Nanotechnology & Society: Activity 1

Water Clean-up

Dirty Business

I'm Taylor. My friend Gabe and I love the water, but we know that keeping it clean is not always easy. Just upriver in Palmerton, Pennsylvania, sits an old zinc smelting plant that was one of the factories polluting the local rivers and streams. We headed to **The Franklin** in Philadelphia and learned that nanoiron is being used to clean up contaminants and keep our water safe. Because it is so small, nanoiron can seep through the soil and attach to pollutants both in the ground and in the water.

Our question:

Can nanoiron clean up the pollution in soil and prevent it from getting into drinking water?

We met up with a researcher from **Penn State University** who helped us collect some soil samples for testing. We tested for metals like lead, nickel and copper both before and after treatment with nanoiron.

Nano Matters

The field of nanotechnology covers many disciplines of science and engineering. Numerous efforts are focused on providing solutions for some of the world's environmental problems: dirty drinking water, nonrenewable energy sources and pollution. Here, we focus on the use of nanoiron to neutralize heavy metal toxins and prevent them from entering the drinking water supply. Because of its small size, nanoiron has a large amount of exposed surface area available to neutralize many different types of pollutants such as herbicides, pesticides and other industrial waste. Nanoiron can be injected directly into the ground and maneuver through soil, sand, silt and even fractured rock to reach pollutants. This remediation technique is currently being used in sites across the country. The scientist featured in this segment is also doing work in Ghana to see if this technology can be used to help people around the world who struggle daily for clean water.

Icebreaker
Make a model well.

20 minutes

DragonflyTV Skill: Observing

Guide your kids as they

1) Place the toilet paper tube (your well) upright in the center of the empty coffee can.
2) Hold the tube and pour gravel or small rocks around it, about 1"–2" deep. Be careful not to get anything inside the tube.
3) Place a few drops of food coloring on top of the gravel. This represents pollutants present in the soil.
4) Pour sand on top of the gravel about 1"–2" deep. Again, being careful not to get anything inside the tube.
5) Take a cup of water (representing rainwater) and slowly pour the water onto the sand until it just reaches the top. What happens inside the tube?

You'll need:

- empty coffee can
- empty toilet paper tube
- sand
- gravel or aquarium rocks
- food coloring
- cup
- water

Are you a nano-bit curious?

In this segment, the kids investigate one way nanotechnologists are working to clean pollutants in water. When pollutants are present in the ground, they can make their way into the water we drink, just as you saw in the model of a well in this activity. When it rains, the water enters the ground and falls through the pores and cracks in the rocks and dirt until it reaches the groundwater reservoir below. The food coloring represents pollutants in the ground that can be carried into the groundwater and eventually enter water sources such as wells, rivers and streams. Nanoscientists are excited about possibilities such as nanoiron, because it is small enough to fit through the pores in the rocks and dirt to reach the contaminants both in the ground (preventing them from eventually entering the water supply) and in the groundwater itself.

Investigation

Use this water filter to explore remediation techniques.

3 hours

You'll need:

- iodine (from a drugstore)
- water
- spray starch (liquid form—not aerosol—is best)
- rocks
- pebbles
- sand
- dirt
- clear cups
- old soda bottles (20 ounce) with caps
- ring stands or pieces of cardboard
- vitamin C tablets
- lemon juice
- Kool-Aid (clear)
- Popsicle sticks
- white paper

Preparation

Drill a small hole in the cap of each soda bottle. This activity will work best if the holes are the same size.

1) Break into groups. Each group should make 3 groundwater models by taking old soda bottles and cutting off the bottoms.

2) Place the caps on the bottles. Flip the bottles (with cap sides down) and add rocks, gravel, sand and dirt to create your ground. (These items should be added in order. See the image on the page 60.)

3) The bottles need to sit above the clear cups. If you do not have ring stands to suspend them, take a piece of cardboard and cut out a hole so the bottle fits inside without falling through and place this over the cup. (See the illustration on page 60.)

4) In each of the 3 clear cups, add approximately 1/2 cup water plus 20 drops of iodine. Then, add about 6 drops of liquid starch to each cup until the color turns a dark purple (almost black). This represents the pollutants in the groundwater. Place these cups on a sheet of white paper so the reaction will be easier to see.

5) Take 1/2 cup of warm water and add 2 vitamin C tablets. Stir with a Popsicle stick to dissolve. (Note: the tablets do not have to completely dissolve for the reaction to work.)

6) Mix the clear Kool-Aid according to the recipe on the package. (You do not need to add sugar.)

7) To the top of each ground model (bottle) add one of the following: 1/2 cup of liquid vitamin C, 1/2 cup of lemon juice or 1/2 cup Kool-Aid. (It is best to do this sequentially, so you can watch each model separately.)

Continued on next page...

Investigation
Continued

8) Monitor as the drops begin to fall through the ground and reach the "pollutants" in the groundwater. You may want to swirl the cups containing pollutants. There are several ways to check the effectiveness of the reaction (changing from dark blue to clear):

a. Count how many drops it takes for the color change to occur.

b. Start a timer when each liquid is added and mark the time when the pollutants are completely "neutralized" (only accurate if drip rates are equivalent).

c. Weigh each cup prior to the experiment. After the color has changed, remove the cup and weigh it again. Record the difference in weight.

