ACTIVITY 4

Testing Local Water

FIELD TRIP

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ACTIVITY SUMMARY

Students utilize a smartphone app (such as HydroColor, an app that measures turbidity) to gather water quality data of a local water body, such as a lake. They compare the data collected from their scientific tool to the data collected by their senses. The class discusses how the use of new technologies can enhance the contribution of nonscientists to data collection.

ACTIVITY TYPE
FIELD TRIP

NUMBER OF
40–50 MINUTE
CLASS PERIODS
2

KEY CONCEPTS & PROCESS SKILLS

1 New scientific tools and techniques contribute to the advancement of science by providing new methods to gather and interpret data and can lead to new insights and questions. Technology can enhance the collection and analysis of data.

2 Various observations of a single phenomenon from human senses and scientific tools can be used to verify the accuracy of evidence.

3 Through science, humans seek to improve their understanding and explanations of the natural world. Individuals and teams from many nations and cultures have contributed to the field of science.

CONCEPTUAL TOOLS

SENSES & INSTRUMENTATION

SCIENCE AS A HUMAN ENDEAVOR

MATERIALS & ADVANCE PREPARATION

FOR THE CLASS

- ACCESS TO A LOCAL WATER BODY (such as a lake)

FOR THE TEACHER

- VISUAL AID 4.1 "World Health Organization Drinking Sample Water Standards"

FOR EACH GROUP OF FOUR STUDENTS

- 18% GRAY-SCALE CARD
- DISTILLED WATER SAMPLE (in clear container)

FOR EACH PAIR OF STUDENTS

- pH PAPER WITH pH SCALE
- SMARTPHONE WITH HYDROCOLOR (or similar) APP

FOR EACH STUDENT

- PLASTIC SANDWICH BAG (OPTIONAL)

As first stated in Advance Preparation, Planning Ahead for Activity 1, this activity is a field trip that involves visiting a local water body, such as a lake. In order to use the app, it is necessary to have a site that:

- is optically deep (has a water depth where the light reflection from the bottom does not influence the light leaving the surface).
- has a pier or other outcropping to access water at depth.
- has connectivity. If there is no signal or service, the app will not work at the site.

Prepare for this activity by identifying a local site; providing students with permission slips; having students download the app; arranging transportation for the class; and organizing a teacher substitute, if necessary. Practice using the app prior to conducting the activity with the class. You may wish to have students place phones in sealed sandwich bags and only remove them as needed to avoid any accidents.

Depending on the availability of materials, you may also wish to have students take additional water quality measurements, such as dissolved oxygen or nitrogen. If you have access to turbidity meters or turbidity tubes, you may wish to take measurements using them to compare to the measurements taken on the HydroColor app. You may also choose to bring back water samples for students to examine under a microscope to look for the presence of both beneficial and harmful living organisms as water quality indicators. Modify the activity as needed to address your local environment and access to materials.

If you are not able to arrange for a field trip or have other challenges completing the activity as written, you may wish to arrange an alternative. Options include:

- Gather local water samples to bring to class and provide location photos and turbidity data that you have collected, using the app.
- Gather local water samples to bring to class and use an alternative test for turbidity in the classroom, such as a single turbidity test kit for the class to share. A turbidity test kit, while expensive, contains a bottle of standard turbidity reagent, two 50 mL graduated cylinders, distilled water, and a stirring rod that can be used for testing multiple samples.
- Gather local water samples to bring to class, test the samples for turbidity with the HydroColor app, and evaluate the validity of the resulting data (since the app is designed for use directly with bodies of water).
- Find turbidity and pH data for local reservoirs or water bodies through your local municipal water district and share the data with the class.
- Borrow a set of turbidity meters (or Secchi disks, which also require a pier or other method for taking measurements at depth) from a local college or university to test turbidity at a local lake or pond.
- Complete the activity without testing for turbidity and use tap water (from a different source than the one used in Activity 2) in lieu of water sampling of a local water body.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion** are highlighted in blue.

GETTING STARTED (10 MIN)

1 **Prepare the class for the field trip by reviewing safety rules and making sure that students have access to a smartphone app and other required materials.**

- Depending on the location of your school and your student body, you may have constraints with completing the activity as written. Make modifications as needed (see Advance Preparation), gather available materials, and prepare students to complete the activity safely.
- Review in advance the water quality observations and tests that students are expected to conduct and how they are expected to complete them.

PROCEDURE (30-90 MIN)

2 **Students observe their surroundings.**

Remind students that science is grounded in observation, and an essential practice of naturalists is simply to observe their natural surroundings. Have them take a few minutes in silence, looking, listening, and smelling the area around the body of water to observe as much as they can. Have students share their observations with a partner.

3 **Students make an initial water quality assessment.**

Here, the comparison is of water in a local water body outdoors to distilled water, which is known to have no contaminants or turbidity.

