PLASTIC PANIC

An exploration of microplastics at the wastewater treatment plant

Activity Outline

Overview

Model the journey water takes at a Wastewater Treatment Plant (WWTP) through a series of hands-on steps. Learn about microplastics and discover what happens to them as they enter and pass through a WWTP. This activity was designed around Biological Systems Engineering PhD Student, Derek Ho's, research at UW – Madison in Troy Runge's group.

This activity was developed for an informal family drop-in program held at the Chazen Art Museum at UW–Madison and can be adapted for use in other settings.

Photo Credit: Eric Baillies

Key Lessons and Background

- **What are microplastics?**
  Microplastics are plastic particles 5 mm or smaller.
- **Where are microplastics coming from?**
  Microplastics are often thought about in two groups: Primary-microplastics are those that are deliberately made (ex. small pellets for filling stuffed animals, beads added to face wash and personal care products). Secondary-microplastics are formed by degradation of larger plastic products. Tires wearing on roads and fibers shed from synthetic clothing during laundering are two common sources of these secondary-microplastics.
- **What happens at the WWTP?**
  Wastewater treatment plants are complex and employ a variety of different methods to clean our water (mechanical, chemical, biological). However, these plants aren't designed to filter out microplastics. While some microplastics may be removed during the treatment process, others may pass through WWTPs and be released into the natural environment along with the cleaned water, called "effluent." Additionally, some of the microplastics that are captured and removed

from the water are concentrated in sewerage "sludge" that is sometimes sold to farmers and spread on fields as fertilizers. Public and scientific awareness of microplastics is increasing and much research needs to be done to fully understand the impact of microplastics may have on a wide range of organisms and ecosystems. As of 2019, "No specific treatment process aimed at microplastics removal has been applied in any full-scale WWTP yet and the microplastics-targeted treatment technology is still at the preliminary research state" (Sun 2019).

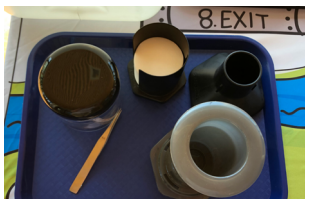
- **What's so bad about microplastics?**
  Fish and other organisms sometimes mistake microplastics for food. A belly full of plastic can make them feel full without providing any nutritional value. Additionally, heavy metals and other pollutants tend to be attracted to and stick to plastics. These can be harmful to the organism that ingests the plastic, and they can work their way up the food chain.

Materials & Setup

15 minutes. Set up tablecloth on 8' table. Place supplies on the tablecloth according to instructions below, fill your water jug, and set up the microscope.

Materials with an asterisk (*) are not included in the activity kit.

Action Step	Materials	Setup Photo
1. Fill	• One water jug* • Five small clear jars with lids • One blue tray	
2. Add	• Microplastic samples • Two ice cube trays	
3. Safety	• Six kids safety glasses	

Action Step	Materials	Setup Photo
Welcome to the Wastewater Treatment Plant!	• No materials	
4. Filter	• Two filters • Two plastic pitchers • One plastic "landfill" container • One blue tray	
5. Skim	• One tea strainer • One plastic "landfill" container • One blue tray	
6. Digest	• No materials	
7. Sanitize	• Blacklight • Blacklight holder	
8. Exit and sample	• One Aeropress coffee maker • Aeropress filters • One small clear jar with lid • Tweezers • One blue tray	
9. Examine sample	• Microscope (USB plug and play with any device)	

Standards

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success constraints on materials, time, or cost.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Run Through

20 minutes. Walk students through the nine action steps to test their sample of "wastewater" contaminated with microplastics. At each step make predictions and observations about what's happening to the sample. After completing the wastewater treatment process, take action step 9 - Examine sample under the microscope to uncover what plastic made it through the WWTP.

