

Clean Water Pollution with Photocatalytic Habitats

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for the STEM Education Center at WPI's Summer 2023 Research Experience for Teachers program

[Google Doc Version](#)

Subject: Biology

Grade Level: High School

United Nations Sustainable Development Goal:

Goal 6 Clean Water and Sanitation & Goal 7 Affordable and Clean Energy

Overview

Wallum Lake in Douglas, MA has been polluted with PFAs. The local conservation commission has requested your guidance to help engineer a way to reduce the pollutant in Wallum Lake. Studies on this new chemical called a *photocatalyst* show promising results and may be useful to you. Your task is to:

- Explain how the PFAs affect the local wildlife and humans citing evidence and reasoning.
- Determine whether the photocatalyst can successfully reduce the levels of pollutants, citing evidence and reasoning.
- Determine the conditions the photocatalyst will work best, citing evidence and reasoning.
- Design and create a prototype for a device that will help reduce the amount of pollutants. The device must incorporate the photocatalyst, and serve as an artificial habitat for wildlife living in or around the lake.
- Report back to the conservation commission about your proposed solution

Standards & Learning Targets

STE/M Standard 1 OR STE/M Practice:

HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.*

Clarification Statement:

- Examples of solutions can include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, and ecotourism.

Vocabulary	Tier 1 - Everyday	Tier 2 - School	Tier 3 - Classroom
	Human Health Pollution	Analyze Direct Indirect Evaluate Refine Impact	Biodiversity Ecosystem Habitat fragmentation Non-native/invasive species Overharvesting



			Climate change Captive breeding Habitat restoration Energy conservation Pollution mitigation Ecotourism
What do students need to KNOW ?	<ol style="list-style-type: none"> Students will use the following vocabulary words in context: <ol style="list-style-type: none"> Pollution Pollution mitigation Habitat restoration Pollution can negatively impact human and ecosystem health Pollution mitigation involves decreasing the severity of pollution Human development can destroy wildlife habitat. Habitat restoration involves rebuilding habitat 		
What do students need to DO ?	<ol style="list-style-type: none"> Analyze data on the effect of pollution on the biodiversity of a local lake. Analyze data in order to write a conclusion about the photocatalyst as a possible means to mitigate pollution Evaluate prototypes for artificial habitats that contain the pollution-reducing photocatalyst Refine prototypes for artificial habitats that contain the pollution-reducing photocatalyst 		
What will students CREATE ?	<ol style="list-style-type: none"> A brief presentation explaining their conclusions from the data about the lake A design of a prototype that can incorporate the photocatalyst and simultaneously serve as a habitat for wildlife A letter or video explaining to the local conservation commission that explains the ecological problems with the local lake and how their prototype will help mitigate those problems. The letter/video includes an explanation as to how they've refined their designs after receiving feedback from fellow scientists. 		

ELA Standard: Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance, and style are appropriate to purpose, audience, and task.			
Vocabulary	Tier 1 - Everyday	Tier 2 - School	Tier 3 - Classroom
	Present Information Organization Audience	Findings Evidence Logically Reasoning	Concisely Substance Style
What do students need to KNOW ?	<ol style="list-style-type: none"> Students will use the following vocabulary words in context: Evidence, findings, Reasoning, present How to present their findings of graph analysis citing evidence and reasoning. How to offer feedback to improve artificial habitats citing evidence and reasoning. How to communicate how the prototype of their artificial habitat will work. 		



What do students need to DO ?	<ol style="list-style-type: none"> 1. Communicate with classmates in order to synthesize an explanation for what the photocatalyst does. 2. Construct an explanation of how the pollution in the lake affects biodiversity and present their findings to the class 3. Explain the design of the prototype.
What will students CREATE ?	<ol style="list-style-type: none"> 1. A brief presentation explaining their conclusions from the data about the lake 2. A letter or video explaining to the local conservation commission that explains the ecological problems with the local lake and how their prototype will help mitigate those problems. The letter/video includes an explanation as to how they've refined their designs after receiving feedback from fellow scientists.

Prior Knowledge

Students at this time will have learned about ecosystem dynamics, predator-prey relationships, symbiotic relationships. They will know how to read a food web. Students will have learned the vocabulary (pollution, habitat fragmentation, invasive species, etc.) Students will have learned about photosynthesis and the role of chlorophyll, which is an organic photocatalyst. They will also have learned about enzymes and will have learned the definition of catalyst.

