5E STEM Unit Lesson Plan: Should I Drink It? (2-3 weeks)

RESET AN AEOP EFFORT aeop

Authors

Leanne Thele

Karisa Boyer

Sarah Cooper, RESET coach

SUBJECT/GRADE LEVEL

Subject Area: Biology
Grade Level: 9-12

Optional Area: Physical Science, Chemistry, Environmental Science

Grade Level: 9-12

Materials

Engage: Students will need access to the video links and the student reflection worksheet to record their thoughts during the video.

Explore: Students will need access to a LaMotte Water Test Kit/Lamotte GREEN program kit, equivalent test strips, a safe drinking water reference sheet, and the Student Lab Sheet. Due to the color of some samples, pH paper is also encouraged. An optional coliform water test kit could be incorporated. Teachers will need the following supplies for lab prep: 1 gallon of distilled water, seven 250 ml beakers, metal scoopula, three watch glasses or weight boats, a digital scale, and two 10 mL pipettes/pumps. If completing the coliform bacteria test, an *E. coli* K12 sample from Carolina Biological (or another supplier)(or another supplier) will be needed. Teachers will access this Teacher Lab Sheet.

Explain: Water Quality powerpoint

Extend: Student worksheet
Per group:
Graduated cylinder, digital scale, empty 1 L bottle (can substitute 2 L), scissors, paper towels, cheesecloth, rubber bands, metal scoopula, weigh boats

Available to class:
zeolite, cotton balls, old socks, kitchen mesh strainer or screen, coffee filters, aquarium gravel,sand, uncooked macaroni noodles, activated carbon, paper cups, plastic cups, pH paper or pH probe, etc.
LaMotte Water Test Kit, Coliform Water Test Kit, small Secchi disk strip for lab use

Sample Wastewater:
In an empty 1-gallon jug add:
2 cups distilled white vinegar, ½ cup of topsoil or sand, several drops of yellow food coloring, 2 complete multivitamin tablets (adult 50+ is best), dust swept from the floor, a handful of pet/ human hair, 3 grams of Miracle Gro plant food, and enough water to fill the jug.

Evaluate:
Students will need access to Canva or other infographic template, rubric, optional: graphing program (Create a graph

STANDARDS

Next Generation Science Standards

- LS2.C: ECOSYSTEMS DYNAMICS, FUNCTIONING, AND RESILIENCE
  A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

- ESS2.A: EARTH MATERIALS AND SYSTEMS
  Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

- ESS3.C: HUMAN IMPACTS ON EARTH SYSTEMS
  *The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

  *Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that precludes ecosystem degradation.

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling. (*HS-PS2*-6).

- CCSS.MATH.CONTENT.HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (*HS-PS2-6*).

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.SL.11-12.1.A: Come to discussions prepared, having read and researched the material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.

- WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (*HS-PS1-3*).

- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (*HS-PS1-3*).

- RST.11-12.1 (HS-PS2-6) Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

- WHST.11-12 Write informative/explanatory texts, including narrating historical events, scientific procedures/experiments, or technical processes. (*HS-PS2-6*).

LESSON OBJECTIVE(S)

- Students will determine what effects pollution has on the water quality of drinking water.
- Students will investigate the chemical aspects of water samples.
- Students will investigate the coliform bacteria presence in water samples.
- Students will determine pH of several water samples.
- Students will evaluate a series of samples and assess ranking safest to most contaminated based on water quality measurements.
- Students will explore different methods for filtering water samples.
- Students will take on responsibility by taking on an active role in the design process and learn how to communicate, organize, and evaluate others.
- Students will design, construct, and evaluate a filter apparatus for water samples.
- Students will peer review other groups' designs for filter apparatus.

CAREER CONNECTION(S)

Mentor Background: My name is Dr. Jesse Roberts, I'm a research chemical engineer within the Environmental Laboratory at the U.S. Army Engineering Research and Development Center (ERDC) in Vicksburg, MS. We provide solutions for tomorrow's environmental challenges by finding new ways to clean water and remediate environmental contaminants. My role focuses on developing and characterizing new materials for synthetic biology and environmental applications. Specifically, I work with graphene nanomaterials to remove harmful cyanotoxins from water sources that pose a significant risk to human health. I have my PhD in chemical engineering from the University of Arkansas where I focused on biomaterial development for tissue engineering and biosensing applications. My team serves to make the world better by developing and utilizing materials to provide sustainable water infrastructure through clean and safe water.



STEM Careers: entomologist, structural engineer, geneticist, chemical engineer, zoologist, ecologist

ENGAGEMENT

Brief Description: While watching the video, you should determine what is happening and why the water is so bubbly and smelly. Watch and discuss the video in a small group. Be prepared to share your ideas or turn in your answers.

Procedures: 1 class period (47 minutes)
Students will watch and discuss the video in a small group. Students should be prepared to share their ideas or turn in their answers.
This Young Woman's App Lets Anyone Test Water Safety Levels | NowThis
TIME: 4:01

Option 2:
Inventing Tomorrow – Trailer – SFF 18
TIME: 1:13

Student Reflection Worksheet: Inventing Tomorrow: Water Quality

Would you want to drink water from this source in the video?
Would you want to take a vacation or field trip to an area like this?
Can you think of anywhere in the US that has a similar water pollution situation?
What do you think has contaminated this area?
What can be done to improve and restore this lake?

