

Filtration as an effective and near-term solution to reduce the release of microplastics in the environment.

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April 2023

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Introduction

Sustainability has become a key theme for the European Union (EU) and an important driver for policy development. In March 2022, the European Commission released its EU strategy for Sustainable and Circular Textiles¹ within the Circular Economy Action Plan. The strategy aims to establish a framework to boost the competitiveness, sustainability and resilience of the EU textile sector. This includes an initiative to tackle microplastics unintentionally released into the environment, with the aim of reducing pollution and human health impacts, while encouraging innovation.

We commend the European Commission’s ambitions and believe this policy could serve as an influential example of best practice globally. France has already shown leadership as the first country in the world to mandate microfibre filters on washing machines from 2025.²

This whitepaper calls for the mandate of filters in new washing machines as the only effective, near-term solution to

reduce the release of microplastics in the environment and presents three innovations that have been tested to high standards and are available now for commercial or industrial use.

This is part of a wider call for systemic change in the industry, which looks at policy and regulatory action to disincentivise synthetic textile production and hold those producers accountable for the impacts of their products.

What are microfibres and why are they harmful?

Microfibres (fibres less than 5mm) from synthetic textiles are contributing to the global plastic crisis. Every year more than half a million tonnes of microfibres are released into the world's oceans simply from washing our clothes³, many of which are made from synthetic materials.

Natural, man-made cellulosic and synthetic materials all shed microfibres.

Synthetic textiles are now thought to be the most prevalent source of microplastics found in waterways and soil.⁴ Microplastics are a pervasive environmental problem; they have infiltrated the most pristine locations on Earth, from Antarctic sea ice⁵ to the guts of marine animals inhabiting the deepest ocean trenches.⁶ They have been found in drinking water⁷ and food systems.⁸

It is estimated that 5.6 million tonnes of synthetic microfibres were emitted from clothes washing between 1950 and 2016, with half of this amount being discharged

between 2006 and 2016.⁹ According to a report by the Ellen MacArthur Foundation, based on current trends, the amount of synthetic microfibres entering the ocean between 2015 and 2050 could accumulate to an excess of 22 million tonnes.¹⁰

It is reported that microplastic pollution has increased 10-fold since 2005, with over 171 trillion microplastic particles now floating in our oceans.¹¹ This figure was calculated from surface water data gathered between 1979 and 2019.

Scientists predict this figure will increase a further 2.6-fold from 2016 – 2040.¹¹

Microfibre vs Microplastic

Microplastic: Microplastics are small fragments of plastic that occur in the environment as a consequence of plastic pollution. Measuring anywhere between 0.1µm and 5mm (see figure 2) they can originate from a variety of plastic consumer products. Synthetic microfibres are considered microplastics.

Microfibre: The use of the word microfibre throughout this document refers to textile fibres shed from clothing throughout a product lifecycle. Microfibres measure <5mm in length and >1µm and can be natural, man-made cellulosic or synthetic.

Synthetic fibres: Synthetic fibres are man-made polymers that are often derived from fossil fuels. These polymers include nylon, polyester and acrylics.

