Charting the Chesapeake: Uncovering the Mysteries of Microdebris

Our vision for a man-made debris indicator in the Chesapeake Bay and Watershed

In the Chesapeake Bay region, man-made debris is seen throughout our environment. Understanding the types, quantities, and locations of debris present is important to create pollution mitigation and prevention strategies. To achieve this, we are developing a man-made debris indicator to organize the available data on the various forms of debris, ranging from small particles to large boats. These debris are found in the air, water, sediment, soil, and organisms in and around the Chesapeake Bay. However, not all of this is measured or monitored, so this effort will also highlight the gaps in information and where resources should be directed.

A brief history of man-made debris

1869: First synthetic material invented from cellulose

1940s: Advancements in synthetic materials increase due to WWII

1973: The MARPOL Convention was created to prevent ship pollution

1997: The Great Pacific Garbage Patch is discovered

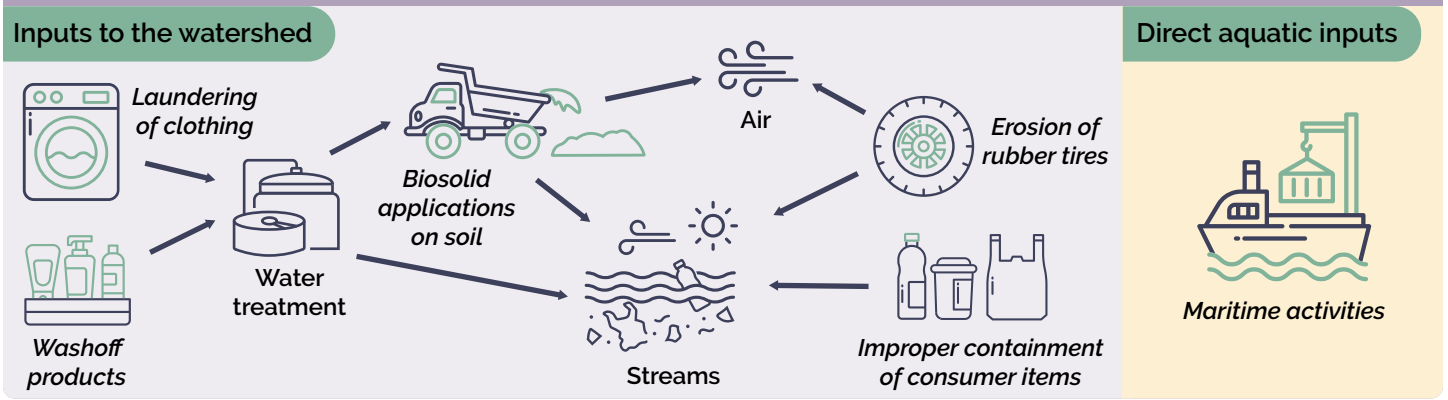
2022: Over 23 million tons of plastics (>5 mm) entered the environment globally

Man-made debris is a modern problem that began with the development of synthetic materials at the end of the 19th century. Ongoing efforts are being made to regulate this debris, requiring the collaboration of governments, industries, and the public to be effective.

Man-made debris breaks up into smaller particles

Through use and environmental exposure, man-made products like plastics, clothes, and tires break up into microscopic pieces called microdebris. Once very small, microdebris looks like many other environmental particles, such as organisms, algae, soil, and sediment, and can be inhaled or eaten by organisms and humans.

What are some ways that man-made microdebris enters the environment?



