Overview:
Youth make a solution of food coloring with a concentration of one part per million and discuss clean water standards.

**Substances dissolved in water can be present in very tiny amounts that are not visible to the eye. In order for rainwater to be used as potable (drinking) water, contaminants must be reduced to amounts approved by the Environmental Protection Agency, often in parts per million or even parts per billion.**

Materials:

- Permanent marker
- “One in a Million” background information sheet
- 1 clear cup of water (for demonstration purposes)

*For each participant, pair, or group:*

- One 9-ounce, clear cup, filled halfway with water
- One empty, 9-ounce, clear cup
- Six 2-ounce cups or ½ of the bottom portion of a Styrofoam egg carton
- 2 water droppers*
- Bottle of blue or red food coloring
- “What Does One in a Million Look Like?” handout (included)
- “One in a Million” background information handout (included)
- Pencil

*If a “dropper” style of food coloring bottle is used, participants will only need one water dropper each.

Activity Duration:

30 minutes

Preparation:

- Review the background information sheet.
- Gather all materials.
- Cut the bottom portion of an egg carton in half lengthwise (to make a strip of six “cups”) or prepare six 2-ounce cups for each participant, pair, or group.

Activity Steps:

1. Ask participants if they think about the cleanliness of their water when they turn on a faucet at their houses. Get responses. (Explain that city water systems have strict rules that keep water safe.) Ask participants if they have been to rivers or lakes and if they feel the water would be safe to drink right from the source. Get responses. Ask participants if they can always drink
water that looks completely clear. Get responses. Discuss contaminants that are too small to see (background information is included).

2. Explain that many people around the world use rainwater for drinking water. In order for it to be “potable” (safe for drinking), people must filter and disinfect it. Ask what contaminants might get into a rainwater harvesting container? Get responses.

3. Explain that youth are going to participate in an activity that will demonstrate how contaminants are measured. The U.S. Environmental Protection Agency has standards for the amounts of contaminants allowed in drinking water. Many of the contaminants are measured in parts per million. This activity will demonstrate what one part in a million looks like.

4. Distribute to each participant, pair, or group, six cups (or one egg carton strip), one 9-ounce cup filled halfway with water, one empty cup (for cleaning a water dropper), two water droppers (or one if using a “dropper” style food coloring bottle), and the two handouts.

5. Participants place their six cups (or strip of egg carton) in a line in front of them. If desired, they can label their cups 1 through 6 with their pencils. Their 9-ounce cups can be placed nearby.

6. Following the instructions on the “What Does One in a Million Look Like?” handout, participants place 1 drop of food coloring into Cup 1. Using a clean water dropper, participants add 9 drops of water to the cup. Ask youth, “How many colored drops did you add to the cup? How many drops are in the cup all together?”

7. Instruct participants to collect 1 drop of the mixture from Cup 1 and place it in Cup 2. Using a clean water dropper, youth add 9 drops of water to Cup 2. (Youth may need to rinse their droppers with tap water and squirt the excess into the empty cup.)

8. Participants will repeat the procedure, using 1 drop from the previous cup until all 6 cups are filled.

9. When participants have completed making their solutions, have them observe the colors of the solutions in the different cups. Ask, “What happened to the color of the water in the different samples?” “In which sample does the color seem to disappear?” “Do you think that Cup 6 contains no food coloring?” Get responses.

10. Participants look at the fractions represented in the “What Does One in a Million Look Like?” handout. Have youth note that the concentration in Cup 6 is one part in one million. Each of the cups has a solution that is 10 times more diluted than the solution in the preceding cup. Ask, “Is there another way that we could make a mixture that has one part in 1 million?” (One way is to add 1 drop of food coloring to 999,999 drops of water! Another would be to add one drop of food coloring to a fill bathtub of water—this would be an approximation.)

11. Hold up one of the cups of tap water. Ask, “What about this water? Could it also have tiny amounts of other things in it? What might those tiny things be?” (Possible answers could include minerals, microorganisms, or chemicals.) Ask if all the things that cannot be seen in water are harmful? Get responses. Help youth understand that almost no water, except in a laboratory, is completely pure. There are minerals that can be very healthy in water. On the other hand, point out that some pollutants can be harmful to human beings in very tiny amounts, often measurable in parts per million or parts per billion (for example, heavy metals like lead and...
mercury, pesticides and some industrial chemicals). Mention that certain city, county, state and federal agencies test drinking water for potentially harmful chemicals. Ask youth why testing might be important?

