November 2024

Green Explorers: Inquiry and Action for Environmental Stewardship

By Gilda Nappo, ABE Italy

ABE Master Teacher Fellowship Program

AMGEN® Biotech Experience

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The projects designed by the 2023–24 ABE Master Teacher Fellows are a compilation of curricula and materials that are aligned with Amgen Biotech Experience (ABE) and prepare students further in their biotechnology education. These projects were created over the course of a 1-year Fellowship in an area of each Fellow's own interest. Each is unique and can be adapted to fit the needs of your individual classroom. Objectives and goals are provided, along with expected outcomes. Projects can be used in conjunction with your current ABE curriculum or as an extension.

As a condition of the Fellowship, these classroom resources may be downloaded and used by other teachers for free. The projects are not edited or revised by the ABE Program Office for content, clarity, or language except to ensure safety protocols have been clearly included where appropriate.

We are grateful to the ABE Master Teacher Fellows for sharing their work with the ABE community. If you have questions about any of the project components, please reach out to us at ABEInfo@edc.org, and we will be happy to connect you with the author and provide any assistance needed.

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Product Summary Cover Page (Curriculum)	
My overall topic is… (1-3 sentences)	My overall topic is climate change. Climate change is one of the greatest threats that humanity is facing today. That's why it is really important to educate our students about causes, consequences and possible interventions to invert the path (or at least to limit the damage). The overall topic of my project is environmental pollution and climate change. I chose this subject because climate change is one the greatest threats that humanity is facing today: it not only affects human health directly, but it acts on every aspect of natural and human systems, including social and economic aspects, and the poorest countries are going to pay the heaviest price. It's really important for our students to understand causes, consequences and possible interventions.
I want students to understand how we can protect and how we can spoil our planet and be able to make informed decisions.	Participants will be able to: ● Understand the causes that have determined climate change and loss of biodiversity (which is the human role?) ● Understand the effects of climate change and what we expect will happen in the coming years ● Understand what the actions that EU and UN are taking at a global level ● Understand what the good behaviors are and discuss what we can do now to help
The reason why I wanted to pursue this is…	Our students are born in a society that is already facing climate change, and they understand (or need to) that their future depends on our ability to preserve the environment and the biodiversity of the planet and to reverse the dangerous path that humanity has started. The aim of this project is to let students understand how we can protect our planet and how we can spoil it, and to be able to make informed decisions.
Resources used or created	I created a path to explore pollution (in particular water pollution), with several activities organized on different levels of inquiry, starting from guided investigations to open inquiry. Although there is a suggested "direction" in this path, every teacher can choose to follow different parts of the path or even just one activity. The different activities are marked by a color code, making it easy to figure out whether is a video, a hands-on experiment, or another kind of activity, like simulations or games.

Skills or Standards Addressed	These are the skills that students are expected to develop after participating in this experimental path on water pollution and inquiry-based science education: ● **Scientific inquiry skills**: Students will learn to formulate questions, develop hypotheses, design experiments, and analyze data related to water pollution. ● **Critical thinking**: They will enhance their ability to evaluate information, draw conclusions, and solve problems based on evidence. ● **Environmental awareness**: Students will gain a deeper understanding of water pollution, its causes and effects, and the importance of sustainability. ● **Collaboration**: Working in groups, students will improve their communication and teamwork skills. ● **Practical skills**: Hands-on activities will help students develop practical skills in scientific experimentation and data collection. ● **Responsibility and citizenship**: Students will become more aware of their role in protecting the environment and promoting public health.
Assessments or Post-Surveys	Assessment will be based on continuous observation and the creation of communication products. Instead of traditional tests, students will demonstrate their understanding and investigative skills through: ● **Video presentations**: Students will produce videos summarizing their findings on water pollution. ● **Infographics**: They will create infographics to visually represent their data and conclusions. ● **Reports**: Written reports will detail their experimental processes and results. This approach emphasizes practical application, creativity, and the ability to communicate scientific concepts effectively.

