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RELEASE OF MICROPLASTICS WHEN WASHING MICROFIBRE MATERIALS

RELEASE OF MICROPLASTICS WHEN WASHING MICROFIBRE MATERIALS

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PREFACE

The research that is presented confirms what we could reasonably have assumed: During the washing process of microfibre cloths, fibre loss occurs, which means that synthetic fibres and microplastics will end up in the environment and in particular in surface water.

Whether this contribution is large or small, significant or negligible cannot be concluded from this report. This is due to a multitude of causes.

First of all, for good quantification you need a suitable measuring method and ideally a standardisation that matches this method of measuring.

Standard methods for reliable sampling and analysis of microplastics are currently still in full development. (There is currently no standard protocol for sampling and determining microplastics and therefore no analysis method that can measure microplastics without errors.) In the absence of such a standard protocol, there are also no standards or agreements on emissions or discharges.

Microplastics enter the environment via many different sources, such as tire wear, washing (synthetic) textiles, atmospheric deposition, weathering of agricultural foil and fragmentation of litter. Knowledge and insight into the contribution of these different sources to the total amount of microplastics in sewage and surface water is not yet complete enough to provide a clear interpretation.

There does seem to be a consensus that the biggest polluter is the wear of car tires (other sources mention litter as the biggest source). And although we are used to looking at the biggest polluter first, we would like to go into the possible contribution of our sector to this problem, based on the principle of "change the world, start with yourself", and see where there is potential for improvement.

The rinse water from the washing process is ultimately discharged as sewage. In this chain, it passes through a sewage treatment plant before being discharged into surface water. Here, a significant portion of the microplastics and fibre residues are filtered from the water: a maximum efficiency of 99.9% removal of microplastics has been established in some cases. This is relatively high, but the absolute number that ends up in the environment remains significant. Moreover, the limit of this solution is in sight.

In a next step, the inflow into the sewage water will have to be limited. For example, in France it has been decided that by 2025 all washing machines must have a filter to capture microplastic fibres. It is not entirely inconceivable that this legislation will be copied to other countries (like the Netherlands).[1] It would be a relatively easy solution to limit the amount of synthetic fibres that end up in the waste water through washing.

Options that can reduce fibre loss in the domestic environment, such as washing for a shorter period and at a colder temperature, or washing less often, do not offer a solution for the professional washing of microfibre material. In addition to placing a filter behind the washing machine, a contribution to limiting or reducing fibre loss will be made when the wash is only run with a full load.

At the front of the chain, there is also profit to be made in the long term by, for example, producing microfibre cloths in such a way that fibre loss is reduced.

In short, there is a problem where we can also make progress in the short term, and hopefully we can arrive at an acceptable solution in the long term.

UK Parliament 29th October 2024: Alberto Costa – Motion for leave to bring in a Bill: The "Microplastic Filters (Washing Machines) Bill"; and Australia has an industry-led goal of introducing these filters by 2030.

CONTENTS

CHAPTER 1 INTRODUCTION

1.1 Background of the study

Microplastics are very small plastic particles that are created during the production (primary microplastics) and the many applications of plastic (secondary microplastics). They easily enter the environment. Well-known examples are the abrasion of car tires, the disintegration of plastic litter and the leaching of additives in cosmetics and abrasive cleaners. Microplastics pose a potential threat to humans, the environment and animals are therefore in the spotlight [1, 6].

Several studies have shown that microplastics generated during the wearing and washing of synthetic textiles, is one of the major sources of microplastics in the environment [1]. The washing of synthetic clothing releases small fibres and particles that disappear into the sewer via the washing water [1, 2]. In waste water treatment, microplastics are only partially captured [1]. The smallest parts eventually end up in surface water.

Synthetic materials are frequently used in professional cleaning. The use of synthetic microfibre cloths and mops is widely recommended there. These microfibre materials have shown to have ergonomic, as well as economic and hygienic benefits [7]. The environmental impact, when it comes to the release of microplastics from washing, has hardly been studied [1].

