TAKE CARE OF TEXAS: EDUCATOR MATERIALS

LESSON PLAN

Testing Water: Physical Properties

Objectives

Students will determine the water's physical properties by measuring temperature, pH, dissolved oxygen, and flow rate.

Prerequisites

Teachers should determine the number of supervisors needed and ensure that those supervisors understand their responsibilities before starting this lesson.

Duration

Two- 40-minute lessons

Materials

Note: If you do not have one of the following test kits, feel free to remove that station from the lesson.

- Student Worksheet
- Thermometer
- pH Test Kit
- Dissolved Oxygen Test Kit
- Meter Stick
- Two Measuring Tapes (one should be 30 meters or greater, depending on the width of the survey area)
- Cork
- Stopwatch
- Rubber Boots or Waders

LP11 (5/25)

Introduction

TEACHER BACKGROUND INFORMATION

The following sections describe several key indicators that scientists use to evaluate aquatic environments in Texas.

Unexpected Changes in Water Temperature

Water temperature, one of the simplest water quality measurements to take, is one of the most important to the health of an aquatic ecosystem because temperature affects the composition of the biological community that ecosystem can support (Table 1). In general, aquatic organisms are cold-blooded and have body temperatures that fluctuate with the water temperature, and each aquatic species has an optimum temperature at which it functions best. Most fish and other aquatic species in Texas are among those that can tolerate warmer water in summer and colder water in winter.

Table 1.

Temperature Ranges Required for Growth of Certain Organisms

Temperature	Examples of Life
Over 68° F (warm water)	Most plant life; most bass, crappie, bluegill, carp, catfish, caddis-fly
Less than 68°F (cold water) • Upper Range (55-68°F)	Some plant life; stonefly; mayfly, caddis-fly, water beetle
• Lower Range (less than 55°F)	Trout, caddis-fly, stonefly, mayfly

The effects of temperature on a stream are normally long-term, with gradual changes in the aquatic community. However, extreme weather conditions and drastic temperature changes can cause die-offs. Artificially heated water bodies (bodies receiving discharges from warm water) can become dependent on warm water, and fish kills can occur if warm water discharges stop during cold weather.

The removal of tree canopies and the channelization of a stream reduces the thermal buffering capacity of that water body, resulting in bigger and more rapid shifts in temperature, higher than average temperatures in summer and colder than average temperatures in winter. Native aquatic fish and invertebrate species are adapted to the normal seasonal shifts in temperature but can be affected by alterations to normal stream conditions.

High water temperatures increase the metabolism, respiration, and oxygen demand of fish and other aquatic organisms (in general, metabolic rates in aquatic organisms double with every 10°C rise in temperature). Increased temperatures also enhance the effect of nutrients on plankton blooms. The effects of oxygen-demanding substances are intensified by temperature increases. Unnaturally warm temperatures can favor tolerant species over intolerant ones. This can lead to an aquatic community dominated by tolerant species (such as carp) with a reduced number of intolerant species (such as Guadalupe bass, the state fish of Texas).

High or Low pH

The pH scale, numbered from 0 to 14, is used to measure the acidity of a water body. Pure water has a pH value of 7.0, which is considered neutral and is neither acidic nor basic. When the pH is less than 7.0, water is considered acidic; and when its pH is greater than 7.0, it's considered basic (alkaline). Generally, the ability of aquatic organisms to complete a life cycle greatly diminishes as pH becomes greater than 9.0 or less than 5.0 shows the habitable pH range for certain aquatic organisms.

pH Ranges That Support Aquatic Life

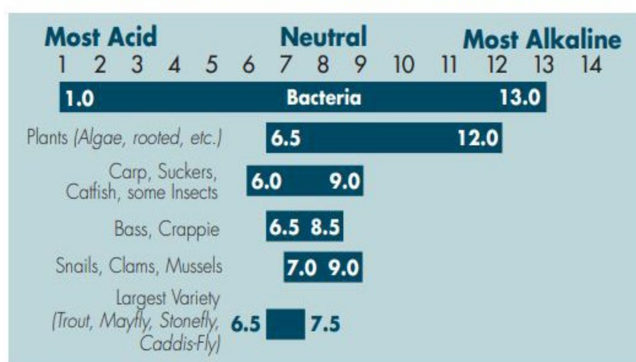

Figure 3.