Human Exposure to Microplastics and Nanoplastic Particles

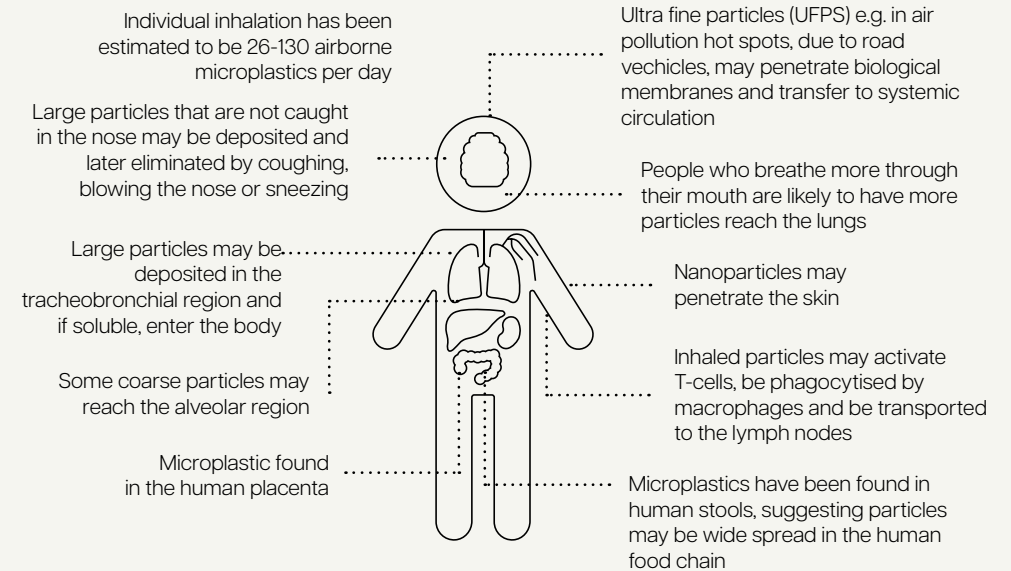


Figure 1: Human Exposure to Microplastics and Nanoplastic Particles (Credit United Nations Environment Programme (Unep). From Pollution to Solution - A Global Assessment of Marine Litter and Plastic Pollution).¹²

The negative impacts of microplastic pollution on wildlife have been widely documented. Synthetic microfibres, such as polyester and nylon, can impact animals' survival, growth and energy balance,¹³ and reproduction.¹⁴

Microplastics are pervasive in the environment, but also in the human body. They have been found in stools¹⁵, blood¹⁶, lung tissue^{17,18,19} breast milk²⁰, and the placenta²¹.

More research is needed to understand how microfibres impact human health. In laboratory tests, microplastics have been shown to cause damage to human cells, including both allergic reactions and cell death.²³

A recent report by Plastic Soup Foundation presented a compelling range of studies highlighting potential health risks associated with microplastics.²⁴ For example, one study found that children under the age of 6 inhale 3 times more microplastics than an average adult and that children are most likely to be at risk from adverse effects of microplastics because their systems are developing.²⁵

Further, various studies have shown that high exposure to inhalable microplastics, as found in the flocking industry, can lead to chronic interstitial lung disease, a work-related condition that induces coughing, breathlessness, and reduced lung capacity.^{26,27}

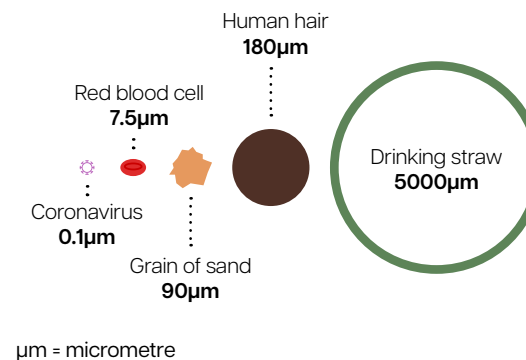


Figure 2: Items comparable in size to a microplastic: Svalbardi. Microplastics Found In Drinking Water.²²

Microfibre shedding and textiles

There are several sources of microfibres and various pathways through which they enter the environment. These include the production and disposal of textiles but also everyday acts such as wearing and washing our clothes.

Synthetic fabrics, such as polyester, acrylic or elastane, are the biggest source of primary floating microplastics in the world's oceans, accounting for 35% of the total, according to a report by the International Union for Conservation of Nature.³

Microfibres are released during textile manufacturing, everyday consumer activities (washing, drying, wearing) and the disposal of clothes. Studies show that most textile-based primary microplastics are released in the consumer use and laundry phases.^{28,29}

Textiles shed microfibres during washing due to the effects of water, friction and abrasion, and detergents.³⁰ Shedding

varies between fabrics and materials, but research shows that **some garments can shed hundreds of thousands to millions of microfibres in a single laundry load.**³¹

Synthetic fibres are so inexpensive that they have become ubiquitous in fast fashion.³² They currently represent a 69% textile market share, and this figure is expected to reach almost 75% by 2030 (a total of more than 101 million tonnes).³²

Growing demand for fast fashion and the proliferation of synthetic textiles means plastic microfibres are expected to increase. This is concerning due to the persistence of microplastics in the environment, which poses a serious ecological and public health risk.

