Microplastics in the Environment Experiment

#Eco360
Activity
Grade Level: 9-12

Main Objectives

Learners will get to collect flowing water and/or sediment samples to analytically test for plastics via density separation and visual inspection.

Learning Outcomes

After completing this activity, learners will:

- Develop proper sample collection techniques for water and sediment
- Separate sample solutions to isolate for plastics via density separation
- Visually inspect plastics with a microscope to identify plastic-type and colour

Curriculum Connections

Alberta

Grade 8 Unit E: Freshwater and Saltwater Systems

- 4 - Analyze human impacts on aquatic systems; and identify the roles of science and technology in addressing related questions, problems and issues

Grade 9 Unit C: Environmental Chemistry

- 1 - Investigate and describe, in general terms, the role of different substances in the environment in supporting or harming humans and other living things

Biology 20, 30 All Units

- STS outcome (science, technology and society): explain how science and technology have both intended and unintended consequences for humans and the environment

Ontario

Grade 9 Biology (B1.2, B2.3, B2.4, B3.5)
Grade 9 Geography

- B1. The Physical Environment and Human Activities: analyse various interactions between physical processes, phenomena, and events and human activities in Canada.
- C1. The Sustainability of Resources: analyse impacts of resource policy, resource management, and consumer choices on resource sustainability in Canada

Length of Activity

1 - 2 hours

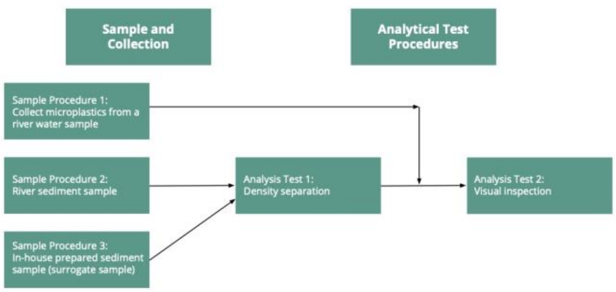
Materials List

Eco 360 notebook (we recommend asking learners to maintain a notebook for this program to write down reflections as they go through the program)
Water source
Plankton net (student grade with a mesh size between 25 and 150 μm diameter)
Flow meter to measure the water flow rate
PFDs or any other required safety devices
1L glass bottle
Aluminum foil
Metal shovel
Glass jar
Scale
PE or PP plastic with a bright colour
500 mL Beaker
Microscope (from 2x to 40x objective lens) or magnifier

Sediment, dirt, or sand
Saturated NaCl solution
Metal spatula
Sieve (300 μm mesh size)
Forceps

Step 1: Overview

Educators will decide based on what's best for their own classroom if they will allow learners to do sample procedures 1, 2, or 3. Below you will find the flowchart of the experiment based on what sample procedure is decided, and what analytical test procedure is done after.



Step 2: Sample and Collection

Sample Procedure 1

a. <u>Location:</u> River or another moving water sample.
b. <u>Time:</u> When the weather becomes warm, and the river water is clear (high suspend solids in the river will clog the net). August or later is the best time for the reduced river sediments.
c. <u>Tool:</u> plankton net (student grade with a mesh size between 25 and 150 μm diameter), a flow meter to measure the water flow rate
d. <u>Procedure:</u> Take a sample near the shore by wading into the river. Nets should be fully submerged into the flowing water just below the surface with the net opening facing the direction of water flow. Use the flow meter to measure the volume of water that is filtered by the net. Usually, 500 L of water needs to be filtered, which takes ~10 minutes in the North Saskatchewan River. The contents of the net will be transferred into 1 L glass bottles and brought back to the classroom. Aluminum foil should cover the bottle to avoid plastic contamination from the cap.
e. <u>Safety:</u> Learner safety must be assessed when sampling from a river. The use of PFDs or other safety devices are encouraged. Please review to Alberta or your associated provinces' health guidelines for further requirements.
f. <u>Note:</u> This method doesn't work for a pond as water doesn't flow.

Sample Procedure 2

a. <u>Location:</u> River or another moving water sample.
b. <u>Tools:</u> 1 L glass jar, metal shovel, and aluminum foil.
c. <u>Procedure:</u> Scoop about 500 g sand/sediment sample (maximum 5 cm in depth) into the jar, cover the jar with aluminum foil, then add a plastic cap.
d. <u>Analysis:</u> Analysis can be conducted by density separation in combination with a visual inspection.
e. <u>Safety:</u> Learner safety must be assessed when sampling from a river.

Sample Procedure 3

a. <u>Location:</u> Lab
b. <u>Tools:</u> plastic (PE or PP) with bright colour, dirt or sand, glass jar or beaker.
c. <u>Procedure:</u>
   i. Break down the plastic into small pieces. Ideally, pieces should be <5mm and >500 μm diameter to be seen by the naked eye. Particle size can be smaller if a microscope is available.
   ii. Add 10 plastic debris pieces into 100 g sand, dirt, or river sediment.
   iii. Add other typical fibres and debris in a similar size to mimic natural river samples (optional).
   iv. This can be prepared by the learner to see if they can find the plastics added. Alternatively, this can be prepared by the educator and the learner can report the number of plastics found.

Step 3: Analytical Test Procedures

Analysis Test 1

To be done if Sample Procedure 2 or 3 were performed. Continue to Analysis Test 2 once Analysis Test 1 is completed.

a. Tools: River sediment, dirt, or sand sample, saturated NaCl solution, 500 mL beaker, metal spatula, sieve (300 μm mesh size)

b. Procedure:

  i. Prepare a saturated NaCl solution.

  ii. Transfer sand or dirt into a 500 mL beaker, add 300 mL saturated NaCl solution, and stir the mixture with a spatula.

