Modeling Color Perception of Phytoplankton Densities with Serial Dilutions

Materials: (per group)

- 2 plastic pipettes
- 3 wooden coffee stir sticks or toothpicks
- 1 gridded white paper 8.5" x 11" (attached) and 1 piece of waxed paper, same size and tape OR
    - white plastic paint mixing tray with at least 5 wells.
- colored pencils
- paper towel
- yellow food coloring – the "mystery liquid"
- water – the "mystery solvent"

Note: Food coloring stains! Use with care. Each group needs five drops. You can decide how to do this best for your students.

Set Up for Each Group:
I. Place a sheet of waxed paper over the gridded paper and tape it in place. OR label the wells in your tray from 1 – 5.
II. Place 5 drops of yellow food coloring into well #1 or grid #1. Do not disclose what this "mystery liquid" is.

To Do and Notice:
1) Notice the color of the liquid in #1.
2) Fill in the data on your table:
    - use colored pencils to record the color of the liquid
    - write the fraction in which the numerator tells the number of parts of "mystery liquid", and the denominators tells the number of parts of liquid total
    - express the number as an exponent
    - express the number as a decimal
    - express the number as a per cent
3) Place 4 parts of "mystery solvent" into #2.
4) Add 1 part of "mystery liquid" from #1 to #2, and stir with a coffee stirrer or toothpick.
5) Fill in data table for #2.
6) Place 4 parts of "mystery solvent" into #3.
7) Add 1 part of "mystery liquid" from #2 to #3, and stir with a coffee stirrer or toothpick.
8) Fill in data table for #3.
9) Repeat serial dilution procedure for #4 and #5, adding 4 parts of "mystery solvent" and 1 part of "mystery liquid" solution from well #n-1 to well n.
10) Compare the colors produced.

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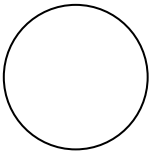
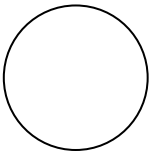
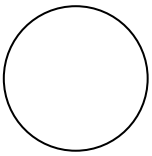
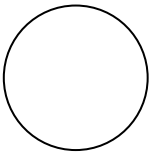
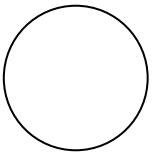
What's Going On?
Comparing the color of the different solutions, you will notice that the most concentrated "mystery liquid" is red, and through the series of dilutions, you will end up with a solution that is light yellow. The "mystery liquid" is yellow food coloring. At low concentrations, the yellow food coloring appears yellow. At high concentrations, the yellow food coloring appears red. This is a good model for algal blooms – at low concentrations, phytoplankton can appear one color, and and at higher concentrations, the color of the water can be dramatically different. Many "red tides" are caused by organisms that are not red.
Mathematically, the color concentration can be described by an exponential function. Since we diluted in parts of 5, each solution is 5 x more concentrated than the one next to it. Therefore, our most dilute solution is 5x5x5x5 less concentrated, or 1/625 as concentrated as the original solution.

More Information:

Dierssen, H. M., Kudela F. M., Ryan, J. P., and Zimmerman, R. C.
Red and Black Tides: Quantitative Analysis of Water-Leaving Radiance and Perceived Color for Phytoplankton, Colored Dissolved Organic Matter, and Suspended Sediments.

in *Limnology and Oceanography*, Vol 51, No. 6 (Nov. 2006).

Concentration of Mystery Liquid to Total and Volume of Liquid

Well or Square #	Color	Fraction	Exponent	Decimal	Per cent
1		1/1	10^0 or 5^0	1.00	100%
2		1/5	$1/5^1$ or 5^{-1}	0.2	20%
3					
4					
5					

Square #1

Square #2

Square #3

Square #4

Square #5

Square #6

Square #7

Square #8

Square #9

Square #10

Square #11

Square #12

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