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Master Teacher Fellowship

UNIT NAME: GREEN EXPLORERS: Inquiry And Action For Environmental Stewardship

TIME FRAME: 1–3 weeks
SUGGESTED AGE RANGE: Lower Secondary School (11–14 yrs)
SUGGESTED COURSE OR CONTENT AREA: Biology
CONNECTION DESCRIPTIONS:

- Environmental biology
- Civic education for sustainability
- Integrating inquiry
- Data analysis/Data literacy
- Project or problem-based learning

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PROGRAM SITE: ABE Italy

LEARNING ACTIVITY DETAILED GUIDE

EXPLORE WATER POLLUTION

1. **OVERVIEW**. Pollution occurs when chemicals, particles, or other materials are released into the environment, harming the organisms living there. For most of human history, contaminants released by human activities had relatively little environmental impact. But over the last few centuries, pollution levels soared as a result of population growth and the Industrial Revolution. Pollution has damaged the environment and destroyed biodiversity, contributing to the decline of many threatened species. Moreover, it represents a serious risk for human health, in particular, for the poorest countries.

2. **LEARNING GOALS**. Through this path, students will analyze the causes and effects of water pollution. Students will explore directly the effect of water pollution on a biological system, such as the small invertebrate *Artemia salina*. Students will analyze the action of surfactants on water properties, in particular, on water surface tension. They will learn how this impacts the ability of insects to walk on water surfaces. Students will also test the quality of water in their town and get to know more about oil spill clean-up and mitigation. Finally, students will discuss what we can do to prevent pollution.

3. **CONNECTION WITH SCHOOL CURRICULUM**.
   - Civic education for sustainability
   - Biology: animals and life cycle
   - Genetics: DNA, mutations
   - Chemistry: water properties (surface tension), difference between hydrophobic and hydrophilic substances

4. **PROPOSED ACTIVITIES**.

ACTIVITY DESCRIPTION	TIME	MATERIALS
ENGAGE	~1h	
Students are asked to discuss if they would swim in the Seine river	10 min	
Students watch the video 1	10 min	Video 1: Bathing sites in UE
Discussion	10 min	Document: Appendix 1
Students watch the video 2	10 min	Video 2: Lake Erie

ACTIVITY DESCRIPTION	TIME	MATERIALS
Discussion	15 min	Document: Appendix 1
WHAT IS THE EFFECT OF SURFACTANT RELEASE IN WATER?	2–3h	
I: Engage - The teacher shows students the effect of surfactants in lowering water surface tension.	1h	Appendix 2. Phase I
II: Reflect - Students reflect on the results of the experiment and search for explanations.	2h	Appendix 2. Phase II
WHAT HAPPENED TO THE WATER STRIDERS?	2–3h	
Case study - Students reflect on a real case of water pollution.	2–3h	Interactive with Genially: The incredible story of the ponds
CAN YOU SEE THE EFFECT OF WATER POLLUTION ON A LIVING ORGANISM?	4 days	
I: Presentation of the model system	1h	Appendix 3. Phase I Video 1: Artemia salina life cycle
II: THINK-PAIR-SHARE. Students are asked to propose an experimental plan and share with the whole class their experimental set up.	1h	Appendix 3. Phase II
III: Experiments with *Artemia salina*	3 days	Appendix 3. Phase III
IV: Reflection on the results of the experiment	1h	Appendix 3. Phase IV
IS IT SAFE TO SWIM IN THE LAKE?	10h	
I: Engage. Presentation of the problem. Planning of the investigation.	1–2h	Appendix 4. Phase I
II: Field activities	3h	Appendix 4. Phase II
III: In-class lab work	2h	Appendix 4. Phase III

ACTIVITY DESCRIPTION	TIME	MATERIALS
IV: Analysis of the results	1h	Appendix 4. Phase IV
V: Development of the final product	2h	Appendix 4. Phase V
OIL SPILL CHALLENGE: CLEAN-UP ADVENTURE	8h	
I: Engage	1–2h	Appendix 5. Phase I
II: Ideas for oil spill clean-up. Planning of the investigation.	2h	Appendix 5. Phase II
III: Clean-up experiment	1h	Appendix 5. Phase III
IV: Analysis of the results	1h	Appendix 5. Phase IV
V: Discussion	2h	Appendix 5. Phase V

5. **A GLIMPSE OF THE ACTIVITIES.**

Appendix 1

Questions to support the discussion after watching the videos.

VIDEO 1:

- Which part of the video had the greatest impact on you?
- What are the main contaminants that are usually found in the water?
- Where are the sewage effluents discharged after heavy rainfall? What are the consequences?

