District of Columbia
Office of the State Superintendent of Education

PLASTIC BOTTLES IN THE WATERSHED

High School Environmental Science Instructional Sequence

This high school environmental science instructional sequence was created to support teaching the Next Generation Science Standards through the Biological Sciences Curriculum Study (BSCS) 5E instructional model. Developed by District of Columbia teachers, these lessons include real-world contexts for learning about environmental science through a lens that encourages student investigation of local issues.

The lessons also support Scope and Sequence documents used by District local education agencies:
Unit 3: Earth and Human Activity: Chesapeake Bay and Anacostia Watershed Analysis
Advisory 4

Acknowledgements:
Steve Donkin, Cardozo Education Campus

This curriculum resource can be downloaded online:
https://osse.dc.gov/service/environmental-literacy-program-elp

Overview and Goal of the Lesson:

In this sequence of lessons, students investigate the impact of solid waste on the local watershed and the larger ocean ecosystem. Students are first introduced to the global phenomenon of non-biodegradable plastics becoming concentrated in large patches created by ocean gyres (spiraling currents), specifically the north Atlantic gyre, and the impact of this pollution on marine life and marine food webs. The problem source is traced to local watersheds which empty into the ocean and how human behavior is the cause of this problem. Students gather evidence to specify the sources of plastics pollution in their own communities, using their knowledge of watershed dynamics, and develop solutions to the problem that include aspects of science, engineering and social science.

Essential Question(s):

What effect does solid waste have on the watershed, and how can we minimize solid waste pollution?

NGSS Emphasized and Addressed in this Lesson Sequence:

PERFORMANCE EXPECTATIONS	SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. **HS-LS2-7.** Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	**Constructing Explanations and Designing Solutions** Construct an explanation based on valid and reliable evidence obtained from a variety of sources. **Engaging in Argument from Evidence** Evaluate competing design solution to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors.	**ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. **Science addresses Questions About the Natural and Material World** Science and technology may raise ethical issues for which science, by itself, does not provide answers and solution.

Materials

ITEM	QUANTITY	PURPOSE
Global Oceans Map handout	1 per student	Garbage Patches (**Engage**)
Computers or tablets	1 per group	**Explore 1** and **Elaborate**
Survey Template Form	1 per group	Sources and Causes (**Explore 1**)
Blind Taste Test Protocol	1 per student	Why We Use Plastic (**Explore 2**)
Paper cups	~10-15 per group	Why We Use Plastic (**Explore 2**)
Various brands of bottled water	2-4 per group (plus drinking fountain water)	Why We Use Plastic (**Explore 2**)
Water Quality Test Data Table	1 per student	Why We Use Plastic (**Explore 2**)
Water test kit	1 per group	Why We Use Plastic (**Explore 2**)
Plastic Recycling Protocol	1 per student	How Plastic Recycling Works (**Explore 3**)
Assorted plastic bottles and/or caps	as many as possible	How Plastic Recycling Works (**Explore 3**)
350 degree oven	1 per class	How Plastic Recycling Works (**Explore 3**)
Metal bowls	2 per group	How Plastic Recycling Works (**Explore 3**)
Aluminum tray with wax paper lining	1 per class	How Plastic Recycling Works (**Explore 3**)
Scissors	1 per student	How Plastic Recycling Works (**Explore 3**)

