SCIENCE ON A SHOETRING

Testing the waters

Students use Secchi disks to measure water turbidity

BY ANNE FARLEY SCHOEFFLER

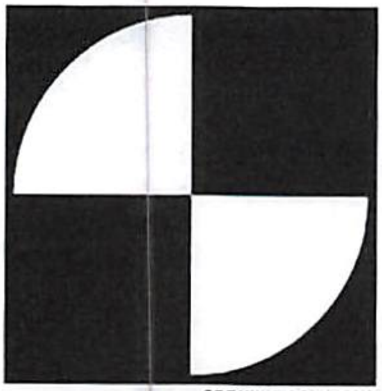
Turbidity testing is a simple activity that can be conducted either indoors or outside. *Turbidity* refers to the cloudiness, caused by suspended solids, in a body of water.

Often the result of human activity (e.g., construction or agriculture), high turbidity is caused by soil erosion, waste discharge, or urban runoff. Sediment-filled water clogs fish gills, smothers fish eggs and aquatic insects, and reduces the available habitat for bottom-dwelling species. Because suspended particles absorb energy from sunlight, turbidity can also increase water temperatures and reduce dissolved oxygen. Furthermore, less sunlight limits the population of photosynthetic organisms.

Measuring turbidity

A Secchi disk (Figure 1) can be used to measure the turbidity of water. Pietro Angelo Secchi first used the disk in 1865 while working as a science adviser for the Pope, who asked him to quantify water quality in the Mediterranean Sea (Hinterthuer 2015). There are modern ways to measure water quality, but his methodology is simple for students to use. The 30 cm (12 in.) disk, mounted on a pole or suspended on a line, is lowered into water until it is no longer visible. Typically on the disk are two black and two white quadrants designed to contrast with the surrounding water. Measurements—in centimeters or inches on the pole or line—indicate the depth of visibility. To figure out the murkiness of the water, the measurements are then converted to a scale of Jackson turbidity units (JTUs) or nephelometer turbidity units (NTUs).

FIGURE 1: Secchi disks



CREATIVE COMMONS

CONTENT AREA

Earth Science

GRADE LEVEL

6–8

BIG IDEA/UNIT

Water quality/stream assessment

ESSENTIAL PRE-EXISTING KNOWLEDGE

Surface water, watershed, sediment

TIME REQUIRED

40–60 minutes

COST

$5–$10

If you only have access to a shallow body of water, or you want to avoid the risks associated with a deep body of water, you can still determine turbidity with a mini-Secchi disk positioned in the base of a transparency tube (Figure 2). Mini-Secchi disks (Figure 3) are useful for measuring the turbidity of an artificial river or lake sample inside the classroom. Mini-Secchi disks can also be used as a precursor activity before taking students outside for a field experience.

Classroom activity

Once students understand the connection between sediment and turbidity, provide them with the investigation sheet (see Online Supplemental Materials), or ask them to create a data table to record observations. In groups of two to four, students test the turbidity of the eight water samples and collect data. *Safety note*: Students must wear splash goggles during the activity. Afterward, students use a graph (see Online Supplemental Materials) to convert their measurements in centimeters to modified NTUs. (*Note*: This investigation uses mini-Secchi disks in a classroom setting, so the graph is scaled to the

Mini-Secchi disk construction

1. Tie a string to a washer.
2. Cover the washer and string with tape. Be sure to orient the string from the center of the washer, so the disk can be lowered horizontally into a water sample.
3. Use a permanent marker to draw the pattern on to the disk.
4. Tie the other end of the mini-Secchi disk to the pencil or stick to retrieve it.

Measuring the turbidity of water samples

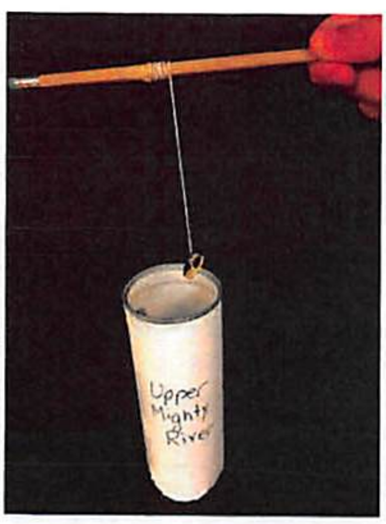
1. Cover each water sample container with paper and label it with the name of a fictional body of water: Chattering Mountain Stream, Idyll Pond, Upper Micro River, Lower Micro River, Holiday Lake, Upper Mighty River, Lower Mighty River, and Agua Bay.
2. Fill each container with water to about 1 cm from the top.
3. Add a few drops of chocolate milk to simulate turbidity. Scale the turbidity to the size of the body of water and its sequence in a watershed system; that is, make the lower rivers more turbid than upper, and make the Mighty River more turbid than the Micro River. Practice this before students arrive in order to gauge what works. For example, 20 drops of milk will create a fairly turbid sample. The chocolate milk should remain suspended throughout the day, although stirring it before each class is also a good idea. Don't tell students what causes the sedimentation!

