Water, Water, Everywhere…Is There a Drop to Drink?

INTRODUCTION

Watch the videos provided by your instructor featuring survival water collection.

Questions:
1. Do the survivalists drink straight from the water source? Why or why not?

2. What did the survivalists do to prepare the water for drinking?

3. After completely removing these physical containments is the water safe to consume? What other impurities may remain?

Water Collection:

Please note on the map at right the location where you collected your water sample.
EXPLORATION

Materials:
The following materials will be required per group:
- 1 pair of goggles (including rubbing alcohol for disinfecting)
- 1 pair of disposable gloves
- 1 stopwatch
- 1 clipboard

Procedures:
1. Each member in your group needs to select a role that he or she will follow at each station in the Exploration. Cards at each station provide the title and task for each given role.

2. Follow the procedure card at each station when testing the tap water sample and pond water samples. Procedures for calculating turbidity and Coliform are found on the following page.

3. Record your data in the appropriate column in Table 1.

<table>
<thead>
<tr>
<th>Water Quality Parameters</th>
<th>Tap Water</th>
<th>Pond Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature - physical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity - physical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate - chemical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate - chemical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen - chemical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH - chemical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coliform count - biological</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Values for Water Quality Parameters
a. **Procedure for calculating turbidity from distance in units centimeter to turbidity in units of NTU:**

1. Compare the distance of the water depth (cm) when using the Turbidity Tube or the Secchi Disk tests to the equivalent turbidity value (NTU).

   For example, if your distance was measured to be 6.0 cm, then the equivalent NTU Turbidity value would be between 200 and 100 NTU.

   ![Turbidity-Myre_Shaw.pdf](http://cee.mtu.edu/sustainable_engineering/resources/technical/Turbisity-Myre_Shaw.pdf)

<table>
<thead>
<tr>
<th>Distance (cm)</th>
<th>Turbidity (NTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>500</td>
</tr>
<tr>
<td>3.7</td>
<td>300</td>
</tr>
<tr>
<td>5.1</td>
<td>200</td>
</tr>
<tr>
<td>8.3</td>
<td>100</td>
</tr>
<tr>
<td>13.5</td>
<td>50</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>

2. Record the NTU value in the appropriate space in Table 1, which is found on page 2.

   The conversion from distance to turbidity can be calculated using the following equation

   \[
   \log (T) = -1.4249 \log (d) + 3.2935
   \]

   Where \( T \) = turbidity in units of NTU (Nephelometric Turbidity Unit)
   And \( d \) = distance in units of cm

   Taken from [http://cee.mtu.edu/sustainable_engineering/resources/technical/Turbisity-Myre_Shaw.pdf](http://cee.mtu.edu/sustainable_engineering/resources/technical/Turbisity-Myre_Shaw.pdf)

b. **Procedure for calculating Coliform bacteria using a multiple-tube fermentation technique**

   At the given station, a series of test tubes have been filled with lactose broth and inoculated with various amounts of tap and pond water. From the equation below calculate the MPN/100 ml for each water sample. (MPN = Most Probable Number of Coliform per 100 mL)

1. First, determine the volume of sample used in all tubes.

   \[\text{mL of sample in all tubes} = 6 \text{ tubes (1.0 mL/tube)} + 6 \text{ tubes (0.1 mL/tube)} = 6.6 \text{ mL}\]

2. Next, determine the volume of sample used in the tubes that were negative (negative tubes are pink in color).

   Fill in the following blanks with the number of negative tubes.

   \[\text{mL of sample in negative tubes} = \_ \text{ negative tubes (1.0 mL/tube)} + \_ \text{ negative tubes (0.1 mL/tube)} = \_ \text{ mL}\]
CONCEPT DEVELOPMENT

1. Compare the tap water data and the pond water data found in Table 1. Which water quality parameters are the same between the two samples?

2. Which water quality parameters are different between the two samples?

3. Based on the data you have collected, which parameters do you believe have an effect on the drinkability of water?

Certain agencies, such as the Environmental Protection Agency and the World Health Organization, have developed standards that apply to drinking water quality. These standards protect public health by limiting the levels of contaminants in drinking water.


