PFN

Plastic Footprint Network

Plastic Footprint Guidelines

Module on microplastic from textile fibres

Version 1. November 2023

Convened by EA – Earth Action · www.plasticfootprint.earth

Introduction to the Plastic Footprint Network

Leading organizations have united within the Plastic Footprint Network to chart a new, more effective **path toward plastic pollution** mitigation.

The network's first priority was **unifying the framework** for measuring plastic leakage into a **single**, **science-based methodology** for organizations to accurately assess the environmental impact of their plastic use. Over **100 professionals** from **35 organizations** worked to establish the resulting **methodology**, which consists of **11 modules**, all optimized for usability and delivery of **actionable results**.

Objectives

Unifying the methodologies and perspectives of leading scientists, experts, and global practitioners, PFN enables organizations to understand the full impact, or footprint, from the use of plastic in their companies, products, and services.

1. Update and unify plastic footprinting methodologies
2. Ensure the methodology is used consistently by practitioners
3. Disseminate and scale the use of plastic footprinting
4. Explore link with plastic credit schemes, and how to prevent greenwashing claims

What are the objectives of this module

The aim of this module is to establish a standardized approach for evaluating the impact of microplastics originating from textile fibres within the broader context of a plastic footprint. To fulfill this goal, we will address the following three key questions:

1. What is the current understanding and knowledge regarding the contribution of microplastics from textile fibres to an overall plastic footprint assessment?
2. How can an effective methodology, drawing from diverse sources including past experiences and literature, be structured and implemented to accurately gauge the impact of microplastics from synthetic textile within the context of a plastic footprint?
3. What secondary data is essential for accurate calculations, and how can it be integrated into the assessment process?

This module emphasizes the necessity for users to gather primary data to ensure a thorough and meticulous evaluation of the contribution of microplastics from textile fibres within their plastic footprint analyses.

At the end of this module, the users should know how to include textile fibres in their plastic footprint assessment.

Where does this module fit in the PFN landscape?

Guidance

Strategic | Cross-cutting or specific issue

- Introduction to plastic footprinting
- Scopes and boundaries
  Alignment with environmental reporting standards
- new — Data governance
- 2024 — Target setting and mitigation

Technical

- Technical introduction to plastic leakage
- Glossary

Inventory: Macroplastics

- Packaging
- Textile
- new — Fishing gears
- new — Leakage from export
- new — Release rates
- 2024 — Automotive
- 2024 — Construction

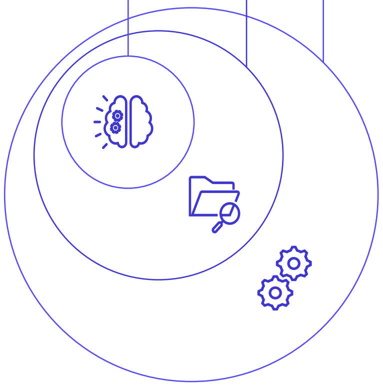
Inventory: Microplastics

- Micro tire dust
- Micro textile fibres — Current module
- 2024 — Micro pellets
- 2024 — Micro paint
- 2024 — Micro agriculture

Impact

- new — Impact MariLCA

Structure of each technical module



1 Methodological choice

High level overview and different methodologies available at the moment, which one(s) to use and when.

Target audience: busy reader, scientific journalist

2 System map and calculation routes

- The different elements to take into account during a plastic footprint.
- How these elements interact.
- The calculation routes to follow.

Target audience: scientist, experts

3 Key data & background assumptions

The secondary data needed to perform the assessment and the main assumptions for the modeling.

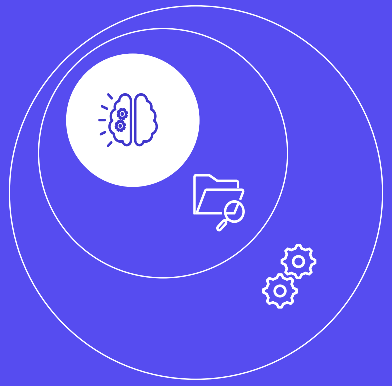
Target audience: scientist aiming at performing a plastic footprint.

Reading keys: Main take away Supporting information Key warning

Part. 1

Methodological choice

The different methodologies available at the moment, which one(s) to use and when.