5E Lesson Sequence

TOTAL DURATION: 420-490 MINUTES				
5E Model Stage	**Duration**	**Teacher and Student Actions**		**Notes**
Engage The Phenomenon of Ocean Garbage Patches	40-50 minutes	What Teacher Does	1. Teacher introduces the phenomenon of ocean garbage patches by showing the video Atlantic Garbage Patch[1]. 2. Teacher asks students to locate the North Atlantic Garbage Patch on the *Global Oceans Map* handout, draw a circle to indicate it, and label it, then answer the questions pertaining to the video. 3. Teacher shows the video It's an historic day . . . unfortunately[2] and asks students to answer the questions on the handout pertaining to the video and where the plastics and up. 4. Teacher tells students there are four more garbage patches in the oceans, and asks them to label them on the global oceans map.	Atlantic Garbage Patch is a 1:33 video on YouTube that shows the 50Gyres research expedition at work collecting and examining small pieces of plastic in seine nets in the North Atlantic Gyre. It's an historic day . . . unfortunately is a 3:22 video on YouTube that shows the Plastics at SEA Expedition halfway through its journey in the Atlantic, at which point they have collected 42,000 pieces of plastic in 10 days. One day they collected 23,000 pieces of plastic in one net in 30 minutes of towing, which extrapolates to 26 million pieces of plastic per square km, hence the title of the video. The video offers an extension of the other video by showing the dissection of fish digestive systems to demonstrate that marine life actually ingest the plastics. Supporting Document 1: Global Oceans Map. The handout questions prompt students to think about how the garbage patches are formed (currents), why they form (gyres), where their sources are (primarily watershed runoff, although ocean dumping as well, despite laws that prohibit this), and what effect they have on the ecosystem (ingestion by organisms and bioaccumulation, impacting even human food sources).
		What Students Do	1. Students watch the videos and answer questions on handout.	
Explore 1 Sources and Causes	30-40 minutes	What Teacher Does	1. Teacher has the students use the interactive plastics migration map from Plastic Adrift to follow the movement of plastics from the Washington, D.C./ Chesapeake Bay area through the ocean. 2. Teacher says, "Now that we know there's a problem, let's try to find out where it comes from." The teacher helps students formulate questions for a survey to give to students and staff on their plastic bottle use. Students can work in groups to brainstorm, then come to consensus as a class to finalize survey questions. The teacher has students write the questions on *Survey Template Forms* and asks them to survey a good size sample of students and staff before next class.	The interactive map at plasticadrift.org allows students to click on an ocean location and see how plastics originating from this site move through the ocean over time. Students begin by experimenting with different source locations, but should focus specifically on the Washington, D.C./Chesapeake Bay area as a source. The purpose is for them to see how our own local pollution contributes to the North Atlantic Garbage Patch. As students brainstorm survey questions, the teacher can guide them by asking prompting questions: What do we want to know? What do you think the answers will be? What's the best way to ask the question to get the information we need? Example questions may be: • How many plastic bottles do you use per day? • Do you always recycle? • What types of drinks do you buy in plastic bottles? • If water, why use plastic bottles instead of the water fountain? • If you don't use a refillable bottle, why not? • Would you use a refillable bottle if the school had hydration stations with filtered water?
		What Students Do	1. Students observe the movement of plastics from their local area through the Atlantic Ocean using the interactive map, then answer questions on the *Global Oceans Map* handout. Students hand in handout for grading. 2. Students brainstorm on survey questions and come to consensus on the final version of the survey. Students use class time to survey each other and the teacher, then administer the survey to others for homework.	

