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Exploring the Chemical Properties of Textile Microfibers

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Introduction

Microfibers are the most common microplastics found in most terrestrial, freshwater, and marine biota, as well as human tissues, and have been collected from environmental compartments in nearly all ecosystems and species sampled worldwide. These materials, which are composed of various compound types, range from semi-synthetic and treated natural fibres to synthetic microfibers. Microfibers expose organisms of various taxa to a wide range of chemicals, both during the manufacturing process and through environmental adsorption, with effects ranging from subcellular to population levels.

Microplastics have been found in almost every environment on the planet, including deep sea trenches, freshwater lakes and rivers, groundwater, and the atmosphere, to name a few. Microfibers make up the vast majority of microplastic particles found in marine, freshwater, and terrestrial biota. While there is no standard definition for'microfiber,' the following is one proposed by the US National Oceanic and Atmospheric Administration (NOAA): Microfibers are chemically modified polymeric fibrous particles with a length to width aspect ratio of 3:1 [1].

Description

Microfibers in the environment can be made of a wide range of materials. Synthetic fibres account for nearly 14% of global plastic production, and synthetic materials such as polyester, nylon, polyamide, and others are used in the production of approximately 60% of textiles. These materials, like other microplastics, are derived from fossil fuels and, in some cases, recycled feedstock. While a large proportion of microfibers found in environmental samples are made of plastic or synthetic materials, an equal (if not greater) proportion of anthropogenic microfibers are made of semi-synthetic (i.e., rayon) and natural materials (i.e., wool, cotton). While the majority of microplastics found in environmental samples are microfibers, the majority of experimental studies on the effects of microplastics expose organisms to microspheres (or beads), pellets, or fragments, which can be purchased in a variety of sizes and polymer types. Microfibers have been used in far fewer studies. When the effects of microfibers are compared to those of non-fibrous particles (such as spheres, fragments, and pellets), fibres are more toxic. The majority of microfiber research has concentrated on the effects of synthetic fibres, while natural and semi-synthetic fibres have received little attention. Nonetheless, when tested, natural and semi-synthetic fibres have comparable effects to their synthetic counterparts. Furthermore, many experimental studies on fibres use exposure concentrations that are significantly higher than those found in the environment, exposing organisms for extended periods of time [2].

The polymeric materials that make up microfibers can vary, as can the suite of chemicals that are intentionally added during production (i.e., chemical additives, dyes, and finishes) and unintentionally accumulated from the environment (i.e., persistent environmental contaminants). Many of these chemicals are known carcinogens, mutagens, and/or endocrine disruptors (EDCs), and they can potentially leach from fibres into the environment. Persistent environmental contaminants, such as heavy metals, PCBs, and PAHs, can adsorb to fibres once they are in the environment, causing "weathered" (or environmentally exposed) fibres to have different associated chemical profiles and thus different toxicity than "virgin" fibers [3].

The reported effects of synthetic fibres on aquatic and terrestrial organisms are increasing, and our current understanding indicates effects ranging from subcellular to community levels. Effects on aquatic taxa such as fish, Crustacea, Mollusca, Echinodermata and Rotifera, as well as terrestrial organisms such as insects, Annelid worms and Nematodes, have been documented. Exposure to synthetic fibres can alter subcellular and cellular processes such as gene expression and enzyme activity, DNA damage, and zinc retention. For example, after being exposed to environmentally relevant concentrations of synthetic microfibers, both juvenile and adult sea cucumbers, Apostichopus japonicus, exhibit altered acid phosphatase and alkaline phosphatase activity levels-key biomarkers of immune health-as well as oxidative stress.

Despite their origin in natural materials, many studies have found semi-synthetic and natural textile fibres in marine, freshwater, and terrestrial biota. When reported, these fibres frequently make up the majority of anthropogenic microfibers in a sample. Natural fibres can be biodegraded in the environment by factors such as naturally occurring microbes that consume cellulose, aerobic degradation, or enzymatic breakdown in soils. Although natural and semi-synthetic fibres degrade faster in the environment than synthetic fibres, they are sufficiently persistent to undergo long-distance transport and accumulate in sensitive ecosystems. Furthermore, the chemicals incorporated into non-plastic fibres may extend their environmental persistence [4,5].

Conclusion

Despite the fact that textile microfibers are the most prevalent microplastic type in the environment, now found in all niches, textile production is expected to increase in the future, and thousands of chemicals are used in production and finished products. Plastics and related chemicals are now recognised as planetary boundary threats, as the massive quantities produced, which are largely uncontrolled and with little transparency from the industry, are endangering our environment, health, and ability to thrive. Production exceeds societies' ability to conduct safety assessments and monitoring. Improved understanding of the environmental impacts of microfibers will inform risk assessments and mitigation strategies, along with a deeper understanding of sustainability and increased circular approaches in the industry, allowing us to slow environmental degradation and move back toward sustainability.

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Conflict of Interest

There are no conflicts of interest by author.

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