Spinning Greenwash:

How the fashion industry's shift to recycled polyester is worsening microplastic pollution

Changing Markets
FOUNDATION

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Executive summary

A new study commissioned by the Changing Markets Foundation and carried out by the Microplastic Research Group at Çukurova University finds that recycled polyester, the fashion industry's flagship 'sustainable' solution, sheds more microfibres than virgin polyester. Testing of 51 garments from Adidas, H&M, Nike, Shein and Zara showed that recycled polyester releases both the highest number of fibres and the finest particles, worsening the microplastic pollution problem.

Fashion brands regularly market recycled polyester as a 'preferred fibre.' Changing Markets' 2024 *Fashion's Plastic Paralysis* report found that 82% of brands that responded to the questionnaire plan to increase its use, with some pledging full transition by 2030. [1]

Yet according to industry figures 98% of recycled polyester comes from plastic bottles, not textile waste.[2] Brands market this as circularity: Nike claims that its use of recycled polyester made from plastic bottles helps in 'reducing waste' by diverting around one billion bottles each year from landfills and waterways;[3] Adidas states that 'the use of recycled plastic in products is part of the company's efforts to avoid plastic waste and stop the pollution of the world's oceans';[4] and Shein markets its recycled polyester garments[5] through a glossy video depicting a bottle's journey into clothing.[6]

In reality, bottle-to-textile removes bottles from closed-loop recycling, downcycling them into garments that shed microplastics and cannot be effectively recycled again, ultimately ending up in landfills or incinerators.

Major brands already rely heavily on this false solution: Adidas claims that 99% of its polyester is recycled,[7] and H&M reports that in 2024, 94% of the polyester it sourced was recycled.[8] Even Patagonia – often held up as a sustainability leader – discloses that 93.6% of its polyester is recycled (mostly from plastic bottles), [9] which represents more than half (52%) of its entire materials.[A]

Recycled polyester has become a convenient cover for the industry, allowing brands to claim progress on reducing virgin plastic reliance while increasing overall synthetic fibre production. Textile Exchange data shows this clearly: although recycled polyester volumes rose last year, its overall market share fell from 12.5% to 12%, because virgin polyester grew even faster.[10]

A According to the 2025 Progress report 55.8% of its material use by weight is polyester, with 93.6 of this being recycled.

This trend unfolds amid an escalating plastic crisis. Annual plastic production has surged from 2 megatonnes (Mt) in 1950 to 475 Mt in 2022, and is projected to hit 1,200 Mt by 2060. Roughly 8,000 Mt of plastic waste now contaminates the planet's land, air and oceans.[11] A newly released report, by Pew, *Breaking the Plastic Wave 2.0* (December, 2025), finds that plastic pollution is set to more than double within 15 years, driven largely by packaging and textile production. The report estimates that by 2040, annual plastic waste leaking into the environment will rise from 130 Mt to 280 Mt, far outpacing improvements in waste management. It also finds that while packaging will remain the biggest plastic user until 2040, textiles will experience the steepest growth, fuelled by the rapid expansion of low-cost synthetic clothing.[12]

These plastics break down into microplastics, now recognised as one of the most pervasive forms of pollution. They contaminate soil, water, air and enter the food chain, with growing evidence of harm to ecosystems and human health. Synthetic textiles are estimated to generate up to 35% of primary microplastics entering the ocean.[13] Microplastics have been detected in the human stomach,[14] circulatory system,[15] placenta[16] and numerous other organs and are linked to a higher risk of stroke, heart attack, cardiovascular disease, inflammation, hormonal disruption[17] and premature death.[18]

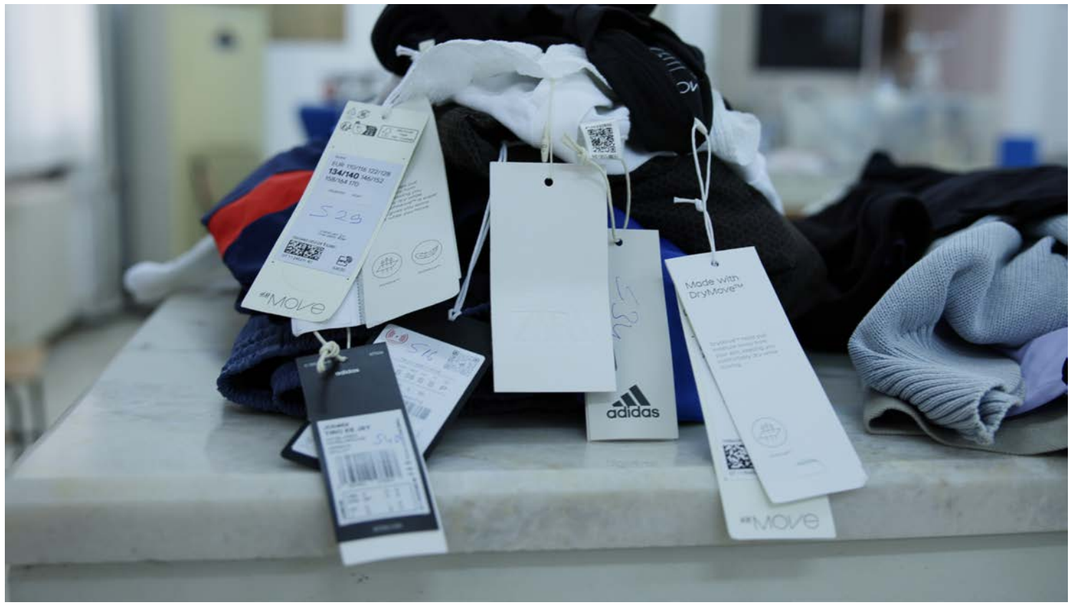
The fashion industry sits at the heart of this problem, driven above all by polyester: synthetic fibres made from fossil fuels account for around 69% of all textile production, with polyester making up the majority, accounting for 59% of global textile production.[19] Its low cost – around half that of cotton – has fuelled a surge in cheap, disposable clothing; since the early 2000s, polyester's rise has doubled global fibre output, cementing its place as a key driver of fast fashion. This dependence spans the entire sector: ultra-fast-fashion giant Shein uses synthetics for

about 89% of its production, with 82% coming from polyester,[20] while Patagonia relies on synthetics for roughly 80% of its materials, with 56% from polyester.[21]

Fashion's Plastic Paralysis found that although most companies acknowledge microplastics from synthetic fibres as an environmental issue, few have taken meaningful or measurable action to address it.[22] Concerns about bottle-derived recycled polyester are shared by Europe's beverage industry, which has urged policymakers since 2021 to stop the downcycling of plastic bottles into textiles. They warn that fashion's growing demand disrupts closed-loop bottle-to-bottle recycling and puts both sectors in direct competition.[23],[24] This concern is backed by McKinsey projections showing that, by 2030, recycled polyester demand will be three times higher than available supply in the US.[25]

At the same time, the fashion industry has deflected attention from synthetics by promoting claims that natural fibres such as cotton or viscose shed similar or even greater amounts of fibre. It has highlighted studies reporting that natural fibres were more common than polyester in coastal seawater along the Kenyan and Tanzanian coasts,[26] and that most microfibres found in fish come from cotton or wool.[27] These findings are used to argue that all fibres deserve equal attention and that synthetics should not be singled out.[28] In 2023, the industry published a widely cited study claiming that mechanically recycled polyester sheds no more than virgin polyester.[29]

Our study helps to fill the evidence gap by comparing microfibre shedding across fibres from well-known brands, providing independent data to guide policymakers, consumers, and industry in reducing textiles' environmental impact.



Examples of clothes purchased for this study

This study

We analysed 51 garments from Adidas, H&M, Nike, Shein and Zara (owned by Inditex), testing virgin and recycled synthetics alongside natural fibres. For most brands, this included three cotton, three virgin polyester and three recycled polyester items. We selected garments of broadly comparable size and type (T-shirts, tops, dresses and shorts). However, limited information on production methods and textile construction meant this was not always possible (for a full list of garments see Annex I).

Although this study reveals the microfibre release from garments made with specific fabrics and yarn types on selected production lines, it represents only a consumer-level snapshot of shedding behaviour that signals broader industry trends. A more comprehensive assessment would be required to capture the full scale of impacts

across the large production volumes of the brands examined. The study also has limitations, including differences in garment types and construction across brands. Although the sample size may appear small, in tests of this kind, the numbers can be considered statistically significant because garments are produced in long, uniform fabric runs; one item is therefore representative of an entire production batch rather than a single product.

We tested the items using two recognised laundering systems:

- The GyroWash (measuring fibre count and fibre size). This method is only used for garments with a uniform fabric structure suitable for cutting consistent 4 × 10 cm samples. 40 items were able to be tested this way.

- The Wascator (measuring total fibre mass loss) - all 51 items were tested through this system.

Both washing systems simulate household washing but answer different questions, allowing us to compare shedding across fibre types in terms of fibre number, size and fibre mass.

The main purpose of the study was to compare fibre shedding between fibre types. In addition, we assessed whether the fibre shedding behaviour of any brand was significantly different, using the one-way ANOVA statistical test to compare the average results from the five brands.

Full methodology is available in the Annex on the report webpage.

Main findings

1. Recycled polyester sheds the most microfibres

A sample of 23 virgin and recycled polyester items[B] revealed that recycled polyester released ≈12,000 fibres per gram on average — 55% (54.8%) more than virgin polyester (8,028 fibres/g). We believe that this is an underestimate, as when we removed Shein's items-5) because of our suspicion that their 'recycled polyester' garments may in fact be made from virgin polyester (see point 5), the discrepancy in fibre shedding between recycled and virgin polyester increased to 72%.

Recycled polyester fibres were also consistently smaller than those of virgin polyester (with an average length of 0.42 vs. 0.52 mm), increasing toxicity, environmental dispersion and chemical load. Because each fibre is a separate particle, it can be inhaled, ingested, transported through ecosystems, or carry harmful chemicals.[30],[31] Smaller fibres carry greater environmental and health risks — they travel further, penetrate deeper into lungs and tissues,[32],[33] and are more readily ingested by aquatic and soil organisms.[34],[C] A larger sample of 29 items testing for fibre mass loss (12 virgin polyester, 17 recycled) also indicated that recycled polyester lost 50% more mass than its virgin counterpart (0.36 vs 0.24 mg/g).

B Virgin-polyester fibre-count results are based on nine items tested from H&M, Nike and Shein, because no virgin-polyester items were available from Zara, and Adidas samples were unsuitable for GyroWash due to non-uniform fabric. Recycled-polyester fibre-count results are based on fourteen items tested from Adidas, H&M, Nike, Shein and Zara.