5E Model Stage	Duration	Teacher and Student Actions		Notes
Explore 2 Why We Use Plastic Bottles	60-90 minutes	What Teacher Does	1. Teacher facilitates the compiling and analysis of survey data. 2. Water Taste Test Activity: Teacher says, "Many people choose bottled water because they say it tastes better than water fountain water" (refer to survey data). "Let's see if that's true." The teacher follows the *Blind Taste Test Protocol* to facilitate a test of various brands of bottled water and water fountain water among student groups. Groups share out their findings and the teacher leads a discussion of whether bottled water actually tastes better. 3. Water Quality Test Activity: Teacher says, "Many people choose bottled water because they think it is safer than water fountain water" (refer to survey data). "Let's see if that's true." Teacher helps students perform tests to gather data for *Water Quality Data Table* on various brands of bottled water and water fountain water (see Supporting Document 4). Groups share out their findings and the teacher leads a discussion of whether bottled water is safer than water fountain water.	The data analysis can be taken as far as the teacher desires. Example points of examination might be: What is average daily bottle use per person per day? Per month? What is the average recycling rate? What percentage of people use refillable bottles? What's the most common reason people give for choosing bottled water over the water fountain? (Presumably concern over taste and/or safety). Students can create visual displays of data (line or bar graphs, pie charts). The Water Taste Test Activity can be preceded by the students making their own hypotheses about which water sample will be found to taste the best to the most people. See Supporting Document 3 for *Blind Taste Test Protocol.* The Test Assured website[3] provides a number of simple testing kits, including tests for lead, bacteria, chlorine, copper, and other contaminants. Lead may be the contaminant of most concern to students, but the teacher may supplement with other tests as well. Results of Department of General Services lead tests in District schools can be found at dgs.dc.gov/page/water-sampling-results-dc-public-schools. As with the survey data, there are numerous ways that the teacher can utilize the taste and water quality data. If student groups obtain data from an identical cohort of water sample types, then results can be pooled and statistically analyzed (mean, range, standard deviation, etc.). Alternatively, students can collect data from a wider range of samples (more brands, different sources of tap water in the school), which may provide a broader picture but may be less statistically reliable if the numbers of test samples per source is diminished.
		What Students Do	1. Students gather data and compile and analyze data according to teacher instructions. 2. Students complete the *Blind Taste Test Protocol* and the *Water Quality Data Table Protocol.*	

5E Model Stage	Duration	Teacher and Student Actions		Notes
Explore 3 How Plastic Recycling Works	70-80 minutes	What Teacher Does	1. Teacher leads a discussion on recycling plastic that encourages students to think about why recycling is important and whether it is a solution to the problem of plastics in the watershed. 2. Teacher hands out the *Plastic Recycling Protocol* and helps students answer the questions, then goes over the procedure for recycling plastic in the lab.	The discussion on plastic recycling should touch on several points about plastics: • Where does plastic come from? (Crude oil - a nonrenewable resource.) • What happens to plastic when we don't recycle and it ends up in the environment? (Remind students about what they learned in the Explore stage about the non-biodegradability and bioaccumulation of plastics.) • Why should we recycle? (Both to reduce pollution and save energy and oil.) • And finally, what happens to plastic that we put it in the recycle bin? (The focus of this investigation.) There are many variations of how to do plastic recycling activities, such as making art work, beads, or bowls, many on YouTube (a good example is Making Recycled HDPE Plastic Bowls[4]). The protocols all essentially involve cutting up plastic into small pieces, heating them in an oven, and molding the melted plastic into the desired shape. Students should be made aware that this is how plastic recycling is done on a large scale. Because the activity involves hot materials and possible fumes, appropriate cautions against burns and proper ventilation should be in place.
		What Students Do	1. Students participate in discussion of plastics recycling. 2. Students follow protocol for plastic recycling lab, creating their own recycled item, and answer questions on Protocol worksheet.	
Explain Implications	70-80 minutes	What Teacher Does	1. Teacher asks students to think about how the information they've gathered so far helps to explain why plastic waste is such a problem in our watershed. To get an idea of the impact on their immediate environment, the teacher leads students on a local field experience around the school campus to collect, sort and measure the amount of plastic bottles on the school grounds. Data is compiled, analyzed and saved for the Evaluation stage. 2. Optional field trip - Sorting and recycling facility. 3. Optional Field Trip - Anacostia River canoe trip. 4. Teacher asks the students to summarize what they learned and consider if this is a problem with a solution. "If so, what can we do?"	The collection, sorting and analysis of plastic bottles in the local environment can be done in various ways: • The activity can be divided to give classes a chance to participate by focusing on different sections of campus and/or including surrounding streets, blocks or other areas as determined by the teacher. • The activity can be done over several days or weeks to see how bottles accumulate over time. • Students can be assigned small areas across the city from which to collect bottles for homework and share their results. This may be a good time to supplement class work with a field trip to a sorting and recycling facility or a canoe trip in the Anacostia River to observe the impact of plastics on the river first-hand.
		What Students Do	1. Students collect, sort and measure the amounts of plastic bottles in their local environments and interpret the results. 2. Students brainstorm possible solutions to the problem of plastic bottles in the local watershed and in the ocean garbage patches, while considering the inter connectedness of the watersheds. They discuss in groups and maintain a list of their solutions and why they consider them feasible. This will be used for later discussion.	

