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Reliable quantification of microplastic release from the domestic laundry of textile fabrics

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ABSTRACT

This study explores the significant variation in test methods used to quantify microplastic release from the domestic laundry of textile fabrics. A wide review of the existing methods is made, with the important characteristics of these methods identified and assessed. This includes reviewing the type of washing apparatus, filtration methods, quantification metrics and the influence of fabric samples on the reported release of microplastics from domestic laundry. Based on this review, a new method for the quantification of microplastic release was developed using existing textile testing equipment. The reliability of the method to consistently assess microplastic release was validated through an inter laboratory study involving 10 independent globally distributed laboratories and a filter efficacy in excess of 99% demonstrated. The study showed the method has good inter and intra laboratory qualities, thus indicating this method can be considered robust and reliable. Importantly the method has the potential to provide a standardised method to allow direct comparison of results for different laboratories and for different fabrics with a high level of confidence.

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Mircoplastics; textiles; laundry; ocean pollution; quantification

Introduction

Media attention has led to a significant increase in academic, public and government attention on plastic pollution of the world's oceans, with numerous studies attempting to quantify the amount and identify the source of this plastic pollution. More recent academic research has concentrated on understanding the impact and scale of small plastic particles (<5 mm), commonly known as microplastics. Microplastics are of particular concern due to their potential for bioaccumulation, which increases with decreasing size (Barnes, 2002; Browne et al., 2008). They have the potential to be easily ingested by marine life and could, therefore, enter the human food chain with potential implications for human health (Forrest & Hindell, 2018; Rochman et al., 2015; UN Environment Programme, 2016; Wright & Kelly, 2017). Additionally, while microplastics may be inert in their original form, they commonly contain potentially harmful additives, such as softeners or antibacterial agents that could be released into the environment (Browne et al., 2013; Syberg et al., 2015), while also having the potential to adsorb harmful hydrophobic substances and subsequently become a vector in the transport of such contaminants to marine life (Sillanpää & Sainio, 2017; Teuten et al., 2009). Several researchers have indicated that a large proportion of microplastics are likely to be fibrous (Mathalon & Hill, 2014; Miller et al., 2017), with textile laundering being identified as a significant source of these fibres (Carney Almroth et al., 2018).

Although quantification of microplastic pollution from laundry has been investigated by numerous studies, the multitude and diversity of methodologies makes meaningful conclusions about the scale of impacts difficult to establish. For example, estimates of microplastic pollution from a garment during one domestic laundry cycle varies between 120 (Browne et al., 2011) and 700,000 microplastic particles (Napper & Thompson, 2016). Furthermore, the reliability and reproducibility of these methods have not been clearly assessed leading to additional questions regarding the robustness of estimates of microplastic release from domestic laundry.

This paper presents a comprehensive review of the challenges for accurately quantifying microplastic release from textile fabrics during domestic laundry. We also present a robust method for measurement of microfibre release that has been validated to demonstrate reliability and reproducibility *via* correlation testing with 10 independent global laboratories.

Literature review

The sources of microplastics have broadly been defined as primary, meaning direct input of microplastic sized particles, or secondary caused by fragmentation of larger plastic debris (Napper & Thompson, 2016; Pirc et al., 2016). Textiles, particularly the domestic laundry of clothing, have

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been identified as an important source of secondary microplastics. Synthetic textile microplastics have been found extensively in the environment including in marine sediments and terrestrial soil samples (Hartline et al., 2016; Mathalon & Hill, 2014; Miller et al., 2017) while it is important to note that cellulosic textile fibres have also been reported in large numbers (Miller et al., 2017; Sanchez-Vidal et al., 2018). Furthermore, microplastics consistent with materials used in clothing, such as polyester, acrylic, and polyamide, are regularly reported in high concentrations downstream of water treatment facilities (Eriksen et al., 2013; Hoellein et al., 2014) indicating that the standard filtration of waste water is not always effective in stopping microplastics from domestic laundry reaching ocean ecosystems. Despite multiple research studies to investigate the scale of textile microplastics from domestic laundry, the true importance of textiles as a microplastic source is not well understood. Some researchers suggest that textiles is the most important source of microplastics, responsible for 500,000 tonnes per year, while other studies suggest textiles as only a marginal contributor to ocean plastic pollution (Jönsson et al., 2018).