C Kim, D., Kim, S.A., Nam, S.-H., Kwak, J.I., Kim, L., Lee, T.-Y., Kim, H., An, S. and An, Y.-J. (2024). Microplastic ingestion in aquatic and soil biota: A comprehensive review of laboratory studies on edible size and intake pattern. *Marine Pollution Bulletin* 200: 116056. doi.org/10.1016/j.marpolbul.2024.116056

Comparison of fibre shedding across materials

Fibre type	Average fibre count (fibres/g)	Average fibre length (mm)	Average fibre mass (mg/g)
Recycled polyester	12,430	0.42	0.36
Virgin polyester	8,028	0.52	0.24
Cotton	9,776	0.66	1.85
Recycled polyamide	5,133	0.38	0.20
Virgin polyamide	1,565	0.65	0.08

2. Recycling worsens shedding for synthetics

Recycled versions of polyester and polyamide both shed more than their virgin counterparts. While recycled polyester shed approximately 55% more fibres than virgin polyester (12,430 fibres/g vs. 8,028 fibres/g), recycled polyamide shed over three times as much as virgin polyamide (228%; 5,133 fibres/g vs. 1,565 fibres/g).[D] We tested for polyamide as for one brand, Zara, we were unable to get recycled polyester.

3. Cotton sheds heavier, longer fibres

Our tests focused on virgin cotton and found that it released 1.85 mg/g of heavier, longer fibres (0.40-0.94 mm),[E] which are less likely to reach the lower respiratory tract, potentially posing a lower health risk compared to smaller, inhalable fibres. [35,36]

D Virgin polyamide fibre count results are based on four items, while recycled polyamide fibre count is based on three items – all from Zara.

E Cotton fibre count results are based on 11 items, while fibre mass loss results are based on 14 items, from all five brands.

4. Shedding is systemic, but some polyester results stand out

The study found minimal differences between brands, indicating that microfibre shedding is a systemic industry-wide issue driven mainly by material and production choices. However, across polyester fabrics, Nike showed the highest fibre release in both virgin and recycled polyester. Nike's virgin-polyester items released on average around 20,258 fibres per gram of garment sample – nearly three times more than Shein (6,931 fibres/g) and over seven times more than H&M (2,737 fibres/g). [F]

Nike's recycled-polyester was also the highest-shedding across all brands tested with an average of 30,772 fibres/g): [G] this is around 16% more fibres than Adidas, nearly four times more than H&M, and seven times more than Zara (see section 2.2.4).

Comparison of average fibre release (GyroWash) for virgin and recycled polyester fabrics across brands

Brand	Virgin polyester fibre count (fibres/g)	Recycled polyester fibre count (fibres/g)
NIKE	20,258	30,772
SHEIN	6,931	3,519**
H&M	2,737	8,289
adidas*	–	26,517
ZARA*	-	4,276

*No virgin polyester items from Zara were found for purchase through the brand's online store and Adidas virgin polyester samples did not come from uniform fabric and therefore were not suitable for testing through GyroWash.

**We suspect Shein's 'recycled polyester' garments may in fact be made from virgin polyester (see point 5).

F For virgin polyester fibre count, Nike was compared with H&M and Shein (two items from Nike, four H&M, three Shein) because no virgin-polyester items were found on Zara's online store and the Adidas samples were not uniform enough for GyroWash testing.

G For fibre count, Nike's recycled polyester items were compared to items from all four other brands (two Nike, two Adidas, four H&M, three Shein, three Zara).

5. **'Recycled polyester' claims may be misleading** When selecting garments, we found repeated discrepancies between brands' online claims and the fibre content listed on physical labels, raising doubts about the accuracy of recycled polyester claims. Shein's items advertised as 'recycled polyester' in June 2025 when we purchased the garments, were months later relisted simply as 'polyester'. This is likely to explain why Shein's samples, initially sold as 'recycled' showed shedding levels (3,519 fibres/g) similar to its virgin polyester items. We found similar inconsistencies appeared in some of the samples purchased from H&M and Nike, where garments marketed online as containing recycled polyester did not state this on their care labels. These findings highlight the need for stronger oversight, clear labelling rules and independent verification to prevent fraud.

Broader implications and the way forward

This study's findings challenge the industry narrative that recycled polyester is a solution to plastic pollution. Environmentally and biologically, recycled synthetics worsen microplastic pollution by increasing the number of fibres released, their toxicity, their ability to disperse, and the total mass entering the environment.

While smarter design and manufacturing choices, such as using continuous filaments, higher-twist low-hairiness yarns, tighter weaves, laser-cut edges, industrial pre-washing, fibre-capture systems and non-toxic finishes, can help reduce microfibre release, these are only partial fixes. The fundamental solution is to reduce the use of both virgin and recycled synthetic fibres. This is because no amount of fibre optimisation and filtration technologies can fully eliminate the pollution they create.

Achieving fundamental – and even intermediate – solutions will require strong regulatory measures. The EU should introduce eco-design criteria with mandatory testing and labelling of all fabrics for shedding performance, microplastic emission limits in finished products, and clear consumer warnings on synthetic textiles. Policies should also account for the ecotoxicity impacts of microplastic release in life-cycle assessments, mandate industrial pre-washing and promote innovation in low-shedding materials.

The delayed EU initiative on unintentional microplastic release must be revived,[37] and the revised Waste Framework Directive should include fees linked to microplastic emissions and product volumes to curb overproduction and help incentivise a real shift toward producing fewer, higher-quality and lower impact garments.

Beyond the EU, a global plastics treaty that sets limits on virgin plastic production and prioritises source reduction would help address the root causes of microplastic pollution, ensuring that fashion's growing reliance on synthetics does not continue unchecked.

Meanwhile, consumers can help reduce microplastic pollution by buying fewer, better-quality garments, washing less and on gentler cycles, and avoiding ultra-fast-fashion items made largely from synthetics. They should also be wary of potentially misleading 'recycled polyester' claims, and make efforts to support brands which are genuinely reducing their reliance on plastic-based fashion.

Detailed policy and brand recommendations are presented at the end of this report.

1. Fashion's plastic addiction and the shift to recycled polyester

For years, the global fashion industry has relied on synthetic fibres such as polyester, polyamide and acrylic to produce low-cost, high-volume clothing. Polyester, a petroleum-based material, is the world's dominant fibre, making up about 59% of global textile production. Since the early 2000s, polyester's rise has doubled overall fibre production and represents the largest source of current and future growth in fibre manufacturing.[38]

This dependence on synthetics is part of a much broader and accelerating plastic pollution crisis. A newly released report by Pew, *Breaking the Plastic Wave 2.0* (December 2025) finds that plastic pollution is on track to more than double by 2040, with annual leakage rising from 130 Mt to 280 Mt. While packaging remains the biggest plastic user, textiles are projected to experience the fastest growth, driven by the rapid expansion of cheap synthetic clothing.[39]

Fashion's reliance on these petroleum-based materials comes with another, largely invisible price: synthetic textiles shed microscopic plastic particles at every stage of their life cycle. Fibres are released during cutting, weaving and finishing in factories, entering wastewater long before garments reach stores, and once in use, a single household wash can release hundreds of thousands of microplastics into wastewater systems.[40] End-of-life brings further harm: when synthetic garments are landfilled, they slowly break down into smaller and smaller fragments; when incinerated, they emit toxic substances into the air. Even recycling is not exempt from microplastic shedding. In 2025, *The Lancet* found mechanical recycling releases considerable quantities of microplastics into the environment.[41]

Micro- and nanoplastics consist of a polymer matrix plus thousands of embedded and adsorbed chemicals, as well as absorbed biological materials and bacteria. More than 16,000 chemicals can be present in plastics.[42] A 2025 GLOBAL 2000 study found that many ultra-fast-fashion items contain dangerous levels of toxic chemicals. Seven out of twenty products from Shein and Temu exceeded multiple legal limits, including for 'forever chemicals' (PFAS), plasticisers, and heavy metals like lead. Notably, 85% of the tested items were made from petroleum-based synthetics.[43]

The recycled polyester rush

When its reliance on plastic-based fibres came under scrutiny, the fashion industry's main response was to promote recycled polyester as a so-called 'preferred fibre' of the future.[44] In 2024, 82% of companies responding to our questionnaire said they planned to reduce virgin synthetics by switching to recycled polyester. In September 2025, Textile Exchange reported that 98% of recycled polyester is made from plastic bottles and that most of its 423 reporting brands and retailers are 'reducing their use of virgin fossil-based polyester'.[45] But a closer look reveals

© dreamstime: 98% of recycled polyester today is made from plastic bottles.

the opposite trend. While recycled polyester increased from 8.9 million tonnes in 2023 to 9.3 million tonnes in 2024, virgin polyester grew even faster, causing recycled polyester's market share to fall from 12.5% to 12% of global production.[46] This reveals how the industry's strategy masks its deepening reliance on virgin polyester. It also fails to address microplastic pollution; instead, it removes bottles from closed recycling loops and locks plastics into textiles that cannot be effectively recycled again.

Packaging was the dominant end-use for recycled PET in 2022, with 48% used in bottles and 25% in sheet (trays). The rest went into non-packaging sectors – most notably polyester fibres (15%), alongside strapping and various smaller applications.[47]

Adidas claims that 99% of its polyester is recycled,[48] and H&M reports that in 2024 94% of the polyester it sourced was recycled.[49] Even one of the world's most celebrated 'sustainable' brands, Patagonia, relies heavily on plastic-based textiles. Its materials breakdown shows that 52.2% of its entire collection is made from recycled polyester. Since the brand states that the vast majority (93.6%) of its recycled polyester comes from plastic bottles, it's clear that Patagonia's sustainability model is still fundamentally built on downcycling.[50]

© Shutterstock: Microplastics are circulating through every part of the environment — soil, air, water and living organisms.

