Water Chemistry

Grade	6th
Time	45 minutes
Overview	Students conduct water chemistry tests to assess the water quality and suitability of a local body of water to determine if the system is at a healthy level for the ecosystem.
Objectives	Understanding: Students test abiotic water quality indicators and explore how changes in these factors, as well as land use, impact water quality and aquatic ecosystem health. Skills & Processes: Students use water quality test tablets, strips, and thermometer to measure water quality. Students analyze water quality indicators and describe what they mean to the health of an ecosystem. Values: Students appreciate the importance of water quality to the health of a system.
Essential Question	How is water quality measured? What are healthy water quality levels for human consumption and for organisms in an aquatic ecosystem?
Primary VA SOL	Science (2018): 6.1, 6.6, 6.9
Related VA SOL	Math (2016) 6.6

Materials

- 5-gallon buckets
- 2-gallon buckets
- Turbidity Tube
- pH test strips
- nitrate test strips
- phosphate test (tabs and tubes)
- DO test (tabs & tubes
- Field thermometers
- Datasheet for students
- Information Sheets for each water quality parameter
- Mats

Special Safety

Do not ingest any of the materials in the tests and avoid touching eyes, nose, mouth.

Set Up

1. Gather water from a stream or river.
2. At teaching location, scoop water into smaller buckets, one per group.
3. On each station mat, place testing materials and information sheets.

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- As written, at each mat is a different test, however all tests can be placed in one bin per mat and group. Students then conduct all tests with their teammates (except turbidity) and do not rotate. The second datasheet supports this approach.

Instructional Strategy	
Recommended Grouping/Instructional style	Small groups Hands-on Sampling
Steps	**Inquire:** What do you know about water testing? Water chemistry? What does water quality mean to you? What are some ways we can measure water quality? How do we evaluate the quality of water in a stream, river, or pond? **Safety review:** 1. Have a quick discussion of some of the parameters that will be measured. Be sure to review safe practices to use when conducting water tests. (These materials are not dangerous to touch but should not be consumed and please keep chemicals and water away from your face. At the end of the testing, pour the water down the drain or waste bin, dispose of testing materials, and wash hands.) 2. Next, inform students that one of the things they are investigating today is determining the overall health the ecosystem's water – not for human consumption, but as a habitat. Inquire: a. What are some ways in which we can determine if a body of water is healthy or not? b. What are things that we can see with the human eye? (trash, erosion) c. What may be water quality parameters we can measure that we CANNOT see with our human eye? (invertebrates, pH, nitrates, phosphates, bacteria) 3. Optional: Briefly describe to students the important water quality factors that can be measured. Mention that water scientists can use a variety of tests that vary in technology. We will use a "low-tech" approach. Discuss the difference between low tech and high tech; high tech is more accurate but is costly, low tech can be done quickly and at any time but is less accurate. **Water Testing-** The instructor walks everyone through one test, modeling following the instructions and recording the data. 4. Instruct- Tell students they will be rotating through each station mat in small groups. At each mat, there is a bucket of water, an information sheet, and directions and the materials to conduct the test. They will read about the test they are

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	doing, then follow the directions to complete the test. After groups are finished recording their data on their data page, they will rotate to the next mat. 5. Ask teacher to split into groups of no more than 5 students, then send groups to a mat to start. Chaperones can help by either staying at a station or rotating with their groups. 6. While students are reading about and conducting tests, circulate to make sure students understand concepts. Note: concepts that may need support are: dissolved oxygen (where does it come from, where does it go, relationship to temp), nitrates and phosphates, turbidity. 7. Rotate groups through each mat and test. 8. Discuss results with students. Ask students how healthy they think the water they tested is based off their test data. Could there be errors in the data collection? Is the water polluted? If so, what pollutants could be causing it? Would they drink it? Why or why not? What didn't we test for? What steps could be taken to improve the water quality? **Analyze & Conclude:** Students compare their findings to the healthy ranges for humans and for aquatic organisms. Take two minutes to review your data sheet, what is your quick assessment of the health of the water based on the data before you? What other elements of water quality could we test for? (Turbidity, bacterial load, salinity, heavy metals, other pollutants). How might the water from Blandy change if there were a big rainstorm? **NOTE:** Ideally students would do three tests, which is why three are three blanks on the first datasheet, and then find the mean. Realistically there isn't time at Blandy to do this, but since they are all testing water from the same sampling, they can analyze in this way as an extension.

Extensions:

- Students can read the background information on the tests to better understand why we performed these tests while they wait for everyone to complete their procedure.
- Data comparison: a math/science lesson could include comparing student findings to find means for the parameters and looking at available data from NOAA & Save Our Streams to create graphs for comparison.

Assessments

Formative: Do students follow muti-step directions to correctly conduct tests?

