Nitrates in Our Water

Adapted from: "What's in Our Water?" in Living in Water. National Aquarium in Baltimore, 1997.

Grade Level: intermediate

Duration: 1 class period

Setting: classroom

Summary: Students will test nitrate levels in drinking water sources, bottled water, and local waterways. They will record and map their findings.

Objectives: Students will correctly conduct nitrate tests and determine nitrate levels in various water samples and determine if these levels are safe.

Related Module Resources:

- "Nutrients: Nutrition or Nuisance"
- "A 'Soily' N & P"
- HANDBOOK: nitrates section
- FIELD MANUAL: p.42-51
- Nitrate Info./Fact Sheet
- Phosphorus Info./Fact Sheet
- Nitrogen Cycle Info. Sheet
- Phosphorus Cycle Info. Sheet

Vocabulary: phytoplankton, periphyton, macrophytes, eutrophication, decompose, aerobic, hemoglobin

Materials (Included in Module):

- Sample bottles
- Bailer
- extra nitrate test tubes
- Activity envelope: map pins, construction paper (green, red, and yellow)

Additional Materials (NOT Included in Module):

- samples of water
- map of geographic area sampled
- Hach Nitrate test kit
- Hach PhosphateTest Kit

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

7th Grade:

4.1.7.B Understand the role of the watershed.
- Explain factors that affect water quality and flow through a watershed

4.3.7.B. Describe how human actions affect the health of the environment.
- Identify land use practices and their relation to environmental health.
- Identify residential and industrial sources of pollution and their effects on environmental health.
- Explain the difference between point and nonpoint source pollution.
- Explain how nonpoint source pollution can affect the water supply and air quality.

10th Grade

4.1.10.B. Explain the relationship among landforms, vegetation and the amount and speed of water.
- Explain how vegetation affects storm water runoff.
- Describe factors that affect the quality of groundwater.

4.3.10.A Describe environmental health issues.
- Identify the effects on human health of air, water and soil pollution and the possible economic costs to society

4.3.10.B Explain how multiple variables determine the effects of pollution on environmental health, natural processes and human practices.
- Explain how human practices affect the quality of the water and soil

12th Grade

4.1.12.C Analyze the parameters of a watershed.
- Interpret physical, chemical and biological data as a means of assessing the environmental quality of a watershed
- Apply appropriate techniques in the analysis of a watershed (e.g., water quality, biological diversity, erosion, sedimentation)

4.3.12.A Analyze the complexity of environmental health issues.
- Identify invisible pollutants and explain their effects on human health

BACKGROUND:

Nitrogen and nitrates are important nutrients used by plants and animals to build proteins, DNA, and RNA. Nitrates are found naturally in waterways and plants and animals need only small amounts of nitrates for growth. Nitrate levels are usually very low in groundwater. Nutrients are naturally added to water by the decomposition of organic (once-living) material, such as plant, animal, and waste decay. But humans adding extra nutrients to an ecosystem can disrupt a natural balance or the nitrogen cycle. High nitrate levels are usually a bad situation for a number of reasons.

Nutrient enrichment of a waterway can cause excessive plant growth. This photosynthetic plant growth can include more **phytoplankton** (algae, some protists, and cyanobacteria that are floating or drifting in the water), **periphyton** (algae attached to the bottom of the waterway) and **macrophytes** (larger leafy plants and mosses with roots and usually flowering). All of these are found naturally in waterways, but extra nutrients may cause a certain type of plant to grow out of control, possibly out competing other plants. Phytoplankton in the water column may shade out bottom plants. These changes in the plant composition will also affect aquatic creatures that rely on plants for food or habitat. Perhaps an aquatic insect may starve if the periphyton it eats is shaded out. Aquatic creatures may not like the kinds of algae that dominate from nutrient enrichment. Too many macrophytes may also make it more difficult for open water fish to hunt for food.

