Ocean Health - Absorption of Micropollutants (5 days - 1 week)

Authors

Tiffany N. Jones

Shajuana Rhodes

SUBJECT/GRADE LEVEL

Computer Science
Biology
Biochemistry
Environmental Science
Grades: 9-12

Materials

Materials

For each group:

- 28-cm x 19-cm x 4-cm clear glass baking dish (or equivalent)
- water
- blue food coloring
- 12 Tbsp vegetable oil
- 8 Tbsp pure cocoa powder
- 1 tsp sea salt (use table salt if sea salt is unavailable)
- a tablespoon
- a teaspoon
- 5 wooden stirring rods
- a coffee mug
- sorbents (paper towel, cotton balls, rag, string, nylon pot scrubber, sponge, Styrofoam cup, garden peat moss)
- droppers
- liquid dishwashing detergent
- tweezers or tongs
- bird feathers

- Plan for a class of 30 students.

- Engineering notebook or composition notebook

- Micro:bit Class set https://www.eduporium.com/micro-bit-v2-club.html
- Environment Science Expansion Board V2.0 for micro:bit qty 2 https://www.dfrobot.com/product-2194.html

STANDARDS

Next Generation Science Standards

- HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Mathematics Standards | Common Core State Standards

- MP.2 Reason abstractly and quantitatively.
- HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- MP.4 Model with mathematics.

English Language Arts Standards | Common Core State

- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
- RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- RST.11-12.1 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.
- RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

LESSON OBJECTIVE(S)

Students will determine which sorbents best absorb oil from fresh and saltwater, develop an algorithm that could be used on a boat drone to clean up an oil spill, and develop a sample program to monitor the water quality of different water sources.

CAREER CONNECTION(S)

Mentor Background: Dr. Jesse Roberts

Dr. Jesse Roberts is a Research Chemical Engineer in the Environmental Engineering Branch of the Environmental Laboratory within the U.S. Army Engineer Research and Development Center (ERDC). He received his B.S. ('15) in Biochemistry, M.S. ('17) in Chemical Engineering, and Ph.D. ('21) in Chemical Engineering from the University of Arkansas Fayetteville. Dr. Roberts received the Department of Defense S.M.A.R.T. Scholarship to pursue his Ph.D., where he worked on creating biomimetic nanomaterials for disease detection and treatment. He currently leads and supports research focused on material development for the treatment of biological toxins, environmental contaminant remediation, and the detection and recovery of rare earth metals. During his PhD studies, Dr. Roberts served as a teacher for several undergraduate and graduate level courses including, Reactor Design, Fluid Dynamics, and Colloid and Interface Science. He is a member of the American Chemical Society and the American Institute for Chemical Engineers where he has given presentations at national conferences each of the last 5 years. He was born and raised in central Arkansas and in his free time enjoys hunting, kayaking the many rivers of Arkansas, attempting to play golf, and playing with his two black labs, Jax and Tilly Mae.

STEM Careers:

Chemical Engineering, Biological and Agricultural Systems Engineering, Environmental Engineering, and Metallurgy, Mineral Processing Researcher

CENTRAL FOCUS

Clean water, healthy oceans and seas, is essential to our existence. Water covers 70 percent of our planet, Earth. We rely on this resource for food, energy and water. Harmful algal blooms (HABs) occur when inorganic substances like nitrogen and phosphorus are introduced into a body of water, leading to the overgrowth of blue-green algal species. HABs can adversely impact water chemistry, degrade drinking water supplies, and impact aquatic life through variation in dissolved oxygen content. Graphene, a nanomaterial in the Carbon family, has been found to be an absorbent that can successfully remove cyanotoxins and other contaminants from water. Can granulated activated carbon (GAC) be used to absorb contaminants from water?

ENGAGEMENT (20-25 minutes)

Brief Description:

Oil spills cause damage to ecosystems. A group of marine scientists have asked you to test filter media to assist in the development of a prototype to help with cleanup at oil spill sites.

In this project we will explore traditional water filter media (i.e. granular activated carbon, powdered activated carbon, coconut activated carbon, mesoporous carbon, bio-char, etc.) to determine the removal of contaminants over time and absorption capacity at equilibrium to determine which one is more effective for contaminant removal.

In addition you will use Computer Science to develop an algorithm that could be used on a boat drone to drag around a sheet of this smart material to clean up an oil spill. You will also learn about TDS (total dissolved solids) and develop a sample program to monitor the water quality of different water sources.

