Parts Per Million

Overview

Water dissolves tiny amounts of some things. For example, water may dissolve a small amount of the copper pipes that carry it through your school. The amount of copper in the water is measured in “parts per million.” A million is such a huge number that we can’t picture what a part in a million might be. Can you taste a few parts per million of something in drinking water? Can you see it? Can it make you sick? In this activity, students get some answers.

Materials

*Materials to be supplied by the teacher or the students are marked with an asterisk.

Materials for the whole class

- 4 dropper bottles of red dye
- 2 column “Million – Millionth” transparency (from black line master below)
- Powers of Ten transparency (from black line master below)
- Chemplate® Wells transparency (from black line master below)

Materials for groups of 2

- 1 Chemplate® with white paper under it and clean water in the large well
- Access to 1 dropper bottle with red dye
- 9-oz cup of rinse water
- *paper towels

Procedure (for the Teacher)

1. Show the 2-column “Million – Millionth” transparency and ask students for concrete examples of a million things. Also, ask for concrete examples of a millionth of something. Write these into the columns. Some examples:
    - A million people would fill 10 stadiums.
    - Work out how high a stack of a million sheets of paper would be: 1 ream (500 sheets) is 2 inches high. 1000 sheets are 4 inches high. A million sheets are 4,000 inches high. 4,000 inches is 333 feet. That’s as high as a 28 story building.
    - One second is a millionth of about 12 days (and a billionth of more than 30 years).
    - One inch is a millionth of about 16 miles.
    - If a singer sells a million copies of her CD, then a single CD is 1 part per million (1 ppm).
2. Discuss which is larger, 1 million or 1 billion? 1 millionth or 1 billionth? (Use the Powers of Ten transparency.)
3. Explain how 10 ml of a 10 % solution by volume of red dye is made. [1 ml of pure red dye and 9 ml of water.] Students typically think that it is 1 ml of red dye

and 10 ml of water. Discuss why it's 9 ml of water and not 10. The red dye supplied in the kit is a 10% solution.

4. Add 6 drops of red dye to well #1 on the Chemplate.® Move a drop of this to well #2. Rinse the pipette in a cup of clean water, and then add 9 drops of clean water from the large well on the Chemplate® to well #2. Stir with the pipette tip.

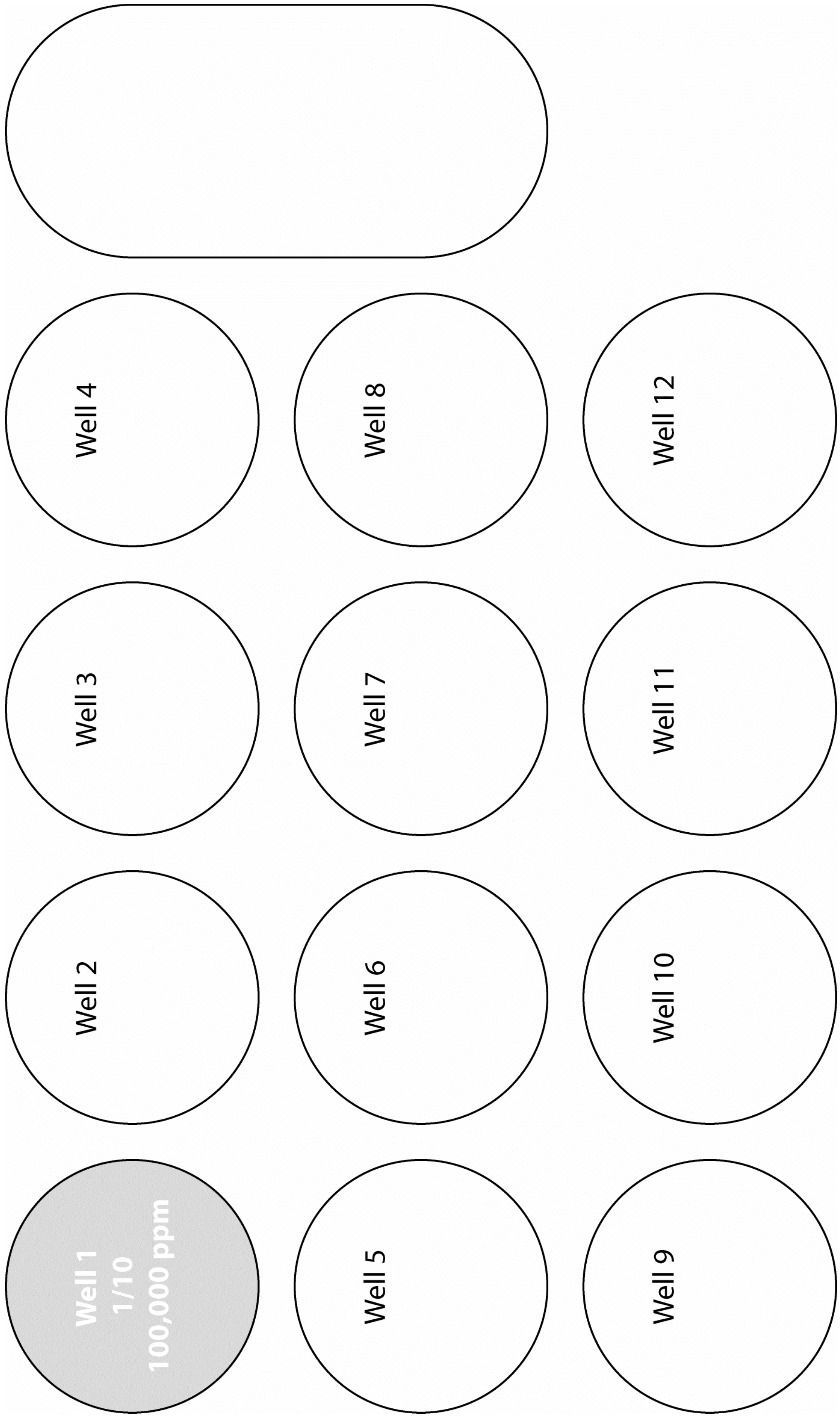
   [Demonstrate this whole procedure for students. Show them how to use the pipette—hold it vertically, avoid air bubbles, and don't let fluid get into the bulb.]