Materials for mini-Secchi disks

- 2–4 washers for each group of 2–4 students
- 1 roll of masking tape
- 1 ball of string (45 cm per disk)
- 1 permanent marker
- pencils, chopsticks, or narrow dowels (1 per disk)
- 8 water sample containers (e.g., tennis ball tubes or milk cartons)
- Paper to cover water sample containers (1 per container)
- 1 oz. chocolate milk
- 1 eyedropper
- a pair of safety goggles for each student
- rulers (1 per student group)
- investigation sheet with instructions (1 per student) and NTU scale graph (1 per student)

FIGURE 2: Transparency tube

FIGURE 3: Mini-Secchi disk suspended over a water sample



PHOTOS COURTESY OF THE AUTHOR

samples.) Then, students relate the NTUs to the scaled *Q-Value*, a water quality index value that assigns a score to a body of water. The Q-Value is also scaled to the mini-samples. Q-Value and NTUs are standardized values for water-quality tests, allowing scientists to compare water samples collected under different conditions. In these miniature water samples, the NTUs are artificially scaled to small samples, fewer than 20 cm deep.

Analysis

This activity can be carried out as a stand-alone, how-to lesson, or it can be used as part of a larger watershed unit. The names of fictional bodies of water (see sidebar) can be used to demonstrate a sequence in which the Chattering Stream is the headwaters of the system, and the Micro River is a tributary of the Mighty River, as long as the teacher scaled the turbidity in that way. In a watershed, each succeeding river should be more turbid than the one preceding it, whereas the ponds, lakes, and the bay are less turbid due to deeper, slow-moving water that allows sediment to settle. Streams flow into larger rivers that feed into the bay; however, any water system can settle into ponds, lakes, and still water, causing students to wonder how slower, deeper water differs from moving water. Encourage students to make inferences about the sequence and identify the cumulative nature of turbidity and pollutants in a given watershed. Discussion points can include:

- Why are the headwaters of a river cleaner than the lower river?
- Which streams or rivers were more or less turbid? Why might that be?
- Why is the bay cleaner than its tributaries?
- What possible sequence(s) of water bodies seems to show an increase in sediment load over a geographical region?

Via table-top Secchi disks, students get to use a scientific field method to investigate water quality in a watershed system. As long as the teacher is careful to increase the turbidity of downstream rivers, students can observe the cumulative nature of a watershed system. Accumulation refers not only to increasing the volume of water in the water body but also its sediment and pollutant load. For example, the Allegheny and Monongahela rivers combine to form the Ohio River, which flows into the Mississippi River. After collecting water and pollutants from numerous tributaries, the Mississippi ultimately dumps loads of pollutants into the Gulf of Mexico, thereby creating a mas-

Anne Farley Schoeffler (*schoefflera@setoncatholicschool.org*) is a middle school science teacher at Seton Catholic School in Hudson, Ohio.

sive dead zone. Similarly, an increase in fertilizer runoff in Lake Erie watersheds has created toxic algae blooms. The turbidity investigation developed in this article can be used to explore watershed systems, storm water runoff, and pollutant build-up. Students can conclude the activity by mapping this artificial watershed and making inferences about the sequence of water bodies. ●

REFERENCES

Hinterthuer, A. 2015. The Secchi disk celebrates 150 years of clarity. UW-Madison Center for Limnology. *http://limnology.wisc.edu/blog/the-secchi-disk-celebrates-150-years-of-clarity.*

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states.* Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards.*

RESOURCES

Environmental Detectives—*http://familylearningacademy.files.wordpress.com/2012/08/environmental-detectives.pdf*

Mitchell, M.K. and W.B. Stapp. 2008. *Field manual for water quality monitoring.* Dubuque, IA: Kendall/Hunt Publishing Company.

ONLINE SUPPLEMENTAL MATERIALS

Investigation sheet, turbidity graph—*www.nsta.org/scope1702*

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectations listed below.

Standard

MS-ESS2: Earth's Systems
www.nextgenscience.org/dci-arrangement/ms-ess2-earths-systems

Performance Expectation

MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the Sun and the force of gravity.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practices	
Developing and Using Models Analyzing and Interpreting Data	• Students collect data (turbidity measurements) from different parts of an artificial watershed. • Students graph data and relate it to a scale. • Students construct a map to show a watershed.
Disciplinary Core Idea	
ESS2C: The Role of Water in Earth's Surface Processes	• Students trace sediment movement through a watershed. • Students make connections to pollutant loads.
Crosscutting Concept	
Systems and System Models	• Students use artificial water samples to deduce a tributary sequence.