Investigation on Emission of Fibrous Microplastic from Textiles through Household Laundry and its Reduction by Optimizing of Textile Parameter

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Introduction

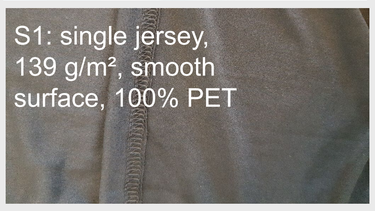
Microplastic is widely distributed in the environment and every year app. 950 kt microplastics enter the aquatic systems [1]. Textiles, especially from polyester (polyethylene terephthalate, PET, PES), were identified as the third biggest pollutant. Household laundry plays an important role in the emission of fibrous microplastics (FMP, fiber fragments < 5 mm) from textiles [2]. At the Research Institute for Textiles and Clothing at Niederrhein University of Applied Sciences (FTB), the release of FMP during household laundry was investigated and furthermore, construction and manufacture of textiles were optimized in order to reduce FMP emission as part of the BMBF joint project "TextileMission" [3].

Emission of Fibrous Microplastic during Household Laundry – Parameter Investigation

F1: plush knit, reversed plating, 180 g/m²
2 sides raised, gg 24, 100% PET

F7: double fleece, 370 g/m²
2 sides raised, pre-washed gg 22, 100% PET

F6: structured plush knit, 182 g/m², 1 side raised, gg 22, 55%PP/45%PET



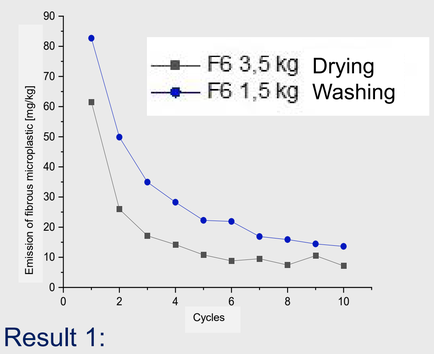
S1: single jersey, 139 g/m², smooth surface, 100% PET

F3: bonded fur knit,470 g/m², different gauges, 100% PET

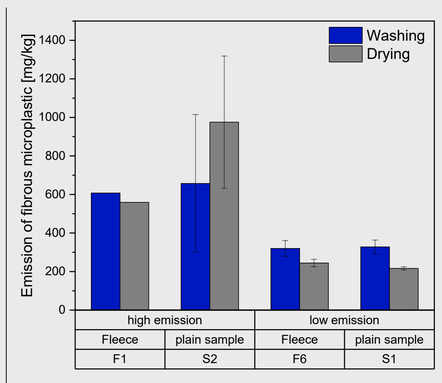
S2: double knit with tuck stitch structure, 149 g/m², smooth surface, 100% PET

23 textiles tested in >1050 washing experiments:

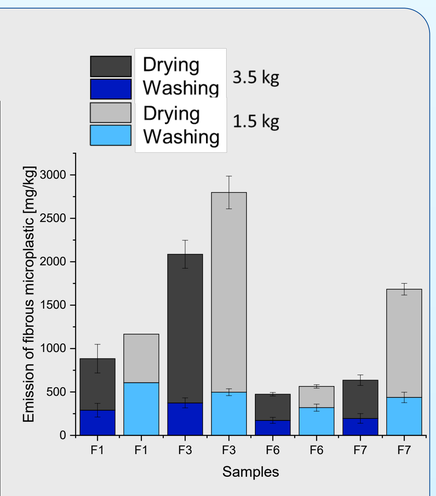
- washing, filtration of washing water
  - load (1.5 & 3.5 kg)
  - speed (900 & 1200 rpm)
  - ± softener
  - time
- drying: line drying or tumble dryer
- analysis: mass, µ-FTIR, TED-GC/MS



Result 1:
- FMP emission in range of 173 – 843 mg/kg textile, (accumulated over 10 washes) depending on textile and investigated parameter,
- highest FMP output within in the first two washes,
- textile production has large impact.

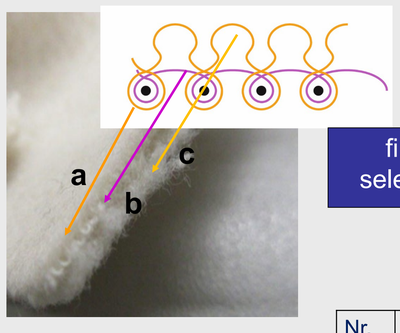


Result 2:
- Non-mechanically finished textiles are not always superior compared to mechanically raised fabrics.



Result 3:
- A high load in the washing machine can reduce FMP emission.
- A good cleaning effect is required.

