

Lesson 8: Water Pollution

☐ Getting Started

Have you ever looked at a lake or river and wondered if the water is actually healthy? Water can look clear but still be polluted. It can seem fine on the surface, but hidden changes, like lower oxygen levels or extra nutrients, can make it difficult for plants and animals to survive. Scientists study water carefully to understand these changes and figure out what is affecting it.



In this lesson, you will think like a scientist as you investigate water quality. You will explore how factors like temperature, pollution, and human activities, especially farming, can change the balance of aquatic ecosystems. Along the way, you will use evidence to explain what is happening and consider how people can reduce their impact on Earth's water systems. By the end of this lesson, you will understand that water is not just something we use—it is part of a complex system that supports life and must be carefully protected.

Stuff You Need

- *Water: The Story of the Hydrosphere, Second Edition* by Lynne Z. Petkovic, M.Ed., J.D.
- colored pencils
- large clear cups (kit)
- organic material* (Activity 2 - e.g. dead leaves or grass)
- pebbles (kit)
- permanent marker (kit)
- ruler or straight edge
- soil (kit)

Ideas to Think About

- Human activities affect water quality and availability.

Things to Know

- **Agricultural runoff** is water that flows over farmland and carries fertilizers, pesticides, and waste into nearby rivers, lakes, and oceans.
- **Hypoxia** is a lack of oxygen.
- **Eutrophication** is when excess nutrients in water cause rapid algae growth, leading to oxygen depletion and harm to aquatic life.
- As human populations grow and resource consumption increases, the negative effects on Earth's environment, including those from farming, typically rise—unless activities and technologies are carefully engineered to reduce harm.

- Ecosystems are dynamic in nature; disruptions to any physical or biological component can lead to shifts in all its populations.
- Oxygen is a key factor in the chemistry and biology of coastal waters, and its concentration indicates water quality, with higher levels supporting thriving ecosystems.
- Nitrogen is essential for photosynthesis in marine plants, but it must first be converted into usable forms like nitrate or ammonia before plants can absorb it.

☐ Reading and Questions

Read Chapter 8 in the book *Water: The Story of the Hydrosphere*. Then, answer the questions.

1. What is hypoxia?

2. How can agricultural runoff lead to problems for aquatic ecosystems?

3. Why can pollution that enters water in one location affect ecosystems far away?

Activities

☐ Activity 1: Evaluating Graphics

Before scientists can understand how pollution affects water, they first have to understand something very important: how much oxygen is in the water. Just like you need oxygen to breathe, fish and other aquatic organisms depend on dissolved

oxygen in the water to survive. But here's something surprising: *The amount of oxygen in water is not always the same.*

It changes depending on factors like:

- temperature
- type of water (fresh vs. salt)
- and even pollution

This means pollution can lower oxygen levels in water, sometimes leading to **hypoxia**, or low oxygen conditions that make it hard for organisms to survive. In this activity, you will act like a scientist by turning data into a graph, looking for patterns, and using evidence to explain what is happening in the water. As you work, think about this question: *How might changes in temperature and pollution affect the survival of organisms in water?*

For the first part of the activity, examine Graph 1: Fresh Water and Salt Water on the "Graphs" activity page. The graph shows how dissolved oxygen levels change as temperature increases in both fresh water and salt water. Study the graph carefully and look for patterns. As you analyze the data, think about these questions:

- How does temperature affect dissolved oxygen levels?
- How do dissolved oxygen levels compare in fresh water and salt water?
- What patterns do you notice as temperature changes?

After studying the graph, answer the questions on the activity page using evidence from the graph.

For the second part of this activity, examine Graph 2: Dissolved Oxygen and Pollutants and answer the questions about that graph. Look for relationships between pollutant levels and dissolved oxygen, and use evidence from the graph to support your answers.

☐ Activity 2: Population Growth, Farming, and Water Use

In the last activity, you explored how water quality can change and what might be present in the water we use every day. Now, let's take a bigger step back and ask: *Why is water quality changing in the first place?*

As the human population grows, people need more food, more water, and more resources. Farming plays a huge role in meeting these needs, but it also has consequences. Farms use large amounts of water, and materials like fertilizers and pesticides can wash into rivers and lakes. This process is called **agricultural runoff**.

Runoff often carries nutrients like nitrogen into water systems, which can lead to **eutrophication**, a process where excess nutrients cause rapid algae growth and reduce oxygen levels.