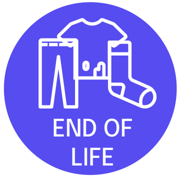


An overview of leakage from textile

Textile leakage into ocean and land

Leakage of microfibres during production

Leakage of microfibres during usage phase



Leakage of macroplastic originating from textile waste

This depends on the mass of textile produced

This depends on the number of wash of the textile products.

Macroplastic are not treated in this module.
For more information about this, please refer to the module on macroplastic focusing on textile waste.

How do textile pollute the environment?

Leakage of microfibres during production & usage phase

Washing synthetic textile, both during industrial production and at household level, creates primary microplastics because of the abrasion and shedding of fibres.

These microplastics are then discharged in sewage water and could end up in the ocean or captured in the sewage sludge and end up in the soil.

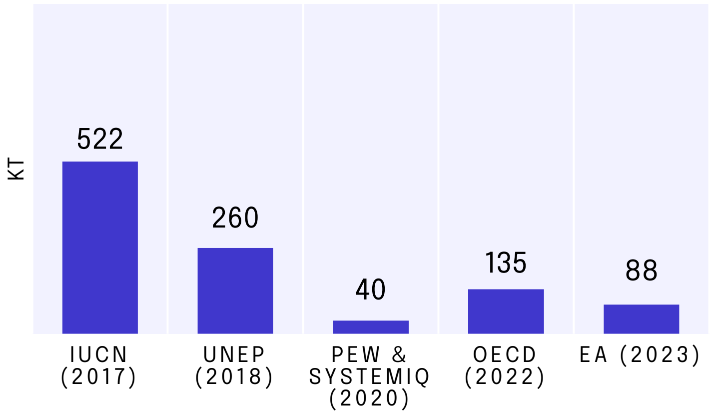
Furthermore, during the usage phase, textiles shed fibres into the air. However, the existing research on this subject is not sufficiently advanced for precise quantification of this phenomenon.

Leakage of macroplastic originating from textile waste

Synthetic textile pollute in the form of macroplastic when becoming textile waste which is improperly disposed in unsanitary landfills or dumpsites, uncollected or littered. For more details about this, please refer to the module on macroplastic from textile.

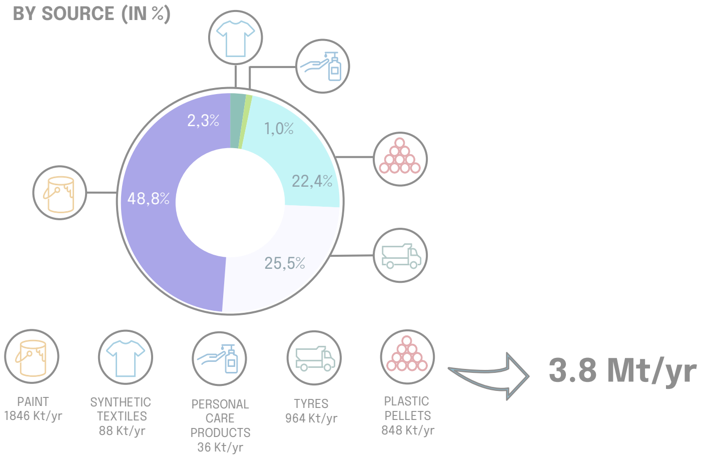
How big is microfiber leakage?

MICROPLASTIC FROM TEXTILE – LEAKAGE TO OCEAN



It is estimated that between 40 and 522 kt per year of synthetic microfibres are released into the oceans and every year. To this quantity it is important to add the quantity of microfibres that are released into land, which is estimated to be smaller, around 14 kt (internal computations at EA).

