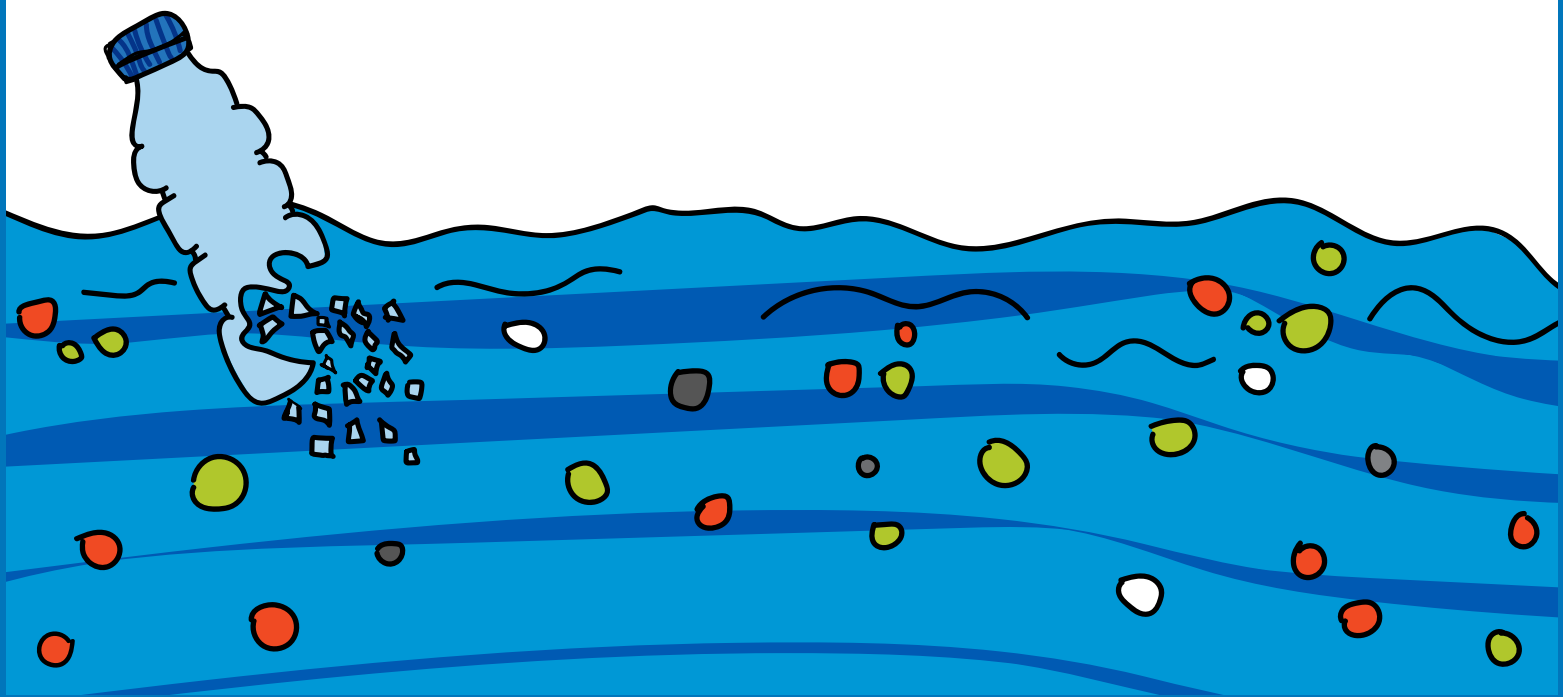
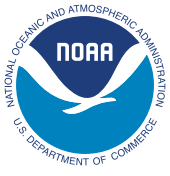
EDUCATOR'S GUIDE

PLASTIC PANIC

An exploration of microplastics
at the wastewater treatment plant

GRADE 4-7





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PLASTIC PANIC

An exploration of microplastics at the wastewater treatment plant

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ABOUT

CENTER FOR GREAT LAKES LITERACY (CGLL)

The Center for Great Lakes Literacy (CGLL) is a collaborative effort led by Sea Grant educators throughout the Great Lakes watershed. CGLL fosters informed and responsible decisions that advance basin-wide stewardship by providing hands-on experiences, educational resources and networking opportunities promoting Great Lakes literacy among an engaged community of educators, scientists and youth. Learn more on the CGLL website at **cgll.org**.

