**Vanderbilt Student Volunteers for Science**

**Bottled Water/Filtered Water – Are they the same?**

**Spring 2013**

**Goal:** To have students investigate the quality of their drinking water. To test water from home for pH, chlorine, hardness, copper and iron, and compare it to other sources of potable water.

**Lesson Outline**

1. **Introduction**

Note that the “tap water” in this lesson is made in the lab, using regular chlorinated tap water. The following chemicals were added to per liter to enhance the pre and post filtering testing:

.03gm Iron sulphate (Fe2(SO4)3

.06gm copper sulphate (CuSO4)

1. **Observing Color Changes.**

Students are given the 3 jars containing spiked tap water, filtered spiked tap water and bottled water. They observe the change in the color of the contaminated water after it has been filtered.

1. **Testing pH**

Introduce pH testing using tablets in 3 prepared samples—acidic, neutral, basic. Students then test their own water samples.

1. **Testing for Chlorine**

VSVS test chlorine levels in two prepared samples. Students then test their own water samples.

**Materials:**

9 test tube racks (1 for VSVS demonstrations)

8 color coded charts

8 sets of 3 water samples in jars (Bottled water, Tap water (spiked), Filtered water)

 (the tap water was altered in the lab so that it contains iron and copper contaminants)

1 plastic bag for pH analysis:

 VSVS demonstration plastic bag:

1 vial distilled water

1. vial water and baking soda (basic)
2. vial water and vinegar (acidic)

3 pH Wide Range pH tablets

3 10 mL test tubes

For students, 8 plastic bags containing:

3 x 8 pH Wide Range pH tablets

3 x 8 10 mL test tubes

1 plastic bag for chlorine analysis:

For VSVS demonstration:

1. 2 oz bottle of concentrated sample (4 drops chlorox bleach to 500 mL tap water
2. 2 oz bottle of diluted sample (tap water)
3. 2 oz bottle of distilled water

3 test tubes

3 Chlorine DPD #4 tablets

For students:

8 plastic bags containing:

3 Chlorine DPD #4 tablets

3 test tubes

Preparation of solutions:

Basic solution - dissolve 1 tsp of baking soda in 1L of distilled water.

Acidic solution - add 5 drops of vinegar to 1L of distilled water.

**I. Introduction**

**What do we expect when we turn on a faucet?**

* We can drink the water and it will not make us sick.
* The water tastes right, looks right and smells right
* Note: nearly 1 billion people – about one in eight – do not have access to safe water, and 3.3 million people die from water-related health problems each year.

**What pollutes water and where do the contaminants come from?**

* Many people think that most of our pollution comes from industries, businesses, sewage treatment plants.
* OVER HALF THE POLLUTION IN OUR WATERWAYS COMES FROM YOU.

Make a list of pollutant sources, dividing them into 2 columns:

**Everyday Activities**

**Industry, businesses**

|  |  |
| --- | --- |
| * Viruses and bacteria you’re your pet’s waste.
* Pesticides and herbicides from your grass, garden, local golf courses, city parks
* Organic chemicals from household detergents, discarded paint, used motor oil, antifreeze,
 | * Viruses and bacteria from farm and wildlife animals, sewage plants.

 * Pesticides and herbicides from farms.
* Organic chemicals from leaking gas

stations, industrial discharge |

When it rains, all these pollutants on Nashville’s roads, parking lots and backyards are washed into the storm drains, which flow into the Cumberland river.

**Where does Nashville’s water come from?**

It comes from the Cumberland River.

It is treated at 2 local waste water plants so that contaminants are removed before it is piped to houses, businesses etc.

1. Screened to remove twigs and large objects.
2. Chemicals are added to coagulate mud and algae.
3. Water is allowed to sit to settle out the mud etc.
4. Water is filtered.
5. The city adds chlorine to water to kill germs (pathogenic organisms) and fluoride ion to aid in dental health.

After contaminants are removed, the pH of water is adjusted to be very close to neutral, pH7.

**Is Nashville’s tap water safe to drink? Is bottled water better for us?**

* Tap water is regulated by the EPA (Environmental Protection Agency). Bottled water is regulated by the FDA (Food and Drug Administration).
* Nashville’s water is tested DAILY for 105 possible contaminants. The results are reported on the Nashville government website and are all below the level required.

