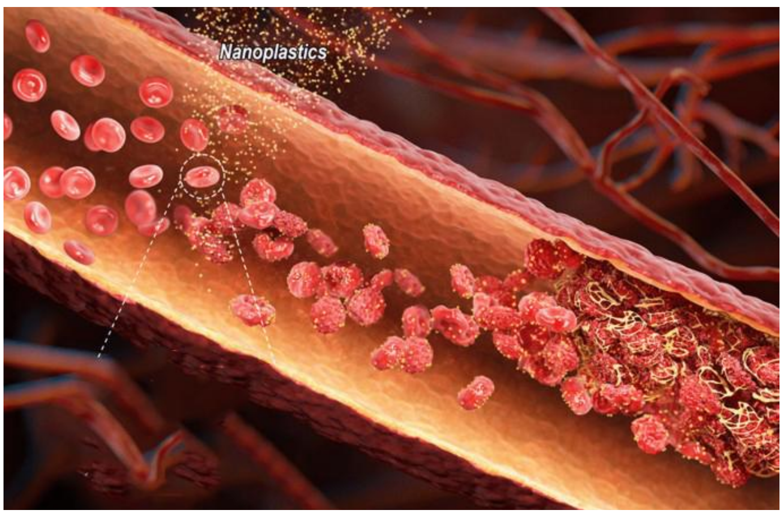
PERVASIVE PLASTICS

AN OVERVIEW OF PLASTIC WASTES AND THEIR IMPACT ON OUR ENVIRONMENT



Nanoplastic particles & red blood cells inside a blood vessel. (Ref 41)

PRESENTED BY THE LES CHENEAUX WATERSHED COUNCIL

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March 2025

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Introduction

This is an overview of the pervasive nature of plastic waste, its environmental and health impacts as well as alternatives to petroleum-based plastics. Plastics are widely used in various commodities, but they pose a significant environmental problem due to their long-lasting nature and the large volume of over 400 million tons of plastic waste generated annually around the globe. Microscopic plastic breakdown particles, nanometers in size, contaminate air, soil, and water, and have been found in human organs, potentially causing health issues. Single-use plastics make up about 45% of all plastic waste. Measures that can be taken by individuals and communities to limit exposure to single-use plastics include reducing purchase of pre-packaged foods, using water filters and improving municipal water and wastewater treatment facilities. Developing alternatives to petroleum-based plastics using packaging materials from natural ingredients such as seaweed and polysaccharides can help reduce environmental plastic contamination and offer cost-competitive solutions.

“Pervasive Plastics”

This is an introduction to plastic waste as a global trash issue with suggested actions that communities and individuals can take to reduce potential environmental impact and exposure to health risks associated with plastic breakdown particles commonly referred to as microplastics.

Plastics are petroleum products that touch people around the world virtually every day of their lives. Plastics in one form or another are a two-generation old miracle material (Fig.1). Plastics are used in a wide spectrum of commodities including aircraft, surgical equipment, electronics, tea bags and ultra-thin films. To bring the utility of plastics into closer focus, consider everything in your present environment that makes use of some form of plastic. Include your reading glasses, beverage container, clothing, shoes and devices. Yes, plastics in many forms contribute to comfort and convenience in our everyday lives. These products can be manufactured as long-lasting equipment or as disposable, single-use items.

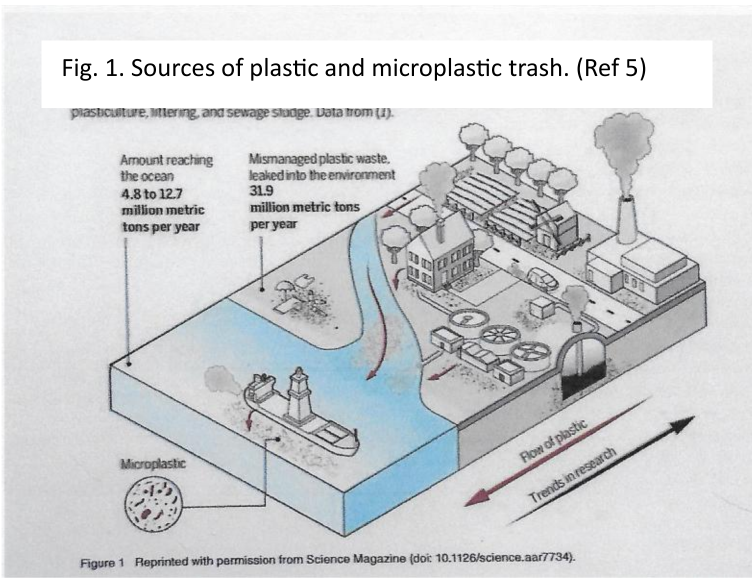

Fig. 1. Sources of plastic and microplastic trash. (Ref 5)

