WATER QUALITY TESTING

OBJECTIVES

- Identify different water quality parameters and how to perform water quality tests by sampling water at a local creek
- Conduct independent study to learn more about the factors that influence various water quality parameters, as well as how organisms can be effected by water quality

TOPICS

- Water quality
- Stream ecosystems
- Human impact on streams

TEKS ALIGNMENT

Grade 5 Science:

1A, 1B, 2A, 2B, 2C, 2D, 2E, 2F, 2G, 3A, 4A, 4B, 5A, 5D, 9A, 9C, 9D

Grade 7 Science:

1A, 1B, 2A, 2C, 2D, 2E, 3A, 4A, 4B, 5B, 6A, 8B, 8C, 13A

Grade 8 Science:

1A, 1B, 2A, 2C, 2D, 2E, 3A, 4A, 4B, 5D, 11B, 11C

BACKGROUND MATERIAL

Stream water quality is a combination of physical and chemical properties of the environment. Physical water quality properties can be observed and measured without breaking and forming chemical bonds. Some examples of physical water quality parameters are temperature, turbidity, and odor. Chemical properties can only be measured by observing chemical reactions that break and form chemical bonds. Several important chemical water quality parameters include pH, dissolved oxygen, nitrates and phosphates. Every stream ecosystem has a natural range physical and chemical water quality parameters to which the organisms that live there have adapted.

But human activity, both next to the channel and within the watershed that feeds the stream, can have a significant impact on all of these physical and chemical water quality parameters. Changes to water quality outside of the natural ranges can in turn negatively affect stream organisms. Degradation of water quality can also lead to adverse impacts for humans when function is reduced.

To preserve natural streams for human use and for conserving stream biodiversity, the Texas Commission on Environmental Quality (TCEQ) has developed water quality standards for different segments of certain streams within the state.

The student and teacher sheets provide a wealth of additional information about the water quality parameters listed above, including what human activities impact water quality, the effect on local streams and how water quality parameters can depend on each other. A chart detailing the water quality standards for major streams within the San Antonio River Basin can also be found in the student sheets.

KEY TERMS

Diffusion is when something spreads from an area of higher concentration to an area of lower concentration. An example of this is when all the air is let out of a balloon into the surrounding air and when a drop of food coloring or dye is placed into a glass of water

Homeotherm is a warm-blooded animal; able to maintain a stable internal body temperature

Metabolism is all of the chemical reactions that take place within an organism's body that keep it alive

mg/L is an abbreviation for milligrams per liter. Since 1 liter of pure water weighs 1,000 grams, and since 1,000 grams contains one million milligrams, then 1 mg/L of a substance in water is equal to 1 part per million (ppm)

pH indicates how acidic or basic a substance is. The pH scale ranges from 1-14. On the scale, 1-6 indicates acid substances, 7 indicates a neutral (neither acidic nor basic) substance and 8-14 indicates basic substances. The lower the number the more acidic it is and the higher the number the more basic it is.

Photosynthesis is the chemical process in which plants (or anything that contains chlorophyll) convert the sun's energy to carbohydrates (food). Oxygen is given off as a byproduct of photosynthesis

Poikilotherm is a cold-blooded animal; not able to maintain a stable internal body temperature

Respiration is the chemical process in which living things convert carbohydrates to energy. Oxygen is consumed during respiration.

Riparian is the zone of land adjacent to a stream

Thermal pollution is when an activity causes the temperature of the water to change, such as from lower to higher temperatures when water is used to cool power-generating plants, or from higher to lower temperatures when cooler water at the base of a dam is released

Turbid is when a liquid is cloud, murky or not clear

PROCEDURES

MATERIALS

- Water quality test kits for pH, dissolved oxygen, nitrates, phosphates, turbidity, and 5-day biochemical oxygen demand
- Thermometer
- Student sheets

A. In the classroom before the activity begins, provide the students with a list of the following environmental factors: food, water, light, habitat, oxygen, temperature and pH. Ask the students whether or not each of these factors affect stream organisms. If so, how?
B. Then before going out to the stream, make sure the students understand all safety precautions:
   1. Do not go out or wander off alone; always stay with a group.
   2. Do not wade into the water unless you can see the bottom and know that the current and depth are safe (remember that rocks in streams are often covered with algae and are slippery).
   3. Steep banks indicate deeper water and are often slippery.
   4. Carry a first aid kit, insect repellent and drinking water.
   5. Watch for poison ivy, briars, fire ants, mosquitoes, wasps, etc.
   6. Wear rubber gloves when you are collecting water samples (because you do not know if the water is polluted or not).
   7. Do not go into the water barefooted or wearing water shoes or old tennis shoes. These will be slippery.
   8. Do not engage in horseplay, rock throwing, etc.
   9. Respect the stream – leave it in the condition that you found it. Do not leave garbage or equipment behind.
C. Have the students conduct water quality tests using the test kits, and then have them write the results of what they measured for each water quality parameter in the table found in their student sheets.
D. In the classroom, divide the room into six groups and have each one pick a different water quality feature about which to report to the rest of the class (note that nitrates and phosphates are combined). For their water quality parameter, the students should compile the data from the whole class, calculate the average value, make comparisons to the standards (if applicable), read about the water quality parameter, and list ways in which this parameter can impact wildlife (See Guided Questions). Then have each group present their findings to the rest of the class.