Brainstorm the pros and cons of tap water/bottled water with the class:

**Tap Water**

**Pros**

Easy to get

“Free” (1 cent buys you 5 gallons of water)

 Tested daily

Strict regulations (EPA)

**Cons**

 Tastes bad

 Contaminated

 Can make you sick

Public water fountains not easy to find

**Bottled Water**

 Easy to buy

 Tastes good

 Pure

 Healthier for us

Safe source of water when disasters occur

 Bottles pollute environment

Not tested very often

 Untrue advertising

Expensive (about $1 per bottle?)

May come from your local water plant!

Tell the students that they are going to analyze tap water for contaminants sometimes found in houses that have poor plumbing, and compare it with the filtered and bottled water.

**Divide the class into groups of 4.**

Pass out: student data sheets to each student

 the 3 jars containing the different waters to each group

 a color-coded chart per group

**II. Color Observation**

Tell students that: Jar 1 contains bad tap water.

Jar 2 contains the tap water filtered through an inexpensive (Brita) table-top filter.

 Jar 3 contains store-bought bottled water.

Emphasize that the tap water in Jar 1 was treated by the city waste water treatment plant and contained no contaminants when it left the plant. Any contaminants present in it have come from household pipes.

Tell students to look at the color of the water in the 3 jars, and to note that the tap water looks rusty-colored.

Note that the filtered and bottled water are clear.

Students will now test the “tap water”, filtered water and bottled water for pH, chlorine, copper, iron, and hardness.

Tell students to take turns testing the water samples. Each group of 4 students can have 3 testers and 1 recorder. There are 5 different tests to be performed.

**III. Testing pH**

Most liquids can be classified as being an acid or base or neutral. Scientists use the term “pH” to define how acidic or basic a substance is.

Distilled water is neutral and has a pH of 7

Liquids that are acidic have pH’s below 7.

Liquids that are basic have pH’s above 7.

Tell students that the Federal government requires that the pH of drinking water be between 6.5 and 8.5. Nashville city water is treated and pH adjusted to close to pH 7.

Water can become harmful to humans and wildlife if the pH gets too high or too low, and can damage water carrying pipes.

pH < 5 will react with metal pipes and corrode them and contaminate the water.

pH > 8 can cause minerals to be deposited and clog pipes.

1. **Demonstration Using pH Wide Range Tablet**

This demonstration is to be done by VSVS members only. Students will test their own samples after this.

Materials

For VSVS demonstration:

1 vial distilled water

1 vial water and baking soda (basic)

1 vial water and vinegar (acidic)

3 pH Wide Range pH tablets

3 10 mL test tubes

1 test tube rack

For VSVS demonstration using distilled, basic and acidic waters:

1. *Add 10 mL of each prepared sample (distilled, basic and acidic) to a different tube.*
2. *Remove three pH Wide Range tablets from the foil packaging and drop one into each test tube. Place the cap on securely.*
3. *While holding a finger over the cap, invert the tube repeatedly to mix until the tablet has dissolved completely (30 seconds to 1 minute).*
4. *Compare the colors of the samples to the pH chart on the colored poster to interpret pH reading. Record the results on the handout.*
5. *Make sure to show the students how to read the pH from the chart, and what to do if their color does not exactly match a color on the chart.*
6. *Do NOT dump out the water or throw the test tube away.*
7. **pH Activity 1**

Materials

1. sets of water samples – labeled Bottled water, Tap water (spiked), and Filtered water

8 test tube racks

8 sets of 3 pH Wide Range tablets

8 sets of 3 10 mL test tubes

Split the class up into groups of 4 and pass out one test tube rack, test tubes, tablets and water samples to each group.

Tell students to:

* + - 1. Fill test tubes with 10 mL of each water sample.
			2. Remove one pH Wide Range tablet from the foil packaging and drop it into the test tube. Place the cap on securely.
			3. While holding a finger over the cap, invert the tube repeatedly to mix until the tablet has dissolved completely (30 seconds to 1 minute).
			4. Compare the color of the water to the pH chart on the colored poster to interpret pH reading. Record the results on the handout.
			5. Report results to VSVS members to record the results on the board.
			6. Do NOT dump out the water or throw the test tube away.

Ask students: is there any difference in the pH results for the different waters? Are any of these waters hazardous to your health?

