A "Soily" N and P

Adapted from: "Dirty Water" in Living Water. National Aquarium, Baltimore, MD, 1997.

Grade Level: all

Duration: 1-2 class periods

Setting: classroom or laboratory

Summary: Students examine what happens to nitrate and inorganic phosphate levels in water when soil is added.

Objectives: Students will learn the effect that soil erosion has on nutrient levels in a waterway.

Related Module Resources:
- "Nutrients: Nutrition or Nuisance" Activity
- "Nitrates in Our Water" Activ.
- HANDBOOK: Nitrogen & Phosphorus sections
- FIELD MANUAL: p.42-51
- Nitrate Info./Fact Sheet
- Phosphorus Info./Fact Sheet
- Turbidity Info./Fact Sheet
- Nitrogen Cycle Info. Sheet
- Phosphorus Cycle Info. Sheet

Vocabulary: erosion, riparian, eutrophication

Materials (Included in Module):
- 2 cups potting soil (limited amount supplied)
- large plastic cups
- Activity envelope: spoons, 8 small coffee filters

Additional Materials (NOT Included in Module):
- Hach Nitrate test kit
- Hach Orthophosphate test kit
- additional potting soil (not peat)
- 10 ml graduated cylinder (optional)
- distilled water
- access to a refrigerator (optional)

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.
- Explain how the speed of water and vegetation cover relates to erosion.

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)

4.6.12.A Analyze the interdependence of an ecosystem.
- Analyze the relationships among components of an ecosystem

BACKGROUND:

Heavy rainstorms and sudden snowmelts can increase soil and sediment **erosion** into the stream, the process of wearing away the earth's surface. Erosion is more prone to occur on land that has been disturbed by humans (deforested, plowed, and constructed on). Erosion can dump large loads of sediment into nearby water bodies. Moving water moves soil, and the stronger the water flow, the more soil it moves. Along with sediment can come other pollutants, such as bacteria, nutrients, and toxic chemicals. These substances can be attached to the sediment and get carried along with it.

In watershed disturbed by people, improper land use practices can increase soil erosion, increasing sediment load faster than water ecosystems can adjust. Removing **riparian** (streamside) vegetation for farming, construction, and timbering can increase erosion because plant roots are no longer holding the soil in place. Riparian zones also slow the flow of storm runoff before it enters a stream, and actually trap some of the soil that the storm water was

Carrying. Maintaining a healthy riparian buffer zone along a waterway's edge can effectively prevent soil erosion and help trap sediments.

Agricultural practices can further contribute to high turbidity when poor tilling methods are used. Late spring is a sensitive period because fields have been plowed and seeded, but crops have not yet emerged or are too small to provide much resistance to heavy rains and runoff. A heavy rain on an open field can carry away a valuable soil resource and wash it into the stream, especially if the riparian zone vegetation is no longer intact. Tilling methods such as terracing and contour farming help to slow the flow of water across the fields during heavy rains and prevent erosion.

Soil in waterways causes numerous problems. It can disrupt the amount of light that penetrates the water for plants to use. Suspended sediments reduce visibility for aquatic life, clog gills, and cause difficulties for filter feeding organisms. Soil that settles to the bottom impacts bottom dwelling insects, covers and smothers fish and insect eggs. Sediments in the water also make it more difficult for drinking water authorities to clean the water.

One of the other main consequences of soil erosion entering waterways involves the dissolved substances (toxins, minerals, and nutrients) that may wash in with the sediments. Nutrients such as nitrates and phosphates dissolve into the water when they mix. Unlike soil particles, these chemicals cannot be seen, but they can be measured. These nutrients affect the plants and animals that live in water. Nitrates are essential for plants to build proteins, which then can be passed along to plant eating animals to convert to their own proteins. Nitrates are naturally added to waterways by the decomposition of organic material, such as plant and animal decay or waste decay. Chemical fertilizers or manure spreading can add nitrates to farm fields or lawns, but may wash into a waterway if applied in excess.

Phosphorus is a fundamental element for growth and metabolic reactions of plants and animals. It is also a major component of nucleic acids and cell membranes. Phosphorus is found in two forms, organic and inorganic phosphates. Organic phosphates are derived from living plants and animals. Inorganic phosphates, also known as orthophosphates naturally occur in rocks and soil, and can be dissolved in water. In waterways, inorganic phosphates are used by plants and algae and are usually the limiting nutrient for plant growth. Plants absorb the phosphates through their roots, and algae absorb them through their cell walls. Animals obtain the phosphates by eating the plants.

Nutrient enrichment to 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). Algal blooms (excessive growth) can create a soupy green stream. Aquatic weeds can clog waterways making boating and swimming difficult. Most importantly, these plants do not live forever. Eventually they die and are decomposed by bacteria, a process that pulls oxygen out of the water. This process of nutrient enrichment induced

plant growth decomposing and removing oxygen is called **eutrophication**. Lower oxygen levels can stress fish and aquatic insects, possibly even causing pollution sensitive creatures to leave or die.