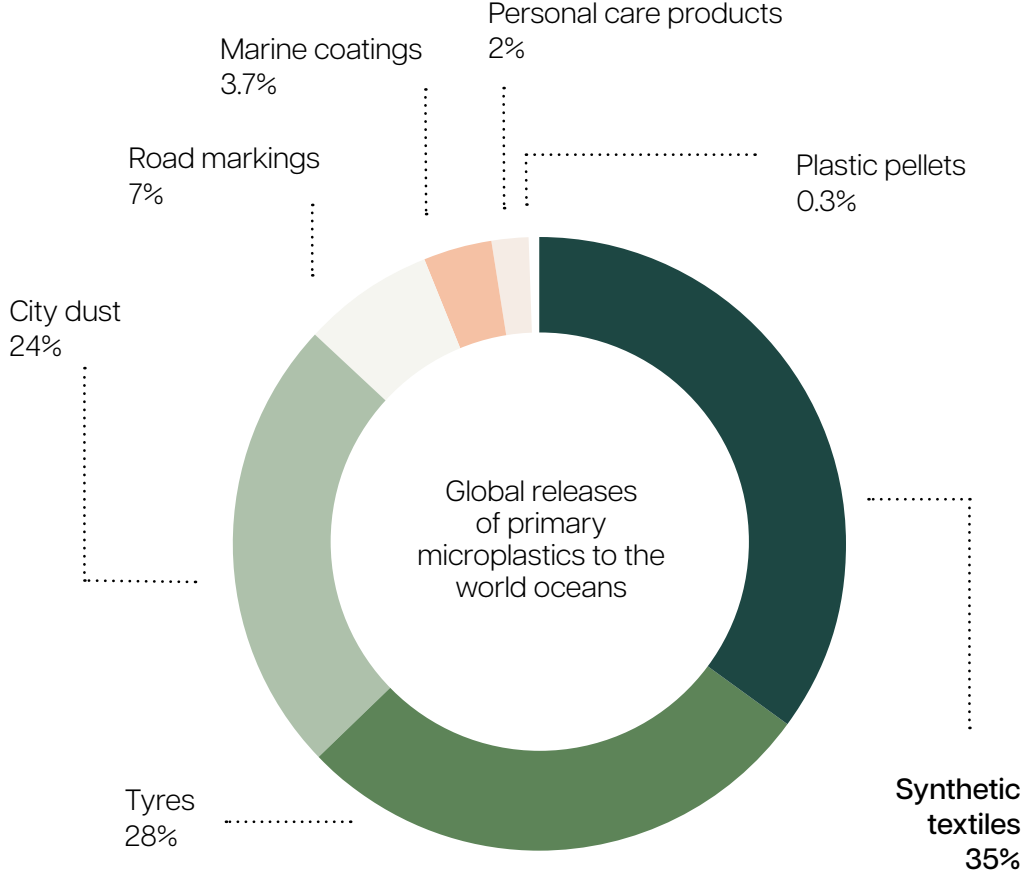


Figure 3: Global Releases of Primary Microplastics to The World Oceans (Credit: International Union for Conservation of Nature³)