GLOBAL RELEASE OF PRIMARY MICROPLASTICS INTO THE OCEANS, 2023



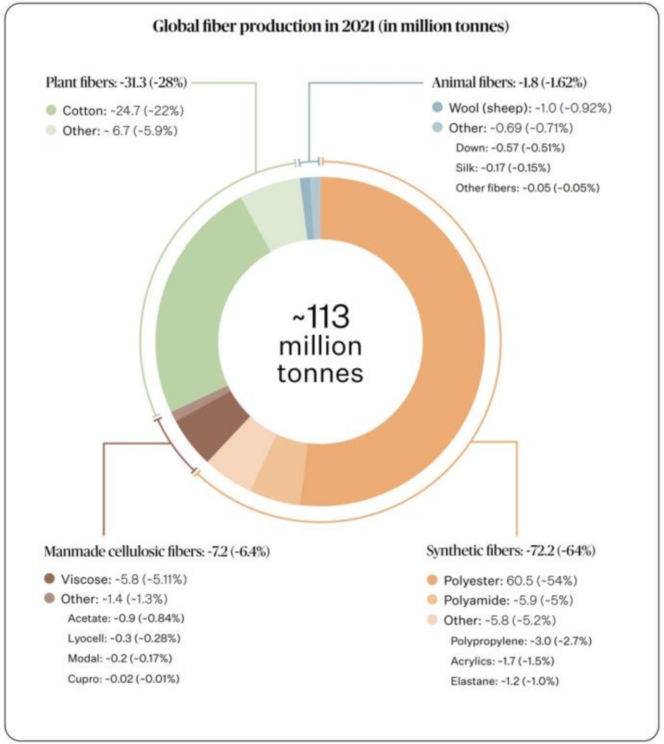
Out of a total of 12 Mt of microplastics released into the environment (ocean and land), microplastics from textile constitute roughly the 1% (88 kt). If we focus exclusively on leakage into ocean, microplastics originating from textile constitute more than the 2%.

Source: EA computations, 2023

While this study focuses on microplastics, specifically synthetic microfibres, it's crucial to acknowledge the presence of natural microfibres in the environment. These natural microfibres could pose a similar level of risk to both the ecosystem and human health.

Which polymers are used in the textile industry?

The apparel industry has steadily increased over the last two decades, and this is connected almost exclusively with an increase in the consumption of synthetic fibres, which now constitute around 64% of the fibres production. These fibres are mainly polyester (54%), polyamide (5%), polypropylene (2.7%), acrylic (1.5%) and elastane (1%).



Source: Textile Exchange (2022). Preferred fibers and material market report.

Useful definitions

Activity/Mass

We identify the quantity of plastic of interest through a mass.

- For textile fibres during production, the mass is the total weight of textile produced multiplied by the number of times it is washed or processed in wet environments (dyeing, etc..).
- For textile fibres during usage, the activity of relevance is the domestic laundry, a process through which textile fibres are lost and released to the environment. In this case we need to know how many times the bought products are washed in their lifetime, and under which conditions.

Release

The quantity of plastics that ultimately leaves the human environment for the natural environment is said to be released. In this case, fraction of lost microfibres that are not captured by a WWTP and end into the oceans, or microfibres that are captured but ultimately released to soil.

Loss

The loss is the quantity of plastics that leaves a properly managed product or waste management system. In this case fraction of fibres lost during washing or other processes.

Plastic leakage to the environment

Plastic leakage is defined as the plastic potentially leaving the technosphere (human environment) and accumulating in the natural environment.

Methodology choice

Methodology from Plastic Leak Project

The PLP model is based on four phases:
Loss –first release – redistribution – final release

- ⊗ **Redistribution**: Redistribution: Because our compartments are already oceand and freshwater altogether, and soil and other terrestrial compartments altogether, we don't model the redistribution and we give release rates directly to the final compartments.

PLP mentions losses both at production and usage stage, but only give data and methodology for the usage one.

PROD

- ✓ **Production**
  - ✓ We improve on PLP by giving methodology for production and data for it.

USAGE

- ✓ **Usage**
  - ✓ We update the data collection for loss rates at use stage
  - ✓ We introduce more parameters in the methodology such as the number of washings according to the type of garment.

- ⊗ Release from air still out-of-scope

For each leakage pathway, three main calculation steps are foreseen:

- The loss (defined as the quantity of fiber that leaves a properly managed product or waste management system) is applied as a loss rate ($LR_{textile}$), which is the fraction of material that is detached from the plastic product during manufacturing, use or transport for microplastics or as mismanaged waste for macroplastics. Losses of different amounts of synthetic microfibers occur during each stage of the supply chain. It is understood that synthetic microfiber losses occur mainly through the wastewater pathway and the direct pathway (when no wastewater treatment infrastructure is available) at different life cycle stages: (1) pre-wash and processing during textile production, and (2) washing by hand or machine during the use stage. A washing machine filter may reduce the loss of synthetic microfibers during laundering by capturing some fibers before their transfer to a sewage system. These filters are then disposed of in the solid waste management system and assumed to be properly managed ultimately, i.e., disposed in landfill or incinerated. Synthetic microfibers can also be emitted into the air while the textile is being worn, dried in a clothes dryer, dry cleaned or recycled. These pathways are further described in section 7.3. Following these various transfer pathways, synthetic microfibers reach various environme… quantify t…
- The releas… transporte… ocean or s… and sewa… the loss t…
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For example, if a… income country… waterways and u…