2. Environmental and health impacts of microplastics

From an environmental perspective, the simple act of washing synthetic clothing poses a significant pollution risk. Each laundry cycle can release up to 900,000 microplastic fibres,[51] many of which end up in sewage sludge that is widely spread as fertiliser, turning farmland into major reservoirs of microplastics. Once in the soil, these particles infiltrate terrestrial ecosystems, harming organisms from earthworms to microscopic nematodes and moving up the food chain to birds, mammals and livestock. Microplastics have been found in the meat, milk and blood of farm animals. They also travel through the atmosphere and waterways, contributing to global contamination, and can even penetrate plant roots, accumulating in crops such as wheat and rice. A growing body of evidence shows that microplastics are circulating through every part of the environment – soil, air, water and living organisms – forming a continuous 'plastic spiral' that connects human activity to ecosystem and human health impacts.[52]

Investigations have found microplastics in various human tissues and fluids, including lung tissue, stool, stomach contents, unborn babies' placentas,[53] brain tissue[54] and penises.[55] Research on the health impacts of microplastics from textiles reveals concerning links between exposure and various health problems, such as inhibiting lung tissue repair and exacerbating lung damage caused by diseases like Covid-19.[56] A 2022 study concluded that inhalation or ingestion of microplastics can cause chronic inflammation of the lungs (known to be a leading cause of diseases such as cancer, heart disease, asthma and diabetes) and intestinal inflammation, as well as irritable bowel disease.[57] Microscopic plastic particles in blood vessels have been linked to higher risks of stroke, heart attack and early death. Patients with arterial microplastic contamination were nearly five times more likely to experience serious cardiovascular events.[58]

Research from Australia indicates that children under six inhale about three times more microplastics than the average adult.[59] A European Chemicals Agency study has found substances causing cancer, genetic mutations or harming reproduction in childcare products such as bibs and car seats, most often in synthetic polymers and textiles.[60]

Box 1. **Industry misdirection: Using natural fibres to deflect from microplastic pollution**

In principle, natural fibres pose a lower environmental risk, as they have the potential to biodegrade under the right conditions. A 2025 review of current evidence found that under most environmental conditions (soil, freshwater and wastewater) cotton and other cellulose fibres biodegrade by 30–90% within roughly 15–90 days —far faster than synthetic fibres like polyester or nylon, which can persist for years. The main exception is dry, oxygen-poor environments like landfills, where even natural fibres degrade only over many years. [61] Fate modelling, used to forecast and evaluate the behaviour of chemicals and other substances once introduced into the environment, also suggests that natural fibres generally degrade faster than persistent petrochemical polymers, so they remain for a shorter time in marine water and sediments.[62]

However, chemical treatments and finishing processes can significantly reduce the biodegradability of natural fibres. Water-repellent coatings, flame retardants and other additives alter fibre structure, meaning natural materials are not automatically harmless. [63] Natural fibres should therefore not be overlooked in discussions about microfibre pollution, and the challenge of chemical additives in textile fibres should be tackled through strengthened EU chemical and eco-design regulations, to ensure natural and synthetic materials are designed to be non-toxic, environmentally safe and, where applicable, biodegradable at end of life.

However, recognising the environmental disadvantages associated with chemically treated natural fibres must not become an excuse for inaction on synthetic-fibre microplastic pollution. Although the chemical complexity of natural fibre processing requires attention, synthetic microfibres remain the dominant concern. Whether chemically treated or not, synthetic fibres dominate global fibre production today, and their use continues to rise. Because they are inherently non-biodegradable and persist indefinitely in the environment, reducing reliance on synthetic fibres must become a priority.

Even the industry body Textile Exchange has admitted that: *'As synthetics are the most-used fibers across the industry today, meaningful action should be prioritized to reduce fiber fragment shedding within this category specifically.'*[64]

Microplastics: Infiltrating our bodies

Brain

POTENTIAL LINK TO DEMENTIA

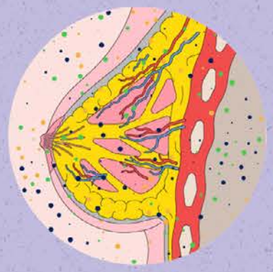
(National Institutes of Health 2024)

Lung

INHIBITS LUNG AND TISSUE REPAIR

(Plastic Soup Foundation 2021).

Breast



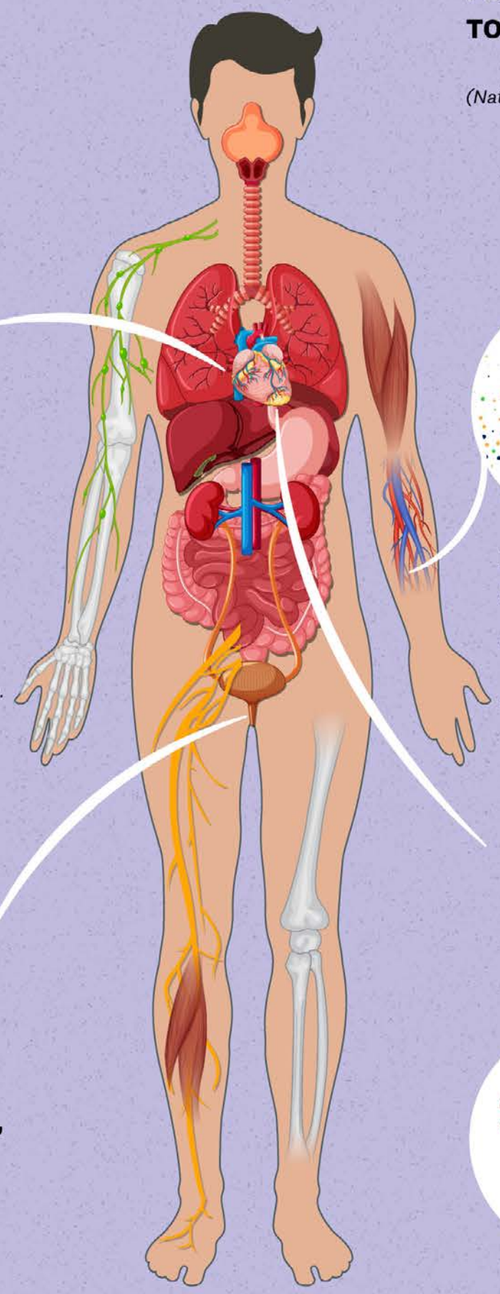
FOUND IN HUMAN BREAST MILK, CAUSING CONCERN OVER THE POTENTIAL HEALTH IMPACTS ON BABIES

(Polymers 2022)

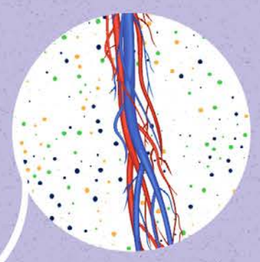
Heart

LINKED TO HEART DISEASE, HIGH BLOOD PRESSURE, DIABETES AND STROKE

(The American College of Cardiology, 2025).



Blood Vessels



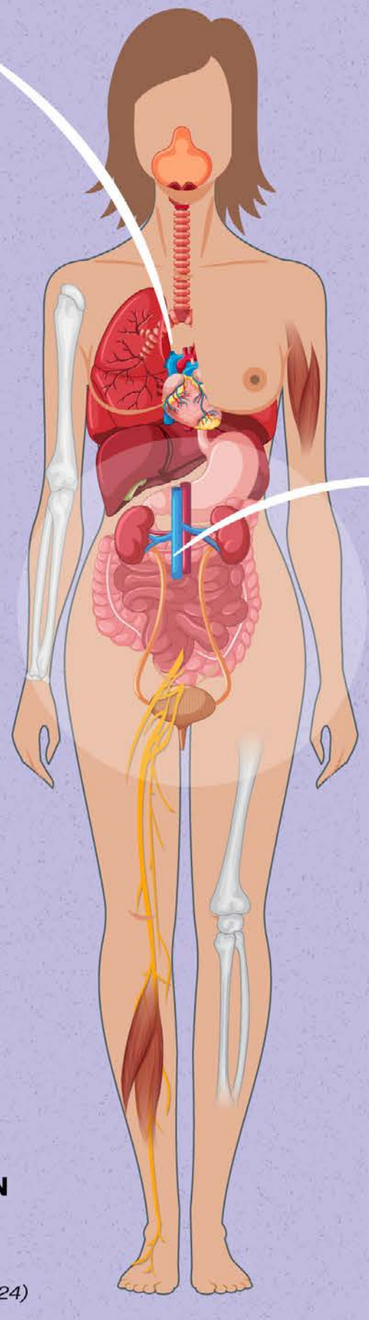
LINKED TO INCREASED STROKE AND HEART ATTACK RISK

(New England Journal of Medicine 2024)

Stomach

PRODUCES INTESTINAL INFLAMMATION

(Plastic Soup Foundation 2024)

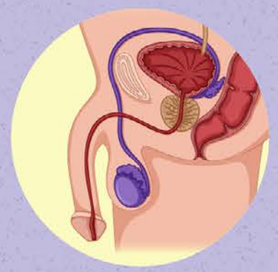


Placenta

FOUND IN 100% OF HUMAN PLACENTAS TESTED

(University of New Mexico).

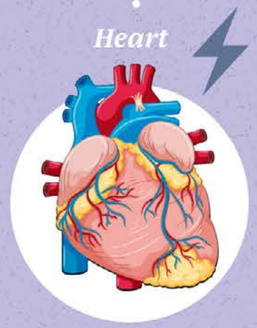
Penis



FOUND IN HUMAN PENISES, A POTENTIAL LINK TO ERECTILE DYSFUNCTION

(Nature Study 2024)

Heart



Bone Marrow

HARMS THE BODY'S BLOOD CELL PRODUCTION SYSTEM

(The Journal of Hazardous Materials 2024)

© Shutterstock : Each laundry cycle can release up to 900,000 microplastic fibres.

3. Tiny threads, big problem: Synthetic and natural fibres under the microscope

3.1 Methodology

This study analyses a total of 51 garments from five major global fashion companies – Adidas, H&M, Nike, Shein and Zara – covering cotton, polyester (virgin and recycled) and polyamide (virgin and recycled).

Although this study reveals the microfibre release from garments made with specific fabrics and yarn types on selected production lines, it represents only a consumer-level snapshot of shedding behaviour that signals broader industry trends. A more comprehensive assessment would be required to capture the full scale of impacts across the large production volumes of the brands examined. The study also has limitations, including differences in garment types

and construction across brands. Although the sample size may appear small, in tests of this kind, the numbers can be considered statistically significant because one sample does not represent one single item; in mass production, brands do not make garments one by one. They produce hundreds of metres of the same fabric in a single run and then cut it into thousands of identical items. Testing one garment therefore effectively tests that whole production batch.

We selected garments of broadly comparable size and type (T-shirts, tops, dresses and shorts). However, limited information on production methods and textile construction meant this was not always possible (for a full list of garments see Annex I).Our goal was to test at least nine items per brand, which for most brands meant three predominantly (or fully) cotton garments, three predominantly or fully virgin polyester garments, and three predominantly or fully recycled polyester garments. The main exception was Zara: because we were unable to source virgin polyester items from its online store, we included virgin polyamide and recycled polyamide garments to allow for a fair comparison.

The sample distribution was as follows: Adidas (9 garments), Nike (9), H&M (11), Shein (9) and Zara (13). These companies were selected because they are among the world's largest fashion retailers and, as shown in our previous investigations, most are significant users of synthetic fibres.[65]

To ensure scientific robustness and comparability, the study applies two internationally recognised textile testing standards, each capturing a different dimension of fibre release - the number and size of fibres released (GyroWash) and the total amount of material loss (Wascator). This approach strengthens scientific credibility, and makes the results more robust against methodological criticism.