Summative: Students use evidence to make inferences and conclusions.

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PHOSPHATE

Nitrates and phosphates are nutrients essential for plant growth. While these are very important for plants, too much causes problems in streams and ponds. With extra nutrients, photosynthesizing algae grows very quickly, die, then are decomposed, which uses up dissolved oxygen in the water. Some algae release toxic chemicals into water.

The algae bloom in the Chesapeake Bay by the start of the Hampton Roads Bridge Tunnel in Norfolk was taken on Tuesday, Aug. 18, 2009. (Ryan C. Henriksen | The Virginian-Pilot)

Even very small amounts of phosphates cause pollution; therefore, for your sample to be healthy, the test should read **no phosphates** in the water.

Algae uses up dissolved oxygen during respiration at night and has a very short life span. When algae die, decomposers use up more dissolved oxygen. Eventually the area has no more oxygen for aquatic animals to breathe and becomes a "dead zone".

Causes of Increased Phosphates

- Phosphate from lawn and agriculture **fertilizers** attaches to soil. **Erosion** carries it into water
- Natural phosphates in rocks weather and erode into aquatic systems
- Partially treated and untreated **sewage**
- Some **detergents** (laws restrict this)
- Animal (wild and domestic) **waste**

How to reduce Phosphates

- **Treat sewage** to remove phosphates.
- Use **best practices** when applying fertilizers on lawns and farms.
- Keep **livestock out** of water sources.
- Leave a wide strip of **deep-rooted plants** along shores.
- Keep **grass clippings** and leaves out of the street and water.
- **Pick up** pet waste.

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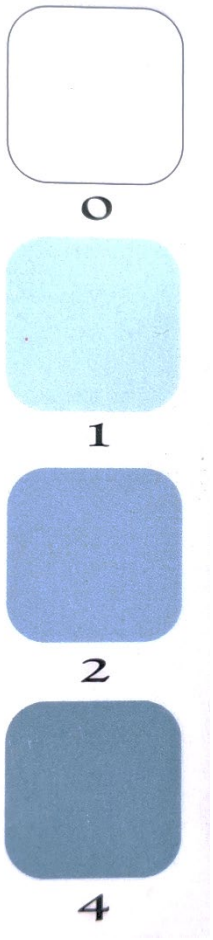
To Test for Phosphates

Make sure all team members record data

1. Use a pipette to fill the test tube with sample water to the 5mL line.
2. Add **one Phosphate TesTab** to the tube.
3. Cap and gently invert (turn over back and forth) **until the tablet has completely dissolved.**
4. AFTER the tablet has dissolved, set a timer for **5 minutes**.
5. **Compare** the color of the sample to the phosphate color chart.
6. Record your results in parts per million (ppm).
7. Once your test is complete, clean up.
    a) Empty the tested water into the **wastewater container** and throw away garbage.
    b) Rinse the test tube with the squirt bottle and pour rinse water into the **wastewater container.**
    c) Leave the test area neat and ready for the next group.



Materials: TesTabs, test tube, color chart, timer
Clean up materials: Squirt bottle, waste container

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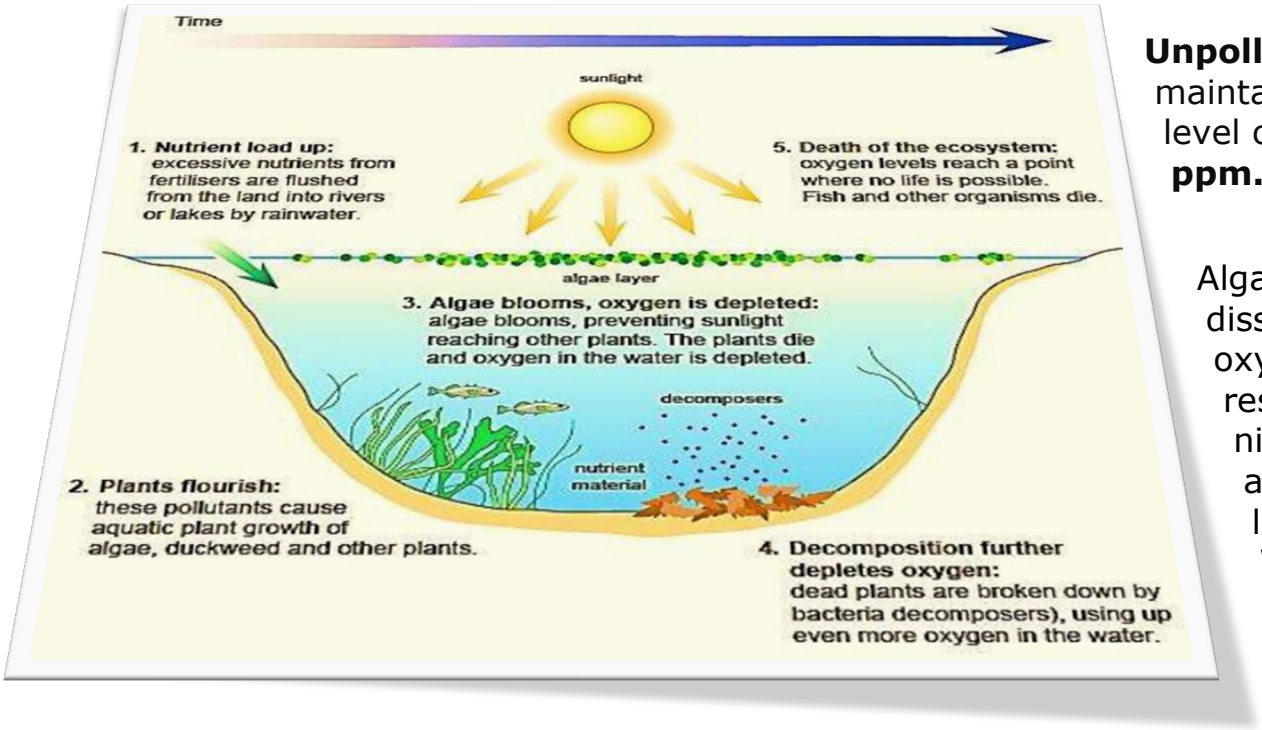
NITRATE

