Dynamic Design: The Cleanroom

How Clear is the Water?

TEACHER GUIDE

BACKGROUND INFORMATION


McREL

Once the component parts are washed in the Cleaning Room, the scientists employ two methods to verify if these samples are in fact clean. A binocular microscope is used for visual inspection. Everything that is cleaned is observed to verify that all the particles have been removed. A liquid particle counter is also used to verify clean. The samples are rinsed with water that is placed in a beaker. The beaker is put through a liquid particle counter that indicates the number and size of particles in the rinse water. In this activity students will model the process of verifying clean on a macroscopic level by using a small Secchi (se-key) disk. Students will read about how the Secchi disk is used in environmental science and compare this with the liquid particle counter that is used in the Genesis cleanroom.

The Secchi disk is typically an eight-inch diameter circle. It is a flat metal object that has alternating black and white quadrants. A calibrated line is attached to the Secchi disk in order to measure the maximum depth at which it is visible. The Secchi disk is used to estimate the depth that light can penetrate into water. It is lowered into a body of water by unwinding the cord to which it is attached until the observer loses sight of it. The disk is then raised until it is visible again. The depth of the water where the disk vanishes and reappears is the Secchi disk reading. A more accurate measurement is obtained when this process is done several times and the mean is calculated. A Secchi disk measures water clarity. Water clarity may be affected by three different factors: 1) algae, 2) sediment, and 3) water color. A photometer is used for a more precise measurement of light in aquatic environments.

The Secchi disk and the liquid particle counter are similar in that they both measure the clarity of water. The Secchi disk measures clarity on a macroscopic level and the liquid particle counter measures clarity on a microscopic level. The liquid particle counter can be set to measure eight sizes of particles from 0.5-300 microns. If the particles are from 0.5 to 1.5 microns, the light from the liquid particle counter is scattered. If the particles are greater than ten microns, light is blocked. Whether something needs to be cleaned again depends on the type of item. Contamination Control Lead Scientist Eileen Stansbery states that, “he rinse analysis results show the concentration of particles based on the surface area rinsed. Generally, any particles larger than 10 microns need to be re-cleaned and if there are more than about 100 particles of 1 micron sized need to be removed. “Each component must be assessed differently.”

NATIONAL SCIENCE STANDARDS ADDRESSED

Grades 5-8

Science As Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science
- Properties and changes of properties of matter

Life Science
- Populations and ecosystems

Earth and Space Science
- Structure of the Earth System

Science and Technology
- Abilities of technological design
- Understandings about science and technology

History and Nature of Science
- Science as a human endeavor

History of Science

Grades 9-12

Science As Inquiry

Abilities Necessary to do scientific inquiry

Understandings about scientific inquiry

Physical Science

Structure and properties of matter

Science and Technology

Abilities of technological design

Understandings about science and technology

History and Nature of Science

Science as a human endeavor

Historical Perspectives

(View a full text of the National Science Education Standards.)

MATERIALS

Alternate Strategy Tip

Starch solutions of different dilutions can be used instead of water with food coloring.

For the teacher demonstration and discussion:

- Four 1000 mL beakers with different concentrations of colored salt water. (See Procedure 1 below.)

For each group of three to four students:

- Four 1000 mL or larger graduated cylinders or similar tubes
- Salt
- Green food coloring
- Water
- Card stock or thick paper with transparent tape to protect paper or plastic yogurt container
- Black magic marker
- Scissors
- Washers or weights that have a hole
- String (about 1.5 meters per group)
- Paperclip
- Ruler
- Drawing compass or other way to draw a circle with a diameter of 6 cm.
- Index card
- Student Activity, "How Clear Is The Water?"
- Student Text, "From Macroscopic to Microscopic"
- Student Recording/Data Sheet, "Testing the Waters"
- Interactive Field Trip, "Liquid Particle Counter"

PROCEDURE

1. Before class make enough copies of the student activity and student texts as you will need for your classes. You will also need to prepare three different liquids for the opening discussion. Fill four beakers with 1000 mL of water and five drops of green food coloring. To the first beaker add nothing and label it "A". To the second beaker, add 15 mL of salt and label it "B". To the third beaker, add 60 mL of salt and label it "C". To the fourth beaker, add 120 mL of salt and label it "D".

Teaching Tip

The following are results obtained by the authors given here to provide guidlines for teachers to show some expected results.

Sample	Secchi Average
A	N/A
B	29 cm
C	20 cm
D	14 cm

2. In the discussion that precedes the activity, show students the three beakers of liquid and ask them to describe the contents of the container and then to note any differences in the contents. (Students may suggest that the beakers contain colored liquids. They may note the clarity of the liquids differ from beaker “A” to beaker “B” to beaker “C” to beaker “D”.) Ask students to infer what may cause the liquids to appear different. Ask them for any evidence they have to make the inferences. Students may write their observations on the Student Recording/Data Sheet, “Testing the Waters.”

3. Discuss the differences between the density of the liquid and its clarity. Ask students to consider a way to determine the clarity of each of the three liquids. As a class, what constraints would everyone agree on? (for instance time, cost, and materials needed) Ask individuals to design a method to measure the clarity of the water. After they have had some time to think alone, ask them to share these ideas with the members of the group. During this share time, students should compare the ideas based on the constraints listed by the class. Student groups should then decide which method or combination of methods they would like to design. Groups should make drawings or simple models to communicate their ideas.