GyroWash method (ISO 105-C06)

The laboratory-scale washing was carried out using a GyroWash-type laundering unit that conforms to ISO 105-C06. This method is typically used for colour fastness testing but can also simulate domestic washing under controlled conditions. This allows the number of fibres and size to be identified accurately under the microscope, ensuring scientific consistency and avoiding methodological bias. Results are measured in the number of fibres per gram of the garment sample that was washed in the GyroWash.

Forty items were tested in this way, because this method was only able to be used for garments with a uniform fabric structure suitable for cutting consistent 4 × 10 cm samples. The 11 garments that could not be tested in the GyroWash contained printed sections or mixed-material panels that would not yield representative samples. These items were still tested as whole garments in the Wascator machine, for fibre mass loss.

Gyrowash washing machine washing 4x10 cm sample sizes in accordance with ISO 105-C06 standard

Wascator washing system (ISO 6330)

All 51 items were tested in a Wascator-type washing machine. To confirm that the results from the small-scale tests were comparable with real household laundering, the same washing temperature, duration and level of mechanical motion were reproduced using a Wascator-type washing machine in accordance with ISO 6330. The Wascator system enables washing under realistic domestic conditions while ensuring precise control over mechanical and thermal parameters. This method allows the study of fibre release from full garments or larger fabric panels, complementing the controlled small-sample tests conducted in the GyroWash system. Results are measured in milligrams of fibre released per gram of garment washed.

Wascator washing machine simulating domestic laundering, where full-sized clothes were washed

Using both the GyroWash and Wascator methods allows us to compare controlled laboratory conditions with domestic-scale washing, ensuring that the fibre-release results reflect real-world laundering.

The main purpose of the study was to compare fibre shedding between fibre types. In addition, to assess whether fibre shedding behaviour differed between brands, we used a one-way ANOVA statistical test to compare the average results from the five clothing brands – to see if any of them stood out as significantly different.

For the full methodology please refer to the report page on our website.

3.2 Key findings from laboratory testing

Table 1: Comparison of fibre shedding across materials

Fibre type	Average fibre count (fibres/g)	Average fibre length (mm)	Average fibre mass (mg/g)
Recycled polyester	12,430	0.42	0.36
Virgin polyester	8,028	0.52	0.24
Cotton[H]	9,776	0.66	1.85
Recycled polyamide	5,133	0.38	0.20
Virgin polyamide	1,565	0.65	0.08

H All apart from one sample contained virgin cotton.

3.2.1. Recycled polyester generates the highest number of and most harmful microfibres

Our study finds that garments made from recycled polyester release more fibres than any other material tested (around 12,000 per gram on average), 55% (54.8%) more than virgin polyester. This is based on 23 virgin and recycled polyester samples; virgin polyester results are based on 9 items tested from H&M, Nike and Shein, while recycled polyester results are based on 14 items tested from Adidas, H&M, Nike, Shein and Zara. A larger sample of 29 items used to test fibre mass (12 virgin polyester, 17 recycled) also indicates that the total mass lost is higher (150% more) for recycled polyester than virgin polyester (0.36 vs. 0.24 mg/g). These fibres are significantly finer.

These results suggest recycled polyester is the most harmful option. Here is why:

I. High fibre counts drive greater environmental and health risks

Although recycling is promoted as an eco-friendly solution, the mechanical and chemical processes to create recycled polyester yarns weaken polymer chains – resulting in shorter molecular structures, surface defects and lower molecular weight. This makes recycled polyester more brittle and prone to fracturing, releasing large quantities of small, lightweight fibres. The number of particles is more significant than mass when it comes to environmental and health impacts, as each individual fibre represents a separate particle capable of being ingested, inhaled, transported through ecosystems, or carrying chemical contaminants.[66,67]

Although particle count is a more important parameter from a toxicological perspective, recycled polyester releases a higher fibre mass than virgin polyester, posing a higher toxicological risk.

II. Fibre size is a key driver of toxicity

Toxicity also increases as particle size decreases. Recycled polyester consistently sheds shorter fibres (ranging from 0.36-0.49 mm; compared with 0.38-0.65 mm for virgin polyester and 0.40-0.94 mm for cotton). Smaller fibres have a far higher surface area relative to their volume, enabling them to absorb more pollutants such as heavy metals, polycyclic aromatic compounds (PAHs) and persistent organic chemicals.[68] Smaller fibres can also penetrate deeper into the lungs, with research showing that fibres below certain aerodynamic diameters can deposit in lower respiratory tissues, increasing inflammation risks.[69],[70] Shorter fibres are more easily ingested by many species: small soil organisms and isopods readily take them up,[71] fish over 20 mm can ingest

fibres under 1 mm,[72] and most soil fauna typically consume fibres below about 300 m, with large earthworms able to take up pieces close to 1 mm.

III. Recycled fibres carry a higher chemical load

Recycled polyester can be made from mixed waste streams (bottles, packaging and other low-grade plastics), which contain dyes, additives, plasticisers, stabilisers and degradation by-products.[73] These substances are not removed during recycling and become embedded in the new fibres. Recycling plastic increases its toxic load: PET made with recycled content contains higher levels of volatile organic compounds (VOCs) and phthalates than virgin PET, with contamination rising as recycled content increases.[74]

IV. Microplastics begin upstream in the recycling process

This shedding risk comes on top of the microplastics released during the recycling process itself. *The Lancet* report shows that mechanical recycling generates considerable quantities of microplastics.[75]

3.2.2. Plastic recycling makes the microplastic problem worse

Recycling affects both polyester and polyamide fibre shedding. The process shortens fibre length and damages its surface, reducing cohesion within the yarn structure. Therefore, it was unsurprising to find that the recycled versions of the materials tested shed more fibres than their virgin counterparts.

Our tests found that recycled polyester sheds approximately 55% more fibres than virgin polyester, and recycled polyamide over three times as much as virgin polyamide (228% more). In polyester, the recycling process breaks down polymer chains and damages the fibre surface, weakening the material and causing it to release more small fibres during washing. Recycling affects polyamide fibres in a similar way, but because polyamide is more flexible, the fibres tend to bend instead of break – which likely explains why recycled polyamide sheds less than recycled polyester. These findings are based on fibre-count results from four virgin polyamide items and three recycled polyamide items, all sourced from Zara.

3.2.3. Cotton sheds heavier and longer fibres

Captured fibres from Wascator machine.

We tested virgin cotton items, and found that these shed heavier (1.85 mg/g) and longer yarns (0.40-0.94 mm). Because cotton is denser (araound 1.52 g/cm) and becomes stronger when wet, it helps prevent fibre breakage. Instead, larger and heavier yarns are released, which are potentially more visible in wastewater. Research also shows that larger fibres cannot pass beyond the upper respiratory tract and are normally

trapped by nasal hairs, suggesting a lower health risk compared to smaller, inhalable fibres.[76],[77] Wastewater treatment plants also retain longer fibres more effectively. As a result, cotton fibres – being longer – are more likely to be captured and removed.[78]

In terms of fibre count, cotton-based items shed amounts that are broadly similar to virgin polyester but remain clearly lower than recycled polyester. Cotton fibre-count results are based on 11 items, and fibre-mass-loss results on 14 items, sourced across all the five brands tested.

3.2.4. Shedding is systemic – but polyester results show clear outliers

The study finds minimal differences between brands, underscoring that microfibre shedding is a systemic, industry-wide problem driven by material and construction choices - such as material type, yarn construction, weave density and finishing processes - rather than a brand-specific problem. For example, our statistical testing found no significant difference between brands on shedding of cotton, polyamide and recycled polyamide microfibres, meaning that overall, all garments shed a similar number of fibres per gram of fabric, regardless of who made them.

This study analyses 51 garments from five major global fashion companies.

However, specifically across polyester fabrics tested, Nike showed the highest fibre release, with the greatest counts in both virgin and recycled polyester. For virgin polyester fibre count, Nike was compared with H&M and Shein (2 items from Nike, 4 H&M, 3 Shein), because no virgin polyester items were found for purchase through Zara's online store and Adidas virgin polyester samples were not from a uniform fabric and therefore not suitable for testing through GyroWash. Clothing from Nike released significantly more fibres than items from H&M and Shein ($p<0.05$);[79] nearly three times more than Shein (6,931 fibres/g) and over seven times more than H&M (2,737 fibres/g). For fibre count, Nike's recycled polyester items were compared to items of all four other brands (2 Nike, 2 Adidas, 4 H&M, 3 Shein, 3 Zara). As with virgin polyester, the highest shedding levels for recycled polyester were recorded for Nike (30,771 fibres/g); releasing around 16% more fibres than Adidas, nearly four times more than H&M, and more than seven times more than Zara. One of its items released around 50,000 fibres per gram, compared with roughly 1,700 fibres per gram from one of the H&M samples.

Table 2: Brand average fibre release (GyroWash) of virgin polyester-based and recycled-polyester-based fabrics

	Virgin polyester	Recycled polyester
Brand	Fibre count (fibres/g)	Fibre count (fibres/g)
NIKE	20,258.15	30,771.84
SHEIN	6,930.94	3,519.24**
H&M	2,737.48	8,289.15
adidas*	–	26,516.68
ZARA*	-	4,276.40

*No virgin polyester items from Zara were found for purchase through the brand's online store and Adidas virgin polyester samples were not from a uniform fabric and therefore not suitable for testing through GyroWash.