5. Repeat by taking 1 drop from well #2, placing it in well #3, rinsing the pipette, and adding 9 drops of water. Tell students they'll continue this procedure until they can no longer see any color in the water.
6. Tell students to record in their notebooks the concentration in parts per million of red dye in the first 7 wells.
7. After students finish, use the Chemplate® transparency and overhead projector (see Chemplate® black line master) to fill in the concentration of red dye in each well for the whole class. The concentration of red dye in well #1 is 10% (this is the concentration of red dye provided). How many parts per million is a 10% solution? [100,000 ppm] Ask students the concentration of red dye in well #2. How many parts per million? [10,000 ppm] Proceed through all of the wells until you reach the concentration where no red dye is apparent (usually 1 ppm).
8. Discuss **observing results** versus **inferring** from this evidence that red dye is present. *We do not observe any red dye, but we can infer that some red dye must be there*.

One Million	**One Millionth**

NAME	NUMBER	# OF ZEROES	EXPONENT	FRACTION	PARTS PER
1 billion	1,000,000,000	9	10^{9}	1,000,000,000/1	
100 million	100,000,000	8	10^{8}	100,000,000/1	
10 million	10,000,000	7	10^{7}	10,000,000/1	
1 million	1,000,000	6	10^{6}	1,000,000/1	
100 thousand	100,000	5	10^{5}	100,000/1	
10 thousand	10,000	4	10^{4}	10,000/1	
1 thousand	1,000	3	10^{3}	1,000/1	
hundred	100	2	10^{2}	100/1	
ten	10	1	10^{1}	10/1	
one	1	0	10^{0}	1/1	
tenth	0.1	1	10^{-1}	1/10	
hundredth	0.01	2	10^{-2}	1/100	
1 thousandth	0.001	3	10^{-3}	1/1,000	1 ppt
10 thousandth	0.0001	4	10^{-4}	1/10,000	100 ppm
100 thousandth	0.00001	5	10^{-5}	1/100,000	10 ppm
1 millionth	0.000001	6	10^{-6}	1/1,000,000	1 ppm
10 millionth	0.0000001	7	10^{-7}	1/10,000,000	100 ppb
100 millionth	0.00000001	8	10^{-8}	1/100,000,000	10 ppb
1 billionth	0.000000001	9	10^{-9}	1/1,000,000,000	1 ppb

- **Names**: Note how the names decrease 100, 10, 1 and then increase 1, 10, 100.
- **Number**: Nice pattern when you line up the decimal points.
- **# of Zeroes**: By including the 0 in front of the decimal, this value goes from 9 to 0 to 9.
- **Exponent**: For numbers > 1 the exponent is the same as the number of zeroes.
  To fit the pattern, 1 is defined as 10^{0}.
  For numbers < 1, the exponent is defined as the negative of the number of zeroes (counting the 0 in front of the decimal point).
- **Fraction**: Kind of artificial (though legitimate) to write the whole numbers as n/1, but it makes the point that the number of zeroes rule works here as well.
- **Parts per**: ppt = parts per thousand, ppm = parts per million, ppb = parts per billion


Well 1
1/10
100,000 ppm
Well 2
Well 3
Well 4
Well 5
Well 6
Well 7
Well 8
Well 9
Well 10
Well 11
Well 12