Alternative Fiber Material for Fleece Production – Performance and Sustainability



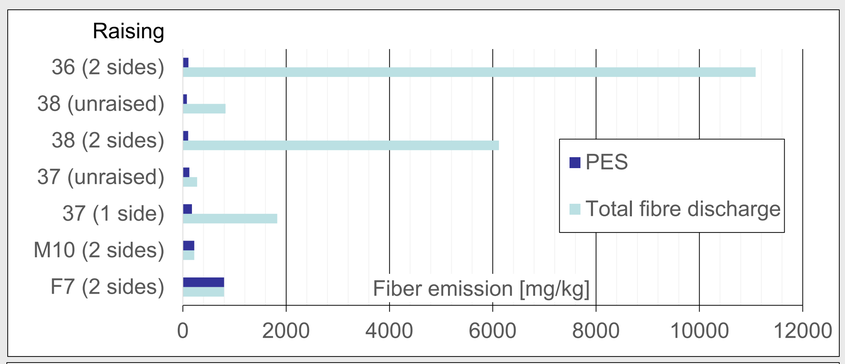
Layer construction of fleece material (single knit with plush reverse plating, 2 sides raised):
a: pile thread (regen. mat)
b: core thread (PES)
c: pile thread (regen. mat)

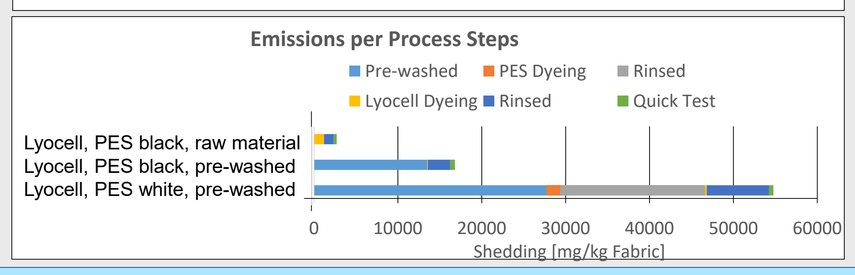
fiber selection → yarn production → textile production → analysis performance, washing

Nr.	Spinning	Material*		Rasing
36	Ring yarn :	TENCEL™ Lyocell + PES	336,4 g/m²	2 sides
37	Compact yarn	TENCEL™ Modal with eco color technology + PES	378,3 g/m²	1 side
38	Compact yarn	TENCEL™ Lyocell +PES	340,3 g/m²	2 sides
M10	100 % PES, own development			2 sides

*yarn count: Nm 40/1; PES: 100f80dtex, 34% in textile

performance parameter varied



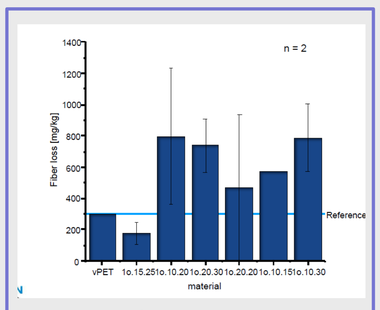


Results:
- Alternative textiles emit many fibers, but very few FMP from PES – less than commercial products (F7).
- FMP is emitted in every production / finishing step → often find in 1st wash at consumer

Textile Technology Research – Knitting and (Garment) Construction

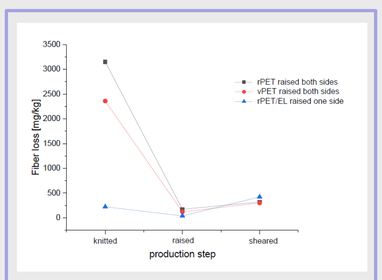
yarn selection
- 100% PES
- rPES
- titer variation (6x)
- variation of number of filaments

knitting
- lab scale
- industrial scale (31x)
  - yarn distribution
  - yarn tension
  - sinking depth (loop size)
  - knitting tension
  - fabric take down



Impact of loop size and fabric take down.

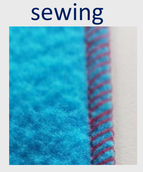
wet & mechanical treatment
- washing & dyeing
- raising
  - raising fillets
  - no. of passages
  - raising energy
  - rotation direction of rollers
  - fabric tension
- shearing



Impact of knitting process on fiber emission.

garment construction
- cutting
  - standard cutting
  - ultrasonic welding
  - laser cutting
- joining
  - sewing
  - ultrasonic welding

sewing



ultrasonic welding

mono material zero waste monitors

Summary and Conclusion

- Washing of commercial PES textiles reveal different amounts of FMP emission, depending on various parameter. Garment construction has inconsistent influence.
- Production and finishing processes of synthetic textiles led to FMP generation, mainly emitted in the first two washes at the consumers. Waste water treatment facilities in the producing countries should be taken in account.
- New developed garments with PES in the core thread and TENCEL Lyocell in der pile thread emit much lower amount of FMP than commercial textiles from pure PES with similar function parameter.
- Alternative textile construction technology of 100% PES monitors with sealed or covered edges showed reduced FMP emission.

References

[1] http://www.eunomia.co.uk/reports-tools/plastics-in-the-marine-environment/ (17.09.2021)
[2] Y.Q. Zhang et al., Microplastics from textile origin – emission and reduction measures. Green Chemistry 23, 5247-5271 (2021), DOI: 10.1039/d1gc01589c.
[3] Projektbroschüre: Textiles Mikroplastik reduzieren - Erkenntnisse aus einem interdisziplinäre Forschungsprojekt, Hrsg. Bundesverband der Deutschen Sportartikel-Industrie e.V. 2021, https://textilemission.bsi-sport.de/.

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