Action Step	Activity Instructions	Guiding Questions
1. Fill	We're going to model what happens to water as it goes to the WWTP. Fill a sample jar with water ¾ full.	**What is wastewater?** Any water that has been used/ affected by humans. **Where does wastewater come from?** Whatever we send down the sink, toilet, etc. from our homes, schools, businesses, and factories. **What happens to the water we send down the drain?** In some communities, wastewater travels through the sewer system and gets pumped to a WWTP to be processed before being released to the environment.
2. Add	Microplastics have gotten into the wastewater! Add one sample of microplastics to your jar and, with the lid on, give it a shake to mix it up. Notice the different kinds of plastics in your sample.	**What are microplastics?** Tiny (smaller than 5mm) pieces of plastic. **Where are they coming from?** Many sources including washing polyester clothes, contacts flushed down the sink, microbeads in soaps, tires, road markings/paint. More than 2/3 of global releases of primary microplastics into the oceans comes from laundering synthetic textiles (63%) and abrasion of tires while driving (28%).
3. Safety	Put on a pair of safety glasses before entering the treatment plant! Scientists and engineers of all sorts wear protective equipment during their work.	**Why do scientists need safety glasses?** Safety glasses protect eyes from cuts and splashes and are an important part of PPE, personal protective equipment. **Have you ever had to wear safety glasses before?**
Welcome to the Wastewater Treatment Plant!		
4. Filter	When water enters the treatment plant (called "influent") it passes through fine filters to remove rags and other large materials like paper towels, hygiene products and "flushable wipes." Pour your sample through the filter to see what it catches. Use the measuring cup to return the filtered water from the bucket (and any microplastics that made it through the filter) to your jar for the next step.	**Why do you think the WWTP has a filter at the very beginning of the treatment process? What do you think would happen if WWTPs didn't have filters like this?** WWTPs have a filter to prevent clogging or damage in other parts of the treatment system. **What are the costs of having a filter?** WWTP staff have to constantly remove debris and clean clogs. ***Make a prediction:* what's going to happen to the microplastics in your sample when you pour it through the filter? How much, and what, will get caught?**
5. Skim	In the WWTP's "settling tanks" heavier solids settle at the bottom while greases, oils, and light solids float to the surfaces. The settled and floating materials are skimmed off, allowing the cleaner middle water to keep moving through the treatment process. Use the mesh strainer to try to remove microplastics from the surface of your sample in the jar. Make sure to hold your sample in another bucket or over a tray while you do this to catch any spills! After a few (we recommend 3) attempts, take your sample to the next step.	At this station, notice how the microplastic pollutants in your sample separate into different layers in the water. **What water is the cleanest? Top, middle, or bottom?** **Why do some plastics float and some sink?** Plastics have different densities that impact whether they float or sink. The size of the particle might also have an impact. **What do you notice about what floats vs. what sinks? What do you think would float and sink at the real WWTP?**

Action Step	Activity Instructions	Guiding Questions
6. Digest	In what's sometimes known as "secondary treatment," the wastewater is pumped into large aeration tanks, where the wastewater is mixed with bacteria and air. The mixed in bacteria (microbes) "eat" organic matter and nutrients that we don't want in our water. Use the questions to the right to have a conversation before moving on from the aeration tanks.	**What are the microbes doing here?** They are digesting the organic materials and excess nutrients that get into the water from things like human waste and food that goes down the drain. **What happens to the microplastics during this step of treatment?** Nothing. The microbes don't digest nonliving or inorganic things. This is a crucial part of the treatment process, but it doesn't help our plastic problem.
7. Sanitize	In the final step of the cleaning process at this WWTP, the water passes through sanitization chambers designed to kill bacteria that might cause disease. In the chambers, ultraviolet (UV) light kills bacteria by harming their DNA. Pass your sample through the sanitization chambers and look at it through the view hole.	This step kills bacteria. **Are all bacteria bad?** Not all bacteria are harmful. Bacteria, like in the step before, do so many important things for humans. **Does anything in your sample look different under the black light?** Some remaining microplastics may appear more or less visible under the light. **What other ways to sanitize water do you know about?**
8. Exit and sample	The treated water, called "effluent," is returned to the environment, in this case a stream. Scientists are working to learn more about microplastics, where they are in our environment, and where they are coming from. Imagine you're a scientist sampling the effluent to check for microplastics. Pour your sample into the coffee maker with a fresh filter paper. The microfilters will catch remaining particles as the water passes through. Then, remove your filter paper and take it over to the microscope to study your sample.	**Are you satisfied with the cleanliness of your sample? Is it clean enough to go into the river?** **What didn't the WWTP catch?** Some of the initial microplastics made it through the plant. In addition to microplastics, WWTPs aren't designed to remove salt, pharmaceuticals, and other emerging pollutants. **What sorts of things could we do to prevent microplastics from getting through the WWTP to the streams?** Use less plastic in our daily lives, create less microplastics, install filters on washing machines, engineer and design processes at the WWTP to catch the microplastics. **What could we do with microplastics once we've collected them?** **Who do we need to work on this problem?** All people with lots of different skills! Government – WWTP, industry – product design and manufacturing, Scientists – study what's actually happening. **What about the WWTP process makes you curious?**
9. Examine sample	Examine your sample under the microscope. Notice what kinds and how many microplastics there are. Compare your sample to the clothing and fabric samples. Optional Extension: Collect data on your sample and compare it to your classmates.	**What shape are your microplastics? Are they Fibers? Beads? Something else? What do you think could be the source of your microplastics?** **Do you notice any patterns with what types of microplastic make it through the treatment plant and which get caught in the treatment?** **What can you do to help stop the plastic panic at the WWTP?**

Debrief

- Discuss the potential impact of microplastics released into the natural environment.
- Design a method that could be used to monitor and minimize the impact of microplastics in the environment.
- How could the technological solutions currently used at WWTP be refined to reduce impacts on natural systems?

Clean-up

Let all the materials dry out. Once dry, brush the dried microplastics from the sieve and "landfill" containers back into the microplastics sample bag. Aeropress filters with microplastics may be thrown into the trash.

References

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