Microfibers in the Freshwater Environment

Plastic Fibers Emerge as Contaminant of Concern

By Jaclyn Harrison

These plastic microfibers were found in the esophagus of a double-crested cormorant. Rachel Ricotta took this photo through a microscope while assisting with a study of microplastics in the Great Lakes.

On average, synthetic fleece jackets release 1.7 grams of microfibers each wash, which equates to an average of 80,000 microfibers.

It seems almost unfair. Lightweight, warm, and economical polyester fleece, often made in America from recycled plastics, is the source of a stealth contaminant that is polluting our waterways and food chain on a massive scale, especially in areas near dense human populations. The consequences to aquatic organisms and to humans are not known.

Among the various types of microplastics that have been found in the aquatic environment, plastic microbeads are better known. Congress banned microbeads in 2016 in the U.S. However, recent studies have found microfibers to be even more pervasive.

Polyester fleece is nearly ubiquitous today but was unknown before the late 1970s. An early commercial fleece product, Polartec, originated in the old mill city of Lawrence on the Merrimack River in Massachusetts. There the Malden Mills company created Polartec in 1979, and would grow to 3,000 employees.

Microfibers are small plastic particles, less than 5 millimeters long and fibrous in shape. Polyester, acrylic, nylon, and rayon are the most common types of microfibers now being found in water bodies and in the food chain. Researchers are finding the fibers incorporated into fish tissue. The production of polyester, the most common synthetic fiber, has grown two to three times that of all other fibers over the course of the last five years. Its production will likely reach 84 million metric tons per year by 2025. As demand for polyester grows, its life-cycle impacts should be of increasing concern.

Pervasiveness

Ecologist Mark Browne was one of the first researchers to study microfibers in marine environments. In 2011, Browne published a study in which he sampled 18 shorelines around the world and found that 85 percent of the synthetic materials at those sites were microfibers, especially at sites near wastewater treatment plants.

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Microfibers are also found in the freshwater environment. On the surface of Lake Michigan, researchers found 19,000 strands of microfibers per square kilometer, which amounted to 16 percent of the total plastic recovered. It is important to note that in this study the samples were collected by skimming a fine-mesh net along the surface of the lake. That sampling method did not account for any fibers that may be present throughout the water column or that may have settled at the lake bottom. To date, researchers have sampled 29 tributaries of the Great Lakes using same surface-only technique. Microfibers account for 71 percent of microplastics found in these smaller bodies of water, in particles per cubic centimeter.

Patagonia Study

Apparel seems to be the obvious and logical source of the microfibers being found in our waterways. A study released by researchers at the University of California at Santa Barbara, and funded by the outdoor clothing manufacturer Patagonia, found that, on average, synthetic fleece jackets release 1.7 grams of microfibers each wash, which equates to an average of 80,000 microfibers.

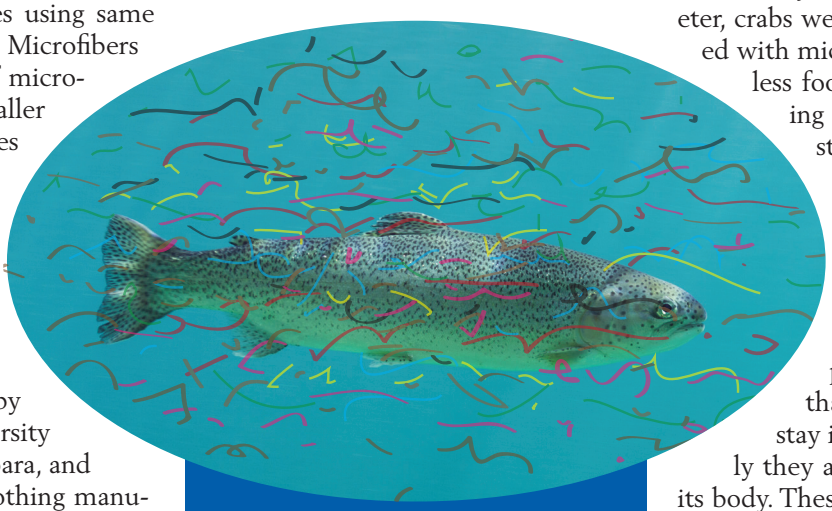
Clothing age, washing machine type, and clothing construction significantly alter shedding characteristics. Older jackets shed almost twice as many fibers as new jackets. Higher shedding in older jackets is most likely due to the weakening of fibers as a result of wear. Top-load washing machine trials had over five times the average microfiber shedding of the front-load machine trials because of the agitator used in top-loading machines to wash clothes.