Algal blooms (excessive growth of algae) can create a soupy, green stream or pond, which is very visually displeasing. Aquatic weeds can clog waterways making boating and swimming undesirable. To combat this excessive plant growth, chemical herbicides may be added to clear the waterway. There are health concerns about adding unnatural chemicals to water, especially in excessive amounts, and unless the addition of extra nutrients is stopped, the chemicals will have to constantly be used. There are some non-chemical alternatives for removing extra plants, such as harvesting the weeds or bringing in aquatic organisms to eat the extra vegetation, but these methods are not perfect either.

Eutrophication is one of the biggest problems with nutrient enrichment in waterways. **Eutrophication** involves extra nutrients being added to a waterway, sparking excessive plant growth. Algae and other plants eventually die and are **decomposed** (broken down) by **aerobic** (oxygen-using) bacteria and fungi that pull oxygen out of the water. The bacteria thrive on all the new organic material to decompose and deplete more dissolved oxygen. Whereas live plants add oxygen to the water, decomposing plants remove oxygen, causing stress for aquatic life. Some fish or insects are not able to tolerate low oxygen conditions so they will leave or die.

Nitrates can be unnaturally added to a waterway from a number of sources. Farmers need to add fertilizers containing nitrates to fields for crops growth. Sometimes these fertilizers wash into nearby waterways because of precipitation or they seep down into the groundwater supply. Cropland early in the season before plant growth is more prone to soil erosion and fertilizer loss; there is no plant life to keep soil in place or to use the nitrates added to the field. If more nitrates are added than needed by the plants, the excess nitrates are likely to be washed away, possibly entering a waterway. Nitrates can also wash off over-fertilized homeowner lawns and pastures where animal waste has accumulated. The nitrates can also enter the groundwater supply. Any land practices that promote soil erosion (poor tilling practices on farms, removal of streamside vegetation, deforestation, and construction) can also contribute nitrates to a waterway as nutrient rich soil and organic material wash away. Failing sewage systems (municipal and private) also contribute nutrients to waterways. All these sources of nutrients can disrupt the stream ecosystem or contaminate sources of drinking water.

There is a human health risk to people who drink water from surface or groundwater sources with excessive nitrates. It can be especially dangerous for unborn fetuses and young babies. Nitrate can be changed to nitrite (an ion that differs from nitrate by having one fewer oxygen atom) in the stomach when it is consumed. If nitrate reacts to form nitrite, it can bind with **hemoglobin** in the blood. Hemoglobin normally carries oxygen. When bound to nitrite, however, no oxygen can be carried by hemoglobin. As a result, the tissues of the body cannot get enough oxygen to survive. This is called infant methemoglobinemia or "blue baby syndrome." Cattle can have a similar response, and fish can suffer from a similar condition called "brown blood disease."

The Environmental Protection Agency (EPA) has regulations for the amount of nitrate-nitrogen permitted in public drinking water supplies. Nitrogen as nitrate is limited to 10 mg/L. However, because of logistics, the EPA does not control or monitor the amounts present in private wells or bottled water.

OVERVIEW: Students will test nitrate levels in drinking water sources, bottled water, and local waterways. They will record and map their findings. They will also determine if any samples have unsafe nitrate levels.

PROCEDURE:

Teacher Preparation:

1. Assign students to bring in a drinking water or tap water sample from different locations and wells (possibly from students' homes). Either give them clean sample bottles to fill or have them collect samples in *well-rinsed* plastic bottles with no soap residue. You may want to test bottled water (not carbonated!) or compare filtered tap water with unfiltered tap water. Natural water from streams and other water bodies can be tested as well.

2. Secure a corresponding topographic map to match the area where the water samples were found. Portions of topographic maps can be printed from internet websites - try https://ngmdb.usgs.gov/topoview/.

3. If you are going to have the entire class conducting nitrate-nitrogen tests, you will need to ensure that you have as many nitrates kits as possible or have stations of extra test tubes, chemicals, and instructions. They will have to share the black comparator boxes to obtain their final readings. Contact Creek Connections for extra test kits if needed.

Student Experiment:

1. If not already done, students should become familiar with the nitrate-nitrogen testing procedure. Directions for using the kits can be found in the Test Kit Instruction section of the Module Resource Guide.