Numerous studies have developed different methodologies to quantify microplastic pollution from domestic laundry and Table 1 provides a summary of these methods.

Washing apparatus: domestic washing machines

In general, methods used to quantify microplastic release can be divided into two broad categories; washing machine methods and gyrowash methods.

The use of domestic washing machines to assess microplastic release is an obvious choice and those studies based on this option have used commercially available front or top loading domestic washing machines (Belzagui et al., 2019; Browne et al., 2011; Cotton et al., 2020; De Falco et al., 2019; 2020; Hartline et al., 2016; Karlsson, 2015; Napper & Thompson, 2016; Pirc et al., 2016; Sillanpää & Sainio, 2017). However, there are a number of limitations associated with using domestic washing machines to analyse microplastic release.

The type of domestic washing machine used, front or top loading, has an influence on the microplastics generated during the laundry process. Hartline (2016) compared microplastic release from a front-loading washing machine with a top loading machine. Using controlled conditions for both machines, the top loading machine was found to release of 47.7 mg of microplastics compared to 7.3 mg from the front-loading machine per garment per wash: a 6-fold difference in microplastic release.

There is a very wide selection of makes and models of domestic washing machines, all with different machine and washing characteristics. The level of agitation and friction within the washing process is considered to be a major factor affecting the quantity of microplastic release. (Kelly et al. (2019) investigated the effect of agitation and water volume on the number of microplastics released from a single laundering cycle and showed increased levels of agitation resulted in a greater release of microplastics, as did using larger volumes of water in the washing process. Agitation is a function of drum size and configuration, rotation speeds and wash cycle details. Agitation can be increased when washing loads are small relative to the drum capacity, and when the load is large relative to the drum capacity, there is less movement and therefore, less friction (Mac Namara et al., 2012; Yun & Park, 2015). Similarly, the wash liquor ratio (ratio of water volume to mass of fabric) influences friction and therefore, microplastic release. Spin speeds will also influence the level of agitation and microplastic generation. Where spin speeds were stated, the studies in Table 1, showed they varied from 600 rpm (Browne et al., 2011; Pirc et al., 2016) to 1400 rpm (Napper & Thompson, 2016).

Furthermore, due to use of simple control units in domestic washing machines, the consistency and reproducibility of spin speeds, water intake/outflow and cycle duration is often poor. As these factors have a major impact on microplastic release, a test method based on using these machines will be inherently inconsistent. Poor consistency of domestic washing machines has led to development of laboratory grade washing machines, such as a Wascator, which are used in standards such as BS EN ISO 6330 (2012). These offer greater control and consistency of washing factors, however, none of the methods in Table 1 used machines such as the Wascator.

From a practical perspective, the use of domestic washing machine, and even Wascator type machines, has two further drawbacks. Firstly, to replicate a 'standard domestic wash load' implies each experiment should use 3–5 kg of test fabric. To facilitate repeat testing for statistical analysis, multiple wash samples would result in the use of hundreds of kilograms of fabric. Secondly, a complete wash cycle creates a significant volume of effluent. Where stated, the volume of effluent collected in the reviewed studies ranged from 22 litres (Belzagui et al., 2019) up to 136 litres (Hartline et al., 2016). The variation in wash liquor ratio impacts the test results as already discussed, but the large volume of wash effluent creates very significant practical challenges for filtration and for repeat testing for statistical analysis. Most of the reviewed studies using washing machines did not assess the total effluent discharge but sampled smaller aliquots of liquid for subsequent filtering and analysis. This approach assumes a homogenous distribution of fibres in the effluent during the washing cycles and within the storage containers for the effluent.

A further practical challenge for washing machines is the complex nature of the machines themselves, with sealed units containing large surface areas and inaccessible pipework, making it very difficult to determine if all microplastics released by the fabric are captured in the effluent. All reviewed studies included a cleaning cycle between each test in an attempt to remove any residual microplastics in the machine.

Washing apparatus: gyrowash

A growing number of studies have used gyrowash based methods to replicate domestic washing in an attempt to minimise experimental variables (Carney Almroth et al., 2018; De Falco et al., 2018; Haap, 2019; Hernandez et al.,

Table 1. Measurement of microplastic loss from the domestic laundering of textiles: literature comparison.