5E Model Stage	Duration	Teacher and Student Actions		Notes
Elaborate Finding Solutions	60-70 minutes	What Teacher Does	1. Teacher shows the 12:10 YouTube video The 20-Year-Old With a Plan to Rid the Sea of Plastic.[5] The teacher asks students to work in group analyzing the project devised by Boyan Slat (the subject of the video) and determining whether they think it will work. 2. Teacher asks students to research similar but local solutions such as trash traps and trash skimmer boats. 3. Teacher asks the students whether they think hydration stations are a solution to encourage people to use refillable bottles (refer back to their survey results). If so, how can we get them in schools?	In their research the students use information on the websites boyanslat.com/ and theoceancleanup.com. Online information for Trash Traps and local trash reduction initiatives is available at: • anacostiariverkeeper.org • anacostiaws.org • fergusonfoundation.org • doee.dc.gov • doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Nash_Run_TT_Final_Tech_Report_Entire.pdf • dcwater.com/cleaning-our-waterways A resource for student field trips (tours or work days) at local trash traps is groundworkdc.org or anacostiaws.org
		What Students Do	1. Students use internet resources and other texts to research solutions. 2. Students answer guided questions about the solutions and their feasibility.	
Evaluate Implement-ing Solutions	70-80 minutes	What Teacher Does	1. Teacher asks students to brainstorm in groups on how to campaign for hydration stations in the school using the information they have gathered in this unit. 2. Teacher asks the students to develop an effective education campaign on the importance of plastic bottle reduction and recycling for the school.	It is unclear how many, if any, schools have hydration stations. The Partnership for a Healthier America[6] is one possible resource for general information, as hydration stations are a part of their Drink Up campaign. Students can conduct a letter writing campaign to the chancellor, mayor and/or DC Council advocating for hydration stations. This and other ideas that they have for education/ advocacy campaigns on plastic bottle reduction and recycling serve as evaluative methods (for teacher and students) on student learning as they should incorporate information (summarized and explained) that they have learned and data they have gathered throughout this unit.
		What Students Do	1. Students develop campaign strategies and materials, using the data and information they have gathered, and monitor their success into the future.	

