

Introduction

Microplastics have become a growing issue in the past several decades as researchers are beginning to unpack the environmental and health risks associated with microplastics. Microplastics are fragments of plastics ranging from 5 millimeters to 10 nanometers. These micro fragments of plastic impose a huge threat to many different ecological systems including aquatic environments, livestock farming, and wastewater, and they have a major effects on human health. Figure 1 illustrates the sizes of microplastics in wastewater from clothing, detergents, and cosmetic products. It is important to analyze the main contributors to microplastics in wastewater, their effects on ecological systems, and approaches to minimize and remove microplastics from our water.



Figure 1: Common microplastics found in water¹

Process Description

There are two categories of microplastics: primary microplastics, which are manufactured as pellets or powders for producing plastic products, and secondary microplastics, which are broken down from larger plastics.² Additionally, there are numerous sources of both primary and secondary microplastics and multiple entry points into the environment for each. Wastewater is an entry point of great concern that microplastics contaminate primarily through the washing of clothes made of synthetic fibers and cosmetic products that contain microbeads as abrasives.³ At the wastewater treatment plant, the majority of microplastics are removed, however, the high volume of effluent contributes to a significant amount of microplastics still entering water environments.³ In underdeveloped countries with poor wastewater treatment the amount released is even greater.³ Once into the marine environment, these microplastics begin to degrade through solar exposure, thermal aging, oxidation, and biofilm growth.⁴ These factors change the chemical and physical properties of the plastic, ultimately leading to morphological change and greater sorption of pollutants.⁴ These toxic chemicals can then accumulate in organisms that consume them and work their way up the food chain into humans.⁵