As useful and versatile as plastics are in our modern world, this is their major shortcoming as well. Plastic products typically retain their original form for dozens of years, if not longer. Herein lies an overriding issue. Over 400 metric tons of plastic products are manufactured annually, about that same tonnage of plastic waste is generated each year (Fig. 2.). Waste plastic takes many

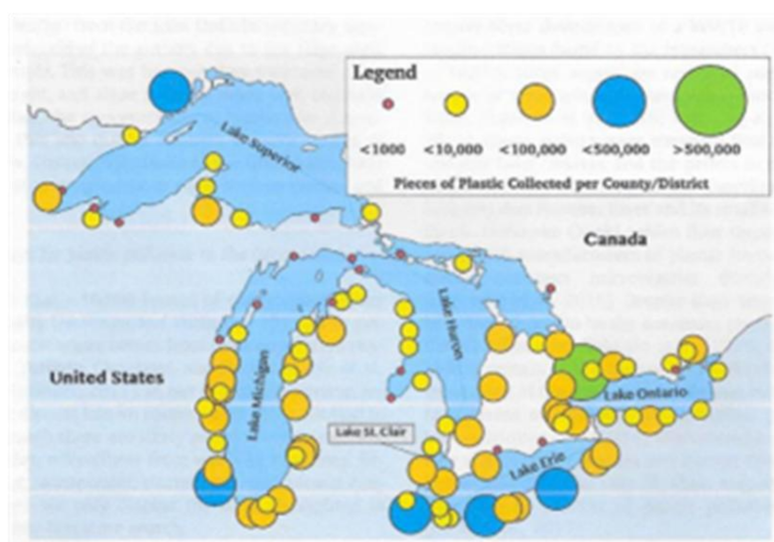

Fig. 2. Plastic litter collected in the Great Lakes region by citizen scientists from 2016 through 2018. (Ref 2)

forms, ranging from intact products to broken and weathered commodities to microscopic plastic beads used in personal care products.

Only about 10% of the estimated 350-400 million metric tons of plastic waste generated each year is recycled. The remainder of plastic waste finds its way into the air, soil, waterways, lakes and into oceans where they form huge islands in gyres. In short, plastic waste is found throughout our environment around the globe (Fig.3, Fig. 4). Plastic refuse is commonly shipped to developing countries where it is sorted into forms for remanufacturing. Sheer volumes of plastic trash have now reached a level that countries such as Thailand have halted their import.

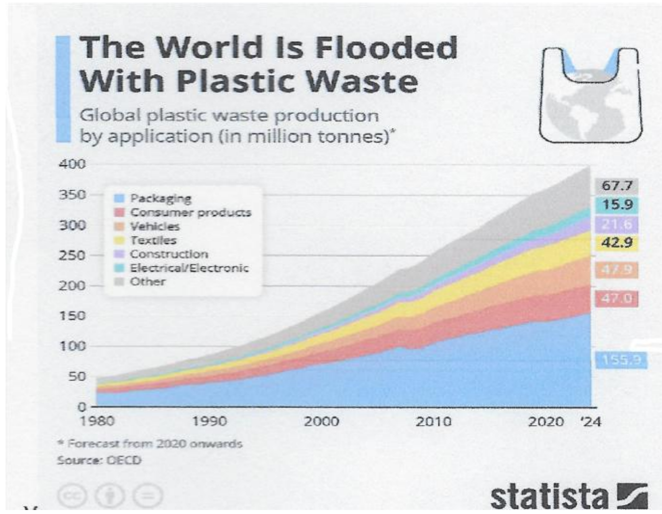

Fig. 3. Global plastic waste, 2020 (Ref 36)

Weathering is a primary factor in slowly degrading plastics from their original form into small fragments. Even smaller degraded plastic forms are known as microplastics (MP, less than 5 millimeters) and nanoplastics (NP, one billionth of a meter). In these minute NP sizes, less than 1000th the thickness of a sheet of paper, MP and NP invade plants, animals and even the human body. Researchers have recovered MP and NP from all major organs, blood, even inside the brain. Although not shown as causative agents, multiple studies implicate microplastics in damage to human reproductive, digestive, endocrine, immune and respiratory health with possible links to colon and lung cancers.