Procedure:

Classroom	Virtual
Teacher Actions: • Introduce the lesson or engage the students with a short 2 minute video of the 2010-Deepwater Horizon incident off the coast of Louisiana. The link is shown below. https://youtu.be/vff7wCFLtvQ The video will be displayed for whole class view as the students focus quietly. • Randomly select or accept volunteer students to share their reflections aloud with the class for 10 to 15 minutes. • Take the opportunity to steer the discussion toward the lesson objectives. **Student Actions:** • Silently reflect and document observations, questions, or concerns for 5 to 10 minutes • Reflections share-out to class for 2 to 3 minutes **Possible Adaptations:** • Permission to be granted for students to independently watch the video with headphones or personal hearing devices	**Teacher Actions:** • Introduce the lesson or engage the students with a short 2 minute video of the 2010-Deepwater Horizon incident off the coast of Louisiana. The link is shown below. https://youtu.be/vff7wCFLtvQ • Provide a range of critical thinking questions (10-20) to guide focus while watching video. Provide additional resources for student review and research 1. https://www.epa.gov/enforcement/deepwater-horizon-bp-gulf-mexico-oil-spill#information 2. https://www.livescience.com/deepwater-horizon-oil-spill-disaster.html **Student Actions:** • Independently watch the video and document observations, questions, or concerns of the events. • Review additional resources to determine the solution for best oil absorption in fresh and saltwater.

and to document observations, questions, or concerns of the events. • Provide guided or targeted questions to direct student focus while watching video.	• Research and review additional resources to develop a sample program to monitor the water quality of different water sources. • Complete summary of findings and prepare a real-world solution presentation (20-30 minutes) **Possible Adaptations:** • Provide guided or targeted questions to direct student focus while watching video.

EXPLORATION (30-40 minutes)

Brief Description:

Classroom	Virtual
Teacher Actions: • Students will explore traditional water filter media (i.e. granular activated carbon, powdered activated carbon, coconut activated carbon, mesoporous carbon, bio-char, etc.) to determine the removal of contaminants over time and absorption capacity at equilibrium to determine which one is more effective for contaminant removal. This will allow students to determine which sorbents best absorb oil from fresh and salt water. Though this lab is set up for students to either work alone or in groups, it will lead to their ability to see how granulated activated carbon (GAC) be used to absorb contaminants from water. • In addition you will use Computer Science to develop an algorithm that could be used on a boat drone to drag around a sheet of this smart material to clean up an oil spill. You will also learn about TDS (total dissolved solids) and develop a sample program to monitor the water	**Teacher Actions:** • Students will be able to complete the activity in their home environment. It is highly suggested that the student is performing the activity under the supervision of a parent. The materials needed to complete the activity are available for purchase in local markets and are usually reasonably priced. • Additional options can be that the teacher records her/himself performing the activity and includes the recording in assignment for student review. • In addition you will use Computer Science to develop an algorithm that could be used on a boat drone to drag around a sheet of this smart material to clean up an oil spill. You will also learn about TDS (total dissolved solids) and develop a sample program to monitor the water quality of different water sources.

quality of different water sources. **Student Actions:** **Student Handout** Students will be able to follow the link or complete a pre-printed copy of the worksheet provided by the teacher. **Possible Teacher Adaptations:** • The teacher records her/himself performing the activity and includes the recording in assignment for student review. • In addition you will use Computer Science to develop an algorithm that could be used on a boat drone to drag around a sheet of this smart material to clean up an oil spill. **Possible Student Adaptation Actions:** **Student Handout** • Students will be able to follow the link or complete a pre-printed copy of the worksheet provided by the teacher. • Students will use Computer Science to develop an algorithm that could be used on a boat drone to drag around a sheet of this smart material to clean up an oil spill. • Students will present the algorithm via slideshow format.	**Student Actions: Student Handout** **Possible Adaptations:** **Student Actions:** • Students will use Computer Science to develop an algorithm that could be used on a boat drone to drag around a sheet of this smart material to clean up an oil spill. • Students will present the algorithm via slideshow format.

EXPLANATION (45 min - 2 class periods)

Brief Description: TDS stands for Total Dissolved Solids and refers to the total concentration of dissolved substances in drinking water. The unit is mg/L, which indicates how many milligrams of the soluble solid are dissolved in 1 liter of water. The higher the TDS value is, the more dissolved substance there is in the water.

The TDS level helps indicate whether the drinking water is fit for consumption, requires filtration or is highly contaminated. Parts per million (PPM) is the measurement used for measuring TDS level in the water. The lower the TDS value, the purer the water; the higher the TDS value, the more soluble solids in the water.