Author	Washing method	Temp. (°C)	Time (min)	Agitation (no. ball bearings)	Liquor Ratio	Sample material	Sample type	Filter size (μm)	Microplastic release
Browne et al. (2011)	Washing machines	40	NS	NS	NS	Polyester	Garment	NS	>1900 particles/wash
Dubaish and Liebezeit (2013)	Not stated (NS)	NS	NS	NS	NS	Polyester	Garment	NS	220–260 mg/garment
Karlsson (2015)	Washing machines	40	NS	NS	NS	Mixed load	NS	1.2	NS
Mermaids (2016b)	Washing machines and gyrowash	30, 40, 60, 75	45, 60	0, 10, 50	NS	Polyester, polyamide, acrylic, polypropylene, poly-cotton	Garment and fabric	0.1, 0.2, 5, 30, 40	Polyester: 11,000 particles/wash or 7 mg)/wash Polyamide: 2500 particles/wash or 2.35 mg/wash Acrylic: 4000 particles/wash or 2.5 mg/wash
Napper and Thompson (2016)	Washing machines	30, 40	75	NS	NS	Polyester, acrylic, poly-cotton	NS	25	Poly-cotton: 137,951 fibres/6 kg wash Polyester: 496,030 fibres/6 kg wash Acrylic: 728,789 fibres/6 kg wash
Pirc et al. (2016)	Washing machines	30	15	NS	NS	Polyester	Fabric	200	11,300 particles/500g of fabrics or 6 mg/500g fabric
Hartline et al. (2016)	Washing machines	30, 40	30, 48	NS	NS	Synthetic	Garment	333, 20	220 mg/30 garments or 1906 mg/ 40 garments
Hernandez et al. (2017)	Gyrowash	25, 40, 60, 80	14, 60, 120, 240, 480	10	7:1 l/m^2	Polyester, polyester-spandex	Fabric	0.45	NS
Sillanpää and Sainio (2017)	Washing machines	40	75	NS	NS	Polyester, cotton	Garment	0.7	Polyester: 223,000 particles/wash or 340 mg/wash Cotton: 978,00/wash or 809 mg/wash
Carney Almroth et al. (2018)	Gyrowash	60	30	25	13:1 l/m^2	Polyester, acrylic, nylon	Fabric	1.2	Fleece: 110,000 fibres/garment/wash Knit: 900 fibres/garment/wash
De Falco et al. (2018)	Gyrowash	40, 60	45, 75, 90	0, 10, 20	NS	Polyester, polypropylene	Fabric	5	Polyester: >6,000,000 fibres/ 5 kg wash
Jönsson et al. (2018)	Gyrowash	40	60	25	5:1 l/m^2	Polyester and recycled polyester	Fabric	0.65	NS
Belzagui et al. (2019)	Washing machines	Ambient	15	NS	NS	Polyester, polyester-elastane, acrylic-polyamide	Garment	20	Polyester-elastane: 175 fibres/g/wash or 30,000 fibres/m^2/wash Acrylic polyamide: 560 fibres/g/ wash or 465,000 fibres/g/wash
De Falco et al. (2019)	Washing machines	40	107	NS	NS	Polyester, recycled polyester, polyester-cotton-modal	Garment	400, 60, 20, 5	Polyester: 640,000–1,100,000 fibres/ garment/wash Poly-cotton-modal: 1,500,000 fibres/garment/wash
Haap et al. (2019)	Gyrowash	40	30	50	6:1 l/m^2	Polyester-cotton	Fabric	NS	NS
Kelly et al. (2019)	Washing machines and gyrowash	30, 15	60, 15	NS	120:1 l/m^2 and 240:1 l/m^2	Polyester	Garment and fabric	22	Standard wash: 663,523 fibres/kg/ wash Delicate wash: 1,474,793 fibres/ kg/wash
Yang et al. (2019)	Washing machines	30 ,40, 60	15	NS	17:1 l/m^2	Polyester, polyamide, acetate	Fabric	5	Acetate: up to 74,816 fibres/m^2/wash Polyester: up to 72,130 fibres/ m^2/wash
Zambrano et al. (2019)	Gyrowash	25, 44	16	25	15:1 l/m^2	Cotton, rayon, polyester, polyester-cotton	Fabric	1.2	NS
Cotton et al. (2020)	Washing machines	25, 40	30, 85	NS	NS	Cotton, polyester, poly-cotton-rayon	Garment	22	NS
De Falco et al. (2020)	Washing machines	40	107	None	NS	Polyester, polyester-cotton	Garment	400, 60, 20, 5	Poly-cotton: 3898 fibres/g/wash Polyester: 709–1747 fibres/g/wash