Microfibre shedding and textiles

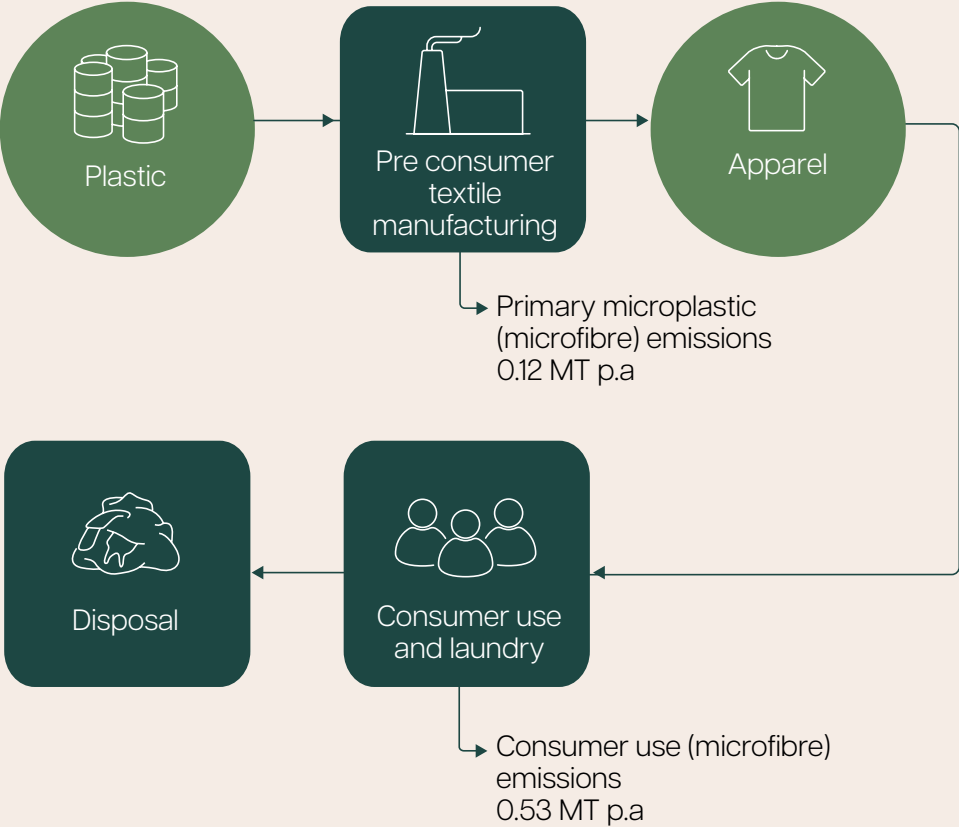


Figure 4: Release of Textile-Based Primary Microplastics

(Credit: The Nature Conservancy and Bain & Company³⁰)

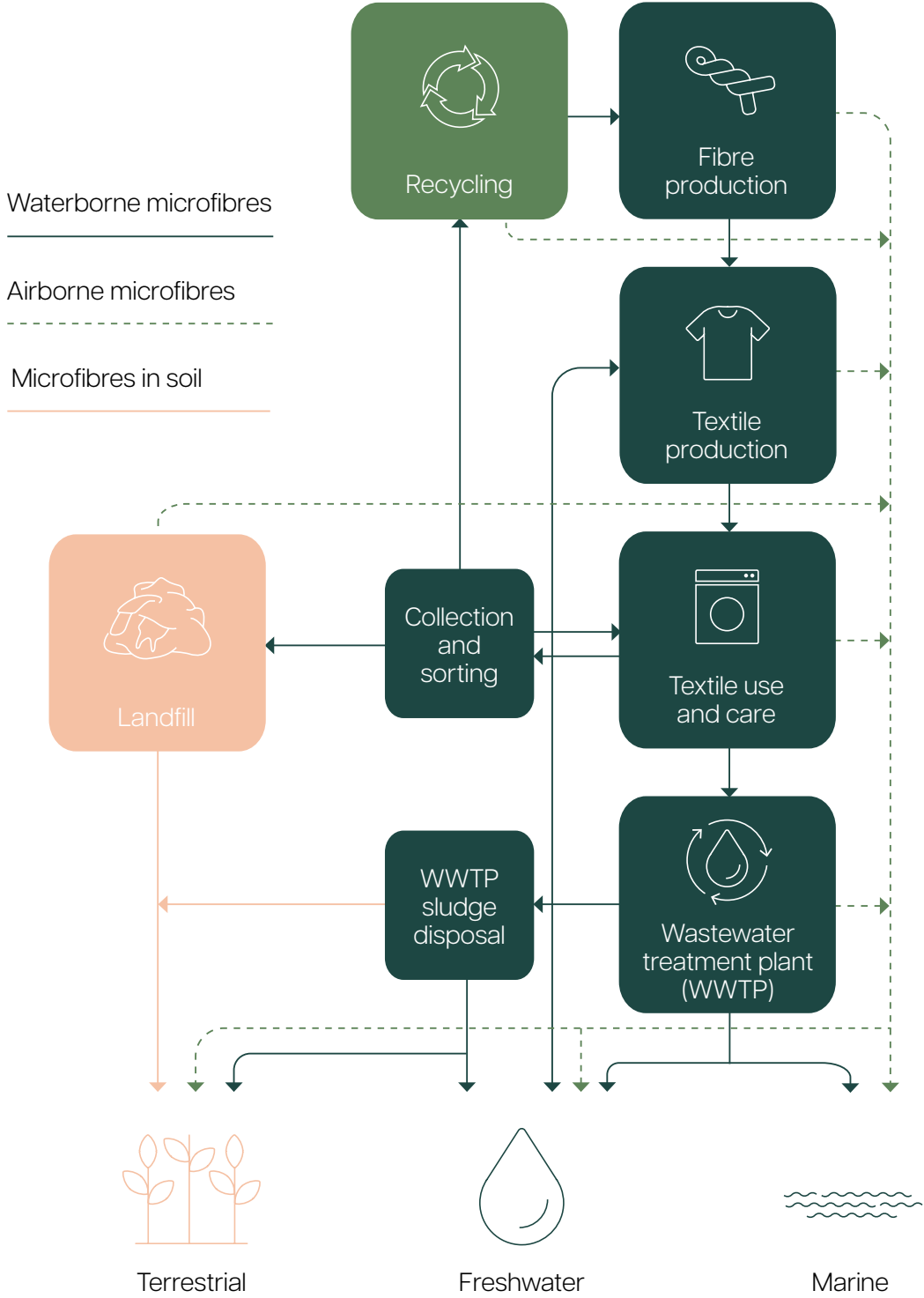


Figure 5: Microfibres Emitted Into the Environment During the Textile Production Chain

(Credit: UNEP Sustainability and Circularity in the Textile Value Chain).³³

Solutions to microplastic pollution from textiles

A variety of solutions are needed to reduce the release of microfibrils in the environment. The fashion and laundry industries must undergo significant transformations, with fundamental changes required.