An exploratory preliminary study by SOHIT, found evidence that, like with consumer textiles washing, microplastics are also released when washing microfibre materials used in professional cleaning. As there is a need for more information on this topic, the Technical Committee of VSR (the Association for Cleaning Research) initiated an exploratory study. In it, the release of microplastics when washing microfibre cloths and mops is investigated in more detail.

1.2 Purpose of the study

This study aims to give an impression of the extent to which microplastics are released when washing microfibre materials in professional cleaning in absolute terms and in relation to washing consumer textiles.

For this purpose, the following research questions have been formulated:

1. How many microplastics are released in the first washing cycles, when washing new microfibre cloths and mops and after consecutive washes of used microfibre cloths and mops?
2. How many microplastics are released in repeated washings of new microfibre cloths and mops and how does this compare to consumer textiles?
3. How does the type of microfibre cloth affect the release of microplastics from repeated washing of new microfibre cloths?

CHAPTER 2
MATERIALS AND METHOD

2.1 Global set-up

In this laboratory study, both new and used microfibre materials were washed under standard controlled conditions. Washing water from the washing machine was collected and filtered. The microplastics on the filters were quantified by counting or weighing. Besides the age of the microfibre materials, the influence of repeated washing and the type of microfibre material on the release of microplastics were examined.

To better interpret the results, a number of washes were performed with consumer textiles. Synthetic clothing was washed repeatedly and the collected washing water was filtered. The microplastics on the filters were quantified by weighing. The numbers of microplastics are compared with those of the microfibre materials used in professional cleaning.

The definition of microplastics is broad. The Dutch National Institute for Public Health and the Environment (RIVM) indicates that they are plastic particles with a maximum size of 5 mm [6]. In its advisory report, Dutch Organization for Applied Scientific Research (TNO) uses fibres with a length of 3 nm to 15 mm [1]. In this study, the length or size of the plastic particles was not determined and microplastics are defined as all plastic fibres or particles.

2.2 Microfibre materials and consumer textiles

Both new and used microfibre materials were used in this study. These materials, microfibre cloths and mops, are of different quality and composition (Table 2.1). The used materials are partly from real-life daily practice (hospitals; from now on named as: real-life) and partly from in the laboratory artificially used (from now on named as mimicked-use) to mimic the real-life, daily practice situation.

The consumer textile consists of various items of clothing (fleece sweaters, t-shirts, ties), pillowcases and blankets.

Table 2.1 Materials in the study

Code	Type	Quality	Age	Composition
Microfibre cloths				
D-A	knitted	100% microfibre	new	70 % PE, 30% PA
D-B	knitted	20% split microfibre	new	70 % PE, 30% PA
D-C	non-woven	100% microfibre	new	70 % PE, 30% PA
D-D	non-woven	100% microfibre	used (real-life)	70 % PE, 30% PA
D-E	knitted	100% microfibre, coated	new	70 % PE, 30% PA
D-F	knitted	100% microfibre	new	100% PE
Microfibre mops				
M-A		microfibre	new	90% PE, 10% NY
M-B		microvezel	new	80% PE, 10% NY, 10% PP
M-C		50% microfibre	new	50% PE, 50% microfibre
Consumer textiles				
K-A			new	100% synthetic (mainly PE and PA)

During the study, a number of materials were artificially aged in the laboratory to simulate a real-life situation. Prior to and during this ageing process, these materials were washed with a standard detergent (ECE-2 Wfk, 10 g/kg laundry), spin-dried and air-dried. Ageing was done using a cleaning robot (with standard movement, speed and pressure) and is such that it simulates a 1-year use .

2.3 Washing

The test materials were washed in a domestic washing machine (Siemens iq300 WM14NO75NL). This washing machine was purchased for this study so that the research started with a clean machine. Washing was done with tap water of medium water hardness. Between different tests, the washing machine was rinsed (rinsing programme).

The microfibre cloths and mops were washed with a 60°C main wash programme, which is in line with the maintenance labelling. The consumer textiles were washed with a 40°C wrinkle-resistant programme, according to the maintenance labelling.
Washing was carried out using a liquid colour detergent. After washing, all test materials were air-dried.