VIDEO 2:

- Which part of the video had the greatest impact on you?
- Why is Lake Erie so important for Canada from an ecological and economical point of view?
- What happened to Lake Erie? What are the consequences?
- What are the causes of the toxic bloom that happened in Lake Erie?
- What are the environmental hazards of intensive farming and agriculture?

Appendix 2
What is the effect of surfactant release in water?

Phase I: ENGAGE

Title	**What happened to the paper clip?**
Aim	Explore the effect of surfactants in lowering water surface tension.
Materials & tools	● Tap water ● Dish soap ● Spoon ● Pipette ● 5 paper clips (for each group) ● 2 hard plastic cups (for each group)
Expected time	45 minutes
Procedure	● Fill one cup with about 50 mL of tap water. ● Add 1 spoon of dish soap. ● Stir gently to avoid bubbles. ● Fill the other cup up to the edge with tap water. ● Starting from the edge of the cup, very gently place one paper clip on the surface of the water. If you have been gentle enough, you should observe that the paper clip does not sink. You can also add other paper clips and see that they remain on the surface. ● With a pipette, add a few drops of soap solution and observe what happens to the paper clips. You should now see that the paper clips sink in the water.
Notes	The teacher should perform the experiment in front of the class without commenting or explaining anything. Then students are asked to work in pairs or in small groups of three to repeat the experiment and do some hypothesis about the mechanism.

Phase II: REFLECT

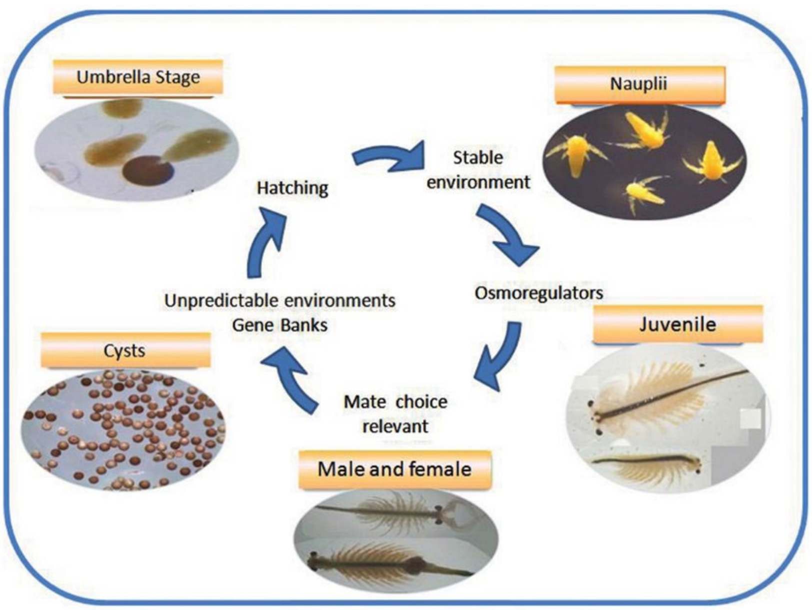
- Describe the results of your experiment.
- Why did you observe a different behavior of paper clips on water with or without the soap?
- Pair with a classmate and discuss your hypotheses.
- Do an internet search to confirm the hypothesis or to find an alternative explanation.
- Share with the whole class your findings.

Appendix 3

Can you see the effect of water pollution on a living organism?

Phase I: Brine shrimp life cycle

Artemia salina, also known as brine shrimp, is a microscopic crustacean adapted to live in highly saline waters, such as the pools of salt flats. It is considered an extremophilic model organism, adapted to survive in conditions of extreme stress, and is therefore extensively studied to understand these processes. It produces cysts that are extremely resistant when kept in the dark: they can survive for years without hatching, waiting for optimal hydration conditions. Sixteen hours after hatching, the "umbrella" larval phase is observed: the newborns, called *nauplii*, are still enclosed in a membrane, within which the larva completes its development. At the time of hatching, the nauplii are about 3 mm long and can survive up to 48 hours from birth without additional sources of nutrition, thanks to the presence of their yolk sac. Nauplii are photophilic, meaning they require light to forage for food, which generally consists of photosynthetic algae. For the rest of their lives, they feed on phytoplankton and bacteria. They undergo two molts to become reproductive adults and can live up to 700 days.