SEA GRANT

Sea Grant is a federal/university partnership program that brings science together with communities for solutions that work.

The National Sea Grant College Program was established by the U.S. Congress in 1966 and works to create and maintain a healthy coastal environment and economy. The Sea Grant network consists of a partnership between the National Oceanic and Atmospheric Administration (NOAA) and 34 university-based programs in every coastal and Great Lakes state, Puerto Rico and Guam. The network draws on the expertise of more than 3,000 scientists, engineers, public outreach experts, educators and students to help citizens better understand, conserve and utilize America's coastal resources. Visit **seagrant.noaa.gov** for more information.

THE WISCONSIN ENERGY INSTITUTE

The Wisconsin Energy Institute (WEI) is the collaborative home of energy research and education at the University of Wisconsin–Madison. The WEI is led by scientists and engineers committed to crossing traditional research boundaries in order to transition to new, clean energy systems and solutions. Learn more about the WEI and their resources for educators at **energy.wisc.edu**.

INTRODUCTION

* Italicized words can be found in the glossary on **page 18**.

SUMMARY

Learn about *microplastics* and model the journey they take through a *wastewater* treatment plant (WWTP) with a series of hands-on steps.

GRADE LEVEL

Fourth through seventh.

KEY CONCEPTS AND BACKGROUND

What are microplastics?

Microplastics are plastic particles less than 5 mm in length. They can come in the form of films, fragments, foams, fibers or *nurdles (plastic resin pellets)*.

Where do microplastics come from?

Microplastics are often grouped into two categories. Primary microplastics are deliberately manufactured small plastic pieces, such as the small pellets used for filling stuffed animals. Secondary microplastics are formed by the degradation of larger plastic products. Examples include the material from worn tires that is left on roads and highways, fibers shed from *synthetic* clothing during laundering, or larger plastics (such as plastic bottles) that enter a waterway and break down into smaller pieces.

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. This "sticking" is called adsorption. Plastics with adsorbed contaminants can also be harmful to the organism that ingests the plastic. Furthermore, the adsorbed contaminants can work their way up the *food web*.

How do microplastics get in our surface water?

1. ***Sanitary sewers***
   Sanitary sewers consist of a network of underground pipes or tunnels that transport sewage from homes and commercial buildings to a WWTP. The WWTP typically releases water into a nearby river or lake.
2. ***Stormwater sewers***
   Unlike sanitary sewers, water that goes through stormwater sewers does not go to the WWTP. Stormwater sewer pipes flow directly into bodies of water, such as rivers and lakes, along with any pollutants, microplastics and other contaminants that went down the same drain. These sewers collect stormwater runoff from inlets, catch basins or drains located along street curbs or parking lots.
3. **Runoff**
   In rural areas, there are no sanitary or stormwater sewers. Most dwellings have septic tanks. Runoff from storms and other events flows into nearby water bodies or drains into the soil.

What happens at the WWTP?

Wastewater treatment plants are complex and use multiple methods (mechanical, chemical and biological) to treat wastewater. The wastewater these plants process, called *influent*, comes from water used in homes (toilets, laundry, shower, dishwasher, etc.) and businesses or as part of industrial processes. However, treatment plants aren't explicitly designed to remove 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 (*effluent*).

Additionally, some microplastics that are captured and removed from the water are concentrated in sewage "*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 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 et al., 2019).

What can we do about the amount of microplastics that go through the WWTP?

We don't know exactly how much each source contributes to the overall amount of microplastics in each body of water. However, some estimates found that the washing of textiles contributes 34.8% and the wear of tires 28.3% to ocean microplastic totals. "City dust" is the third largest contributor at 24%.

