Chlorine: Friend or Foe?

Grade Level:
All grade levels

Subject Area:
Water quality, Chemistry, Mathematics, Health (human, fish/aquatic animal), Disinfection, Sanitation

Time:
First day: less than one hour
Second day: less than one hour

Student Performance Standards (Sunshine State Standards):
03.01 Employ scientific measurement skills (SC.912.E.7.8; SC.912.L.14.4; MA.912.S.3.1, 2; MA.912.S.4.2; MA.912.S.5.1, 2, 3, 4, 5)

03.02 Demonstrate safe and effective use of common laboratory equipment (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.14.6SC.912.L.16.10; SC.912.L.17.12, 14, 15, 16; MA.912.A.2.1, 2)

03.06 Interpret, analyze, and report data (SC.912.L.16.1; SC.912.N.1.1, 2, 3, 4, 6, 7; SC.912.N.2.2, 5; SC.912.N.3.1; SC.912.N.4.1; MA.912.S.3.1, 2; MA.912.S.4.2; MA.912.S.5.1, 2, 3, 4, 5)

12.01 Recognize and observe safety practices necessary in carrying out aquaculture activities (LA.910.1.6.1, 2, 3, 4, 5;).

13.01 Identify and describe the qualities water should possess for use in aquaculture (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.17.In.a).

13.02 Explain how changes in water affect aquatic life (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.17.2, 3, 7, 10)

Objectives: Students will be able to:

1. Construct values for the amount and types of disinfectants used in tap water.
2. Describe the effects of sanitizing agents on pathogens and aquatic life.
3. Formulate mathematical calculations to aquaculture.

4. Describe the relationships existing between humans, aquaculture, and water.

Abstract:

We are all familiar with the uses of chlorine from making your whites whiter, to disinfecting your sinks and counter-tops, as well as sanitizing your bathroom and keeping your swimming pool crystal clear, but few of us ever think about our drinking water and even fewer still think about the effects of tap water on aquarium or aquacultured fish. The truth is that chlorine is a very effective sanitizing agent against algae, bacteria (Gram-positive and Gram-negative), fungi, as well as some viruses and at times certain spores, but when it comes to fish and other aquatic life even the slightest trace of chlorine will prove fatal. Almost all U.S. public municipal water sources use at least chlorine to disinfectant their water with many adding ammonia as a secondary disinfectant. This forms an even deadlier compound known as chloramines, as both chlorine and ammonia are very toxic to fish.

In this very simple activity students will be able to determine the amount of chlorine present in parts per million (ppm) of their tap water as well as ammonia when chloramines are being used. They will then use one of two methods to remove the chlorine: 1. application of a dechlorinator (instantaneous) and 2. the use of aeration and time to simply "degas" (roughly 24 hrs). Both methods will require the students to take a pre- and post- treatment reading of the amount of chlorine present. This will allow for student teacher interaction regarding the effectiveness of each treatment as well as discussion regarding disinfection, human health, fish and aquatic animal health, sanitation, as well as utilizing mathematical skills (gallons, liters, ppm, grams…).

Interest Approach:

Guide students through a discussion about what they know about chlorine. Lead them around to chlorine in water and the significance of this regarding people and animals.

Student Materials:

First Day

1. Access to municipal water (not well water)
2. (1) Individual water sample each, (1) shared water sample
3. Sodium thiosulfate (enough to neutralize the chlorine in the volume of the container)
4. (1) Stirring implement (i.e. plastic spoon)
5. (3) Chlorine Water Quality Test strips (above steps 2 and 5)
6. (3) Ammonia Water Quality Test Strips (optional)

Second Day

1. (1) Chlorine Water Quality Test Strip (above Step 7)
2. (1) Ammonia Water Quality Test Strip (optional)

Note: Students should have available pencils, paper, calculator

Teacher Materials:

Material	*Store*	*Estimated Cost*
Individual containers (plastic or paper cups)	WalMart, Sam's Publix	$6 and up
Large container (used for 24-hour dechlorination, ~1 gallon or more, clear would allow observation of air lifting and circulating)	WalMart, Publix	$10 and up
Aquarium air pump	WalMart, Aquatic-Eco, PetsMart, PetCo	$10 and up
Air line (should reach from the air pump into the container and down to the bottom)	WalMart, Aquatic-Eco, PetsMart, PetCo	$5 and up
Air stone (for each outlet of the air pump)	WalMart, Aquatic-Eco, PetsMart, PetCo	$3 and up
Chlorine water quality test strips -3/student-first day -1/test-second day	Aquatic-Eco (#H27450, 50 strips per kit)	$10 and up
Ammonia water quality test strips -3/student-first day -1/test-second day	Aquatic-Eco (H#27553)	$16 and up
Sodium thiosulfate (4 pound jar treats ~65,000 gallons @ 1 ppm of chlorine)	Aquatic-Eco (#ST1A)	$18 and up
Zeolite-used to neutralize ammonia (1.5 pound jar treats ~500 gallons @ 1 ppm of ammonia)	Aquatic-Eco (#ZAR12)	$11 and up
AmQuel-neutralizes both chlorine and ammonia	Aquatic-Eco (#AM16P)	$10 and up

(16 ounce bottle treats ~2,400 gallons)

Note: Water treated with AmQuel may interfere with the ammonia test.