Hordijk, Wim & Steel, Mike. (2018). Autocatalytic Networks at the Basis of Life's Origin and Organization. Life. 8. 62. https://doi.org/10.3390/life8040062

Phase II: Think-pair-share

Take 10 minutes to think alone about how to answer the questions. Then take another 10 minutes to write the answers with your classmate. Last, share your answers with the whole class.

- What is the biological question that you are trying to answer with this experiment?
- What kind of materials do you require?
- Which protocol are you going to use?
- Which are your expected results? Which are the possible conclusions you expect to find?

Phase III: Experiments with *Artemia salina*

Title	**Infusion preparation**
Aim	Prepare cigarette, microplastic, and other infusions to be tested with *Artemia salina*.
Materials	● 250 mL tap water ● 7 50-mL tubes or glass jars ● Used cigarette filters (butts) ● Acetone-free nail polish remover (see MSDS) ● Plastic pieces (plastic bag, plastic film, …) ● Tweezers ● Gloves ● Gauze
Expected time	20 minutes for set up and at least 24 hours for infusion.
Procedure	● Set up tubes or glass jars for infusions, naming them with letters A, B, C, D, A*, B*, C*. ● Pour 50 mL of tap water into tube/jar A and B. ● Using tweezers, take three cigarette butts and place in tube A. Immediately close the tube. ● To prepare the nail polish remover solution (we'll use it as solvent for microplastics), pour 60 mL of tap water in tube/jar D, then add 40 mL of nail polish remover. ● Pour 50 mL of nail polish remover solution into tube/jar C.

	● Cut all the plastic objects into small pieces (bag, film, envelope, …). ● Place the same amount of plastic pieces into tube/jar B and C. ● Wait for at least 24 hours (for microplastics longer incubation times are recommended). ● To remove any macroscopic residues from the infusions, use gauze to filter solutions A, B, and C respectively into tubes/jars A*, B*, and C*. Immediately close the tubes/jars. ● Infusions are ready to be used for your experiments.
Notes	Since cigarette butts are products of the combustion of used cigarettes, it is important to handle them with care, using tweezers and gloves. At the end of the experiment, it is advisable to seal the butts in a resealable bag (such as those used for freezing food) and waste them. In some countries, it not allowed to bring tobacco products to school. Teachers may be able to overcome these restrictions by making the extracts at home and bringing them into the classroom.

Title	***Artemia salina* as model for water pollution**
Aim	Investigate the effects of chemical compounds that can contaminate water on the hatching of *Artemia salina* cysts to highlight the direct effects of these substances on a living organism.
Materials & tools	● Tap water ● Instant Ocean Salt (available in pet stores or online) ● Infusions (cigarettes, microplastics) ● *A. salina* cysts (see attached document) ● Laundry detergent (see MSDS) ● Laundry softener (see MSDS) ● Nail polish remover solution (used for infusion preparation) ● Liquid fertilizer ● Vinegar (see MSDS) ● Alcohol (see MSDS) ● Petri dishes (6 cm in diameter)

	• Toothpicks • pH indicator papers • Gloves • Microscope or magnifying glass • Micropipette or graduated pipette • Desk lamp
Expected time	45 minutes for preparation, then observation after 24 and 48 hours.

Procedure	• Prepare salt water for the hatching of *A. salina*: add 20 g of Instant Ocean salt to 500 mL of chlorine-free water (bottled mineral water). Initially, the solution will be cloudy, so wait until the salt is completely dissolved in the solvent. The added salt concentration is twice what is necessary for *A. salina* but will be diluted in the plate preparation.
	• Prepare Petri dishes as follows:
	  ○ Plate A – 2.5 mL salt water + 2.5 mL infusion A
	  ○ Plate B – 2.5 mL salt water + 2.5 mL infusion B
	  ○ Plate C – 2.5 mL salt water + 2.5 mL infusion C
	  ○ Plate D – 2.5 mL salt water + 2.5 mL solution D
	  ○ Plate E – 2.5 mL salt water + 1.5 mL tap water + 1 mL vinegar
	  ○ Plate F – 2.5 mL salt water + 1.5 mL tap water + 1 mL laundry detergent
	  ○ Plate G – 2.5 mL salt water + 1.5 mL tap water + 1 mL laundry softener
	  ○ Plate H – 2.5 mL salt water + 1.5 mL tap water + 1 mL liquid fertilizer
	  ○ Plate I – 2.5 mL salt water + 1.5 mL tap water + 1 mL alcohol
	  ○ Plate L – 2.5 mL salt water + 2.5 mL tap water
	• Check the pH in all the plates using pH indicator strips.
	• Prepare 10 toothpicks to transfer the cysts: measure 6 mm from the tip and draw a line with a marker.
	• Dip the toothpick into salt water, up to the marker, ensuring the surface of the toothpick's tip is completely wet.
	• Dip the toothpick into the cysts, making sure the surface of the toothpick's tip is completely covered with cysts.

