LESSON 7

Survey: Physical Properties

Applicable TEKS

Science Grade 4	**Science Grade 5**	**Science Grade 6**
4.1 A 4.2 A, B, D, E, F 4.3 A 4.4 A, B	5.1 A 5.2 A, C, D, E, F 5.3 A 5.4 A, B	6.1 A 6.2 A, E 6.3 A 6.4 A, B
Math Grade 4	**Math Grade 5**	**Math Grade 6**
4.1 A, C 4.8 C	5.1 A, C 5.7 A	6.1 A, C 6.3 B

Duration

Two 40-minute lessons

Objectives

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

Prerequisites

Students should complete *Lesson 4—Water Pollution* before starting this lesson.

Teachers should determine the number of supervisors needed (example: one per station) and ensure those supervisors understand their responsibilities before starting this lesson.

Materials

- *Handout 7—Survey: Physical Properties*
- thermometer
- pH test kit
- dissolved-oxygen test kit
- meter stick (that can get wet)
- two measuring tapes (one should be 30 meters or greater, depending on the width of the survey area)
- cork or an orange
- stopwatch
- rubber boots or waders

Procedure

1. Discuss the safety procedures. Since students might come in contact with the water and harmful chemicals, remind your students to:
   a. stay only in shallow water,
   b. wear rubber boots or waders if entering the water,
   c. wash their hands at the completion of the lesson, and
   d. wear safety glasses and gloves when handling any harmful chemicals included with the test kits.
2. Have all students open their binders to *Handout 7—Survey: Physical Properties*. Remind them to enter test data on the handout.
3. Send student teams to each of the testing stations. If time permits and resources are available, have your student teams conduct more than one reading at each station to verify that their data is accurate.

Temperature Station

1. Discuss information in "Pollution Indicators" about temperature, including:
   a. When temperature increases, the amount of dissolved oxygen water can hold decreases.
   b. It is uncommon for high water temperatures to be the cause of death for aquatic organisms; instead, it's the effects of high water temperatures that kill them, such as low dissolved-oxygen levels.
2. To test water temperature:
   a. One student enters the water and places the thermometer bulb below the surface of the water, about a third of the way down.
   b. After a while, he or she pulls the thermometer out of the water and immediately reads the temperature to their team.
3. If needed, help students convert the water temperature from degrees Fahrenheit to degrees Celsius.
4. Discuss factors that influence water temperature—atmospheric temperature, the amount of cover, turbidity, the temperature of incoming waters (such as warm water from a shallow ditch), etc. Have students write down the factors they believe are affecting the water temperature in the survey area.

pH Station

1. Discuss information in "Pollution Indicators" about pH, including:

   a. A pH less than 7.0 is acidic; greater than 7.0 is basic.
   b. It can be difficult for aquatic organisms to complete their life cycle if the pH becomes less than 5.0 or greater than 9.0.
2. Follow the directions included with the pH test kit; this may require a student to enter the water to collect a water sample.
3. Discuss factors that influence pH—photosynthesis (photosynthesis decreases dissolved-CO_2 levels, causing the pH to increase), leaching of soils or minerals, the pH of incoming waters (such as stormwater containing sulfuric acid), etc. Have students write down the factors they believe are affecting the pH in the survey area.

Dissolved-Oxygen Station

1. Discuss information in "Pollution Indicators" about dissolved oxygen, including:
   a. Dissolved oxygen levels increase when photosynthesis and natural aeration are high and respiration is low.
   b. Dissolved oxygen levels decrease when photosynthesis and natural aeration are low and respiration is high.
   c. Generally, a dissolved-oxygen concentration of 5.0 ppm or higher is favorable for fish and other aquatic organisms.
2. Follow the directions included with the dissolved-oxygen test kit; this may require a student to enter the water to collect a sample.
3. Discuss 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. Have students write down the factors they believe are affecting the dissolved-oxygen levels in the survey area.