2.4 Filtration and isolation of microplastics

In order to determine the number of microplastics released, water from the washing phase of a washing process was collected and filtered. Through a cascade of filters (Figure 2.1), the microplastics were separated from the wash water. The filters (Nitex ®) have a mesh size of 250 µm, 125 µm, 65 µm and 30 µm.

After filtration, the biological, non-synthetic material on the filters was removed by rinsing with a diluted hypochlorite solution (1:1 in demineralised water). The filters were then rinsed with demineralised water and dried in a drying oven (2 hours at 50°C).

Figure 2.1
Cascade filtration set-up

2.5 Quantifying microplastics

The quantification of the microplastics is done by counting or weighing.

2.5.1 Counting

The dry filters were examined under an optical microscope. The microplastics were identified using UV light; plastic fibres and particles light up under UV light in contrast to non-synthetic fibres and particles. To give a better contour and definition of the fibres, the filters were also examined in daylight (D65).

The number of microplastics was then determined by counting. With large numbers, it is impossible to count the numbers on the entire filter. Therefore, the number of microplastics on a representative surface of the filter was counted under the microscope. From this, the number of microplastics on the entire filter was calculated. In case of accumulation, the number of microplastics cannot be determined correctly (Figure 2.2). In such a situation, the number of microplastics was estimated (approximate counting).

Figure 2.2 Accumulation of microplastics at 125 µm filter

2.5.2 Weighing

As often the number of microplastics can only be determined approximately, alternatives for quantification have been studied. Mass determination is mentioned in literature as a simple and fast technique for quantifying microplastics [1].

To determine the amount of microplastics by weighing, the filters were dried to constant weight (at least 2 hours at 50°C) in a drying oven before and after filtration of the wash water. The filters were then weighed on an analytical balance. The amount of microplastics (Md) was calculated as follows:

$$Md\ [mg] = MFbefore - MFafter$$

where:

Mfbefore = mass of dry filter before filtration

Mfafter = mass of dry filter after filtration

2.6 Study design

2.6.1 Determination of the number of microplastics in tap water and washing machine

To determine the baseline situation, the presence of microplastics in tap water and in the new washing machine was investigated. For this purpose, one litre of tap water and one litre of washing water from a 60ºC main wash programme are filtered. The residues on the filters were examined under the microscope using UV light to confirm that they were microplastics. The number of microplastics on the filters was counted. This determination was repeated 3 times.

2.6.2 Determination of the number of microplastics after washing new and used microfibre materials

To investigate the release of microplastics in the first washings, 1 kg of new microfibre cloths (D-A and D-B) and 1 kg of new microfibre mops (M-A and M-B) were washed separately. The total volume of wash water was filtered. After drying the filters, the number of microplastics on the various filters was determined by counting.

The number of microplastics released during the washing of frequently washed and used microfibre materials was determined in two ways.
1 kg of the mimicked-use microfibre cloths (D-A and D-B) and 1 kg of microfibre mops (M-A and M-B), were washed two more times. The total volume of the wash water was filtered and the number of microplastics on the dry filters has been determined by counting.
Real-life microfibre cloths (D-D), also weighing 1 kg, were washed twice in the laboratory. The total volume of wash water was filtered. The number of microplastics on the dry filters was determined by counting. It is not known how often these cloths were used and washed in hospitals.

2.6.3 Determination of the amount of microplastics after repeated washing

The release of microplastics after repeated washing was investigated, without taking into account the age of the materials (new or used).

New microfibre mops (M-C, amount: over 4 kg) were washed twice. The load was than halved (2.2 kg) and washed another five times. After each wash, the total volume of wash water was filtered. After drying the filters, the amount of microplastics was determined by weighing.