**IV. Testing for Chlorine**

After the waste water treatment plant has made the river water drinkable, chlorine is added to kill the invisible live germs that can make us sick.

The U.S. Environmental Protection Agency requires that all water systems that treat drinking water maintain a **residual** level of chlorine throughout their water distribution systems. **This residual chlorine is the reason we can smell it in our tap water.**

A positive test for chlorine in tap water is a good sign – it means that enough chlorine was added to kill germs and it is protected from recontamination as it travels to the consumers’ taps. But too much chlorine makes the water smell and taste bad, and can irritate eyes and skin.

Note - before cities began routinely treating drinking water and disinfecting it with chlorine, thousands perished every year from waterborne scourges such as cholera, typhoid fever, dysentery and hepatitis A.

1. **Chlorine Demonstration**

Materials for VSVS demonstration:

1. vial containing 10 mL of concentrated sample
2. vial containing 10 mL of diluted sample

1 vial containing 10 mL of distilled water

3 test tubes

3 Chlorine DPD #4 tablets

* + - 1. *Add 10 mL of concentrated sample to one 10 mL test tube, 10 mL of diluted sample to a different 10 mL test tube and 10 mL distilled water to a 3rd test tube.*
			2. *Remove 3 Chlorine DPD #4 tablets from the foil packaging and drop one into each respective test tube. Place the cap on securely.*
			3. *While holding a finger over the cap, invert the tube repeatedly to mix until the tablet has dissolved completely (30 seconds to 1 minute).*
			4. *Compare the color of the water to the Chlorine chart on the colored poster to interpret Chlorine reading.*
			5. *Explain that the students will be doing this same test on all three of their own water samples now.*
1. **Chlorine Activity**

Materials For students:

8 plastic bags containing:

2 Chlorine DPD #4 tablets

2 test tubes

Pass out the plastic bags containing Chlorine DPD #4 tablets and test tubes to each group and explain that this test will follow the same procedure as the previous test on pH.

Tell students to:

* + - 1. Fill test tubes with 10 mL of each water sample.
			2. Remove one Chlorine DPD #4 tablet from the foil packaging and drop it into the test tube. Place the cap on securely.
			3. While holding a finger over the cap, invert the tube repeatedly to mix until the tablet has dissolved completely (30 seconds to 1 minute).
			4. Compare the color of the water to the Chlorine chart on the colored poster to interpret Chlorine reading. Additionally compare the color of the water to the samples prepared in the previous activity. Record the results on the handout.
			5. Report results to VSVS members to record the results on the board.

**Ask students: is there any difference in the pH results for the different waters? Are any of these waters hazardous to your health?**

**V. Testing for Iron**

Iron makes up about 5% of the earth’s crust, and rainfall seeping through the soil dissolves it and carries it into almost every kind of natural water supply, including well water.

Ask students if they have ever noticed rusty colored stains in sinks, tubs, toilet tanks….

High concentrations of dissolved iron (as low as 0.3 milligrams per liter ( mg/L) can result in poor tasting, unattractive water that stains both plumbing fixtures and clothing with reddish-brown stains.

Ferric iron deposits within corroded pipes can break free and generate rusty tap water.

Health considerations

At concentrations most commonly found in drinking water, the presence of iron is not considered a health problem. Iron in drinking water can even provide a health benefit. Small concentrations are essential to human health, because iron helps transport oxygen in the blood. The majority of water supplies in the United States provide approximately 5 percent of the daily dietary requirement for iron.

Pass out three Iron LR tablets to each group and explains that this test will follow the same procedure as the previous tests on pH and Chlorine.

1. **Iron Activity**
	* + 1. Fill test tubes with 10 mL of the water samples
			2. Remove an Iron LR tablets from the foil packaging and drop into the test tube. Place the cap on securely.
			3. While holding a finger over the cap, invert the tube repeatedly to mix until the tablet has dissolved completely (30 seconds to 1 minute).
			4. Compare the color of the water to the Iron chart to interpret the reading.
			5. Report results to VSVS members to record the results on the board.

**Ask students: is there any difference in the pH results for the different waters? Are any of these waters hazardous to your health?**

**VI. Testing for Copper**

Pass out three Copper HR tablets to each group and explain that this test will follow the same procedure as the previous tests on pH, Chlorine and Iron.

1. **Copper Activity**

Fill the 10 mL test tubes with the water samples.

