Lesson Plan - Water Quality through Water Treatment

Goals: To demonstrate two options for water treatment: filtration and distillation and to highlight the effectiveness of these treatment options for water quality of a hypothetical ‘contaminated waters’.

Learning Objectives:

➢ Demonstrate a working knowledge of the processes of filtration and distillation by using common household items.
➢ Measure the physical and chemical properties of water (smell, color, pH, TDS, temperature)
➢ Propose alternatives for improved water quality
➢ Compare and contrast effectiveness of the different treatment options

Purpose/Rationale:

The water we drink comes from surface sources or groundwater aquifers and it must be treated in some manner to remove contaminants before consumption. We then produce waste water that must also be treated before it is released back into the hydrologic cycle. This exercise will have the students create two different treatment processes to create ‘clean’ water and evaluate the energy needed for each treatment to work and the effectiveness of the processes. Note: Students should never drink the treated water.

Prior Teacher Preparation: ~ 30 minutes

• Premeasure the amount of alum (one teaspoon) to minimize student exposure, have it ready for when they request it.
• You may want to prepare the ‘contaminated water’ ahead of time to minimize messy accidents.

Suggested Materials/Resources:

Filtration:

Cheese Cloth (1 per group)
Coffee Filters (1 per group)
Coarse Sand (1 cup per group)
Fine Sand (1 cup per group)
Gravel (1 cup per group)
Alum (1 teaspoon per group) **
2 Liter Soda Bottle (1 per group)
Rubber bands (1 per group)

Contaminants:

Dirt
Coffee Grounds
Food Coloring
Vegetable Oil
Soap

Instruments:

Thermometer
Litmus Paper
TDS Probe

Small solar still:

Small bowl (1 per group)
Plastic wrap (to cover the bowl)
Plastic cup, 1” shorter than the bowl (1 per group)
Rock or weight (1 per group)
Rubber bands (1 per group)

** Contact with alum (potassium aluminum sulfate, available in pharmacies, or the spice/baking aisles in grocery stores) should be limited. If students touch the alum, they should immediately wash their hands.
Introduction:
Most municipalities have treatment plants that integrate the processes of aeration, chlorination and/or UV radiation, flocculation with alum, sedimentation, and filtration to remove colloids, suspended sediments, and biological pathogens. However, most of the treatments can be accomplished with a simple set up within one class period. The additional comparison with the Solar Still output can help to integrate the concept of energy consumption and effectiveness of each process (will take an additional class period).

Exploration:
Have the class collectively discuss where their drinking water comes from. Is it treated before it reaches the school? How? Where? Also have them discuss the sources of waste water. Where does the water go after you flush the toilet? What happens there?

Discuss the two processes to be evaluated in this exercise. How does filtration work? How does solar distillation work? Which process does the class think will work better? Why? Have the class created testable hypotheses (i.e. filtration will work the same as distillation OR filtration will work better, which filtration process will remove which contamination, etc.) and create an experimental design or use the attached worksheet.

Application:

Solar Still:
If the solar still comparison is to be used, have the class set that up first.
1. Each group should have one bowl or large container to act as the reservoir for evaporation.
2. In the center of this bowl, place a small plastic cup.
3. Pour the ‘contaminated water’ in the bowl.
4. Have the student record observations of smell, color, pH, TDS, temperature.
5. Cover the bowl with plastic wrap and place a small rock or marble to depress the plastic over the cup (See Figure 1).
6. Place the still in the sun to start the distillation process allow to sit for 1-2 days.
7. After enough water has collected in the plastic cup, have the students record their observations of smell, color, pH, TDS, and temperature.

![Figure 1: Small Solar Still Setup.](http://www.energywhiz.com/3-5/EXPERIMENTS/solarstill.htm)

Filtration:
1. Cut the two liter bottle in half. Pour the ‘contaminated water’ in the bottom half; have the students record observations of smell, color, pH, TDS, temperature.
2. Pour the water back and forth between the top of the bottle and the bottom of the bottle ten times to aerate the sample. End with the water in the bottom half, record observations.
3. Add a teaspoon of alum crystals to the contaminated water. This encourages coagulation and settling of the suspended solids. Slowly stir for five minutes, record observations.
4. The floc is allowed to settle out in the sedimentation process. Allow the water to sit for 20 minutes, recording observations every five minutes.
5. Set up a filtration apparatus in the top of the bottle. Remove the cap and rubberband a coffee filter in place. Turn the bottle upside down and pour in one cup of gravel, one cup of coarse sand, and finally one cup of fine sand. Very slowly pour several cups of clean water through the filter to clean it. Pour the ‘contaminated water’ through the filter with a beaker underneath to collect the water. Record observations.
6. Compare the results.

Assessment:

- Have the students outline the effectiveness of each step of the filtration process.
  o Which step removed what contaminant?
  o How did the end results compare with the beginning observations?
  o Were there any contaminants that were not removed?
    ▪ Have them propose viable alternatives for removal.

- Have the students then explain what occurred in the distillation process.
  o How did the end results compare with the beginning observations?
  o Were there any contaminants not removed?
    ▪ Have them propose viable alternatives for removal.

- Remind the students about the amount of energy (time of active manipulation) each process demanded.
  o Is the amount of time of manipulation for filtration worth it?
    ▪ In energy use?
    ▪ In quality of output?
    ▪ In quantity of output?
  o Is the more passive process (solar still) more effective?
    ▪ In energy use?
    ▪ In quality of output?
    ▪ In the quantity of output?

References:

