

Quick research on existing literature on mechanical action

APPLiA was looking for studies that assess the correlation between the washing cycle and the release of microplastics from textiles. Here's a comprehensive overview of sources and key findings, categorised by factors related to the washing cycle (i.e. sinner circle). It's important to note that while there's a growing body of research, methodologies can vary, making direct comparisons between studies challenging. **Standardised testing protocols are still needed to provide a more consistent understanding of microplastic release from textiles during washing.**

Disclaimer 1: *This literature review attempts to provide a comprehensive overview of existing research; however, it is important to note the **limited availability of studies that fully adhere to rigorous scientific standards or have been published in highly renowned, peer-reviewed journals.** Consequently, some of the included articles may exhibit a particular tendency or methodological approach that warrants critical consideration.*

Disclaimer 2: *APPLiA intentionally tried to structure the **document based on the Sinner Circle** (temperature, duration, etc.). Nevertheless, the studies were not designed nor performed necessarily with the sinner circle in mind.*

APPLiA considerations

APPLiA conducted a short and quick review of existing literature that investigates the impact of washing cycles on textile care and the release of microplastics. As a result of this assessment, the following considerations became clear:

- **Varying Methodologies:** Methodologies differ significantly across studies. This makes direct comparisons challenging and hinders the ability to draw common lines or assumptions. Standardised testing protocols are needed.
- **Different Assumptions and Equipment:** Studies use different assumptions, often with laboratory equipment, and different types of samples and machines. This variation makes it difficult to arrive at consistent conclusions.
- **Simulated Washing vs. Real-life Conditions:** Some studies involve simulated washing (e.g., using steel balls, textile patches instead of a garment), which are not comparable to real-life washing machine conditions and thus limit the applicability of their findings. These studies were not considered.
- **Variability in Textile Types:** The textile sample significantly affects the study results on microplastic release, making generalisation from a small number of studies particularly difficult.



- **Textile testing differs from household washing machine testing:** when the textile research tries to investigate washing behaviour, they do not necessarily follow the real-life assumption used and understood by the washing machines standards (e.g. use of terms like 'full load' when the machine has only 2.5kg load; use of steel balls inside washing machine; use lab-based machines instead of real life washing machines, etc.).
- **Conflicting Results:** There are conflicting results across studies, such as regarding the effect of washing temperature and detergent use on microplastic release. These discrepancies further complicate identifying clear patterns.
- **Lack of Proof for Correlation:** The document states that with current data, there is no definitive proof of a correlation between the type of washing cycle and textile damage or microplastic release.
- **Influence of Other Factors:** Factors beyond the washing cycle (e.g., UV light, fabric structure, garment age) also influence microplastic release, adding complexity to the analysis. Therefore, these other factors further complicate the analysis, reinforcing the inherent complexity of the topic. The mechanical action of the washing machine is merely one of many elements influencing microplastic release, and the individual impact of each factor is challenging to determine. As an example, the [Kelly](#) study shows that textile manufacturing appears to remain one of the major contributors.
- **Shredding and release of microplastics:** Many studies fail to differentiate between general fibre losses throughout the textile's lifecycle and the specific release of microplastics during washing. Therefore, the release during washing may become irrelevant as the source of microplastic entry into the drain is less important than the overall quantity released, which is difficult to determine precisely due to various external factors such as wear, environmental conditions like sunlight, and other sources of plastic debris. Finally, studies do not yet differentiate between microplastic release caused by the mechanical action of the washing machine itself and other factors external to the washing machine that may act before or during the washing cycle. This would further highlight the complexity and limitations of current research.
- **Feasibility study by Consortium led by APPLiA:** different from certain studies mentioned below, the data collected during Consortium tests did not show a correlation between Gentleness of Action and Fibre release.

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General Information and Reviews

APPLiA Europe - Updated Literature Review on Microplastics from Household Washing Machines (2020-2024): This comprehensive review assesses recent data (2020-2024) on microplastic emissions, particularly from polyester garments. It highlights the variability in microfiber emissions and notes that fibre release tends to stabilise after several washes. It also points out the need for more standardised testing protocols due to differing methodologies across studies.

https://www.applia-europe.eu/images/2024-10-30_APPLiA_RISE_Updated_literature_review_on_MP-1.pdf

Wasser 3.0 - Microplastics and Textiles - a state description: This article summarises studies showing that washing releases significant amounts of microfibers and that factors like temperature, rpm, and detergent use influence release. It suggests simple tricks like reducing washing temperatures and lowering rotations per minute to minimise microfiber release.

<https://www.laborpraxis.vogel.de/mikroplastik-hotspot-waschmaschine-a-b1c1cec5a12e730d1d17d760f66b6022/>

PBS - Laundry is a top source of microplastic pollution.² Here's how to clean your clothes more sustainably: This article reinforces that washing is a major source and discusses factors like fabric type, mechanical action, detergents, temperature, and duration of the wash cycle. It offers tips to reduce shedding, such as washing full loads, using cold water, less detergent, and front-loading machines.

<https://www.pbs.org/newshour/science/laundry-is-a-top-source-of-microplastic-pollution-here-how-to-clean-your-clothes-more-sustainably>

Specific Washing Cycle Parameters and Their Impact

1. Washing Temperature:

The studies by APPLiA and Wasser 3.0 suggest that higher washing temperature releases more microplastics.

Wasser 3.0 - Microplastics and Textiles - a state description: Found that reducing washing temperatures (e.g., from 60°C to 30°C) helps minimise microfiber release.

<https://www.laborpraxis.vogel.de/mikroplastik-hotspot-waschmaschine-a-b1c1cec5a12e730d1d17d760f66b6022/> .

APPLiA Europe - Updated Literature Review on Microplastics from Household Washing Machines (2020-2024): Notes that higher washing temperatures were found to increase fiber shedding.

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https://www.applia-europe.eu/images/2024-10-30_APPLiA_RISE_Updated_literature_review_on_MP-1.pdf

Improved garment longevity and reduced microfibre release are important sustainability benefits of laundering in colder and quicker washing machine cycles: Compared several washing conditions and found that the microfibre release was significantly greater for the 40°C, 85 min cycle in comparison with the cold-quick cycle. The effect continued with further washes. Higher temperatures cause more rapid swelling in water of cellulose fibres, approximately twice the rate at 60°C compared to 20°C.

<https://www.sciencedirect.com/science/article/abs/pii/S0143720819320431>

2. Detergent Use:

Most studies identify an influence of the kind of detergent on the release of microplastics. The study by ResearchGate presents conflicting results in that regard.

ResearchGate - Airborne emissions of microplastic fibres from domestic laundry dryers: Mentions conflicting results on detergent's impact, with some studies showing increased release, others decreased, or no influence. It also notes that the type (powder or liquid) and chemical composition can be significant.

<https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2024.1330922/full#:~:text=The%20experiments%20showed%2C%20that%20the,washing%20machine%20load%20and%20a>

Assessment of microplastic release from polyester fabrics: The impact of different washing conditions: The study compared two washing loads over five cycles. To one of the washing cycles, a liquid stain remover was added. The microplastics release in the washing load with the stain remover was only slightly higher (16% compared to 12% without stain remover).

<https://www.sciencedirect.com/science/article/abs/pii/S0269749119341065>

3. Washing Time/Cycles:

Most sources indicate that the majority of microplastics are released during the first few washes. Some sources suggest that the release stabilises after a number of washes, while others note variations in textile type.

APPLiA Europe - Updated Literature Review on Microplastics from Household Washing Machines (2020-2024): Highlights that fibre release tends to stabilise after several washes (around eight washes in one study), suggesting that initial washes may

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produce the most substantial fibre loss.

https://www.applia-europe.eu/images/2024-10-30_APPLiA_RISE_Updated_literature_review_on_MP-1.pdf

Assessment of microplastics release from polyester fabrics: The impact of different washing conditions: Found that a longer programme time, a higher temperature, the speed of the centrifugation, and the number of drums have an impact on the microfibrés' release in polyester fabric.

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4. Washing Load/Machine Fill Level:

The sources agree that increasing the washing load helps to reduce microfibre release.

APPLiA Europe - Updated Literature Review on Microplastics from Household Washing Machines (2020-2024): Mentions that larger washing loads tended to reduce fiber release.

https://www.applia-europe.eu/images/2024-10-30_APPLiA_RISE_Updated_literature_review_on_MP-1.pdf

Release of fibrous microplastics from functional polyester garments through household washing: States that a high washing machine load (loading quantity was 3.5kg considered almost full drum and 1.5kg half drum) and a shortened washing time were found to be effective in reducing MP release. The fibrous microplastics output is highest in the first washing cycle and continues to decrease over the course of further cycles.

<https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2024.1330922/full#:~:text=The%20experiments%20showed%2C%20that%20the,washing%20machine%20load%20and%20a>

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Importance of Water-Volume on the Release of Microplastic Fibers from Laundry:

The article investigates the factors influencing the release of microplastic fibers (MFs) during laundry. The study found that, contrary to previous assumptions, a higher water-volume-to-fabric ratio is the most influential factor for MF release, rather than mechanical agitation. Specifically, "delicate" wash cycles, which typically use a greater volume of water, resulted in a significantly higher release of MFs. For instance, delicate cycles released an average of 800,000 more MFs (94 mg/kg) per wash compared to lower water-volume standard washes. To reduce MF release, the authors suggest consumers avoid high water-volume washes (like delicate cycles), consider using high-efficiency washing machines that use less water, and ensure full wash loads.

https://pure.bangor.ac.uk/ws/portalfiles/portal/28889521/Kelly_et_al_2019_author_s_accepted_version.pdf

Washing load influences the microplastic release from polyester fabrics...:

indicates a progressive decrease of microfibre release with increasing washing load (max load used was 2,5kg). The quantity of released microfibrils increased by around 5 times by decreasing the washing load due to a synergistic effect between the water volume to fabric ratio and mechanical stress during washing.

<https://www.nature.com/articles/s41598-021-98836-6>

5. Washing Cycle Agitation/Speed:

All three sources concur that reducing agitation or speed in the wash cycle helps to mitigate microfibre release.

Textile Quality Depletion due to Household Machine Washing: Found that longer programme durations and smaller load sizes increase the mechanical damage on the wash load and deliver absolute numbers for these effects.

<https://www.swissatest.ch/download/publication-frederik-scheid-edith-lambert-writi-maitra-marina-niestrath-daniel-faeh-christian-portmann-susanne-gorny-und-rainer-stamminger.pdf>

Assessment of microplastics release from polyester fabrics: The impact of different washing conditions: Found that a longer programme time, a higher temperature, the speed of the centrifugation, and the number of drums have an impact on the microfibrils' release in polyester fabric.

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6. Other Factors Influencing Microplastic Release (often studied in conjunction with washing cycle):

Fabric Composition: Synthetic fibres (polyester, acrylic, polyamide) are primary contributors (<https://pmc.ncbi.nlm.nih.gov/articles/PMC9412705/>).

Natural and mixed-composition fabrics can also release microfibers.

(<https://www.eea.europa.eu/publications/microplastics-from-textiles-towards-a>).

Fabric Structure: Knitted fabrics often release more microplastics than woven fabrics (<https://www.cambridge.org/core/journals/cambridge-prisms-plastics/article/designing-out-microplastic-pollution-released-from-textiles-and-apparel-during-laundrying/81FD8D1A8D09B1584963C3743AF8B61D>).

Pre-washing: Some studies indicate that pre-washing procedures at manufacturing plants can release significant amounts of microfibers.

<https://www.eea.europa.eu/publications/microplastics-from-textiles-towards-a>

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