Fibers TO Filters

A Toolkit for Microfiber Solutions

Ocean Conservancy®

5 GYRES SCIENCE TO SOLUTIONS

The Nature Conservancy

Ocean Conservancy

Ocean Conservancy is working to protect the ocean from today's greatest global challenges. Together with our partners, we create evidence-based solutions for a healthy ocean and the wildlife and communities that depend on it. For 40 years, we have been on the forefront of tackling one of the ocean's biggest threats, plastic pollution, through organizing the largest cleanup effort in the world and successfully advocating for state, national and international policies to prevent plastics from becoming pollution in the first place.

The 5 Gyres Institute

The 5 Gyres Institute employs a "science to solutions" approach to combat plastic pollution worldwide. Through scientific research, 5 Gyres informs leaders and advocates for high-impact policies aimed at mitigating harm from plastic pollution. Additionally, they engage and empower communities by fostering grassroots action to drive meaningful change. Holding special consultative status with the United Nations Economic and Social Council since 2017, 5 Gyres is committed to advancing science-based solutions and promoting a sustainable future for our planet.

The Nature Conservancy

Established in the United States through grassroots initiatives in 1951, The Nature Conservancy's (TNC) mission is to conserve the lands and waters on which all life depends, envisioning a world where the diversity of life thrives, and people act to conserve nature for its own sake and its ability to fulfill our needs and enrich our lives. TNC has evolved into one of the globe's most impactful and expansive environmental organizations. With the support of over a million members and the committed endeavors of a diverse team, TNC influences conservation efforts in over 75 countries and territories. Directly impacting 37 regions and collaborating with partners in 42 others, its reach extends far and wide.

Specific technologies and policies cited in this report are included as examples and are not intended to be an exhaustive list. Inclusion is not an endorsement of technologies or policies by the author organizations.

Scientists have found microplastic pollution nearly everywhere they've looked—from the deepest part of the ocean, to the tops of remote mountain ranges, to inside our own bodies. Microfibers, small thread-like materials less than 5mm in length, are among the most ubiquitous forms of microplastics and potentially the most harmful in preliminary research.[1, 2] This distinct form of microplastic pollution requires targeted and urgent action for the health of our communities, ocean and planet.

Addressing microfiber pollution requires interventions across the lifecycle of textiles. Microfiber filtration in washing machines represents an important near-term solution. This Toolkit outlines the role of washing machines in releasing microfiber pollution and their potential to be a solution, existing microfiber filtration technologies and their costs, examples of state and local policies that have been proposed and key recommendations for effective filtration policies.

5.6M

metric tons of synthetic microfibers were emitted from washing clothes between 1950 and 2016.

That is equivalent to

28.2B

t-shirts entering the environment.

50%

of those were in the last decade alone.

Laundry is a Major Source of Microfiber Pollution

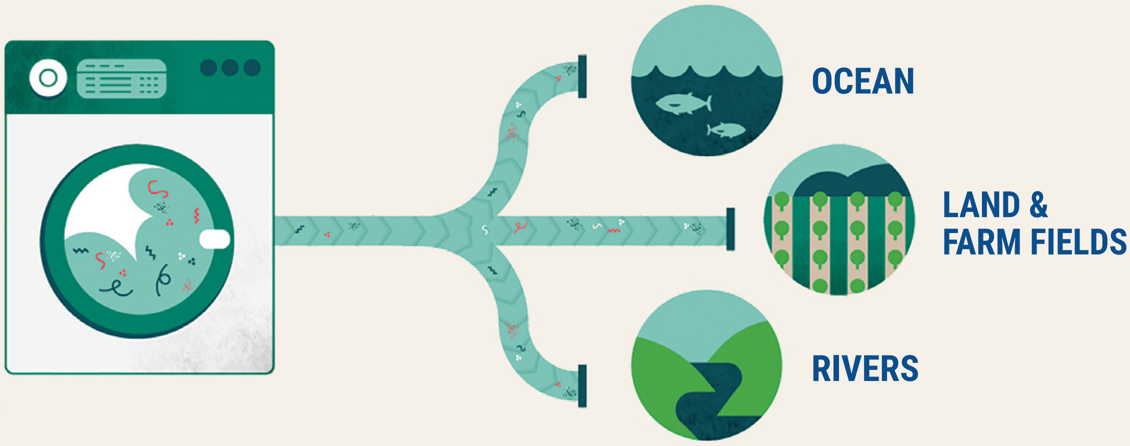
Our clothes and other textiles we use every day are increasingly made of plastic. Synthetic fibers account for 69% of the materials used in textiles—a number that is projected to grow to nearly 75% by 2030.[3,4] Clothing and other textiles (e.g., home goods, carpets) shed microfibers throughout their lifecycle, including during the production process, normal wear and tear, and washing.