Part 1: Watch the Video

In this activity, you will first watch a video about modern farming and think like a scientist. Read the questions first. Then, pause the videos to answer the questions on the activity page titled "Population Growth, Farming, and Water Use."



Can We Create the "Perfect" Farm?

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Part 2: Modeling Agricultural Runoff

In the video, you learned that farming can affect ecosystems through water use, fertilizers, and runoff. Now, you will create a simple model to investigate how materials from farmland can affect water quality. When rain falls on farmland, water can flow across the land and carry soil, nutrients, and other materials into nearby rivers, lakes, and streams. This process is called **agricultural runoff**. Scientists study runoff because it can change water quality and affect aquatic ecosystems.

As you complete this investigation, think about these questions:

- Which conditions cause the most change in water quality?
- What evidence do you see of human impact on Earth's systems?
- What might farmers do differently to protect water resources?

Procedure

Set up Low Runoff Cup (Cup 1)

- Fill the first cup with water.
- Add 2 tablespoons of soil.
- Label this cup with a marker: "Low Runoff."
- Stir gently and observe and record the water's appearance on the "Farming Practices" Activity Page.

Set Up Farming with Organic Material Cup (Cup 2):

- Fill the second cup with water.
- Add 2 tablespoons of soil.
- Add a handful of dead leaves or grass (to represent organic farming).

- Label this cup with a marker: "Organic Material Runoff."
- Stir gently and observe and record any changes in the water's appearance on the "Farming Practices" Activity Page.

Set Up Farming with Heavy Runoff Cup (Cup 3)

- Fill the third cup with water.
- Add 2 tablespoons of soil.
- Add small rocks or gravel (to represent a disturbed land with less plant cover).
- Label this cup with a marker: "Heavy Runoff."
- Stir vigorously to simulate heavy runoff, and observe and record changes in the water's appearance on the "Farming Practices" Activity Page.

Observe and Record

- Immediately after stirring, observe each cup and write down what you see on the Activity Page: Is the water clear or cloudy? Are there floating particles? Have materials settled to the bottom? Which cup appears to have the poorest water quality?
- After 5 minutes, observe again and note any changes in water clarity and material settling.

Now, answer the questions on the "Farming with Erosion" Activity Page.

Wrapping Up

In this lesson, you explored how water quality can change and why it matters for living things. You saw how factors like temperature, pollution, and human activities, especially farming, can affect oxygen levels in water and impact entire ecosystems. You also began thinking like a scientist and engineer by using evidence to explain these changes and designing ways to reduce harm.

Next, you will take the next step: learning how people work to clean, protect, and conserve water. You'll discover how water is treated to make it safe to use and explore ways we can all help keep Earth's water clean and available for the future.

☐ **Life Application (Optional): Mini-Design Challenge**

Scientists and engineers are constantly looking for ways to produce food while protecting water quality. In this optional activity, you will act as an environmental engineer. Imagine a farm is experiencing heavy runoff after storms. Soil and other materials are being washed into a nearby stream, making the water cloudy and affecting aquatic organisms. Using what you learned in the video and the runoff