To reduce your impact, consider wearing clothes made from natural fibers and wash your clothes only when they need it. Use tools (balls or bags) or install a microfiber filter in your washing machine to catch synthetic fibers. No matter what fabric you're wearing, try to take care of it and make it last.

ESSENTIAL QUESTION

What happens to the water after we brush, flush or wash?

Driving Questions

1. What is wastewater?
2. What does wastewater have to do with me?
3. What are some common contaminants found within wastewater?
4. What are some techniques for treating water to remove contaminants?
5. What are microplastics and why are they such a problem in wastewater?
6. What are possible consequences (both negative and positive) related to my choices of how, when, why and where I interact with water?

LEARNING OBJECTIVES

After this exploration, students should be able to:

- **Make and record observations** of untreated and treated water, and the impacts of various filtration media on water quality.
- **Describe** water treatment process steps as wastewater moves from a home to, and through, a wastewater treatment plant.
- **Respond** to the essential and driving questions associated with this exploration.

ANTICIPATED PRIOR LEARNING

- The water cycle

GREAT LAKES LITERACY PRINCIPLES

A Great Lakes literate person understands essential principles and fundamental concepts about the characteristics, functioning, and value of the Great Lakes; can communicate accurately about the Great Lakes' influence on systems and people in and beyond their watershed; and is able to make informed and responsible decisions regarding the Great Lakes and the resources of their watershed.

Principle 1
The Great Lakes, bodies of fresh water with many features, are connected to each other and to the world ocean.

Principle 4
Water makes Earth habitable; fresh water sustains life on land.

Principle 6
The Great Lakes and humans in their watersheds are inextricably interconnected.

Principle 9
The Great Lakes are socially, economically, and environmentally significant to the region, the nation and the planet.

The complete list of Great Lakes Literacy Principles can be found at **cgll.org/principles**.

MATERIALS

MATERIALS SUPPLIED

- [ ] Educator's Guide
- [ ] Wastewater treatment plant tablecloth
- [ ] 6 empty jars
- [ ] Small spoon
- [ ] 1 jar with microplastics
- [ ] 5 kids' safety glasses
- [ ] Adult safety glasses
- [ ] 2 "landfill" containers
- [ ] 2 sieves
- [ ] 2 metal pitchers
- [ ] 4 blue trays
- [ ] Tea strainer
- [ ] Blacklight flashlight
- [ ] UV sanitation station (for black light)
- [ ] Coffee filters
- [ ] Small, round white filters
- [ ] Rubber bands
- [ ] Tweezers
- [ ] USB 2.0 digital microscope
- [ ] 10 sample cards

ACTIVITY SHEETS

- [ ] Down the Drain
- [ ] Wastewater Treatment Steps
- [ ] Wastewater and Plastics True or False
- [ ] Wastewater and Plastics True or False Answer Key

MATERIALS NEEDED

- [ ] 6-foot table
- [ ] Water jug or pitcher
- [ ] Bucket for wastewater
- [ ] Computer with USB port or appropriate dongle to use with digital microscope
- [ ] Electrical outlet and possibly extension cord to power computer and digital microscope
- [ ] Drawing paper (2 sheets per student) and drawing utensils

ACTIVITY SETUP **15 MINUTES**

Set up tablecloth on a six-foot table. Place supplies on tablecloth according to instructions below, fill your water jug and set up the computer and microscope. **Five or ten learners can participate in the tabletop activity at a time**.

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

4. FILTER

- One “landfill” container
- Two sieves
- Two metal pitchers
- One blue tray

WELCOME TO THE WASTEWATER TREATMENT PLANT

- No materials

3. SAFETY

- Five pairs of kids’ safety glasses
- One pair of adult safety glasses

2. ADD

- Small spoon
- Jar with microplastics

1. FILL

- One water jug*
- Five sample jars
- One blue tray

START HERE

5. SKIM

- One “landfill” container
- One tea strainer
- One blue tray

6. DIGEST

- No materials

7. SANITIZE

- Blacklight flashlight
- UV sanitation station

8. EXIT

- One small clear jar with lid
- Coffee filter
- Rubber band
- Tweezers
- Small, round white filters
- One blue tray

EXAMINE SAMPLE

- Computer*
- USB 2.0 digital microscope
- 10 sample cards

EXPLORATION PLAN **TOTAL TIME 60 MINUTES** depending on class size and number of activities.

