WATER QUALITY

Physical and chemical water testing

Focus questions	How can we analyze the abiotic components (chemical and physical tests) of the stream in order to determine the stream's overall water quality?
Learning target	Students describe how dissolved oxygen (DO), biological oxygen demand (BOD), phosphate, nitrate, temperature, pH, and turbidity can impact water quality and aquatic life.
Vocabulary	Resilience, temperature, turbidity, dissolved oxygen (DO), pH, phosphate, nitrate

This activity is adapted from Earth Force, LaMotte Low Cost Water Monitoring Kit and procedures.
earthforce.org/GMGREEN/wp-content/uploads/2016/03/Low-Cost-Water-Monitoring-Kit-Manual.pdf

MS-ESS3: Earth and Human Activity

Performance expectation MS-ESS3-3	**Classroom connection:** This activity provides the chemical and physical data needed to construct an explanation for the current water quality.

Science and engineering practices

Constructing Explanations and Designing Solutions	**Classroom connection:** Students begin to construct an explanation by gathering chemical and physical data to support their explanation of the current water health in the aquatic ecosystem. **Classroom connection:** Students begin to design solutions to improve the water quality of the provided sample based upon their calculated chemical and physical data.

Disciplinary core ideas

ESS3.C: Human Impacts on Earth Systems	**Classroom connection:** The chemical and physical testing will provide data that will indicate the health of the aquatic ecosystem. Students will analyze these factors to determine if they are the result of human interaction with the aquatic ecosystem.

Cross-cutting concepts

Cause and Effect	**Classroom connection:** Human impacts have made a significant impact on aquatic ecosystems. Students will test for factors that have led to ecosystem decline and design possible solutions to correct this decline.

This lesson focuses on Constructing Explanations and Designing Solutions as a means to identify the factors that affect the health of aquatic ecosystems and the corresponding conditions that allow aquatic organisms to survive. Students will collect data on the chemical and physical health of a water sample and create a water health explanation for that sample. Students can then utilize the collected data to create solutions to either maintain or improve the health of the aquatic ecosystem.

Background

Temperature is very important to water quality. Temperature affects the amount of dissolved oxygen (DO) in the water, the rate of photosynthesis by aquatic plants, and the sensitivity of organisms to toxic wastes, parasites and disease.

Turbidity is the measure of the relative clarity of water. Turbid water is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter, and microscopic organisms. Turbidity should not be confused with color, since darkly colored water can still be clear but not turbid. Turbidity may be the result of soil erosion, urban runoff, algal blooms, and bottom sediment disturbances.

pH is a measure of the hydrogen ion (H+) concentration of a solution. The pH scale ranges from a value of 0 (very acidic) to 14 (very basic), with 7 being neutral. The pH of natural water is usually between 6.5 and 8.2. Most aquatic organisms are adapted to a specific pH level and may die if the pH of the water changes even slightly. pH can be affected by industrial waste, urban and agricultural runoff, or drainage from mining operations.

Dissolved oxygen (DO) is important to the health of aquatic ecosystems. All aquatic animals need oxygen to survive. Natural waters with consistently high dissolved oxygen levels are most likely healthy and stable environments, and are capable of supporting a high biodiversity of organisms. Natural and human induced changes to the aquatic ecosystem can affect the availability of DO. Dissolved oxygen percent saturation is an important measurement of water quality. Cold water can hold more DO than warm water. High levels of bacteria or large amounts of decaying material can cause the percent saturation to decrease. This can cause large fluctuations in DO levels throughout the day, which can affect the ability of plants and animals to survive.

Nitrate is a nutrient form of nitrogen that is needed by all aquatic plants and animals to build protein. The decomposition of dead organisms and the excretions of living animals release nitrate ad other forms of nitrogen compounds into the aquatic ecosystem. Excess nutrients like nitrate increase plant growth and decay, promote bacterial decomposition, and consequently decrease the amount of DO available in the water. Sewage and fertilizer from urban and agricultural runoff contribute to high levels of nitrate.

Phosphate is a nutrient needed for plant and animal growth. It is a limiting factor in aquatic plant growth. High levels of phosphates can lead to overgrowth of plants, increased bacterial activity, and decreased DO levels.

Materials

- LaMotte Low Cost Water Monitoring kit
- BOD bottle or quart jar with lid
- Water sample from local water system
- Protective gloves

Prior knowledge

Students should have a good understanding of ecosystems and the complex interactions that occur within ecosystems. A freshwater aquatic ecosystem is an ecosystem that exists in a body of water with a salinity of less than 0.05 percent. It consists of a community of aquatic organisms living interactively with their abiotic environment. Ecosystems with a higher biodiversity tend to be more stable with greater **resilience** in the face of disruption to the ecosystem. Students will need to gain an understanding of how **pH, dissolved oxygen, temperature, turbidity** and nutrients such as **nitrate** and **phosphate** interact with the ecosystem to maintain or cause disturbance within the ecosystem.