4 **Students test a local water body for turbidity and pH.**

- Table 4.1 in the Student Book contains a turbidity value of <0.1 NTUs for distilled water, though measurements using classroom equipment may not be so precise, and the app is designed for use with deep water bodies (and not water samples). If you are using another method of determining turbidity, you may wish to take your own measurement of the turbidity of distilled water.
- Students should measure pH, using the method of pH paper as instructed in Activity 2.
- Procedure Step 6 describes how to use the HydroColor app to take a turbidity measurement at a local water body. Assist students as necessary in using an app.

5 **Students compare their pH and turbidity measurements and make a final water quality assessment.**

After completing their measurements, students should compare their data to the information found in the Science Review for Activity 2 and the information in Table 4.2 of the Student Book. Students should utilize these comparisons to make a final water quality assessment and explain their reasoning. A sample student response is shown here.

Sample student response, procedure step 1

TABLE 4.1: TESTING LOCAL WATER

WATER SAMPLE	OBSERVATIONS OF ODOR AND APPEARANCE	INITIAL WATER QUALITY ASSESSMENT AND REASONING	pH	TURBIDITY	FINAL WATER QUALITY ASSESSMENT AND REASONING
distilled water (control)	*no odor; appears clear (no color or suspended solids)*	*very good because it looks and smells fine; not sure if it has other chemicals in it*	*7*	*<0.1 NTUs*	*Very good because both the pH and turbidity data are the same as my observations and fall within ranges for good water quality for drinking water.*
local water body	*smells slightly musty; slightly cloudy brown*	*okay; probably has bacteria and other stuff we aren't testing*	*8*	*5 NTUs*	*Good; pH and turbidity were better than I thought they would be and fall within ranges for water recreation.*

SYNTHESIS OF IDEAS (10 MIN)

6 **The class discusses the use of new technologies to gather evidence.**

- Having completed water quality assessments based on odor, appearance, pH, and turbidity, students may have questions about other water quality indicators and their recommended (or legal) limits for safe drinking water. Use Visual Aid 4.1, "World Health Organization Drinking Sample Water Standards," to review some additional water quality indicators that are measured to determine safe drinking water. Discuss what impact these standards can have globally.

- Highlight the idea that water quality standards vary for different uses as well as for different organisms. The focus of this unit is primarily on drinking water. Standards exist for recreational use of water bodies as well as ecological standards for other living organisms.

- Have students discuss what was easy and what was challenging with using the app to collect turbidity data. Ask, How can technology enable nonscientists to contribute to data collection (that is, crowdsourcing)? The Internet and smartphones make it possible for anyone with an Internet connection to contribute observations to a central database and to look at the whole collection of information. Smartphones often have many tools for detecting and recording different types of data, including sounds, photos, videos, temperatures, geolocations, etc. As a result, there are increasing numbers of scientific projects that are utilizing crowdsourced data to create a bigger snapshot of what is happening in different parts of the world.

- Discuss how new technologies can improve the availability of evidence and enhance the contribution of nonscientists to data collection, resulting in larger data sets and increased scientific evidence. Ask, What are the advantages and disadvantages of crowdsourcing data collection? Crowdsourcing makes it possible to collect a much larger amount of data from a larger geographic area over more time than a team of professional scientists or even volunteers can do on their own. It also means that more people can be part of the process of science, contributing and learning from one another. One disadvantage is that the data may be of lower quality and reliability, since the people collecting it are not all trained in common methodologies. Such datasets might also be vulnerable to people trying to influence the conclusions made from the data (i.e., trolls). It is only possible to gather data from places where people are participating and making observations that they think are worth adding, so scientists have to be careful in interpreting the data; there might be missing data in places without much participation or when observations by untrained people are determined not to be relevant. Connections to Everyday Life items 4 and 5 provide an opportunity for students to apply their own thinking to the use of this technology.

- Ask, How can new technologies make new evidence available? New technologies make it possible to observe phenomena not visible to human senses or measured by previously existing technology. Then ask, How can new technologies help validate previously existing evidence? More precise or accurate technology can also help validate results from older technology.

- Complete the activity by evaluating if your students are able to identify the essential ideas of the activity related to the key concepts and process skills by revisiting the Guiding Question, *How can technology improve people's ability to collect information about the natural world*?

EXTENSION (10-30 MIN)

7 Use the Extension as an opportunity for advanced learning.

Students can conduct additional water quality tests on samples from your local water body. Highlight the use of human senses, as well as scientific tools and technology, in gathering data to evaluate the health of aquatic ecosystems and local water sources such as reservoirs.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① **What was the difference between the information you were able to discover with your senses alone compared to the information you were able to discover with the pH and turbidity tests?**

I could make observations about the general appearance of the water and odor. My senses could not provide pH information and could only provide a general observation of turbidity. The tests provide measurable values that I could compare to other groups to determine accuracy and reliability of the data.