EXPLORATION

Brief Description: "Would I Drink This?"

Students are given a hypothetical situation regarding walking into a cabin and finding several samples of water that may or may not be consumable. They will be asked if they would be comfortable drinking the sample and must justify why or why not.

This will be conducted in three stages:

1. No equipment- just vision and olfactory senses used to determine drinkability.
2. Test kits or strips introduced- students test the chemical nature of the water samples and adjust opinions as necessary.
3. Bacterial testing (if time permits).

Students will evaluate the samples and rank them in order of safest to most dangerous for consumption. They must include a justification for the ranking.

Procedures: 2-3 class periods (47 minutes each)

Teacher Lab worksheet

Student Lab worksheet

Scenario:

You find yourself stranded in the woods after getting lost on a hike. Having hiked over 10 miles you are super thirsty. Luckily, you see an abandoned cabin. You enter the cabin and see several jars of liquids.

1. First, observe each jar of liquid your group has been given and record any observations you noticed that would give you clues about whether the water was safe or unsafe to drink. Be thorough in your description, including as many adjectives as you can think of to describe the sample. Use good lab safety techniques with each sample. Complete the provided data table (student lab worksheet).
2. Use the provided testing equipment to gather additional data about each sample. Complete the provided data table (student lab worksheet).
3. Water quality is regulated by the Environmental Protection Agency. Laws have been passed (Clean Water Act, Safe Drinking Water Act) to protect citizens. The FDA regulates bottled drinking water. The CDC provides information about drinking water from several sources. According to an expert at the Missouri American Water Company, the below document illustrates the recommended levels for drinking water.
   Drinking Water Reference Sheet
   Please compare these values with the values tested above. Highlight any level that is too high in pink. Highlight any level that is too low in yellow. Highlight any level that meets the recommended standard in green. Use the previously completed data table to do the highlights (student lab worksheet).
4. OPTIONAL: The EPA considers total coliforms a useful indicator of other pathogens for drinking water. To determine safe drinking water, a bacterial test needs to be conducted. Use the provided bacterial test kit and reference guide to record the presence of coliform bacteria. Complete the provided data table (student lab worksheet).

5. **Evaluation time!** Now that you have collected qualitative and quantitative data on all samples, please rank the samples in order of “safest” to “most dangerous” to drink. Complete the provided data table (student lab worksheet).

EXPLANATION

Brief Description: Students will learn about different chemical factors that can be tested to determine water quality. In addition, students will examine recommended levels for these factors based on research conducted by national/ international organizations such as the World Health Organization and the Environmental Protection Agency. Lastly, students will learn about different ways to filter water such as microfiltration, boil/heat, mechanical, and activated carbon.

Procedures: 2 class periods (47 minutes each)

Students will review the Water Quality powerpoint to understand the chemical factors that can be tested to determine if drinking water is safe. Students then need to review filtration methodology for removing different chemicals, microbes, and physical traits (ex. cloudiness) using the provided Water Filtration Types powerpoint.

Students will then evaluate two hypothetical samples to apply this knowledge.

Student worksheet: Hypothetical Water Sample Evaluation

Teacher worksheet: Hypothetical Water Sample Evaluation ANSWER KEY

ELABORATE

Brief Description: Students will bring in water samples or go on a walk around the neighborhood to gather water that they think may be contaminated or polluted in some way. They will then use water quality testing previously learned to design the best water filter they can to remove the materials. They will then run the water through the filter they make to see the changes in the water quality readings. If time permits they will revise their original water filter prototype and filter water a second time to look for improvements to their design and the quality of the water.

Procedures:

Student Sheet

Teacher Sheet

Peer Review Sheet

Students will be encouraged to bring in samples of water they believe to be polluted to test which contaminants might be within the water and then to design and build a water filter. This water filter will then be used to try to remove the chemicals.

Step 1: Student groups will either bring in a sample of water or be given a previously made-up sample of polluted water.

Step 2: Student groups will test the water sample with known water quality tests.

Step 3: Once the students know what pollutants they have in their sample they will design a model of a water filter to remove those pollutants. Student groups will then peer review each other's designs and offer solutions. The group will then evaluate all the information and decide on the final design.

Step 4: The finalized design of the water filter prototype will be built and tested and the water quality tests will be re-run to compare to the original data.

Step 5: Prototype changes to the water filter design can be made and tests rerun if desired results do not match actual results.

EVALUATION

Brief Description: Students will finalize the engineering design process by communicating their solution and water filter design they built into an infographic that includes a design model, an advertisement of the effectiveness of their design, and a graph that shows which contaminants and how much were removed.

Procedures:

The design will be evaluated for its effectiveness in removing the pollutants and communicated to the class or school as an infographic poster presentation where they create an advertisement as the best water “cleaners” in the area or that their water source is now the “cleanest in town” They will incorporate models, graphs, and calculate the efficiency of their water filter to clean the water. Rubric is attached to both the teacher and student sheet above.

