Water Quality: An Analysis of the Chemicals and Pollutants Within

Lesson Plan for Grades: 11th-12th grades *(due to sensitive topic, lesson plan materials/video resource should be viewed only by the teacher and used appropriately to maintain a safe learning environment)*
Length of Lesson: Two 45-minute class days (Day 1: 45 minutes, not including ~20 mins time needed to leave the classroom and go to nearby pond, etc.; Day 2: 45 mins)

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Date created: 5/2/19

Subject area/course:
- Biology II
- Environmental Science (main focus area)

Materials:
- board/projector for Engage warm-up (for teacher)
- Water Quality Handout (1 per student)
- access to computer with internet (1 per student OR 1 per group)
- blank piece of paper and/or large poster board (1 per group)
- water quality testing kits, to specifically measure pH, heavy metals (like lead, iron, calcium, etc.), and/or other chemical pollutants. (1 per group)
- 3 plastic test tubes with lids that can hold 20-45 mL of water (1 set of 3, per group)
- 3 plastic, disposable 1-mL dropper (1 set of 3, per group)
- 1 thermometer (1 per group)

TEKS/SEs:

§112.34. Biology (One Credit), Adopted 2017.

(c) Knowledge and skills.

(12) Science concepts. The student knows that interdependence and interactions occur within an environmental system. The student is expected to:

(E) describe how environmental change can impact ecosystem stability.

§112.37. Environmental Systems, Beginning with School Year 2010-2011 (One Credit).

(c) Knowledge and skills.

(4) Science concepts. The student knows the relationships of biotic and abiotic factors within habitats, ecosystems, and biomes. The student is expected to:

(E) measure the concentration of solute, solvent, and solubility of dissolved substances such as dissolved oxygen, chlorides, and nitrates and describe their impact on an ecosystem;

(5) Science concepts. The student knows the interrelationships among the resources within the local environmental system. The student is expected to:

(B) identify source, use, quality, management, and conservation of water;

(9) Science concepts. The student knows the impact of human activities on the environment. The student is expected to:

(A) identify causes of air, soil, and water pollution, including point and nonpoint sources;

(B) investigate the types of air, soil, and water pollution such as chlorofluorocarbons, carbon dioxide, pH, pesticide runoff, thermal variations, metallic ions, heavy metals, and nuclear waste;

(C) examine the concentrations of air, soil, and water pollutants using appropriate units;

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(E) evaluate the effect of human activities, including habitat restoration projects, species preservation efforts, nature conservancy groups, hunting, fishing, ecotourism, all terrain vehicles, and small personal watercraft, on the environment;

Lesson objective(s): Students Will Be Able To (SWBAT):

- test water quality based on specific chemical pollutants
- interpret water quality results for possible exposed species and ecosystems
- identify probable causes of pollutants and chemicals in tested water and other local waters
- create a public service announcement regarding the significance of water quality testing to protect ecosystems and our health

Differentiation strategies to meet diverse learner needs:

- Students will work on any readings in groups and discuss as a table, so if a student doesn't fully understand, they can be informed and caught up in a low pressure scenario.
- Roles will be differentiated that students will be allowed to choose for themselves, so if a student isn't comfortable writing a lot, for example, they can choose not to be the scribe for their group.
- ELL students and students with learning disabilities should have multiple forms of instruction including visual and written instruction sheets as well as a verbal instruction and demonstration.

ENGAGEMENT (8 minutes)

- On Day 1 of the two-day lesson plan, the teacher will start the class by posing the following question as a warm-up: "What factors determine whether water is drinkable for humans?"
    - Possible student responses: *really low salinity, if there's bacteria present, if other animals can drink it, if it has nutrients, etc.*
- The teacher should have this question written on the board/projector and displayed to the students. The teacher should explain that this warm-up is a Think-Pair-Share activity, where students will write down their thoughts on a piece of paper (1 minute), then share their responses with their classmate sitting next to them (3 minutes), and then finally share with the class (2 minutes).
- The teacher will then go over the agenda for the day (learning about water contamination and pollutants as the main topic for the lesson) and transition to the Exploration. (1-2 minutes)

EXPLORATION (40 minutes)

Explore Day 1: *(20 minutes, not counting time needed to get to water testing site for* ***Outside Activity,*** *and not counting time needed for water sample preparation for* ***Alternative Classroom Activity)***