2017; Jönsson et al., 2018; Kelly et al., 2019; Mermaids, 2016a; Zambrano et al., 2019). Gyrowash devices have been recommended for many years for use in international standards for assessing textile colour fastness to laundering using test methods such as ISO 105-C06 (BS EN ISO 105-C06, 2010) and ISO 105-C12 (ISO 105-C12, 2004). They consist of a heated water bath containing a rotating shaft that supports, radially, a number of stainless-steel canisters. The canisters contain the test sample in a liquor with a prescribed number of stainless-steel ball bearings that replicate in-wash agitation and abrasion.

The main advantage of using a gyrowash based method is the greater control and repeatability of test conditions. Parameters such as water volume and temperature, rotation speed, and wash duration can be set far more accurately than for domestic washing machines. In addition, the entirety of the test liquor can be filtered and analysed, reducing potential errors or uncertainty in results.

There is existing work that suggests that the gyrowash approach can replicate domestic washing results for microplastic release. Kelly et al. (2019) and Zambrano et al. (2019) compared microplastic release from gyrowash testing and from domestic washing machines, with both reporting general agreement between the gyrowash results and domestic washing machine.

Gyrowash methods do have limitations. The small canister size means full scale garments cannot be tested, only fabrics swatches can be tested, so gyrowash devices assess material losses from fabrics not garments.

Filtration methods

Although nearly all reviewed studies utilised vacuum-assisted filtration in order to collect microplastics from the test liquor, the specific size and type of filters varied.

Cascade filtration was used by a number of research groups (De Falco et al., 2019; 2020; Hartline et al., 2016) to determine the size distribution of microplastic released. De Falco et al. noted, most microplastics particles were collected on the 60 µm filters, indicating that a majority of the microplastics were in the range of 60–400 µm (De Falco et al., 2019; 2020).

Several studies used either cellulosic (Cotton et al., 2020; Kelly et al., 2019) or polyamide-based (Belzagui et al., 2019; De Falco et al., 2019; 2020; Hartline et al., 2016; Napper & Thompson, 2016) filters which all had a pore size of around 20 µm.

Glass fibre, PVDF, or PTFE filters were used in other studies and these tended to comprise pore sizes ranging from 0.1 to 5 µm (Carney Almroth et al., 2018; De Falco et al., 2018; Jönsson et al., 2018; Karlsson, 2015; Mermaids, 2016a; Sillanpää & Sainio, 2017; Yang et al., 2019; Zambrano et al., 2019). The smaller pore sizes ensured the capture of smaller particles, and hydrophobic nature of these filters ensured moisture regain of the filters did not influence measurements. It is of interest to note that none of the studies reviewed reported any validation of filter efficacy to show that the filters capture all microplastic particles released during testing.

Quantification of microplastics

Microplastic release was quantified in one of two ways. Some studies quantified microplastic release by counting fibres on the filters (Belzagui et al., 2019; Carney Almroth et al., 2018; De Falco et al., 2018; Hernandez et al., 2017; Jönsson et al., 2018; Mermaids, 2016a; Napper & Thompson, 2016; Sillanpää & Sainio, 2017; Yang et al., 2019), others chose to measure the mass of microplastics (Cotton et al., 2020; De Falco et al., 2019; 2020; Kelly et al., 2019; Pirc et al., 2016; Sillanpää & Sainio, 2017; Zambrano et al., 2019).

Counting microplastics is a time-consuming approach. Apart from Hernandez et al. (2017) who counted all microplastics on the filters, most studies tended to count from selected areas of the filter considered to be representative of the whole filter (De Falco et al., 2018; 2019; Mermaids, 2016a; Napper & Thompson, 2016). This approach assumes a homogenous distribution of fibres across the filter area. In addition, manual counting of fibres leaves considerable potential for counting errors especially as microplastics are often in fibrous form and are intertwined with each other across a 3-dimensional spaghetti-like structure.