Teacher preparation

1. If possible, conduct these tests on site at the aquatic ecosystem to be tested. If this is not possible, record the temperature and dissolved oxygen results at the time of collection for your students to use later for the most accurate results.
2. Print off the accompanying student handout.
3. Determine the tests that your students will conduct for this lesson. The following tests will provide your students with the ability to predict overall water health: temperature, pH, turbidity, dissolved oxygen, nitrate, and phosphate.
4. Collect water samples for the students to test in a sterile, wide-mouthed jar or container with a cap. The container should be filled completely with your water sample and capped to prevent the loss of dissolved gases. Test each sample as soon as possible or within one hour of collection.
    - Biological Oxygen Demand (BOD) bottles will allow you to extend your water testing time frame.
    - When possible, perform the temperature and dissolved oxygen (DO) at the monitoring site immediately after collecting the water sample.

    a. Remove the cap of the sampling container.
    b. Wear protective gloves. Rinse the bottle 2–3 times with the stream water (or other water source).
    c. Hold the container near the bottom and plunge it (opening downward) below the water surface.
    d. Turn the submerged container into the current and away from you.
    e. Allow the water to flow into the container for 30 seconds.
    f. Cap the full container while it is still submerged. Remove it from the river completely.
5. The turbidity test is meant to be conducted in the LaMotte Low Cost Water Monitoring kit container. If possible, adhere the Secchi disk icon sticker to the container on the bottom 8-24 hours before testing slightly off-center.
6. Prepare 1 water sample for each student testing group and a Lamotte Low Cost Water Monitoring kit to conduct the tests. Students will need the colored indicator cards to record the test results.
7. Determine if you want the students to conduct all of the tests, or allow the students to determine the tests they feel are necessary to conduct in order to determine the health of the aquatic ecosystem.
8. Remind students to carefully dispose of all reacted test samples by carefully flushing them down the drain with excess water. *While in the field, reacted samples can be poured together into a waste container for later disposal.*

Student handout

Reflection

Create an explanation for the current water health of the water sample. Look at the recorded information above. Reflect on the following questions while creating your explanation.

1. How did your water sample results compare? How are they similar or different?

Answers will vary. Students will compare their test data in the ranking chart. Students will be able to determine if the sample is poor, fair, good, or excellent water quality based upon the ranking results.

2. Did any test stand out? For example, did any test show different results than the rest? If so, why do you think this test was different?

Answers will vary. Students should support their answer with data.

3. How do the water quality tests interact with one another or potentially change throughout the year? For example, temperature has a direct impact on the percent saturation of dissolved oxygen. How could the local climate impact the biodiversity of the aquatic ecosystem if the percent saturation changes?

Answers will vary. Students should conduct research on each test to support their explanation.

4. What tests, if any, demonstrate that the health of the aquatic ecosystem could be improved? What are some ways that humans can remediate their impact to improve water quality?

Answers will vary. Students should conduct research on each form of remediation to support their explanation.

Differentiation

Other ways to connect with students with various needs:

- **Local Community:** Students may investigate local aquatic ecosystems to test the physical and chemical properties of the ecosystem and observe possible causes for that health assessment. Students can hear a presentation from a local water quality district or water quality chemist to learn more about chemical testing.
- **Students with special needs (language/reading/auditory/visual):** Students that perform better with visual aids can read directly from the LaMotte Water Monitoring kit: `earthforce.org/GMGREEN/wp-content/uploads/2016/03/Low-Cost-Water-Monitoring-Kit-Manual.pdf`. Students that do not perform well in groups may perform testing on their own. Students may create connections between the tested materials through graphic organizers.
- **Extra support:**
  - Volunteer Stream Monitoring, A Methods Manual `epa.gov/sites/production/files/2015-06/documents/stream.pdf`
  - Earth Force `earthforce.org/GMGREEN`
  - Nebraska Department for Environmental Quality, Stream Monitoring `deq.ne.gov/NDEQProg.nsf/OnWeb/SBMP`
- **Extensions:** Students can observe real-time data in Nebraska through USGS: `nrtwq.usgs.gov/ne/`. Students can help to solve real water problems within their community. Take part in organizations such as Give Water a Hand: `erc.cals.wisc.edu/gwah/`.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Constructing Explanations	Student can conduct the chemical and physical water quality tests.	Student can conduct the chemical and physical water quality tests. Student can create an explanation for the data that resulted from the chemical and physical water quality tests.	Student can conduct the chemical and physical water quality tests. Student can create an explanation for the data that resulted from the chemical and physical water quality tests and design some forms of remediation for negative test results.

Rubric for self-assessment

Skill	Yes	No	Unsure
I can conduct chemical and physical water quality testing.			
I can explain how/why the test results indicate water quality or ecosystem health.			
I can describe possible ways that the health of a disrupted aquatic ecosystem can be improved.			