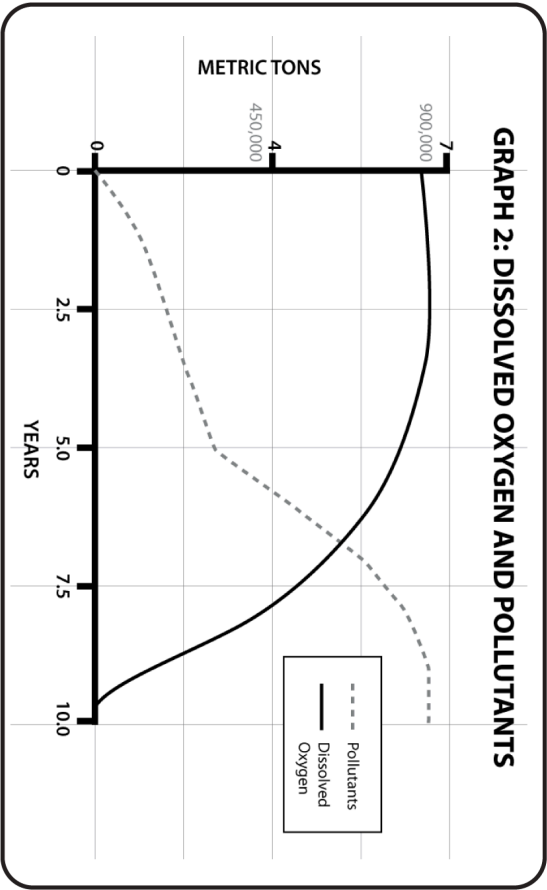
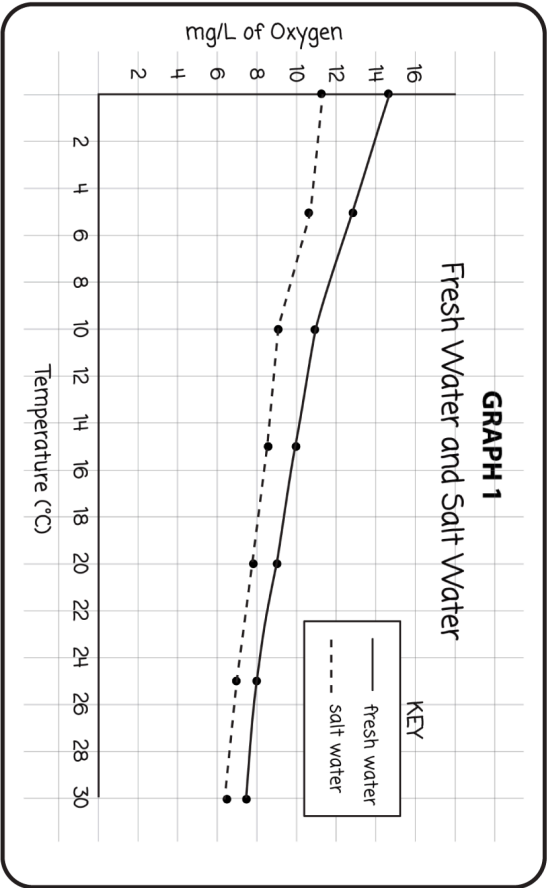
investigation, design a solution that could help reduce runoff and improve water quality.

Draw a simple diagram of your solution and label its important features. Your design might include:

- Cover crops
- Buffer strips of grass or trees
- Improved irrigation systems
- Reduced soil disturbance
- Other ideas you think would help

Label your design and be prepared to explain how it works to a parent.

GRAPHS



1. Based on the need for oxygen, at what temperature would you expect to find the greatest number of organisms?

2. What would possibly limit the number of organisms at 0°C?

3. Compare fresh water and salt water. What do you notice?

4. How might differences in dissolved oxygen affect the organisms that live in fresh water and salt water?

1. What do you think could be the cause of the increased level of pollutants?

2a. What relationship do you notice between pollutants and dissolved oxygen?

2b. If oxygen levels decrease and hypoxia occurs, how might this affect fish and other organisms?

2c. How could this impact the entire ecosystem over time?

Population Growth, Farming, & Water Use

Directions: Watch the video in its entirety and then answer the questions.

You may go back and rewatch it if you need to.

1. Why is agriculture important?

- a. It helps make all weather patterns predictable.
- b. It enabled the existence of civilization.
- c. It eliminates the need for natural ecosystems.
- d. It prevents all forms of water pollution.

2. About what percentage of Earth's land is used for agriculture?

- a. About 10%
- b. About 25%
- c. About 40%
- d. About 75%

3. What was one negative effect of the First Agricultural Revolution mentioned in the video?

- a. It made it impossible for people to form permanent settlements.
- b. It reduced the amount of food available to people.
- c. It led to environmental problems because more land had to be cleared and used for farming.
- d. It eliminated the need for technology in farming.

4. Farmers are having to grow more food for a growing population. How are ecosystems being negatively impacted by the farming practices being used?

5. What are some design and process solutions the video presents that will help farmers protect ecosystems and, in turn, protect biodiversity?



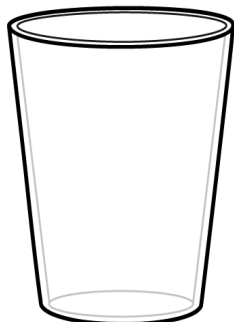
Farming with Erosion

Guiding Question: How do different farming practices affect water quality and ecosystems?



