Name______________________________ Period _____________Date____________

Ah…Clean Water!
Making a Home-made Aquarium Water Filter

Objective

The learner will construct a water filter and measure the effectiveness of the filter by comparing unfiltered aquarium water to filtered aquarium water.
The learner will compare the effectiveness of the home-made filter to a commercial filter.

Introduction

The survival of fish in an aquarium is greatly increased by having a healthy environment that includes high quality water. While the water quality in the aquarium may initially be good, over time there is usually a decrease in water quality. Aquarium water quality deteriorates for several reasons. As a part of their metabolism, fish produce various waste products that accumulate in the water, and other organic matter such as uneaten food decays into substances that can contaminate the water. Over time, these pollutants build up in an aquarium to a level that is dangerous to the inhabitants. These pollutants include ammonia, nitrites and nitrates.

Ammonia result of fish waste and decomposing food in the aquarium. Ammonia is the leading killer of tropical fish. New tanks that are going through the aquarium cycle or heavily stocked tanks will show ammonia readings with your test kits. Ideally, you want the ammonia reading to be 0 ppm.

Ammonia gets converted to nitrite by the bacteria in your tank. Nitrite levels will soar in new tanks that have not yet been cycled. Nitrite is nearly as toxic to tropical fish as ammonia and the only way to quickly reduce nitrite levels is through a water change. Nitrites will eventually be converted to nitrate by the bacteria growing in the tank and filters. Ideally, in established tanks you want this reading to be 0 ppm.

Nitrites are converted to nitrates during the cycling process. Nitrates are not as toxic as ammonia or nitrites but they are harmful and will stress your fish at high enough levels. The only way to remove the nitrates is a partial water change. Ideally you want to have test kit readings of less than 20 ppm.

Another important issue in aquarium water quality is pH. pH is the scale used to measure the acidity or alkalinity of water. The scale ranges from 0 to 14 with 0 being the most acidic, 7 being neutral and 14 being the most alkaline. An ideal pH range for most freshwater fish in an aquarium is 6.0 – 7.0.

A typical fish aquarium filtration system uses activated charcoal as well as the sand and gravel substrate to purify the water. In this lab you will first test aquarium water for a variety of impurities and pH. Next you will construct a filter using sand, gravel and activated charcoal. Then you will filter the water and then re-test it for the same impurities to determine the effectiveness of the filter. Lastly, you will compare the effectiveness of the home-made filter to a commercial filter.

National Standards Addressed

Science As Inquiry A—Abilities to do scientific inquiry
Physical Science B—Chemical Reactions

Materials Per Group

Water testing kit(s) to test for pH, ammonia, nitrate and nitrite
2 liter clear plastic soda bottle
2 – 400 mL beakers
Magnifying glass
Ruler
Rubber bands
Gravel for a fish aquarium
Sand for a fish aquarium
Activated charcoal for an aquarium filter
Cheesecloth or nylon mesh, like that used in women's hosiery.
Aquarium water
Scissors or utility knife
Goggles and lab apron
300 mL "unknown" freshwater sample

Safety Precautions

Goggles and aprons should be worn during the lab.
If the soda bottles are not pre-cut, students should be closely monitored as the bottoms are cut off.
Depending on the testing kit(s) used, the safety guidelines included with the kit(s) should be followed.
During the filtering process, the filter should be supported to avoid tipping over.

Procedures

Part A: Constructing and Using Water Filtration Systems

Safety goggles and aprons should be worn during the entire lab.

1. Obtain about 200 mL of aquarium water in one of the 400 mL beakers.

2. Observe the aquarium water with the magnifying glass and record your observations in the data table.

3. The test kit will have directions for the volume of water to be tested. Remove measured portions of the aquarium water and test the pH, ammonia concentration, nitrate concentration and nitrite concentration according to test kit(s) directions. Record the pH, ammonia, nitrate and nitrite concentrations in Table 24.1. Save the remaining aquarium water for filtration.

4. Carefully cut out the bottom of the soda bottle. Cover the mouth of the bottle with several layers of cheesecloth or nylon mesh and secure them with a rubber band.

5. Add about 6 centimeters of the charcoal to the upside down bottle.

6. Add about 6 centimeters of sand on top of the layer of charcoal to the bottle.

7. Place about 6 centimeters of the gravel on top of the sand and charcoal.

8. Carefully place the mouth of the bottle over the second 400 mL beaker and pour the remaining aquarium water from step 3 through the filter. Watch closely as the water seeps down through the layers of rock, sand and charcoal and into the beaker below.

9. After all of the water has passed through the filter, observe the filtered water with a magnifying glass and record your observations in Table 24.1.

10. Remove measured portions of the filtered water and test the pH, ammonia concentration, nitrate concentration and nitrite concentration according to test kit(s) directions. Record the pH, ammonia, nitrate and nitrite concentrations in Table 24.1.