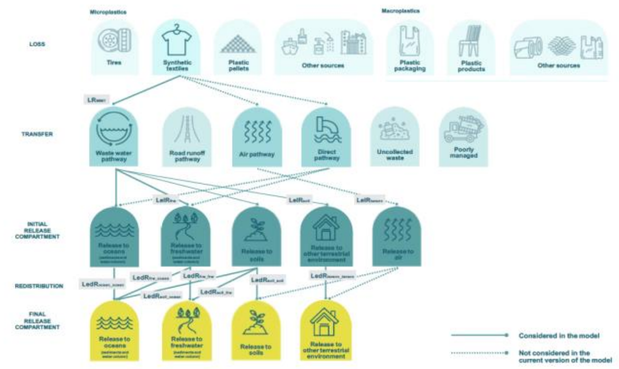

Figure 7.1: Losses, transfer pathways and plastic release compartments for synthetic microfibers from textiles

Source: PLP - Section 7 - Inventory of microplastic leakage from textiles - page 86,87

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Recommended methodological approach

PROD

Methodology for production to apply in case the product is a textile product, or the company is a textile producer

Primary data needed:

- Kilograms of synthetic textiles washed, number of washings during production, country of production.

Primary data good-to-have:

- Washing parameters and textile parameters (to tune the loss rate accordingly)

Secondary data needed:

- Loss rates for production (global), release rates (country-specific).

The percentage of synthetic should ideally be primary data and product-specific, but in case this is missing, average percentages can be used.

Loss rates can be chosen according to washing and textile parameters, but in case these are missing, it is suggested to choose the average value.

It is important to look both at ocean and land for a full comprehension of the leakage.

Steps:

1. Collect primary data: the amount of textile produced and washing parameters.
2. Compute mass: Apply the synthetic percentage to obtain the weight of synthetic textiles that are washed. Multiply this mass by the number of washings to obtain the total washed mass.
3. Compute loss: Apply the loss rates to the total washed mass.
4. Compute release: Multiply the lost mass with the release rates of the country the textiles are produced in, which can be found in the excel file

$$\text{Leak}_{compartment} = \sum_{Country} \sum_{Process} \underbrace{M_{textiles}(t) * share_{synthetic}(\%) * \#process}_{\text{Mass}} * \underbrace{LR_{process}(\%)}_{\text{Loss}} * \underbrace{RR_{Country,compartment}(\%)}_{\text{Release}}$$

With compartment = ocean, land

Generally speaking, always prefer primary data if available but be sure they are reliable. In case of doubt, use secondary data

Recommended methodological approach

Methodology for usage to apply in case the plastic footprint includes in its scope the utilization of textile products

USAGE

Primary data needed:

- Weight of synthetic textiles produced
- Countries and shares where products are sold

More parameters enable better tuning of the loss rate

Primary data good-to-have:

- Washing parameters
- Textile parameters
- Polymer specific shares
- Amount/share of clothing per type

All secondary data are provided in this module

Secondary data needed:

- Number of washings per item (global)
- Loss rates for use stage (global)
- Release rates (country-specific)

The percentage of synthetic should ideally be primary data and product-specific, but in case this is missing, average percentages can be used.

Loss rates can be chosen according to washing and textile parameters, but in case these are missing, it is suggested to choose the average value.