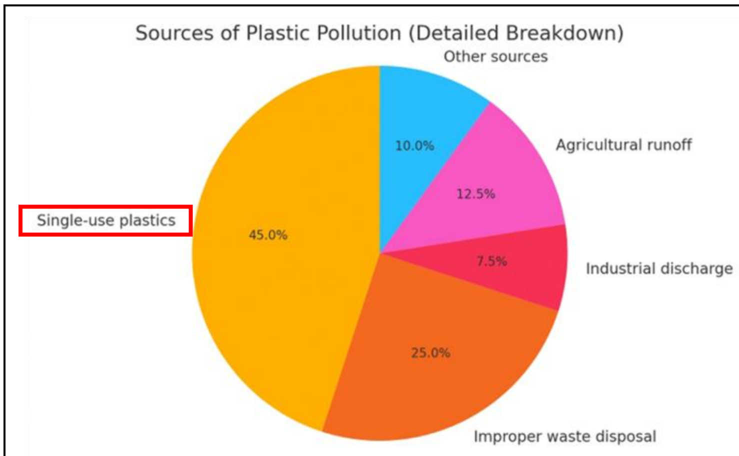

Fig. 4. Sources of plastic pollution (Ref 40)

MP exist in multiple compositions. Virgin MP are comprised only of petroleum-based plastic. Thousands of MP variants exist in which other compounds are incorporated into the virgin plastic. It is these forms that pose more environmental and human health risks, especially plastics that are combined during manufacturing with chemicals that are known toxins to plant and animal metabolism. Moreover, toxic compounds adsorbed on the surface of MP can also cause adverse effects.

MP concentration in organisms correlates with exposure levels. Higher MP exposures result in higher concentrations within organisms. MP can be shed in proportion to the encountered dose (Fig. 5)

Challenges are presented with simply measuring MP effects in both laboratory and human subjects because concentrations used to induce and detect an effect are usually magnitudes higher than would be encountered during normal exposures.

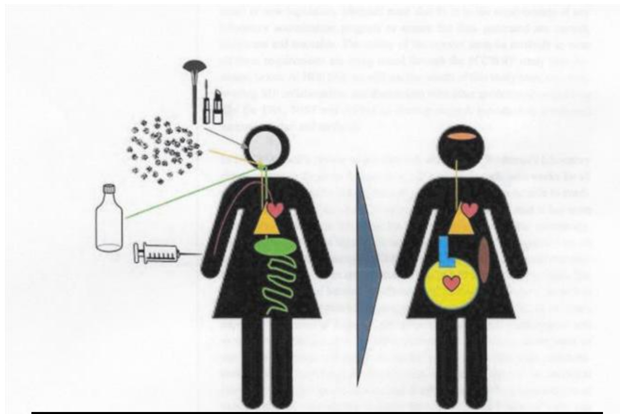

Fig. 5. Primary routes of MP exposure and organs of concentration in humans. (Ref 19)

Exposure to MP can be reduced by taking measures such as limiting the single-use plastics, minimizing purchasing food in plastic packaging, using shorter dishwasher cycles, avoiding cooking in plastic, and use of water filters.

Bottled water is not exempt. MP are found in 90% of common bottled water brands, with concentrations ranging from 300 to 10,000 particles per liter. Reverse osmosis and ultrafiltration are proven ways to reduce exposure. Systems to remove MP less than 100 nm are readily available.

Techniques such as coagulation, flocculation, sedimentation, ultrafiltration, biological removal, and chemical treatment remove MP from municipal water supplies and wastewater treatment facilities with efficiencies of over 80%.