Nitrates and phosphates are nutrients essential for plant growth. While these are very important for plants, too much cause **problems in waterways**. With extra nutrients, photosynthesizing algae grows very quickly and **uses up dissolved oxygen** in the water. Some algae release toxic chemicals into water.



Unpolluted waters maintain a nitrate level of **below 1 ppm.**

Algae use up dissolved oxygen during respiration at night and have a very short life span. When algae die, decomposers use up more dissolved oxygen. Eventually the area has no more oxygen for aquatic animals to breathe and becomes a "dead zone".

Causes of Increased Nitrates	How to reduce Nitrates
• Nitrogen from lawn and agriculture fertilizers is carried into water by runoff. • Partially treated and untreated sewage • Animal (wild and domestic) waste • Decomposition • Industrial pollution	• Treat sewage to remove nitrates. • Use best practices when applying fertilizers on lawns and farms. • Keep livestock out of water sources. • Leave a wide strip of deep-rooted plants along shores. • Keep grass clippings and leaves out of the street and water. • Pick up pet waste.

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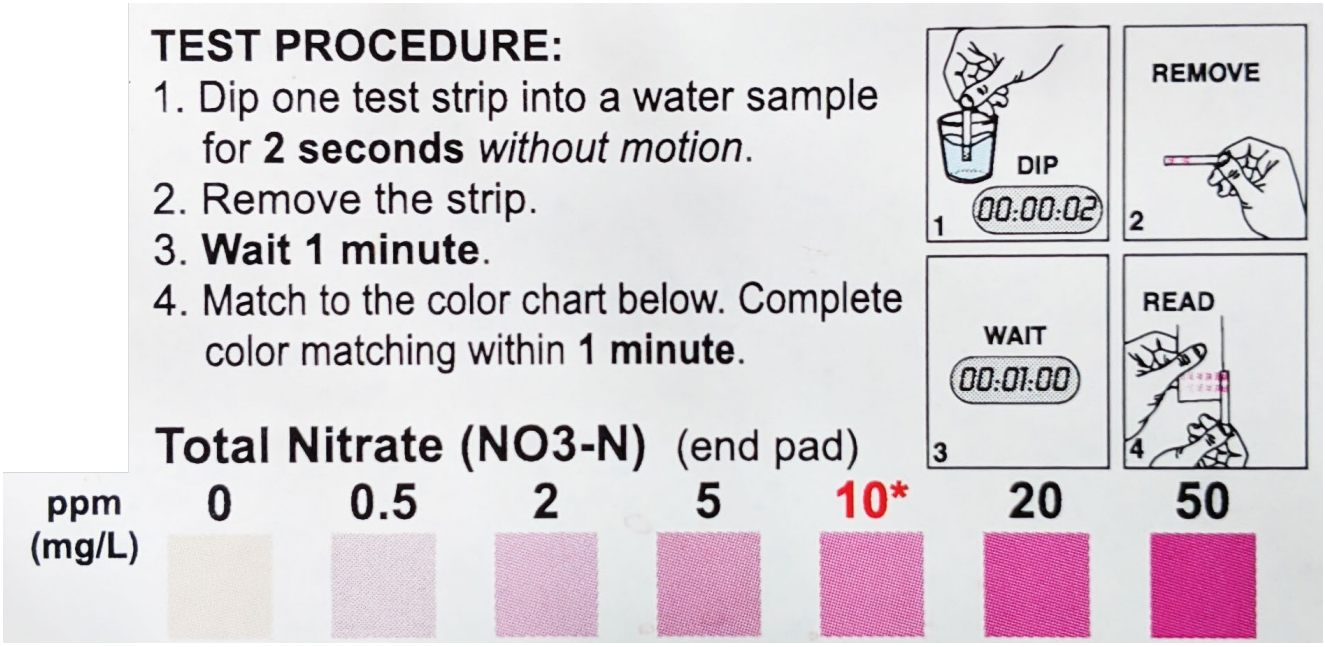
To Test Nitrates using nitrate test strips