GUIDING QUESTIONS

- What was the mean value for all measurements of the water quality parameter that you studied?
- If applicable, how does the water quality result for your stream compare with the standard for the San Antonio River Basin? If there is not standard for your water quality parameter, describe the condition that you observed.
- What impact do you think that your water quality parameter might have the aquatic organisms that live in the stream that you sampled?

EVALUATION

Instruct the students to write a report that summarizes the results for all of the water quality parameters. If applicable for any of the parameters, have the students conduct an analysis of the watershed that feeds into their stream to determine what human activities might be contributing to water quality degradation. Ask the students to think about how the numbers that they measured for each parameter might change given: heavy floods, drought, or movement of more people into the area.

STUDENT SHEET 1

Measured characteristic	Measured value
Temperature	_____ °C
pH	
Dissolved Oxygen	_____ mg/L
Nitrates	_____ mg/L
Phosphates	_____ mg/L
Turbidity	_____ JTU
5-Day B.O.D.	_____ mg/L

If you know the temperature in Celsius and want to convert it to Fahrenheit, use the following formula:

$$°F = (°C \times 1.8) + 32.$$

If you know the temperature in Fahrenheit and want to convert it to Celsius, use the following formula:

$$°C = \frac{(°F - 32)}{1.8}$$

STUDENT SHEET 2

Segment	Segment Description	Minimum Dissolved Oxygen (mg/L)	pH Range	Maximum Temperature (OF)
1901 – Lower San Antonio River	From the confluence with the Guadalupe River in Refugio/Victoria County to a point 600 meters (660 yards) downstream of FM 791 at Mays Crossing near Falls City in Karnes County.	5	6.5 – 9.0	90
1902 – Lower Cibolo Creek	From the confluence with the San Antonio River in Karnes County to a point 100 meters (110 yards) downstream of IH 10 in Bexar/Guadalupe County.	5	6.5 – 9.0	90
1903 – Medina River Below Medina Diversion Lake	From the confluence with the San Antonio River in Bexar County to Medina Diversion Dam in Medina County.	5	6.5 – 9.0	90
1904 – Medina Lake	From Medina Lake Dam in Medina County to a point immediately upstream of the confluence of Red Bluff Creek in Bandera County, up to the normal pool elevation of 1064.2 feet (impounds Medina River).	5	6.5 – 9.0	88
1905 – Medina River Above Medina Lake	From a point immediately upstream of the confluence of Red Bluff Creek in Bandera County to the confluence of the North Prong Medina River and the West Prong Medina River in Bandera County.	6	6.5 – 9.0	88
1906 – Lower Leon Creek	From the confluence with the Medina River in Bexar County to a point 100 meters (110 yards) upstream of SH 16 northwest of San Antonio in Bexar County.	5	6.5 – 9.0	95
1907 – Upper Leon Creek	From a point 100 meters (110 yards) upstream of SH 16 northwest of San Antonio in Bexar County to a point 9.0 kilometers (5.6 miles) upstream of Scenic Loop Road north of Helotes in Bexar County.	5	6.5 – 9.0	95
1908 – Upper Cibolo Creek	From the Missouri-Pacific Railroad bridge west of Bracken in Comal County to a point 1.5 kilometers (0.9 mile) upstream of the confluence of Champee Springs in Kendall County.	5	6.5 – 9.0	90
1909 – Medina Diversion Lake	From Medina Diversion Dam in Medina County to Medina Lake Dam in Medina County, up to the normal pool elevation of 926.5 feet (impounds Medina River).	5	6.5 – 9.0	90
1910- Salado Creek	From the confluence with the San Antonio River in Bexar County to Rocking Horse Lane west of Camp Bullis in Bexar County.	5	6.5 – 9.0	90
1911 – Upper San Antonio River	From a point 600 meters (660 yards) downstream of FM 791 at Mays Crossing near Falls City in Karnes County to a point 100 meters (110 yards) upstream of Hildebrand Avenue at San Antonio in Bexar County.	5	6.5 – 9.0	90
1912- Medio Creek	From the confluence with the Medina River in Bexar County to a point 1.0 kilometer (0.6 mile) upstream of IH 35 at San Antonio in Bexar County.	4	6.5 – 9.0	95
1913- Mid Cibolo Creek	From a point 100 meters (110 yards) downstream of IH 10 in Bexar/Guadalupe County to the Missouri-Pacific Railroad bridge west of Bracken in Comal County.	3	6.5 – 9.0	90

STUDENT SHEET 3

TEMPERATURE

All invertebrates are sensitive to temperature change because their body temperatures and metabolism change as the surrounding water temperature changes. Because these animals often feel cold to the touch, they are referred to as "cold-blooded" animals, but a more appropriate term for them is "poikilotherms."