- Immediately after stirring, observe each cup and write down what you see on the Activity Page:
 - Is the water clear or cloudy?
 - Are there floating particles?
 - Have materials settled to the bottom?
 - Which cup appears to have the poorest water quality?
- After 5 minutes, observe again and note any changes in water clarity and material settling.

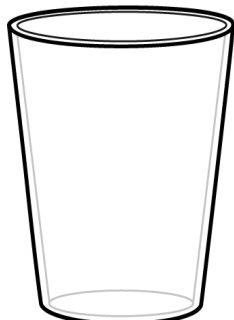
Cup 1



Immediate Observations

After 5 minutes

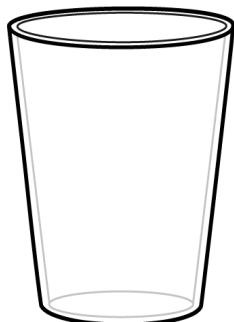
Cup 2



Immediate Observations

After 5 minutes

Cup 3



Immediate Observations

After 5 minutes

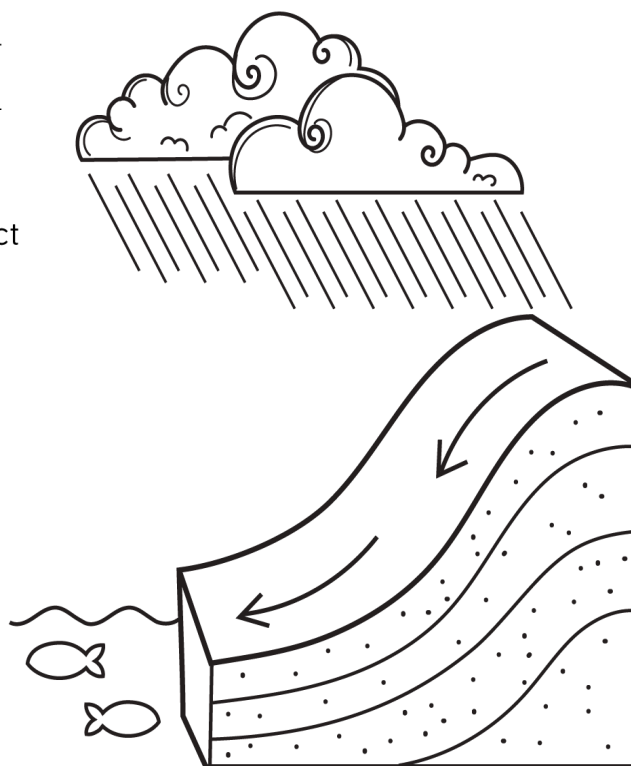
Questions

1. Which cup has the clearest water? Which is the cloudiest? What evidence supports your answer?

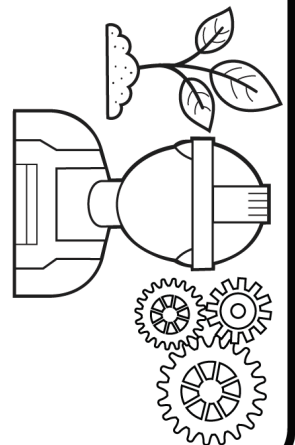
2. How did the materials added to each cup affect the water quality? Use your observations to explain.

3. How does this activity model what can happen when runoff carries materials from farms into streams, rivers, and lakes?

4. Based on your observations, what is one farming practice that could help reduce runoff and protect water quality? Explain your reasoning.



Mini-Design Challenge



Lesson 8: Water Pollution

Getting Started

✿ Ideas to Think About

- Human activities affect water quality and availability.

Things to Know

- Agricultural runoff** is water that flows over farmland and carries fertilizers, pesticides, and waste into nearby rivers, lakes, and oceans.
- Hypoxia** is a lack of oxygen.
- Eutrophication** is when excess nutrients in water cause rapid algae growth, leading to oxygen depletion and harm to aquatic life.
- As human populations grow and resource consumption increases, the negative effects on Earth's environment, including those from farming, typically rise—unless activities and technologies are carefully engineered to reduce harm.
- Ecosystems are dynamic in nature; disruptions to any physical or biological component can lead to shifts in all its populations.
- Oxygen is a key factor in the chemistry and biology of coastal waters, and its concentration indicates water quality, with higher levels supporting thriving ecosystems.
- Nitrogen is essential for photosynthesis in marine plants, but it must first be converted into usable forms like nitrate or ammonia before plants can absorb it.