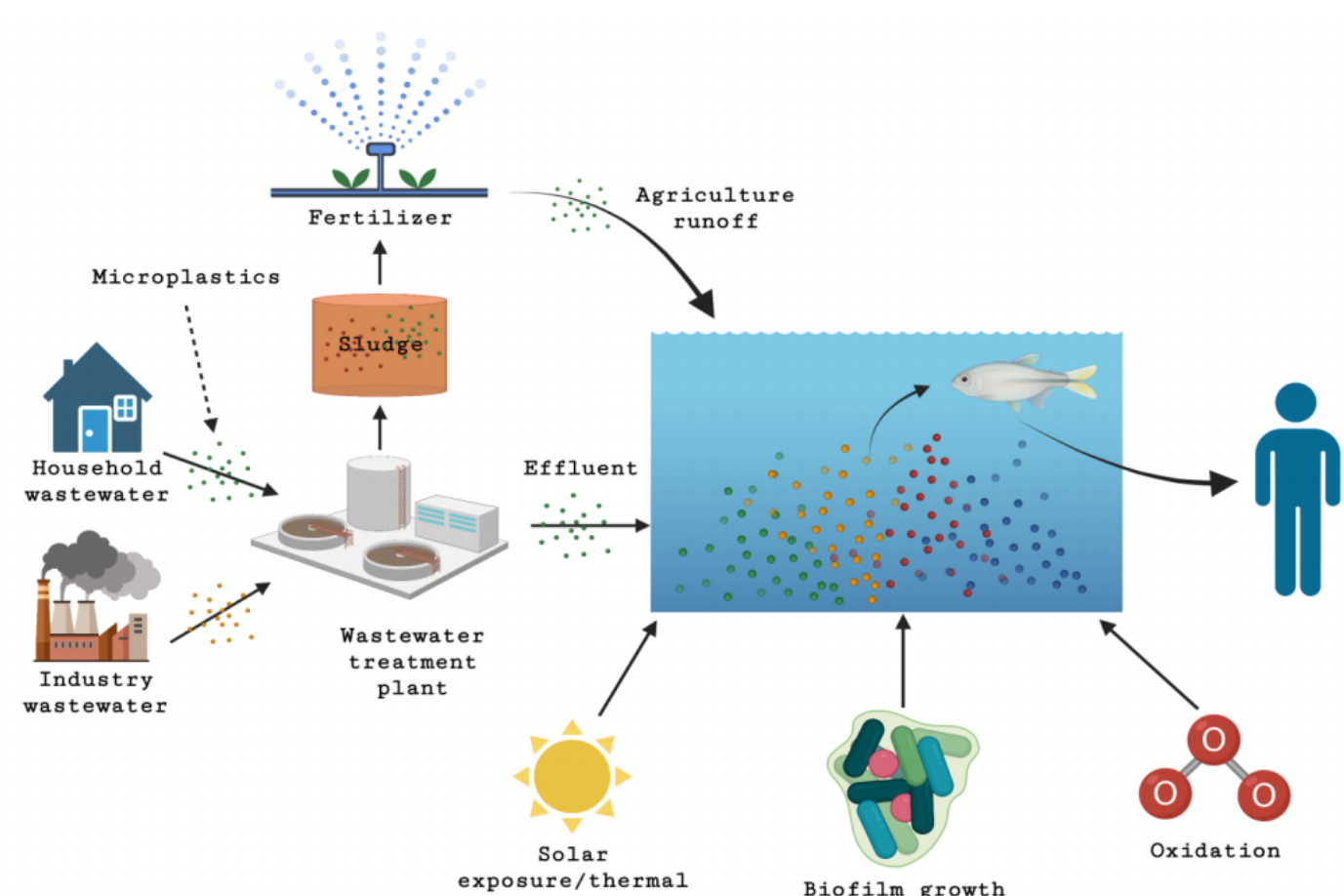


Figure 2: Condensed life cycle of microplastics entering the environment through wastewater.

Potential Impact

Although researchers and customers are becoming more aware of the health and environmental risks of plastics, they are still used every day in many different household products. These products are huge contributors to microplastics in water. For example:

- As shown in figure 3, it is estimated that over 6,000,000 microfibers per 5 kg of textiles are released during the wash cycle
- Harsh laundry detergent can increase the microfibers released

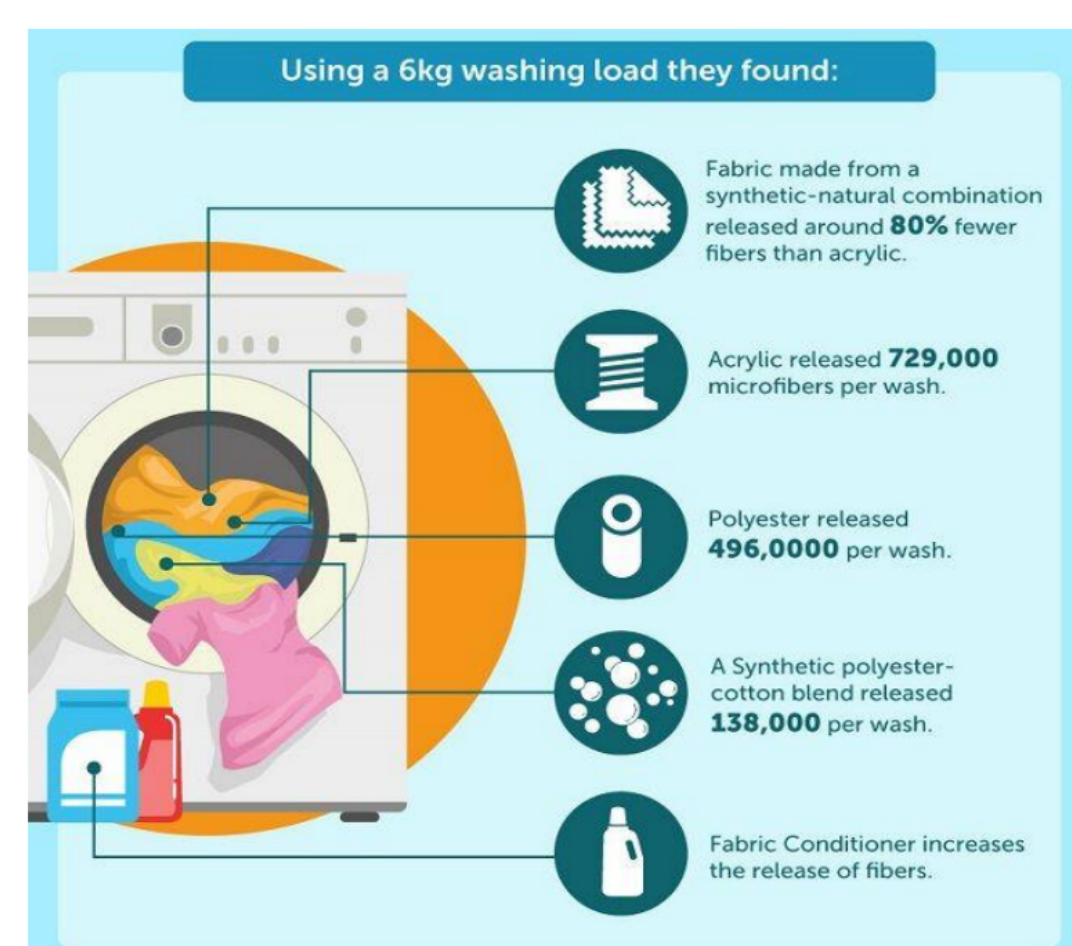


Figure 3: Five different ways microplastics enter wastewater systems from laundry services⁶