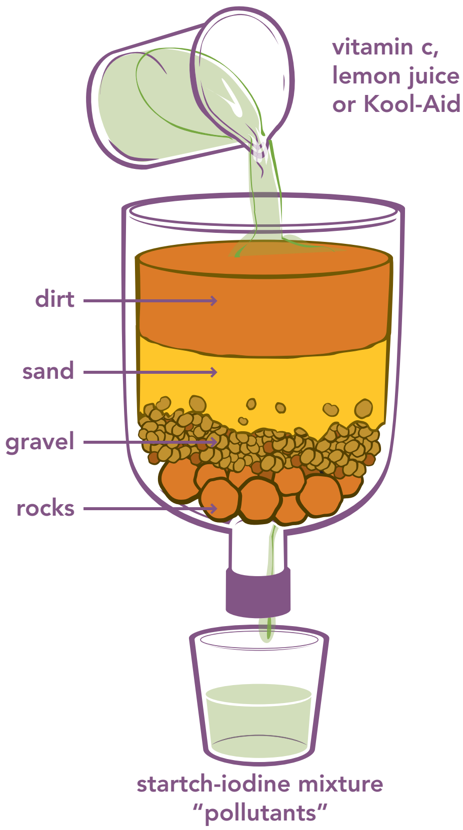
d. Measure the volume of liquid prior to the experiment. After the color has changed, measure the final volume of the liquid in a graduated cylinder. Record the difference in weight.

9) Which solution worked best? Why?

This activity was created in part through the Penn State MRSEC and The Franklin Institute MPS: Internships in Public Science Education program.

DFTV Science Helper

The liquid starch in this experiment is not a requirement and only acts as an indicator. If you add vitamin C to iodine, the color will disappear, but it is hard to see the exact moment of the switch. When starch (a coiled molecule) is mixed with iodine, groups of three iodine atoms squeeze into the spaces within the molecule's coils, changing the color from brown to dark blue. The iodine can still react with the vitamin C, making it easier to determine the end point of the experiment.


vitamin c,
lemon juice
or Kool-Aid
dirt
sand
gravel
rocks
startch-iodine mixture
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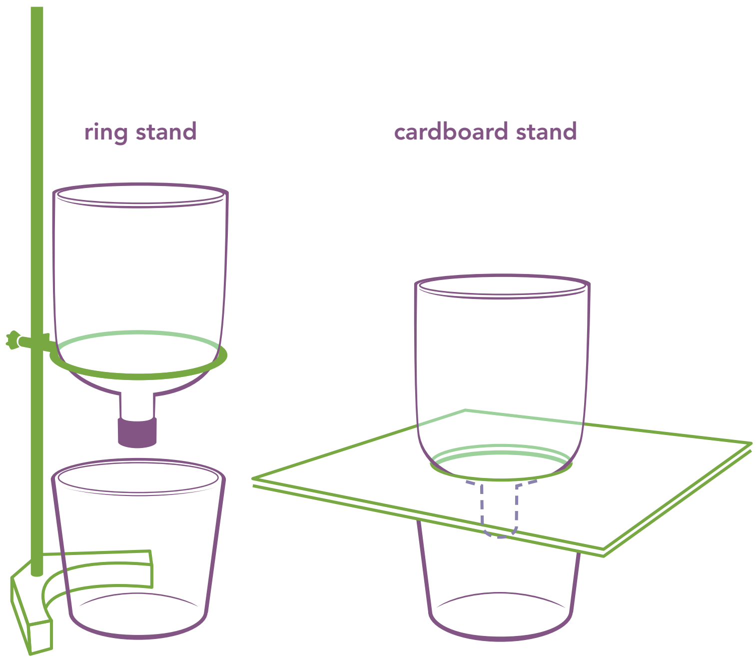

ring stand
cardboard stand

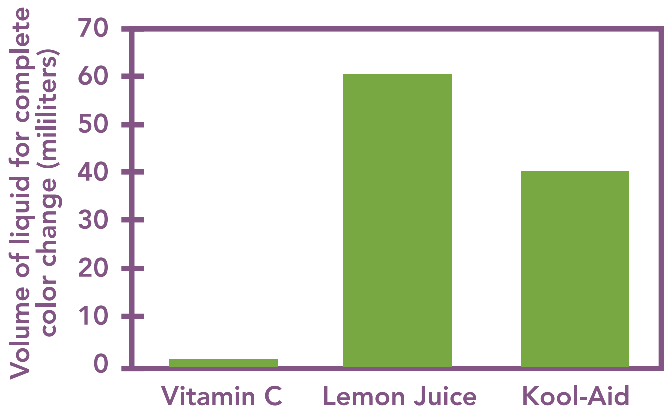
Are you a nano-bit curious?

You conducted a reduction-oxidation (redox) reaction in which vitamin C acted as a reducing agent. Vitamin C (ascorbic acid) gave up electrons to iodine (I_3) and caused it to break up into 3 ions of charged I^-. When this occurs, the iodine (or iodine/starch complex) loses its color (see Science Helper on page 59). Nanoiron is another example of a reducing agent. In the same way, nanoparticles of iron donate electrons to contaminants in the groundwater converting them to nontoxic forms.

DFTV Kids Synthesize

Data and Analysis

From this graph, can you tell which substance is the most powerful reducing agent (i.e., caused the quickest color change)? Which is the weakest?



Keep Exploring!

This activity doubles as a great way to test how much vitamin C is in a substance. Is there any vitamin C in lemon-lime soda? White grape juice? Vitamin water? Sports drinks? Test them to see!