If the temperature of their environment changes too much, poikilotherms may either die outright or become weaker and more likely to die from other stresses, such as disease or parasites. Water temperature also affects the oxygen content of water. Warm water is not able to hold as much oxygen as cooler water, so as water temperature increases, the amount of dissolved oxygen in the water decreases.

Many human activities can affect the temperature of water. The type of pollution resulting from changing the temperature of water is called thermal pollution. People can release cold water from the bottom of reservoirs into rivers. There are no reservoirs on the San Antonio River, but the water that is released from Canyon Reservoir on the Guadalupe River is cold enough for trout to live in.

People also use water to cool machinery and return the water that absorbed the heat from the machinery to rivers. Victor Braunig Lake and Calaveras Lake, both in Bexar County, are used to cool machinery for power plants that produce electricity. Neither returns water to area streams except during flood events when water from the reservoirs must be released. Many types of tropical fish, like tilapia, are able to live in these lakes. Do you think trout could live in Braunig Lake or Calaveras Lake?

Cutting down trees along rivers and streams within the riparian zone also affects the water temperature. It reduces streamside shade causing the water to warm up. Soil erosion can cause water temperature to increase too. The soil particles carried into the water through erosion absorb sunlight.

STUDENT SHEET 4

pH

The pH of a substance tells you how acidic or basic it is. The pH scale ranges from 0-14. A substance with a pH of less than 7 is acidic. A substance with a pH of greater than 7 is basic. A substance with a pH of 7 is neutral (neither acidic nor basic). Most natural lakes and rivers in the US have a pH of 6.5-8.5. Normal rainwater is slightly acidic, with a pH of 5-5.6. This is because the carbon dioxide (CO_2) in the atmosphere mixes with the rainwater (H_2O) to make a dilute carbonic acid (H_2CO_3) solution.

Rainfall can become more acidic if air pollutants such as nitrogen oxides or sulfur dioxide mix with water in the atmosphere. This can form nitric acid and sulfuric acid. The result is acid rain. If this acid rain falls on a lake, it can lower the pH of the lak.

Acid rain harms aquatic life because most aquatic organisms are adapted to live within a narrow pH range. The optimal pH is 6.5-8.2 for most forms of aquatic life. Different organisms can live at different pH ranges, but all fish die if the pH is below 4 (the pH of orange juice) or above 12 (the pH of ammonia).

STUDENT SHEET 5

DISSOLVED OXYGEN

Organisms that live in the water need oxygen to live, just like organisms that live on land. The atmosphere contains about 21% (or parts per hundred) of oxygen. Different bodies of water may contain different amounts of dissolved oxygen, but the most oxygen that water may contain naturally is about 13 mg/L (or parts per million).

Since there is more oxygen in the atmosphere than in the water, oxygen naturally tries to move from the atmosphere to the water by diffusion. Several things can affect the amount of oxygen that is dissolved in water. Fast-flowing water that is tumbling over rocks tends to have more oxygen than slower flowing or stagnant water because the tumbling activity allows oxygen from the air to better mix with the water in turbulent areas.

Temperature has a major effect on oxygen in water. Cold water is able to hold more dissolved oxygen than warm water. Anything that causes water temperatures to increase can reduce the amount of oxygen in the water. The amount of organic matter, such as sewage or dead plants, that is in the water also affects dissolved oxygen levels. Bacteria in water decompose organic matter and use up oxygen in the process.

Living plants and algae also have an effect on oxygen in the water. During the day plants and algae produce oxygen in the water through photosynthesis and oxygen levels can increase. But at night plants and algae use oxygen through respiration (which is the opposite of photosynthesis) and cause dissolved oxygen levels to decrease. All organisms undergo respiration; only plants and algae undergo photosynthesis.

STUDENT SHEET 6

NITRATES AND PHOSPHATES

Nitrate is a form of nitrogen; phosphate is a form of phosphorus. Nitrogen and phosphorus are elements that all living things need to grow, and they are found in all living things. Nitrogen is used to make protein; phosphorus is used to make cell membranes. Plants require a lot of nitrogen and phosphorus, so these elements are almost always found in the fertilizers that farmers put on crops to make them grow.

