buffer so that the tip is away from the stir bar. Adjust the speed of the stirrer so the stir bar is rotating evenly at a moderate speed.

5 Click **Start** on the LabScribe **Main window** to begin recording. The trace will eventually reach a stable baseline toward the top of the recording channel. Type the words **Calibration - pH 7** on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the stable baseline of the recording. This comment marks the output of the pH electrode in pH 7 buffer at room temperature. Continue recording while changing the beakers of buffers.

6 Turn off the stirrer and remove the pH electrode from the beaker of pH 7 buffer. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode.

7 Remove the beaker of pH 7 buffer from the stirrer and place the beaker of pH 4 buffer on the stirrer. Carefully place a stir bar in the beaker. Position the tip of the pH electrode in the beaker of pH 7 buffer so that the tip of the electrode is away from the stir bar. Adjust the speed of the stirrer so the stir bar is rotating evenly at a moderate speed.

8 As you continue to record, the trace will reach a stable baseline toward the bottom of the recording channel. Type the words **Calibration - pH 4** on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the stable baseline of the recording. This comment marks the output of the pH electrode in room temperature pH 4 buffer. Click **Stop** to halt the recording.

9 Select **Save As** in the **File menu**, type a name for the file. Choose a destination on the computer in which to save the file (e.g., a class folder). Click the **Save button** to save the file (as an ***.iwd** file).

10 Turn off the stirrer. Remove the pH electrode from the beaker of pH 4 buffer. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode and place it in a beaker of deionized water.

Units Conversion-pH

1 Locate the section of the recording where output of the pH electrode was measured in pH 4 and pH 7 buffers. To view this section of the recording in its entirety on the same window, it may be necessary to click either of the **Display Time icons** in the LabScribe **toolbar** (Figure GB-3-2 on page 3).

2 Click the **2-Cursor icon** (Figure GB-3-2 on page 3) so that two blue vertical lines appear over the recording window. Place one cursor on the plateau recorded while the pH probe was in pH 7 buffer. Place the other cursor on the plateau recorded while the pH probe was in pH 4 buffer.

3 **Right-click** on the Channel 4 window to open the **right-click menu**. Select **Units** from the **right-click menu**. Note that the voltage values for the positions of Cursors 1 and 2 are already entered in the **units conversion window**.

- Next to the voltage value for **Cursor1**, enter **7**.
- Next to the voltage value for **Cursor2**, enter **4**.
- Next to the **unit name**, enter **pH**.
- Click **OK**. The units on the Y-axis are equal to **pH** units.

Exercise 1: Dissolved Oxygen Concentration of a Water Sample

Aim: To measure the dissolved oxygen concentration of a water sample.

Procedure

Warning: Use gloves, goggles, and lab coats when handling water samples.

1 Place a magnetic stirrer on or next to the base of a ringstand. Open the first water sample bottle and place a stir bar in the bottle. Place the cap on the bottle and turn it until it is tight. Turn on the stirrer and position the stir bar in the center of the bottom of the bottle (Figure GB-3-1 on page 2). Turn off the stirrer before Step 2.

2 Remove the dissolved oxygen electrode from the beaker of deionized water. Blot the drops of deionized water from the electrode. Mount the electrode on the ringstand using a clamp.

3 Remove the cap from water sample bottle, loosen the clamp holding the dissolved oxygen electrode, and place the tip of the electrode in the water sample as close to the center of the bottle as it will go. Quickly seal the opening of the bottle around the electrode with parafilm or plastic wrap to prevent the exchange of gases between the water sample and the environment.

4 Turn on the stirrer so that the stir bar rotates evenly and moderately. Wait two minutes before recording the dissolved oxygen concentration of the water sample.

5 Click **Start** on the LabScribe **Main window** to begin recording. When the recording reaches a stable level on **[Oxygen] channel**, type **DO2** and the name of the location where the sample was taken on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the recording.

6 Click **Stop** to halt the recording.

7 Select **Save** in the **File menu**. Complete Step 8 and then proceed directly to Exercise 2.

8 Remove the dissolved oxygen electrode from the water sample. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode and place it in a beaker of deionized water.

Exercise 2: pH of a Water Sample

Aim: To measure the pH of a water sample which indicates the acidity of the water.

Procedure

1 As soon as the dissolved oxygen concentration of the first water sample is recorded, record the pH of the same water sample.