② ***Cryptosporidium* is a microscopic parasite that can cause gastrointestinal illness in humans and animals. At one stage of its life cycle, it can become part of the solids suspended in the water column. Which water-quality test—pH or turbidity—would be a more valid test for the presence of this organism in drinking water? Explain.**

Turbidity is a more valid test because turbidity measures suspended solids, and Cryptosporidium *can be part of that material. pH would not provide any information about the parasite (unless, for example, there was information about a pH range in which it could survive).*

③ **Do you have enough evidence to determine if your local water body could meet drinking water quality standards, such as the ones listed in Table 4.3? Why or why not? Address strengths and/or limitations in the evidence in your response.**

I do not have enough evidence to determine if the water body meets these drinking water standards. I had several pieces of evidence to support the idea that the water quality was good (odor, appearance, pH, turbidity). The quality of evidence from the measurements taken with scientific tools (pH and turbidity) was accurate. It was reliable because most groups had the same results. I don't have enough evidence to determine if the water body meets other drinking water standards, such as tests for lead or other contaminants.

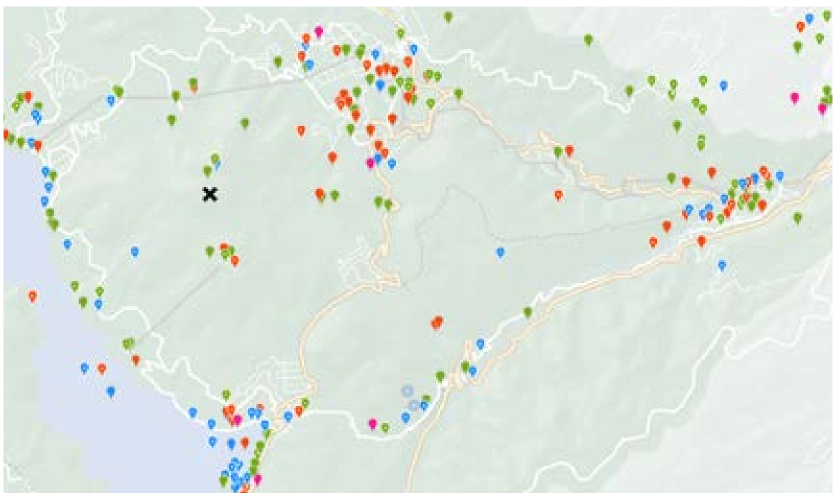
TABLE 4.3
SOME DRINKING WATER QUALITY STANDARDS

WATER QUALITY TEST	MAXIMUM ALLOWABLE LIMIT
Cryptosporidium parasite	0
E. coli bacteria	0
Lead	0
Nitrates	10 mg/L
pH	6.5 – 9
Turbidity	< 0.3 NTUs

CONNECTIONS TO EVERYDAY LIFE

④ **Technology is being used to collect scientific data in many ways. In the iNaturalist app, users contribute observations of plants and animals, which can then be identified through photos. The app generates maps that show where different species were observed. Biologists can use the app to track biodiversity and animal ranges.**

The following map is an example of an iNaturalist map from Fuji Hakone Izu National Park in Japan. It is a mountainous area with many hiking trails. Look carefully at the map and notice the pattern of data. Would it be valid to use this data to determine the habitats of local plants and animals? Why or why not?



INATURALIST MAP

- plants
- vertebrates
- invertebrates
- fungus and lichens

A sample student response is shown here. Look for accurate reasoning that demonstrates an understanding of validity when evaluating student responses.

It would not be valid to use this data to determine the range of local organisms because the data is collected by people on hiking trails. This means that there are areas on the map where very little data is collected, and information about an organism's habitat would be missing.

⑤ **Today there are an increasing number of apps that provide opportunities for citizens to contribute data or access information about the natural world. One such app is the U.S. Environmental Protection Agency's Bloomwatch app. It educates users about algal blooms—the rapid growth of algae that results in a layer of greenish scum on the surface of a body of water. Users can upload photos and provide additional information about observed blooms. Do you think information from such apps should be used to make government policy? Why or why not?**

Student responses will vary. A sample response is provided here:

I think this data should be used to create policy because lots of people gathering information will increase the amount of evidence. The use of apps, especially with photos, means that the evidence can be evaluated by others, including scientific experts. Large amounts of reliable data can provide strong evidence for making decisions about policy.

REFERENCES

iNaturalist. Available from https://www.inaturalist.org. Accessed June 2022. Retrieved from https://www.inaturalist.org/observations?nelat=35.25733755&nelng=139.16704295&place_id=any&subview=map&swlat=35.16452535&swlng=138.94757515

The University of Maine, School of Marine Sciences In-situ Sound & Color Lab. Hydrocolor app. Available from Apple App Store, Google Play Store, Facebook Page. Retrieved from http://misclab.umeoce.maine.edu/research/HydroColor.php

STANDARD	MAXIMUM ALLOWABLE LIMIT
Aluminum	0.2 mg/L
Calcium	75 mg/L
Cryptosporidium parasite	0
E. coli bacteria	0
Iron	0.3 mg/L
Lead	0
Magnesium	50 mg/L
Nitrates	10 mg/L
pH	6.8 – 8
Total dissolved solids (TDS)	1000 mg/L

VISUAL AID 4.2 | 18% GRAY-SCALE CARD