Evaluation of Drinking Water

Objectives

- Explain the process of water filtration and treatment.
- Evaluate water samples for contaminants.
- Complete a critical analysis of laboratory experimental findings.
- Research a current topic on the environment and its impact on the environment and human health.
- Explain how contaminated drinking water can impact human health.
- Explain the potential impact of pollutants on drinking and groundwater.
- Research, compile, and complete an analysis of scientific findings water chemistry.
- Develop opinions on scientific topics supported by empirical facts.
- Identify sources of error in completing laboratory experiments.
- Communicate lab procedures, observations, and results in the form of laboratory notebook, written reports, and verbal presentations effectively.
- Interpret and analyze qualitative observations and quantitative results, incorporating graphs and tables as appropriate.

Related Textbook

Please read section 3.4 of your textbook before beginning this experiment. The textbook provides terms, concepts, and other important background information that will help you succeed on this assignment.

Introduction

Water quality impacts our daily lives. We need water to shower, brush out teeth, wash our clothes, cook our meals, and to drink. Clean water is essential to a healthy life. Drinking water can come from groundwater, surface water (such as lakes and rivers), and rainwater. In the United States, all drinking water comes from groundwater aquifers and surface waters (EPA 2022). According to the EPA Drinking Water Mapping Application to Protect Source Water (DWMAPS) website, Mower County and the eight surrounding counties (Minnesota - Freeborn, Dodge, Steele, Olmsted, and Filmore; Iowa – Worth, Mitchell, and Howard) all rely on groundwater obtained from aquifers. Most drinking water has to be processed in some way to ensure it is clean of bacteria and other contaminants. The EPA outlines impacts to drinking water and effects of drinking contaminated drinking water. Please read the information on this page before continuing.

The EPA website also provides Water Quality Standards: Regulations and Resources regarding federal and state standards. You may need this information as you complete this lab or your final project for this course.

As long as the groundwater aquifer that feeds a private well is uncontaminated, the drinking water drawn from the aquifer doesn't need to be processed before drinking. However, it is still important that private wells are tested regularly to ensure no chemical or bacterial contaminants become present.

When a city or county provides drinking water to a community, it is treated and tested prior to consumption. This process involves many steps to ensure chemicals that are dangerous to human health are removed and bacteria is killed. Watch How City Water Purification Works: Drinking and Wastewater for information on how drinking water is treated to remove sediment, chemicals, and bacteria. I encourage you to take notes on this content so you can easily refer back to this content and review it for future assignments.

The National Defense Council (NRDC) also provides additional information on water pollution, including its effects on human health and the environment. The United States Geological Society (USGS) also provides information on wastewater treatment use. Please review these resources and take notes to better understand the impact from improperly treated drinking water.

This Week's Lab

In this lab, each student will obtain a drinking water sample from their home and test it for the contaminants listed below. Your instructor will provide you with a clean bottle to collect your sample and bring it to class. You must bring a drinking water sample from your home to class, or you cannot do this lab.

There is no post-lab assignment for this experiment. The pre-lab assignment is worth 25 points.

During this experiment, we will be testing for:

- Total Dissolved Solids (TDS) – the amount of solids dissolved in the water
- Chlorine – added to drinking water to kill microorganisms
- Iron – which colors the water, distorts the taste, and can cause staining in showers, tubs, and sinks
- Hardness – which is a measurement dissolved calcium and magnesium (in the form of calcium carbonate or magnesium carbonate) and contributes to the build-up of soap scum
- Arsenic – which is poisonous to humans and can lead to multi-organ failure when enough is digested

- pH – the measurement of how acidic or basic something is
- General Appearance, Taste, and Odor
- Temperature
- Conductivity – which will let us know if there are any ions dissolved in the water
- Copper – which gives the water a metallic taste

Each table will have Chlorine, Copper, and Iron and Hardness test kit and a TDS probe. The pH test and Arsenic tests will be conducted at a station in the classroom. The first test everyone will conduct is the taste test. This must be done outside of the laboratory since drinking and eating are prohibited in the lab. Once this test is complete, you can enter the lab and conduct the remaining tests using your water sample. DO NOT repeat the taste test once you have taken the water sample into the laboratory.

