Great Lakes Research Center
Michigan Technological University

RTW Ride The Waves with GM

Center for Science & Environmental Outreach
Michigan Tech University

Subject: Science, Social Studies

Grades: 8-12

Duration: 45-minute class period

Materials:

- 6 L flask
- Filtration column filled with sand, anthracite coal, and gravel
- Second column filled with granular activated carbon (GAC)
- Jar test apparatus
- Two B-KER^2 jars
- 500 mL turbid bentonite solution
- 300 mL algae
- Yellow food dye
- NaOH pellets
- Coffee grounds
- 10 mL of 20 mg/L alum
- Dilute bleach solution (1:1000 bleach to water)
- Laser pointer/flashlight
- Hach turbidimeter
- Four vials for turbidimeter
- KimWipes
- Hach chlorine calorimeter and packets
- Small dropper
- Two 1000 mL beakers

Drinking Water Treatment

Lesson Overview

Students will be given a demonstration of four stages of the water treatment process: coagulation, flocculation, filtration, and disinfection. They will learn about major contaminants in drinking water sources. They will also learn about the main purposes and characteristics of each stage of the drinking water treatment process.

Objectives

By the end of the lesson, students should be able to:

- explain coagulation, flocculation, filtration, and disinfection
- identify five major drinking water contaminants

Preparation

- Make sure the treatment apparatus is in working order by testing the stirrers, filtration columns, and checking for any leaks
- After checking for leaks or any other malfunctions, run water through the GAC column

Introduction

Begin by asking the class:

Where does your water come from? (Flint River, Detroit River, etc.)

Usually, your water would come from somewhere like the Flint River or a nearby lake. But today, your water comes from here:

Procedure

At this point, hold up the 6 L flask to the class. This is where you will mix the "influent" water source. Put 1 L of tap water into the flask, then add 300 mL of algae. Next, add 500 mL of bentonite (turbid) solution and mix. Then, add three drops of yellow food dye to the mixture. The dye acts as a simulation of dioxin, an extremely toxic class of chemicals present in industrial waste. Next, add three pellets of sodium hydroxide (NaOH) to the solution. Take care in adding these; adding NaOH to water does release some heat. Make sure to mix up the solution after adding the pellets to help dissolve them. Finally, add a pinch of coffee grounds to the water. This will act as a simulation of fecal contamination. Fill the rest of the 6 L flask up with tap water and mix by covering the top with one hand tightly and tipping the flask upside down two or three times.

As you go through this procedure, make sure to talk to the class and ask questions the whole time, and tell them what each element represents. For example,

Next, we're going to add a bentonite solution to our water. What exactly is bentonite?

Bentonite is a type of clay, and this solution has a high concentration of that clay in it. We're adding this to our water to increase the turbidity, which is a measure of how "clear" the water is. Most lake and stream waters are far too turbid for human consumption. Turbidity is something we'll have to decrease in the drinking water treatment process.

Once the 6 L of influent water is made, take a turbidity reading using the Hach turbidimeter. The influent water should have an NTU reading of around 50, +/- 20. Next, pour 2 L of the water into each B-KER jar. Add 10 mL of 20 mg/L alum coagulant to one jar and use the other as a control to compare. Mix both jars for one minute at 100 rpm, then mix for five minutes at 30 rpm.

As the samples are mixing, use the laser pointer and/or flashlight to show the floc forming in the first jar, and to show the difference between the two jars. Let the students use the pointer/flashlight as well.

OPTIONAL: Take a small sample from each jar using the dropper immediately after the mixing phase. Use these samples and make up slides for each, then look at each one under a microscope. The sample from the first jar (with floc formed) should show large conglomerated particles. The second sample (control) should only show small, individual particles.

After the five-minute slow mix phase, let the particles in each jar settle for 5~10 minutes. During this time, give a short lesson on settling velocity and some of the theory behind it (Stokes' Law). The main idea to drive home here is that the settling velocity depends on the diameter of the particle (the larger the particle, the higher the settling velocity). Therefore, flocculation improves settling because the small particles become aggregated into bigger particles, which settle more quickly.

Once the settling phase is complete, use the flashlight to show how clear the top half of the first jar has become as compared to the control jar. Take another turbidity reading. It should now be around 10-20 NTU.

Next, we will go to the filtration phase. Place a 1 L beaker underneath the outlet of the first filtration column, consisting of sand, anthracite coal, and gravel. **IMPORTANT:** Make sure to backwash this filter before using it. Show and describe this process to the students, as well as its importance in the filtration process. After backwashing, decant water from the top of the first jar into the filtration column. This will filter out much of the remaining particulate matter in the sample. Take another turbidity reading, where it should now be around 5-10 NTU.

After collecting about 500 mL, pour this through the second filtration column, consisting only of granular activated carbon (GAC). **IMPORTANT:** Be sure to rinse the GAC before beginning the experiment. This

will ensure the carbon is active and yield the best results. The GAC will remove the yellow coloration due to the food dye. After this filtration, the water should look clear and have an NTU reading of below 1.0.

Finally, we will enter the disinfection phase. For this step, we will use the Hach chlorine calorimeter to measure how much chlorine is present in the sample. Pour 10 mL of the twice filtered sample into a cylinder, and add two drops of a bleach solution (diluted 1:1000 parts water). Add this to the calorimeter, then add the powder packet. The solution should turn pink. If not, add one more drop, or add drops until it turns pink. Take a reading. The chlorine concentration is required to be above 0.5 mg/L, but no more than 4.0 mg/L. Once this requirement is met, the water is both palatable and potable. Before disinfection, the water was palatable; it looked clear and safe to drink. After disinfection, it also became potable; it was actually safe to drink.