An organic light-emitting diode (OLED or organic LED), is a light-emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound that emits light in response to an

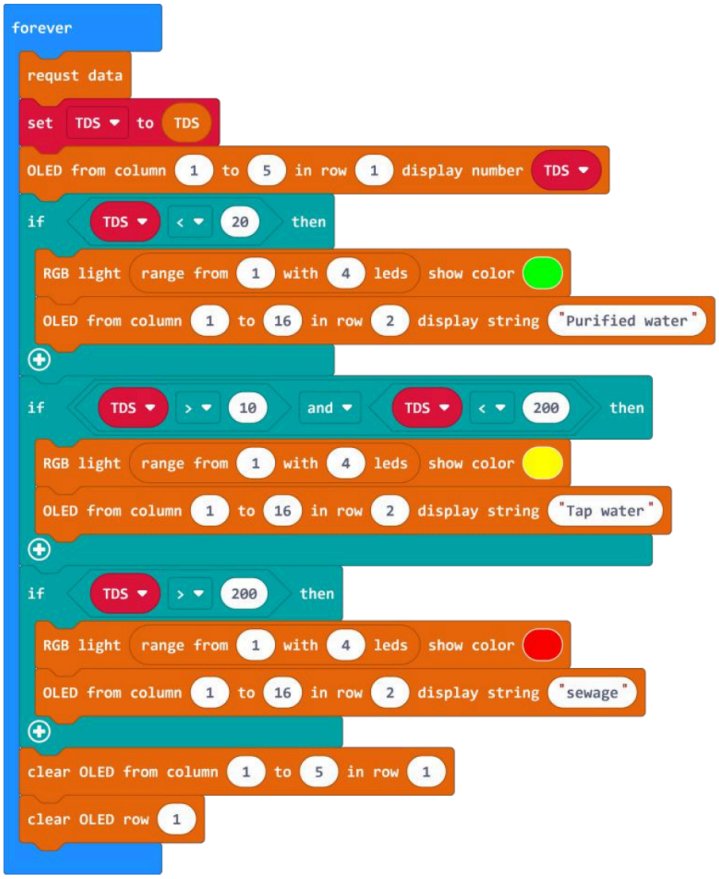
electric current. The RGB color model is an additive color model in which the red, green, and blue primary colors of light are added together in various ways to reproduce a broad array of colors. The name of the model comes from the initials of the three additive primary colors, red, green, and blue.

Students will work in teams of 2-4 and use a micro:bit and the Environment Science Expansion Board V2.0 for micro:bit. They will need access to a laptop or computer to complete the code. The TDS Water Quality probe will be used to measure Total Dissolved Solids. The value will display on the OLED screen.

Procedures:

1. Develop a TDS Water Quality Monitor program that will monitor the water quality of different water sources and classify the water quality.
2. TDS value below 20 ppm is considered as pure water, 20-200 ppm as tap water, and above 200 ppm as sewage.
3. The OLED will show the classification and the different colors of the RGB lights represent different grades.
4. Use variables and conditional statements in your program.
5. This program will need to be used to test the samples from the lab experiment.
6. Test the water quality of your initial water sample, contaminated water sample, and water sample after the contaminant has been removed. Record your results.
7. Determine if the water quality is suitable after contaminant removal.
8. Create a video or FlipGrid to explain and show how your code works with the water samples, TDS Water Quality probe, and expansion board.

Sample Solution: https://makecode.microbit.org/_7k2Xx4MJKLsk



ELABORATION (45 min - 2 class periods)

Brief Description:

Thousands of oil spills occur in US waters every year. When an oil spill happens, response time is everything. The longer you wait, the further the oil will spread and the more damage it will do. So it's important to get to the scene as quickly as possible.

Drones can help assess oil damage to coastlines, tankers, and response equipment. For example, they can identify, measure, and map oil buildup on coastlines, especially those inaccessible by foot. Drones also can help to limit humans to direct exposure of contaminants.

Develop an algorithm that could be used on a boat drone to drag around a sheet of your filter prototype* to clean up an oil spill.

*The activity described will only be coding the Micro:bit. Having the micro:bit drag the filter to collect "oil spill" (such a dyed water or chad disks) is a great extension that is not found in this unit plan.

Safety First: Do not test the products in water. Micro:bits are not waterproof!

