Measuring Turbidity with Filters

Adapted from: "It's Sedimentary, My Dear Watson" in Environmental Resource Guide: Nonpoint Source Pollution Prevention Grades 9-12. Tennessee Valley Authority and Air and Waste Management Association, 1993.

Grade Level: advanced

Duration: 2 class periods

Setting: laboratory or classroom

Summary: Students measure turbidity and sediment load of samples from local waterways.

Objectives: Students will perform the techniques necessary to measure sediment load and relate results with turbidity levels and soil erosion conditions.

Related Module Resources:
- "Turbid Vision" Activity
- "A 'Soily' N and P" HANDBOOK: p.99-104
- FIELD MANUAL: p.52-55
- Turbidity Fact/Info. Sheets
- Secchi disk [A-3]
- Turbidity tube [A-4]

Vocabulary: turbidity, suspended solids, inorganic matter, organic matter, fine particulate organic matter, sediment load, suspended load, bedload, sedimentation, total solids, erosion, riparian.

Materials (Included in Module):
- Water collection bottles – one per sample site [A-4]
- Filter paper [B-3-envlp]
- LaMotte turbidity test kit (for intermediate adaptation) [A-3]
- Spoons [B-3-envlp]

Additional Materials (NOT Included in Module):
- Funnels (optional, but very helpful)
- Stirring rods or spoons
- Balances (electronic, if possible)
- Beakers and large watch glasses

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

7th Grade

4.3.7.B. Describe how human actions affect the health of the environment.
- Identify land use practices and their relation to 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.
- Analyze a stream's physical characteristics.
- Explain how vegetation affects storm water runoff.
- Explain how the speed of water and vegetation cover relates to erosion.

4.1.10.C Describe the physical characteristics of a stream and determine the types of organisms found in aquatic environments
- Describe and explain the physical factors that affect a stream and the organisms living there

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)

BACKGROUND:

Turbidity measures the cloudiness of water: the higher the turbidity, the cloudier the water. The numerical measurement is usually given in Jackson Turbidity Units (JTUs) or Nephelometric Turbidity Units (NTU); both are equal.

Suspended solids found in the water column cause turbidity. These are the materials that you *can see* in the water; they are not dissolved. These solids include **inorganic matter** (minerals and elements not composed of living or dead plant or animal matter). Commonly inorganic matter includes sediments like clay (very small) and silt (a little bigger) sized particles that are suspended in water flow. Turbidity also includes **organic matter** (composed of living or once living material, containing carbon). Phytoplankton (algae, some protists, and cyanobacteria), **fine particulate organic matter** (FPOM, small pieces of dead plant and animal parts), and animal waste can contribute to turbidity levels.

Sediments being transports flowing water can be described by the terms **sediment load** or **suspended load** or **bedload**. Sediment load is material mixing and moving with the flowing water, making the water muddy. This fine material will eventually settle in the water because of its density and weight, but it can be lifted again from the bottom into the water column during disturbances (high flow rates, dredging, boating, swimming, and water withdrawals for industry or municipalities). When the motion of the water slows or stops, suspended solids settle out of the water in a process called **sedimentation**. The smallest, lightest soil particles stay suspended in the water the longest, and the largest, heaviest settle first.

Sometimes scientists measure the **total solids** of a waterway. Total solids include suspended solids (the matter in the water that you can see and that can be trapped in a filter) and also dissolved solids (material that you cannot see in the water that would pass through a filter). Total solids can be measured by using meters and electrode sensors or by heating and evaporation methods to find the weight of the total solids per volume of water. Dissolved solids can be measured using a total dissolved solids handheld meter and is recorded in mg/L or parts per million.

There are natural levels of turbidity and suspended solids in all waterways because of normal stream processes occurring, but human disturbance of land can increase turbidity levels. Humans can increase sediment load faster than ecosystems can adjust. Heavy rainstorms and sudden snowmelts can increase soil and sediment **erosion**, the process of wearing away the earth's surface into the stream. 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/or get carried along with it. Increased stream flow can also scour the sides of the waterway's channel; sediment-filled water acts like sandpaper against the edges, scraping away more sediment. Sewage and industrial discharges into a waterway can also increase turbidity.

Some turbidity is from natural soil erosion, a main source of suspended inorganic matter and some organic matter. Geology of a watershed greatly influences turbidity. Regions with steep slopes composed of fine-grained sediments are most prone to erosion and contributing particles to the stream. In Western Pennsylvania, shale is a rock type that easily erodes compared to sandstone and limestone. Human impact on the geology and land in a watershed also attributes to higher turbidity.

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 traps 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. Farmers can further contribute to high turbidity when they choose poor tilling methods (not contour plowing). 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 farmer has not left any riparian zones intact. Timbering practices that remove all vegetation can have similar effects. Construction sites that do not take precautions to put up and maintain sediment fences/barriers also can contribute to soil erosion into streams. Dirt and gravel roads are also another source of sediments and turbidity to streams.

OVERVIEW: Students use turbid water samples to determine sediment load, which involves using filter paper and a weight scale. They will compare sediment load to turbidity levels and compare with land uses and potential pollution sources that were near the water sample's location.