Synthetic textiles are the source of almost 35% of microplastics in the ocean.[5] With production of plastic-based textiles like polyester and nylon rapidly increasing with the rise of "fast fashion," the plastic microfibers they shed represent an urgent threat to humans, wildlife and the environment.[a] These microfibers have been found to accumulate and persist in the environment, where they can be inhaled or ingested by wildlife and humans, raising growing concerns around the health impacts of microfibers.[6]

Laundering of textiles, including clothing most notably, is a major source of microfiber pollution in the environment. An estimated 5.6 million metric tons of synthetic microfibers were emitted from washing clothes between 1950 and 2016 with nearly half emitted during the last decade alone.[7] A single load of laundry can release up to 18 million microfibers.[8]

Without filtration systems in place, microfibers shed during the washing process are released into the wastewater from washing machines, which then flows into municipal wastewater treatment plants (WWTPs). While WWTPs can capture about 90% of microfibers, at the scale of water treated and of increasing microfiber pollution, large quantities of microfibers are still released into the aquatic environment via the treated wastewater.[9] In 2019, as many as 2,200 metric tons of microfibers were released into California's lands and waters alone, even with effective WWTP filtration.[10] That amounts to 7.3 quadrillion individual microfibers, or 500,000 microfibers per Californian per day. Microfibers captured by WWTPs are retained in solid residue, referred to as biosolids, from wastewater treatment processes. Biosolids are often land-applied as fertilizer, including on agricultural lands, and are another significant pathway of microfiber pollution into the environment.

A single load of laundry can release 18 million microfibers, which contaminate our:



a Microfibers from semi-synthetic materials (like rayon) and natural fibers (like wool and cotton) are also of concern due to their persistence in the environment and human and environmental health concerns associated with their production and release into the environment.

Microfibers Impact Human Health, Wildlife and the Environment

Once they enter the environment, microfibers are nearly impossible to clean up. They leach toxic chemicals, including per- and polyfluoroalkyl substances (PFAS), into the environment[11] and adsorb and transport other pollutants they encounter. These pollutants are then passed on to wildlife and humans through ingestion and other pathways.

Microfibers are the most common microplastics consumed by marine fishes, aquatic crustaceans and bivalves—often representing more than 90% of plastic ingested.[12] Reported impacts of microfiber ingestion on wildlife include blocked digestive tracts, reduced nutrient absorption and food consumption, internal damage, reduced energy for growth and altered gene expression.[13, 14]

On land, microfibers can cause chemical uptake in plants, have negative impacts on crop growth and production,[15, 16] and pose potential risks to consumers and farming communities.[17] Microfibers have been found in our drinking water, processed foods, meats[18] and produce. These tiny plastic fragments are also now being found in our bodies. Microfibers have been found in human lung tissue, where they cause inflammation and damage,[19] and even in placentas.[20]

Solutions

Solutions are needed across the full lifecycle of clothes and other textiles to eliminate microfiber pollution. These include upstream interventions such as textile redesign, capture and filtration technologies for manufacturing processes, and improved wastewater treatment. However, many of these solutions will require time, and the scale of current and projected microfiber pollution warrants more immediate action.

Photo credit: Lisa Erdle

Washing Machine Microfiber Filters

Washing machine microfiber filters are a near-term, cost-effective solution to address microfiber pollution. These filters are specifically designed to capture microfibers released while washing textiles, preventing them from entering the environment. Although some machines may have some level of filtration to capture larger debris, these coarse filters do not adequately capture microfibers, which tend to be 10-20 micrometers in their smallest dimension. The smaller mesh size of microfiber filters is far more effective at capturing microfibers.

Peer-reviewed scientific studies have demonstrated that properly designed and installed washing machine microfiber filters can reduce microfiber emissions by up to 90%.[21] Adopting these technologies at scale would significantly reduce microfiber pollution. Researchers estimate that at the scale of a city with around a million households, washing machine microfiber filters could divert and capture over 4 quadrillion microfibers per year if filters with a 100 micrometer mesh size were installed on all washing machines.[22, 23]

While microfiber filters integrated into washing machines show high efficacy and offer a promising solution, external filters attached to outflow of the machines and other interventions like washing bags can also reduce fiber emissions. The effectiveness of microfiber filters varies significantly based on the design and usage of these solutions, such as mesh size and whether filtration is used for all wash cycles or garments.

Available Microfiber Filters

Table 1 below compares available microfiber filter technologies and reveals key differences in efficacy, installation type, maintenance needs and cost.

