Microplastics from textile origin – emission and reduction measures

(Electronic Supplementary Information, ESI)

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S1. Estimation of the release of fibrous microplastics (FMPs) in textile washing in terms of "moderate scenario" of washing.

1. According to the studies in **Table 1** in the main text, FMPs released after the 1st wash cycle were summarised in the range of 0.0018 – 0.042% w/w (termed as **'x'**);

2. Calculate the amount of new synthetic textiles that are consumed and washed based on the annual fibre production in 2018 (**Figure 2** in the main text):

   a) the global production of fibres was 111 million tons (Mtons), in which 65% were synthetic fibres;

   b) of which a share of 67% was for clothing production;[1]

   c) 3 % loss of material between fibre and yarn; 6 % loss of material between textiles and finishing and garmenting;[1]

   d) global population: 7.9 billion.

Therefore,

the annual amount of new synthetic textiles that are consumed and experienced washing is assumed with the calculation:

(111 Mtons · 65% · 67%) · (1 - 3%) · (1 - 6%) ÷ 7.9 billion ≈ 5.5 kg new textiles/person

this value, as mentioned in the main text, was comparable to the estimated weekly washing load according to the general household washing practice in Germany, i.e., a person generates on avg. 5.0 kg/week[2]. Therefore, it was assumed that the amount of new textiles i.e., 5.5 kg/person is washed once every week.

Regarding the washing cycles and release, according to peer-reviewed studies, FMPs shedding decreased in maximum to approximately 1/4 (ref[3]), 1/10 (ref[4]), 1/20 (ref[5]) after the 4th, 5th and 10th of washing, respectively relative to the 1st washing, and usually after 10 cycles the release became constant[5]. Therefore, the released FMPs per year (**M**) can be estimated with the consideration as below:

Total FMP release (M) = release after the 1st washing + release from 2nd to 10th cycles + constant release after the 10th washing

Consequently, the consideration turned into an equation was established, for per 100,000 population, with:

$$M = [x'] + \left[\left(x' \cdot \sqrt[(4-1)]{1/4}\right) \cdot (4 - 2)\right] + [x' \cdot 1/4] + [x' \cdot 1/10] + \left[(x'/10) \cdot \sqrt[5]{\frac{1}{20} \div \frac{1}{10}} \cdot (5 - 1)\right] + [x' \cdot 1/20] + [(x' \cdot 1/20) \cdot (52 - 10)] \cdot 100{,}000 \text{ population}$$

where

a) the 7 terms in the equation (shown in []) indicate the FMP release, from the left to the right:

   - after the 1st wash cycle

   - release between the 1st and 4th washing, i.e., the 2nd and 3rd washing

- after the 4th washing

- after the 5th washing

- release between the 5th and 10th washing, i.e., the 6th,7th, 8th and 9th washing

- after the 10th wash cycle, and

- the release after 10 washing cycles for the following weeks in a year (constantly, a total of 52 weeks per year).

b) The term **x′**, i.e., FMP released after the 1st wash cycle, can be calculated using:

$$x' = x \cdot 5.5 \text{ kg/person}$$

for example, with the abovementioned release range obtained in **Table 1** (0.0018 – 0.042% w/w, **x**), it can be calculated:

- low release in the 1st washing:

$$x'_{low} = 0.0018 \text{ \%w/w} \cdot 5.5 \text{ kg/person}$$

- high release in the 1st washing:

$$x'_{high} = 0.042 \text{ \%w/w} \cdot 5.5 \text{ kg/person}$$

In sum, for each reviewed study in **Table 1** the amount of FMP shed from the 5.5 kg/person new textiles during the whole year of washing can be calculated, in a scale of 100,000 population (**M**). This leads to an overall range of 50.6 – 1180 kg/year/100,000 population.

S2. Estimation of the release of FMPs in textile washing in terms of "fast-fashion mode" of washing (i.e., "worst-case" scenario).

In this case, the new textiles (5.5 kg/person) were assumed to be washed once during use and subject to disposal. The annual amount of FMP release was calculated with:

$$x'_{low} = 0.0018 \text{ \%w/w} \cdot 5.5 \text{ kg/person} \cdot 52 \text{ weeks}$$

$$x'_{high} = 0.042 \text{ \%w/w} \cdot 5.5 \text{ kg/person} \cdot 52 \text{ weeks}$$

This leads to an overall range of 515 – 12,012 kg/year for per 100,000 population.

References

1   Ellen MacArthur Foundation, *A new textiles economy: Redesigning fashion's future*, 2017 (http://www.ellenmacarthurfoundation.org/publications).

2   A. Kruschwitz, A. Karle, A. Schmitz and R. Stamminger, *Int. J. Consum. Stud.*, 2014, **38**, 265–277.

3   M. R. Kelly, N. J. Lant, M. Kurr and J. G. Burgess, *Environ. Sci. Technol.*, 2019, **53**, 11735–11744.

4   M. Sillanpää and P. Sainio, *Environ. Sci. Pollut. Res.*, 2017, **24**, 19313–19321.

5   U. Pirc, M. Vidmar, A. Mozer and A. Kržan, *Environ. Sci. Pollut. Res.*, 2016, **23**, 22206–22211.