

# Quantifying shedding of synthetic fibers from textiles; a source of microplastics

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**Introduction:** Sources, occurrence and fate of microplastics in the environment are a subject of intense research as they pose a potential threat to marine organisms. **Plastic fibers from textiles** have been indicated as a major source of this type of contaminant, entering the oceans via wastewater from washing machines.

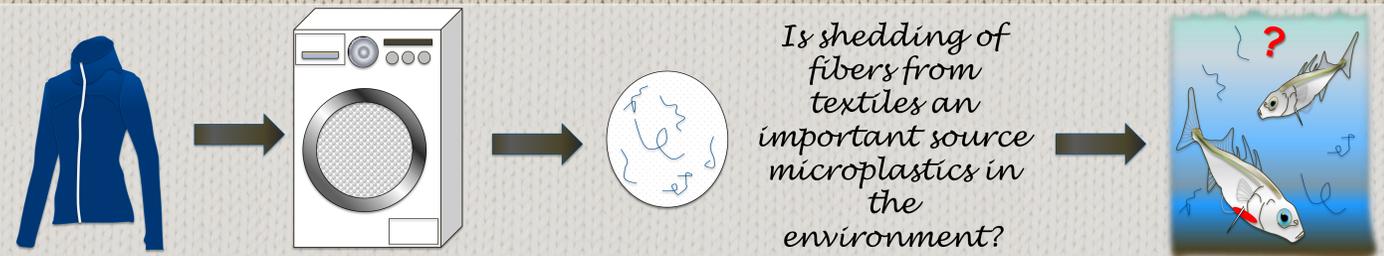
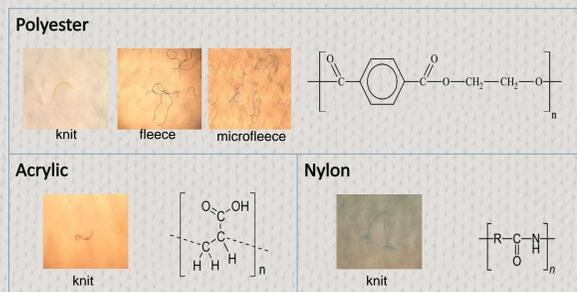
**Objective:** To quantify the amount of fibers shed from synthetic textile fabrics knit with different gauges and techniques.

**Materials and Methods:** We manufactured polyester, acrylic and nylon fabrics with different techniques. The fabrics differed in structure (knit or fleece), in knitting gauges (E18 or E28), and yarn structure (no. of filaments- 36 or 144, or staples). See **Table 1**. Fabrics were cut, dyed and washed according to standard procedures (SS-EN ISO 105-C06), using industrial growwashers. The number of fibers shed per wash was quantified following filtration through Whatman GF/C filters, pore size 1.2 µm. We also tested the importance of detergent in washing, changes in release of fibers with number of washes, and the effects of mechanical wear and tear of fabrics. n=6.

Polymer composition	Common name	Structure of fibers in textile	Abbrev.	Origin	Repolished / Worn	Washed without detergent
A	Polyethylene terephthalate	Knit (E18 100/36)	PET-1	SST	Yes	
B	Polyethylene terephthalate	Knit (E18 100/144)	PET-2	SST	Yes	
C	Polyethylene terephthalate	Knit (E28 100/36)	PET-3	SST	Yes	
D	Polyethylene terephthalate	Knit (E28 100/144)	PET-4	SST	Yes	
E	Polyethylene terephthalate	Knit, staple (E18 Nm 24/1)	PET-5	SST	Yes	
F	Polyacrylic	Knit, staple (E28 Nm 32/2)	A1	SST	Yes	Yes
G	Polyamide	Nylon Knit (E28 44/13/2)	N1	SST	Yes	
H	Polyethylene terephthalate	microfleece	PET-PMF	Polartech		Yes
I	Polyethylene terephthalate	microfleece	PET-TMF	Tenson		Yes
J	Polyethylene terephthalate	Fleece	PET-TFL	Tenson		Yes

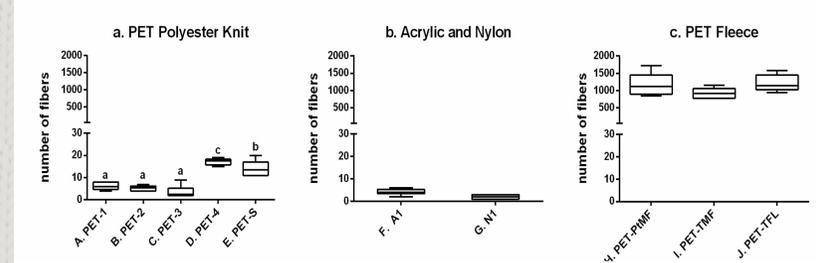
**Table 1:** Description of textiles used in this study. PET = polyethylene terephthalate (polyester), A= acrylic (polyacrylonitrile), N= nylon (polyamide), MF= microfleece, FL= fleece, Pt= Polar Tech, T= Tenson. Supplier of commercial fabrics are shown, SST = Swedish School of Textiles. The specifications describing the textiles indicate the knitting gauge, density and number of filaments in the fibers. Size of each fabric was 10 x 10 cm, n=6.