The pH scale is logarithmic, with a base of 10. This means each whole number on the pH scale is ten times more acidic or basic than the whole number that precedes it. For example, a pH of 4 is 10 times more acidic than a pH of 5; and a pH of 4 is 100 times more acidic than a pH of 6. A pH change of one whole number is therefore quite a large change.

The pH of an aquatic system is influenced by several factors. Water dissolves mineral substances it encounters, picks up aerosols and dust from the air, receives human-originated wastes, and supports photosynthetic organisms—all of which affect pH. Carbon dioxide reacts with water to form a weak acid called carbonic acid. This weak acid serves as a buffer (conferring the ability to resist pH change) which diminishes extreme fluctuations in the water's pH. When photosynthesis occurs, carbon dioxide (CO_2) levels in the water are reduced, along with carbonic acid levels. When carbonic acid decreases, pH increases. Therefore, you should expect the pH to increase in waters with abundant plant life during a sunny afternoon, especially in slow or still waters. Other events in the watershed that may affect pH include the increased leaching of soils or minerals during heavy rainfall runoff, accidental spills, agricultural runoff (pesticides, fertilizers, soil leachates), and sewage overflows.

Low Levels of Dissolved Oxygen

Dissolved Oxygen (DO) is one of the most important indicators of water quality for aquatic life because it is essential for all aquatic plants and animals. DO is a particularly sensitive factor because chemicals, biological processes, and temperature often determine its availability at different times during the year. DO levels often vary during the day with low levels usually occurring early in the morning, slightly after dawn and before photosynthesis begins.

The DO saturation level tells you how much DO the water can hold at a given temperature, pressure, and salinity. Elevated temperatures, increased salinity (salts), and decreased pressure reduce the amount of DO that water can hold. For example, water at 0°C, at sea level (where pressure equals 1 atmosphere), with no salt, can hold up to 14.6 parts per million (ppm) of DO. When the same water is at 30°C, it can hold up to 7.6 ppm of DO. Table 2 shows this relationship at various temperatures.

Table 2.

Variation in Levels of Dissolved Oxygen as Temperature Increases

Temperature		Saturation*
°F	°C	mg/L (ppm)
32	0	14.6
33.8	1	14.2
35.6	2	13.8
37.4	3	13.5
39.2	4	13.1
41	5	12.8
42.8	6	12.5
44.6	7	12.1
46.4	8	11.8
48.2	9	11.6
50	10	11.3
51.8	11	11.0
53.6	12	10.8
55.4	13	10.5
57.2	14	10.3
59	15	10.1
60.8	16	9.9
62.6	17	9.7
64.4	18	9.5
66.2	19	9.3
68	20	9.1
69.8	21	8.9
71.6	22	8.7
73.4	23	8.6
75.2	24	8.4
77	25	8.3
78.8	26	8.1
80.6	27	8.0
82.4	28	7.8
84.2	29	7.7
86	30	7.6

*Maximum amount of oxygen water will hold at a given temperature, under 1 atmosphere of pressure and 0% salinity.

In addition to temperature, pressure, and salinity, there are other things that influence DO levels—including photosynthesis, natural aeration, and respiration. For example, during algal blooms, daytime DO levels can be extremely high (often greater than 10 ppm) because of photosynthesis; at night, DO can drop to lethal levels when photosynthesis stops producing oxygen and organisms can only respire using the DO stored in the water. As another example, decreased sunlight causes a reduction in photosynthesis, which results in a net loss of DO.

Water can sometimes have DO levels above its saturation level, called supersaturation. Water bodies with elevated nutrient concentrations (eutrophic), high temperatures, and large amounts of filamentous and planktonic algae can create supersaturated conditions during daylight hours.