	● Dip the toothpick with the cysts into the plate. The cysts will immediately detach. Set the toothpick aside. ● Leave the cysts in incubation for 24 or 48 hours under a constantly lit desk lamp. ● Observe the plates under a microscope or a magnifying glass and count how many cysts have hatched under different conditions: frame three different parts of the plate and count, for each frame, the number of unopened cysts, mature nauplii, and immature nauplii. Take note of each count and create a graph to compare different hatching conditions.
Notes	● With this protocol, it is possible to test a variety of water contaminants according to students' experimental plans. For example, they may also want to test bleach, ammonia, oil, and other substances. ● The count can be performed after 24 hours to observe also a possible delay in hatching under some of the analyzed conditions. ● Light is necessary for hatching. If it is not possible to leave the lamp on for 24 hours, it is important to provide light for as many hours as possible. ● Under these conditions, the hatched nauplii will not be able to survive for long. To grow them, refer to the protocols described here.

Phase IV: Reflection on the results of the experiment

- What are the results of the experiment?
- Did they follow your expectation or did you obtain odd results?
- What is the cause of odd results?
- Review your experimental procedure in the light of finding and possible errors.
- Share your reflections with your classmates.

Appendix 4
Is it safe to swim in the lake?

Tips for the teacher

This activity is conceived as an open-inquiry experimentation in which students are given a question to investigate, and they must design their own procedure and determine the expected results. The teacher provides minimal guidance and support. This level of inquiry allows students to practice fully independent thinking and decision-making.

The ideal setting is to choose a pond, a lake, a river, or a creek that students know very well, where they play and maybe in which they can also swim or take a bath. This allows them to be more engaged in the investigation because their results can be of interest for the entire community. At the end of the investigation, after the discussion on the results, students can be asked to prepare an infographic to share their findings.

For this activity, the teacher has to split the class in small groups of three to five students. Every group should follow its own investigation plan under the supervision of the teacher; therefore, it is very possible that different groups will do different experiments and end up with different results.

To effectively guide students towards affordable investigations, the teacher can also show the instruments and the materials that students have access to.

Here are some suggested materials for this activity:

- Slides, coverslips, pipettes
- USB microscope
- Optical microscope with digital camera
- Commercial kits for biological and chemical analysis of water
  - Europe: (1) Chemical analysis kit; (2) Biological analysis kit
  - USA: (1) Chemical analysis kit; (2) Chemical analysis kit

Among all the possible indicators of water quality, these are some elements that can be easily analyzed:

- Carbonates
- Nitrates
- Turbidity
- Temperature
- Total hardness
- Ammonia
- Phosphate
- Iron
- Chlorine
- Dissolved O_2
- pH
- Microscopic analysis of water
- Coliform bacteria

Additional resources for the teacher: ebook Investigating Water Problems - Water Analysis Manual

Phase I: Engage. Presentation of the problem. Planning of the investigation.

- The teacher shows students a picture of the pond, lake, river, or creek selected for the investigation.
- The teacher splits the class in groups of three to five students.
- The teacher asks a few questions to engage students in the investigation. The following are some examples. *In your opinion, is it safe to swim in it? How would you assess this point? What kind of materials do you require? Which protocol are you going to use? Which kinds of controls do you need?*
- The teacher asks each group to share their plans and engages students in the discussion. Students are then asked to review their protocols after the discussion. At the end of this phase, each group should have a detailed investigation plan.

Phase II: Field activity

The teacher brings the groups of students to the lake. The field activity has to be conducted according to students' plans. They can include photo documentation and pick up water samples. Samples and pictures will be analyzed in the following phase of the investigation.

Phase III: In-class lab work

The teacher supervises groups while performing experiments as described in their investigation plans. The use of commercial kits for chemical and biological analysis of water is highly recommended (see tips for the teachers).