Internal filters, such as Xeros XF1, have high microfiber reduction efficacy of up to 90%. These units are built in and require periodic cleaning. In contrast, external filters like Filtrol 160 and Grundig FiberCatcher offer similar efficacy, up to 88% and up to 90%, respectively, with installation costs for the Filtrol 160 and occasional filter replacement for the Grundig FiberCatcher. Most filter devices, whether internal or external, require periodic cleaning similar to how lint is removed from a dryer lint trap after a load of laundry is completed. Frequency of cleaning will vary with model, but a pilot study indicates filters only need cleaning every 1-3 weeks for typical household use.[24]

Alternative filtration methods, such as washing bags and retrofit kits, which are filtration devices that attach externally to the washing machine, offer reduced reduction efficacy but may require less maintenance. Guppyfriend washing bag, achieving up to 86% reduction efficacy (according to in-house testing), requires manual use to load and clean out the bag, and only captures microfibers from items placed in the bag, often limited to a garment or two. Retrofit kits like PlanetCare Filter and CleanR offer up to 80% and up to 82% reduction efficacy, respectively, with aftermarket installation and different maintenance needs. The Cora Ball, a porous plastic ball placed in the drum of the washing machine, can reduce microfibers released by 26%.[25]

Multiple peer-reviewed laboratory and field studies indicate that microfiber filters do not clog and, therefore, do not cause increased flood risks from washing machines.[26, 27, 28] Because consumers are already familiar with cleaning out a filter when doing laundry, as they do with dryers, consumer behavior and education is anticipated to be easier to change than a larger-scale intervention. This education can be supported through thoughtful policy provisions, like labeling or funding for education campaigns, which can inform consumers of the need to clean filters and how to properly dispose of captured microfibers in household trash.

Table 1: Comparison of filtration technologies[b]

Technology Type	Brand/Model	Reduction Efficacy	Installation Type	Maintenance Needs	Cost
Internal Filter	Xeros -Xeros XF	Up to 90%[c]	Built-in	Occasional cleaning required	Not available
External Filter	Environmental Enhancements – Lint LUV-R	Up to 88%[d]	Aftermarket	Regular filter cleaning	$150
External Filter	Grundig FiberCatcher	Up to 90%[e]	Built-in	Regular filter cleaning and occasional replacement required	$14 filter replacement
External Filter	Filtrol 160	Up to 88%[f]	Aftermarket	Regular filter cleaning	$159
External Filter	PlanetCare Filter	Up to 98%[g]	Aftermarket	Subscription filter service	$96.97

b Data from April 2024 and subject to change.

c 78% reduction found in the X-filtra (Napper et al., 2020), up to 90% reported from in-house testing by Xeros.

d McIlwraith et al. (2019) reported an 80% reduction by weight and 87% reduction by count (polyester). Napper et al. (2020) reported a 29% reduction by weight (mixed load). Browne et al. (2020) reported a 65% reduction by weight (polyester, no effect observed for cotton). Vassilenko et al. (2021) reported an 88% and 14% reduction (polyester and nylon, respectively).

e "FiberCatcher® Synthetic Microfibre Filter." Grundig*. Last accessed May 2024.*

f 46% and 89% reduction for polyester and nylon, respectively. (Vassilenko et al. 2021)

g Reported by PlanetCare, not independently tested.

Microfiber Filters are a Cost-Effective Solution

Table 2 below, based on a study by The Blue Sky Consulting Group commissioned by The Nature Conservancy, outlines the estimated costs associated with integrating microfiber filters into washing machines across different sectors, using California as a case study. It includes estimates of costs for consumers, state agencies, public institutions and commercial purchasers based on current microfiber filter options. The table also provides insights into potential future cost reductions as technologies advance and production volumes increase to achieve economies of scale. In the table below, the cost to consumers spans a ten-year period, which is the average lifespan of a washing machine.

Table 2: Comparison of costs across different sectors—California case study[29]

Consumer Costs	
Cost increase per machine for including microfiber filters	$14 to $20 per machine
State Agencies & Public Institutions	
Additional annual cost for state agencies	$2,500 per year for state agencies* **cost based on state agencies owning >400 machines*
Additional annual cost for public colleges/universities	$37,000 per year for public colleges/universities* **total annual cost across all state colleges, serving a population of ~200,000 students*
Commercial Washing Machines	
Additional cost per machine for commercial purchasers across the state of CA	Up to $60 per machine
Current Microfiber Filter Options	
Range of purchase prices for external microfiber filters	$45 to $320
Range of total costs over a ten-year useful life of a washing machine for current filters	$45 to $917
Additional cost for Grundig model with internal filter compared to similar model without filter	About $39 extra
Cost of replacement filters over the life of the machine for Grundig model	About $247
Future Outlook	
Expectation of decreased costs as technology develops, production volumes increase and filters become integrated	The Department of Energy estimates that the cost of washing machines decreases by 14.4% with every doubling of total units produced.[30]