Make sure all team members record data

8. Dip a strip into the sample water for **1 second**.
9. **DO NOT SHAKE**. Hold test strip pad side up for **30 seconds**.
10. Compare the color of the sample to the nitrate color chart.

Make sure you test NITRATE not NITRITE.



11. **Record** your results in parts per million (ppm).
12. Once your test is complete, **clean up**. Leave the test area neat and ready for the next group.

Materials: sample water, nitrate test strips

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TEMPERATURE

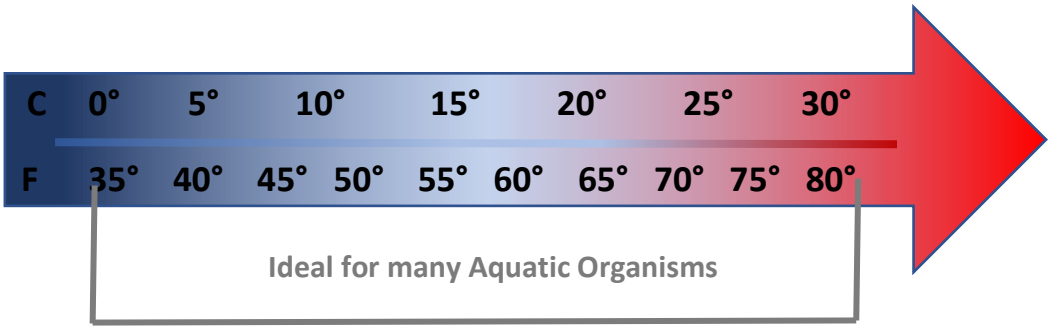
The temperature of the water affects how much oxygen can stay in the water. The higher the temperature, the less oxygen found in the water.

Most aquatic organisms need **a range of 0-32 ˚C (32 - 89.6˚F)**.

Different organisms need different temperature ranges.

Temperature	Species That Thrive
Greater than 20 C (Warm water)	**Much plant life**, **bass**, bluegill, carp, catfish, leeches, caddisfly
Middle Range 12-20 C	**Some plant life**, **trout**, stonefly, mayfly, caddisfly, water beetles
Low Range 12 C (cold water)	**Trout**, stonefly, mayflies, caddisfly

When water of a different temperature enters a body of water, it can cause unnatural changes in the temperature of the water (thermal pollution).



Causes of Increased Temperature

- Industries & power plants: water is used to cool hot machinery. The **hot water is dumped** into waterways.
- **Stormwater** running off hot surfaces like pavement.
- Trees shade and cool waterways. Cutting trees exposes water to the **sun's heat**.
- Increased turbidity (cloudiness) **Sediment** in water absorbs sunlight, increasing temperature.

How to Reduce Thermal Pollution

- Hot industrial water can be allowed to cool before returning to waterways.
- Stormwater can collect in **retention ponds** instead of storm drains.
- Leave trees and vegetation on water banks (**riparian buffer**) keeps the water cool.
- R**educe erosion** and decrease sediment. All of the above help do so.

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To test Temperature using a thermometer:

Make sure all team members record data

1. Look at the face of your thermometer. Make sure you can easily **read the numbers.**
2. Find "0", notice that the thermometer is in Celsius and is missing the tens place for every number that ends in five…like this:
   -20 -5 -10 -5 0 5 10 5 20 5 20 5 30 5 40
3. Place the thermometer in your sample.
4. Wait for 30 seconds to a minute
5. Read the temperature with the thermometer still in the water. **Be careful with the 5s!**
6. **Record** the data on your data sheet.
7. Remove the temperature probe from the water and place back on the table/mat.