INTRODUCE THE TOPIC **10 MINUTES**

Introduce the topic by providing general information on microplastics and wastewater treatment using the open discussion points below. You can use the Down the Drain Activity Sheet as a pre-evaluation to determine learner knowledge.

Essential question

What happens to the water after we brush, flush or wash?

Driving questions

1. What is wastewater?
2. What does wastewater have to do with me?
3. What are some common contaminants found within wastewater?
4. What are some techniques for treating water to remove contaminants?
5. What are microplastics and why are they such a problem in wastewater?
6. What are possible consequences (both negative and positive) related to my choices of how, when, why and where I interact with water?

Open discussion

Key points to make during the open discussion

1. Everyone uses water every day – water is life.
2. When we use water, often other things (e.g., soap, dirt, toilet paper) intentionally get into the water.
3. When we use water, sometimes things unintentionally get into the water, and we might not know when this happens.
4. Things that get into the water, whether intentionally or unintentionally, that make the water less useful are called “contaminants.” We’ll be talking more about one type of contaminant — microplastics — later.
5. We are going to continue by doing an activity that follows the steps in a WWTP and investigates what happens along the way.

Pre-evaluation

- Down the Drain Activity Sheet

LEARNING ACTIVITIES **50 MINUTES**

Wastewater Treatment Plant Tabletop Activity

Walk students through the nine action steps of the WWTP with their sample "wastewater" contaminated with plastics. At each action step, students make predictions about what will happen based on their prior knowledge, the name of the action step (e.g., fill) and observations about what's happening to the sample. After completing the simulated wastewater treatment process, students will look at what remains in the sample under a microscope.

FACILITATION NOTE

The WWTP Tabletop Activity works best with groups of 10 students or fewer. For groups that are larger than 10, see the additional learning activities on **page 15**.

Preparing for the Wastewater Treatment Plant Tour

1. FILL

We're going to model what happens to water as it goes through the WWTP.

GUIDING DISCUSSION

What is wastewater?
Any water that has been used by humans.

Where does wastewater come from?
Sinks, toilets, bathtubs and other drains 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. Or, if you live outside an urban area, your home or dwelling may have a *septic system*. A septic system is an installed underground wastewater treatment structure that uses a combination of natural and technological processes to treat wastewater from household plumbing. More than one in five households in the United States depends upon a septic system.

ACTIVITY INSTRUCTIONS

Fill a sample jar half full of water.

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2. ADD

Plastics have gotten into the wastewater!

GUIDING DISCUSSION

What are microplastics?
Some plastics that enter our waterways are tiny pieces of plastic. These microplastics are shorter than 5 mm in length and can cause problems for the WWTP.

Where are they coming from?
Sources include washing *polyester* fabrics, contacts washed down the sink, tires or road markings. We don't know exactly how much each source contributes to the overall amount of microplastics in each body of water. However, some estimates found that the washing of textiles contributes 34.8% and the wear of tires 38.3% to ocean microplastic totals. "City dust" is the third largest contributor at 24%.

ACTIVITY INSTRUCTIONS

Add one teaspoon of plastics to the jar, cover with the lid and shake to mix. Notice the different kinds of plastics in the sample (e.g., some plastics float while others sink).

---

3. SAFETY

Scientists and engineers wear protective equipment during their work.

GUIDING DISCUSSION

Why do scientists need safety glasses?
Safety glasses protect the eyes from cuts and splashes and are an important part of personal protective equipment (PPE).

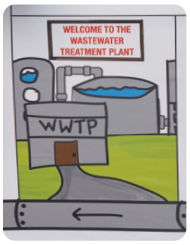
Have you ever had to wear safety glasses before? When?