There are a number of solutions already in development at differing levels of maturity. Whilst there is growing awareness and action in the fashion sector, recent research highlighted that of 46 of the largest fashion brands surveyed in 2021, none had detailed strategies of how they would reduce their microfibre impact³², and a quarter had no mention of microfibrils at all on their website or in response to the research.³²

Within the EU, the Water Framework Directive, which was introduced in

December 2000, does not currently, explicitly address microplastics either. Whilst the EU has been subject to eco-labelling on washing machines since 1994 the latest review of ecodesign framework considered a number of solutions to not be mature enough including microfibre filtration.

In this section we highlight important remedies needed to mitigate microfibre pollution and their current status.

1 Reduction of synthetics

The fast fashion industry relies on cheap fossil-fuel based materials. Reducing the production and use of synthetic textiles should be a critical focus of any policy and regulatory action when looking at the fashion industry's impact on microplastic pollution. Synthetic fibres represent over two-thirds of textiles, which is predicted to rise to 73% by 2030.³²

The EU Textile Strategy states that 'fast

fashion is linked to the growing use of fossil-fuel-based synthetic fibres' and acknowledges synthetics as the main culprit of microplastic pollution. The EU Commission's 2030 vision for textiles says "Fast fashion is out of fashion."

Policymakers must implement measures that would lead to a reduction in synthetic fibres as a way of curbing fast fashion and reducing microplastic pollution.

Upstream

Downstream



Figure 6: Upstream and Downstream Solutions to the Microfibre Pollution Problem.

2 Material design

Upstream, one of the most effective remedies is textile redesign. Changes to the materials and production processes used by manufacturers are critical for reducing leakage of microfibrils into the natural environment.^{34,35}

Research shows that woven fabrics release fewer microfibrils than knitted ones into water when they are washed or into the air through everyday use.³⁶ Compact textiles, made up of high twist, high-density yarns and low hairiness, release fewer microfibrils, as do those

consisting of yarns made of continuous filaments instead of short staple fibres.²⁸

But improving material design and manufacturing processes is still only in its initial phase and therefore cannot be considered a near-term solution to tackling the microplastic problem. Furthermore, the majority of existing clothes do not have these design features and therefore will continue to shed large amounts of microfibrils. This solution requires a major mindset shift towards a more circular way to make and buy our clothes.

3 Wastewater treatment

Wastewater treatment has potential to be an effective long-term solution for reducing microplastics in the environment but currently it isn't fit for purpose. In developed countries, most wastewater goes through a wastewater treatment plant (WWTP) where it is treated before entering aquatic environments. WWTPs can be highly efficient at removing microplastics from final treated discharge through membrane bioreactors, rapid sand filtration and filters,⁴ with removal rates ranging between 80 – 99%.³⁷ However, in view of the large volumes of discharge in question, the remaining proportion still represents a significant volume and therefore environmental hazard. For example, a study on a modern treatment plant in the UK found that, despite the efficient removal rates of microplastics, 65 million microplastics were still being released into the receiving water every day from this one plant.³⁸

Furthermore, **the majority of microplastics captured in wastewater treatment end up in sewage sludge,³⁹ which is commonly used as organic fertiliser in the US and Europe.⁴⁰** In the

latter, this is a requirement of EU directives promoting a circular waste economy.

An estimated 8-10 million tonnes of sewage sludge are produced across Europe each year, of which roughly 40% is spread on farmland.⁴¹ Between 31,000 and 42,000 tonnes of microplastics, or 86 trillion to 710 trillion microplastic particles, contaminate European farmland each year.⁴²

Microplastics can also penetrate deep into the soil profile, potentially contaminating groundwater or entering aquatic environments via runoff.⁴³ Microplastics have been found up to 90cm (35in) below the surface on agricultural fields where sewage sludge had last been applied 34 years ago.⁴⁴

Even more worryingly, it is not uncommon for WWTPs to experience spills in which untreated sewage is discharged directly into water bodies. Water companies in the UK released untreated sewage for a combined total of 2.7 million hours in 2021, according to the Environment Agency.⁴⁵

Filtration is therefore the best applicable, near-term solution to deal with this ever-growing problem.