Impact to Marine life :

- Microplastics are small enough to be ingested by small aquatic organisms and remain in their bodies⁷
- Ingested plastic transfer across trophic levels to large biota⁸
- 28% of seafood processed out of California contains microplastics⁷
- At least 44% of sea birds have ingested microplastics⁸

Impacts to livestock and farming:

- Microplastics are contaminating livestock feed from factory production⁹
- Cows, chickens and pigs are then ingesting the microparticles of plastic⁹
- Some microparticles can not be digested and remain in animal meat⁹
- Digested microplastics remain in manure which then contaminates soil and crops⁹

Impact to human health:

- 80% of human blood contains microplastics⁸
- Half the plastic particles found come from water bottles, a third comes from food packaging and a quarter comes from plastic bags⁸
- On average, 10x more microplastics are found in infants than adults⁸
- Possible medical risks include clogged arteries, chronic disease such as endometriosis, and a weakened immune system⁸
- Microplastics are damaging cells which is why humans are at risk for these major health concerns⁸

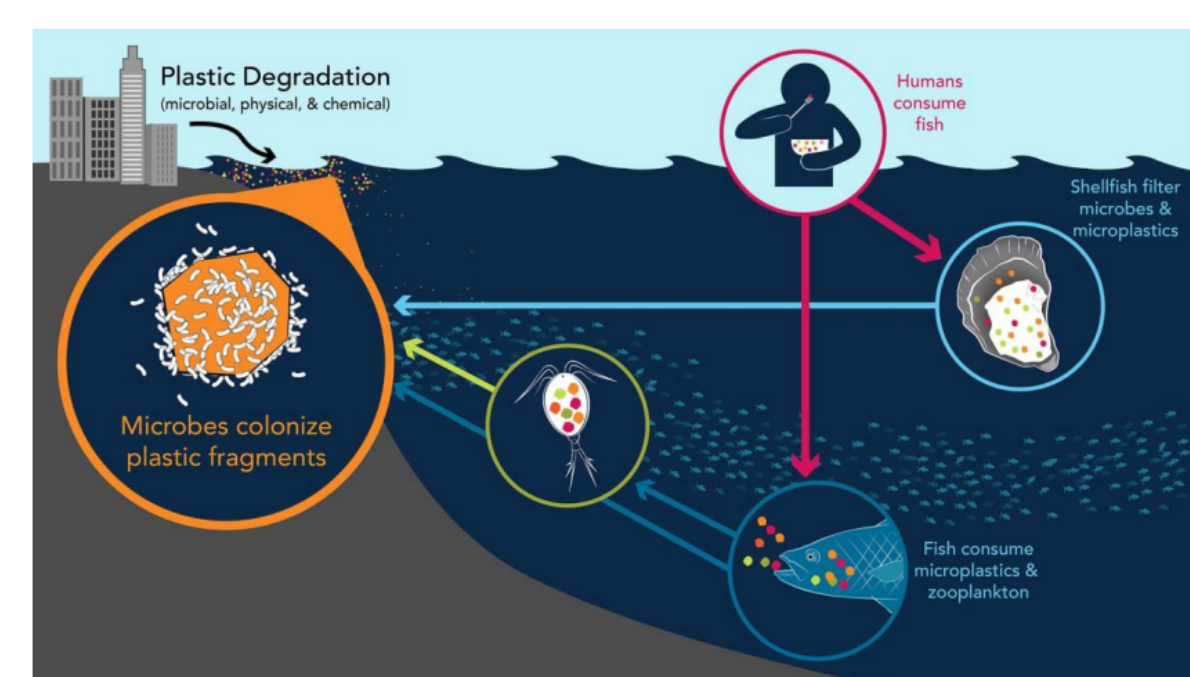


Figure 4: The process of microplastics entering the food web¹⁰

Sensitive Unit

Due to the health risks and environmental risks described in the previous section, several processes to remove microplastics have been implemented. Wastewater in treatment plants is treated through three different phases in order to remove microplastics. These phases include:

1. Primary treatment

-Before the primary treatment, a pre-treatment must be conducted which helps remove larger impurities with a series of filtration methods

-Removal in the first stage is achieved through the settling of heavy microplastics and gravity separation of removable solids, fat, oil, and grease

-After both treatments, 50%-98% of microplastics are removed¹¹

2. Secondary treatment

-Usually consists of biological and chemical treatments

-Removes an additional 0.2%-14%¹¹

-Chemicals used during the secondary treatment such as ferric sulfate could help with the removal of microplastics¹¹

-How microplastics interact with microbial and chemical compounds is still unclear, and must be more researched

-Microplastics are trapped in sludge are not settled properly thus avoiding removal¹¹

-Since it is uncertain how much microplastics are escaping through the sludge there would have to be more research done by measuring the effluent

3. Tertiary treatment

-Removes an additional 0.2%-2%¹¹

-Efficiency depends on different types of filtration systems:

- Disc F-ilter (40-98.5% effective)¹¹
- Rapid Sand Filtration (97% effective)¹¹
- Dissolved Air Flotation (95% effective)¹¹
- Membrane Bioreactor (99.99% effective)¹¹

With these treatments in mind, the total removal of microplastics from wastewater with tertiary treatment prove to be 97% effective and 88% effective without it¹¹. This is because the tertiary treatment enhances the overall removal process efficiency. However, microplastics are still detected in the effluent in the wastewater of treatment plants. An image showing these different treatment phases is shown below in figure 5.