Table 1.0 summarizes the Maximum Contaminant Levels (MCL) for some of the contaminants we are testing for in drinking water. These levels are established by the Environmental Protection Agency to ensure drinking water is provided at safe levels to the public. (National)

Table 1.0

Maximum Contaminant Levels for Drinking Water

Contaminant	MCL (mg/L)	Potential Health Effects from Exposure Above the MCL	Sources of Contaminant in Drinking Water
Chlorine	1.0	Long term: Anemia; infants and young children: nervous system effects	Byproduct of drinking water disinfection
Copper	1.3	Short term exposure: Gastrointestinal distress Long term exposure: Liver or kidney damage People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits
Arsenic	0.010	Long Term: Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass and electronics production wastes

Table 2.0 outlines Secondary Drinking Water Standards established by the EPA. While these standards are not enforceable, they do provide public water systems guidelines for managing their drinking water for evaluating aesthetic considerations such as color, odor, and taste. (Secondary)

Table 2.0

Secondary Drinking Water Standards

Contaminant	Secondary MCL	Noticeable Effects Above the Secondary MCL
Chloride	250 mg/L	salty taste
Color	15 color units	visible tint
Copper	1.0 mg/L	metallic taste; blue-green staining
Iron	0.3 mg/L	rusty color; sediment; metallic taste; reddish or orange staining
Odor	3 TON (threshold odor number)	"rotten-egg", musty or chemical smell
pH	6.5 - 8.5	low pH: bitter metallic taste; corrosion high pH: slippery feel; soda taste; deposits
Total Dissolved Solids (TDS)	500 mg/L	hardness; deposits; colored water; staining; salty taste

Use the guidelines in Table 2.0 to evaluate if your water sample tastes and smells good. It is possible for a water sample to be completely safe to drink and not be at all appetizing. Maximum Contamination Levels and Secondary Drinking Water Standards work together to ensure drinking water is safe and tastes good.

Evaluation of Drinking Water Pre-Lab Assignment

NAME:_____

Answer the following questions on the Evaluation of Drinking Water lab. You may have to do some research beyond what is provided in the textbook and introduction to answer the questions on this assignment. (25 point)

1. In your own words, summarize the process of drinking water processing. (3 points)

2. What is the source of drinking water for your home? (i.e. municipal or county water (name specific provider), well water, etc.) (1 point)

3. Define coagulation and flocculation. (2 points)

4. What is activated carbon? How does it work? (1 point)

5. How is UV light used in drinking water treatment? (1 point)

6. What is wastewater? Where does it come from? (2 points)

7. In your own words, summarize how was wastewater is treated. (3 points)

8. Why is it important to process wastewater before discharge into the environment? (2 points)

9. What is reclaimed wastewater? (1 point)

10. Calculate the cost of tap water for you for one year. Assume you would consume eight 8-ounce glasses of water per day and calculate consumption based on a 365-day year. You will need to contact the local water company for the cost of water. You must show your calculations to receive credit. (3 points)

11. Sometimes, drinking water isn't processed well enough to drink right from the tap. Calculate the cost of using a Brita filter pitcher for one year. Obtain the cost of the original pitcher and replacement filters from Amazon. Calculate how much it will cost you to filter the amount of water you calculated you will drink in a year from the question above. Remember, you would need to obtain the water from the tap and then filter it. Assume you change the filter in your pitcher every 2 months. Your total cost for the filtered water should include the cost of the tap water (calculated in #10) and the Brita pitcher and filters (obtained from Amazon). You must show your calculations to receive credit. (3 points)

12. Assume you are able to buy bottled water wholesale at $1.17/gallon. Using the amount of water you would drink yearly as calculated in problem #10, calculate how much it would cost of consume bottled water for a year. You must show your calculations to receive credit. (3 points)

Experimental Procedure

Experimental Materials

Glassware in lab drawer
Approximately 500mL water sample from student's home
Small cup for water tasting
HACH Total Hardness and Iron Test Kit
HACH Copper, Free and Total Test Kit
HACH Chlorine, Free and Total Test Kit
HACH Arsenic Test Kit
Labquest Interface and pH probe
Total Dissolved Solids Meter with Thermometer

Before Coming to Lab

How to Collect Water Sample

You will need to collect your drinking water sample before the day of this lab. Your instructor will provide you with a clean and unused water sample bottle the week prior to this lab. Below are the instructions for how to collect your drinking water sample:

1.Rinse the bottle and cap three times with sample water and fill the bottle to within one to two inches from the top.