Additional Resources

REFERENCES

- *Choosing Home Water Filters & Other Water Treatment Systems | Drinking Water | Healthy Water | CDC*. (n.d.). https://www.cdc.gov/healthywater/drinking/home-water-treatment/water-filters.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fparasites%2Fcrypto%2Fgen_info%2Ffilters.html. Accessed 20 June 2024.

- Connecta't. (2022, April 19). *Understanding the application of zeolite for water filtration*. Understanding the application of Zeolite for water filtration. https://www.keiken-engineering.com/news/zeolite-for-water-filtration

- Educator Guide: Water Filtration Challenge | NASA/JPL Edu. (2022, May 31). *NASA/JPL Edu*. https://www.jpl.nasa.gov/edu/teach/activity/water-filtration-challenge/. Accessed 18 June 2024.

- *Filter Your Water - Bell Museum*. (2020, July 14). Bell Museum. https://www.bellmuseum.umn.edu/activities-for-kids/exoplanet-exploration-grades-7-8/filter-your-water-experiment/. Accessed 20 June 2024.

- Freitas, Taylor. *10 Types of Water Filters: Find the Clear Choice for Your Home*, Angi, 11 June 2024, www.angi.com/articles/which-water-filter-best-me.htm. Accessed 20 June 2024.

- "Guidelines for Drinking-Water Quality - Iris Home." *Guidelines for Drinking Water Quality-4th Edition*, iris.who.int/bitstream/handle/10665/44584/9789241548151_eng.pdf. Accessed 19 June 2024.

- *How to Make a Water Filter – H2O Distributors*. (2023, December 5). H2O Distributors. https://www.h2odistributors.com/info/how-to-make-a-water-filter/. Accessed 20 June 2024.

- "LaMotte- Coliform Test." *Coliform Bacteria Test Kit Instructions*, LaMotte, lamotte.com/amfile/file/download/file/791/product/268/. Accessed 20 June 2024.

- *Making Water Safe in an Emergency*. (2022, November 16). Centers for Disease Control and Prevention. https://www.cdc.gov/healthywater/emergency/making-water-safe.html#:~:text=Bring%20the%20clear%20water%20to,sanitized%20containers%20with%20tight%20covers. Accessed 20 June 2024.

- Mosley, Singh, & Aalbersberg. (2005). Water quality monitoring in Pacific Islands. https://www.researchgate.net/figure/World-Health-Organization-WHO-Drinking-Water-Quality-Guidelines_tbl2_255700290

- *National Primary Drinking Water Regulations*, Environmental Protection Agency, www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulation. Accessed 19 June 2024.

- "pH in Drinking-Water Revised Background Document for Development of WHO Guidelines for Drinking-Water Quality ." *Guidelines for Drinking-Water Quality*, www.epa.gov/sites/default/files/2014-03/documents/guidelines_for_drinking_water_quality_3v.pdf. Accessed 20 June 2024.

- US Department of Commerce, National Oceanic and Atmospheric Administration. *What Is Eutrophication?*, NOAA's National Ocean Service, 2 Apr. 2019, oceanservice.noaa.gov/facts/eutrophication.html#:~:text=the%20nation's%20estuaries.-,Harmful%20algal%20blooms%2C%20dead%20zones%2C%20and%20fish%20kills%20are%20the,to%20estuaries%20and%20coastal%20waters. Accessed 19 June 2024.

- *Revised Total Coliform Rule And Total Coliform Rule*, Environmental Protection Agency, www.epa.gov/dwreginfo/revised-total-coliform-rule-and-total-coliform-rule. Accessed 19 June 2024.

- Saalidong BM, Aram SA, Otu S, Lartey PO. Examining the dynamics of the relationship between water pH and other water quality parameters in ground and surface water systems. PLoS One. 2022 Jan 25;17(1):e0262117. doi: 10.1371/journal.pone.0262117. PMID: 35077475; PMCID: PMC8789185.

- *Turbidity and Water. U.S. Geological Survey*. (2019, October 22). https://www.usgs.gov/special-topics/water-science-school/science/turbidity-and-water. Accessed 20 June 2024.

- Water--EPH-DW--4200, Drinking. "Coliform Bacteria in Drinking Water." *Coliform Bacteria in Drinking Water*, Washington State Department of Health, doh.wa.gov/community-and-environment/drinking-water/contaminants/coliform#:~:text=exist%20in%20feces.-,E.,either%20fecal%20coliform%20or%20E. Accessed 19 June 2024.

- Water quality monitoring in Pacific Islands - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/World-Health-Organization-WHO-Drinking-Water-Quality-Guidelines_tbl2_255700290. Accessed 20 Jun, 2024.

- *Water Quality Testing Parameters*. Missouri Department of Natural Resources, Department of Natural Resources, dnr.mo.gov/water/hows-water/monitoring-data/quality-assessment/testing-parameters. Accessed 20 June 2024.

- *Technical Information on Home Water Treatment Technologies.* Home Water Treatment Drinking Water, Healthy Water, CDC, www.cdc.gov/healthywater/drinking/home-water-treatment/household_water_treatment.html. Accessed 20 June 2024.