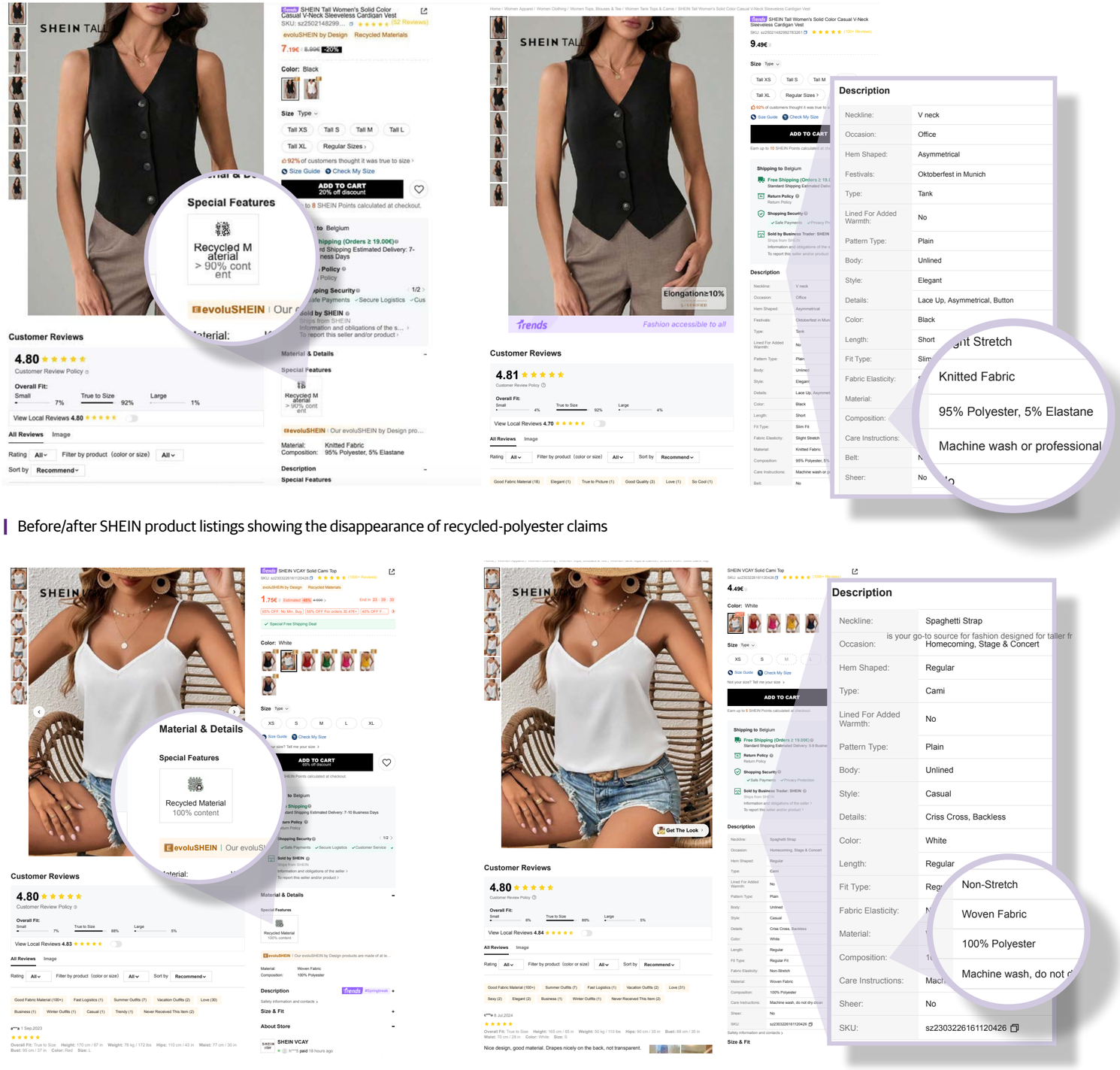
**We suspect Shein's 'recycled polyester' garments may in fact be made from virgin polyester.

3.2.5. Questions around 'recycled polyester' claims

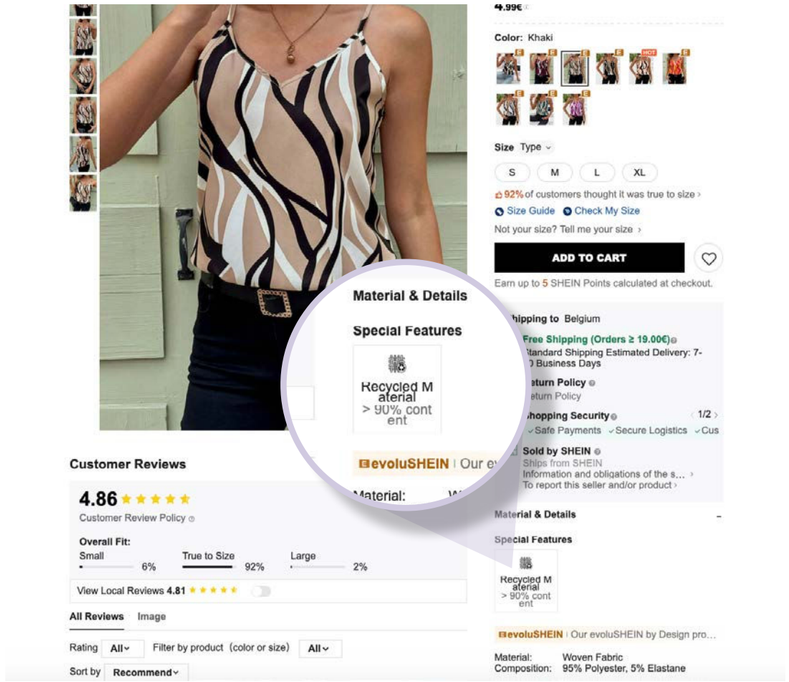
During the garment selection process, multiple inconsistencies emerged between what brands claimed online and what was stated on the physical product labels. This raises concerns about transparency and the reliability of 'recycled polyester' claims.

One of the clearest examples came from Shein. Several garments were advertised online as containing 'recycled polyester' at the time of purchase, yet a month later the same listings described them only as polyester. This inconsistency casts doubt as to whether the items were produced from recycled polyester and may explain why Shein's supposedly recycled polyester garments showed the lowest shedding levels in our tests (mean: 3,519 fibres/g). If these products were not actually made from recycled fibres, their lower shedding cannot be fairly compared with brands using verified recycled polyester – and their supposed better performance would be misleading. Once Shein's items were removed from the recycled-polyester sample, the discrepancy in fibre shedding between recycled and virgin polyester rose from 55% to 72%.

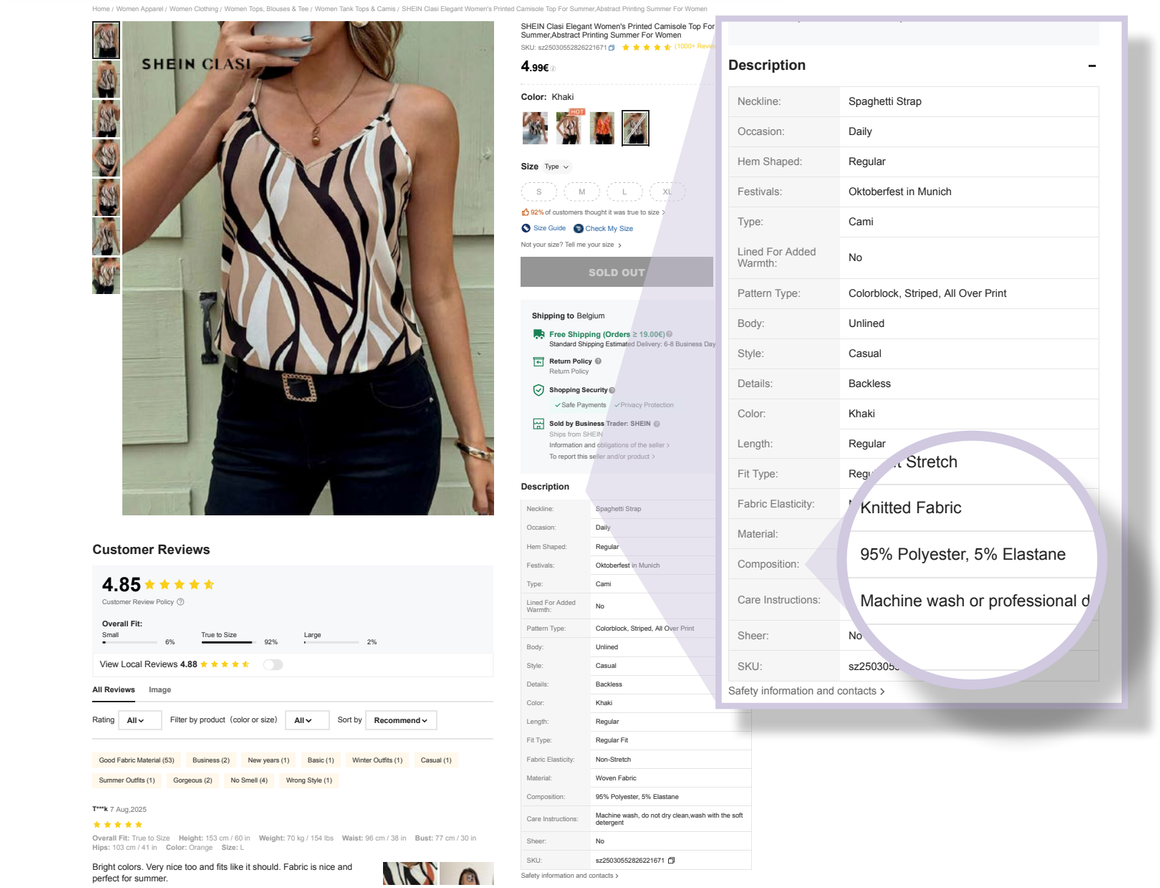
In addition, several garments from other brands were marketed online as containing recycled polyester but did not have this information on their physical care labels, as required for consumers. According to our notes, this was the case for H&M samples S31 and S32, as well as Nike sample S45. This discrepancy may simply reflect poor labelling practices.



Before/after SHEIN product listings showing the disappearance of recycled-polyester claims



Before/after product listing showing potential mislabelling of recycled polyester on SHEIN



Mislabelling and misleading consumers about the use of recycled polyester is hardly surprising in light of a recent laboratory investigation, which found that many garments marketed as 'recycled polyester' contained little to no recycled content. Using a three-step testing method validated by a leading German laboratory, researchers discovered that some high-street items had zero recycled material and others contained far less than their labels claimed.[80]

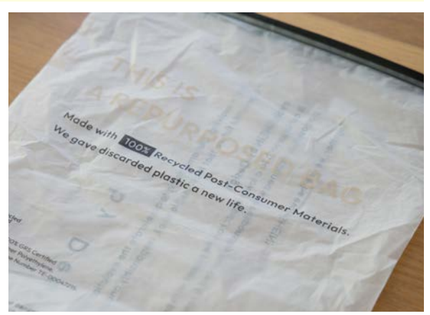
These inconsistencies highlight the need for stricter oversight, clearer labelling standards and independent verification to ensure that all material information given to consumers is correct and consistent across online and physical purchases.

Box 2. **Shein: a textbook case of greenwashing**

Shein's garment packaging arrived labelled *'contains 50% recycled post-consumer materials'* and claims to *'give discarded plastic a new life — so can you!'* On the surface, this messaging suggests a commitment to sustainability, but the reality behind the packaging tells a very different story.

Shein is an ultra-fast-fashion giant producing around 10,000 new items every single day, with an estimated 89% of its massive product range made from synthetic, petroleum-based fibres. In practice, this makes Shein far closer to a plastic producer than a fashion brand. A thin layer of recycled plastic in its packaging does little to offset the enormous volumes of plastic-based material the company pumps into the market — garments that shed microplastics throughout their life and end up as long-lasting waste.

Focusing on minor cosmetic changes while ignoring the core problem — the relentless production of disposable synthetic clothing – it is a textbook example of greenwashing.