Reading and Questions

- What is hypoxia?

Hypoxia is a condition in which there is a lack of oxygen in the water. When hypoxia occurs, fish and other aquatic organisms may become stressed, leave the area, or die.

- How can agricultural runoff lead to problems for aquatic ecosystems?

Agricultural runoff can carry fertilizers into rivers, lakes, and oceans. Excess nutrients can cause rapid algae growth, a process called eutrophication. As the algae die and decompose, oxygen levels in the water decrease, making it difficult for fish and other organisms to survive.

- Why can pollution that enters water in one location affect ecosystems far away?

Water is constantly moving through rivers, lakes, groundwater, oceans, and the water cycle. Pollutants can travel with the water, spreading beyond where they were first introduced. Because ecosystems are connected, pollution in one area can affect organisms and habitats far downstream or even in other bodies of water.

⦿ Skills

- Construct an explanation based on evidence for how pollution and changes in water quality affect aquatic ecosystems. (MS-ESS3-3)
- Analyze and interpret data from graphs to describe how temperature and pollution influence dissolved oxygen levels in water. (MS-ESS2-2)
- Develop and use models to demonstrate how human activities, such as farming, impact water systems through runoff and erosion. (MS-ESS3-3)

- Analyze and interpret observations from investigations to identify how different factors affect water quality. (Science & Engineering Practice)
- Construct an argument supported by evidence for how population growth and resource use impact Earth's water systems. (MS-ESS3-4)
- Construct an argument supported by evidence for how increases in human population and resource consumption impact Earth's systems. (MS-ESS3-4)
- Evaluate competing solutions for reducing the environmental impacts of agriculture while maintaining ecosystem services such as water quality and soil conservation. (MS-ESS3-3)
- Design solutions to reduce human impact on water systems and evaluate how those solutions can improve water quality over time. (Science & Engineering Practice)
- Analyze hydrospheric data over time to predict the health of a water system, including dissolved oxygen.
- Recognize that the good health of environments and organisms requires monitoring of the hydrosphere, water quality standards, methods of water treatment, maintaining safe water quality, and stewardship.
- Describe how humans affect the quality of water through possible effects of excess nutrients in freshwater reservoirs.
- Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- Analyze evidence to explain observations, make inferences and predictions, and develop the relationship between evidence and explanation.
- Observe, collect, organize, and analyze data.
- Use oral and written language to communicate findings.

Introducing the Lesson

In this lesson, your child will explore how human activities affect water quality and ecosystems. He will analyze graphs, conduct a simple experiment, and investigate how farming and population growth impact water systems. By the end, he will use evidence to explain these impacts and think about ways to reduce pollution and protect water resources.

Activities

Activity 1: Evaluating Graphics

Using Graph 1, your child will answer questions. The questions and answers are as follows:

1. Based on oxygen only, 0(degrees)C.
2. Water temperature is at freezing, and not all organisms are adapted to temperatures at this level.
3. At the same temperatures, fresh water has a higher concentration of dissolved oxygen. While subtle, the rate of decrease in the concentration of dissolved oxygen is quicker in fresh water than in salt water.
4. Fresh water may be able to support more organisms because it contains higher levels of dissolved oxygen at the same temperatures. Organisms that need more oxygen may have a harder time surviving in water with lower dissolved oxygen levels. The amount of dissolved oxygen available can affect which organisms are able to live and thrive in a particular body of water.

Next, your child will look at a second graph to interpret the role of pollutants on dissolved oxygen and the effect of temperature and oxygen levels on ocean ecosystems. The goal of this graph is to encourage your

child to begin to understand the relationships among pollutants, whether naturally or humanly introduced. As your child views the graph, encourage him to understand that the relationship communicated in the graph is common. There are often inverse relationships in the hydrosphere between the abiotic factors and the biotic factors.

The questions and answers for the second graph ("Dissolved Oxygen and Pollutants") are as follows:

1. *What do you think could be the cause of the increased level of pollutants?* Because pollution is the unnatural increase or introduction of a contaminant into the water, there are two possibilities: natural disaster (earthquake, volcanic eruption) or human introduction via point or non-point source pollution.

2. a. *What relationship do you notice between pollutants and dissolved oxygen?*

As pollutants increase, the amount of dissolved oxygen decreases. This is an inverse relationship.