Student Instructions:

1. Student will collect a (fresh-with little or no splashing) tap water sample in each of two containers
2. Student will use a Chlorine Water Quality Test Strip to test the amount of chlorine present in both containers (both water samples should be equal at this point)
3. Student will record the amount of chlorine present in parts per million (ppm) (value derived from the color chart supplied with Test Kit)
4. Student will add the proper amount of sodium thiosulfate (S.T.: chlorine neutralizer) to container # 1 and stir until dissolved (approximately 3 – 5 minutes)
5. Student will recheck the amount of chlorine in container # 1 (make sure all the S.T. has dissolved, the reading should be 0.0 ppm, if not recalculate step # 4)
6. Student will add an air line with an air stone to container # 2 allowing vigorous aeration to occur for 24 hours (this air line is connected to an aquarium air pump)
7. After 24 hours the student will check the amount of chlorine in container # 2 (if not 0.0 ppm another 24 hrs can be allowed and then retested)

Note: This activity can be performed by individual students, groups of students, by the teacher or in any combination. A suggestion would be to allow individual students to complete steps 1 through 5 and have the teacher help with a single aeration example (steps 6 and 7), this would limit the need (cost) to only one air pump.

Note: The above chlorine activity can also include an added Ammonia Water Quality Test using similar test strips for ammonia allowing the students to prove or disprove the presence of chloramines as their sanitizing agent.

Teacher Instructions:

Preparations:

1. Take a head count of all the students that will be participating in order to have the proper number of:
   a. individual containers (cups)

b. chlorine test strips (50/kit)
c. ammonia test strips (50/kit)

2. Prepare for the De-Chlorination by Aeration Test:
   a. large container (bucket or clear plastic vase)
   b. aquarium air pump
   c. air line tubing (enough to reach from the bottom of the large container over to the air pump)
   d. sodium thiosulfate (chlorine neutralizer)
3. The teacher should be ready to familiarize the students about the different uses of chlorine in our every day lives and then correlate them to the pros and cons of chlorine in aquaculture.

Activity:

Whether the teacher chooses to have the students work individually or in groups, the teacher should make sure to have all the needed components available to complete the activity. This should also include the sample water as many classrooms do not have a tap water source in them. Once all of the students have acquired their water sample, the teacher should help the students follow the above student instructions. Even though the testing method is very simple (dipping a strip into the water) a color change will appear. The teacher should keep in mind that these changes can vary slightly as well as each students' ability to read that color. If needed the teacher should help the students compare the color of their strips with that of the supplied color chart. The teacher should be aware of the fact that the aquarium air pump needs to be plugged into an electrical outlet, not only for it's location but also as a safety hazard.

Post work/Clean-up:

The cleanup for this activity is very simple. The teacher simply needs to pour all of the water samples either down the drain or apply this water to the lawn or simply use it to water some plants. The cups along with the large container can be dried, stacked and stored until the next use as well as the aquarium pump, air line, air stone and test strips.

Anticipated Results:

Sanitizing Agent: CHLORINE

1. First day
   a. all first day samples should show some level of chlorine present
   b. all first day samples should NOT show any levels of ammonia
   c. after the application of the chlorine neutralizer (sodium thiosulfate) the water samples should show NO measurable amount of chlorine present
   d. all the water samples should continue to show NO levels of ammonia present
2. Second day

a. after 24 hours of vigorous aeration the large container sample should show a greatly reduced amount of chlorine present if not zero

Sanitizing Agent: CHLORAMINE

1. First day
   a. all first day samples should show some level of chlorine
   b. all first day samples should show some level of ammonia
   c. after the application of the chlorine neutralizer (sodium thiosulfate) the water samples should show NO measurable amount of chlorine present
   d. all the water samples should continue to show measurable levels of ammonia
2. Second day
   a. after 24 hours of vigorous aeration the large container sample should show a reduced amount of chlorine present probably not zero

   NOTE: The reason to combine chlorine with ammonia is to form the sanitizing agent known as chloramine. This combination enables the chlorine to remain active and NOT de-gas as easily as chlorine alone.

   b. all the samples should continue to show measurable levels of ammonia

   NOTE: The above chlorine activity can also include an added ammonia water quality test using similar test strips for ammonia, allowing the students to prove or disprove the presence of chloramines as their sanitizing agent.

   NOTE: An ammonia neutralizer (zeolite) or an ammonia-chlorine chloramine combined neutralizer (AmQuel Plus) can be added to this activity in the same way that the chlorine neutralizer was added. This will allow the students to become familiar with BOTH types of sanitizing agents, chlorine, and chloramines; their toxic affects on aquatic life; as well as several methods to neutralize each agent.

Support Materials:

NA

Explanation of Concepts:

1. Generate a value for the amount and type of disinfectants being used in tap water.
2. Understand the effects of sanitizing agents on unwanted pathogens (human health).
3. Understand the negative effects of sanitizing agents on aquatic life (pet fish, food fish, aquatic plants, etc.).

4. Become familiar with mathematical calculations used in aquaculture (volume, dosage rates (ppm), conversion factors: gallons to liters, ounces to grams).
5. Ultimately understand the relationship between humans and aquaculture which is tied together by water.
6. **Note:** examples of mathematics
   a. length x width x depth (in inches) = inches cubed
      inches cubed/231 = gallons
   b. length x width x depth (in feet) = feet cubed
      feet cubed x 7.48 = gallons
   c. when using powders, crystals, or granules use the following formula for the total grams needed:
      gallons x 0.0038 x dosage rate (ppm) x 100% active ingredient = grams
      1 gallon = 3.785 liters
      1 milligram/liter (mg/l) = 1 part per million (ppm)
      1000 milliliters (ml) = 1 liter (1)