2. Using a Sharpe marker, right the date and time the sample was collected, the faucet the sample was collected from (example: kitchen faucet) and your name (first and last) on the side of the bottle.

2. Keep the sample cold until you are ready to come to campus. Deliver your sample to your professor at the start of lecture on the day of your scheduled experiment. Your professor will store your sample in the lab fridge until the start of lab.

During Lab

Appearance, Taste, and Odor Tests

NOTE: This test must be completed outside of the lab, before any other testing is completed. Please complete this part of the lab before coming to class.

1. Pour a small amount of the water to be tested into a small cup provided by your instructor.
2. Look at the sample. Record observations in DATA TABLE 1.0. How does it appear? Does it appear cloudy? What is the color? Are any participles visible in the water? Etc…
3. Taste and smell the sample. Record observations in the DATA TABLE 1.0. How does the water smell? How does the water taste? Does it taste salty? Metallic? Pleasant? Gross? Etc...

4. Everyone should observe, taste, and smell all of the samples, though each group will not be conducting chemical testing of all of the samples.

Preparing a Water Sample

The same portion of water can be used to complete the pH, temperature, and total dissolved solids (TDS) tests. Below are instructions on how to prepare this water sample.

1. Wash and dry a 100mL beaker to ensure it is clean. Use DI water to conduct the final rinse.
2. Pour approximately 50mL of water from your sample the clean and dry 100mL beaker.

pH Test

This test is completed at one of the stations set up in the classroom. Please move to the pH station to complete this test.

DO NOT touch the glass ball on the bottle of the pH probe or allow it to crash into the bottom or side of the containers.

1. Turn on the Vernier Lab Quest using the power button on the top left of the equipment. See Figure 1.0 for the pH probe setup and how to read the LabQuest Screen.

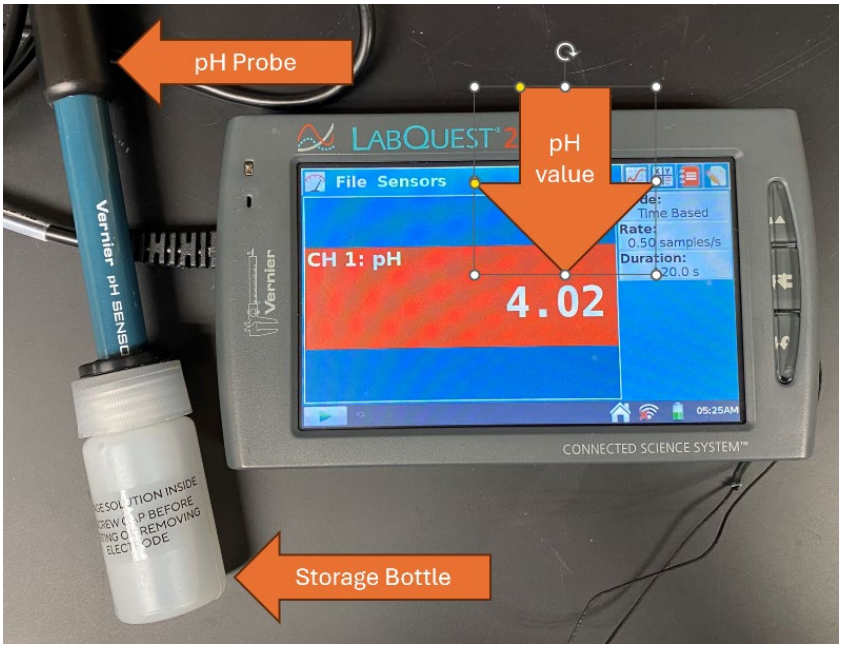

Figure 1.0 – LabQuest Setup using pH probe.