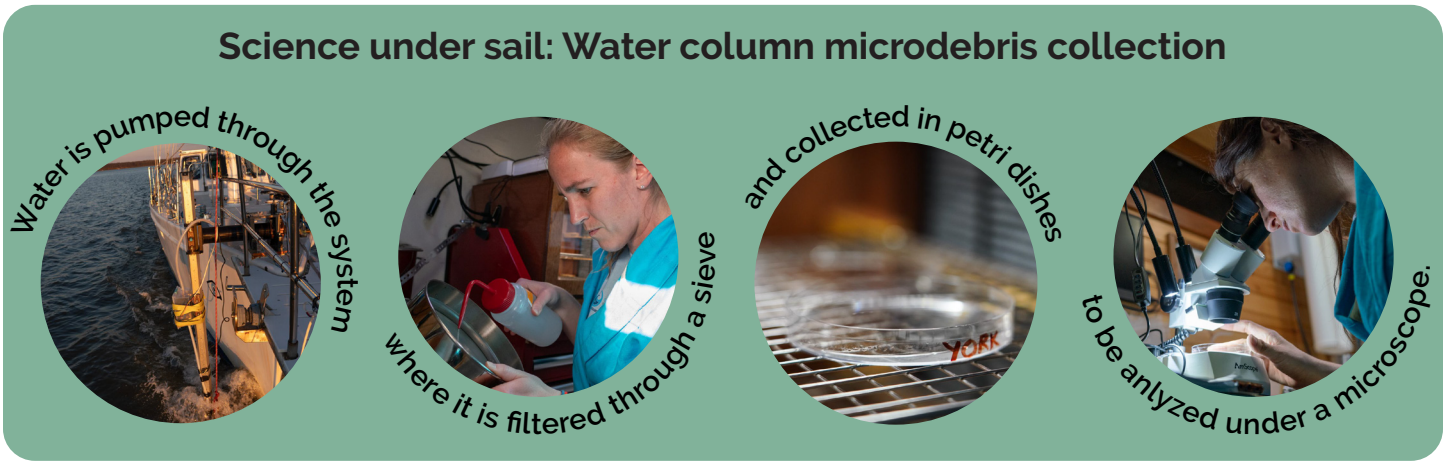
Synthetic materials are used for a wide variety of products and applications, creating many different categories of microdebris. This microdebris gets into the environment through many pathways, including stormwater, wastewater, and direct inputs.

The Chesapeake Bay Plastic Survey

In fall of 2023 and spring of 2024, the Ocean Research Project (ORP) led a pioneering survey with sailing research vessel Marie Tharp. The survey covered 15 major regions of the Chesapeake Bay, corresponding to the score regions assessed by the Chesapeake Bay and Watershed Report Card. While microdebris is commonly found along beaches, marshes, and floating in the air, ORP focused on sampling and assessing microdebris for bay near-surface waters and bay bottom sediment.

The crew aboard the Marie Tharp.

Approximately one cubic meter of water, about the size of a washing machine, was filtered per sampling location, and one mason jar was filled with bay bottom sediment. The ORP sampled particles ranging from microdebris to macrodebris across all regions, specifically within the size range of 500 microns (about the thickness of five sheets of paper stacked together) to 2 cm. Collected debris could include plastic, cotton, rubber, and paint chips.

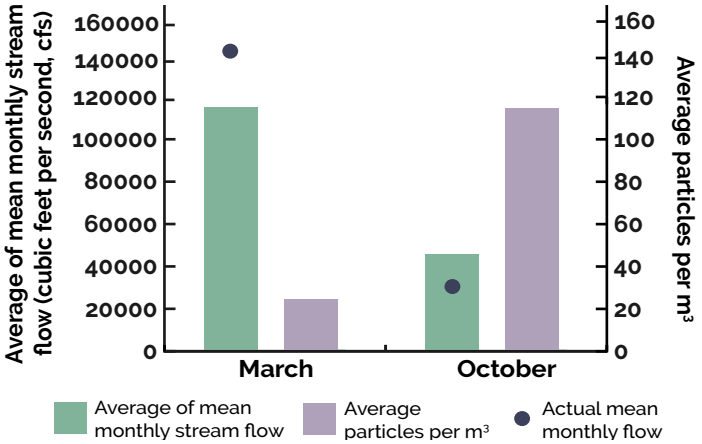


Near surface water microdebris samples were collected, processed, and analyzed on board using visible microscopy. The on board debris interpretation was then validated with post-cruise lab spectroscopy.

