How much is dissolved?

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http://interactive2.usgs.gov/learningweb/teachers/globalchange_change_lesson.htm

KEY CONCEPT

Concentrations of materials dissolved in water are given in various units including percent (parts per hundred), ppm (parts per million), and ppb (parts per billion). The activity models the first two and extends to ppb.

SKILLS: ***Estimating, Counting, Calculating, Observing, Recording, Investigating, Modeling***

TIME: ***30 minutes***

AUDIENCE: ***Teachers and students, grades 5 – 8, but can be adapted for younger students and used for older ones.***

OBJECTIVE

To model the quantity of a million, then apply that concept to the concentrations of materials dissolved in water.

SAFETY

No special precautions.

Background for teachers

CONTENT FOCUS

The quantity of one million is encountered daily, but it is difficult to get a good understanding of how large that is. In this activity, each group of students counts out 100 particles, and then the quantity of one million is estimated through successive multiples of ten. Examples of a million include populations, acres of farm land or areas of countries, miles distant to the sun, and years since dinosaurs roamed the earth.

The term "parts per million" is routinely encountered in discussions of pollution. Drinking water standards include that fluoride should be found in concentrations not exceeding 2 parts per million, but that lead concentrations not exceed 0.015 parts per million (or, 15 parts per billion).

Relation to the Environment

Materials in the environment are mixed with other materials. So, it is important to know the amount of specific materials in relation to others. These relative amounts are often expressed as a fraction. In turn, that fraction is commonly expressed as percent or parts per hundred. But, if the fraction is still smaller, then parts per million or parts per billion are often used.

The environment includes natural as well as man-made influences. The human influences can be controlled and the natural ones taken into account. So, it is necessary to know concentrations of various materials in a pristine environment (including air and water) as well as additions from human activities.

ADVANCE PREPARATION

Gather the materials together. Paint a few grains of rice green to represent the material that is being measured.

TIPS

- There is a lot of variation in the estimation of the individual quantities which can be magnified so in the end the million grains of rice may not fit into a 5 gallon bucket, so be prepared with another container to hold the overflow.

- The estimation steps provide the opportunity for students to consider variation in sampling, measuring, and results. This is a good opportunity for them to consider significant figures: when one million rice grains are measured out, is that one million one grains or one million one hundred thousand?

The Activity

MATERIALS

- One 50 pound bag of small uniformly-sized grain such as rice, big enough to be counted individually.
- 10 small cups (2-oz bathroom cups are OK)
- 10 paper plates to keep grain in one place
- 2 clear plastic vials to hold 1000 grains
- 2 clear plastic cups (about 8 - 10 ounce)
- 2 clear plastic containers at least one half gallon (a gallon sized plastic milk or juice jug with the top cut off works fine)
- Two large plastic containers such as plastic 5 gallon buckets with covers, for storage and final container. If measurements are done carefully, with a grain no larger than rice, one million should barely fit into a 5-gallon bucket, but it may take two.

PROCEDURE

1. Engage students by discussing using one of various classroom structures: "How much is a million?" Take all examples and ideas for discussion later. Use numbers themselves so the students can propose ways to find out what a million looks like.
2. Divide class into ten groups of approximately equal numbers of members per group. Have each group guess how much space a million grains of rice will take up and record their guesses.
3. Give each group a paper plate and a small paper cup with about ¼ inch of grain in it. Have each group count out exactly 100 grains onto the plate. Assign jobs: counter, "quality control" checker, transporter, etc., depending on the number in each group.
4. Have the students return exactly 100 grains to the paper cup without dropping any.
5. One person takes the 100 grains into a single clear plastic cup while the whole group keeps track of the total number of grains. Time how long it takes to put all 10 groups of 100 into the cup. Students can calculate how long it will take to get a million grains if this process is repeated. Students can discuss ways to get to one million more quickly.
6. A student now carefully levels, marks and labels the 1000 grain line on the outside of the plastic container with a grease pencil or permanent marker. Then, a student from each of the 10 groups comes up and fills the container to the 1000 line and dumps it into another plastic cup while the whole group keeps a careful record of the total number of grains. (10,000 grains should fit into an 8 - 10 ounce cup unless a larger grain size than rice or barley is used.)
7. Students carefully level, mark, and measure the 10,000 grains. One student from each of the 10 groups dumps 10,000 grains into the larger clear container. (100,000 grains)
8. Repeat the marking and labeling, and the final round of filling to the 100,000 line with the 10 groups, dumping into the 5 gallon bucket. (1,000,000 grains)
9. Compare the final volume with guesses made initially.
10. Add a few grains of rice that have previously been painted green (green nail polish) to simulate the few parts per million of a material dissolved in water, for example. Students discuss ways that piece of "green" might be recovered. This can extend into consideration of the properties of particular chemicals that can be used to separate it from other components of the environment.

Extension

1. When the first hundred grains are counted out, pause to consider parts per hundred or percent.
2. Extend the activity to estimate, then calculate the volume that such a model of parts per billion and parts per trillion would take up.
3. Have participants note instances when they have heard or used these units of concentration.
4. Discuss the measurement of concentrations so the participants recognize that any units of measure can be used and that the units cancel out when compared to the whole so that parts per million is unitless.