Materials: analog field safety thermometer, water sample

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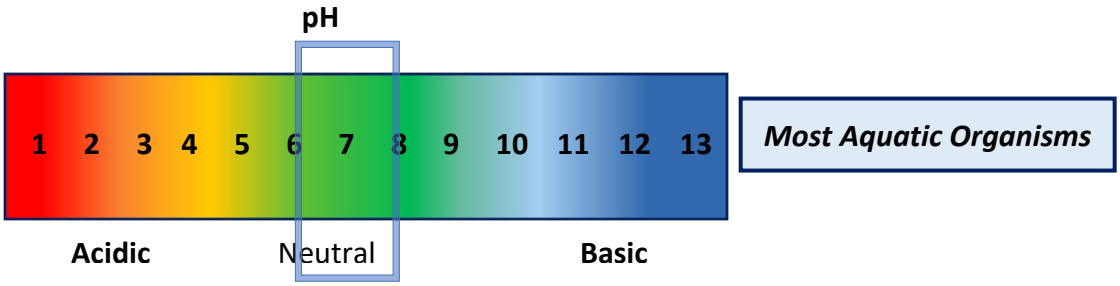
pH

- **Acids** have a **pH < 7**. Examples: vinegar, lemon juice, and battery acid.
- **Bases** have a **pH > 7**. Examples: soap, bleach, and other cleaning solutions.
- **Pure water** has a **pH = 7** and is considered neutral.
- **Normal rainfall** has a **pH about 5.6**, acid rain is **below pH of 5**.

- Organisms absorb nutrients better in water with a pH close to neutral.
- Heavy metals tend to be more toxic in water at a lower pH (more acidic).
- Water with pH values at the far end of the ranges can damage living tissue.

The pH of the water changes throughout the day as the amount of oxygen and carbon dioxide in the water changes. Therefore, scientists look for a pH range to determine water's health.



Most freshwater aquatic organisms live within a pH range of 6.5-8.5. If the pH falls above or below this or changes rapidly, these organisms will struggle to survive.

Causes Decrease in pH (acidification)

- Polluted runoff from coal mines
- Respiration and decomposition
- Industrial pollutants cause acid rain
- Evergreen needles

Causes Increase in pH (basification)

- Polluted runoff from coal mines
- Photosynthesis by algae and plants
- Chemical weathering of limestone
- Wastewater that contains detergents

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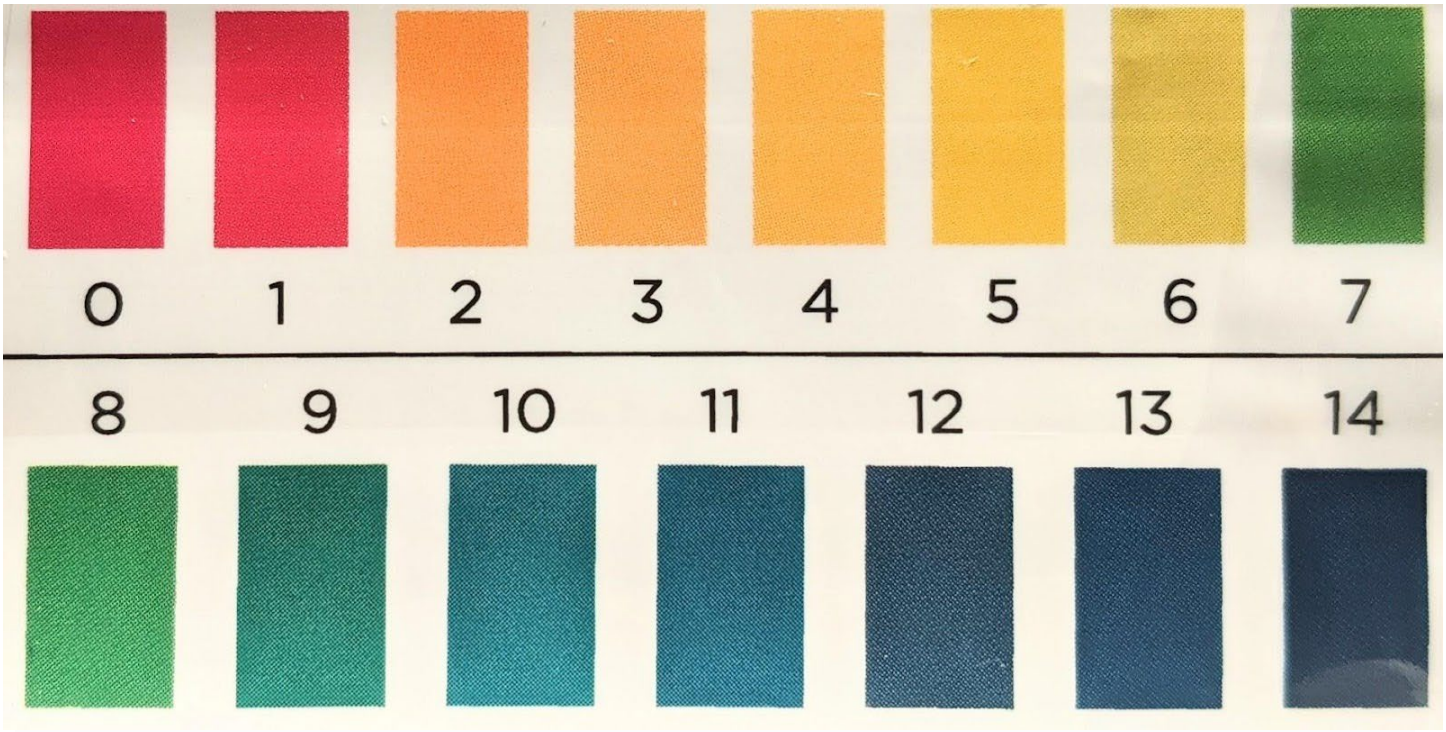
How To Test pH