PROCEDURE:

Teacher Preparation

1. Somehow you need to obtain surface water samples with turbid conditions. So you can do one of the following:
    - Take the class to a waterway/s/ during a rain event or immediately after a rain event. Larger waterways will remain turbid up to a few days after a major rain event, but smaller streams clear up quicker. A lot of water should be collected in numerous sample containers.
    - Obtain samples from various waterways during a rain event or after a rain event on your own. Keep track of sample locations.
    - Assign students that live near waterways to *safely* obtain samples after a rain event using a clean plastic bottle. Make sure they know the location from which they obtained the sample.
    - Make turbid water samples by adding clay and other fine particles to water. You may be able to find fine sediments in soil near the school or you may need to scoop fine sediments out of the bottom of a creek.

2. All sample locations or numbers should be clearly labeled on the bottles.

3. *Optional:* 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 www.topozone.com.

Student Experiment

1. Students should record stream and weather information on the data sheet for each of the samples. Depending on who collected the samples, students may need to obtain this information from the teacher or fellow classmates.

2. *Optional:* Locate the sample's location on a topographic map.

3. *Optional:* Use the LaMotte turbidity kit to determine the turbidity level (in JTU's) of the sample. Record this data.

4. Weigh the bottle/container of each sample with the lid on. Make sure that the outside of the bottle is clean and dry. Record this in the Data Table.

5. Weigh the clean filter paper and record this value in the Data Table.

6. Shake the sample.

7. Fold the filter paper so that it will sit in the funnel. (Fold in half and then in half again so that one fourth of the filter paper is showing. Then separate two of your layers and you will be left with a cone shape that will be able to sit in the funnel.) Dampen the filter paper so that it sticks to the funnel (and none of the sample can escape beneath the filter).

8. Slowly pour the sample through the funnel lined with the filter paper into a receiving beaker. Gently stir with a stirring rod or spoon if the water will not pass through the filter paper.

9. Rinse the bottle several times with small amounts of distilled water. Pour the rinse water through the filter each time to make sure all of the sediment is removed from the collection bottle.

10. Remove the filter paper from the funnel and place it dirty-side up on a watch glass, in a clean beaker, or in some other type of container.

11. Set aside the watch glass/beaker with the filter paper and allow the filter paper and sediment to completely air dry. It is best to let the paper dry at least overnight.

12. Wash, dry, recap and weigh the original collection bottle. Record the weight in the data table.

13. To determine the weight of the water sample, subtract the weight of the empty, dry bottle from the weight of the bottle filled with the water sample. Record this result in the Data Table.

14. Once the filter paper and sediment dries, weigh it being sure not to lose any of the sediments from the filter paper. Subtract the weight of the clean filter paper to get the weight of the sediment. Record this in the Data Table.

15. To calculate percent sediment load, divide the weight of the sediment by the weight of the water sample (water only) and multiply by 100. Record this in the Data Table.

16. Compare the appearance of the various samples with their sediment loads. Compare the JTU value obtained with the LaMotte turbidity kit with the sediment loads. Also compare the results of the various samples with the locations from which they were collected.

DISCUSSION:

Discuss the results with students. Rank the samples according to sediment load.

Are the sediment load results what students expected from the initial appearance of the samples or from the JTU values obtained?

Are they what you would expect from your knowledge about the sites that they were taken from? Think about the places where the samples were collected. What are the possible sources of the sediment that was measured? Using the topographic map, what land uses or potential pollution sources may have contributed to the turbidity levels of the samples. *See background information to review land uses that may contribute to turbidity.*

Discuss how a high sediment load might affect stream life. *(see background info)*

Why is the term "sediment load" not exactly correct to describe the stuff in the filter paper? *Because there may have been living organisms such as algae, which will also be caught in the filter.*

EVALUATION:

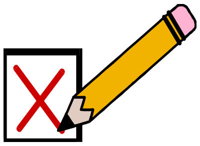
- Discussion questions above
- Correctly filled out data sheet
- Demonstrate or describe how to determine sediment load in a sample.
- Predict relative sediment load by appearance and land use at a location.
- Explain how sediment load may affect stream life.

EXTENSIONS AND MODIFICATIONS:

- Before doing the activity, use the LaMotte turbidity kit to obtain turbidity values in JTU's and make comparisons between JTU values and sediment load.
- Prior to giving them directions on how to determine the sediment load, have students devise the procedure that they will need to do. See if they can figure out the steps they will need to take, what they will need to weigh and when, and how they could sift out the sediments from the water sample.
- Make your own turbid water by mixing water with various amounts of sediment. Make some with high sediment amounts that might be found in poor land use areas, and some with low sediment amounts that might be found in more pristine streams. Use a topographic map that show some land uses to mark fictitious locations from which the samples were obtained and correlate them with turbidity levels your created. See if students can determine from the topographic map what may have contributed to the turbidity of the sample.

NOTES (TEACHERS, PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

Activity Version: January 2002



DATA SHEET: MEASURSING TURBITITY WITH FILTERS

Student Name ________________________________ Date ______________

Section One: Collection Information

Name/s/ of sample collectors____

Sample # or Name ______________________________

Sample Location____

Date sample collected ____________

Weather conditions 48 hours prior to sample collection _________________________

____

Nearby land use or sources of pollution observed ______________________________

____

Section Two: Sample Information

General Appearance of Sample ____

____

Sample # or Name	Turbidity Level (JTU's) *(if measured)*	Weight of sample and bottle	Weight of filter paper	Weight of dry collection bottle only	Weight of filter paper and sediment	Weight of sediment	% Sediment Load