Box 3: **Policy gaps in tackling fashion's plastic crisis**

Despite well-documented environmental and health risks, the growing use of synthetic fibres remains largely unregulated. Industry narratives claiming natural fibres are equally problematic[81],[82] have been used to delay legislation on textile microplastics, leaving major policy gaps at EU, national and international levels.

At the EU level, the Product Environmental Footprint (PEF) framework, adopted in May 2025, still fails to account properly for microplastic pollution. Microfibre data appears only as 'additional information', with no effect on final PEF scores, allowing synthetic garments to appear more sustainable and enabling greenwashing. France's PEF method goes further, capturing the full impacts of synthetic fibres, including microplastics and human health effects. [83]

The 2022 EU Textiles Strategy initially promised action on microplastics, [84] but the European Commission has since scaled back its ambition, reducing the initiative to a brief brochure and proposing no new microplastic-specific measures. [85]

Some promise lies in the Ecodesign for Sustainable Products Regulation (ESPR), which has been in force since July 2024.[86] Delegated acts could set requirements to limit the release of nano- and microplastics, including by determining microplastic emission limits in finished products, requiring warnings on textiles made from synthetics, through considering ecotoxicity of microplastic release in life-cycle assessments, mandatory pre-washing at industrial level, and promoting innovative materials. .

At the national level, since 2025 France has introduced requirements for microfibre filters in all new washing machines. NGOs are now calling for it to be made an EU-wide requirement.[87] However, while filters can have a role to play, they only address symptoms, not the root causes. Microplastics will continue to be released throughout a garment's life cycle and filters cannot curb synthetic fibre overproduction.

France has also proposed a 'fast-fashion law' introducing eco-taxes on ultra-cheap garments. The proposed levy, starting at €5 per item and potentially rising to €10 by 2030, aims to slow down the flood of disposable clothing and shift the industry toward more durable, lower-impact models. In addition, the country has adopted a bill aimed at banning advertising for fast-fashion companies and their products, including financial penalties. However, the law does not address all fast fashion equally. Major European players such as Zara and H&M are largely exempt, despite their business models also depending on speed, volume and cheap outsourced labour. And the root issue — dependence on fossil-fuel-based synthetics — remains unaddressed. [88]

Internationally, negotiations for a global plastics treaty have stalled. Countries remain divided on whether to cap virgin plastic production or rely on recycling-focused solutions. Over 100 countries supported production-reduction measures, while key petrochemical and oil-producing states insisted on a recycling-first approach.[89] Taxing polymer producers at the source has also been proposed as a way to internalise the environmental costs of synthetics. The revenue could then support a more sustainable textile system and fund research & development into alternative fibres.[90]

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4. Conclusion and recommendations

This study provides clear and independent evidence that textile materials do not shed microfibres equally, and that the fashion industry's growing reliance on synthetic fibres, particularly recycled polyester, is significantly worsening microplastic pollution.

Across all materials tested, recycled polyester was the highest-shedding fabric by far, releasing the largest number of fibres and the smallest and most environmentally harmful particles. These scientific results expose a deeper systemic problem. Rather than reducing its dependence on fossil-fuel-based fibres, the industry has doubled down on synthetics and used recycled polyester as a sticking plaster solution to avoid tackling its core dependency on plastic. Greenwashing narratives – from 'circular' bottle-to-T-shirt claims to 'preferred fibres' – have helped brands present a business-as-usual model as environmental progress. Meanwhile, synthetic fibre production continues to rise, microplastic emissions remain unregulated, and waste from cheap clothing accumulates in countries least responsible for overconsuming fashion.

Our research indicates that synthetic fibre recycling weakens fibre structure, creating brittle yarns that fracture into large quantities of small, light and chemically complex particles. Garments made from recycled polyester generate more microfibres, with higher potential for ingestion, inhalation and toxic chemical exposure. In other words, the environmental burden is higher because the pollution becomes finer, more numerous and more difficult to control.

While we found some differences between the clothes of different brands, these were - with the exception of Nike's polyester range - not significant. This is an industry-wide problem, exposing the Achilles heel of the industry's addiction to synthetic materials. It is not enough to rely on end-of-pipe fixes such as washing-machine filters. Meaningful action must focus on the root cause of the problem: capping and phasing down the production of fossil-fuel-based fibres, ending downcycling of plastic bottles, and introducing strict, mandatory regulations that limit shedding at its source.

Recommendations

Recommendations for fashion brands and retailers

1. **Set time-bound targets to cut synthetic fibre use**

   Reduce reliance on synthetic fibres — both virgin and recycled — with clear milestones such as a 50% reduction in fossil-fuel-based materials by 2030. Prioritise phasing out synthetics in children's clothing and collections for new mothers, as these groups have been shown to be the most vulnerable to microplastic exposure.

2. **Develop strategies to curb microfibre pollution**

   A. Design and manufacture textiles to shed less: Use fibre types, yarns and constructions that minimise fragmentation, for example:continuous filaments, higher-twist and lower-hairiness yarns, tighter weaves and fewer blends — alongside abrasion-resistant fabrics, better cutting and sewing methods (e.g., laser cutting).

   B. Capture fibres during production: Deploy fibre-capture systems at dying, finishing and other manufacturing stages where shedding is already significant, preventing microplastics from reaching consumers or waterways.

   C. Eliminate harmful chemicals at the design stage: Remove toxic additives and finishes that can accumulate or re-enter textiles through recycling, ensuring safer, low-shedding, non-toxic materials.

   D. Set product standards and invest in innovation: Embed microfibre-release limits into design standards so responsibility lies with manufacturers, and invest in scalable research & development for low-shedding, safer material alternatives.

Invest in true circularity, not downcycling

Prioritise the creation of timeless, well-made, repairable garments, and shift business models away from overproduction. Phase out bottle-derived recycled polyester and support fibre-to-fibre recycling technologies that exclude toxic chemicals from the design stage.

Ensure full transparency and accurate communication

Publicly disclose all suppliers across all tiers and clearly label fibre content on online platforms and physical care labels. Avoid false or misleading sustainability claims, including unsubstantiated recyclability claims or portraying growth in recycled synthetics as environmental progress. Claims must be clear and unambiguous. Do not omit important and relevant information, ensure comparisons made are fair and meaningful and that claims are substantiated and easily accessible to consumers.

Recommendations for EU legislators

1. **Reduce reliance on fossil-fuel-based fibres through economic and regulatory measures**

   Introduce a tax on virgin plastic materials and adopt strong eco-design criteria through the adopted ESPR, alongside eco-modulation fees under the recently adopted WFD, tied to microplastic release and the volume of products placed on the market. Prioritise eliminating toxic chemicals in textiles to avoid toxic recycling loops and protect vulnerable groups, such as children and pregnant women.

2. **Set binding limits on microplastic and microfibre release from textiles**

   Create strong criteria under the ESPR to measure, disclose and limit microplastic emissions across the full life cycle. Eco-design criteria should require mandatory pre-market shedding tests, clear labelling of shedding performance, and emission limits for finished products, alongside explicit plastic content warnings on synthetic textiles. Measures should also mandate industrial pre-washing to capture microplastics before products reach consumers, incorporate the ecotoxicity impacts of microplastic release into life-cycle assessments, and actively promote innovation in low-shedding, non-toxic materials.

3. **Support true circularity and prevent false solutions**

   Mandate increasing levels of fibre-to-fibre recycled content while preventing misleading recycled-content claims. Prohibit bottle-to-textile recycled polyester that undermines closed-loop food-grade polyester systems and does not reduce dependency on synthetic fibres.

4. **Strengthen environmental performance assessments**

   Revise the PEF methodology to include indicators on microplastic emissions, circularity, renewability and biodegradability, improving transparency and avoiding greenwashing – especially for products reliant on synthetic fibres.

5. **Curb overproduction and address textile waste**

   Implement robust extended producer responsibility schemes through the recently adopted WFD, with meaningful eco-modulation fees tied to the volume of products to discourage high-volume production. Strengthen controls on textile waste exports, including advancing amendments to the Basel Convention to require prior informed consent for textile waste shipments.

6. **Advance global action on plastic and microplastic pollution**

   Push for high ambition in the global plastics treaty, including binding measures to reduce virgin plastic production, limit synthetic polymer use, and address microplastic emissions throughout the textile life cycle.

7. **Ensure fair, enforceable rules on marketing and green claims**

   Adopt a strong Green Claims Directive and enforce regulations to prevent misleading or unsubstantiated sustainability claims, including those related to recyclability, recycled polyester from plastic bottles, and recycled-content percentages. Ensure proper market surveillance and enforcement.

Recommendations for citizens

1. **Buy fewer but better, avoiding plastic-based fibres:** choose good-quality, timeless pieces and avoid ultra-fast-fashion products made primarily from synthetics.
2. **Wash less and wash smarter:** lower temperatures, shorter cycles and full loads reduce shedding.
3. **Support brands that reduce synthetics** and invest in safe, low-impact fibres.
4. **Advocate for policy change,** adding your voice to calls for microplastic regulation and stronger oversight of fashion's environmental claims.

Annex I: Full research

AI. 1 Cotton-based fabrics

Cotton fabrics were tested with both washing approaches to understand how much fibre they shed.

In the GyroWash tests, the number of fibres released varied widely between products and brands. On average, cotton garments shed between 3,433 and 30,909 fibres per gram of fabric. The highest fibre counts were observed for Nike item (30,909 fibres/g), followed at a distant second by Shein (14,182 fibres/g). Even when averaging all cotton-based products within each brand, the highest overall fibre release in GyroWash was observed for Nike (17,439 ± 12,728 fibres/g), followed at less than half value by Shein (9,920 ± 4,114 fibres/g) and H&M (8,644 ± 4,511 fibres/g).

The results also showed clear differences in the average length of the released fibres, from as short as 0.4 mm (Adidas) to nearly 1 mm (Nike). This suggests that even fabrics with similar composition can behave quite differently, likely due to differences in yarn structure, weave, finishing or fabric weight.

When full garments were washed in the Wascator system, the total mass of fibres released ranged from 0.26 to 17.46 mg of fibres per gram of fabric. The highest value – 17.46 mg/g – was recorded for Nike (sample S40-2), whose mass release was higher than all other cotton-based garments tested. Nike also exhibited by far the highest average fibre mass loss (7.00 ± 9.13 mg/g), indicating greater mass-based shedding intensity than all other brands.

Considering the two datasets together, Nike consistently exhibits the highest shedding, whereas Zara ranks lowest in terms of fibre count, and Adidas ranks lowest in mass loss. This distinction highlights that 'number of fibres released' and 'mass of fibres released' do not always correlate directly (Pearson's correlation test, $p>0.05$, $r=0.575$, $n=12$), as shedding behaviour is strongly dependent on fibre fineness, fragment morphology and fabric construction.