Make sure all team members record data



1. Dip the strip into the water for one second.
2. Immediately compare the color of the strip to the chart provided with the strips.
3. Record your data.

Materials: Sample water in a bucket, pH test strip, datasheet

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TURBIDITY

Turbidity measures how clear or cloudy the water is. The cloudiness of the water is **caused by sediments in the water or algae growth**.

Aquatic plants use light to make their food. The clearer the water, the more light they can get. During photosynthesis plants **add dissolved oxygen** to the water.

Cloudy water absorbs more of the sun's heat energy, heating the water. Clear water reflects the heat water and stays cooler. **Cold water holds more dissolved oxygen.**

High turbidity (extremely cloudy water) resulted in the loss of nearly 90% of the aquatic plants in the Chesapeake Bay, reduced dissolved oxygen, thus creating huge dead zones with no living organisms.

A healthy aquatic ecosystem requires **less than 10 NTU***. (Drinking water for humans must be <1 NTU.)

Causes Increased Turbidity

- Water running off bare soil causes **erosion** of soil into waterways.
- Construction, mining, plowing, etc. can cause **sedimentation** in water.
- Increased nutrients can cause **growth of algae** suspended in water.
- Storms and other fast increases of water can cause **flooding**. This digs up sediment from the base of the waterway.

How to Reduce Turbidity

- **Grow plants** over bare soil, especially on the banks of waterways.
- "Best Management Practices" make sure professionals have a plan to **prevent erosion**.
- **Reduce nutrient runoff.**
- Use retention ponds and other tools to **slow down runoff** from paved surfaces.

*nephelometric turbidity units

To Test Turbidity using the Turbidity Tube:

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Make sure all team members record data

- Measurements should not be done in direct sunlight. Put yourself between the sun and the tube to **shade it**.
- Do not wear sunglasses when reading the tube.

Filling Procedure:

1. All team members look into the tube at the black and white secchi disk at the bottom of the tube.
2. **Stir or swirl the water** sample bucket to mix up any sediment that has settled on the bottom.
3. Slowly fill the turbidity tube with your sample water.
4. Wait for ALL the bubbles to rise out of the water.

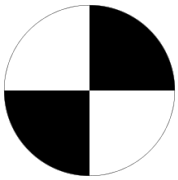

Figure 1: secchi disk

Measuring Procedure: Two people work together

1. *If you can see the viewing disk pattern when the tube is full:* Record the turbidity value as <5 on your datasheet. If you can't…

One person looks into the tube and **shouts when you see the secchi disk** (barely seeing it counts).

Another person **slowly releases water** by loosening the clamp on the tube until the other person shouts.

2. The rest of the team looks for the secchi disk. If 2 can see it, then…
3. **Measure the depth** of water in centimeters (on the side of the tube).
4. **Convert centimeters to NTUs** using the length to turbidity conversion table.
5. **Record your data** and pour the sample water **back** into the bucket.

Materials: Sample water in a bucket, turbidity tube, length to turbidity conversion table, datasheet

Length-to-Turbidity Conversion

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Centimeters	NTU
85.4	5
53.4	10
50.9	11
48.3	12
45.8	13
43.3	14
40.7	15
38.2	17
35.6	19
33.1	21
25.5	30
20.4	40
17.9	50
11.5	100
8.9	150
7.3	200
6.7	240

Read the height of the water in the turbidity tube in centimeters. Find the closest value in the centimeter column, and then move right along the row to find the NTU (Nephelometric Turbidity Units[1]) value. You may need to estimate.

DISSOLVED OXYGEN (O_2)

[1] Turbidity is measured in NTU: Nephelometric Turbidity Units. The instrument used for measuring it is called nephelometer, which measures the intensity of light scattered at 90 degrees as a beam of light passes through a water sample.