- Continuing on with Day 1 of the two-day lesson plan, the teacher will go through the procedures of this activity, as follows, as well as the procedures for completing the Water Quality Handout:
- In groups of 4, students will be instructed to test out different variables for their water samples. They will first be instructed to bring their Water Quality Handout, 3 clean, empty test tubes (that have lids), along with their test kits (for their chosen variables), and disposable droppers to transport water from different mediums.
- Students should be allowed to choose their variables from a list designated by the teacher and will be instructed to circle their variable on the **Water Quality Handout**. (prelab section)
- Before the outside activity, students will be instructed to make sure they find the EPA guidelines for their chosen chemical pollutant they wish to test for their water. They **must** record these values on their data tables and have it **approved** by the teacher prior to going outside/collecting data. (*Section I in Water Quality Handout*)

- On the provided example water testing kit link under the Resources section (based off Amazon), a disclaimer is stated that: **"Currently, it is not possible to measure trace levels of fluoride, lead, chromium, iron and copper in drinking water using visual colorimetric test strip technology. In order to measure trace levels, please obtain a digital meter, or seek lab or 3rd party testing,"** (HealthSnap, https://www.amazon.com/HealthSnap-Water-Test-Strips-Count/dp/B07CS2PGPQ/ref=sr_1_20?crid=13P91H15Z20U4&keywords=water+test+kit&qid=1558295244&s=lawn-garden&sprefix=water+test+kit%2Clawngarden%2C153&sr=1-20).
- The teacher should be make sure students are aware of this so that they don't choose chemicals that occur in trace amounts (due to the trace chemical measuring abilities of the testing kit).

- Students will be given time in class to do their pre-lab section research and complete the EPA guideline portion of their data tables. They can work together as a group, but each student will write on their own handout.
  - Ensure that students understand what this research means by asking questions- What is this pollutant composed of? Where else have you seen this? Would you want it in your body? Does it belong in the ecosystem we will be viewing?
- Students will be either taken outside to a nearby pond/local source of water **OR** be given pre-prepared water samples (representing water from different sources, like a pond, river, sea, etc.) to conduct their experimental data collection.

  For outside excursion:
  - Students will be instructed to test for pH at the site (as testing pH of sampled water is rendered inaccurate). Other similar tests that require on-site testing will be listed as well by the teacher (this depends on what tests and what kit the teacher chooses during the lesson plan preparation stage). For additional chemical pollutants that require on-site testing, additional time for activity (to collect data) will be required.
  - Students will record the data collected for the test, as well as the date and time and outdoors weather temperature (using the thermometer) and rainy/cloudy/sunny weather condition (general observation). This data collection will be recorded on the Water Testing Data Tables on the Water Quality Lab Handout. (Section II)
  - Students will be also be instructed to take samples of water for classroom tests, if needed (that don't need to be taken on-site, in order to save class time).
  - Teachers should allow for student-directed learning during this time, but should also be highly engaged while students are collecting water samples, asking questions of the students one-on-one or while they are working in groups.
  - If students get done early with collecting data (for nearby ponds that don't require long commutes), students can begin answering questions on the Water Quality Lab Handout (see "Explore Day 2" section below).

Explore Day 2: *(20 mins)*

- For classes that started this section on Day 1 (in case of shorter commute time to pond), the teacher can pose a question for students to answer and write a response to, on a blank piece of paper: "Is it possible to clean water that is contaminated? Suggest several possible ideas for potentially cleaning polluted/un-drinkable water?"
- This question should serve as an Engage in this situation and would last 5 minutes (2-3 mins writing, and remaining time to discuss as a class).
  - *Expected Student Responses: Yes, but it's costly and not efficient. Desaline water in plants (to reduce NaCl concentrations and TDS), boil water (to kill off most*

pathogens), use chemical agents that react with and change the chemicals present in water (look at EPA website), etc.

- On Day 2 of the two-day lesson plan, students will begin class by finishing collecting data from the sampled water (if needed), and recording their results.
- The teacher will introduce this part of the activity with a refresher on how to find an average. (Section III of *Water Quality Handout*)
  - Average = (Sum of Trials)/ (Number of trials, which in this case is 3)
  - Students will individually take the average and of their 3 samples of the water (per each variable they tested).
- They will then compare their results to their group members to check and revise their calculations/solutions.
- They will record the average on the data tables, and answer the questions listed on the Lab Handout (as a group). (Section IV)
  - The given questions relate to the consequences of having their specific chemical be above the accepted EPA drinking water range (for animals, humans, and ecosystems).
  - During this time, the teacher will circulate and ask probing questions relating to the environmental impact of having contaminants in drinking or surface water.