<table>
<thead>
<tr>
<th>Water Quality Parameters</th>
<th>Tap Water</th>
<th>Pond Water</th>
<th>WHO Water Quality Standards</th>
<th>EPA Water Quality Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td>&lt; 0.3 NTU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coliform</td>
<td></td>
<td></td>
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</tbody>
</table>

Table 2 – Comparison of Drinking Water Quality Standards
2. Compare the values of the tap water and pond water (See Table 1) to the values of the Drinking Water Quality Standards (See Table 2).

3. If a water quality parameter value of the tap water sample or the pond water sample is outside (either above or below) the range of the drinking water quality standards, then place a check mark in the appropriate column (tap water or pond water) in Table 1. If a check mark is placed in any cell of a column for tap water or pond water, then that means the water is not safe to drink according to the Drinking Water Quality Standards.

4. For each sample, what parameters were not within the acceptable range for drinkability?

5. When comparing the values of the Drinking Water Quality Standards to the values of the tap water and the pond water parameters, what conclusions can you make regarding the drinkability of each water sample – which parameters seem to be most important?

6. What do you think could be done to improve the quality of the pond water?
CONCEPT APPLICATION – Part A

We have now observed that the drinkability of water can be determined by a variety of different parameters. However, why do you think that these parameters are important, and how do you think they affect the drinkability of water?

Each student group will be given a water quality test to investigate. Using the websites provided below, you will determine what effects your parameter has on the drinkability of water as well as the effect on other water quality parameters.

**All parameters:** http://www.h2ou.com/h2wtrqual.htm  
http://bcn.boulder.co.us/basin/data/BACT/info/  
http://www.epa.gov/volunteer/stream/vms50.html

**Dissolved Oxygen:** http://www.nerrs.noaa.gov/Monitoring/WaterOxygen.html

**Turbidity:** http://www.cotf.edu/ete/modules/waterq3/WQassess4f.html  
http://en.wikipedia.org/wiki/Turbidity  

**Phosphates:** http://www.earthforce.org/section/programs/green/handson/phosphates  
http://www.epa.gov/volunteer/stream/vms56.html

**Your water quality parameter:**___________________

<table>
<thead>
<tr>
<th>Definition of parameter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What affects the parameter?</td>
<td></td>
</tr>
<tr>
<td>Effects on drinkability</td>
<td></td>
</tr>
<tr>
<td>Effects on other tests</td>
<td></td>
</tr>
</tbody>
</table>
CONCEPT APPLICATION – Part B

Materials:
The following materials will be required per group:
- Graduated cylinder
- Plastic bottle
- Stopwatch

The following materials will be required per class:
- Turbidity meter

You have been shipwrecked on a deserted island with only the clothes on your back. After panicking for several hours, you realize you need to locate a source of clean water to stave off dehydration. Unfortunately, the only source of fresh water is a small dirty pond, so the water must be cleaned before it is suitable for drinking.

The only materials you have available for water treatment are your clothes, the dirt, sand, rocks and plant life on the island, and a small plastic bottle you discovered washed upon the beach. Your goal is to design a filter using the available materials that will produce a significant amount of drinkable water in the fastest possible period of time (you will have to filter several liters of water a day to survive).

1. Build your filter, and draw and label a picture of your filter in the space below:

2. Why did you use your chosen materials?

3. Why did you put the chosen materials in the order that you did?
4. You will now test your filter by pouring 200 mL of pond water through it. You will record the amount of time required for 100 mL of water to filter through, the amount of water remaining after the filtering process, and the final turbidity.

<table>
<thead>
<tr>
<th>Time required for 100 mL (sec)</th>
<th>Amount filtered (mL)</th>
<th>Turbidity (NTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st filtration</td>
<td>2nd filtration</td>
</tr>
<tr>
<td></td>
<td>1st filtration</td>
<td>2nd filtration</td>
</tr>
</tbody>
</table>

5. Was your filter successful? Why or why not?
CONCEPT APPLICATION – Part C

Now that we have designed our own filters, it is time to look at another type of filtering process.