Phase IV: Analysis of the results

Students analyze and discuss the results of their experiments and answer the initial question about the safety of the lake. They discuss the effectiveness of their investigation plan, review the experimental procedure in the light of finding and possible errors.

Phase V: Development of the final product

Students develop an infographic or a presentation to share the results of their investigation.

Appendix 5

Oil spill challenge: Clean-up adventure!

Phase I: ENGAGE

The teacher introduces students to the topic of oil spills and their impact.

1. Show students pictures and videos of the 2010 Deepwater Horizon oil spill, the largest marine oil spill in history.
2. Explain the event, its environmental impact, and the challenges involved in clean-up efforts.
3. Facilitate a class discussion to gather students' initial thoughts and reactions.

Resources for the teacher: Deepwater Horizon oil spill

- Description and pictures
- Video showing a timeline of the Gulf oil spill, from the Deepwater Horizon rig explosion to the containment cap that has slowed the flow of oil.
- Video showing the effects of oil spill on ecosystems
- Video showing how dispersants work

Phase II: Ideas for oil spill clean-up. Planning of the investigation.

1. Conduct a brainstorming session where students suggest possible clean-up strategies.
2. Implement think-pair-share: Students think individually about solutions, discuss ideas in pairs, and then share with the class.
3. Record all ideas on the whiteboard for reference.
4. Divide students into small groups.
5. Each group selects one or more cleanup strategies to investigate (e.g., sorbents, dispersants, direct removal).
6. Groups research their chosen method and plan an experiment to test its effectiveness, including forming a hypothesis, listing materials, detailing procedures, and deciding on data collection methods.

Tips for the teacher.

If students need some help in finding possible sorbents, dispersant, and methods for direct removal, the teacher can support them with some suggestions.

- Possible sorbents: A reusable coffee filter can be filled with different materials, like fur, hair, straw, cotton, corn husk, coconut husk, polypropylene pads, fiber cloth square, paper, paper towel; other possibilities are cotton swabs or feathers. Feathers are useful also to figure out the effects of oil contamination for birds and other animals.
- Possible dispersant: soap, liquid dishwasher detergent
- Possible tools for direct oil removal: pipette, spoon

Provide students with graduated cylinders to allow them to measure the removal capacity of each method.

Phase III: Clean-up experiment.

In an open-inquiry-based setting, the teacher is a facilitator and supervises students to design and set up their investigation. This means that the teacher does not provide a protocol but lets every group of students free to develop and perform its own investigation.

A possible experimental plan is described in the following protocol.

Title	**Clean-up experiment**
Aim	The aim of this activity is to investigate the effects of oil spills in water. In a simulated "ocean" (a pan of water), students will drop a small amount of motor oil into the water and see the effects and interaction. Students will use a variety of materials to see what method works best for recovering the oil from the water. The effects of dispersants are addressed in the form of soap droplets added to the water in the second phase of the activity, allowing students to examine the effects of such chemical dispersant that are commonly used in oil spill recoveries.
Materials	● tap water ● 250 mL of vegetable oil or motor oil ● newspaper ● mesh coffee filters (at least 3 for each sorbent tested plus more filters) ● sorbents (e.g., fur, hair, straw, cotton, corn husk, coconut husk, polypropylene pads, fiber cloth square, paper, paper towel, cotton swabs, feathers). ● cups (at least one for each sorbent)

<table>
<tr><td></td><td>

graduated cylinders or beakers
50 mL of liquid dishwasher detergent
teaspoon
pipette

</td></tr>
<tr><td>Expected time</td><td>45–90 mins</td></tr>
<tr><td>Procedure</td><td>

Spread newspaper onto your work surface, to make cleanup easier.
Prepare sorbents by cutting each sorbent into small, thumb-sized pieces, and put them into cups.
Pour 750 mL of water into the graduated cylinder or beaker.
Slowly 250 mL of oil. Do the oil and water separate or mix? Write your observations in your lab notebook.
Organize your lab notebook in order to record the results of the experiment. Make a table like this:

<table>
<tr><th>Sorbent name</th><th>Total water and oil level after removing</th><th>Remaining water level after removing</th><th>Remaining oil level after removing sorbent (A-B)</th><th>Ratio B/(A-B)</th></tr>
<tr><td>__________
trial n. ___</td><td></td><td></td><td></td><td></td></tr>
<tr><td>__________
trial n. ___</td><td></td><td></td><td></td><td></td></tr>
<tr><td>__________
trial n. ___</td><td></td><td></td><td></td><td></td></tr>
</table>

Fill the mesh coffee filter with the first sorbent. Repeat this step to prepare three filters for each sorbent.
Put it slowly into the water–oil mixture and gently move it from side to side for a few seconds until the sorbent is completely submerged.

