Microfiber release from clothes after washing: Hard facts, figures and promising solutions

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Introduction
The American Captain Charles Moore made a shocking discovery in 1997 when sailing the Pacific Ocean. In the middle of the ocean, thousands of miles away from civilization, he found plastic in a high concentration in an area as large as the combined surface of Portugal, Spain and France. With that, he had discovered the 'Great Pacific Garbage Patch' and called it the Plastic Soup.

From that moment on, we knew sea currents collect plastic fragments of marine litter. It is also known since then that at least five of such gyres exist and each one has an accumulation of litter. The oceans are the world's sinks for plastic particles and are fast becoming a plastic everlasting dump.

By 2025, there will be 1 ton of plastic for every 3 tons of fish in the oceans[1], and by 2050 the weight of plastic will overtake that of fish. The cause of this future scenario partly lies in our clothing and the plastic microfibers it sheds during washing. Without intervention the amount of fibers that is released via the sewer into our waterways will increase significantly in the near future: 30% of the world population is already doing the laundry with a washing machine. The remaining 70% will buy one as soon as they have the chance[2].

A powerful, fast-growing global coalition tries to stop this source of plastic pollution since early 2016 through the Ocean Clean Wash campaign.

Microplastics in our oceans
Microscopic plastic fragments and fibers are widespread in the oceans and have accumulated in the pelagic zone and sedimentary habitats. At first, the discovered fragments appeared to have resulted from degradation of larger marine litter items.

In 2011, the ecologist Mark Anthony Browne, who was studying the accumulation of microplastics on shorelines worldwide, was the first to conclude that 85% of the human-made materials discovered on the shorelines were microfibers, and matched the types of material used in clothing[3], such as nylon and acrylic.

Taylor et al. proved him right and demonstrated in 2016 that microplastics are already becoming integrated into deep-water organisms that live at depths between 300 and 1800 meters. All microplastics found in this study were microfibers[4]. There is a considerable potential for large-scale accumulations of fibrous microscopic plastic debris[5].

Dris et al. (2015) proved for the first time, the presence of microplastics, mostly fibers, in atmospheric fallout (29–280 particles m^2 /day)[6].

The contribution of microfibers to the plastic soup

One of the first studies on microfiber release by Browne in 2011 showed that a single garment might produce >1,900 fibers per wash[3]. A study by Napper & Thompson (2016) examined the release of fibers from polyester, polyester-cotton blend and acrylic fabrics and found high amounts, e.g. 728,789 fibers from acrylic clothing for every 6 kilos of laundry[7]. A Californian study found 9 kg -110 kg of microfibers being discharged in waste water treatment plants effluent daily[8].

Plastic Soup Foundation published research, as the dissemination partner of the EU-funded Life+ Project MERMAIDS (www.life-mermaids.eu), showing that significantly more fibers are released in washing machine effluent than previous research suggested. Synthetic clothing releases a huge quantity of fibers when it is machine washed, although this depends largely upon the washing conditions and the material. One single polyester fleece jacket releases almost one million fibers per washing[9]. The study also found that a moderate load of laundry releases 20 million fibers of micro plastic!

Microfibers are one of the biggest sources of primary microplastics that are directly released into the environment in the form of small particulates. Close to two-thirds (63.1%) of the on average 3.2 million tons per year that is released as primary microplastics into the environment is due to the laundry of synthetic textiles (34.8%), and to the erosion of tires while driving (28.3%)[10]. Napper & Thompson[6] also consider washing of synthetic materials as an important source of microplastics into the environment.

Results from a study by Pirc et al. (2016) performed at the University of Ljubljana (Slovenia), confirm that domestic washing of textiles and garments is a constant and widespread source of plastic microfiber emissions into the environment[11]. Wastewater treatment plants are unable to effectively prevent them from entering our rivers, seas and oceans.

Environmental effects and consequences of synthetic micro fiber release

The plastic fibers, that are only visible with sophisticated microscopes, are present in the environment; in animals, at the bottom of the sea and in our food.