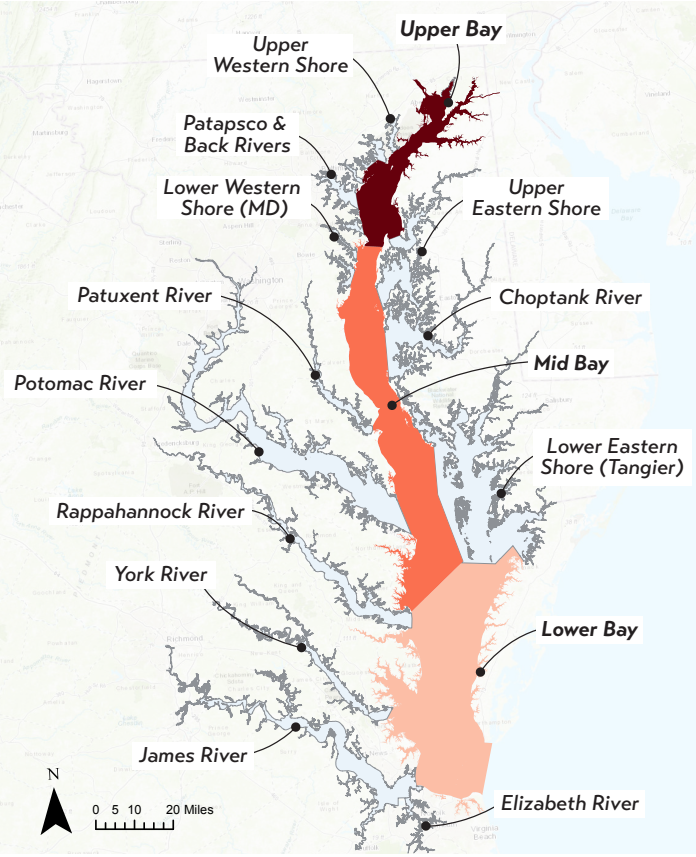
Bay water samples reveal interesting microdebris patterns

Fibers were a dominant type of microdebris: Of the various morphologies of microdebris observed in bay waters (film, fiber, foam, bead, fragment), microfibers—which can be plastic or natural fibers such as cotton or wool—made up about 94% of all observed particles.

Drier months likely show greater microdebris concentration: Our observations reveal that microdebris in bay waters was nearly 5 times more abundant across the bay in drier months of lower river discharge. We found an average of 70 microdebris particles per cubic meter (m^3) in the bay waters, with an average concentration of 24 in March and 114 in October.

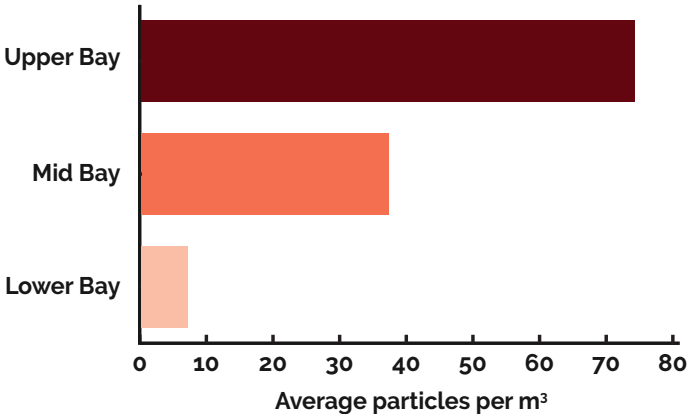


River discharge and microdebris abundance during sampling months differed greatly between high and low discharge periods. Blue dots represent the actual flow during sampling months.



The 15 score regions of the Chesapeake Bay where water and sediment samples were obtained. The colored portion represents the three mainstem regions of the Chesapeake Bay.

Microdebris concentration decreased from the Upper Bay to the Lower Bay: The average microdebris concentration in bay waters (particles per cubic meter) was 74 in the Upper Bay, 37 in the Mid Bay, and 7 in the Lower Bay. The bay appears to be a trap for microdebris, consistent with the findings of a previous study (Lopez, 2021).