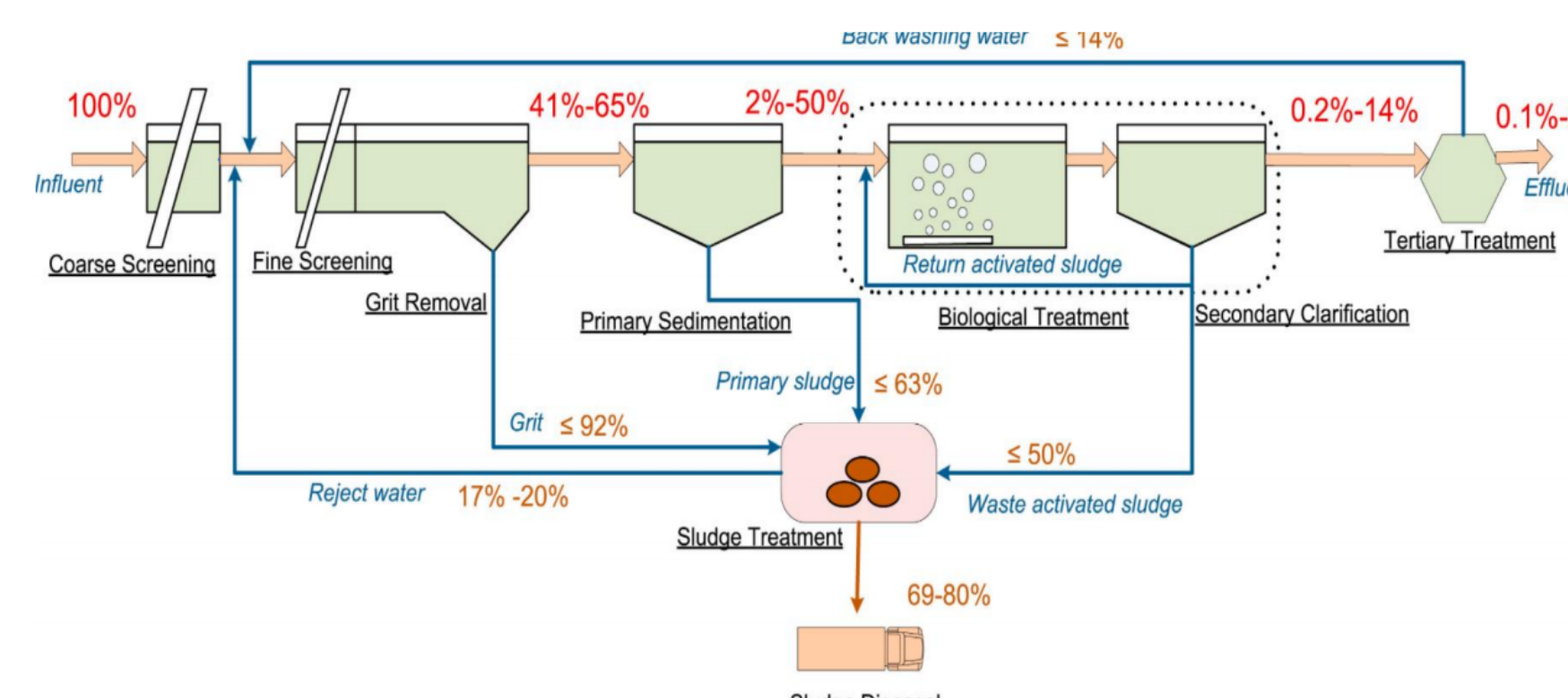


Figure 5: Phases of treatments¹¹

Research

Hypothesis: By implementing pressure sensitive adhesive technology into the wastewater treatment process, the amount of microplastics in sludge and the effluent will decrease.

Objectives:

- Decrease the concentration of microplastics entering the sludge
- Decrease the concentration of microplastics being released into marine environments

Methods:

- 1) Zirconium silicate beads are coated in an adhesive substrate that attracts microplastics¹²
- 2) The adhesive beads are secured within a filtration system
- 3) The secured, adhesive beads are then suspended into the wastewater
- 4) Polystyrene microplastics stick to the beads¹²
- 5) After 5 mins, the beads have accumulated microplastics and effectively removed them from the wastewater⁹

Procedure:

This microplastic removal technology would be best implemented in the primary treatment because it has a high removal success in a short amount of time. It is important to have this technology implemented before the formation of sludge to avoid microplastics becoming embedded.¹²

Feasibility:

Additional research is needed to further evaluate the effectiveness of this technology based on applicable plastic types, wastewater factors, and scalability. Once this is done, research can be done on the implementation of this technology within a wastewater treatment process including a cost analysis, its ability to be integrated into existing WWTP, its maintenance, and its user ability.

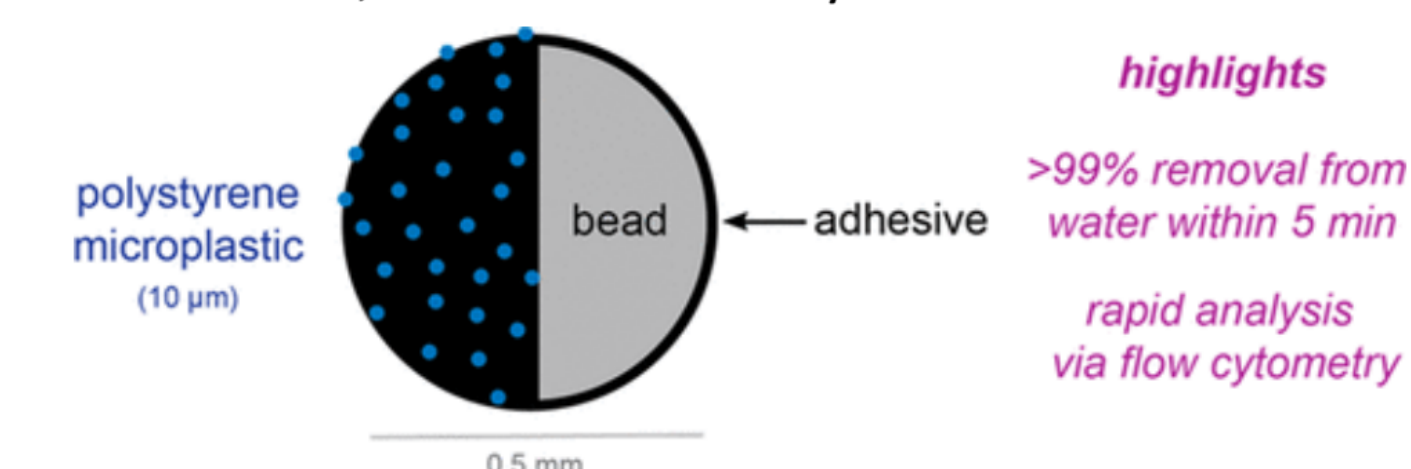


Figure 6: Pressure sensitive adhesive technology¹²

Acknowledgements

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