Materials/Resources

- [Slideshow with graphs and figures](#)
 - Data about PFA biological magnification
 - Data of photocatalyst in light with PFAs vs Dark
 - Aerial maps of Wallum Lake
 - Lake ecosystem food web
 - PFA vs fish population graph
- Craft supplies
 - *Plastic aquarium plants to build prototypes?*
 - *Cut up pool noodles*
- Chromebooks
- [Graphic organizer](#)
- Large aquarium or bucket so students can demonstrate their prototypes to the class if they choose to use
- Photos of aquatic plants/habitats to serve as inspiration for their prototype



Timeline of Activities

Each lesson takes one, 47 minute class period.

Duration	Activity	Instructions	Product
Day 1			
5 mins	Bell Ringer	What do you think of when you hear the word <i>pollution</i> ? In what ways is our community affected by pollution?	Student responses
10 mins	Introduce problem	Students read the article about PFAs and their health effects. Introduce problems of PFAs in Wallum Lake by showing them the list of Lakes with elevated PFAs. Highlight Wallum Lake. Have students generate a list of questions as to why there are elevated levels of PFAs in Wallum Lake.	Student-generated questions.
10 mins	Group work	Students work in groups to collect information about the problem. Students use the identify-interpret protocol (I ²) to analyze the data sets. Group 1: PFA concentration data (biological magnification) Group 2: PFA vs fish population Group 3: Wallum Lake watershed over time Group 4: Photocatalyst vs PFAs Group 5: Photocatalyst in light vs dark	Students record their main takeaways in their graphic organizer citing specific data or trends they observed.
10 mins	Share out & discussion	Students share their main take-aways from their data sets and explain how they came to those conclusions. After groups 1 and 2 present, show a figure of a food web ecosystem. Have students share ideas about what happens to the food web if fish decline and why. As students present, review the vocab term <i>catalyst</i> to make the connection to what a <i>photocatalyst</i> does.	Students listen and take notes on their classmates' conclusions while they are not presenting.
10 mins	Report drafting	Groups begin drafting their letter (or video script) to the Douglas conservation commission based on the information they gathered today	Drafts
5 mins	Exit ticket		



Day 2			
5 mins	Bell Ringer		
10 mins	Brainstorm & planning	Instruct students that they are going to design a device that will contain the photocatalyst and also serve as a habitat for wildlife. The teacher shares images of aquatic plants and habitats for student inspiration. Students work in groups to brainstorm and plan the design of their prototypes.	Student notes, sketches, 3-D models.
15 mins	Prototype building	Students work to construct their prototypes	Prototype models
15 mins	Prototype Demo and Feedback	Students share with the class the design of the prototype. Classmates share what they like about the design and how the design can be improved by completing the feedback forms .	Student presentations and feedback
5 mins	Exit ticket	What will you do to improve the design of your device?	
Day 3			
5 mins	Bell Ringer		
10 mins	Prototype Revision	Students revise their designs. Based on the feedback they received.	Revised designs
30 mins	Report writing	Students work on their reports for the conservation commission. Teacher works with students in small groups to assist with writing letters and/or scripts	Student reports (typed letters or videos)
5 mins	Exit ticket		



Attending to Equity - Teaching Strategies

Strategy	Explain how the strategy contributes/relates to the lesson/activity
Voice & Choice	Students may choose how to present their synthesis of the problem with the pollution of Wallum Lake. Students may produce a written letter or a video. Students may also choose the way in which they share their prototype designs. They may choose to build a 3D model, create a hand-made drawing, or a digital drawing.
Community Connections	Students are specifically addressing pollution of a local lake, one in which students may visit throughout the year.
Collaboration	Students will work with each other to analyze the data sets and will work in small groups to design their prototypes and letter to the conservation commission about how the prototype works.

Career Connections

Drs. Pratap Rao and Ceren Akkaya are working on a grant to the EPA on a similar project that involves using the photocatalyst on floating discs to remove pollutants from bodies of water. They have offered to come and visit the class or offer feedback on student prototype designs.

Assessment

Write a proposal to the town including discussions of the effects of the pollution, how the photocatalyst works and proposed solution. Describe how the prototype works. Can be powerpoint, letter & with labeled diagram/photo, or video.

[Performance Assessment Rubric](#)