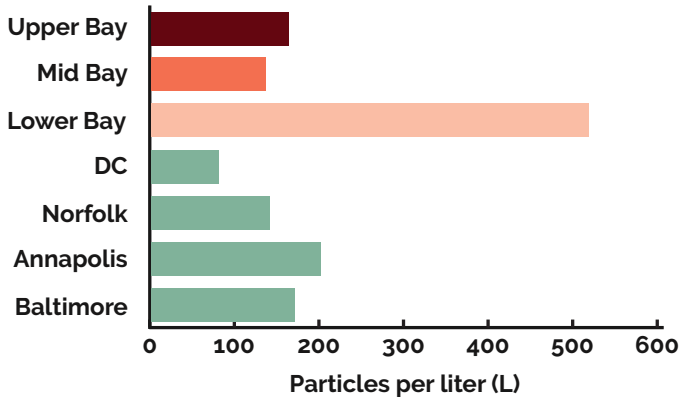
The average number of particles per cubic meter for the near-surface water samples in the Upper Bay, Mid Bay, and Lower Bay.

New insight on microdebris in bay bottom sediment

It is also important to observe how much microdebris accumulates in the bay bottom sediment and where it is most concentrated because the bay bottom is a critical habitat for marine life such as oysters, clams, and crabs. Bay bottom sediment was also collected from the 15 score regions of the Chesapeake Bay with a grab sampling device and transferred to a glass jar for later processing and analysis.

Lower Bay bottom sediment contains the largest concentration of microdebris: The microdebris concentration in sediment (particles per liter) was 162 in the Upper Bay, 135 in the Mid Bay, and 517 for the Lower Bay. Concentrations in urban rivers varied by about 120 particles per liter.

Bay bottom sediment was collected in a glass mason jar.



Concentration of particles per liter in bay bottom sediment samples for the Upper Bay, Mid Bay, and Lower Bay and for four major cities closest to the grab sites.

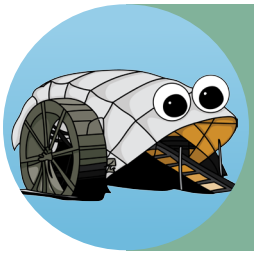
Expanding methods and data monitoring efforts

These initial efforts are the starting point for understanding microdebris pollution in the Chesapeake Bay and watershed. Moving forward, we need to explore strategies to monitor large debris pollution in the bay, such as water bottles, tires, and abandoned fishing gear. We also need a standard approach for sampling marsh, wetland, submerged aquatic vegetation (SAV), beach areas, and pelagic and benthic species.

We believe that we can leverage existing data, such as data collected from beach and waterway cleanups and Mr. Trash Wheel, to create a man-made debris indicator. Future monitoring efforts may include affixing cameras on buoys, towers, or other infrastructure across the bay. We plan to use the Potomac River as our first case study area to assess man-made debris.

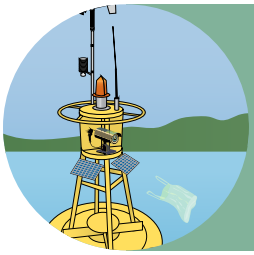
Beach & waterway cleanups

Every year there are many cleanup efforts which can provide an understanding of the type and amount of man-made debris present in and around the water.



Mr. Trash Wheel

An iconic feature of the Baltimore Harbor, Mr. Trash Wheel is a trash interceptor that collects about 500 tons of debris each year.



Remote monitoring on buoys and towers

Cameras on buoys and other existing infrastructure throughout the bay can provide snapshots of debris in the water.

A network of buoys, towers, and lighthouses in the bay may make for excellent locations to observe larger macro-sized debris and aerial microdebris particles.

How can you help?

We are looking for partners to contribute data on man-made debris to help build a robust indicator. Scan the QR code to reach out to us.

Acknowledgments

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Photos by Timothy Wolfer (pages 2-3) and Kevin Turpie (page 4). Mr. Trash Wheel logo courtesy of Waterfront Partnership of Baltimore.

Disclaimer: Results presented are based on preliminary data and require further testing.

Sources:

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