Activity 5

Free and Total Chlorine

Part 1

According to the U.S. Centers for Disease Control and Prevention (Morbidity and Mortality Weekly Report, July 30 1999), one of the "Ten Great (U.S.) Public Health Achievements" of the 20th century was the control of infectious diseases by water treatment and sanitation. In the United States, chlorination is a primary contributor to a 30-year increase in life expectancy since 1900.

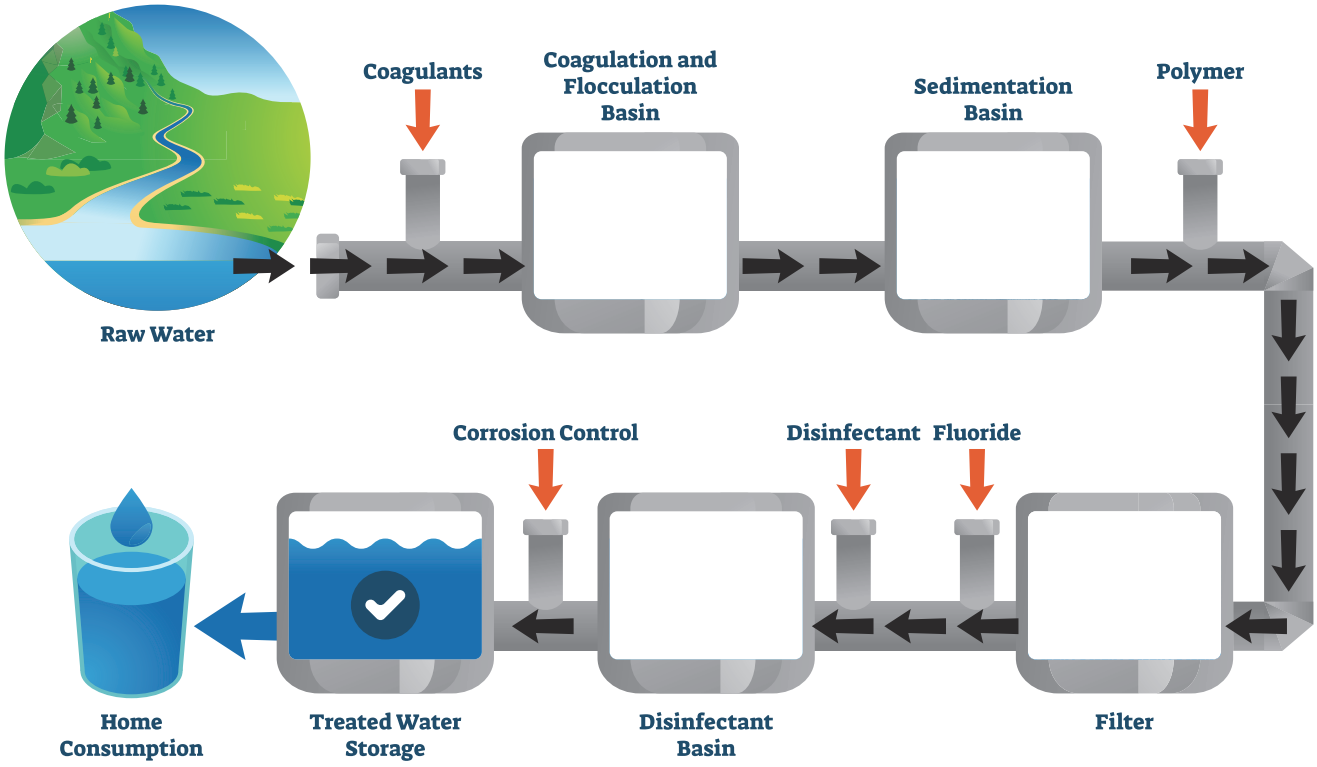
Waterborne diseases continue to kill people in underdeveloped countries with poorly treated water. In 1990 over 3 million children under the age of five died of diarrheal diseases. It is estimated that more than 25,000 children worldwide die every day from waterborne diseases.

Today, over 200 million Americans and Canadians receive chlorine-disinfected drinking water. Chlorine is an effective disinfectant, killing disease-causing microorganisms as well as the nuisance organisms such as mold, slime, algae, and bacteria that typically grow in pipes and storage tanks. As a chemical oxidizer, it destroys substances that may cause unpleasant odors and other problems. Ammonia and organic nitrogen-containing compounds combine with chlorine to form chloramines, which provide a residual disinfectant that helps protect water all the way from the treatment center to the tap.

Water treatment scientists use a variety of substances to chlorinate water. Compressed chlorine gas [Cl2] is widely used in commercial drinking water and wastewater treatment and in swimming pools. Solid calcium hypochlorite [Ca(OCl)2] and sodium hypochlorite [NaOCl, commonly known as liquid bleach] are also used by dairies, food processing plants and restaurants

Water treatment professionals carefully monitor chlorine levels in the system to make sure that levels are high enough for effective sanitation (0.2 ppm free chlorine), but not too high (4.0 ppm). Even up to 10-20 ppm, free chlorine has no detectable taste or smell.