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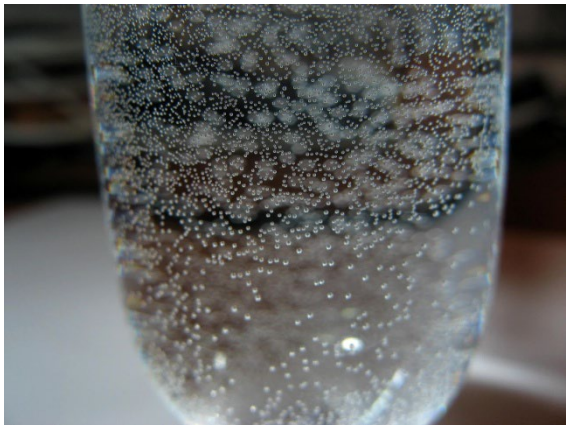


You can't tell by looking at water that there is oxygen (O_2) in it. The oxygen dissolved in lakes, rivers, and oceans is crucial for the organisms and creatures living in it. Just like you, aquatic organisms need oxygen to live.

Dissolved Oxygen INCREASES when:

- Algae and aquatic plants deliver O_2 to water through **photosynthesis**.
- **Water moves** over rocks adds oxygen from the air to the water.
- **The water is Cold** (like tree-shaded streams). Cold water holds more O_2.

Dissolved Oxygen DECREASES when:

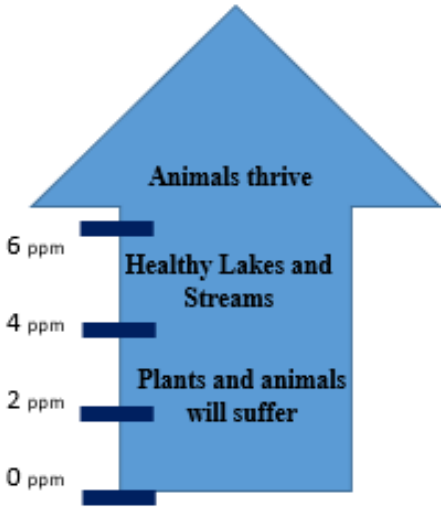
- Too much phosphate or nitrate causes algae growth. **Algae uses up O_2** during respiration at night and has a very short life span.
- **Dead organisms decompose** because decomposer organisms use up O_2.
- **It is a cloudy day.** Photosynthesis slows down.
- The water is warmer (like un-shaded streams). Warm Water holds less O_2.

Healthy lakes and streams have at **least 5 mg/L (or PPM*) of dissolved oxygen**.

Once the level drops below 5 mg/L, the plants and animals start to suffer.

Below 4 mg/L (or PPM), the water quality is considered poor.

*parts per million



To test for Dissolved Oxygen using the test tabs

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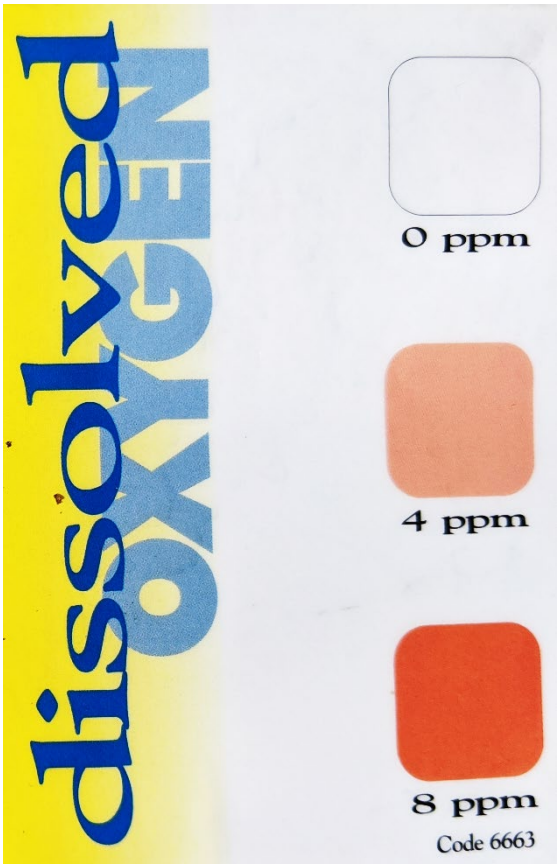
Make sure all team members record data

1. Fill a small test tube to **overflowing** with sample water.
2. Add **two Dissolved Oxygen TesTabs** to the test tube.
3. Cap the tube. Be sure **no air bubbles** are in the sample.
4. Gently invert (turn over back and forth) **until the tablet has completely dissolved**.
5. Wait 5 minutes.
6. **Compare** the color of the sample to the dissolved oxygen chart (below) and record your results on your datasheet.
7. Clean up:
    a. Pour the contaminated water into the **waste water** container.
    b. Use the squirt bottle to **rinse** the tube.
    c. Pour the rinse into the waste water container.
    d. Leave the test area as you found it.