Source:

Activity adapted from My World: Water Teacher’s Guide
Activity: “What is a One Part in a Million Solution?
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http://www.k8science.org/resources/files/Water_7_OnePPM.pdf

For more information, contact:
Center for Educational Outreach
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, TX  77030
(713) 798-8200
(713) 798-8244
www.BioEdOnline.org
www.CCITonline.org/ceo
What Does One in a Million Look Like?

1. Add one drop of food coloring to Cup 1. Now add nine drops of water to Cup 1.

How many drops of food coloring does Cup 1 have? ________________________

How many drops does Cup 1 have in all? ________________________

The amount of food coloring in Cup 1 is: 1 drop in 10.

2. Take one drop from Cup 1 and put it in Cup 2. Add nine drops of water.

How many drops does Cup 2 have in all? ________________________

The amount of food coloring in Cup 2 is: 1 drop in 100.

3. Continue adding 1 drop from the previous cup and 9 drops of water to each new cup until all six cups have 10 drops each. Then finish the chart. (Hint: look for a pattern in the amount of food coloring that ends up in each cup.)

<table>
<thead>
<tr>
<th>Cup Number</th>
<th>Total Drops in Cup</th>
<th>Amount of Coloring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>1 drop in 10</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>1 drop in 100</td>
</tr>
<tr>
<td>3</td>
<td>__________</td>
<td>1 drop in 1,000</td>
</tr>
<tr>
<td>4</td>
<td>__________</td>
<td>1 drop in ________</td>
</tr>
<tr>
<td>5</td>
<td>__________</td>
<td>1 drop in ________</td>
</tr>
<tr>
<td>6</td>
<td>__________</td>
<td>1 drop in ________</td>
</tr>
</tbody>
</table>
One in a Million” Background Information Sheet

All the water on Earth ultimately forms part of a single, immense system. Oceans, wetlands, streams, lakes, and underground water supplies are all linked through drainage patterns in watersheds and through the endless cycling of water on our planet. Because water sources are connected, pollutants travel from one part of the system to another and, eventually, can affect very distant ecosystems and populations (human and wildlife).

Water can look clean and clear and still contain many different types of chemical and biological materials. Most of these are harmless—especially in tiny quantities. In fact, even water that comes from crystal clear wilderness sources, or water that is sold in stores as “natural” spring water, contains dissolved minerals and other substances.

Some types of water contaminants are harmful to human health even in very small amounts. The concentration of many of these substances usually is measured in parts per million or even in parts per billion. The Environmental Protection Agency (EPA) sets limits for the amounts of potentially harmful chemicals in drinking water sources.

Water pollutants can be divided into several major categories, all of which impact human health and well-being.

Nutrients. These can come from chemical sources (fertilizers or detergents) or can be biological in origin (sewage or manure). Nutrients usually are carried into water sources by rainwater. They cause excessive growth of water plants and algae, which can clog navigable waterways and use up oxygen (needed by other organisms such as fish) when they decompose. These changes cause the decline of important lakes and wetlands, and can affect drinking water quality as well. In groundwater, fertilizers can make water from wells unsafe to drink.

Soil and sand from plowed fields, construction sites, logging sites, urban lands and areas being strip-mined. These sediments make lakes, wetlands and streams more shallow, affecting the use of waterways for transportation and decreasing the quality of habitats for wildlife. Washed-off soil also can be a source of excess nutrients.

Disease-causing organisms. Bacteria, viruses and single-celled parasites can enter water supplies from inadequately treated sewage, storm water drainage, septic systems, livestock pens, and boats that dump human wastes. These organisms cause diseases such as dysentery and typhoid, as well as skin and respiratory illnesses.

Metals (such as mercury and lead) and toxic chemicals (such as those found in pesticides, herbicides, cleaning solvents, plastics and petroleum derivatives). These substances can be poisonous to humans as well as to wildlife. Metals and many manufactured chemicals persist in the environment. They build up in the bodies of fish and other animals, and can find their way into groundwater, making it unsafe to drink.

Heat. Warm water discharged from power plants (where water is used for cooling) can drastically alter aquatic ecosystems. Changes in water temperature can affect the quantity of oxygen in the water and can make some organisms more susceptible to disease, parasites and toxic chemicals.

Most sources of water pollution are spread over large areas. Water from rain and irrigation collects pollutants as it washes over the land or sinks into the soil. This type of pollution, which is not attributable to a single location, generally is referred to as non-point source pollution. It is much more difficult to monitor and to control than point source pollution—which is pollution that is discharged at a single place (such as from a factory, a single water treatment plant or a chemical spill).