ACTIVITY INSTRUCTIONS

Put on a pair of safety glasses before entering the treatment plant.

Wastewater Treatment Plant Tour

WELCOME TO THE WASTEWATER TREATMENT PLANT



GUIDING DISCUSSION

Do you know where the wastewater from your home goes after you flush the toilet, take a shower or wash your clothes?

Does your home connect to a wastewater treatment plant in your community? Or are you connected to a septic system?

Find a wastewater treatment plant on a map in your community, your county or somewhere in your state.

ACTIVITY INSTRUCTIONS

There is no activity at this step of the tabletop activity.

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4. FILTER

Water entering the WWTP (called "influent") first goes through *primary treatment*, passing through fine filters to remove large materials like paper towels, hygiene products and "flushable" wipes.

GUIDING DISCUSSION

Predict what will happen to the microplastics in your sample when you pour it through the filter. What will be caught and how much?

Why does a WWTP have a filter at the very beginning of the treatment process?

What would happen if WWTPs didn't have filters like this?
WWTPs have a filter to prevent large items from clogging or damaging other parts of the treatment system.

What are the challenges that result from having a filter?
WWTP staff have to constantly remove *debris* and clean clogs.

ACTIVITY INSTRUCTIONS

Pour the sample through a sieve to see what it catches. Use the measuring cup to return the filtered water from the bucket (and any waste that made it through the sieve) to the jar for the next step. Place what has filtered out into the "landfill" bucket.

Wastewater Treatment Plant Tour cont.

5. SKIM

In the WWTP's settling tanks, heavier solids sink to the bottom while greases, oils and light solids float to the surface. The floating materials are skimmed off, allowing the cleaner middle water to keep moving through the treatment process.

GUIDING DISCUSSION

Where (top, middle or bottom) is the water cleanest?

Why do some plastics float and some sink?
Plastics have different densities that affect whether they float or sink. The size of the particle might also have an impact.

What do you notice about the sample at this step?
The pollutants will separate into different layers in the water.

What would float or sink at a real WWTP?

What happens to the heavier stuff on the bottom?

ACTIVITY INSTRUCTIONS

Use the mesh strainer to try to remove microplastics from the surface of the sample in the jar. Make sure to hold the sample in another bucket or over a tray to catch any spills! After a few attempts (approximately three), take the sample to the next step.

---

6. DIGEST

In what is sometimes known as "*secondary treatment*," wastewater is pumped into large aeration tanks, where it is mixed with bacteria and air. The bacteria (*microbes*) "eat" organic matter and nutrients that we don't want in our water.

GUIDING DISCUSSION

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 go down the drain.

What happens to the plastics during this step of treatment?
Nothing. Microbes do not digest nonliving or inorganic things. This is a crucial part of the treatment process, but it does not help our plastic problem.

ACTIVITY INSTRUCTIONS

Use the questions above to have a conversation before moving on from the aeration tanks.

---

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.

GUIDING DISCUSSION

Are all bacteria bad?
Not all bacteria are harmful. In step 6 above, bacteria help clean the wastewater. Bacteria do many important things for humans.

Does anything in the sample look different under the black light?
Some remaining microplastics may appear more or less visible under the light.

What other ways could you sanitize water?

ACTIVITY INSTRUCTIONS

Place your sample in the sanitization chamber and look at it through the view hole.

Wastewater Treatment Plant Tour cont.

8. EXIT
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 come from. Imagine you are a scientist sampling the effluent to check for microplastics.

GUIDING DISCUSSION

Are you satisfied with the cleanliness of the sample?

Is it clean enough to go into the stream?

What didn't the WWTP catch?
Some of the initial microplastics made it through the plant. In addition to microplastics, WWTPs are not designed to remove salt, pharmaceuticals and other *contaminants of emerging concern*.