2b. *If oxygen levels decrease, how might this affect fish and other organisms?*

Fish and other aquatic organisms may struggle to survive because they need oxygen to breathe. Some may become stressed, get sick, or die.

2c. *How could this impact the entire ecosystem over time?*

If oxygen levels stay low, many organisms could die or leave the area. This can disrupt the food chain and cause the ecosystem to become unbalanced.

Activity 2: Population Growth, Farming, and Water Use

In this activity, your child will first watch a video about farming practices and their effect on the environment. Encourage your child to pause and rewind the video if needed. The goal is not to rush, but to gather evidence and think critically about how human actions affect Earth's systems. After watching the video, discuss with him how farming practices can impact water resources, including the large amount of water used and the potential for pollution from chemicals. You can also explore ways farmers can reduce these negative effects and conserve water while protecting the environment.

Answer Key:

1. b
2. c
3. c
4. As the demand for food increases, farming uses more land, water, and other resources. Some farming practices can lead to soil erosion, habitat loss, and pollution from fertilizers and pesticides. Runoff from farms can carry these materials into rivers and lakes, affecting water quality and harming plants and animals.
5. The video describes using technology such as sensors, drones, and data collection to help farmers apply water and fertilizer only where they are needed. It also discusses precision agriculture and more efficient irrigation systems. These approaches reduce waste, conserve resources, limit pollution, and help protect ecosystems while still producing enough food for a growing population.

In this activity, your child investigates how agricultural runoff can affect water quality. He creates simple models of different farming conditions, observes changes in water clarity, and uses evidence from his observations to explain how materials carried by runoff can impact aquatic ecosystems. He also considers farming practices that can help protect water resources and reduce environmental impacts.

Answer Key:

1. Answers may vary. Cup 1 will likely have the clearest water, while Cup 3 will likely be the cloudiest. Evidence may include the amount of suspended particles, water clarity, and how much material settled to the bottom.
2. The materials changed the water quality in different ways. The soil made the water cloudy, the organic material added floating particles, and the combination of soil and disturbed material in Cup 3 caused the greatest decrease in water clarity.
3. The activity models agricultural runoff by showing how rainwater can carry soil, organic matter, and other materials from farmland into nearby streams, rivers, and lakes. These materials can change water quality and affect aquatic ecosystems.
4. Answers may vary. Farmers can reduce runoff by planting cover crops, maintaining vegetation near waterways, using buffer strips, reducing soil disturbance, or using farming methods that keep soil in place. These practices help prevent soil and other materials from washing into nearby water sources.

Wrapping Up

In this lesson, your child explored how pollution, temperature, and human activities can affect water quality and aquatic ecosystems. He used evidence from graphs, investigations, and a video to explain how changes in water systems can impact living things and considered ways to reduce human impacts on the environment. Next, he will learn how water is cleaned, protected, and conserved to help ensure safe and healthy water for the future.

Life Application (Optional): Mini-Design Challenge

This optional activity encourages your child to apply what he learned about agricultural runoff, water quality, and ecosystem health by designing a farm that reduces pollution and protects nearby water resources. After he completes his design, discuss the following questions together:

- What problem is your farm design trying to solve?
- Which part of your design do you think would be most effective at protecting water quality? Why?
- How might your design help protect fish, plants, and other organisms that live in or near water?
- What evidence would you collect to determine whether your design is working?
- What challenges might farmers face when trying to implement your solution?
- How does your design balance the need to produce food with the need to protect ecosystems?

These questions help your child think like a scientist and engineer by evaluating solutions, considering trade-offs, and using evidence to explain how farming practices can impact water systems and biodiversity.

Questions to Discuss

- Why is oxygen important for organisms living in water, and what happens when oxygen levels drop? (Answer: Oxygen is important because aquatic organisms need it to breathe and survive. When oxygen levels drop, organisms can become stressed, get sick, or die, which can disrupt the entire ecosystem.)

- How do human activities like farming affect water quality, and what is one way people can reduce this impact? (Answer: Farming can affect water quality through agricultural runoff, which carries soil, chemicals, and nutrients into water. This can cause pollution and reduce oxygen levels. One way to reduce this impact is by planting vegetation or buffer zones to keep soil and pollutants from washing into water.)

Things to Review

- Human activities, especially farming and pollution, can change water quality and affect oxygen levels in aquatic ecosystems.
- Changes in oxygen levels can impact organisms and disrupt the balance of entire ecosystems.