## WASTEWATER TREATMENT PLANT MODEL

To understand the fate of microfibers after leaving the washing machine, we developed a model of microfibers in wastewater treatment plants (WWTPs). Based on a literature review of wastewater treatment plants, we estimated the mass of microfibers entering local water bodies using a microfiber removal rate between 65-92%.

Based on these removal rates, a city of 100,000 people produces 170-441 kilograms of microfibers from washing synthetic clothing per day. Of the amount of microfibers that enter the WWTP, 9-110 kg of microfibers would be released into local waterbodies daily, which is an average of 15,000 plastic bags.

 = **Mass of 1,000 Plastic Bags**

## CONCLUSIONS

This study highlights current research regarding microfiber pollution and analyzes the impacts of two variables on microfiber shedding: garment age and washing machine type.

**The results of our wash experiments show:**

- **aged jackets shed higher masses of fibers than new jackets**
- **jackets washed in the top-load washing machine shed more than those washed in the front-load**

Higher shedding in aged jackets is most likely due to the weakening of fibers as a result of wear, and higher shedding from the top-load washing machine is likely influenced by the central agitator found in these appliances. These results were significant; however, several other variables were identified that could affect shedding and should be evaluated further including water temperature, cycle length, and detergent type. Future work should also evaluate differences in shedding between traditional top-load machines with a central agitator (like the one used in this study) and high-efficiency top-load washers without a central agitator.

## ACKNOWLEDEGMENTS

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# Microfiber Pollution & the Apparel Industry

Patagonia, Inc.

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## ENVIRONMENTAL PROBLEM

Among the various types of microplastics that have been found in aquatic systems, microfibers have been found to be the most prominent form in some habitats, specifically near dense human populations. Once in the environment, these fibers are readily consumed by aquatic organisms, which can result in gastrointestinal blockages and starvation. Furthermore, microfibers readily sorb chemicals they encounter during the wastewater treatment process as well as in the aquatic environment; when organisms consume fibers, they also ingest these toxic substances which have been found to cause organ stress and reproductive disturbances in some species.


Microfibers have been found in a variety of aquatic organisms, from zooplankton to whales, and are especially prevalent in filter feeders such as mussels and oysters. Humans consume many of these species, making us susceptible to ingesting microfibers as well. Of further consequence to human health, the surface of microfibers have been found to host bacterial assemblages that are substantially different from those normally found in a certain ecosystem. Some of the bacteria that have been identified are associated with human gastrointestinal infections.


## BACKGROUND

Patagonia, Inc. is part of an apparel industry that contributes to microfiber pollution through their production facilities as well as from consumers washing their products. Information is lacking for Patagonia and the apparel industry as a whole in terms of the magnitude of their role in microfiber pollution and the extent of the impacts this pollution has on the ecosystems in which it is found. As such, the Patagonia Plastics Project is assisting Patagonia in assessing the quantity of microfibers shed by their products and the potential ecological impacts of those fibers as well as develop recommendations to inform future steps to mitigate this pollution.

## SIGNIFICANCE

Microplastic pollution is increasingly becoming a national issue. On December 31, 2015, President Obama signed the "Microbead-Free Waters Act of 2015", an amendment to the Federal Food, Drug, and Cosmetic Act that bans the manufacturing of products with plastic microbeads by 2017 and the sale of these products by 2018. Cosmetic companies such as Unilever and L'Oreal Paris have already begun to transition from microbeads to natural alternatives such as sugar, sand, and ground seeds.

Unlike microbeads which have economically feasible alternatives that fulfill the function of their plastic counterparts, the apparel industry faces a more difficult situation as alternatives to synthetic textiles are limited and struggle to mimic the performance capabilities of materials like polyester. As such, the elimination of synthetic textiles extremely unlikely, and mitigation appears to be the only means by which microfiber pollution will be reduced. In order to develop strategies to limit microfiber release, apparel companies need to understand how much their products shed and what factors contribute to higher shedding as well as educate consumers on the issue.

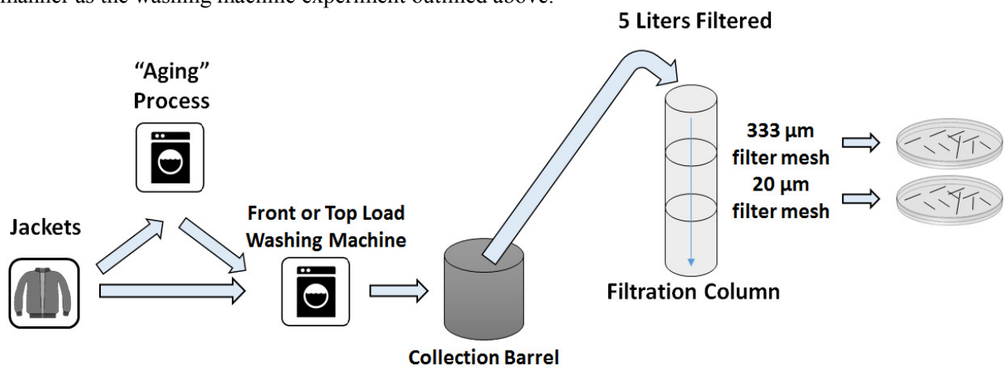
Our extensive literature review of the distribution and ecological impacts in addition to our original and easily replicable experimental design provide the requisite infrastructure for Patagonia and other apparel companies to assess their contributions to microfiber pollution.