What can all of us do to prevent microplastics from getting through the WWTP to the streams?
Some ideas: Use less plastic in our daily lives, create fewer microplastics, install filters on washing machines, and engineer and design processes at the WWTP to catch microplastics.

What could be done with microplastics once they are collected?

Who do we need to work on this problem?
People with lots of different skills, including those working in government, WWTP industry, product design and manufacturing, and science.

What about the WWTP process makes you curious?

ACTIVITY INSTRUCTIONS

Secure a fresh coffee filter over the clear jar with a rubber band. For each student, place one small white filter on top. Pour the sample through the two filters. The small filter will catch the remaining particles as the water passes through. Remove the white filter and place on the top of the clear jar and take to the microscope to examine.

Evaluate the Effluent

EXAMINE SAMPLE
Engineers and scientists may need to know what is and isn't being filtered or treated in the WWTP.

GUIDING DISCUSSION

What shape are your microplastics? Are they fibers? Beads? Something else?

Are the microplastics in your sample the same colors?

What 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 and/or your family do to help stop the plastic panic at the WWTP?

ACTIVITY INSTRUCTIONS

Examine the white filter paper under the microscope. Notice the different types and amounts of microplastics.

Compare any materials on the white filter paper with the clothing and fabric samples.

Optional extension: Collect data on the sample and compare it to others' data.

Additional Activities

Flushable or Not Flushable?
https://www.jea.com/About/Community_Impact/Educational_Resources/Flushable_or_Not_Flushable_/

NOAA Marine Debris Art Contest
https://marinedebris.noaa.gov/annual-noaa-marine-debris-program-art-contest-and-calendar

Sampling for Microplastics in Beach Sand
https://flseagrant.ifas.ufl.edu/media/flseagrantifasufledu/sea-grant/pdf-files/microplastics/Sampling-for-Microplastics-in-Beach-Sand.pdf

Stormwater Pollution Solutions Student Opportunity
https://www.scholastic.com/waterpollution/index.html

Teach Engineering — WWTP Model
https://www.teachengineering.org/activities/view/uok-2216-wastewater-treatment-plant-model-water-quality

The Dirty Water Project: Design-Build-Test Your Own Water Filters
https://www.teachengineering.org/activities/view/cub_environ_lesson06_activity2

Trash Trunk
https://www.seagrant.wisc.edu/our-work/focus-areas/education/for-educators/trash-trunk/

Turning the Tide, Taking Action — lesson on organizations helping prevent and address marine debris, and how to get involved with volunteering
https://oregoncoaststem.oregonstate.edu/sites/oregoncoaststem.oregonstate.edu/files/MD/turning-the-tide-taking-action.pdf

EVALUATION STRATEGIES

Choose one, or more, based on your needs.

1. **Reprise Down the Drain Activity Sheet • 10 MINUTES**
   After the exploration, have students reflect as a group, as pairs, or individually on the original driving questions and their original responses to these questions. What, if anything, has changed from their initial thoughts?
2. **Wastewater Treatment Steps Activity Sheet (for post-evaluation) • 5 MINUTES**
   After the exploration, have students draw a picture to represent what happens to wastewater after it goes down the drain. Students should label their drawing with the vocabulary words from the exploration and explain the drawing by including descriptions of the treatment steps.
3. **Wastewater and Plastic True or False Activity Sheet (for post-evaluation) • 10 MINUTES**
   Using what they have learned from the exploration, students answer true/false questions in pairs. Students are encouraged to discuss why they chose each answer.

CLEANUP

CLEANUP AND PREPARATION BETWEEN GROUPS

If you are working with multiple groups, the following steps need to be completed in between groups working at the table station.

1. Remove water and any remaining plastics from jars by dumping them into a bucket. Return empty jars (it is okay if some microplastics remain) to the “fill” station.
2. If time allows, refill the pitcher with clean water so it is available for the next group. Otherwise, water from the bucket of wastewater can be used as the starting material for subsequent groups.
3. Have students return safety glasses to the safety station.
4. Be sure to turn off the ultraviolet flashlight.