It is important to look both at ocean and land for a full comprehension of the leakage

Steps:

1. Collect primary data: the amount of textile produced (ideally per type), and countries where products are sold and used.
2. Compute mass: Apply the synthetic percentage to obtain the weight of synthetic textiles that are washed. Multiply by the # of washing per type to get the total mass washed over the products lifetime.
3. Compute lost mass: Apply the loss rates to the total washed mass.
4. Compute released mass: Multiply the lost mass with the release rates of the countries the textiles are washed in, which can be found in PLP.

$$\text{Leak}_{compartment} = \sum_{Country} \sum_{Garment\ types} \underbrace{M_{garment\ type}(kg) * \#wash_{garment\ type}}_{\text{Mass}} * \underbrace{LR(\%)}_{\text{Loss}} * \underbrace{RR_{Country,compartment}(\%)}_{\text{Release}}$$

With compartment = ocean, land

Generally speaking, it would be best to have access to primary data. One can generate primary data and have accurate product-specific material loss rate following the standard ISO 4484-1:2023 https://www.iso.org/standard/82238.html

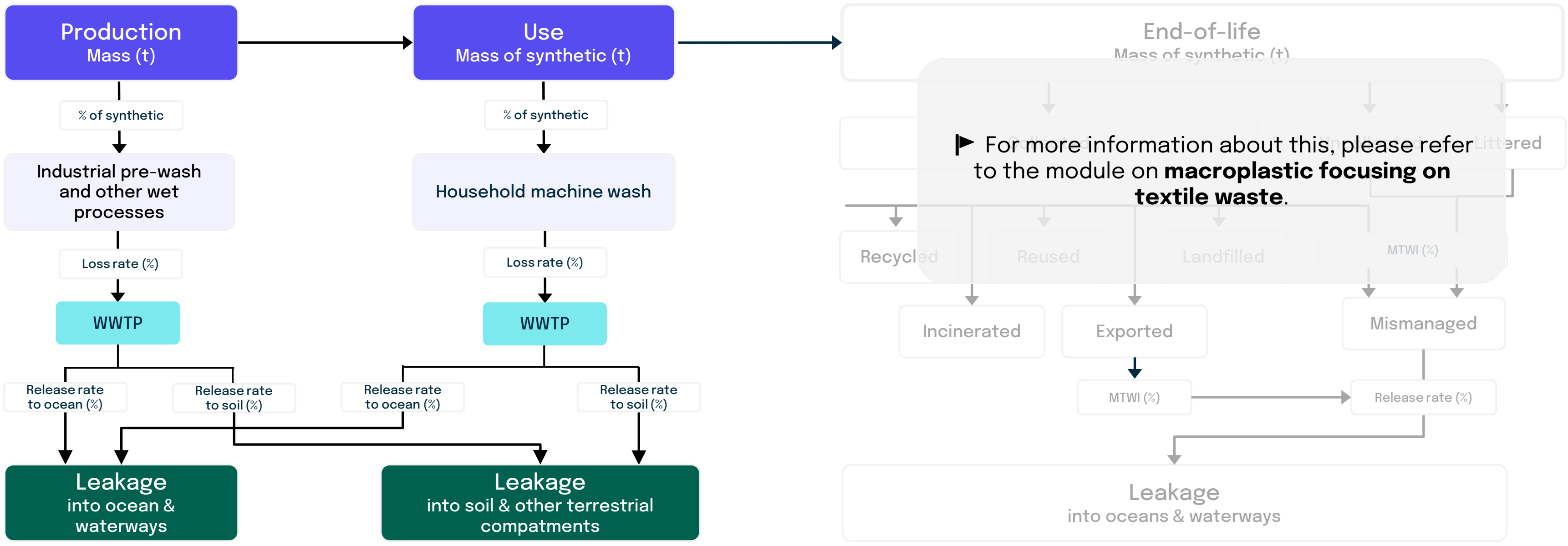
Part. 2

System map & calculation routes

The different elements to take into account during a plastic footprint. How these elements interact? Which calculation routes to follow?

System map

The path of textile, from production to final release



The number of wash is product specific. The percentages of machine and hand wash is region specific.

Loss rates vary depending on the process and other textile parameters.

Release rates depend on the presence of WWTP and they are country specific.

Calculation routes for production

$$\text{Leak}_{compartment} = \sum_{Country} \sum_{Process} M_{textiles}(t) * share_{synthetic}(\%) * \#process * LR_{process}\ (\%) * RR_{Country,compartment}(\%)$$