11. Dispose of the tested aquarium and filtered water samples according to the kit directions.

Part B: Comparing Water Filtration Systems

1. Obtain 300 mL of the "unknown" freshwater sample.

2. The test kit will have directions for the volume of water to be tested. Remove measured portions of the aquarium water and test the pH, ammonia concentration, nitrate concentration and nitrite concentration according to test kit(s) directions. Record the pH, ammonia, nitrate and nitrite concentrations in Table 24.2. Save the remaining aquarium water for filtration.

3. Using the filter prepared in Part A, filter 100 mL of the unknown water sample.

4. Test the filtered water using the test kit. Record the data in Table 24.2.

5. Using a commercial aquarium filter provided by your teacher, filter 100 mL of the unknown water sample.

6. Test the filtered water using a test kit. Record the data for the commercial filter in Table 24.2.
7. Answer the discussion questions.

Data

Table 24.1 - Home-made Filter

Water Sample	Observations	pH	Ammonia (ppm)	Nitrate (ppm)	Nitrite (ppm)
Aquarium					
Filtered					

Table 24.2 - Filter Comparison

Unknown Freshwater Sample	pH	Ammonia (ppm)	Nitrate (ppm)	Nitrite (ppm)
Initial				
Commercial Filter				
Homemade Filtered				

Discussion Questions:

1. Compare the appearance (observations with the magnifying glass) of the aquarium water to the filtered water.

2. Based on the results of this lab, compare the pH, ammonia concentration, nitrate concentration and nitrite concentration of the aquarium water to the filtered water.

3. Using the water quality standards given in the introduction of the lab, did the filtered water meet all of the standards? Explain.

4. What are some other possible impurities still remaining in the water after filtration?

5. What extra steps could be used to further purify the water?

6. A fish aquarium is a man-made habitat that has a water supply that will deteriorate if not treated and maintained. How does a natural fish habitat like a pond, lake or stream maintain water quality?

7. Spring water that bubbles up from underground aquifers is 99.9 % pure. Explain the purity of spring water.

8. Which filter was most effective in removing nitrates, nitrites and ammonia, the commercial filter or the one you prepared? Support your answer using data collected during Part B.

Elaborations and Extensions

Have students construct a filter made from different combinations of charcoal, sand, gravel and the water tested to see which component is removed by the filter.

Have students place three drops of aquarium water on a microscope slide. Students should observe the microorganisms under a microscope. Afterwards, have students do the same process using filtered water. Students should write a paragraph discussing the similarities and differences they observed under the microscope.

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Answer Sheet

Intended Grade Level
9th, 10th, 11th and 12th

Teacher Information
The soda bottles can be pre-cut to save laboratory time. Also, there are numerous test kits on the market. Most multi-purpose test kits will test for pH, ammonia, nitrates and nitrites. Kits to test for these individually as well as other ions can be purchased through your school science catalog. The commercial filters can be reused between classes. The self contained, charcoal filters are easy to use for this activity.

Discussion Questions and Possible Answers

1. Compare the appearance (observations with the magnifying glass) of the aquarium water to the filtered water.

   Depending on the quality of the aquarium water, students should note some improvement in the appearance of the water, especially in the area of clarity and dissolved solids.

2. Based on the results of this lab, compare the pH, ammonia concentration, nitrate concentration and nitrite concentration of the aquarium water to the filtered water.

   Students should note some change. However, activated charcoal does not remove nitrates.

3. Using the water quality standards given in the introduction of the lab, did the filtered water meet all of the standards? Explain.

   Students should compare the measured pH, ammonia concentration, nitrate concentration and nitrite concentration to the following standards:

   pH: 6.0 – 7.0 ; ammonia = 0.0 ppm ; nitrites = 0.0 ppm; nitrates < 20 ppm

4. What are some other possible impurities still remaining in the water after filtration?

   Activated charcoal is very effective in removing organic solvents and pesticides.

   Activated charcoal does not remove microbes, sodium, nitrates, fluoride or heavy metals.

   While slow sand filters can remove pathogens, the amount of sand in the student filter probably did not remove bacteria, viruses, protozoa and cysts.

5. What extra steps could be used to further purify the water?

   Additional purification could include boiling the water, distillation, UV treatment and reverse osmosis.

6. A fish aquarium is a man-made habitat that has a water supply that will deteriorate if not treated and maintained. How does a natural fish habitat like a pond, lake or stream maintain water quality?

   Ultraviolet (UV) light from the sun, natural sand and gravel, plants and beneficial microbes and bacteria can all help purify a natural habitat.

7. Spring water that bubbles up from underground aquifers can be as high as 99.9 % pure. Explain the purity of spring water.

   As spring water rises up from the aquifer, it can pass through material such as limestone, dolomite, sand, clay and soil. All of these materials can act as natural filter.

8. Which filter was most effective in removing nitrates, nitrites and ammonia, the commercial filter or the one you prepared? Support your answer using data collected during Part B.

   Answers to this question will depend upon the quality of the commercial filter. The water samples with lowest levels of nitrates, nitrites, and ammonia would be considered most effective.