Growwashers and filtering apparatus.

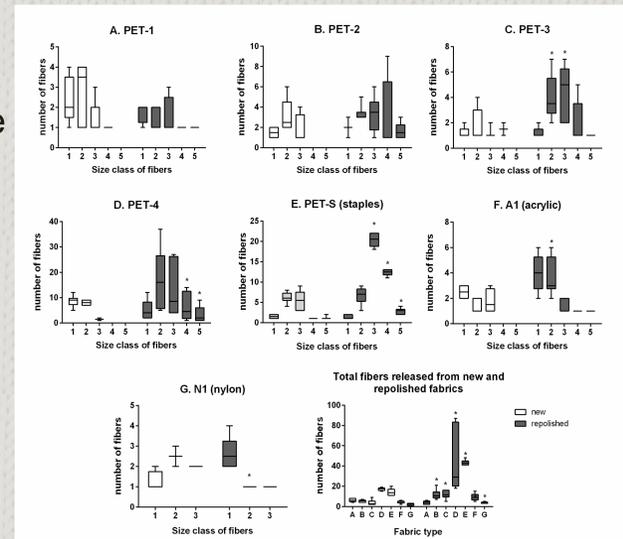


## Results:

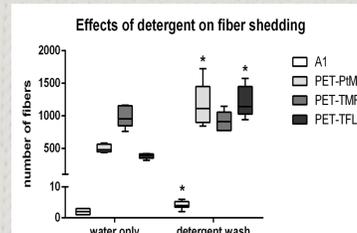
- All textile fabrics in the study were found to shed. Fig. 1. Polyester fabrics shed on average 87 fibers per m<sup>2</sup> /L/wash. **Polyester (micro)fleece shed an average of 7360 fibers per m<sup>2</sup> /L/wash or an estimated 110 000 fibers per garment.**
- Loose textile constructions shed more (see Fig.1, D. PET-4), as did worn fabrics. High twist yarns are to be preferred for shed reduction.
- Shedding increased with wear and tear. Fibers shed from fabrics differed in size, with some increases in shedding of longer fibers from worn fabrics (Fig.2).
- Tests showed a higher fiber loss when washing fabrics with detergent rather than without (Fig.3). The amount of fibers lost per wash decreased with consecutive washes (Fig.4).



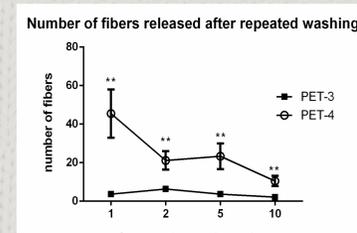
**Figure 1:** Total number of fibers released from 100 cm<sup>2</sup> of fabric per wash. Results are presented in box plots showing median, 25<sup>th</sup> and 75<sup>th</sup> percentiles, max and min. Different types of fabrics are divided into separate figures; note that y-axis scale is identical in all figures, to emphasize differences. a. five polyester (PET) fabrics of differing structure, b. acrylic (A1) and nylon (N1), c. three different polyester (PET) fleece (FL) or microfleece (MF) fabrics, commercially produced by Polar Tech (Pt) or Tenson (T). Statistically significant differences are indicated by letters (p<0.05). See Table 1 for more detailed descriptions of fabrics. n=6.



**Figure 2:** Total number of fibers released from 100 cm<sup>2</sup> of fabric per wash, using new and repolished (worn) fabrics: five polyester (PET) fabrics of differing structure, acrylic (A1) and nylon (N1). Results are presented in box plots showing median, 25<sup>th</sup> and 75<sup>th</sup> percentiles, max and min. Results are presented together in final graph for easier comparison; letters indicating fabric type correspond to the previous graphs in this figure and to Table 1. Size 1 = 0.025mm - 0.25 mm, size 2 = 0.25mm - 1 mm, size 3 = 1mm - 1.75mm, size 4 = 1.75mm - 3 mm, size 5 = >3 mm. Statistically significant differences between washes for each fabric are indicated by \*, (p<0.05). n=12. Note: y axes differ in scale.



**Figure 3:** Total number of fibers released from 100 cm<sup>2</sup> of fabric per wash, when fabrics were washed with water alone or with a commercially available detergent. Fabrics tested: acrylic (A1), and polyester (PET) fleece (FL) or microfleece (MF) fabrics, commercially produced by Polar Tech (Pt) or Tenson (T). Results are presented in box plots showing median, 25<sup>th</sup> and 75<sup>th</sup> percentiles, max and min. Statistically significant differences between washes (with or without detergent) for each fabric are indicated by \*, (p<0.05). n=6.



**Figure 4:** Number of fibers release after repeated washing from polyester fabrics knit with different gauges (PET-3, knit E28 100/36 and PET-4, knit E28 100/144). Results are presented as mean ± SEM. Statistically significant differences between number of fibers released from each fabric following the indicated number of washes are indicated by \*\* (p<0.01). n=6.

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## Take home message:

- PET fleece sheds an estimated 110 000 fibers per garment!**
- Shedding of fibers can potentially be mitigated via **smarter textile construction**.
- The results provide a strong indication that the shedding of fibers from clothing during washing is a potentially important source of microplastics.