However, the one-way ANOVA statistical test found no significant difference between brands. This means that, overall, all garments shed a similar number of fibres per gram of fabric, regardless of who made them. However, when comparing the length of the released fibres, the differences between brands were statistically significant. A follow-up test, Tukey HSD, showed that Nike and H&M tended to release longer fibres, while Adidas and Shein released shorter fibres. Zara fell in between, without a clear difference from either group

Table 1: Mean fibre count, length (GyroWash) and fibre mass release (Wascator) of cotton-based fabrics

Brand	Sample code	Fibre composition	Fibre count (fibres/g)	Fibre length (mm)	Mass (mg/g)
SHEIN	S01 (Top)	100% Cotton	6525.30	0.43	1.43
	S02 (Top)	100% Cotton	14182.19	0.50	1.63
	S03 (Dress)	82% Viscose / 18% Linen	9052.81	0.77	1.20
ZARA	S10 (Shorts)	95% Cotton / 5% Elastane	9609.67	0.53	1.49
	S11 (Sweater)	60% Recycled Cotton 40% Organic Cotton	3432.70	0.69	2.24
	S12 (Polo shirt)	100% Organic Cotton	3950.31	0.59	1.67
H&M	S22 (T-shirt)	100% Cotton	10983.98	0.90	3.17
	S23 (Top)	100% Cotton	12584.78	0.72	1.96
	S24 (T-shirt)	100% Cotton	3948.01	0.73	0.26
adidas	S33 (T-shirt)	100% Cotton	8169.32	0.40	0.84
	S34* (T-shirt)	100% Cotton			2.47
	S35* (T-shirt)	100% Cotton			0.33
NIKE	S39-2 (T-shirt)	100% Cotton	30909.41	0.76	2.89
	S41-2 (T-shirt)	100% Cotton	3968.23	0.94	0.65
	S40-2* (T-shirt)	100% Cotton			17.46

** Samples washed only in Wascator, because of the presence of printed regions or local structural variations (e.g., different weave pieces or coated/printed zones)*

The summarised results are presented in Table 3, which ranks the brands according to their average fibre release expressed as fibres per gram (fibres/g) for GyroWash and milligrams per gram (mg/g) for Wascator.

Table 2: Brand average fibre release (GyroWash & Wascator) of cotton-based fabrics

Brand	**Fibre count** (fibres/g)	**Fibre length** (mm)	**Fibre mass** (mg/g)
NIKE	17,439 ± 12,728	0.85 ± 0.19	7.00 ± 9.13
SHEIN	8,644 ± 4,511	0.54 ± 0.19	1.42 ± 0.29
H&M	9,920 ± 4,114	0.77 ± 0.18	1.80 ± 0.63
adidas	8,169 ± 10,857	0.40 ± 0.02	1.21 ± 0.37
ZARA	6,799 ± 2,914	0.56 ± 0.05	1.80 ± 0.38

Note: Values represent mean one standard deviation calculated from replicate measurements.

AI. 2 Virgin polyester-based fabrics

For polyester garments, only four out of the five selected brands could be assessed because no virgin polyester items from Zara were found for purchase through the brand's online store. In the GyroWash tests, only three brands were analysed, as Adidas samples were not from a uniform fabric and therefore not suitable for this method. They were instead tested only in the Wascator system.

The number of released fibres ranged from about 1,000 to over 20,000 per gram of fabric. The highest counts were recorded for Nike samples (21,469 fibres/g for a 100% polyester item). Lower shedding levels were found in Shein and H&M garments (below 7,000 fibres/g on average). The results suggest that polyester-elastane blends with a lower polyester content tended to shed fewer fibres than 100% polyester fabrics.

Using the one-way ANOVA to assess differences between brands, clothing from Nike released significantly more fibres than items from H&M and Shein ($p<0.05$). The difference between Shein and H&M was not statistically significant.

Table 3: Mean fibre count, length (GyroWash) and fibre mass release (Wascator) of virgin polyester-based fabrics

Brand	Sample code	Fibre composition (%)	Fibre count (fibres/g)	Fibre length (mm)	Mass (mg/g)
SHEIN	S04 (Top)	100% Polyester	2,802	0.52	0.42
	S05 (T-shirt)	95% Polyester / 5% Elastane	14,684	0.47	0.33
	S06 (Dress)	97% Polyester / 3% Elastane	3,307	0.48	0.37
H&M	S25 (Top)	89% Polyester / 11% Elastane	3,474	0.64	0.16
	S26 (Top)	90% Polyester / 10% Elastane	2,531	0.63	0.29
	S27 (T-shirt)	91% Polyester / 9% Elastane	3,863	0.45	0.29
	S32 (Shorts)	94% Polyester / 6% Elastane	1,081	0.38	0.18
NIKE	S43-2 (Shorts)	96% Polyester / 4% Spandex	19,047	0.65	0.22
	S44 (Shorts)	100% Polyester	21,469	0.61	0.19
adidas	S36* (Shorts)	100% Polyester	/	/	0.12
	S37* (Shorts)	100% Polyester	/	/	0.13
	S38* (Shorts)	100% Polyester	/	/	0.14

** Samples washed only in Wascator, because of the presence of printed regions or local structural variations (e.g., different weave pieces or coated/printed zones)*

The average fibre length varied between 0.38 and 0.65 mm. Nike and H&M shed longer fibres (on average 0.64 mm and 0.52 mm respectively). Nike's polyester fabrics released noticeably longer fibres, while Shein (0.48-0.52 mm) released the shortest. This indicates that even within the same fibre type, differences in knit structure, stretch content and finishing treatments can influence how fibres detach during washing. ANOVA testing for fibre length indicated that the average fibre lengths of shed particles varied significantly between the tested polyester garments.

The average fibre length was much smaller for polyester than cotton (two samples t-test, $p<0.05$). Cotton released longer fibres (0.40-0.94 mm, with an average of 0.66 mm), while polyester shed shorter ones (0.38-0.65 mm, with an average of 0.53 mm). Smaller fibres are far more likely to be inhaled and to reach the deepest parts of the lungs, unlike larger fibres that are usually trapped in the upper airways. Fine fibres can deposit in lower respiratory tissues, where they are more likely to trigger inflammation and long-term health effects. [91],[92]

In the Wascator tests polyester garments released smaller overall fibre masses than cotton. Shedding ranged from 0.12 mg per gram of fabric from an Adidas item to 0.42 mg per gram of fabric for a Shein item, several times lower than typical cotton results. Shein's polyester items released the most material (up to 0.42 mg/g), while Adidas consistently showed the lowest shedding levels (0.12-0.14 mg/g). Nike and H&M fell in the middle range.

However, mass alone is a poor indicator of environmental and health risk. As indicated above, environmental and health impacts tend to correlate more strongly with the number of fibres released rather than their total mass.[93]

The summarised results are presented in Table 5, which ranks the brands according to their average fibre release expressed as fibres per gram (fibres/g) for GyroWash and milligrams per gram (mg/g) for Wascator.

Table 4: Brand average fibre release (GyroWash & Wascator) of virgin polyester-based fabrics

Brand	Fibre count (fibres/g)	Fibre length (mm)	Fibre mass (mg/g)
NIKE	20,258.15 ± 9,097.60	0.64 ± 0.17	0.21 ± 0.02
SHEIN	6,930.94 ± 3,592.63	0.49 ± 0.07	0.37 ± 0.05
H&M	2,737.48 ± 1,177.45	0.52 ± 0.10	0.23 ± 0.06
adidas*	–	–	0.13 ± 0.01

** Samples washed only in Wascator, because of the presence of printed regions or local structural variations (e.g., different weave pieces or coated/printed zones)*

Note: Values represent mean one standard deviation calculated from replicate measurements.

These results suggest that while all polyester garments shed fibres to a similar extent, their structure and finishing influence the type of fibres released. Nike's fabrics tended to lose longer strands, which may reflect differences in yarn construction or fabric density, whereas Adidas and Shein materials produced smaller, shorter fragments that break off more easily during washing.

AI. 3 Recycled polyester-based fabrics

Tests on recycled polyester fabrics followed the same approach as for cotton and virgin polyester, using both GyroWash laboratory testing and Wascator domestic-scale washing.

In the GyroWash tests, recycled polyester garments showed much larger differences in fibre shedding between brands. As with virgin polyester, the ANOVA analysis confirmed that recycled polyester exhibited clear brand-specific variation in the number of fibres released during washing. The number of fibres released ranged from about 1,700 per gram of fabric from an item from H&M to over 50,000 per gram from Nike. The highest shedding levels were recorded for Nike (S48-2) and Adidas (S39-1), both of which released far more fibres than the other brands. H&M and Shein garments shed the fewest fibres, though this needs to be considered against the uncertainty about the composition of Shein's garments (see section 3.2.4).

The average length of released fibres was similar across most brands, typically between 0.32 and 0.50 millimetres. Nike tended to release slightly longer fragments, while others produced shorter ones. These small differences suggest that recycled polyester fabrics fragment in a fairly consistent way, regardless of brand, although construction and finishing still play a role.

Table 5: Mean fibre count, length (GyroWash) and fibre mass release (Wascator) of recycled polyester-based fabrics

Brand	Code	Fibre composition	Fibre count (fibres/g)	Fibre length (mm)	Mass (mg/g)
SHEIN	S07 (Top)	95% polyester 5% elastane (>90% recycled)	3,175	0.37	0.23
	S08 (Top)	100% recycled polyester	3,878	0.40	0.42
	S09 (Top)	100% recycled polyester	4,505	0.40	0.25
ZARA	S16-2 (Trousers)	100% recycled polyester	3,035	0.38	0.41
	S17-2 (shirt)	100% recycled polyester	6,794	0.36	0.21
	S18-2 (Top)	99% recycled polyester, 1% elastane	2,900	0.50	0.16
H&M	S28 (Top)	100% recycled polyester	8,372	0.49	0.10
	S29 (Top)	100% recycled polyester	22,954	0.32	0.20
	S30 (Top)	Recycled polyester 94%, elastane 6%	1,731	0.36	0.17
	S31 (Top)	Recycled polyester 87%, elastane 13%	2,101	0.39	0.23
adidas	S39-1 (T-shirt)	93% recycled polyester, 7% elastane	38,035	0.35	0.34
	S40-1* (Top)	100% recycled polyester	/	/	1.63
	S41-1 (T-shirt)	100% recycled polyester	14,998	0.38	0.52
NIKE	S47-2 (Top)	100% recycled polyester	10,573	0.49	0.12
	S48-2 (Top)	100% recycled polyester	50,971	0.36	0.41
	S45* (Top)	100% recycled polyester	/	/	0.13
	S46* (Top)	100% recycled polyester	/	/	0.69

**Samples washed only in Wascator, because of the presence of printed regions or local structural variations (e.g., different weave pieces or coated/printed zones)*

In the Wascator tests, the same general pattern was observed. Adidas and Nike again showed the highest mass-based fibre losses, ranging from about 0.3 to 0.5 milligrams of fibres per gram of fabric, while H&M and Zara released less (0.1-0.4 mg/g). Shein garments also showed moderate shedding levels, similar to Zara.