4 Filtration

By contrast with longer-term production and disposal changes, microfibre capture solutions are effective and commercially available now.

Microplastic filtration solutions

We have presented three innovative filtration technology solutions that are effective at reducing the microplastic problem and are available in the near-term.

1 Matter

<https://matter.industries/>

Matter is focused on capturing, harvesting and recycling microplastics and other micropollutants. It has developed a patented “self-cleaning” filtration process that enables the effective separation of micropollutants in wastewater without the use of disposable filter components, ensuring the technology is both sustainable and scaleable.

The first commercial product is Gulp – a retrofittable microfibre filter for domestic laundry, designed for consumers. The core pillars of this product are efficiency, sustainability, and usability. Sustainability means that the product has a positive social and environmental impact, and that it lives by the principles of the circular economy. Usability is critical as, even with perfect filtration technology, it means nothing if consumers are unwilling to engage with it. Simplicity is crucial.

Matter's process enables the separation of captured waste from the filter itself, so it is available for recycling. The company is working with researchers and universities to develop new technologies for reusing

captured microfibres, as it aims to create a truly closed-loop system and keep this harmful pollution out of landfill.

The technology optimises for efficiency (capture rate), pressure consumption and/or the maintenance cycle. Internal testing carried out by the University of Glasgow, following the process set out by Napper et al in 2020⁴⁶, showed the filter had an average efficiency rate of 91%.

The filter can be fitted in many different locations: above or below the water line, inside or outside the machine. It works with both liquid and powder detergent. It is designed to be as easy to operate as possible; installation is possible without professional support and the cleaning process takes less than a minute to complete. Because the technology does not require replacement cartridges, there is no ongoing cost to maintain effective microfibre filtration, significantly reducing the average cost per wash to the consumer.

Matter also offers an integration programme called Matter Inside and is working with domestic and commercial laundry industries to enable them to use the filters in their products.

<https://planetcare.org/>

PlanetCare is a leader in microfibre filtering solutions in Europe. As early as 2019, PlanetCare put the **first purpose-built, retrofit, external microfibre filter on the market and now has several thousand users around the globe**. The retrofit filter is a passive device that fits all domestic-type washing machines. It is attached directly to the washing machine drain pipe and does not raise water and energy use. The filtration occurs in an exchangeable filter cartridge. Due to its innovative structure, the cartridge offers high fibre capture rates and has an extended lifetime before it needs to be replaced. The current replacement rate is once per month. Cartridges are part of a closed-loop circular, return-and-reuse scheme through which customers return used cartridges for refurbishing. Cartridge bodies are efficiently reused several times and fibre release is avoided due to controlled disassembly and cleaning. A benefit from this scheme is a faster ramp-up to waste quantities that can support a dedicated recycling process.

PlanetCare technology was tested in the Zero Microplastics Challenge conducted by the Swedish RISE Institute in 2020 where it was found to have “the best technical function for removing microfibers along with the lowest environmental impact”. In a demanding test with fibres from a real washing process, the capture rate of the filter was 90 %.⁴⁷

Based on the proven cartridge technology PlanetCare also offers a large-capacity microfibre filter adapted for use in commercial washing machines that require efficient fibre capture in a small-footprint. A sturdy and reliable filter adapted to high water flows.

PlanetCare is actively working on the development of an integrated filter for domestic washing machines that will be included in next-generation washing machines. The solution is characterised by an automatic function that is invisible to the user and requires no consumables. Users will only need to remove fibres as we do with tumble dryers, but at longer intervals. Work on industrialisation and integration into washing machines is currently underway with a target to have the new washing machines with integrated microfibre filtration on the market in time to meet first regulations in 2025.

PlanetCare has been a frontrunner in the efforts to establish microfibre filtration as a viable microplastic prevention method. They have raised awareness about microfibre pollution, working together with international organisations, NGOs and consumer groups and supporting policymakers in their efforts to put a stop to this pollution.

<https://www.xerostech.com/>

Xeros has developed a patented filtration technology - XFilter (XF¹) - the highest performing microfibre filtration device available.

XF¹ (the domestic version of XFilter) is designed to be integrated into any domestic washing machine during its manufacture, to help trap the microfibres that our clothes release. To achieve the lowest lifecycle impact on the planet, XFilter is designed to last the lifetime of a washing machine with no replacement cartridges. It works in the detergent drawer and when full the consumer is alerted by a sensor. They can then easily remove the filter and empty the trapped fibres into household waste, or recycling as and when this capability is developed, making it as simple as emptying the lint from your tumble dryer.