2. Partially unscrew the bottle around the pH probe and pull the pH probe out of the bottle. Be careful not to spill the contents in the bottle.
3. Rinse the probe by placing it in the beaker of DI water and gently swirling the probe.

4. Place the probe in your water sample. Once the value on the tens place on the screen has stabilized, record the pH on Data Table 2.0.
5. Rinse the pH probe again with DI water.
6. Place the probe back in the storage bottle and twist the lid until tight. Do not let the end of the probe rest on the bottom of the storage bottle. The end should be suspended a little above the bottom of the bottle and be fully submerged in the storage solution.

NOTE: If you spilled any of the storage solution from the bottle, please let your instructor know so they can refill the bottle.

Temperature and Total Dissolved Solids (TDS)

Each table should have at least one COM-100 probe. Use this probe to obtain the temperature and TDS for your water sample.

1. Turn on the COM-100 probe. Make sure "ppm" appears at the top of the screen. If this does not appear, hold down the *Hold/Mode* button until it appears. Release the button when "ppm" appears. The top number on the screen is the TDS in ppm.
2. The bottom number on the screen is the temperature. This should measured in °C. If °C does not appear after the temperature, press the *Temp/Cal* button once to change the temperature to °C.
3. Place the probe in your beaker with your water sample.
4. Once the numbers on the screen stabilize, record the temperature (to 0.1°C) and the TDS (in ppm) on Data Table 2.0. Record every number that appears for these measurements, even if it's a zero.
5. Rinse the COM-100 probe with DI water and allow the probe to air-dry. DO NOT dry the probe sensors using a paper towel. DO NOT put the cover back on the probe until it is dry.

WASTE DISPOSAL: All your waste for the pH, temperature, and TDS tests can go down the drain.

HACH Test Kits

Test kits of the Chlorine, Copper, and Iron/Hardness tests are provided on each benchtop. Groups will need to share these test kits. The Arsenic test kits are provided at a separate station in the classroom. Please clean and dry all glassware/equipment provided in each kit and neatly place it back in the kit when you are done.

Leave any waste from the HACH kits in the waste container provided at that station. The waste from these tests cannot be disposed of down the drain.

The instructions for each of these tests are provided below. Record all data from each of these tests on Data Table 2.0.

Iron

1. Fill the two tubes to the first line (closest to the bottom of the tube) with your water sample. This is 5mL of water sample.
2. Put Tube 1 on the left opening of the color comparator box (black box) (Figure 2.0)

Figure 2.0 – The color comparator box with Tube 1 in the left opening.

3. Add one FerroVerIon Reagent Powder Pillow to Tube 2. Swirl to mix. An orange color will likely develop.
4. Place Tube 2 in the second compartment in the color comparator box.
5. Hold the color comparator box in front of a light source. Turn the color disc to find a color match for the solution in Tube 2. (Figure 3.0)
6. Read the result in gm/L in the scale window (the third window below the windows into the tubes). Record this value on Data Table 2.

Figure 3.0 – The color comparator box with both tubes in place. Turn the floor disc until the color in both tubes matches. Record the value (visible in the bottom window) on Data Table 2.0.

7. Place all waste in the bottle marked "Iron Test."

Hardness

1. Fill the Erlenmeyer to the 100mL mark with your water sample.
2. Add two full droppers of Hardness 1 Buffer Solution. Swirl to mix.
3. Add four drops of Hardness 2 Indicator Solution to the Erlenmeyer. A pink color should develop. Swirl to mix.
4. Add the Hardness 3 Titrant Solution dropwise, counting the number of drops added. Swirl to mix after each drop. Continue until the color changes from pink to blue or you add 100 drops. If you add 100 drops of the Hardness 3 solution and your solution still hasn't turned blue, discontinue testing and indicate on your data table that your hardness is >100mg/L. This just means that your water is very hard. No need to test your hardness further.

5. Record the number of drops on Data Table 2.0. The number of drops delivered equals the hardness of the solution in mg/L.
6. Place all of your waste for the hardness and iron in the bottle marked "hardness."

Free Copper (Steps 1-7) and Total Copper (Steps 8-14)

1. To determine free copper in sample, fill the two tubes to the first line (closest to the bottom of the tube) with your water sample. This is 5mL of water sample.
2. Put Tube 1 on the left opening of the color comparator box (black box) (Figure 4.0)

Figure 4.0 – The color comparator box with Tube 1 in the left opening.