With compartment = ocean, land

PROD

Symbol	Description	Unit	Value	Reference	Additional comments
$M_{textiles}$	Mass of textiles produced	Tonnes	From primary data		
$share_{synthetic}(\%)$	Percentage of synthetic textiles out of total quantity produced	%	From primary data if available. Otherwise, 64%.	Textile Exchange (2022). Preferred fibres and material market report.	
$\#process$	Number of times each process is performed		From primary data.		
$LR_{process}$	Loss rate during production processes	%	From the tool available with this presentation.	Forum for the future (2023). Tackling microfibres at source	It depends on the process. We have a value specific to dyeing, scouring, rinsing, heat setting.
RR_{OCEAN}	Release rate to ocean and waterways	%	From the tool available with this presentation.		Country specific and depends on the presence and type of WWTP.
RR_{LAND}	Release rate to soil and other terrestrial compartments	%	From the tool available with this presentation.		Country specific and depends on the fate of the sewage sludge.
$Leak_{OCEAN}$	Quantity released to oceans and waterways	Tonnes	Calculated		
$Leak_{LAND}$	Quantity released to soil and other terrestrial compartments	Tonnes	Calculated		

Calculation routes for usage

$$Leak_{compartment} = \sum_{Country} \sum_{Garment\ types} M_{garment\ type}(t) * share_{synthetic}(\%) * \#wash_{garment\ type} * LR(\%) * RR_{Country,compartment}(\%)$$

With compartment = ocean, land

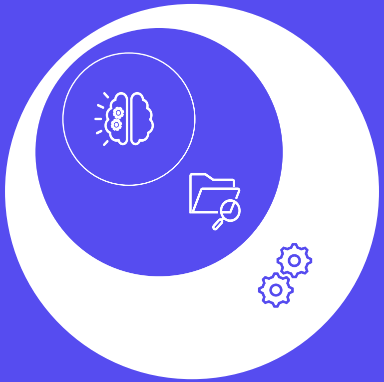
USAGE

Symbol	Description	Unit	Value	Reference	Additional comments
$M_{garment\ type}$	Mass of textiles by type	Tonnes	From primary data		
$share_{synthetic}(\%)$	Percentage of synthetic textiles out of total quantity produced	%	From primary data if available. Otherwise, 64%.	Textile Exchange (2022). Preferred fibres and material market report.	
$\#wash_{garment\ type}$	Number of times each product is washed in its lifetime		From the tool available with this presentation.	PEFCR for Europe.	
LR	Loss rate during household washing	%	From the tool available with this presentation.	Extensive literature review. All sources and other info can be found in the excel file.	Can be tuned according to textile and washing parameters.
RR_{OCEAN}	Release rate to ocean and waterways	%	From the tool available with this presentation.		Country specific and depends on the presence and type of WWTP.
RR_{LAND}	Release rate to soil and other terrestrial compartments	%	From the tool available with this presentation.		Country specific and depends on the fate of the sewage sludge.
$Leak_{OCEAN}$	Quantity released to oceans and waterways	Tonnes	Calculated		
$Leak_{LAND}$	Quantity released to soil and other terrestrial compartments	Tonnes	Calculated		

Part. 3

Data

The secondary data needed to perform the assessment.



Loss rates for use – results from literature analysis

More than 40 research papers were analysed. The variety of washing conditions makes it difficult to infer strong correlation between textile parameters and loss rates. We can however draw some conclusions on washing parameters.

CONCLUSIONS

Temperature impact

Our analysis seems to suggest that higher temperature washes potentially release more microfibres compared to those at lower temperatures.

Load impact

Different papers suggest that the load capacity of the washing machine significantly influences the quantity of lost fibres. The larger the load, the lower the fiber loss.

Detergent presence

Our analysis seems to suggest that the presence of a detergent increases the loss rate.

The sample size for this observation is very small, making it less reliable than the others.

Number of wash impact

Observations suggest that the initial washes release a significantly higher quantity of microfibres, likely a result of fibres rupture during manufacturing processes.

Guidelines for washing and production

GUIDELINES FOR WASHING

Whenever feasible, opt for washing laundry at a lower temperature (≤40°C) to minimize both plastic and carbon footprints.

PLASTIC CARBON

Maximizing machine load capacity is recommended to minimize both plastic and carbon footprints.

PLASTIC CARBON

GUIDELINES FOR PRODUCTION

Organize an industrial pre-washing of finished products before commercialization

PLASTIC

Manage the wastewater with filters to collect microplastic fibres.