Materials: TesTabs (2), test tube, sample water, datasheet
Clean up materials: Squirt bottle, waste water container

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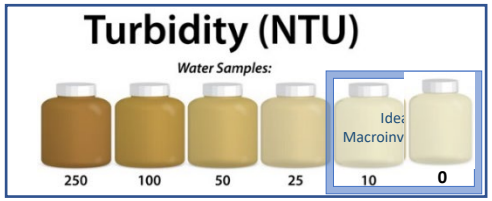
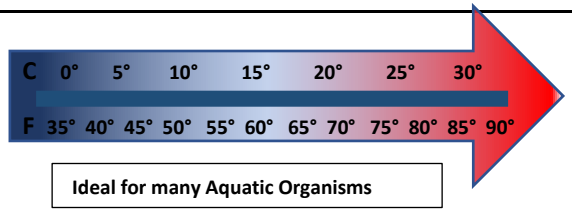
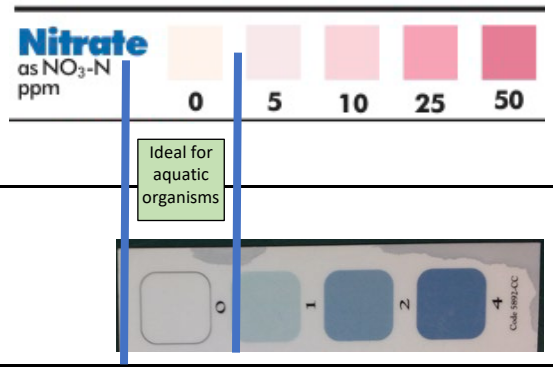
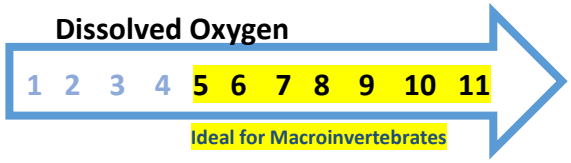
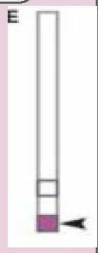
Test	Image of Unpolluted Range	Unpolluted Range	My Results		Healthy? Explain why.
			3 tests	Mean	
Turbidity			1 _____ 2 _____ 3 _____		
Temperature			1 _____ 2 _____ 3 _____		
pH			1 _____ 2 _____ 3 _____		
Nitrates			1 _____ 2 _____ 3 _____		
Phosphates			1 _____ 2 _____ 3 _____		
Dissolved Oxygen			1 _____ 2 _____ 3 _____		

Nitrate Test
Materials - nitrate test strip & timer

1. Set timer for 1 minute (use in step 3)
2. Dip test strip into sample for 2 seconds*
3. Start timer for 1 minute
4. Compare to color chart below
5. Record your data

*Say one-Mississippi, two-mississippi to estimate the time



Nitrate: _____ ppm

Temperature Test
Materials - thermometer & timer

1. Set timer for 1 minute (use in step 3)
2. Place thermometer in the water
3. Start timer for 1 minute
4. Read the temperature. Pay attention to how the numbers are organized.
5. Record your data

Temperature:

_____ ° C

Water Chemistry Tests:
The test strips and tabs are taped to each test.

ONLY remove the test strip when you are ready to do the test.

Follow the directions to collect and record your data.

Dissolved Oxygen (DO) Test
Materials - Two DO pills, glass DO jar, & timer

1. Set timer for 5 minutes (use in step 6)
2. Uncap and fill jar **underwater** until completely full.
3. Add two DO pills
4. Put the lid on the jar. Make sure there is no air in the jar
5. Slowly shake the jar until the pills dissolve (about 4 minutes)
6. Wait 5 minutes
7. Compare to the color chart below
8. Record your data

DO:

_____ ppm

Phosphate Test
Materials - one phosphate test pill, Plastic phosphate test tube & timer

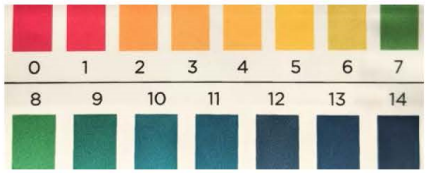
1. Set timer for 5 minutes (use in step 5)
2. Fill the test tube to the 5mL line
3. Add one test pill
4. Cap the tube and mix until the pill has dissolved
5. Wait 5 minutes
6. Compare to the chart below
7. Record your data

Phosphate :

_____ ppm

pHTest
Materials - pH test strip

1. Dip test strip into sample and remove immediately
2. Compare to color chart below
3. Record your data



pH:_____