3. Add one Free Copper Reagent Powder Pillow to the second tube. Stopper and insert tube to mix, keeping your thumb on top of the stopper.
4. Wait 2 minutes. A purple color will develop if free copper is present in the sample.
5. Place Tube 2 in the second compartment in the color comparator box.
6. Hold the color comparator box in front of a light source. Turn the color disc to find a color match for the solution in Tube 2. (Figure 5.0)
7. Read the result in gm/L in the scale window (the third window below the windows into the tubes). Record this value on Data Table 2 under Free Copper.

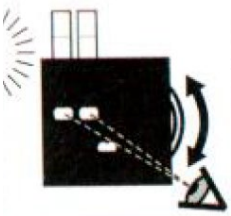

Figure 5.0 – The color comparator box with both tubes in place. Turn the floor disc until the color in both tubes matches. Record the value (visible in the bottom window) on Data Table 2.0 under Free Copper.

8. To determine total dissolved copper, add one Hydrosulfite Reagent Powder Pill to Tube 2. No need to empty content from previous tests.
9. Stopper and insert tube to mix, keeping your thumb on top of the stopper.
10. Wait 2 minutes. A purple color will develop if free copper is present in the sample.
11. Place Tube 2 in the second compartment in the color comparator box.
12. Hold the color comparator box in front of a light source. Turn the color disc to find a color match for the solution in Tube 2.
13. Read the result in gm/L in the scale window (the third window below the windows into the tubes). Record this value on Data Table 2 under Total Copper.

14. Dispose of all of your waste for the copper tests in the bottle marked "copper."

Arsenic

This test must be conducted in the hood. You can find the kits for his test in the hoods in the lab. Once you have prepared your test, label your container with your name using a piece of label tape and leave it in the hood. This test takes approximately 40 minutes to complete.

DANGER: Hydrogen and arsine (aka arsenic trihydride) gases are generated during the test. Work in a well-ventilated area, away from open flames and other sources of ignition.

1. Insert the test strip so the pad completely covers the small opening. Close the flap and press to secure (Figure 6.0).

Figure 6.0 – Place the test strip in the cap with the pad covering the small opening on the cap.

2. Fill the reaction bottle with your water sample to the fill line (50mL).
3. Add one Reagent #1 powder pillow to the water sample. Swirl to mix. Most of the powder will dissolve.
4. Add one Reagent #2 powder pillow to the sample. Swirl to mix. Most of the powder will dissolve. The solution may turn cloudy. Wait 3 minutes.
5. Add one Reagent #3 powder pillow to the water sample. Swirl to mix. Not all of the powder will dissolve. Wait two minutes. Swirl to mix again.
6. Add one level scoop of Reagent #4 to the sample. Swirl to mix. Most of the powder will dissolve.
7. Add one Reagent #5 powder to the sample. Immediately attach the cap to the reaction bottle. Swirl to mix. Do not shake, or invert, or otherwise allow the solution to touch the cap of the bottle.
8. Allow 30-35 minutes for the reaction to occur. Swirl the solution twice during this time, being careful to not let any of the solution touch the cap on the bottle.
9. Remove the test strip and immediately compare the color on the end of the strip with the color chart provided on the side of the test strip bottle. Record the amount of arsenic in your sample on Table 2.0 in mg/L.
10. Put all of liquid your waste for the arsenic test in the bottle marked "arsenic." The test strip goes in the disposal packet provided in the kit. Wash your arsenic testing bottles with soap and water and rinse with DI water before packing everything back into the kit and passing it to another group.

Free and Total Chlorine

There are two tests for free and total chlorine everyone should start with the test below for low-range.

1. Fill Tube 1 to the top line with your water sample.
2. Put Tube 1 on the left opening of the color comparator box (black box) (Figure 7.0)

Figure 7.0 – The color comparator box with Tube 1 in the left opening.