Remove one Copper HR tablet from the foil packaging and drop it into the test tube. Place the cap on securely.

While holding a finger over the cap, invert the tube repeatedly to mix until the tablet has dissolved completely (30 seconds to 1 minute).

Compare the color of the water to the Copper chart to interpret Copper reading.

Record the results on the handout and report results to VSVS members to record the results on the board.

**VII. Testing Hardness**

Start with a discussion about hardness of water and how water can be “hard”. Pass out three Hardness T tablets to each group and explain that this test will follow the same procedure as all of the previous tests.

1. **Hardness Activity**

Fill the 10 mL test tube with the water samples.

Remove one Hardness T tablet from the foil packaging and drop it into the test tube. Place the cap on securely.

While holding a finger over the cap, invert the tube repeatedly to mix until the tablet has dissolved completely (30 seconds to 1 minute).

Compare the color of the water to the Hardness chart to interpret Hardness reading.

Record the results on the handout and report results to VSVS members to record the results on the board.

**Conclusions and Random Discussion Points:**

Facts from [www.filterforgood.com/facts](http://www.filterforgood.com/facts):

It takes 2000X more energy to produce a bottle of water than it does to produce the same amount of tap water.

Over 69% of bottled water containers are thrown away, not recycled.

One Brita pitcher filter can replace 300 16.9 oz bottles.

Bottled water is no healthier than good tap water. Sometimes it is just packaged tap water.

If you don’t like the taste of your tap water, use an inexpensive water filter.

**Recyclable is not the same as recycled.**

In the U.S. about 75 percent of plastic bottles are tossed in the landfill. And most of the stuff that’s recycled doesn’t get made into new plastic bottles. Instead, it’s shipped to China where it’s downcycled into secondary plastic materials like fiber filling.

Bottled water produces up to 1.5 million tons of plastic waster per year (= 47 million gallons of oil). Plastic bottles take years to decay. There are eddies of plastic bottles spinning forever in the ocean Great Pacific Ocean Garbage Patch). And they are not recycled into more bottles, but some other plastic product. Make sure bottles from bottled water are ALL recycled (tell EVERYONE to do it).

**What is wrong with drinking bottled water?**

Look at some ads given for bottled water - the labels of the bottled waters do suggest they're special. Some show mountains or polar bears or glaciers. You have to look at the fine print to find out Everest Water is not from Mount Everest. It's from Corpus Christi, Texas. Glacier Clear Water is not from a glacier in Alaska. Its source is tap water from Greeneville, Tenn.

Big-selling Dasani and Aquafina are also just reprocessed tap water from cities around the country. One of Aquafina's sources is the Detroit River!

Advertising and marketing play a big role. Often-deceptive advertising convinces us that bottled water is going to make us healthier, skinnier, smarter, sexier ... even holier.

Fiji water in particular is in many ways emblematic of the problems with bottled water: the high cost of production and transportation, and the advertising that’s required to sell it. It’s such a strange idea that it could possibly be an appropriate thing to do — to bottle water in Fiji and transport it all the way to the U.S. to be bought and sold.

The first line of defense against bad tap water systems isn’t bottled water, it’s making our tap water systems better and making sure the public has confidence in them. We need to tackle all of these issues if we’re really interested in reducing bottled water consumption.

To compare the stringency of federal regulations of bottled water and “big city” tap water, note the following:

* City tap water must be tested 100 or more times a month; bottled water plants must test for coliform bacteria once a week.
* City tap water must meet standards for certain important toxic or cancer-causing chemicals such as phthalate (a chemical that can leach from plastic, including plastic bottles); bottled water is exempt from regulation regarding these chemicals.
* Cities generally must test at least once a quarter for many chemical contaminants; bottled water manufactures generally must test only annually.
* Tap water test results and notices of violations must be reported to state or federal officials; there is no mandatory reporting for bottled water manufacturers.
* City water systems must issue annual “right-to-know” reports telling consumers what is in their water; bottled water manufacturers are not subject to such annual consumer reports. (Source: <http://www.realmama.org/archives-summer-2007/bottled-water.php>)

Finally, if mineral water is consumed through plastic bottles, there is the additional disadvantage the environmental footprint to consider due to the high volume of waste created by the plastic bottles, as well as the pollution created from shipping the bottles, which are heavy when filled with water.