The mass of microplastics collected on the filters was expressed as an absolute mass of microplastics or as a percentage relative to the sample mass. Although an accurate assessment release, the weight of microplastics does not provide a direct correlation to the number of particles and therefore, potential harm to the environment.

Fabric selection

Finally, in addition to choices for the test method, filters and metric for quantification, the fabrics under test also vary significantly between studies. The majority of studies tested synthetic materials, with several focussing exclusively on polyester (Browne et al., 2011; Dubaish & Liebezeit, 2013; Hernandez et al., 2017; Jönsson et al., 2018; Kelly et al., 2019; Pirc et al., 2016). Other studies included a range of materials and blends including polyamide, cotton, acrylic, modal, rayon and recycled polyester.

Typically, the focus of these studies tended to be only the fibre composition with little attention paid to the fibre properties, yarn type and structure, fabric construction, fabric weight, and any fabric finishes, such as brushing or pre-pilling.

A number of studies used cut fabric specimens (Carney Almroth et al., 2018; De Falco et al., 2018; Haap, 2019; Hernandez et al., 2017; Jönsson et al., 2018; Kelly et al., 2019; Mermaids, 2016a; Napper & Thompson, 2016; Yang et al., 2019; Zambrano et al., 2019). Most studies opted to seal cut edges by sewing methods. Zambrano et al. (2019) used an overlock stitch sewn with polyester thread but did not state if this thread was staple or filament; staple thread is more likely to release microplastics. Several studies used

cotton threads (De Falco et al., 2018; Mermaids, 2016a; Yang et al., 2019), presenting challenges for analysis as the thread would release material that may be interpreted as microplastics. Napper and Thompson (2016) and Hernandez et al. (2017) did not specify the type of thread used. None of these studies specified the stitch type used. Some studies laser cutting (Carney Almroth et al., 2018; Kelly et al., 2019) or ultrasonic welding (Jönsson et al., 2018) to seal edges with Haap (2019) using textile glue.

A new test method for fabric assessment

To maximise reliability, reproducibility and practicality for sample size and test liquor volumes, a gyrowash device (James Heal Gyrowash 1615/8) was used for the test method described in this study. This machine has an established history as a reliable device to replicate domestic laundry conditions and is used in a very wide range of textile laboratories worldwide. To allow testing of large fabric samples, 1500 ml canisters, as specified in AATCC Test Method 61, were used (AATCC TM61, 2013).

Samples were tested in the gyrowash and the resultant liquor was filtered using a vacuum-assisted single stage process to collect microplastic particles.

Filter type and efficacy

The lower size limit for microplastics is poorly defined, with studies suggesting a range of particle sizes. Several studies defined microplastic fibres as being between 100 µm and 5 mm in length (Barrows et al., 2017; Miller et al., 2017) although one study found fibres as short as 15 µm (Frias et al., 2010). This suggests to quantify microplastic release the selection of filter pore size is very important. The determine the filter pore size, filter efficacy for capturing microplastic particles from a control liquor was assessed.

To avoid issues associated with moisture regain, glass fibre filters were selected for this study. It was noted that the multi-layered structure of glass fibre filters created a complex 3-dimensional matrix that would impede the migration of fibre fragments through the filter, thereby increasing filter efficacy (Lykaki et al., 2019). Glass fibre filters also tend to have a relatively high filtering speed compared to other filter types.

The control liquor consisted of 0.2 g of black dope-dyed filament polyester, of diameter 11 µm, manually cut into lengths between 2 mm and 5 mm, mixed with 360 ml of distilled water. Liquor samples were processed in the gyrowash at 90 °C, for 60 min using 50 ball bearings to simulate a very harsh laundry cycle, in an attempt to maximise the generation of microplastic fragments. The resultant test liquor was then filtered through glass fibre filters to assess their efficacy for capturing the polyester fragmentations.

An initial pre-selection assessment using 0.7 µm and 1.6 µm filters demonstrated an efficacy of 98–99%; the mass of material collected on the filter was up to 99% of the mass of material in the test liquor. A more detailed assessment of filter efficacy for these two pore sizes, using 20 test liquor samples for each filter was completed. The 1.6 µm filter demonstrated very good filter efficacy, capturing 99.4% of the polyester fragments, similar to the 0.7 µm filter, but filtering speeds were significantly quicker using this pore size. Also, the 1.6 µm filter had a lower coefficient of variation and was, therefore, selected for this method.

Specimen preparation

The test method was designed to assess the microplastic release from a fabric, but to minimise the impact of microplastic release from raw edges of the fabrics. To determine the edge sealing technique for the method, laser cut, scissor cut and overlocked, and scissor cut and overlocked with lock-stitch edges, were assessed and compared to raw scissor cut edges.

Edge sealing trials were conducted using the same 100% polyester fleece fabric (200 g/m^2) and 20 denier nylon filament sewing thread; a filament thread was used to minimise microplastic release from the sewing thread. Samples were washed in the gyrowash using a wash temperature of 40° C, for 60 min in 360 ml of distilled water, with mechanical agitation generated by 50 stainless steel ball bearings. 8 test samples per sealing technique were assessed.

The quantity of material released from the fabrics during washing was calculated using the following equation:

$$\text{Fibre release} = \frac{Fm_2 - Fm_1}{Sm_1} \times 100$$

where

Fm_1 is the oven dry mass, in grams, of the filter assembly prior to testing,

Fm_2 is the oven dry mass, in grams, of the filter assembly after testing (including any material collected by the filter),

Sm_1 is the oven dry mass, in grams, of the fabric specimen prior to testing.

Figure 1 shows the mean and 95% confidence interval for microplastic release for each edge sealing technique compared to the raw scissor cut edge specimens. The scissor cut edge had the highest mean microplastic release (0.15%), closely followed by the overlock technique (0.14%). This indicates that loose fibres from the scissor cut edge were able to migrate through the overlock stitches during the gyrowash process. The laser cut technique was only marginally better at reducing microplastic losses from the cut edge. However, overlocking with the addition of lock-stitching produced the lowest microplastic release (0.059%), suggesting the extra security of lock-stitching reduces microplastic losses from the scissor cut edge. Therefore, to minimise the influence of edge losses on microfibre release results, the over lock plus lock stitch edging techniques was selected for this method.

Method validation

To determine the repeatability and reproducibility of this method, an interlaboratory study was conducted in accordance with ASTM E691-18 (ASTM E691-18, 2018), a

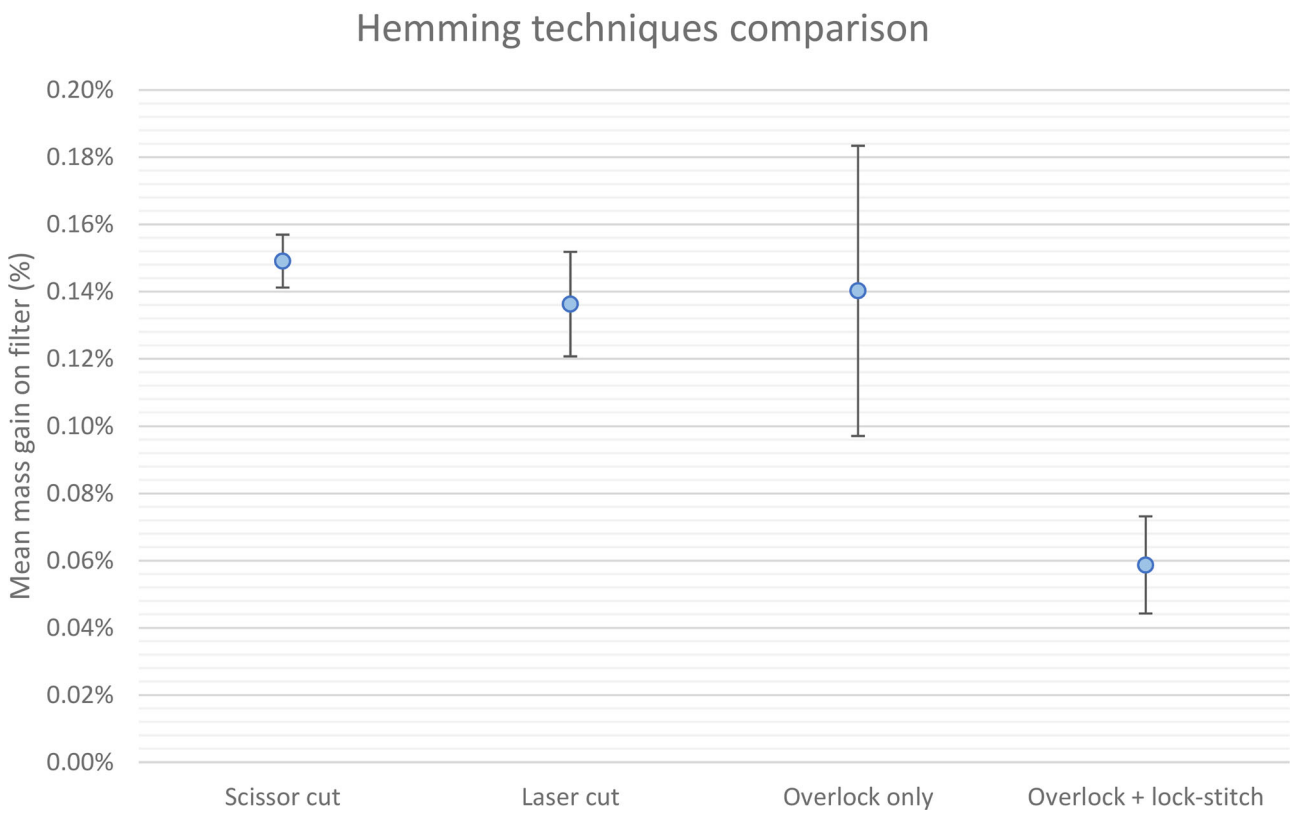

Figure 1. Edge sealing techniques comparison.

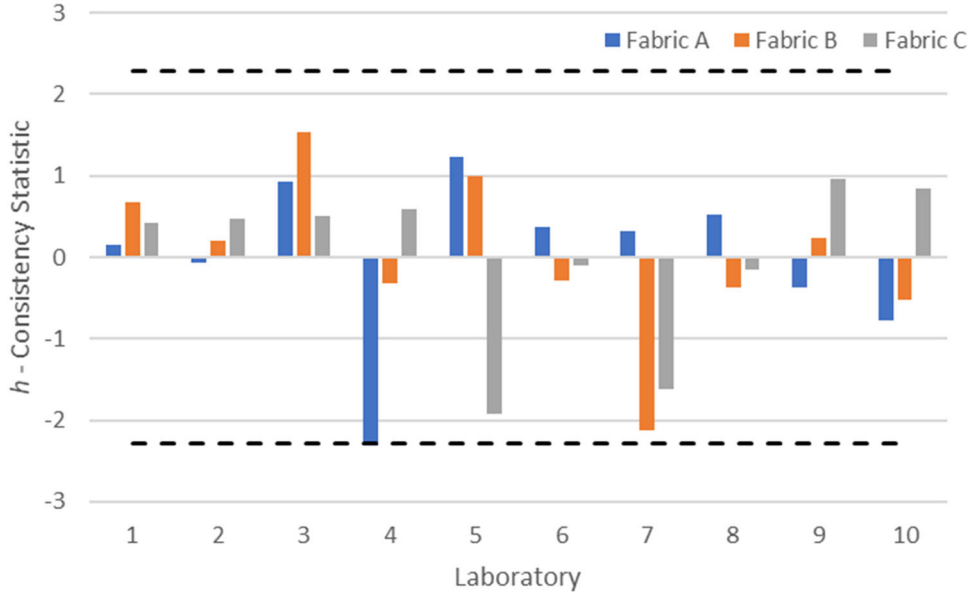

Figure 2. The inter laboratory *h* statistics.

standard technique to determine the precision of a test method by conducting an interlaboratory study (ILS). ASTM E691 requires a minimum of 6 laboratories to be included in the ILS for the results to be considered satisfactory. For this study 10 laboratories testing three different fabrics were used for the ILS. These laboratories were located in Europe, the USA, and Asia and were a mix of academic, industrial and commercial facilities.

24 samples of three different fabrics (Fabric A: 100% filament polyester fleece, 280 g/m^2; Fabric B: 100% filament polyester double knit with brushed back, 240 g/m^2; Fabric C: 100% filament polyester single jersey, 140 g/m^2), prepared using the overlock/lock-stitch edge seal, were sealed in plastic bags to minimise contamination and sent to each laboratory. Samples were washed using the gyrowash method at 40 °C for 45 min in 360 ml of distilled water with 50 ball

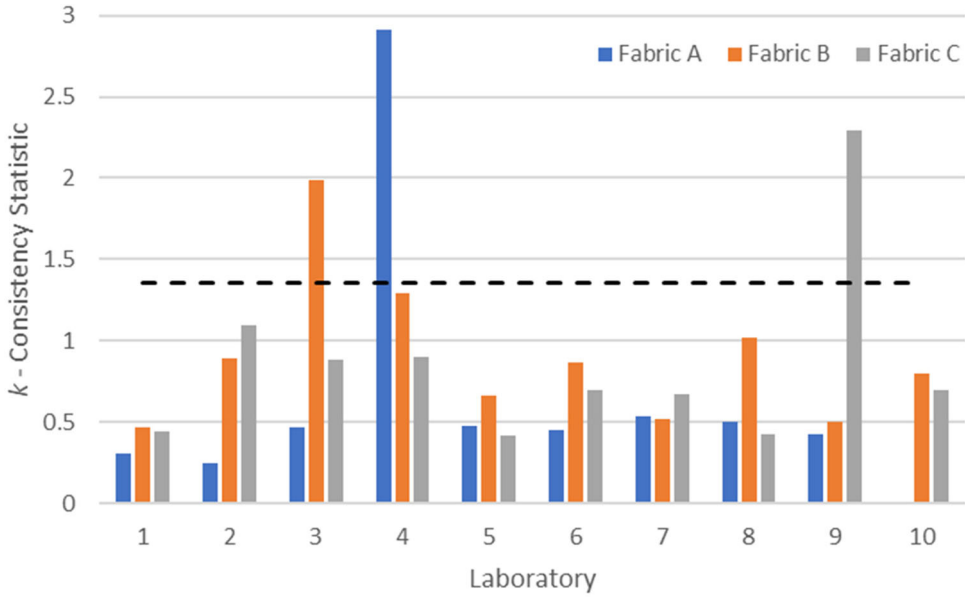

Figure 3. The intra laboratory *k* statistics.

bearings, followed by vacuum filtration through 1.6 µm glass fibre filters.

The data was collected and analysed to determine the Mandel's *h* and *k* statistics (representing the inter and intra laboratory variances respectively) (ASTM E691-18, 2018). Critical values at the 0.5% significance level were obtained using equations X1.9 (*h*) and X1.13 (*k*) from ASTM E691-18 (ASTM E691-18, 2018).

Figure 2 shows the inter laboratory *h* statistics, the dashed line represents the critical value. An extreme value, exceeding the critical limit, may indicate a laboratory exhibits a pattern of results markedly different to other laboratories (Bratinova, 2009). With only one result (Fabric A for Lab 4) exceeding the critical value, this analysis indicates there is very good inter laboratory reproducibility for the test method.

The *k* statistics, representing the intra laboratory variances, are shown in Figure 3. Results over the critical value indicate that an individual laboratory has a poorer repeatability precision compared to the other laboratories in the study. Of the 30 tests, only three results exceed the critical value, therefore these intra laboratory results are also a very positive indication of the reproducibility of the test method.

The results for inter and intra laboratory reproducibility strongly suggests the test method presented here is robust and has a very good potential to be both repeatable and reproducible. This is a major finding and shows microplastic releases results from different laboratories can be compared with concerns about reproducibility or reliability associated with inter and intra laboratory variations being significantly minimised compared to other methods previously published.

Conclusions

There have been a large number of studies investigating microplastic release from textiles during domestic laundry. However, with a wide range of methods being employed in these studies, estimates of microplastic pollution released during domestic laundry are inconsistent and results from these studies can not be compared. Furthermore, the reliability of these methods is poorly understood leaving them open to questions regarding reproducibility.

The method presented here uses simple, but well established, textile testing equipment, that provides accurate quantification of microplastic release. The efficacy of filtration has been demonstrated to be in excess of 99% and the influence of edge sealing has been minimised through the use of effective edge seaming. Importantly, the reliability and reproducibility of the test method has been demonstrated through a thorough inter laboratory validation exercise. This method now provides an opportunity for the creation of a standard for the quantification of microplastics release from the laundry of textile fabrics and is currently being considered as the basis for such a standard by the several European and international standards bodies.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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