OVERVIEW: Students examine what happens to nitrate and inorganic phosphate levels in water when soil is added. Various amounts of potting soil or fertilizer will be added to water samples and nutrient levels will be measured.

PROCEDURE:

Teacher Preparation:

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

Student Experiment – Part 1 - Day 1

1. Discuss the land use disturbances that may cause soil erosion or fertilizers to wash into a stream.

2. Add potting soil (or soil from near the school or manure) in the following amounts to 4 labeled pint jars, cups, or 500 mL beakers: 2 tbs, ¼ cup, and 1 cup. Leave the fourth jar without soil as the control. How many sets of these you want to make is up to you. You may also want to add a container of *diluted* fish water from an aquarium to help demonstrate how animal waste contributes to nutrient levels.

3. Fill the containers with equal amounts of distilled water or tap water, then stir well with a spoon or stirring rod. The water becomes turbid (cloudy) as the soil particles become suspended.

4. Let the jars set overnight. If possible, keep them in a refrigerator or cool place for the night.

Student Experiment – Part 1 – Day 2

5. The next day, observe what has happened to the soil in the containers. It has settled to the bottom, usually with larger particles on the bottom and smaller particles on top.

6. Carefully pour off some of the water at the top of each container (including the control) into a separate clean, labeled container. Try to keep out all of the sediments. If needed, you can use a coffee filter to catch sediments. You will be using this water to test for nitrate-nitrogen and orthophosphates (inorganic phosphates).

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

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

9. At one point during the nitrate-nitrogen test, students must wait between 10-20 minutes for their results. During that time, students should answer the questions on the data sheet or they could start testing their sample for orthophosphates.

10. Students should record their group's nitrate-nitrogen results on the data sheet.

NOTE: What if there is more nitrate than the test kit can measure? If the vial sample looks like grape juice when you finish the test, get out a 10 ml cylinder. Put 1 ml of sample in the cylinder. Add 9 ml of distilled water to make a total of 10 ml. Mix. Pour the appropriate amount back into a clean sample vial. Repeat the nitrate test. Record the result and multiply by 10. For example, if it now reads 8 then the original was 80 mg/L. If it is still off scale, repeat the 1 to 9 dilution on 1 ml of the original dilution. Now you have diluted it twice so you multiply the result by 10 twice or 100. This gives you the nitrate in mg/L.

11. If not already done so, students should start the orthophosphate test on their sample (use the low range test instructions). However, if at any point, the sample's color because darker than the darkest shade of blue on the color comparator wheel, you will need to do the mid-range instructions.

12. Students should record their group's orthophosphate data on the data sheet.

13. Average the data the class obtained and record it on the data sheet.

DISCUSSION:

Discuss the results with the students.
What are the short-term consequences of soil erosion? *See background section.*

Would animals and plants be affected by sediment in the water*? Plants would have light blocked that they need for photosynthesis. Animals would not be able to see. In addition, they might have their gills clogged.*

Did the soil add nitrate to the water? Phosphorus?

Was there a relationship between how much soil was in the jar and how much nitrate or phosphorus was dissolved in the water? *The more soil that was added, the more nitrate and phosphorus.*

If soil erosion adds too many nutrients to a waterway, make suggestions for reducing the potential for soil erosion. *A variety of erosion prevention methods might be suggested here.*

What effects would be seen in a creek or lake if too much phosphorus was present? *Overgrowth of vegetation or algae, or "dead" lakes where eutrophication has occurred.*

Brainstorm what other chemicals may get into water from erosion. What effects might these chemicals have?

EVALUATION:

- State the relationship between soil erosion and nitrates or phosphates in water.
- What are the consequences of high nutrient levels in waterways?
- Appropriate graphs of their results.
- Discussion questions above.

EXTENSIONS AND MODIFICATIONS:

- Graph the relationship between amount of soil and nitrate level measured. Use group average values.

- Analyze the labels of plant fertilizers to discover what some plant nutrients are. Students should find compounds containing nitrogen, phosphate and potassium, three primary plant nutrients. Many brands have a number of other chemicals as well. Test different brands for nitrate.

- Explain that there are other sources of nitrogen, such as animal waste. Then, test the effects of different amounts of cow manure on nitrogen levels of water. Cow manure can be purchased or obtained in most rural areas. Use precautions when using manure in the experiment – safety gloves should be used when handling anything that has come in contact with the manure.

- Identify a problem in your area that affects aquatic environments. You might call your local soil conservation district for ideas. Have the students research problems and propose solutions.

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

Activity Version: November 2021

DATA SHEET: A "SOILY" N AND P

Student Name_____ Date_____

Other group members_____

_____

Container	Nitrate-nitrogen (mg/L)				Orthophosphate (inorganic phosphate) (mg/L)			
	Trial A	Trial B	Your Group's Average	Class Average	Trial A	Trial B	Your Group's Average	Class Average
Control								
2 tablespoons soil								
¼ cup soil								
1 cup soil								
Other:								
Other:								
Other:								
Other:								
Other:								

What are four things/actions that may cause soil erosion?

Other than soil erosion, which can carry nutrients with it, what are some other sources of nutrients in our waterways?