

# Water Sample Riddle

## Overview

In this activity, students test 4 water samples to determine their contents. Students can use many different methods to arrive at the answer to this logic puzzle.

## Materials

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

### Materials for the whole class

- Stock supplies of water samples numbered 1, 2, 3, and 4.
- 1 permanent marker

### Materials for small groups (groups of 3 are recommended)

- 2 **hardness** test strips
- 2 **pH** test strips
- 2 **chlorine** test strips
- 2 **nitrate/nitrite** test strips (only the nitrate pad is used—see below)
- 1 empty 1-oz cup to collect used test strips
- 1 photocopy of the *Directions for Students*
- 1 *Water Analysis Test Instructions* sheet
- \*paper towels

*If teacher labels and pours the student sample cups:*

- 4 1-oz cups, labeled 1, 2, 3, and 4, containing the respective water samples

*If students label and pour their own sample cups:*

- 1 permanent marker for each group
- 4 1-oz cups
- Access to the four stock supplies of water samples labeled 1, 2, 3, and 4

## Preparation

- Label 4 1-oz. cups per team with a permanent marker. Label them 1, 2, 3, and 4. If students are working in groups of 3, fill each cup about  $\frac{3}{4}$  full of the corresponding sample. (Sufficient solutions are provided for 120 students. If students are working in pairs, fill each cup  $\frac{1}{2}$  full in order to have enough for all classes.)
  - *Alternate setup:* Sample bottles can be set up at stations and students can label and fill their own cups.
- The non-toxic mystery water samples are provided in the kit, but if you need to make more, recipes are as follows. We suggest you wear rubber gloves and safety glasses to make these samples.
  - Water Sample #1: Add 1 ml chlorine bleach to 1 L water.
  - Water Sample #2: Add 2 ml chlorine bleach and 0.1 g washing soda ( $\text{Na}_2\text{CO}_3$ ) to 1 L water.
  - Water Sample #3: Add 1 ml chlorine bleach, 0.26 g Epsom salt ( $\text{MgSO}_4$ ), and 0.26 g Calcium Chloride ( $\text{CaCl}_2$ ) to 1 L water.

- Water Sample #4: Add 0.26 g Epsom salt ( $\text{MgSO}_4$ ), 0.26 g Calcium Chloride ( $\text{CaCl}_2$ ), 0.26 g sodium nitrate fertilizer ( $\text{NaNO}_3$ ), and 0.008 g Calcium Hydroxide ( $\text{Ca(OH)}_2$ ) to 1 L water.
- Set out materials at each work place sufficient for 3 students.
- Make photocopies of the *Directions for Students*. They will use the chart on this sheet to plan and record their strategies.

Key for the Teacher:

- #1: Blooming Botanical Gardens.
- #2: Josiah J. Jones household.
- #3: Carbondale Community Center.
- #4: Feline Fitness Facility.

## Procedure

1. Hand out *Directions for Students*.
2. Tell students that there are many different ways to solve this problem, some longer and some shorter. It has been solved in just 3 or 4 tests, though some luck was involved.
3. Before making any tests, teams must first develop a plan of attack, record their plan in a notebook with a reason for each step, and then raise their hands. **Do not** let teams start testing until they show you a complete plan supported by reasons. Teams may alter their plans during the testing, but at least they will have thought through the problem beforehand.
4. Let students begin testing after you see their plan. Tell them not to taste or drink any of the water samples.

## Directions for Students

At Befuddled Testing Corp., a new worker correctly tested a group of water samples and found the following:

- The sample from the Carbondale Community Center has chlorine, hardness  $\geq 120$  ppm, and pH near neutral (near 7).
- The sample from the Blooming Botanical Gardens water supply has chlorine and pH near neutral (near 7).
- The sample from the Feline Fitness Facility has nitrates, hardness  $\geq 120$  ppm, and pH near neutral (near 7).
- The sample from the Josiah J. Jones residence has chlorine and pH  $\geq 9$ .

Unfortunately, the new worker labeled the samples 1, 2, 3, and 4, but forgot to write down which sample went into each 1-oz cup. This person also kept no records. The new worker was immediately fired. You were hired as the replacement and told to sort out the mess.

Your boss says that you must match the identity of each sample (1-4) to its correct source. You may use a total of 6 tests, but a maximum of two of any particular test. (The tests are very expensive.) For example, if you use 2 chlorine tests, you can't test for chlorine again. Which sample (1-4) is in each 1-oz cup?

Use the table below to help you keep track of your work. Try to plan your strategy before you begin. In your notebook, record your testing sequence and the reasons for each step.

### Notes About the Test Strips

- Each strip can be used only once.
- The **chlorine test** strip may turn the sample slightly yellow or green. This will not affect the results.
- On the **nitrate/nitrite test** strip, ignore the nitrite test pad and read the nitrate test. (See the color comparator sheet for the position of each pad.) The nitrate square may take up to 60 seconds to develop. Read it then because the color may change.
- When wet, **the hardness test** becomes slightly shiny, and may appear positive even at low hardness. The color comparator is accurate.

**Water Sample Riddle Table**

	<b>Sample 1</b>	<b>Sample 2</b>	<b>Sample 3</b>	<b>Sample 4</b>
<b>Nitrates</b>				
<b>Hardness</b>				
<b>Chlorine</b>				
<b>pH</b>				