Footnotes

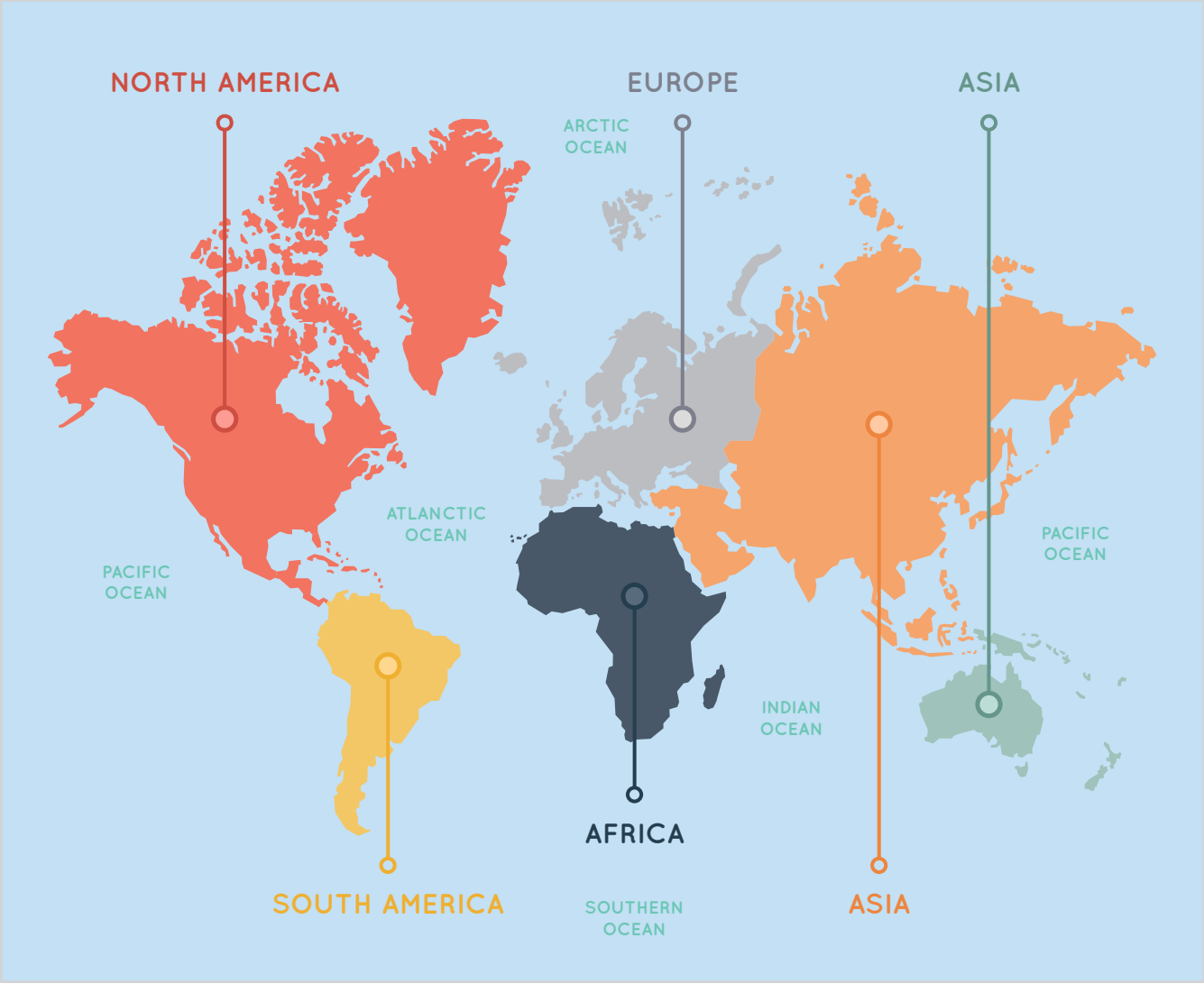
1 www.youtube.com/watch?v=hFLuOQDiDTQ
2 www.youtube.com/watch?v=WdhIEG-Q2hk
3 www.watertestingkits.com
4 www.youtube.com/watch?v=7QZceHIc2zQ
5 www.youtube.com/watch?v=hmPHBhYaCR4
6 www.ahealthieramerica.org

Supporting Documents

Name _____ Period _____ Date _____

GLOBAL OCEANS MAP

The video we watched is about the North Atlantic Garbage Patch. Draw a circle on the map below to show where the North Atlantic Garbage Patch is:



There are four other garbage patches in the oceans:

- The North Pacific Garbage Patch
- The South Pacific Garbage Patch
- The South Atlantic Garbage Patch
- The Indian Ocean Garbage Patch

Draw circles on the map to show where you think these garbage patches are.