4. At this point you may allow the students to implement their proposed design, or complete the Secchi disk activity that is described on the student activity sheet. No matter which you choose, the students should evaluate their design compared with the criteria that they chose. It would also be appropriate for students to suggest improvements on their design or the Secchi design.

5. If you have the students construct the Secchi disk, they should use it to “test the waters.” Either provide the students with about a liter of each of the liquids you made for procedure one or have the students mix up their own.

6. Finally, students should compare the results obtained from the method they completed versus the Secchi disk. Students should list benefits and limitations of each method and suggest improvements to the design. At all time students should use the criteria that they established in procedure three above.

Alternate Strategy Tip

If you choose to have the students mix up the liquids for “testing the waters,” provide the student groups the directions found in this teacher guide procedure 1. If you want to minimize the number of liquids that are mixed, just have the one group of students prepare the liquids. The other groups can use this throughout the day.

7. Students should read the Student Text, "From Macroscopic to Microscopic."

8. Following the reading guide students in a discussion that uses questions similar to the following:

   a) Describe the difference between something that is macroscopic versus something that is microscopic.
   b) Describe some factors that would need to be kept constant if you wanted to get reliable data using a Secchi disk. (Responses may vary. Some factors may include: eyesight of the viewer, the time of day the readings are taken, the reflectance of the disc, the color of the water, clay particles or other materials suspended in the water, etc.)
   c) Suppose you have been taking Secchi readings all year and have noticed that during the summer the water is becoming less and less clear. What could be some explanations for this? (Responses may vary. Some causes may be: Increased abundance of free floating algae, erosion of the shoreline or erosion from site development near the lake, recirculation of bottom sediment from motorboat activity, discoloration of the water from wetland runoff and/or plant decomposition, increased turbidity, reduced zooplankton populations.)
   d) In the Mississippi River study mentioned in the student text, why was the first sample taken before any boats were present? (This was the control sample.)
   e) Why do you think that a higher percentage of commercial boats caused a significant increase in the sediment than recreational boats? (Answers may vary, but students may suggest that commercial boats are often larger, and therefore may cause more sediment to be recirculated.)
   f) Describe examples of when water clarity should be measured. (Answers will vary, students may suggest that a water or sewage treatment plant may need to monitor clarity of the water.)

Alternate Strategy Tip

You may want to have the students construct a Secchi disk for measuring the water clarity of a local lake. Below are instructions for the students to construct and use their own Secchi disk.

Take a firm metal disk (an aluminum pie plate would work) about 20.32 cm in diameter and paint it with several coats of white enamel. Divide the face of the disk into four quadrants and paint the alternate sections black. Attach the disk at the center to a rope or chain. Make sure that the disk is centered and will not tip as it is placed into the water. Lower the disk over the side of the boat and mark the depth at which the disk disappears. Sink the disk several more centimeters then raise it, mark the depth at which it reappears. Pull up the disk and measure the two distances. Average the two observations to obtain a single reading.

You may be interested in having your students enter the Great North American Secchi Dip In. Go to http://dipin.kent.edu/ to learn more about this event.

Alternate Strategy Tip

You may want to have students look at graphs constructed by students over several years based on Secchi readings. Go to http://harborex.gcoe.umb.edu/graphingactivities.html and print out the Secchi disk readings from 1995 to present. Ask students to consider the following questions.

1. In what month is Secchi depth greatest? Lowest?
2. What is the highest Secchi depth recorded? The lowest?
3. Compare the graphs from year to year. Are there any differences in patterns of Secchi depth between each year? Where do the differences occur?
4. Why does Secchi depth vary from year to year?

TEACHER RESOURCES

Cole, Gerald A. (1994). Textbook of Limnology. (4th ed.). Prospect Heights: Waveland Press Inc.

Cooke, Dennis, et. al. (1993). Restoration and Management of Lakes and Reservoirs. (2nd ed.). Boca Raton: Lewis Publishers.

Horne, Alexander, and Charles Goldman. (1994). Limnology. (2nd ed.). New York: McGraw-Hill Inc.

Lind, Owen, T. (1979). Handbook of Common Methods in Limnology. St. Louis: C.V. Mosby Co.

Wetzel, Robert, G. (1975). Limnology. Philadelphia: W.B. Saunders Co.

http://dipin.kent.edu/secchi.htm#whatis1
Information about the history and use of the Secchi disk

http://dipin.kent.edu/makedisk.htm
How to make a Secchi disk

http://dipin.kent.edu/
The Kent State University Great North American Secchi Dip-In

http://mlswa.org/secchi.htm
What is a Secchi Disk?

http://harborex.gcoe.umb.edu/graphingactivities.html
Secchi graphs since 1995 from Harbor Explorations and the University of Massachusetts Boston with much more

http://www.spectrex.com/a_effect%20_commercial.htm
The effect of commercial and recreational traffic on the resuspension of sediment in Navigation Pool 9 of the Upper Mississippi River

http://www.ittc.it/secchi/biblioe.html
Biography of Angelo Secchi