Nitrogen and phosphorus make plants and algae grow in the water also. Too much nitrogen or phosphorus in the water can be unhealthy for a river, stream or lak. The reason is that when plants and algae die, the bacteria that decompose them use up oxygen. The more dead plants there are, the more bacteria are produced to decompose the dead plants. The more bacteria there are, the more oxygen they use and the less oxygen is available for fish and other living things in the water.

Nitrates are found in sewage that is released from wastewater treatment plants. Animal waste from farms can also add nitrates to the water. Soil erosion from farms can add phosphates to the water because phosphorus from fertilizers may be attached to the soil particles. Human activities that increase the amount of sewage and fertilizers within the basin can increase nitrates and phosphates in our water.

STUDENT SHEET 7

TURBIDITY

Turbid water is murky because of tiny particles that are suspended in the water. Turbid water may be caused by soil erosion, algae blooms, discharge from factories, or bottom feeding organisms such as carp or crayfish. There are not set stnadards for turbidity in the San Antonio River Basin because natural levels vary so much.

Turbidity can have a number of effects on the water. Suspended particles in the water absorb sunlight and cause the water to become warmer. Less light is able to penetrate turbid water, so photosynthesis decreases. Tiny particles may settle to the bottom, burying the eggs of fish and aquatic insects. Tiny particles may also settle into the spaces between rocks, making them less hospitable for aquatic insects to live.

STUDENT SHEET 8

5-DAY BIOCHEMICAL OXYGEN DEMAND

Five-day biochemical oxygen demand is a test to find out how much oxygen the small microscopic organisms in the water use. It is a test that compares the amount of dissolved oxygen in a sample to the amount of dissolved oxygen that was in the sample five days before. The difference is equal to the amount of oxygen that was used by microorganisms in the water.

TEACHER SHEET 1

TEMPERATURE AND DISSOLVED OXYGEN

Temperature has a significant effect on the amount of oxygen that water can hold. Cold water is able to hold more dissolved oxygen than warm water. A good way to demonstrate this is to introduce dissolved oxygen into a sample of cool water with an aquarium pump and test for the oxygen conten. Then warm up the sample on a hot plate, test for the oxygen content again, and compare the two dissolved oxygen readings.

TURBULENCE AND DISSOLVED OXYGEN

Turbulent water generally contains more dissolved oxygen than calm water because of the physical mixing that takes place between oxygen and water due to turbulence. This can be demonstrated by measuring the dissolved oxygen content of a water sample, then pouring the water sample several times through a screen to simulate turbulence, measuring the dissolved oxygen content and comparing the two samples.

AQUATIC PLANTS AND DISSOLVED OXYGEN

Aquatic plants can have an impact on the amount of dissolved oxygen in the water. Plants undergo photosynthesis (whereby they produce oxygen) during the day, but at night they only undergo respiration (whereby they consume oxygen). Generally, where aquatic plants are present, dissolved oxygen is higher during the afternoon when plants are undergoing photosynthesis and it is lower early in the morning after plants have undergone respiration during the night. The relationship between plant photosynthesis and dissolved oxygen, and plant respiration and dissolved oxygen, can be illustrated by comparing the dissolved oxygen content of water that contains aquatic plants that are kept exposed to light and plants that are kept in the dark. Aquatic plants such as hydrilla can be placed in two containers of water. One container should be exposed to light (as from a growth lamp) and the other container should be kept covered so that it is not exposed to light. The oxygen content of the two containers of water can be compared after a day or two. The plant that is exposed to light should produce oxygen in the water, as well as consume it, because it carries out photosynthesis. The plant that is kept in the dark should consume only oxygen because it only carries out respiration.

TEACHER SHEET 2

EFFECT OF NITROGEN AND PHOSPHORUS ON PLANT GROWTH

The effect of nitrogen and phosphorus on aquatic plant growth can be observed by comparing growth of aquatic plants that are exposed to nitrogen and phosphorus fertilizer with that of aquatic plants that are not given fertilizer. Algae or aquatic plants such as hydrilla or duckweed can be placed in two containers of water. One container should be supplemented with a tablespoon of fertilizer containing nitrogen and phosphorus, and the other contianer should hold wter that is not supplemented with fertilizer. The growth of the plants can be compared after a week or so.

TURBIDITY

The students may not be familiar with the concept of turbidity. Turbidity can be easily demonstrated by filling a jar with water, pouring in a coupl do teaspoons of very fine sand, screwing the lid on the jar and inverting it several times to mix the sand and water. The students should easily be able to see how the sand increases turbidity (makes the water cloudy).

TURBIDITY AND TEMPERATURE

Suspended particles in the water can have an effect on water temperature because the particles are able to absorb sunlight and become warmer. The warmth is transferred from the particles to the water by conduction. A good waty to demonstrate this is to shine a heat lamp on two water samples: one sample being distilled water and the other sample being distilled water into which has been added and stirred a measured amount of fine sand. After a few minutes, compare the temperatures of the two samples.

REFERENCES

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