EXPLANATION (15 minutes)

- Continuing on with Day 2 of the two-day lesson plan, students will present their group's findings (the results and extensions sections of the Water Quality Lab Handout) for their specific chosen variables to the class. Each group will have 2 minutes to present, and as each group presents, the teacher will draw the class' attention to similar or different findings in the case of multiple groups choosing some of the same variables. The teacher will also ask students what may have lead different groups who chose the same variable to have different observed values (lead into a small discussion on student error or error with the kit).
  - As a follow up, ask students: "Does it matter what water testing kit we use?"
  - "Even if we use the same type and brand of water testing kits, can using different ones (of the same brand and type), change the results or cause an error? Why?"
  - "How could we reduce error if we were to re-do this entire activity again as a class?"
- The teacher will ask these types of probing questions throughout the presentations. The teacher will also ask about the significance of noting the weather conditions and temperature for each variable and trial (as well as date and time).
  - *Expected student response:* rainy weather, may have raised the pH, testing water, post-lots of rainfall, may lead to water that is filled with runoff chemicals, testing water in the winter may be different than in the summer (due to temperature differences), it's important to note extra information when recording data, as it may serve useful when analyzing the data and looking for patterns/trends in order to come to conclusions.
- Discussion of what affects these issues could have on cohesive ecosystem as well as humans after consumption
  - How could animals and people be affected by changes in these chamicals in an ecosystem?
  - Would this affect more than just humans?
  - What are the long term results?
  - If a chemical is present just for a short amount of tme, would it make a difference? Why/ why not?

ELABORATION (15 minutes)

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- After the Explain, which will occur on Day 2 of the two-day lesson plan, students will be given a task: to create a PSA poster or brochure to promote the importance of their chosen variables for the public to be aware of, for water quality testing. This will be done in the same groups of 2-3 students, with each student needing to participate in the final product creation process.
- Students will read the first 4 paragraphs of Rachel Carson's "Silent Spring": https://www.newyorker.com/magazine/1962/06/16/silent-spring-part-1
  - When do you think this article was written?
  - What relevance does this have to today's world?
  - What does this have to do with our lab?
- Students will have to list explanations for the importance of testing all water (pool, well, tap, etc.) as well as surface water in local areas. Students will make sure to name some human activities (like overfishing) which can have negative consequences on bodies of water, and some human activities (like water conservation) that can have a positive impact on water quality and the ecosystem. They can also include real world examples or quotes from the Silent Spring reading. Students will be provided a large poster board or blank white paper to create a large PSA poster or brochure.
- The teacher will collect all student work (as summative assessment artifacts).
- Vocabulary that will be introduced and talked about by students in their product:
  - pollutant
  - contaminant
  - pH

EVALUATION (throughout entire lesson)

- This will occur throughout the lesson, through either Formative or Summative assessments.
- Formative Assessment:
  - Teacher actively listening to students, while circulating around the class, during activities (throughout the lesson)
  - Student responses to the warm-up question (Engage)
  - Students participating and actively collecting data (Explore Day 1)
  - Student group presentations of Lab Handout sections (Explain Day 2)
- Summative Assessment:
  - Student responses on Water Handout
  - Student PSA/brochure creation (Elaborate Day 2)

SOURCES AND RESOURCES

- **Dr. Hayes, Tyrone's *Hot Science – Cool Talks #118,* "From Silent Spring to Silent Night: A Tale of Toads and Men", http://www.esi.utexas.edu/talk/silent-spring-ii/**
- **Example of Water Testing Kit (multiple tests in one),** https://www.amazon.com/HealthSnap-Water-Test-Strips-Count/dp/B07CS2PGPQ/ref=sr_1_20?crid=13P91H15Z20U4&keywords=water+test+kit&qid=1558295244&s=lawn-garden&sprefix=water+test+kit%2Clawngarden%2C153&sr=1-20
- **EPA,** https://www.epa.gov/dwstandardsregulations

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STUDENT HANDOUT:

Name _____ Date _____

Water Quality Handout

Choose variables to test in water and circle the 2 variables you've chosen:

Chlorine Nitrite Bromine Alkalinity Cyanuric Acid

Procedure

In your groups, decide who will be completing each role between researcher, collector, and scribe. Then, complete the following questions after visiting the EPA site to research your topic. You should all be participating in the research, even though the researcher is the one typing and managing research!

Section I. EPA Research:

List 3 facts you find about your chosen variable that are relevant to water consumption:

Would too much or too little of this chemical or compound be beneficial or harmful to humans? In what way(s)?

What do you predict the reading will be?

On the data table below, fill out the variable names and EPA guidelines for drinking water standards (see URL: https://www.epa.gov/dwstandardsregulations).