2 Remove the pH electrode from the beaker of deionized water. Blot the drops of deionized water from the electrode. Mount the electrode on the ringstand using a clamp.

3 Loosen the clamp holding the pH electrode, and place the tip of the electrode in the water sample as close to the center of the bottle as it will go.

4 Turn on the stirrer so that the stir bar rotates evenly and moderately. Wait thirty seconds before recording the pH of the water sample.

5 Click **Start** on the LabScribe **Main window** to begin recording. When the recording reaches a stable level on the **pH channe**l, type **pH** and the name of the location where the sample was taken on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the recording.

6 Click **Stop** to halt the recording.

7 Select **Save** in the **File menu**. Complete Step 8 and then proceed directly to Exercise 3.

8 Remove the pH electrode from the water sample. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode and place it in a beaker of deionized water.

9 Proceed directly to Exercise 3.

Exercise 3: Specific Gravity of a Water Sample

Aim: To measure the specific gravity of a water sample which indicates the concentration of dissolved solutes, like sodium and potassium and chloride, in the sample.

Procedure

1 Transfer enough of the first water sample to the hydrometer cylinder to fill about 80% of the cylinder.

2 Place the hydrometer in the cylinder and gently spin the device so that it rotates freely for at least two turns.

3 Read the specific gravity of the water sample by matching the meniscus of the sample with scale on the stem of the hydrometer. The scale ranges from 1.000 at the top to 1.060 at the bottom.

• If the specific gravity of a water sample is too high (>1.060), measure a given volume of sample and dilute that volume by adding one or two times more deionized water.

• Account for the dilution when the specific gravity of the sample is recorded. For example, if one volume of deionized water was added to one volume of sample and the hydrometer read 1.02, specific gravity would be calculated by:

a) Subtracting 1.000 (specific gravity of water) from 1.020 = 0.02;

b) Multiplying the difference (0.02) x 2 (for 2 volumes) = 0.04; and

c) Adding 0.04 to 1.000 = 1.04, the specific gravity of sample.

4 Record the specific gravity of the first water sample on Table GB-3-2 on page 6 and in the **Journal**.

Other Water Samples

Repeat Exercises 1, 2, and 3 for the other water samples that were collected.

Data Analysis

1 Scroll to the section of data recorded during Exercise 1.

2 Click on the **1 cursor icon** on the LabScribe **toolbar**. Place the cursor in the middle of the stable oxygen saturation level recorded on the **[Oxygen] channel** for the first water sample.

3 Read the dissolved oxygen concentration next to the term. **Value =**, in the upper right margin of the **[Oxygen] channel**.

4 Record the oxygen saturation level of the first water sample in Table GB-3-2 on page 6 and in the **Journal**.

5 Scroll to the section of data recorded during Exercise 2. Place the single cursor in the middle of the stable pH level recorded on the **pH channel** for the first water sample.

6 Read the dissolved oxygen concentration next to the term. **Value =**, in the upper right margin of the **pH channel**.

7 Record the pH level of the first water sample in Table GB-3-2 on page 6 and in the **Journal**.

8 Record the temperature of the first water sample taken at the collection site to Table GB-3-2 on page 6 and the **Journal**.

9 Repeat Steps 1 through 8 for each of the other water samples.

Table GB-3-2: Values for Four Parameters Recorded from Water Samples.

Water Sample/Location	Temperature ^{o}Celsius	Dissolved Oxygen Concentration (µMolar O_2)	pH	Specific Gravity
1				
2				
3				
4				
5				
6				
7				

Questions

1. Which sample had the highest dissolved oxygen concentration? What caused that sample to have that level of oxygen saturation?
2. Which sample had the lowest dissolved oxygen concentration? What caused that sample to have that level of oxygen saturation?
3. Which sample had the highest pH level? What caused that sample to have that pH level?
4. Which sample had the lowest pH level? What caused that sample to have that pH level?
5. Which sample had the highest specific gravity? What caused that sample to have that level of specific gravity?
6. Which sample had the lowest specific gravity? What caused that sample to have that level of specific gravity?
7. Does your data indicate any correlation between pH level and oxygen saturation level, or oxygen saturation level and specific gravity, or any other combination of parameters?

Appendix

Zero-Percent Oxygen Calibration Solution is 15mM Sodium Hydrosulfite in deionized water.