Independent tests, conducted by Hohenstein, a highly respected German testing institute for the textile industry, show it is the highest performing filtration device available, capturing over 99% of microplastics.⁴⁸ The test analysed the retention rate of defined synthetic microfibres (microplastics) using an XFilter device that had been integrated into a washing machine.

XFilter is also very effective at capturing cellulosic fibres, which are chemically modified during the production process to be turned into clothing, reducing their ability to biodegrade. Studies show they can attract positively charged hazardous substances as well as pathogens.^{49,50}

Cellulosic fibres, such as cotton, can be very challenging to filter. The smaller microfibres that break off from cotton escape more easily through filter mesh. In addition, the fragmented nature of the fibres means that as they are captured, they begin to form a ‘cake’ or film on the filter which leads to premature blockages, often before one wash cycle is even finalised. The XFilter technology is uniquely designed to minimise this film build-up – allowing much more time between emptying the collected microfibres.

XF², the industrial solution of XFilter, has the same effective capture rates as XF¹ but is designed to be compatible at a commercial scale. The XFilter can either be integrated directly into a commercial washing machine, or as a stand-alone unit that can be attached to a series of machines, or a whole laundry. The system incorporates a self-cleaning mechanism designed to last 60 wash cycles before it needs to be emptied. It only takes a minute to dispose of the fibres from the collection tray which is then put back into the XFilter to continue to collect further fibre fragments.

In the last 12 months Xeros has licensed their XF¹ technology to three European component suppliers to the washing machine industry. XFilter is engineered to work with any washing machine model to enable partners to scale this solution.

Xeros have begun further exploration into industrial solutions for the textile industry, as well as looking at an external filtration product for consumers.

Responses to the concerns about washing machine filters

Common objections to microfibre filtration are variously misconceived or a distraction from the clear, deliverable benefits these systems offer.

1

The microfibre problem should be addressed through textile design or through wastewater management systems.

Textile design is a necessary long-term solution, but even with redesign, capture may still be necessary. For example, low-shedding materials may still shed a small amount of microfibres, or consumers may continue to use and wash older (high-shedding) clothing even after new designs are introduced. In addition, material design changes require a fundamental industry shift which will take time, with the fast fashion model (which prioritises cheap materials and rapid consumption of new clothing) showing no signs of slowing. The scale of the industry suggests this could take decades to implement.

WWTPs are very efficient at removing microplastics from final treated effluent, with removal rates of between 80 – 99%. This still means an estimated 65 million microplastic particles are discharged every day in the effluent from each treatment plant³⁹. The collected sludge is also often used as fertiliser for agricultural land which raises the issue of hazardous microplastics contaminating soil and groundwater. It is not uncommon for WWTPs to experience spills in which untreated sewage is discharged directly into the environment due to the facility being under strain.

It is clear that a near-term solution is required to stem the ongoing microfibre pollution problem while longer-term, fit-for-purpose solutions are developed.

2

Filters that capture particles of 100 microns will clog, creating the need for bypass that will render them useless.

Many microplastic filters will indicate when they need changing or cleaning. This helps avoid clogging and eliminates the need for a bypass feature.

None of the solutions provided rely on a bypass. Instead the solutions will either provide a warning signal to the consumer or instigate a machine stop, which signifies the filter is ready to be emptied or replaced.

3

This will be a new added waste stream that we don't know how to deal with.

Microfibre waste already exists and is processed through landfill or incineration. Therefore, this technology will not add a new waste stream.

Tumble dryer lint and dust particles in the vacuum cleaner also contain microfibres. Currently, it is preferable for these fibres to enter landfill or incineration as this ensures they are more contained and less likely to spread in the environment.

Research is being conducted by both academia and companies to find solutions to recycle, reuse and upcycle microfibres. This will however require a collection system to be in place.

In 2023, the University of Surrey and Xeros began research into upcycling microfibres captured through filtration into a useful and valuable carbon material, which can be used in various essential products such as batteries, solar cells and medical devices.⁵¹

PlanetCare offers a closed-loop takeback scheme to recover and manage the microfibres captured through its filtration technology. The recycled fibres are converted into insulation mats.⁵²

Responses to the concerns about washing machine filters

4

Consumers are unwilling to pay for the increased cost.