Use the Plastic Adrift website (plasticadrift.org) and a world map to answer the questions:

1. Which garbage patch does the plastic from Washington, D.C. go to?

   _____

2. Which garbage patch does the plastic from California go to?

   _____

3. Which garbage patch does the plastic from Central America go to?

   _____

4. Which garbage patch does the plastic from Europe go to?

   _____

5. Which garbage patch does the plastic from China go to?

   _____

6. Which garbage patch does the plastic from Ethiopia go to?

   _____

7. Choose a different country. What is the country?

   _____

   Which garbage patch does the plastic from that country go to?

   _____

8. Explain how a plastic bottle in the street in Washington, D.C. can move to the North Atlantic Garbage Patch.

   _____

   _____

   _____

   _____

   _____

   _____

Name _____ Period _____ Date _____

SURVEY TEMPLATE FORM

Name of person taking the survey: _____

Question 1:_____

_____

Answer:_____

_____

Question 2:_____

_____

Answer:_____

_____

Question 3:_____

_____

Answer:_____

_____

Question 4:_____

_____

Answer:_____

_____

Question 5:_____

_____

Answer:_____

_____

Name _____ Period _____ Date _____

BLIND TASTE TEST PROTOCOL

Each group will get four types of water to test. First make a hypothesis about which type of water you think will taste best to most people. Write it here: _____

In your group, choose one person to take the test first. This person must look away while the other group members prepare the test (that's why we call it a blind test!).

To prepare the test,

1. Label four paper cups: "A," "B," "C," and "D."
2. Pour a small amount of water into each cup. Each cup gets a different type of water (one drinking fountain water and three different types of bottles water). Be sure to write in your notebook which type of water is in each cup!
3. Have the person taking the test taste each type of water. Ask him or her, which cup had the water with the best taste? Which cup had the water with the worst taste?
4. Repeat steps 1 to 3 for the second person in your group. Change the types of water in the four cups so the person tasting won't guess which is which.
5. Repeat again for everyone in your group, and record the results in the data table below.

Name of Tester	Cup with Best Taste	Cup with Worst Taste

Be sure to write which type of water was in each cup.

When you have written all the data, check your notes and write the name of each type of water next to the letters in the table.

Share your results with the class.

Name _____ Period _____ Date _____

WATER QUALITY DATA TABLE

In your groups, follow the teacher's directions to use the water test kit to test several sources of drinking water. You should test samples from the water fountains and different types of bottled water.

Carefully follow the directions in the test kit. Some of the contaminants we may test for include lead, copper, bacteria and chlorine. Record information about your test samples and the results of your tests (remember to write the amount of contaminant and the units!).

Amount of Contaminant Measured

Source of Water	Name of Contaminant 1: _____	Name of Contaminant 2: _____	Name of Contaminant 3: _____

What contaminants did you find? _____

_____

Which water source had the most contamination? _____

_____

Which water source had the least contamination? _____

_____

Based on your results, what do you think the safest drinking water source is? Why? _____

_____

_____

_____

_____

Name _____ Period _____ Date _____

PLASTIC BOTTLE RECYCLING PROTOCOL

In this activity, we will make bowls out of plastic bottles. This is how we can recycle plastic bottles and reuse the plastic instead of putting it into the trash!

1. In your groups, gather and cut up with scissors several plastic bottles and/or caps and put them into a large aluminum tray lined with wax paper.
2. We will put the tray of plastic scraps into the oven and heat them at 200 degrees Fahrenheit until they melt.
3. While the plastic is heating, get two metal bowls.
4. When the plastic scraps are melted, carefully remove the tray (using gloves) from the oven and use gloves to place the melted plastic over one bowl and put the other bowl over that, as shown in the video "Making Recycled HDPE Plastic Bowls" (www.youtube.com/watch?v=7QZceHIc2zQ).
5. You can keep the bowls pressed together by putting heavy books on top. Wait for it to cool before separating the bowls from each other.

How did it work? This is exactly how our plastic bottles are made into other things when we recycle them, except that they use many more bottles and much bigger ovens!

Talk with your group about other things you can make out of plastic bottles. Write and draw some of your ideas below:

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