For comparison, a load consisting of consumer textiles was washed five times. The weight of the load was adjusted to 1.5 kg to get a comparable load factor of the washing drum. After each wash, the total volume of wash water was filtered. After drying the filters, the amount of microplastics is determined by weighing

2.6.4 Influence of the type of microfibre on the amount of microplastics

Three different types of new microfibre cloths (table 2.2) were each washed 25 times to investigate the influence of the type of microfibre material on the amount of microplastics released. The type of use of the microfibre cloths was not further discussed.
The total volume of water from the washing phase of the first and last wash was filtered. After drying the filters, the amount of microplastics was determined by weighing.

Table 2.2 Types of microfibre cloths

Type	Composition	Amount	Weight [kg]
Knitted with coating	70% PE, 30% PA	30	10,2
Knitted	100% PE	30	10,2
Non-woven	70% PE, 30% PA	30	5,9

CHAPTER 3 RESULTS

3.1 Test conditions

The tests were carried out under controlled laboratory conditions at an ambient temperature of 22°C ± 1.5°C and a humidity of 55% ± 3%RH. Water hardness was 7ºdH (39.2 mmol/l)

The numbers of microplastics in tap water and in the washing machine are shown in table 3.1.

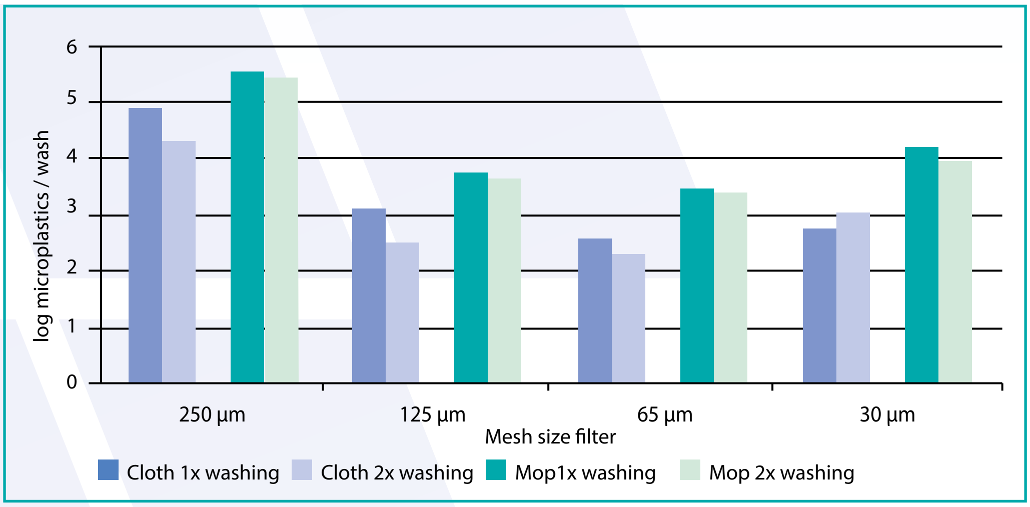
Filter size	Tape water	Washing water
250 µm	< 5	< 15
125 µm	< 10	< 10
65 µm	< 10	< 5
30 µm	< 10	0

Table 3.1 Average number of microplastics in tap water and in the washing water of the new washing machine [number of microplastics per litre]

3.2 Numbers of microplastics after washing new and used microfibre materials

3.2.1 New microfibre materials

Graph 3.1 shows the number of microplastics on the filters after washing new microfibre cloths and mops once and twice. The number of microplastics on the largest filter (250 µm) was estimated because the microplastics accumulated to such an extent that they were uncountable.