PLASTIC

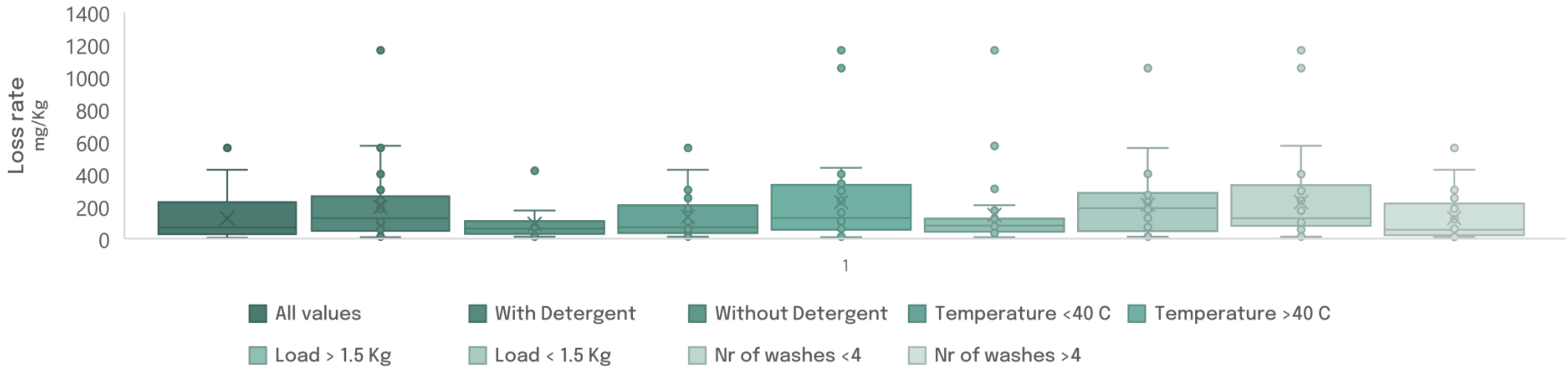
Reduce the production speed on the machine to avoid degradation on the material.

PLASTIC

Integrate a vacuum system to collect microplastics in the air and on the floor

PLASTIC

Loss rates for use – results from literature analysis



Because of the lack of clear correlations between parameters and loss rates, the user is given a generic value for all types of textiles and all washing conditions to use in the context of the plastic footprint. In the following table you can find the suggested values.

	LR Loss rate	Unit
Low value	24.5	mg/Kg
Central value	**64.5**	mg/Kg
High value	202.5	mg/Kg

One can generate primary data for loss rate to have accurate product-specific material loss from fabrics during washing following the standard ISO 4484-1:2023 https://www.iso.org/standard/82238.html

Loss rates for use – detailed values

	All values	All values (excluding first 4 washes)	Detergent		Temperature		Load		Number of washes	
			With	Without	<40 °C	≥40 °C	≥ 1.5 kg	<1.5 kg	≤4	>4
Min	4.5	4.5	9.0	10.8	10.8	9.0	9.0	10.8	12.0	9.0
Q1	41.0	24.5	48.6	35.3	33.8	58.7	44.8	50.0	81.7	28.6
Median	**105.9**	**64.5**	**125.0**	**61.2**	**70.8**	**126.5**	**80.0**	**187.0**	**124.6**	**55.5**
Q3	241.8	202.5	255.0	106.8	200.7	315.7	118.1	270.0	304.7	202.5
Max	1165.0	560.0	1165.0	420.0	573.0	1165.0	1165.0	1054.0	1165.0	560.0
Average	175.3	121.9	196.3	91.5	135.7	225.6	146.0	210.4	226.1	127.8
Sample size	82	40	49	14	31.0	36	27	33	42	24

Key results from the literature review on synthetic microfiber loss rates during washing.

Number of washings per item

$$\#washes_{type} = \frac{\#uses_{type}}{washing\ frequency_{type}}$$

Where:

- type can vary among 10 different types
- #uses = number of uses per product lifetime
- washing frequency = average number of uses prior to washing

Table 7 Default product duration of service per product sub-category

No.	Product sub-category	Product	Number of uses per product duration of service
1	T-shirts	Average	45[1]
2	Shirts and blouses	Average	40
3	Sweaters and midlayers	Average	85
4	Jackets and coats	Average	100
5	Pants and shorts	Average	70
6	Dresses, skirts and jumpsuits	Average	70
7	Leggings, stockings, tights and socks	Average	55
		Leggings/tights	70
		Hosiery	50
		Socks	50
8	Underwear	Average	60
9	Swimwear	Average	30
10	Apparel accessories	Average	100
11	Open-toed shoes	Average	50
12	Closed-toed shoes	Average	100
13	Boots	Average	100