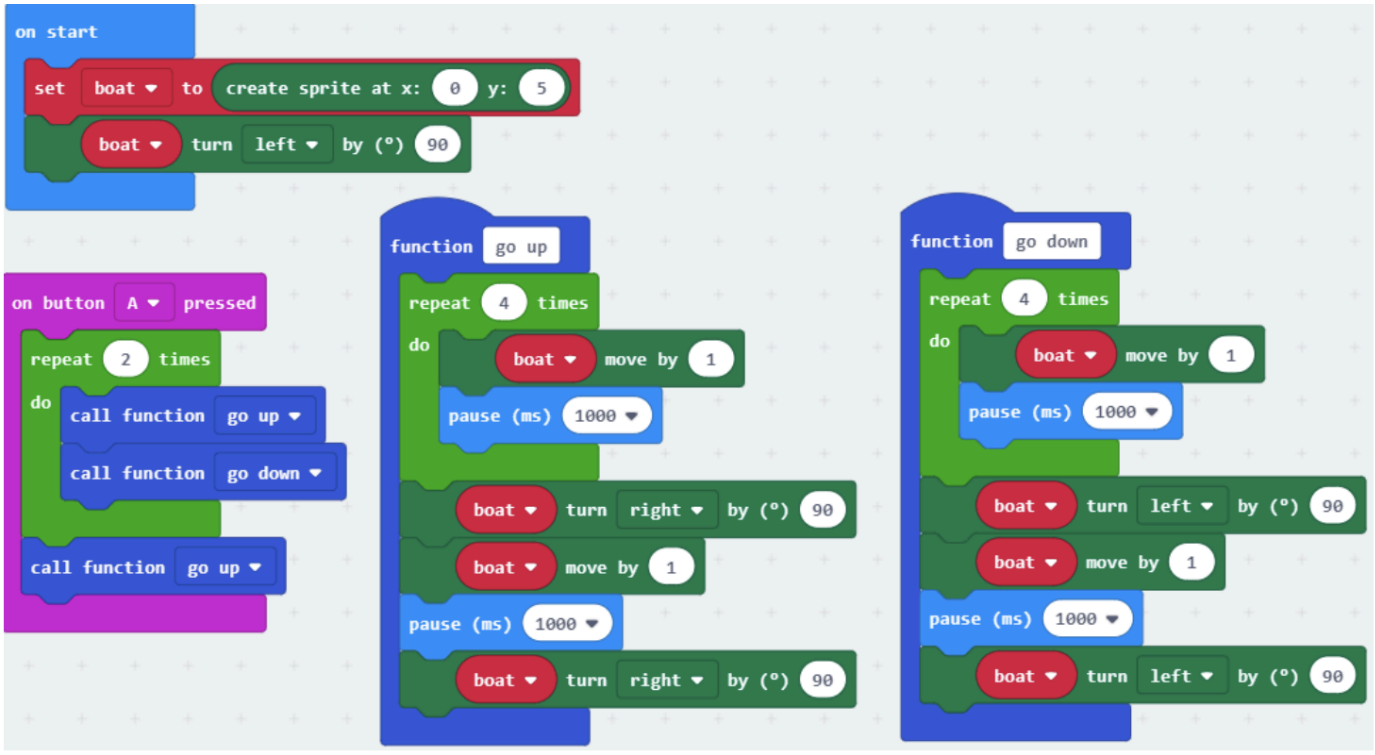
Procedures:

A micro:bit has a LED grid that has x and y coordinates similar to the x-y coordinate plane in math. In this activity you will create an algorithm to navigate the grid of the LED grid.



1. Your boat drone start position is (0,0).
2. Write out steps, in your Engineering notebook, using the following commands: move forward, turn right, turn left to navigate the entire grid and return to the start position.
3. Look for patterns. How can you shorten your sequence?
4. Re-create your sequence as code in the Microsoft Makecode environment using functions, variables, and loops.

Sample Solution: https://makecode.microbit.org/_f0DKUeXEFbi5



EVALUATION (30 min - 1 class period)

Brief Description: Now it is time to test your algorithm! Let's see if your boat drone (sprite) can navigate the entire grid to clean up the oil spill.

Procedures:

1. Download your code to the micro:bit.
2. Observe the LEDs lighting up on the grid.
    a. Did your code clean up the oil from each space on the grid?
    b. Is there anything that you can modify to improve your code?

REFERENCES

- Allread, C. (2022, February 28). Drones are Revolutionizing Oil Spill Response: Here's How. The Drone Life. https://thedronelifenj.com/drones-oil-spill-response/#:%7E:text=Drones%20can%20help%20assess%20oil,and%20contain%20an%20oil%20spill.
- Coordinate grid and LEDs. (n.d.). Microsoft MakeCode. Retrieved July 15, 2022, from https://makecode.microbit.org/courses/csintro/coordinates
- Environment Science Expansion Board V2.0 for micro:bit - DFRobot. (n.d.). DFRobot. https://www.dfrobot.com/product-2194.html

- Life Below Water. (n.d.). Micro:Bit. Retrieved July 15, 2022, from https://microbit.org/projects/do-your-bit/global-goals/life-below-water/
- Understanding TDS and its Role in Drinking Water. (n.d.). Bisleri. Retrieved July 20, 2022, from https://www.bisleri.com/blog-detail/understanding-tds-and-its-role-in-drinking-water
- Wilke, C. (2017, March 7). Sponge can soak up and release spilled oil hundreds of times. New Scientist. https://www.newscientist.com/article/2123391-sponge-can-soak-up-and-release-spilled-oil-hundreds-of-times/
- Zetterholm, S. G., Gurtowski, L., Roberts, J. L., McLeod, S., Fernando, B. M., & Griggs, C. S. (2022). Graphene-Mediated Removal of Microcystin-Lr in Chitosan/Graphene Composites for Treatment of Harmful Algal Blooms. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4045308