2. All samples of water should be clearly labeled so that it is easier to record data. Indicate if the samples came from a municipal water supply (and the original source of the water) or from a private well.

3. Students should assemble into groups according to which type of water they would like to test.

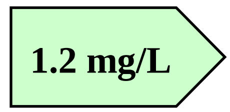
4. Begin testing for nitrate-nitrogen (low range test) in each sample of water using the test kit instructions provided. Two trials should be done to assure accuracy, and those trials should be conducted simultaneously to save time.

5. At one point during the nitrate-nitrogen test, students must wait between 10-20 minutes for their results. During that time, students should make sure they can locate their sample's origin on the map. Be cautious of where municipal water supply samples are mapped.

6. Students should record their group's nitrate-nitrogen results on the data sheet. These results can be combined with the other groups in a table or on the chalkboard or on an overhead.

7. Using green, yellow, and red colored paper, have students cut out a small label, arrow, or flag to write each sample's result on. Use the colors below to correspond with the results.

   - Green paper = 0-3 mg/L
   - Yellow paper = 4-9 mg/L
   - Red paper = 10+ mg/L



8. Affix colored labels to the map, sticking a pin at each location where the water originated. Discuss the results and look for trends. Student may make appropriate graphs to display results as well.

DISCUSSION:

Discuss with the students about what the various nitrate-nitrogen levels mean. If they find high levels of nitrate-nitrogen in the water; is that a good or bad situation? *In the natural environment, only small amounts of nitrates are needed for plants and animals. Human adding extra nutrients to an ecosystem can disrupt a natural balance. Too much nitrates is usually bad for the ecosystem.*

What is the Environmental Protection Agency's water quality standard for nitrate-nitrogen in drinking water supplies? *10 mg/L in domestic water supplies for health reasons.* Did any samples exceed this amount? If so, are there any factors that may have contributed to this level?

Did any sample contain 0 mg/L of nitrate-nitrogen? Does this mean that there really is no nitrate-nitrogen present in the sample? *There probably still is some level of nutrients in the sample (especially surface water), but it might be in such a trace amount that the test kits used do not detect it. More expensive, sophisticated equipment would need to be used.*

What are the health concerns to having too much nitrates in our drinking water supply?
See background section.

Did samples obtained from different locations but from the same municipal supplier have similar results? Should students flag their result of these samples at their home faucet source or from the actual source of the municipal water supply (it may be groundwater wells or surface water)? *From the municipal water supply actual source most likely. All municipal water samples in a community should be similar in water quality assuming that the piping infrastructure is properly functioning.*

What might be causing levels to be higher in some areas compared to others? *Look on the map for possible land uses that would contribute nitrates or soil erosion – ie. crop fields, livestock pastures, sewage treatment facilities, construction sites, logging areas, intense lawn care.*

EVALUATION:

- Successful completion of nitrate-nitrogen testing procedure, correctly completed data sheet, questions, map work, or graphs.
- Does the area you tested have good water quality with regard to nitrates?
- Explain why nitrates are harmful for waterways, aquatic life, and human health.
- What land uses/human practices may contribute to higher nitrate levels in waterways?
- Other discussion questions above.

EXTENSIONS AND MODIFICATIONS:

- Students may want to write letters reporting their findings to environmental agencies, and find out if there are improvements taking place.
- Measure phosphorus concentrations in the samples and compare the values obtained with your nitrate-nitrogen findings. Do the sites with high or low nitrate levels also have corresponding levels of phosphorus?
- Display the map so other students in the school can see it or create an educational display for the public.

NOTES (TEACHERS, PLEASE WRITE ANY COMMENTS ABOUT THIS ACTIVITY BELOW):

Activity Version: November 2021

Data Sheet: Nitrates In Our Water

Student Name________________________________ Date_____________

Other group members____

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Sample Number or Name	**Is it tap water, bottled water, or creek water?**	**Sample's source and location**	**Nitrate-Nitrogen (mg/L)**		
			Trial A	**Trial B**	**Average**