Finally, shedding from a budget jacket was consistently higher than its Patagonia counterpart, which could indicate the importance of textile composition and garment construction.

Wastewater Plants

Wastewater treatment plants (WWTPs) play a critical role in the fate and transport of microfibers in the environment. WWTPs receive large amounts of microfibers daily and while most microfibers are removed, a significant amount are still released into the local environment. The Patagonia researchers calculated that a city of 100,000 people could send anywhere from 20 to 240 pounds of microfibers into local waterbodies daily, which averages out to around 15,000 plastic bags.

Researchers at SUNY Fredonia found microfibers accounted for 85 percent of the plastic in effluent at WWTPs they examined. There is a greater proportion of smaller microfibers in WWTP effluent, which indicates that smaller fibers are more likely to make it through the WWTP process.



Fibers can also harm fish by leaching toxic chemicals into their bodies.

The influent and effluent of numerous WWTPs has been sampled and analyzed for microfiber and microplastic particles. Sampling methods between studies varies, but when you compare influent and effluent concentrations from each WWTP, removal efficiency ranges from 65 to 99.9 percent. Most of the fibers appear to be removed during the grease-removal stage.

Due to the high capital costs of WWTPs, however, upgrading is not a feasible solution to microfiber pollution in the short term.

Even if the removal efficiency were to improve, the fibers would be retained in the sewage sludge. Microfibers can still enter the environment from sewage sludge, which is increasingly being applied to farmland as fertilizer.

Impact

The size of microplastics and microfibers allow them to be easily consumed by fish and other wildlife. These particles have been found to cause physical and chemical impacts on aquatic organisms.

Microfibers in particular are not as easily excreted as other plastic fragments due to their shape. Ingestion of microplastics may cause internal bleeding, abrasion and ulcers, as well as blockage of the digestive tract. In a 2014 study from the University of Exeter, crabs were given food contaminated with microfibers, and the crabs ate less food overall due to the feeling of being full. This could stunt growth overtime or lead to starvation.

Fibers can also harm fish by leaching toxic chemicals into their bodies. While the data are still limited at this point, it is safe to assume that the longer these fibers stay inside a fish, the more likely they are to leach chemicals into its body. These chemicals include fabric finishes, plasticizers, and adhered organic pollutants.

Finished apparel products contain large quantities of chemical substances. These chemicals may include formaldehyde, flame retardants, and perfluorinated chemicals. Some anti-wrinkle finishes in new clothing release formaldehyde, which is a human carcinogen. Flame retardants have been linked to thyroid disruption, memory and learning problems, delayed mental and physical development, lower IQ, early puberty, and reduced fertility. Some perfluorinated chemicals, such as Teflon, which is sometimes added to clothing to make them waterproof, disrupt normal endocrine activity, reduce immune function, cause adverse effects on multiple organs, and cause developmental problems. (Perfluorinated compounds are another class of emerging contaminants; see "Perfluorinated Compounds: Emerging Challenge for States, Communities" in the September 2016 issue of the *Interstate Water Report*, this publication's predecessor.)

Plasticizers are additives that enhance the plasticity or fluidity of a material.

As plastics degrade, they can release these additives. These chemicals include phthalates, alkyl phenols, bisphenol A (BPA), heavy metals, and polybrominated biphenyl ethers (PBDEs). These chemicals are known to disrupt endocrine functions and cause harmful reproductive and developmental effects in aquatic animals. The chemicals have the potential to bioaccumulate, becoming more concentrated as they move up the food chain.

Of even greater concern is the ability of the microfibers to act as a vector for contaminants because they can absorb persistent organic pollutants and bioaccumulate in animal tissues. These pollutants include dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins, etc.

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Reproductive effects from microplastics have been found in filter feeders, such as mussels and oysters, which filter large volumes of water, and thereby ingest suspended plastics. Studies on oysters that consumed microplastics found that the oysters produce fewer and smaller egg cells and slower sperm, which results in fewer larvae.