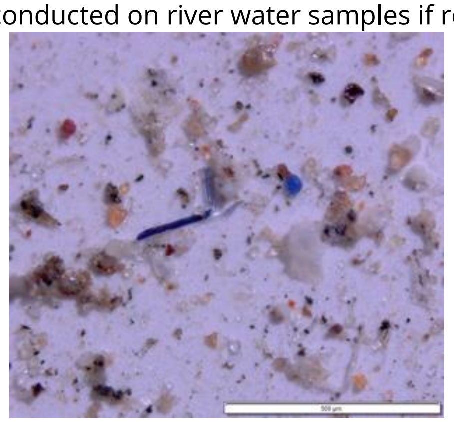
  iii. Allow sand/dirt to settle for about 10 to 20 minutes, transfer the supernatant to a sieve and look for plastic debris with bright colour.

  iv. If the number of plastic debris is less than 10, then repeat steps ii. and iii.

c. Analysis: Analysis can be conducted by density separation in combination with a visual inspection.

d. Note 1: It is also possible to study the real microplastics in the dirt or sand using the same method. But the natural organic content in the dirt makes visual identification difficult.

e. Note 2: Density separation can also be conducted on river water samples if required.



An example above shows plastic with a bright colour (e.g., blue), and how it can be easily identified from sand or dirt.

f. Density Separation Chart:

Abbreviation	Polymer	CAS no.	Density (g cm^{-3})	
PS	Polystyrene (expanded)	9003-53-6	0.01 – 1.06	100% Ethanol or 70% Isopropyl Alcohol may also work
PP	Polypropylene	9003-07-0	0.85 – 0.92	
LDPE	Low-density polyethylene	9002-88-4	0.89 – 0.93	
EVA	Ethylene vinyl acetate	24937-78-8	0.93 - 0.95	
HPDE	High-density polyethylene	9002-88-4	0.94 – 0.98	100% Water
PA	Polyamide	63428-84-2	1.12 – 1.15	
PA 6,6	Nylon 6,6	32131-17-2	1.13 – 1.15	
PMMA	Poly methyl methacrylate	9011-14-7	1.16 – 1.20	Saturated NaCl solution
PC	Polycarbonate	25037-45-0	1.20 – 1.22	
PU	Polyurethane	9009-54-5	1.20 – 1.26	
PET	Polyethylene terephthalate	25038-59-9	1.38 – 1.41	
PVC	Polyvinyl chloride	9002-86-2	1.38 – 1.41	Saturated NaI solution (optional)
PTFE	Polytetrafluoroethylene	9002-84-0	2.10 – 2.30	

When the saturated NaCl solution is mixed with the dirt samples, pieces of plastic should start to separate and float to the top since the NaCl solution has a higher density than most plastics. This new solution that now floats above the dirt is called the supernatant.

Analysis Test 2

This visual inspection test is done after Sample Procedure 1 is completed, or once Analysis Test 1 is completed.

a. Tools: sieve with the same mesh size as net, forceps, microscope (from 2x to 40x objective lens) or magnifier.

b. Procedure:

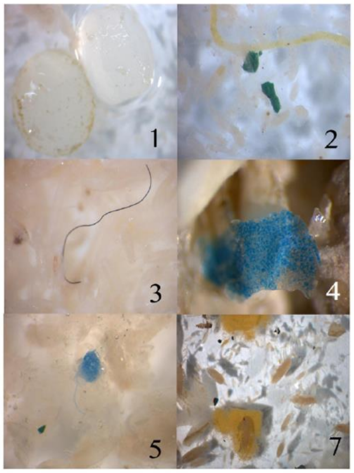
  i. Sieve and rinse field samples with clean water. Identify suspicious particles under the microscope based on the criteria below of shape and colour.

  ii. Use forceps to collect identifiable microplastics from the sieve and transfer them to another container.

  iii. Report the results: number of microplastics/cubic meter of water

  iv. Limitations: Visual identification is considered to be a tentative result. Further analytical methods would be required for positive identification.

c. Visual identification of microplastic based on shape and colour:



Examples of microplastic types. Numbers correspond to the previous type of plastics below. Microbeads (6) are not commonly found in environmental samples; therefore they are not represented in the photo.

d. <u>Type:</u> This criterion is targeted to the most common microplastic types described in peer-reviewed publications and the categories suggested are the following:
   1. Pellet
   2. Fragment
   3. Fibre
   4. Film
   5. Rope and filaments
   6. Microbeads (perfect spheres)
   7. Sponge/foam
   8. Rubber

e. <u>Colour:</u> The classifications for this criterion were collected from the most common microplastic colours reported in peer-reviewed publications. The most common colours identified are shown below:
   1. Black
   2. Blue
   3. White
   4. Transparent
   5. Red
   6. Green
   7. Multicolour
   8. Others

Sources

i. Characterization of microplastics and anthropogenic fibers in surface waters of the North Saskatchewan River, Alberta, Canada

ii. Laboratory Methods for the Analysis of Microplastics in the Marine Environment: Recommendations for quantifying synthetic particles in waters and sediments

iii. Standardised protocol for monitoring microplastics in seawater.

iv. Each Year More Than 1000 Tons of Plastic Rains on Western US Protected Lands