Texas changes greatly in climate, geology, and topography from east to west. For example, streams in the Hill Country of central Texas generally have a higher gradient (slope), are swift-moving, and have rocky bottoms. Aquatic organisms living in these streams are generally adapted for cooler temperatures and higher DO levels. In contrast, streams in east Texas have lower gradients, are warmer, are slower moving, and have muddier bottoms. Aquatic organisms inhabiting these streams are generally more tolerant of warmer temperatures and lower DO levels. A DO level of 5.0 ppm or greater is generally considered the optimum to sustain the growth and health of aquatic organisms.

When DO levels fall below 2-3 ppm, fish and many other aquatic organisms may become stressed and some may not survive. Many fish kills in ponds and streams during the summer months are caused by low DO levels from a combination of elevated nutrients and warm water.

Procedure

1. Split students into small groups.
2. Discuss the safety procedures. You may encounter water and harmful chemicals, remember to:
    a. Stay in shallow water.
    b. Wear rubber boots or waders if entering the water.
    c. Wash your hands at the completion of the lesson.
    d. Wear safety glasses and gloves when handling chemicals included with the test kits.
3. Select a testing station – Temperature Station, pH Station, Dissolved Oxygen Station, or Flow Station – to begin.
   NOTE: If time and resources permit, go to the stations again and conduct another reading to verify your data is accurate.
    - Temperature Station
    - pH Station
    - Dissolved Oxygen Station
    - Flow Station
4. Remember to enter all test data on the worksheet.
   NOTE: Print out the station flyers on the following pages which include student instructions and place at each station.

Glossary

- **Dissolved Oxygen** – The amount of oxygen present in water
- **Flow** – The amount of water flowing per unit of time
- **pH** – A measurement of the acidity or basicity a liquid
- **Temperature** – The heat of a substance or object
- **Velocity** – The speed of something in a general direction

Applicable Texas Essential Knowledge and Skills (TEKS)

Science TEKS

- **6th Grade** – 19 TAC 112.26.b. 1A-H; 5A-G; 11A-B
- **7th Grade** – 19 TAC 112.27.b. 1A-H; 5A-G; 11A-B
- **8th Grade** – 19 TAC 112.28.b. 1A-H; 5A-G; 11A-B

Math TEKS

- **6th Grade** – 19 TAC 111.26.b. 1A,C; 3A-E
- **7th Grade** – 19 TAC 111.27.b. 1A,C; 3A-E
- **8th Grade** – 19 TAC 111.28.b. 1A,C

Temperature Station

DISCUSS:

1. If a lake's temperature rises by 5°C over the summer, how might that affect fish living in it? Explain using evidence from what you've learned.
2. What might happen to aquatic organisms in a river during a heatwave? Why?
3. Explain how low dissolved oxygen, rather than high temperature itself, might be the actual cause of fish dying.
4. If you were a scientist studying fish deaths in a warm pond, what data would you collect to test whether low oxygen was the cause?

TEST:

To test water temperature:

1. Have one group member enter the water and place the thermometer bulb below the surface of the water, about a third of the way down.
2. After a while, have them pull the thermometer out of the water and immediately read the temperature to the team.

Water Temperature: ____°F

Convert to Celsius using the following equation: (____°F – 32) × $\frac{5}{9}$ = ____°C

Potential factors affecting water temperature:

REFLECT:

Review the following factors that can influence water temperature:

- Atmospheric temperature
- The amount of cover
- Turbidity
- The temperature of incoming waters (such as warm water from a shallow ditch)

Write down the factors you believe are affecting the water temperature in the survey area.

pH Station

DISCUSS:

1. Why do you think extreme pH levels (below 5.0 or above 9.0) make it difficult for aquatic organisms to survive or complete their life cycles?
2. What does a pH value actually measure, and why is it important for things living in the water?
3. You are a scientist monitoring a stream with a pH of 5.5. What questions would you ask to determine whether the aquatic life there is at risk?
4. If a lake has neutral pH (7.0), and over time it becomes more acidic, how could this change affect different species living in the lake?

TEST:

Follow the directions included with the pH test kit. This may require a team member to enter the water to collect a water sample.

pH: ____

The water is (circle): **Acidic** **Neutral** **Basic (Alkaline)**

Potential factors affecting pH:

REFLECT:

Review factors that influence pH:

- Photosynthesis (photosynthesis decreases levels of dissolved CO_2, causing the pH to increase)
- Leaching of soil or minerals
- The pH of incoming waters (such as stormwater containing sulfuric acid)

Write down the factors you believe are affecting the pH in the survey area.

Dissolved Oxygen Station

DISCUSS:

1. Why does photosynthesis increase dissolved oxygen levels in water? How is this different from the effect of respiration?
2. What might happen to dissolved oxygen levels on a hot, cloudy day when algae are present in a pond? Explain your reasoning.
3. If the dissolved oxygen drops below 5.0 ppm overnight, what could be causing it, and how might aquatic organisms be affected?
4. You are measuring oxygen levels in a pond at different times of day. When would you expect oxygen to be highest and lowest? Why?

TEST:

Follow the directions included with the dissolved oxygen test kit. This may require a team member to enter the water to collect a sample.

Dissolved Oxygen: ____________ ppm (mg/L)

Potential factors affecting dissolved oxygen:

REFLECT:

Review factors that influence dissolved oxygen:

- Photosynthesis (affected by the amount of sunlight, aquatic plants, etc.)
- Temperature
- Natural aeration
- The amount of oxygen-demanding substances, etc.

Write down the factors that you believe are affecting the dissolved oxygen levels in the survey area.

Flow Station

DISCUSS:

1. Why do you think depth and flow rate affect what types of organisms live in a stream or river?
2. If two rivers have the same flow rate but different depths, how might their ecosystems differ?
3. What might happen to the flow rate if vegetation along a riverbank increases or if a riverbed becomes more shallow due to sediment buildup?

TEST:

To measure flow:

1. Two team members will measure the width and average depth of the water body.
   a) Width – Using the measuring tape, run the tape straight across the survey area, perpendicular to the direction the water is traveling. Do not include any dry land in the measurement. Record the width in meters (Ex. 20.0 meters).
   b) Depth – Along the measuring tape, use a meter stick to estimate the average depth along that line. Record the depth in meters (Ex. 0.25 meters).
2. The other two team members will measure the surface velocity.
   a) Start upstream and roll out two meters of the measuring tape. Make sure the tape is parallel to the direction the water is traveling.
   b) One team member will sit at 0 meters (the upstream point) while the other sits at 2 meters with a stopwatch.
   c) The team member at 0 meters will toss a cork slightly upstream. Once the cork is parallel with the 0 meter mark, they will say “start” so the other team member will start the stopwatch.
   d) Once the cork reaches the 2 meter mark, stop the stopwatch and collect the cork.
   e) Velocity – Divide by the time it took the cork to travel 2 meters (Ex. For a cork that traveled 2 meters in 5 seconds, the calculation is 2 m ÷ 5 s = 2/5 m/s = 0.4 m/s).
3. When ready, calculate the flow by multiplying the width, depth, and velocity (Ex. 20.0 m × 0.25 m × 0.4 m/s = 2 m^3/s)

Width (W): ____________ meters (m)

Average depth (D): ____________ meters (m)

Time the cork traveled two meters: ____________ seconds (s)

Calculate velocity (V) by entering the time above into following equation:

$$\frac{2\ meters}{\_\_\_\ seconds} = \_\_\_\_\_\_\_\_ \frac{m}{s}$$

Calculate flow ($\frac{m^3}{s}$) using the following equation:

$$W \times D \times V = \_\_\_\_\_\ m \times \_\_\_\_\_\ m \times \_\_\_\_\_\ \frac{m}{s} = \_\_\_\_\_\ \frac{m^3}{s}$$