Health Risks

Microplastics and microfibers have been found in marine species consumed by humans. A 2014 study estimated that regular consumers of European shellfish may ingest up to 11,000 microplastic particles per year. A 2015 study found microplastics in the stomachs of swordfish, bluefin tuna, and albacore tuna. A recent study on fish purchased at markets in California found that 25 percent of fish and 33 percent of shellfish contained plastic and natural microfibers. Microplastics have even been found in sea salt.

The U.S. EPA is currently studying the human health impacts of microfiber consumption. Although the effects of microfibers on humans is unknown, studies of chemical compounds often found on microfibers are associated with alterations in normal function of the human endocrine system, impaired brain development, learning disabilities, and increased incidents of cancers.

Next Steps

On December 28, 2015, then-President Obama signed into law the Microbead Free Waters Act, which bans the manufacture of microbead products by July 2017 and the sale of microbead products by July 2018. However, solving the microfibers issue will be more challenging than the banning of microbeads. Despite the sheer volume of microfibers reaching our waterbodies, regulatory action will be difficult because it is hard to assign responsibility to a specific group and it is very expensive to upgrade WWTPs.

The cosmetic industry was able to replace microbeads with natural alternatives, such as sand and nut shells, that provide the same function as their plastic counterparts. The apparel industry, however, faces a more difficult situation. Alternatives to synthetic textiles are limited and struggle to mimic the performance capabilities of materials like polyester.

The simplest solution might lie in the way we do laundry. Consumers can purchase a lint filter for their washing machine, switch to front-loading washing machines, use a nanoball in the machine to attract and capture fibers, wash their clothes less frequently, and/or buy clothing made out of natural fibers like cotton. As of this writing, a German firm is developing a wash bag designed to keep most of the fibers from entering the wastewater system.

Further studies are needed on the effects of water temperature, cycle length, and other washing characteristics.

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The Commission and Its Work

Founded in 1947 by an act of Congress, governed by its seven member states, the New England Interstate Water Pollution Control Commission each year fulfills its broad mandate to help the states preserve, protect, and advance the quality of their precious water resources.

A representative commission appointed by the seven governors sets overall goals and is the medium for a vital conversation among state and federal environmental officials. In workgroups, policy makers and practitioners grapple with particular problems of ongoing concern, bringing to bear the latest science and a deep knowledge of the issues and the waters of the Northeast.

Research and Monitoring

The Commission funds or undertakes through its staff a program of research into, and monitoring of, water-related topics and environmental indicators. A rigorous quality-assurance program renders this work reliable and broadly useful to policy makers and professionals. Much of this work is funded by state and federal grants administered by NEIWPCC through placed-based programs such as the Narragansett Bay Estuary Program. In addition to monitoring and research, the commission funds environmental restoration.

The Commission sponsors or cosponsors regional conferences, workshops, and webinars for those in the field of water quality and resources. Several of these events rotate around the region, such as the annual Nonpoint Source Pollution Conference, usually held in the spring in cooperation with the host state.

Education and Training

The Commission achieves its public-education goals mostly through the work of its staff at place-based programs such as the Long Island Sound Study and the Lake Champlain Basin Program. These and other programs, funded and staffed in part or in whole by NEIWPCC, engage the public through nature walks, educational events, television broadcasts, Internet resources, stewardship programs and events, and permanent programs and exhibits.

On another front, the Commission staff trains and, in some states, certifies thousands of wastewater-plant operators, providing workshops and multi-day training courses that are both popular and useful. The Commission is at the forefront of work to make the region's water infrastructure more resilient to flooding and other extreme weather events. It has hired extra staff members to help the City and the State of New York with permitting, inspections, and other issues related to the still-ongoing recovery from Hurricane Sandy.

Supporting the States

Sandy recovery entails a "surge" of environmental experts over a period of years. However, NEIWPCC staff members also work in many state environmental agencies in the region. These professionals provide critical technical and administrative support to state environmental and drinking-water programs.

Finally, NEIWPCC is regularly asked to share its water expertise beyond the borders of its seven member states, for instance with its National Tanks Conference. NEIWPCC 's leadership is active in regional and national water associations, and the Commission writes comment letters as part of formal federal rule-making processes and on other matters.

The Commission's work, distributed across the region and across many subject areas and institutions, is supported and unified by a small corps of administrative, human resources, and communications professionals, and by an abiding commitment to the health of water bodies and the future of the region and the planet.