Section II. Data Tables:

Table 1: Variable 1: _____

Trial Number:	Observed or Calculated value (units)	EPA guidelines range (units)	Date and Time, Weather Conditions and Temperature
Trial 1			

Trial 2			
Trial 3			
Average (with Std. Deviation):			

Table 2: Variable 2: _____

Trial Number:	Observed or Calculated value (units)	EPA guidelines range (units)	Date and Time, Weather Conditions and Temperature
Trial 1			
Trial 2			
Trial 3			
Average			

Table 3: Variable 3: _____

Trial Number:	Observed or Calculated value (units)	EPA guidelines range (units)	Date and Time, Weather Conditions and Temperature
Trial 1			
Trial 2			
Trial 3			
Average			

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Section III. Calculations:

- What formula did you use to find the Average:

- Show all your calculations here (show all work):

Section IV: Results:

- Which of your variable(s), if any, fell within the accepted EPA range?

- Which of your variable(s), if any, fell outside the accepted EPA range? For the variable(s), was the observed average value higher or lower than the EPA range?

- You are a scientist working for the EPA. Is this water safe to drink based on the three variables you collected data for? Why or why not?

Section V: Extension and Real-World Application:
Based on the variables you analyzed, list out some of the side effects on humans, impact on animals, impact on the ecosystem, and probable causes, if they are present at levels higher than EPA drinking water guidelines:

Variable:	Side Effects for Humans:	Impact on Animals:	Ecosystem Impact:	Probable Causes of Variable Being Present in the Water Analyzed:

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TEACHER HANDOUT:

Name:_____KEY_____

Water Quality Lab Handout

Name _____ Date _____

Water Quality Handout

Choose variables to test in water and circle the 2 variables you've chosen:

Chlorine Nitrite Bromine Alkalinity Cyanuric Acid

Procedure

In your groups, decide who will be completing each role between researcher, collector, and scribe. Then, complete the following questions after visiting the EPA site to research your topic. You should all be participating in the research, even though the researcher is the one typing and managing research!

EPA Research:

List 3 facts you find about your chosen variable that are relevant to water consumption:

Would too much or too little of this chemical or compound be beneficial or harmful to humans? In what way(s)?

What do you predict the reading will be?

On the data table below, fill out the variable names and EPA guidelines for drinking water standards (see URL: https://www.epa.gov/dwstandardsregulations).

II. Data Tables:

Table 1: Variable 1: ____*answer will vary*_____

Trial Number:	Observed or Calculated value (units)	EPA guidelines range (units)	Date and Time, Weather Conditions and Temperature

Trial 1	*answer will vary*	*answer will vary*	*answer will vary*
Trial 2	*answer will vary*		*answer will vary*
Trial 3	*answer will vary*		*answer will vary*
Average (with Std. Deviation):	*answer will vary*		

Table 2: Variable 2: ___*answer will vary*_____

Trial Number:	Observed or Calculated value (units)	EPA guidelines range (units)	Date and Time, Weather Conditions and Temperature
Trial 1	*answer will vary*	*answer will vary*	*answer will vary*
Trial 2	*answer will vary*		*answer will vary*
Trial 3	*answer will vary*		*answer will vary*
Average (with Std. Deviation):	*answer will vary*		

Table 3: Variable 3: ____*answer will vary*_____

Trial Number:	Observed or Calculated value (units)	EPA guidelines range (units)	Date and Time, Weather Conditions and Temperature
Trial 1	*answer will vary*	*answer will vary*	*answer will vary*
Trial 2	*answer will vary*		*answer will vary*
Trial 3	*answer will vary*		*answer will vary*
Average	*answer will vary*		

III. Calculations:

- What formula did you use to find the Average:
  Average = (Sum of Trials)/ (Number of trials, which in this case is 3)

- Show all your calculations here (show all work):

  answers will vary (all work, with formula and units need to be shown)

IV: Results:

- Which of your variable(s), if any, fell within the accepted EPA range?
  answers will vary

- Which of your variable(s), if any, fell outside the accepted EPA range? For the variable(s), was the observed average value higher or lower than the EPA range?
  answers will vary

- You are a scientist working for the EPA. Is this water safe to drink based on the three variables you collected data for? Why or why not?
  answers will vary, reasoning must be provided (b/c variable value was higher than EPA range)

V: Extension and Real-World Application:

Based on the variables you analyzed, list out some of the side effects on humans, impact on animals, impact on the ecosystem, and probable causes, <u>if they are present at levels higher than EPA drinking water guidelines:</u>

Variable:	Side Effects for Humans:	Impact on Animals:	Ecosystem Impact:	Probable Causes of Variable Being Present in the Water Analyzed:
answer will vary	*answers will vary*	*answers will vary*	*answers will vary*	*answers will vary*

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answer will vary	*answers will vary*	*answers will vary*	*answers will vary*	*answers will vary*
answer will vary	*answers will vary*	*answers will vary*	*answers will vary*	*answers will vary*

******Teacher Note: These answers will be dependent on student's chosen variables. Each Handout will have different responses (due to differences in data collection and variables chosen).***