Microfiber Filters Improve Human and Environmental Health

The microfibers captured by filtration devices are from clothes put in the machine and are washed with detergent like everything else in the washing machine, so cleaning out the filters does not present any risks to human health. A peer-reviewed study of approximately 100 families' use of washing machines with microfiber filters reported an ease of cleaning the filters with no reports of health impacts.[31]

In addition to significantly reducing microplastic pollution in the environment, with enormous and hard to quantify ecosystem-wide benefits, the majority of filters used in washing machines are passive and therefore require very little additional energy, water or maintenance. In instances of active (i.e., motor-powered) filtration, tests show the filter required an additional 1-2% of total energy.[32] Other filters do not use additional energy, relying solely on the washing machine's pumping action to function.

Policy Solutions

Several policy approaches to increase the use of washing machine filtration have been introduced across the United States. They range from establishing research mandates and working groups to requiring built-in microfiber filtration in new machines. Some examples demonstrating different approaches taken in state and local policies are provided below and summarized in Table 3.

Mandates

Several bills have proposed mandates for integrated microfiber filtration systems in new washing machines, allowing time for necessary manufacturing developments. Bills in Illinois, California and Oregon proposed requirements for new washing machines to contain a microfiber filtration system with a filter mesh size of 100 micrometers or smaller.[33, 34, 35, 36] An earlier bill in California based its requirement on a filtration efficiency rate rather than a mesh size standard.[37] Some bills also include requirements for labeling to inform consumers of the need to check and clean the filter regularly.[38, 39, 40]

Incentives

Other policies propose incentives rather than mandates. Bills introduced in Illinois and New Jersey would establish consumer rebates for washing machine filtration systems.[41, 42, 43] Another Illinois bill would provide tax credits to qualifying microfiber filtration manufacturers.[44]

Commercial and/or State-owned Pilots

A bill in Illinois and several bills in California target large-scale use such as commercial or state-owned facilities. Approaches include setting mandates for state-owned machines followed by all machines at a later date,[45] a specific requirement for state-owned washing machines,[46] a study followed by a mandate for industrial, institutional or commercial laundry facilities,[47] and a pilot program for state-owned facilities.[48] In considering these policies, it is important to note that commercial and state machines are more similar to each other than to residential machines, and accordingly, early action to address large-scale machines will not necessarily translate to a shift in the residential market.

Studies

A preliminary step to the implementation of microfiber filtration policies can be impact and feasibility studies, typically conducted by a state agency or interagency working group. In 2018, a Connecticut law established a working group of apparel industry and environmental community representatives to examine consumer education opportunities and measures to address microfiber pollution.[49] A California bill would require an interagency coordination group to recommend legislative changes to address microplastics, including policies to promote or require condenser dryer and washing machine filtration technology.[50] However, research already conducted supports the readiness of available technologies to scale, and any additional studies should avoid duplication of these efforts.

Local Pilots

Local governments are also exploring options to address plastic pollution, including from microfibers. The City of Los Angeles' proposed Comprehensive Plastics Reduction Program Draft Program Environmental Impact Report, considers microfiber filtration mandates for new machines, a rebate system for existing machines, and requirements for installation of filtration on existing washing machines in single-family homes, multi-family complexes and commercial laundromats.[51]

Table 3: Examples of Proposed State and Local Microfiber Filtration Policies

State/Local Government	Bill/Policy	Summary	Status
Mandates			
Illinois	HB4269 (2024); SB2727(2024)	Require new washing machines for residential, commercial or state use to contain microfiber filtration with mesh size of no more than 100 micrometers and include consumer notice label by Jan. 1, 2030.	In 2024 legislative session
California	AB1628 (2023)	Require new washing machines for residential or state use to contain microfiber filtration with mesh size no more than 100 micrometers and include consumer notice label by Jan. 1, 2029.	Not enacted
Oregon	SB405 (2023)	Require new washing machines to contain or be sold with microfiber filtration with mesh size of no more than 100 micrometers by Jan. 1, 2026.	Not enacted
California	AB3232 (2020)	Require all washing machines for commercial sale to contain microfiber filtration with 90% or greater filtration rate by Jan. 1, 2023.	Not enacted
Incentives			
Illinois	HB5658 (2024)	Create one-time rebate for washing machine filter or replacement filter equal to the lesser of the cost of the filter or $100.	In 2024 legislative session
Illinois	HB5659 (2024)	Authorize tax credits for qualifying microfiber filtration manufacturers.	In 2024 legislative session
New Jersey	A1482 (2024); S1048 (2024)	Create one-time rebate for washing machine filter or replacement filter equal to the lesser of the cost of the filter or $100.	In 2024 legislative session