</td></tr>
</table>

- After the sorbent has been submerged in the liquid, wait 30 seconds, then lift the filter with the contents of the sorbent inside and hold it just above the surface of the water-oil mixture for 30 more seconds to drain.
- Measure A and B, then calculate A – B and ratio B/(A-B).
- Perform trial 2 and 3 for the same sorbent.
- Use the same procedure to analyze the efficacy of each sorbent.
- To test the action of direct removal tools, prepare on your bench the tool(s) that you are going to assay.
- Organize your lab notebook in order to record the results of the experiment. Make a table like this:

Tool name	Total water and oil level after oil removal (A)	Remaining water level after after oil removal (B)	Remaining oil level after oil removal (A-B)	Ratio B/(A-B)
__________ trial n. ___				
__________ trial n. ___				
__________ trial n. ___				

- To test the effect of dispersant, add 50 mL of liquid dishwasher detergent. Observe and write in your lab notebook what happens to the water-oil mix after the addiction of dispersant.
- To analyze if the dispersant affects the ability of sorbents to adsorb oil, you can test again the mesh coffee filters filled with fresh sorbents.

Notes	If you use coconut husks, be careful when crushing or smashing it. Wear eye protection and gloves, and cover the coconut with a large towel or place it in a burlap bag before smashing it.

Phase IV: Analysis of the results.

The teacher asks students to analyze the results and plot the data to make an appropriate graph of their results.

The teacher can facilitate this phase with some questions, like the ones listed here.

- How can you find the best sorbent at removing oil?
- Are there any sorbents that absorb more water than oil? How can you recognize them? Would you consider them good candidates for cleaning up oil spills?
- Which sorbents have the highest average water-to-oil ratio?
- Why does most of the oil stay above the water surface? How thick is the layer of oil above the water?
- Which materials are most effective at removing the oil? Why?
- What effect did the soap have on the oil? Why?
- How does oil affect feathers? What do you think is the effect for the animal?
- Based on the results of this experiment, can you figure out techniques for rescuing animals affected by oil spill?

Phase V. Discussion

Here are listed a few ideas for final discussion and reflection.

To conclude the activity, the teacher can stimulate a discussion with students by prompting them to reflect on the petroleum-based products they use daily. Here are some questions that can lead the discussion:

- Do we need petroleum oil?
- Where can you find petrol-derived goods in everyday life?
- Are there alternatives to petrol-derived goods?
- How does the use of petroleum impact the environment?
- What are the benefits and drawbacks of using petroleum-based products?
- What can individuals do to reduce their reliance on petroleum-based products?

This discussion helps students connect the activity to real-world applications and environmental considerations.

Moreover, the teacher can conclude the activity showing students the different techniques and procedures developed by scientists and engineers to clean up the oil spill: booms and skimmers, chemical surface dispersants, controlled burns, sorbent materials, vacuum/pumping, vegetation cutting, low-pressure flush, manual/mechanical cleanup (shovels, trucks on shore), natural recovery, water-oil separating devices, gelling agents, biological agents (help decompose soil faster, hay, oil eating mushrooms.

Possible extensions. The teacher can use this activity as a bridge to link this path to other laboratories on green chemistry and biotechnologies for the environment. Some possible extensions are related to genetically engineered organisms that degrade and remove oil from the environment, with simulated experiments with paper molecules showing the effect of specific enzymes on petrol oil.

Other possibilities include experiments to analyze the difference between biodegradable and non-degradable goods (e.g., cellulose peanuts vs Styrofoam peanuts).

Resources for the teacher:

- Scientific article that describes innovations in oil spill clean-up techniques.
- Video showing a novel technique for removing oil spill using magnets.
- Video showing the demonstration of the three techniques analyzed by students.
- Scientific articles on living organisms that degrade oil: article 1; article 2; article 3; article 4.