FINAL CLEANUP

Let all the materials dry out. Once dry, brush the dried microplastics from the sieve and landfill containers back into the microplastics sample jar. Coffee filters with microplastics may be thrown into the trash. **In order to prevent mildew, do not return the materials to the box until they are thoroughly dry.**

GLOSSARY

biological treatment: The secondary stage of wastewater treatment (also known as conventional treatment) in which bacteria and other microorganisms consume and degrade about 85% of the organic matter in the sewage.

chemical treatment: Typically used to remove harmful substances like ozone, hydrogen peroxide and biological contaminants. There are various methods of chemical treatment. For example, the addition of chlorine can remove biological contaminants, and filtering over activated carbon can then remove the chlorine.

contaminants of emerging concern: Pollutants that are detected in environmental sampling that may cause ecological or human health impacts but are not yet regulated under current environmental laws.

debris: Discarded items, trash and litter, materials and solid wastes that are released accidentally or intentionally into the environment.

degradable: Capable of being broken down into smaller pieces by natural forces.

effluent: Treated wastewater flowing out of a WWTP.

food web: A network of living things that depend on each other for food.

influent: Untreated wastewater flowing into a WWTP.

mechanical treatment: The first stage of treatment in which untreated wastewater passes through screens or sieves, removing about 20 - 30% of the contained solids.

microbes: Organisms that are too small to be seen without using a microscope.

microbeads: Tiny pieces of plastic formerly added to health and beauty products, such as some cleansers and toothpastes. In the United States, and many other countries, it is now against the law to add microbeads to these products.

microfibers: A type of microplastic. They include small fibers that may enter the water from washing fabrics made of synthetic materials, like polyester or nylon.

microplastics: Plastic pieces less than five millimeters long.

nurdles/plastic resin pellets: Small, round plastic pellets (nurdles) that serve as the raw material in the manufacture of other plastic products. The pellets resemble fish eggs and can be mistaken for food by marine animals and sea birds.

polyester: A synthetic fabric that is usually derived from petroleum.

primary treatment: The first stage of treatment in which incoming water (influent) passes through fine filters to remove large materials like paper towels, rags, hygiene products and “flushable wipes.”

sanitary sewer: A system of underground pipes or tunnels that carries sewage from bathrooms, kitchens and commercial plumbing to a WWTP.

secondary treatment: The second stage of treatment; it biologically removes contaminants from water using bacteria or other microorganisms.

septic system: An installed underground wastewater treatment structure that uses a combination of natural and technological processes to treat wastewater from household plumbing.

sludge: Solid, semisolid or slurry residual material from treated sewage that is typically found on the bottom of the settling tanks.

solid waste: Any solid, semi-solid, or even liquid or contained gaseous materials discarded from industrial, commercial, mining or agricultural operations and community activities. Solid waste includes garbage, construction debris, commercial refuse, sludge from water supply or waste treatment plants or air pollution control facilities and other discarded materials. What defines something as a solid waste is not its physical form but that it is a waste product.

stormwater sewer: Underground pipe system designed to carry rainfall runoff and drainage. Stormwater is untreated and flows directly into other bodies of water such as streams, rivers, ponds and lakes.

synthetic: Man-made and not produced from natural materials.

wastewater: Water left over from human processes. Wastewater is produced in industrial operations, businesses and homes. Wastewater may contain substances like human waste, food scraps, oils, soaps and chemicals. In houses, wastewater can come from sinks, showers, bathtubs, toilets, washing machines and dishwashers.

ADDITIONAL RESOURCES

Track and Act App — a tool for collecting litter on the landscape data. In the app, you can choose to add your data to the "Great Lakes Track and Act" organization.
https://debristracker.org/

Environmental Protection Agency (1998) How Wastewater Treatment Works…The Basics
https://www3.epa.gov/npdes/pubs/bastre.pdf

Wisconsin Department of Natural Resources (2016) Basic General Wastewater Study Guide
https://dnr.wi.gov/regulations/opcert/documents/StudyGuideBasicGeneral.pdf

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