Microplastics in the food web

There is evidences of microplastics ingestion by the pacific Krill (Euphasea Pacifica), freshwater zooplankton (Daphnia magna)[12,13] and other species such as sea cucumbers[14], shore crabs[15], mussels[16] and lugworms[17,18]. Several observed biological effects of microplastic exposure are gathered by the "Microplastic Litter in the Dutch Marine Environment" report[19].

Persistent Organic Pollutants

Once in the oceans, microplastics attract and absorb persistent organic pollutants (POPs) from the environment, which, in turn, make their way into the marine food web[20]. It is in these dissolved POPs that toxic outcomes arise. The more hydrophobic a chemical is, the greater its affinity for microplastics[21]. In this sense, microplastics have a potential impact on human health by the consumption of contaminated organisms.

Potential effect on human health

Microplastic transfer from prey to predator through the food chain has been clearly demonstrated. Preliminary studies concluded that "airborne nanoplastics (up to 240 nm) can enter the human blood stream and can cross the human placenta, possibly exposing the developing fetus to these particles. Plastic particles from the nm to the low µm range are likely to be absorbed by human tissue should exposure to nano- and microplastics arise"[19].

Microplastic in seafood

Microplastics presence has been demonstrated in different types of seafood like mussels, oysters, shrimps and fish.

Mussels and oysters

Two Belgian studies found microplastics in mussels and oysters. Concentrations varied between 2.6 to 5.1 fibers/10 g of mussel (consumption mussels: 1.6-5.3 fibers per 10 g) [22]. Another study - also in Belgium - found microplastics in the soft tissue of blue mussels and Japanese Oysters[23].

Fish

Rochman reported some of the first findings of plastic debris in fishes directly sold for human consumption, raising concerns regarding human health. Sixteen out of 64 fish from the Californian fish market (25%) were polluted. Most of the pollution (80%) consisted of fibers[24].

In China nine commercial bivalves from a fishery market in China were analyzed on microplastics. Multiple types of microplastics, including fibers, fragments and pellets, occurred in the tissue of all bivalves[25]. The number of total microplastics varied from 2.1 to 10.5 items/g and from 4.3 to 57.2 items/individual for bivalves. Fibers were the most common microplastics and accounted for more than half of the total microplastics.

The microplastic content of shrimps in shallow water habitats of the Channel-area and Southern part of the North Sea were also determined. Synthetic fibers, ranging from 200 µm up to 1000 µm size, were detected in 63% of the assessed shrimps and an average value of 0.68 ± 0.55 microplastics/g w. w. (1.23 ± 0.99 microplastics/shrimp) was obtained for shrimps in the sampled area. Most of the plastics that were detected in the shrimps were microfibers[26].

Honey and cane sugar

A total of 19 honey samples, mostly from Germany but also from France, Italy, Spain and Mexico, were analyzed for non-pollen particulates. Fiber counts ranged from 40/kg to 660/kg of honey, with a mean value of 166 ± 147/kg of honey, whereas fragments were considerably less abundant (0–38/kg of honey; mean 9 ± 9/kg of honey). In all the refined samples, transparent and coloured fibers (mean 217 ± 123/kg of sugar) and fragments (32 ± 7/kg of sugar) were found[27].

Salt

A Chinese study collected 15 brands of sea salts, lake salts and rock/well salts from supermarkets throughout China. The microplastics content was 550-681 particles/kg in sea salts, 43-364 particles/kg in lake salts and 7-204 particles/kg in rock/well salts. In sea salts, fragments and fibers were the prevalent types of particles. The most common microplastics were polyethylene terephthalate (PET or polyester). Table salt appeared to contain several types of plastic particles, a large majority being fibers and small fragments (94%)[28].

The plastics, together with the toxic chemicals and heavy metals are possibly harmful to human health and a risk to food safety. The World Health Organization (WHO) recommends consuming less than 5 grams of salt per day. Based on The World Health Organization

(WHO) consumption recommendation, we could be ingesting 1000 microplastic particles per person per year from table salt alone.

What to do?

The problem of synthetic microfiber pollution is complex and of a considerable scale. There is no quick and easy fix. We can stop using synthetic materials for clothing, but as the current market share is already 63% this is not that easy or realistic. Furthermore, switching from synthetic materials to organic materials comes with other substantial environmental costs.

1. Awareness raising about the microfiber problem

The first step is raising awareness about the microfiber problem. The general public, but also professionals from the fashion industry and policymakers, are not aware (enough). Consumers are not asking for non-microfiber shedding clothing and companies don't use microfiber release criteria in the design and production chain. Policies to avoid microfiber release into the environment are lacking.

By changing the washing behavior, consumers can already mitigate the number of microfibers they send down the drain. MERMAIDS research has shown that by washing on a low temperature, using liquid detergent instead of washing powder, using a softener and washing with a full load, the microfiber loss during the washing process is decreased[29].

See also: MERMAIDS Striptease: https://vimeo.com/146632806

2. Use already available solutions

There are already different solutions available today that help to mitigate the problem of microfiber release into the environment. The initiatives come from environmental minded, grass roots entrepreneurs. We promote these solutions as they contribute to solving the problem of microfiber release into the environment. All solutions listed below agreed to have their innovations tested for their efficiency.

Guppy Friend Washing Bag:
The GUPPY FRIEND washing bag from Langbrett filters out microfibers that are released from textiles during washing. The producers claim that the fabric bag, made of a specially-designed microfilter material, captures 99% of fibers released in the washing process.

GUPPY FRIEND is a start-up based in Germany, Berlin. The goal is to reduce plastics and prevent micro waste pollution entering the world's rivers and oceans. In addition to the GUPPY FRIEND washing machine bag, Langbrett is also developing a filter for washbasins, for household and commercial use as well as restraint devices for floating debris.

http://guppyfriend.com/

Cora Ball:
The Cora Ball is the first microfiber-catching laundry ball. The Cora Ball was designed by a team of ocean scientists, educators and environmental protectors at the Rozalia Project, as a human-scale, consumer solution.

Thanks to a successful Kickstarter campaign, Cora Ball is moving forward with production and expected to launch direct sales in the USA in late July with other countries to follow.

http://coraball.com/

3. MERMAIDS Recommendations:

DESIGN:
The MERMAIDS research identified different critical parameters that have a strong impact on microplastics release during the washing process[30]. These parameters are summarized below:

- ***Fiber length***: the shorter the fibers, the higher the probability to migrate to the yarn surface and increasing their hairiness and their pilling. As a consequence increasing their release during the laundry process.

- ***Yarn twist***: the yarn resistance and elasticity increase with the twist. More compact yarns are achieved with higher twist values.

- ***Linear density (yarn count):*** The number of microfibers released will increase with the yarn count due to a larger amount of fibers per cross section.

- ***Fabric density:*** a higher number of yarns per unit length will result in a tighter structure with lower probability to fiber release.

- ***Textile auxiliaries:*** provide physical protection of fibers against abrasion/reduction of coefficient of friction (fiber-fiber, fiber-detergent) during laundry.

Indications show that the way a yarn is designed has a big impact on the breaking/degrading of the yarn into smaller micro- and nanoparticles. Yarn producers and clothing companies can use these parameters in their design to create yarn and textiles that release less microfibers during the washing process. Pre-sale washing also seems promising. MERMAIDS research showed that during the first wash significantly more microfibers are released. A possible option is to carry out a first controlled washing of fabrics (capturing the microfibers released during this first washing) before putting them on sale.

DETERGENTS AND WASHING CONDITIONS
The research activities carried out during the MEMRMAIDS project also studied the influence of detergents and washing conditions on the microplastic release[30]. Several trials were performed, eventually pointing out that:

- powder detergents, higher pH of the washing liquor and the usage of powder oxidizing agents favor the microfiber release;
- softener or special detergents (for delicate and synthetic fabrics) reduce the release;
- washing conditions such as high temperature, long washing time and strong mechanical actions, favor the release of microfibers from the fabrics.

COATINGS
During the MERMAIDS research, different coatings were tested on different yarn types and materials[31]. Firstly, commercial textile auxiliaries were tested and applied to fabrics. The results of this experimental phase showed that finishing treatments based on silicon emulsions and acrylic resins were able to reduce the amount of microfibers released during washing processes. Then, further researches were carried out developing coatings based on two biopolymers deriving from natural sources: chitosan and pectin.

Chitosan is obtained from the deacetylation of the chitin contained in the exoskeleton of crustaceans. This, being a waste product of the food industry, is widely available in the market at a low price. Moreover, chitosan shows the advantages of being non-toxic, biocompatible and completely biodegradable, with a chemical structure similar to cellulose; it is the polymer of the 2-amino-2-deoxy-β-D- glucopyranose, because the hydroxyls –OH situated in position 2 are substituted by amino groups $–NH_2$.

Pectin is mainly extracted from suitable agro-by-products like citrus peel and apple pomace and used in the food industry as natural ingredients for their gelling, thickening, and stabilizing properties. It is a mainly linear polysaccharide whose principle chemical unit is based on D-galacturonic acid monomer. Such polysaccharide represents an interesting biomaterial because cheap and abundantly available, being a waste product of fruit juice, sunflower oil, and sugar manufacture.

Both finishing treatments based on chitosan and pectin, showed promising results but they still need optimization and further experimental activities.

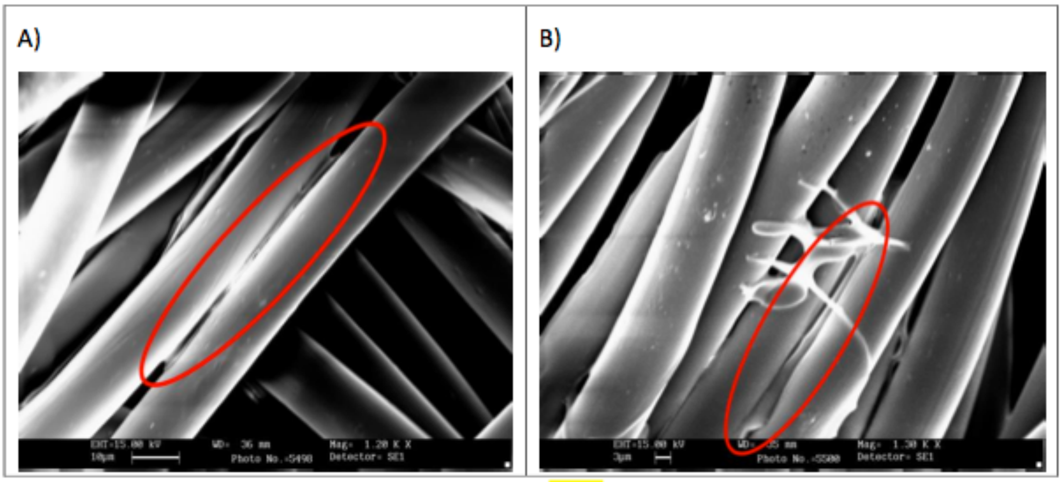
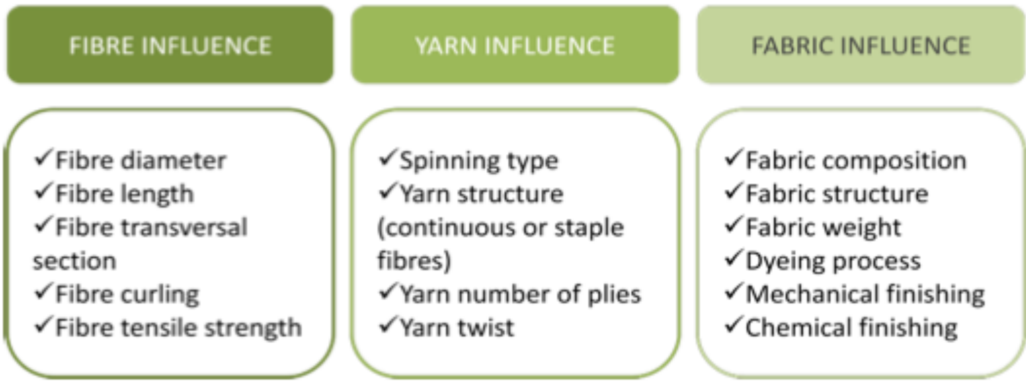
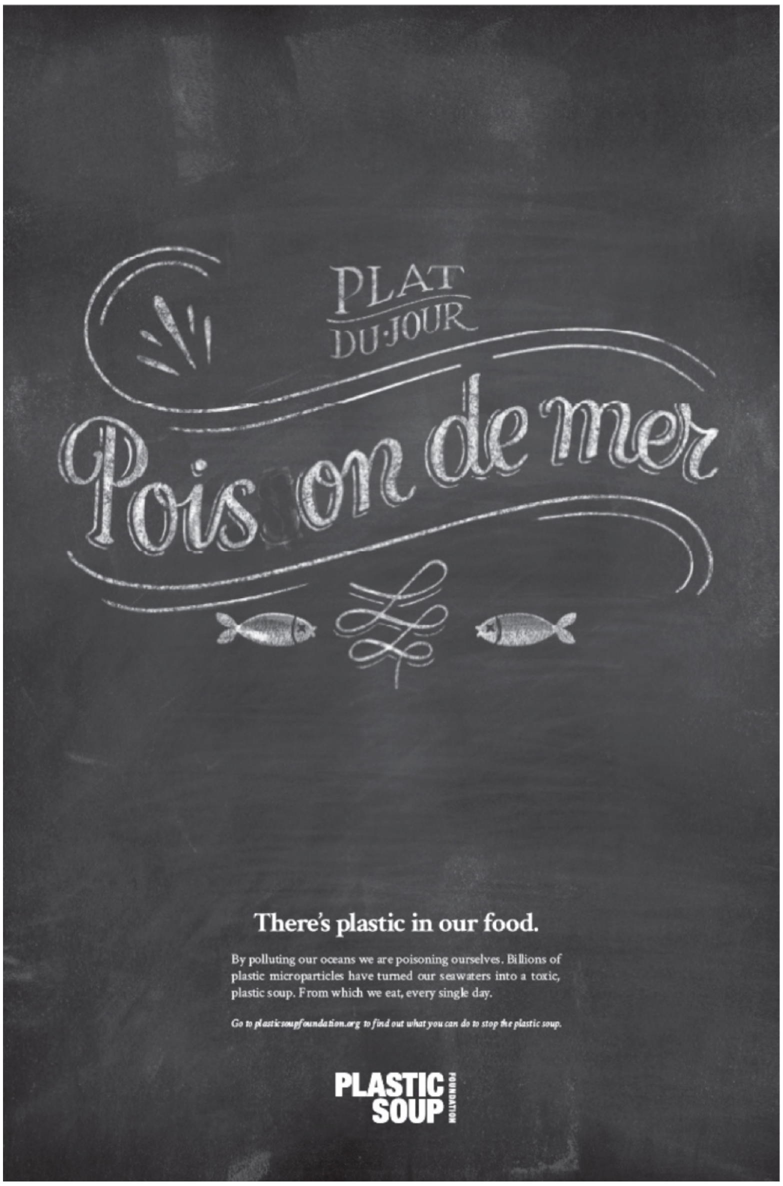


Figure 14. SEM images of polyamide fabrics treated with a chitosan solution with the addition of hydroxylethyl methacrylate. A) treated fabric B) treated fabric after washing (method ISO 105-C06).



4. Fashion industry can and should make the difference

- *Adopt the recommendations from the EU Life+ MERMAIDS research project*[31]
- *Join the microfiber taskforce to tackle the microfiber issue*
- *Publicly support Ocean Clean Wash by stating the importance of a solutions for the emerging problem of microfiber release into the environment*
- *Test your own clothes on microfiber release*
- *Adopt maximum microfiber release targets*



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