3. Fill the bottle to the 25mL mark with your water sample. Add one DPD (Free or Total) Chlorine Powder Pillow. Swirl to mix.
    - For free chlorine, read the result within 1 minute of adding the pillow.
    - For total chlorine, wait 3 minutes for the reaction to occur. Read the results within 6 minutes of adding the pillow.
4. To read the results, fill Tube 2 to the top line with the prepared sample.
5. Place Tube 2 in the second compartment in the color comparator box.
6. Hold the color comparator box in front of a light source. Turn the color disc to find a color match for the solution in Tube 2. (Figure 8.0)
7. Read the value in the scale window (the third window below the windows into the tubes) and divide the value by 5. Record this value on Data Table 2.

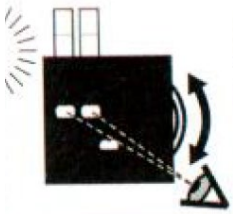

Figure 8.0 – The color comparator box with both tubes in place. Turn the floor disc until the color in both tubes matches. Record the value (visible in the bottom window) on Data Table 2.0. The value for free chlorine should be read within 1 minute of adding the pillow. Total chlorine should be read between 3 and 6 minutes after adding the pillow.

If the low-range test shows that you have more than 0.68mg/L Chlorine, you also need to do the mid-range test demonstrated below. If your test did not exceed the low-range test, you don't need to do the mid-range.

1. Fill Tube 1 to the first line (5mL) with your water sample.
2. Put Tube 1 on the left opening of the color comparator box (black box).

3. Fill the bottle to the 25mL mark with your water sample. Add one DPD (Free or Total) Chlorine Powder Pillow. Swirl to mix.
    - For free chlorine, read the result within 1 minute of adding the pillow.
    - For total chlorine, wait 3 minutes for the reaction to occur. Read the results within 6 minutes of adding the pillow.
4. To read the results, fill Tube 2 to the bottom line (5mL) with the prepared sample.
5. Place Tube 2 in the second compartment in the color comparator box.
6. Hold the color comparator box in front of a light source. Turn the color disc to find a color match for the solution in Tube 2.
7. Read the value in the scale window (the third window below the windows into the tubes) record this value on Data Table 2 in mg/L.
8. Put all of your waste for the chlorine tests in the bottle marked "chlorine."

Clean-Up

- Wash any glassware used with soap and water (the final rinse being with DI water) before placing it back into the equipment drawer.
- Place all chemical wrappers in the trash.
- Wash your hands thoroughly with soap and water.

References

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DATA TABLE 1.0

Water Appearance, Taste, and Odor Observations

Test	Observations
Water Sample Appearance	
Water Sample Smell	
Water Sample Taste	

DATA TABLE 2.0
Water Testing Results

Lab Test	Results
Dissolved Solids (ppm)	
pH	
Temperature (°C)	
Total Hardness (mg/L)	
Iron (mg/L)	
Free Chlorine (mg/L)	
Total Chlorine (mg/L)	
Combined Chlorine (mg/L)	
Free Copper (mg/L)	
Total Copper (mg/L)	
Combined Copper (mg/L)	
Arsenic (ppb)	

Lab Report

You will write a lab report over the experiment and your results. Please review How to Write a Lab Report for general guidelines on how to write a lab report. The due date for this assignment is noted on the semester schedule.

Below are some experiment-specific information you will need to include in your report:

- A data table outlining your results, the equivalent data presented in your local water quality report from your water provider, and the applicable EPA standard.
- Compare your results and those from your local water quality report to the EPA standards for drinking water and determine if the water is safe to drink.
- Specifically state if the data collected is valid. Support your answer with evidence from the experiment/results.
- Cite the water quality report you obtained from your water provider at the end of your report. If the report was accessed online, be sure to include a link to the report. If it is not accessible online, please upload a copy of it with your lab report.
- Research your local water provider. Did you find any evidence of violations or issues with your water provider in the past 5 years? If so, please provide information. If you didn't identify any issues, state this.
- Discuss the type of pipes in your home and the water infrastructure leading up to your house and how/if they contributed to any of your experimental findings.
- Are there any chemical tests we didn't conduct that you think we should have? Explain your reasoning.
- If you discover that your water is not hard, explain why you observed this result.
- Cite all your sources at the end of your report, including this experimental procedure.