Surveys indicate that consumers are willing to pay more for washing machines with microfibre filtration technology:

- An internal study conducted by Trinity McQueen in September 2021 of 2500 adults in the UK, Germany and France, showed that 95% would be willing to pay for filtration, with nearly half willing to pay an additional £70 (€79).
- A YouGov survey commissioned by the Marine Conservation Society found 81% of adults in Great Britain said they would support legislation requiring all new domestic washing machines to be fitted with microfibre filters.⁵³ A quarter (26%) said they would be willing to pay an additional £50 (€57) or more and over half (56%) said they were willing to pay an additional £5 (€5) or more for a washing machine that included a microfibre filter compared to one that didn't.
- In a 2020 study, 96% of respondents said they were interested in a product that tackles microplastic fibre pollution from domestic washing machines.⁵⁴ Cost was seen as a less important factor, but nonetheless something to carefully consider. To distribute the product widely, which is necessary to tackle the microfibre issue, people from all socio-economic classes should be able to purchase the product.
- PlanetCare's 2021 microfibre pollution survey on over 32,000 people found that 96.6% thought washing machines should already have filters that stop microplastic pollution and 84.8% would be willing to pay more for a filter.⁵⁵
- As highlighted in the European Commission's factual summary report of the Public Consultation on the Microplastics Initiative, most stakeholders completely agree on washing machine filters as a measure for reducing the release of microfibres.⁵⁶

5

Filters can have a negative impact on washing machine energy consumption and water efficiency

The majority of filters are passive and require very little additional energy and water to run.

- Filter specs and testing demonstrably contribute to an extremely small additional burden to the power consumption of the drain pump.
- In instances of active (motor-powered) filtration, in-house tests carried out at Xeros show the filter required an additional 0.0128kWh per wash cycle. This was compared to the energy use of an 'Eco 40-60 wash cycle' which was between 0.51kWh and 0.75kWh per cycle.

6

Consumers will be unwilling to take on the additional maintenance that comes with a filter.

Surveys indicate that consumers are willing to take on additional maintenance for washing machines with microfibre technology:

- A 2020 study investigating consumer attitudes towards filtration devices found that customers would be willing to spend an extra five minutes per cycle on the product. It also found that 95% of respondents would not mind cleaning the filter for 10 minutes every 15-17 washes.⁵⁵
- A 2021 peer-reviewed study demonstrated that consumers were willing to collect lint captured by the filters and maintain them over 2 years.²
- Many consumers already capture and dispose of lint from dryers. Therefore, it is a valid assumption that consumers will also be willing to capture lint from washing machines.

Conclusion and call to action for legislators

Washing machine filters are the only available and effective solution that will reduce the release of microfibres into the environment in the short-term while longer-term solutions are developed.

By mandating washing machine filters, the European Commission could significantly reduce the release of microplastics into the environment and therefore deliver on the EU's Strategy for Sustainable and Circular Textiles within the Circular Economy Action Plan.

There are two critical and interlinked considerations for legislation that mandates washing machine filters:

1 Timeliness

Legislation to mandate washing machine filters must be brought into effect as soon as possible in order to have the biggest and most immediate impact on microplastic pollution.

2 Standards

The legislation must require a capture rate of at least 90% of microplastics for every wash cycle in order to have impact. The three solutions presented earlier in this whitepaper meet these standards.

It's important to note that fast-acting legislation that allows for poor standards will not tackle the issue.

Other important considerations for the European Commission:

- Legislation must quickly determine testing processes (borrowing from industry best practices) and standards in an unambiguous way to drive clarity within the industry, and prevent further delay, obfuscation and loopholes.
- Legislation must not support or enable greenwashing. Misleading sustainability statements from washing machine manufacturers must be challenged vigorously.
- Industry-standard testing processes must be created in this space to ensure credible comparability and that consumers have confidence in the solution.

If the Commission were to support these mandates, the EU would be showing real leadership in tackling microplastic pollution. Further, the size of the EU means it will have a substantive impact in reducing microfibre pollution at scale.

The conversations taking place around the UN Plastic Treaty in Paris in May this year show that critical steps are already being taken to introduce binding global measures to tackle the environmental and health risks posed by microplastic and microfibre pollution by 2024.

France has set the benchmark as the first country in the world to take legislative steps in the fight against plastic microfibre pollution, with mandatory microfibre filters on washing machines to be introduced from 2025.⁵⁷

A microfibre filtration bill has also been introduced in California mandating all new washing machines sold in the state to contain a microfibre filtration system with a mesh size no greater than 100 micrometres. If passed, the bill would come into action on the 1st January 2029 and would position California behind France as the second region to introduce legal measures against microfibre pollution.⁵⁸

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