Materials:
Each of the following is required per group:
• 1, 500-710 mL plastic water bottle with cap
• 3, 250 mL beakers
• 1 stop watch
• 1 tablespoon
• 1 tablespoon of alum (potassium aluminum sulfate)
• 1, 500-710 mL plastic water bottle with bottom cut off
• 1 coffee filter
• 1 rubber band
• 75 mL of small pebbles
• 150 mL of fine sand
• 500-710 mL of bottle water
• 1 pair of disposable gloves
• 1 pair of goggles

Safety:
Do not drink the water samples even after the final step of the filtration process.

Procedures:
1. Observe the water sample thoroughly, recording the appearance and odor (if any) in the space below:

2. Vigorously shake for 30 seconds the 500-710 mL plastic water bottle containing the pond water sample. Continue the process by pouring the water from the bottle into a beaker and then pour the water back and forth between the beaker and another beaker about 10 times. Write down your observations in the designated area. What is the appearance of the water now?

Observations:

STEP #1: _______________________

3. Pour 100 ml of pond water into a 250 ml beaker and add alum from the labeled bag. Slowly stir the mixture for 5 minutes. Write down your observations in the designated area. What is the appearance

STEP #2: _______________________

of the water now?
4. Allow the water to stand undisturbed in the beaker. Observe the water at 2-minute intervals for a total of 10 minutes and write down your observations in the following table.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
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<tr>
<td>6</td>
<td></td>
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<td>8</td>
<td></td>
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<tr>
<td>10</td>
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</tbody>
</table>

5. Construct a filter from the 500-710 mL plastic water bottle with its bottom cut off as follows (see illustration below):

a. Attach the coffee filter to the outside neck of the bottle with a rubber band. Turn the bottle upside down placing it in a beaker. Pour a layer of pebbles (75 mL) into the bottle - the filter will prevent the pebbles from falling out of the neck.

b. Pour the sand (150 mL) on top of the pebbles.

c. Clean the filter by slowly and carefully pouring through 150 mL of clean tap water. Try not to disturb the top layer of sand as you pour the water.

6. After a large amount of sediment has settled on the bottom of the beaker of pond water, carefully, without disturbing the sediment, pour the top two-thirds of the pond water through the sand of the filter. Collect the filtered water in the beaker. Compare the treated and untreated water. Has the treatment changed the appearance and smell of the water? Please explain.

   Explanation:

   STEP #3: _______________________

   STEP #4: _______________________

   Sand

   Pebbles

   Coffee Filter

   Beaker
7. Do you think the filtered pond water is now safe to drink according to the water quality standards that were reported in Table 2 on page 4? If so, then why? If not, then why not? Please explain.

8. Do you think the filtered and chlorinated pond water is safe to drink according to the water quality standards that were reported in Table 2 on page 4? If so, then why? If not, then why not? Please explain.
AUTHENTIC ASSESSMENT

We will now visit the Norman Water Treatment Plant, where water from Lake Thunderbird is treated for safe consumption. During the tour, please note the process the water undergoes to be drinkable, what equipment/chemicals are used, and what happens to the quality of the water during each step.

<table>
<thead>
<tr>
<th>Process</th>
<th>What happens?</th>
<th>Equipment/Chemicals Used</th>
<th>How does the water change?</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

1. Compare the actual water treatment procedures at the Norman Water Treatment Plant to your previous experiences in CONCEPT APPLICATION – Part C on pages 8-10.
   - What was similar about the actual water treatment procedures at the Norman Water Treatment Plant when compared to the filtration process in CONCEPT APPLICATION – Part C (the 2nd filter you made)?

   - What was different about the actual water treatment procedures at the Norman Water Treatment Plant when compared to the filtration process in CONCEPT APPLICATION – Part C?

2. In the treatment plant laboratory, what tests are performed most frequently, and what is the reason for performing them?

3. Based on your experiences at the Norman Water Treatment Plant and your knowledge of Drinking Water Quality Standards (see page 3), explain if contaminants can be completely removed from treated water.