Flow Station

1. Introduce the students to the following information regarding flow:
   a. Flow can be expressed as cubic feet per second, cubic meters per second, or even as gallons per second.
   b. To get the flow, you will need to measure three things: width, depth, and velocity (speed).
   c. Flow and depth influence the organisms you will find in the water.
2. To measure flow:
   a. Two team members measure the width and average depth.
      - 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 (example: 20.0 meters).
      - Depth: along the measuring tape, use a meter stick to estimate the average depth along that line. Record the depth in meters (example: 0.25 meters).
   b. The other two team members measure the surface **velocity**.
      - Start upstream and roll out two meters of the measuring tape. Make sure the tape is parallel to the direction the water is traveling.
      - One team member will sit at 0 meters (the upstream point) while the other sits at 2 meters with the stopwatch.
      - The team member at 0 meters tosses the cork slightly upstream. Once the cork reaches 0 meters, he or she will say "start" so the other team member will start the stopwatch.
      - Once the cork reaches 2 meters, stop the stopwatch and collect the cork.
      - **Velocity:** take 2 and divide by the time (example: for a cork that traveled 2 meters in 5 seconds, the calculation is 2 ÷ 5 = 2/5 = 0.4 meters per second).
   c. When ready, team members come together to calculate flow by multiplying together width, depth, and velocity (example: 20.0 × 0.25 × 0.4 = 2 cubic meters per second).

Unexpected Changes to Water Temperature

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

The effects of temperature on a stream are normally chronic, with gradual changes in the aquatic community. However, extreme weather conditions can cause die-offs due to drastic temperature changes. Artificially heated water bodies (for example, bodies receiving discharges of warm water) can create a dependence on warm water. Fish kills can occur if warm water discharges stop during cold weather.

Removal of tree canopy and channelization of a stream reduce 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 in winter. Native aquatic fish and invertebrate species are adapted to the normal seasonal shifts in temperature, but can be affected by alterations to the normal stream conditions.

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

High water temperatures increase metabolism, respiration, and oxygen demand of fish and other aquatic organisms (in general, metabolic rates in aquatic organisms double with every rise of 10°C 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 have impacts on aquatic organisms and favor tolerant over intolerant species. This can lead to an aquatic community dominated by tolerant species (such as carp and gar) with reduced number of intolerant species (such as darters and 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; a pH greater than 7.0 is 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. Figure 3 shows the habitable pH ranges for certain aquatic organisms.

The pH scale is logarithmic, with a base of 10. This means each whole number on the pH scale is ten times the whole number that precedes it. For example, a pH of 4 is 10 times more acidic than a pH of 5; 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.

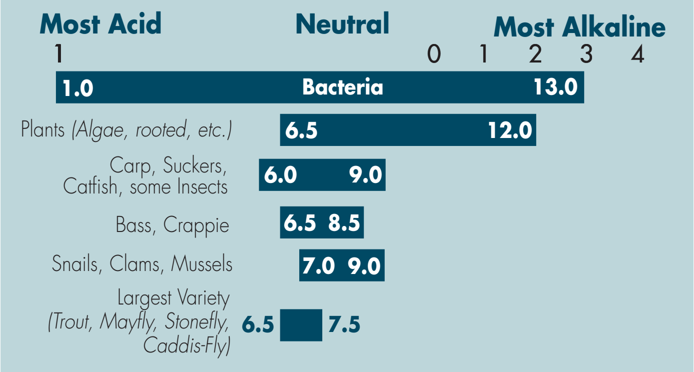
The pH of an aquatic system is influenced by a number of factors. Water dissolves mineral substances it comes in contact with, picks up aerosols and dust from the air, receives human-originated wastes, and supports photosynthetic organisms—all of which affect pH.

As explained in the discussion of the water cycle, 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 reduce, 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 (including planktonic algae) during a sunny afternoon, especially in slow or still waters.

Other events in the watershed that may also affect pH include increased leaching of soils or minerals during heavy rainfall runoff, accidental spills, agricultural runoff (pesticides, fertilizers, soil leachates), and sewage overflows.

Figure 3.

pH Ranges That Support Aquatic Life



Low Levels of 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; levels are usually lowest in the early 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 pressure decreases reduce the amount of DO that the water can hold. For example, water at sea level (where pressure equals 1 atmosphere), with no salts, and at 0°C can hold up to 14.6 parts per million of DO. When this same water is at 30°C, it can hold up to 7.6 ppm of DO. Table 2 shows this relationship at various temperatures.

As shown in Table 2, DO levels can vary greatly. 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, DO levels in the daylight hours 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 respire only 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 are generally higher in gradient (slope), are swift-moving, and have rocky bottoms. Aquatic organisms living in these streams are generally adapted for cooler water and high DO levels. In contrast, streams in east Texas are lower in gradient, 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 to 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.

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.*