State/Local Government	Bill/Policy	Summary	Status
Commercial and/or State-owned			
Illinois	HB1284 (2023)	Require microfiber filtration in all state-owned washing machines by Dec. 31, 2024; prohibit manufacture of washing machines without microfiber filtration by Dec. 31, 2028; and prohibit acceptance for sale of washing machine without microfiber filtration by Dec. 31, 2030. Microfiber filtration standard is 90% reduction in microfiber emission and mesh size of no more than 100 micrometers.	In 2024 legislative session
California	AB1724 (2022)	Require all state-owned washing machines to contain microfiber filtration with mesh size of no more than 100 micrometers.	Not enacted
California	AB802 (2021)	Require state board to identify best available control technology for microfiber filtration in industrial, institutional, or commercial laundry and then require operators to adopt that best available control technology.	Not enacted
California	AB1952 (2020)	Establish one-year pilot program to assess effectiveness of microfiber filtration systems in state-owned laundry facilities.	Not enacted
Studies			
California	AB2214 (2024)	Require interagency coordination group to recommend legislative changes to address microplastics, including policies for condenser dryer and washing machine filtration technology, consistent with the state's Statewide Microplastics Strategy.	In 2024 legislative session
Connecticut	Public Act 18-181 (2018)	Establish a stakeholder working group to develop legislative actions for consumer education and reduction of microfiber pollution.	Enacted
Local Pilots			
City of Los Angeles	Comprehensive Plastics Reduction Program, Draft Environmental Impact Report	Consider potential solutions that include a local mandate for washing machines to include microfiber filtration with mesh size of no more than 100 micrometers; a rebate system to retire or retrofit machines without filtration, and/or requirements for single-family homes, multi-family complexes and commercial laundromats to install filtration on existing washing machines.	Draft proposed

Key Recommendations for Effective Filtration Policies

As future policies are developed to address microfiber pollution from washing machines, key recommendations based on scientific peer-reviewed research and economic analyses that should be considered include:

- **Filtration technology mandates** will be most effective in addressing pollution from new machines. Such mandates promote the adoption of filtration technologies by manufacturers at scale, reaching the greatest number of washing machines and creating consistency and predictability in filtration technologies for consumers. Mandates also ensure a level playing field across all manufacturers, while allowing room for flexibility for manufacturers to address this problem in the ways that make the most sense for their consumers.

- **Incentives**, such as rebates for external filters, will help encourage the retrofitting of machines already in use. Still, voluntary measures like incentives are insufficient on their own to address the scale of microfiber pollution and fail to address new machines entering the market.

- **Standards for filters** should not be overly prescriptive of the technology. Mesh size is the recommended standard rather than filtration rate, as it is likely easier to implement and enforce, which will result in better compliance and better environmental outcomes.

- **Machine filtration is not a replacement for advancing upstream interventions** to address issues in materials design, like improving textile weaves to reduce shedding. These longer-term efforts should continue alongside machine filtration policies.

Conclusion

Policy is a critical tool to scale the adoption of microfiber filtration devices in washing machines. These filters represent a clear, scientifically-based solution to significantly reduce microfiber pollution. While we ultimately need solutions across the lifecycle of textiles—rethinking from design to disposal—filtration technologies are targeted and available solutions that can drastically reduce microfiber pollution now.

The state and local policies described in this Toolkit showcase the potential for policy to drive technological adoption and set precedents. Success hinges on establishing standards that encourage innovation without stifling it, and we need policies focusing on outcomes that reduce microfiber release and allow the market to find the most efficient paths to those ends. A great deal of innovation, especially in recent years, has helped accelerate the movement of microfiber filtration in washing machines, and there is still more work to be done.

Installing filters in washing machines is a practical, cost-effective and evidence-based step forward. It is a proven solution that provides immediate benefits, while we work on the larger, more complex challenges of material innovation and consumer habits to address microfiber pollution from the full textile lifecycle.

Endnotes

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Additional information available upon request. Please contact:

- Angela Noakes (*anoakes@oceanconservancy.org*)
- Alison Waliszewski (*alison@5gyres.org*)
- Alexis Jackson (*alexis.jackson@tnc.org*)