Table 6: Brand average fibre release (GyroWash & Wascator) of recycled polyester-based fabrics

Brand	Fibre count (fibres/g)	Fibre length (mm)	Fibre mass (mg/g)
NIKE	30,771.84 ± 20,565.54	0.43 ± 0.09	0.34 ± 0.21
adidas	26,516.68 ± 4,829.31	0.37 ± 0.02	0.83 ± 0.70
H&M	8,289.15 ± 7,140.77	0.39 ± 0.06	0.18 ± 0.05
ZARA	4,276.40 ± 3,071.89	0.41 ± 0.06	0.26 ± 0.11
SHEIN	3,519.24 ± 1,322.71	0.39 ± 0.02	0.30 ± 0.08

When averaged across all samples, Adidas and Nike consistently stood out as the biggest shedders among recycled polyester garments, both in terms of the number of fibres released and the total fibre mass lost. H&M ranked third in fibre count, while Shein showed the third-highest fibre mass loss, indicating moderate but still notable shedding levels.

Overall, these findings indicate that recycled polyester fabrics can shed substantial amounts of fibres during washing – often at levels higher than virgin polyester. The variation between brands likely reflects differences in fabric construction, yarn processing and finishing techniques.

AI. 4 Virgin vs. recycled polyester fabrics

When comparing virgin and recycled polyester fabrics, clear differences emerged in how they shed during washing. In the GyroWash tests, recycled polyester released about 55% more fibres as virgin polyester (12,430 vs. 8,028 fibres per gram). These fibres were also noticeably shorter on average (0.42 mm vs. 0.52 mm), indicating that the recycling process, which involves heat, mechanical stress and repeated reprocessing, shortens polymer chains and introduces surface defects that make fibres more brittle. As a result, recycled polyester fragments more easily into a larger number of smaller pieces.

In the full-scale Wascator washing tests, the total mass of fibres released was different between the two groups – 0.36 mg/g for recycled and 0.24 mg/g for virgin polyester. Most notably, recycled polyester released many more but smaller fibres, while virgin polyester shed fewer and longer fragments.

Scientific evidence consistently shows that smaller fibres pose far greater environmental and health risks. Fine particles are more easily inhaled and can reach deeper parts of the lungs, where they are more likely to trigger inflammation. In aquatic ecosystems, zooplankton and small benthic organisms ingest microplastics based on size. Smaller, shorter fibres – in this report typical of recycled polyester shedding – fall within the optimal ingestion range for many aquatic organisms. Numerous studies show size-dependent ingestion rates: the smaller the particle, the higher the ingestion frequency and the deeper the potential tissue penetration.[94] Because recycled polyester sheds more fibres – and because these fibres are smaller, more brittle and chemically more complex – the exposure risk is higher. This is why most microplastic toxicology studies – and nearly all ecotoxicological ingestion experiments – measure effects based on particle number, because organisms

interact with microplastics as individual particles.[95] Toxicity also increases as particle size decreases. Smaller fibres have a far higher surface area relative to their volume, enabling them to absorb more pollutants such as heavy metals, PAHs and persistent organic chemicals. [96]

The total mass released is also higher than for virgin polyester, posing a higher potential environmental and human health risk.

Recycled polyester adds another layer of concern: because it is made from mixed waste streams (e.g., bottles, packaging and lower-grade plastics), recycled polyester fibres often contain a wider 'chemical cocktail' of additives, dyes, plasticisers and degradation by-products that are not removed during recycling. These impurities are carried into the new textile fibres and then released into the environment when the material sheds. A 2025 study found that recycling plastic increases its toxic load: PET made with recycled content contains higher levels of volatile organic compounds and phthalates than virgin PET, with contamination rising as recycled content increases. The data shows a direct link between the intensity and complexity of recycling processes and the level of chemical pollutants found in the resulting material.[97]

Table 7: Comparison of GyroWash and Wascator data for virgin and recycled polyester

Type	Codes	Fibre count (fibres/g)	Fibre length (mm)
Virgin polyester	S04–S06, S25–S27, S32, S43-2, S44	776.85 – 21,468.95 (Mean: 7,623.50)	0.38 – 0.65 (Mean: 0.52)
Recycled polyester	S07–S09, S16-2–S18-2, S28–S31, S39-1, S41-1, S47-2, S48-2	1,731.30 – 50,970.77 (Mean: 12,430.14)	0.36 – 0.49 (Mean: 0.42)

AI. 5 Virgin polyamide-based fabrics

Our analysis of synthetic fibres focused primarily on polyester. However, we were unable to source predominantly recycled polyester items from Zara's online store, so instead tested recycled polyamide items – and, for comparability, also included virgin polyamide garments. Two items were tested in Gyrowash and four in Wascator.

Under laboratory GyroWash conditions, the two tested samples released relatively few fibres – approximately 1,200 to 1,900 fibres per gram – with short average fibre lengths of 0.63 to 0.71 mm, indicating that polyamide sheds less than any of the other fibre types tested.

Table 8: Fibre count, length (GyroWash) and fibre mass release (Wascator) of virgin polyamide-based fabrics

Brand	Sample code	Fibre composition (%)	Average fibre count (fibres/g)	Average fibre length (mm)	Mass (mg/g)
ZARA	S13 * (Cardigan)	47% Acrylic / 39% Polyamide /14% Polyester			0.10
	S16 * (Trousers)	92% Polyamide / 8% Elastane			0.05
	S17-1 (Top)	94% Polyamide /6% Elastane	1,889	0.712	0.09
	S18-1 (Top)	94% Polyamide /6% Elastane	1,240	0.630	0.10

**Samples washed only in Wascator, because of the presence of printed regions or local structural variations (e.g., different weave pieces or coated/printed zones)*

During full-scale Wascator washing, the total fibre mass released remained very low, 0.05 to 0.10 mg per gram of fabric. Overall, all polyamide-based Zara fabrics demonstrated consistently low shedding, with only small differences between samples.

This pattern may be explained by polyamide's higher flexibility and toughness compared with polyester, meaning fibres bend under mechanical stress rather than crack or fragment. Polyamide also has a lower density (≈1.14 g/cm), so even fibres of similar length weigh less, contributing to the lower mass-based release observed.

AI. 6 Recycled polyamide-based fabrics

In the GyroWash tests, recycled polyamide-based fabrics released between about 3,500 and 6,000 fibres per gram of material – significantly more than Zara's virgin polyamide fabrics. Fibre lengths were short and very consistent, around 0.36-0.39 mm, indicating similar fragmentation across samples.

In the Wascator tests fibre mass loss ranged from 0.13 to 0.30 mg per gram. Again, these values were roughly twice as high as those measured for virgin polyamide.

Table 9: Mean fibre count, length (GyroWash) and fibre mass release (Wascator) of recycled polyamide-based fabrics

Brand	Code	Fibre composition (%)	Fibre count (fibres/g)	Fibrelength (mm)	Fabricweight (g)
ZARA	S19 (Bodysuit)	93% recycled polyamide 7% elastane	3,555	0.393	113.46
	S20 (Bodysuit)	93% recycled polyamide 7% elastane	6,074	0.381	104.60
	S21 (Bodysuit)	93% recycled polyamide 7% elastane	5,770	0.359	102.74

AI. 7 Virgin vs. recycled polyamide comparison

When directly compared, recycled polyamide fabrics shed significantly more fibres than virgin fabrics in both testing systems. On average, recycled fabrics released about 3.3 times as many fibres in the GyroWash tests (5,133 fibres vs. 1,565 fibres per gram) and around twice as much fibre mass (0.20 mg/g vs. 0.08 mg/g) as virgin fabrics in Wascator washing. At the same time, the fibres released from recycled fabrics were shorter – roughly 0.38 mm compared to 0.65 mm – suggesting that recycling may reduce fibre strength or cohesion, making them more prone to fragmenting during washing.

Overall, recycling appears to increase fibre shedding in polyamide textiles, likely due to changes in fibre structure introduced during the recycling process.

Table 10: Comparison of GyroWash and Wascator data for virgin and recycled polyamide

Type	Codes	Fibre count (fibres/g)	Fibre length (mm)	Mass (mg/g)
Virgin polyamide	S13, S16, S17-1,S18-1	629.06 – 3519.64 (Mean: 1 564.50)	0.59 – 0.71 (Mean: 0.65)	0.05 – 0.10 (Mean: 0.08)
Recycled polyamide	S19–S21	3 261.09 – 8 833.78 (Mean: 5 133.20)	0.36 – 0.39 (Mean: 0.38)	0.13 – 0.30 (Mean: 0.20)

AI. 8 Comparative analysis: What our tests reveal about fibre shedding across materials

When comparing all fabric types — cotton, polyester (virgin and recycled) and polyamide (virgin and recycled) — clear differences emerge in how much fibre each material sheds and what kind of fibres are released. These patterns highlight how both fibre chemistry and production methods influence microfibre release during washing.

Overall shedding intensity

Recycled polyester stood out as the highest-shedding material, releasing on average more than 12,000 fibres per gram of fabric. Cotton came next, followed by virgin polyester, while both polyamide types shed far less overall. Recycled polyamide released roughly three times as many fibres as virgin polyamide, but both were well below cotton or polyester. The general order of shedding intensity was: Recycled polyester > Cotton ≈ Virgin polyester > Recycled polyamide > Virgin polyamide.

Fibre length and fragmentation

Cotton and virgin polyester tended to release longer fibres (around 0.5-0.6 mm), while recycled materials produced shorter fragments (about 0.38-0.42 mm). This suggests that recycling weakens the fibre structure, making them more brittle and prone to breaking into smaller pieces during washing.

Mass-based release

Although the number of released fibres was high, the total fibre mass of recycled polyester was less than that of cotton but more than that of virgin polyester. This indicates that synthetic recycled fibres tend to release a greater number of lighter and finer fibres, while cotton loses fewer but heavier fibres. The general order of shedding mass was: Cotton > Recycled polyester > Virgin polyester ≈ > Recycled polyamide > Virgin polyamide.

Overall pattern

Polyamide — whether virgin or recycled —showed the lowest shedding among all tested fabrics. Polyester, especially recycled polyester, released the most fibres overall, while cotton shed fewer but heavier fibres.

In practical terms, this means that recycled synthetics, particularly polyester, are more prone to generating microplastics during washing. Their tendency to fragment into many small, light fibres makes them a greater concern for microfibre pollution, even when the total mass released per wash is comparable to that of natural fibres like cotton.

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