## APPROACH

The first step of this project was to quantify the mass of microfibers shed from clothing. To accomplish this, we conducted wash trial experiments on four Patagonia jackets and one budget jacket of a similar style to one of the Patagonia jackets for comparison purposes. The goal of the wash trials was to test how washing machine type and garment age impacted the mass of microfibers shed.

The effect of washing machine type (front load vs. top load) on microfiber shedding was evaluated for each jacket. A new garment of each jacket style was washed in a traditional top load and a front load washing machine. The effluent from the washing machines was filtered through a uniquely designed filtration column, and shed fibers were collected on the filters in the column and removed for later massing.

To analyze the effect of jacket age on microfiber shedding, the jackets were the put through a Patagonia test called a "killer wash". The killer wash is a modified 24-hour wash cycle that simulates a lifetime of wear. After the killer wash, the jackets were washed again in a front or top load washing machine. The washing machine effluent was processed in the same manner as the washing machine experiment outlined above.

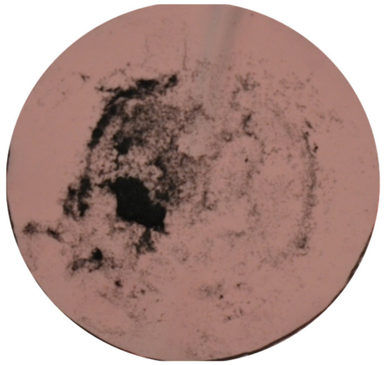



*Microfiber Pollution Project Brief* *Spring 2016*

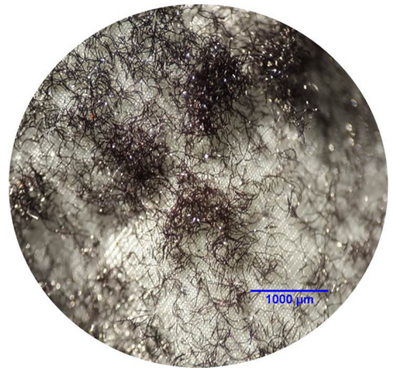
## RESULTS OF WASH EXPERIMENT

During our wash trials, microfiber shedding per jacket ranged between 160 mg to 2,700 mg per wash which equates to approximately 8,500-250,000. Both the type of washing machine and age of jacket significantly impacted shedding. Our experiment shows that a top load, aged, budget jacket shed the most microfibers.

**A 20 µm filter post wash**

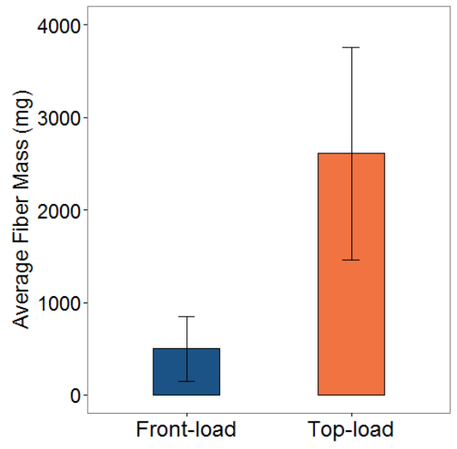


**Magnification of microfibers on a filter**



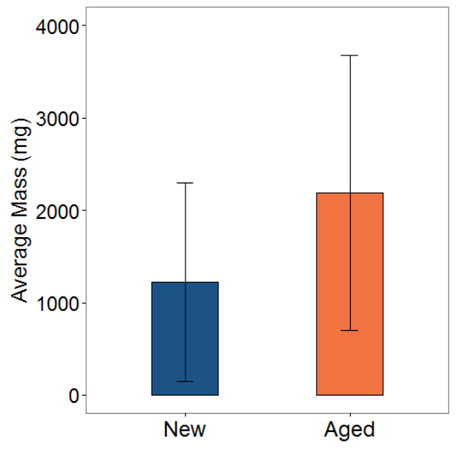

### Washing Machine and Killer Wash Results

**Effect of Washing Machine Type**




**5.3 x** more shedding from top load washing machine

**Effect of Aging**




**1.8 x** more shedding from aged jackets