Table 37 Product uses prior to washing

No.	Sub-category	Average uses prior to washing	Average uses prior to washing for sportswear*	Average uses prior to washing for delicates**
1	T-shirts	1	1	5
2	Shirts and blouses	2	1.5	5
3	Sweaters and midlayers	5	1.5	5
4	Jackets and coats	20	1.5	5
5	Pants and shorts	3	1.5	5
6	Dresses, skirts and jumpsuits	3	1.5	5
7	Leggings, stockings, tights and socks	2	1.5	5
8	Underwear	1	1	1
9	Swimsuits	1	1	5
10	Apparel accessories	20	20	20

Source: Product Environmental Footprint Category Rules (PEFCR) – Apparel and Footwear version 1.3, 2022

Product category	Number of washes per lifetime
T-shirts	45.0
Shirts and blouses	20.0
Sweaters and midlayers	17.0
Jackets and coats	5.0
Pants and shorts	23.3
Dresses, skirts and jumpsuits	23.3
Leggings, stockings, tights and socks	27.5
Underwear	60.0
Swimsuits	30.0
Apparel accessories	5.0

According to how many times the garment is washed in its lifetime, the loss rate can change, since in the first washes it is higher and then it decreases.

Product category	Average loss rate
T-shirts	69.8
Shirts and blouses	76.5
Sweaters and midlayers	78.6
Jackets and coats	112.5
Pants and shorts	74.8
Dresses, skirts and jumpsuits	74.8
Leggings, stockings, tights and socks	73
Underwear	68.5
Swimsuits	72.5
Apparel accessories	**112.5**

Loss rates for production

There is a lack of research and available data on loss of microfibres during production. We could only find one source (reported belowe and in the data tool). More research is needed on the topic for more reliable data.

Loss rates LR (production)

Ratio of microfiber loss per wet process (mg/kg)

More research is needed on the topic for more reliable data.

Process	LR	Unit	Material	Dye	Source
Scouring	102	mg/kg	100% Polyester	Black	Forum for the Future (2023). Tackling Microfibers at Source.
Dyeing	76	mg/kg	100% Polyester	Black	
Rinsing	32	mg/kg	100% Polyester	Black	
Heat Setting	35	mg/kg	100% Polyester	Black	
Total	**245**	mg/kg	100% Polyester	Black	
Scouring	22	mg/kg	61% recycled PE/39% Polyester	Black	
Dyeing	389	mg/kg	61% recycled PE/39% Polyester	Black	
Rinsing	35	mg/kg	61% recycled PE/39% Polyester	Black	
Heat Setting	96	mg/kg	61% recycled PE/39% Polyester	Black	
Total	**542**	mg/kg	61% recycled PE/39% Polyester	Black	
Scouring	29,6	mg/kg	61% recycled PE/39% Polyester	White	
Dyeing	5,2	mg/kg	61% recycled PE/39% Polyester	White	
Rinsing	1,9	mg/kg	61% recycled PE/39% Polyester	White	
Heat Setting	42	mg/kg	61% recycled PE/39% Polyester	White	
Total	**78,7**	mg/kg	61% recycled PE/39% Polyester	White	
Total - Average	**288,6**	mg/kg			

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Our commitment to continuous improvement

The Plastic Footprint Network's successful collaboration is built on pillars of:

- Open
- Non-competitive and productive dialog
- Leveraging science and supporting ongoing research
- Broadly empowering global stakeholders (product manufactuers, brand owners, treaty negotiators, regulators, consultants, NGOs, etc) to effectively do their part to address the plastic pollution crisis.

Given corresponding commitments to transparency and continuous improvement, we welcome and encourage your feedback and input on this document so that the methodology can continue to be enhanced and refined.

Thank you for supporting the work of the Plastic Footprint Network.

Contact us at: contact@plasticfootprint.earth

PFN

Our mission is to continuously advance Plastic Footprint Methodology, ensuring it remains at the forefront of sustainable practices and promoting its widespread adoption. By empowering companies to rigorously assess, enhance, and transparently report their plastic footprints, we aim to make significant strides in mitigating the plastic pollution crisis.

Plastic Footprint Network

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Illustrations by German Kopytkov

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