There are alternatives to petroleum-based plastics. At least 45% of the over 350 metric tons of plastic waste produced each year is from single-use plastics (Fig. 4). Petroleum-based plastics used for packaging, especially in food packaging and single-use plastics, are replaceable with the goals of reducing overall environmental plastic contamination and more rapid deterioration. Multiple single-use packaging alternatives are presently available in addition to seaweed-based packaging materials that have been used for centuries. Food-grade and edible packaging materials are created using natural ingredients such as seaweed, starches, proteins and polysaccharides. Polysaccharide alternatives are unique in that they are recovered using high volume, industrial scale fermentation of a naturally occurring fungus, *Aureobasidium pullulans*, making them a cost-competitive edible source when compared to other alternatives (Fig.6). Alternative polysaccharide packaging is available in many forms such as water-soluble films that dissolve in hot water which allows the protected food to be cooked and consumed without any residual single-use plastic waste. Biodegradable polysaccharide plastic alternatives are also available as conventional packaging and films.

Fig. 6. *Aureobasidium pullulans* produces food-grade polysaccharides during large volume fermentation (Ref 38,39)

Summary: Plastics are used in an endless variety of products and packaging, posing a significant environmental issue due to their long-lasting nature and the large volume of waste generated around the world. Single-use plastics contribute to over half of plastic waste. Over time, plastics break down into microscopic particles, nanometers in size, contaminating air, soil and water. These particles are found in land, aquatic and marine organisms as well as in humans. Microplastics found in humans concentrate in organs and are associated with multiple human health issues. Multiple alternatives to single-use-plastics are presently available in limited markets.

Documentation: Literature sources referenced in this article are available in the LCWC website library section at <lescheneauxwatershed.org>

Acknowledgment: Special thanks to Bill Kurtz and Ed Rusk for their critical review.

Topics of concern discussed in this paper shown with relevant included citations.

- **Prevalence of Microplastics**: Microplastics are found in air, water, soil, and on all continents, affecting all animals and plants. (1,3,4,16,18,20,24,25,33,36)
- **Sources of Microplastics**: Sources include wastewater treatment plants, landfill leakage, litter, agricultural runoff, stormwater runoff, tributaries, industrial effluent or spills, and mismanaged solid waste. (1,2,18,226,27,31,34,36,40)
- **Environmental and Health Impacts**: Microplastics can cause changes in gene expression, reproductive output, gene repair, increased mortality, and potential harm to human reproductive, digestive, endocrine and respiratory health. (13,14,17,19, 37)
- **Microplastics in Human Body**: Microplastics are present throughout the human body, including blood, lungs, liver, heart, guts, brain, testicles, and placenta. (17,19,20,41)
- **Removal and Reduction Strategies**: Strategies to reduce microplastic exposure include using water filters, minimizing plastic packaging, and avoiding cooking in plastic. (7,8,9,10,11,12)
- **Microplastic Removal Methods**: Effective removal methods include physical absorption/adsorption, filtration, biological removal, and chemical treatment. (5,7,8,11,12,15)
- **Impact on Aquatic Environments**: Microplastics disrupt food chains, cause biomagnification and bioaccumulation, and influence ecological environments. (13,14,21)
- **Detection and Analysis**: Advanced microscopy techniques are needed to visualize microplastics, and total volume sampling is preferred for micro and nanoparticles. (10,22,23,24,32)
- **Microplastics in Drinking Water**: Virtually all water systems are potential sources of microplastics. Microplastics are found in 90% of common bottled water brands, with concentrations ranging from 300 to 10,000 particles per liter. (8,9,10,11,12,15, 31)
- **Future Research and Conclusions**: Further research is needed to understand the risks and effects of microplastics, and to develop better models for analyzing their impact on human health. (6,28,29,30,35,38,39)

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Relative sizes of plastic breakdown particles.

Measurements and their unit equivalents referenced in text (Ref 18,24)

- 1 meter = 39.4 inches
- 100 centimeters (cm) per meter
    - 2.54 cm per inch
- 1 cm = 10 millimeters (mm)
- 1 mm = 1000 micrometers (microns)
- 1 micron = 1000 nanometer

Macroplastic particles: greater than 5 mm

Microplastic particles: less than 5mm

Nanoscale factoids

- Nano prefix translates to one-billionth, or 1 x 10^{-9} (1e-9) of a meter (39.4 inches)
- Nanometer (nm) equivalent
    - Sheet of paper is about 100,000 nm thick
    - Strand of human DNA is 2.5 nm in diameter
    - One inch = 25,400,000 nm
    - Human hair is about 80,000 – 100,000 nm thick
    - A single atom of gold is about 0.33 nm in diameter
    - If a normal-size marble were one nm, then the diameter of Earth would be about one meter.
    - One nm is about as long as your fingernail grows in one second.

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