WATER PURIFICATION PLANT



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Part 2

OBJECTIVES:

1. Discuss the concept of dilution.
2. Demonstrate dilution of a contaminant.

VOCABULARY:

Chlorine – a very reactive element that exists in its pure state as chlorine gas (Cl2), a pale greenish-yellow gas that can burn the eyes, throat, lungs and, if handled improperly, can be lethal. It is a very effective disinfectant and oxidizer.

Hypochlorous acid [HOCl] - a weak acid formed by the reaction of chlorine gas (Cl2) in water (H20). Hypochlorous acid dissociates (comes apart) in water to form hydrogen ions (H+) and hypochlorite ions (OCl-). Both hypochlorous acid and hypochlorite ions are effective disinfectants.

Chloramines - NH2Cl (monochloramine), NHCl2 (dichloramine), and NCl3 (trichloramine) that are produced from the reaction of chlorine (Cl2) with ammonia (NH3) in water. Water treatment scientists measure them together as
Combined Chlorine. They do not disinfectant as efficiently as free chlorine. They produce the "chlorine smell" in swimming pools.

Free chlorine – a measure of the hypochlorous acid and hypochlorite ions in a solution

Combined chlorine – a measure of the chlorine tied up in chloramines and other organic nitrogen compounds

Total chlorine – a measure of the free and combined chlorine in a sample

MATERIALS:

School Test Kit Materials:
Free and Total chlorine Test Strips
School Kit Color Chart and Instruction card
Plastic droppers
Data collections sheet

Equipment:
Microscopes
Very Clean 3 - 2L plastic bottles
Wide-mouth Glass Container

Shopping list:
Liquid laundry bleach with 5.25% sodium hypochloriteand NaHOCl
Hay infusion (prepared 7-9 days ahead)
Pond or puddle water
Tap water
Pool or Spa water
Boiled or Bottled Water

SAMPLE PREPARATION:

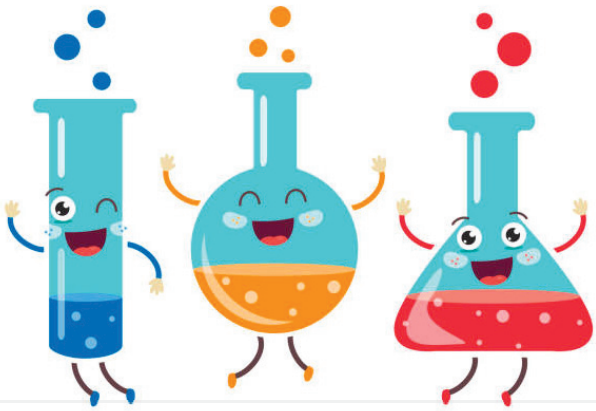
Hay infusion – Boil about 1 quart of water (tap is OK) for two minutes, let cool to room temperature (OR use bottled water). Pour into a thoroughly clean, wide-mouth glass container. Put in a handful of dry hay, grass or straw and set the open container aside in a darkened place at room temperature for 7-9 days.

Bleach solution - 1-drop laundry bleach in 200 ml water

Tap water, pool or spa water, boiled or bottled water – collected in separate clean 2L plastic bottle

PROCEDURE:

1. Place a glass slide on the microscope and use a clean plastic dropper to put a drop of the hay infusion on the slide. Place a cover slip on the water drop. Draw the living protozoans seen on the slide. Record the number of each kind.
2. Do not move the slide. With a different dropper, put a drop of the bleach solution on the slide at the edge of the cover slip. Observe what happens, and record the results on the data sheet.
3. Take 50 ml each of tap water, boiled (or bottled) water, pool or spa water, the hay infusion and the bleach solution. Using the free and total chlorine test strips, measure the free and total chlorine. Enter results on the data table.



Activity 5

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Part 3

ANALYSIS AND APPLICATION

1. Do you think that you saw all the living things in the water? Explain your answer.
2. Use the formula Total chlorine = Free chlorine + combined chlorine (TC = FC + CC) to calculate the chloramine levels in each sample. Enter on the data table.

EXTENSION

1. Explore the environmental and political issues surrounding chlorination of water
   - **a.** Research diseases caused by microorganisms found in the water.
   - **b.** Research the risks associated with water chlorination.
   - **c.** Research alternative methods for disinfecting water.
   - **d.** Debate the relative risks and costs of chlorinating versus not chlorinating water.
2. Visit your local water treatment plant. Find out the source of your water, what contaminants are present, and how they disinfect water. What protection do private well users have to ensure their water is safe? Obtain a copy of the water quality report that the EPA requires commercial water systems to provide to their consumers annually.
3. Where are you on the line? Obtain a map of the distribution system from your local water utility. Pinpoint the location of each student's house on the map. Collect free and total chlorine readings from each location. Compare how the chlorine readings change as water moves through the system from the treatment center to the end of the line.