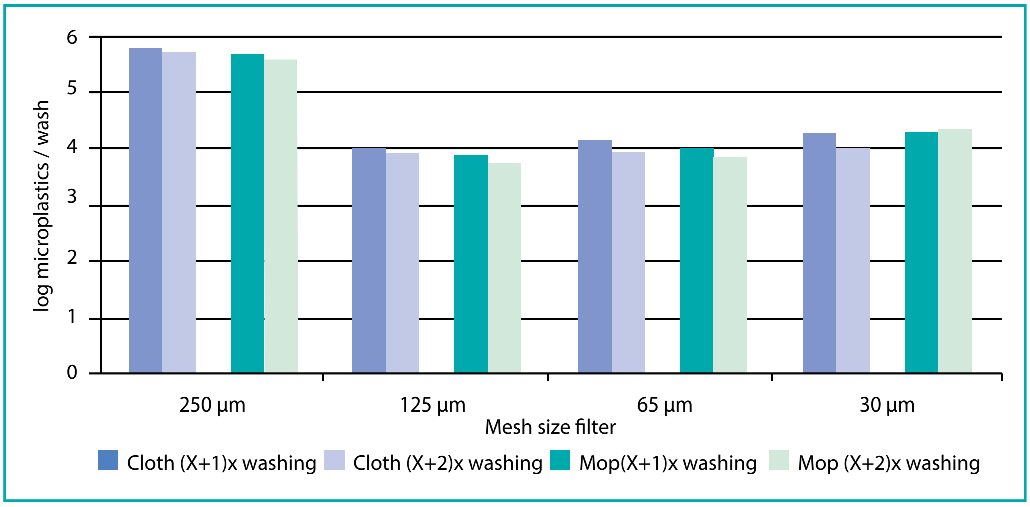
Graph 3.1 New microfibre materials: number of microplastics after 1x and 2x washing [log number of microplastics per wash]

Large numbers of microplastics (roughly between 20,000 and 370,000 per wash) were found on all filters. Washing microfibre mops releases more microplastics than microfibre cloths. Furthermore, it is clear that the number of microplastics released in the first wash is higher than in the second wash in almost all cases.

3.2.2 Mimicked-use materials microfibre

Graph 3.2 shows the number of microplastics on the filters after repeated laboratory washes (X) plus one and two washes of mimicked-use microfibre cloths and mops. The number of microplastics on the largest filter (250 µm) has been estimated.

Graph 3.2 Mimicked-use materials microfibre: number of microplastics after repeated +1x and repeated +2x washing [log number of microplastics per wash]

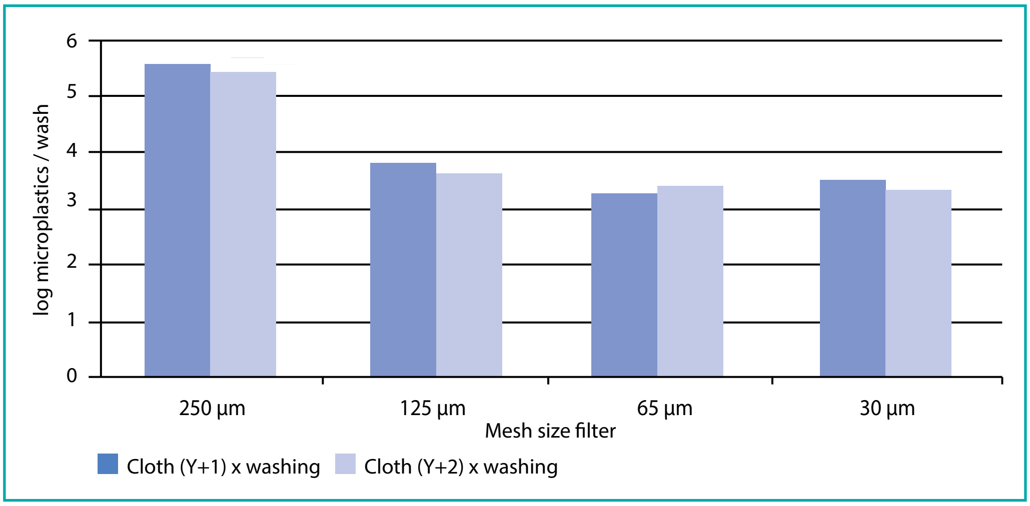


After washing (frequently) used microfibre materials, large numbers of microplastics (roughly between 400,000 and 660,000 per wash) were found on all filters. There is no difference between microfibre cloths and mops. In the 'second' wash, the number of microplastics released is often smaller than in the 'first' wash.

3.2.3 Real-life materials microfibre

Graph 3.3 shows the number of microplastics on the filters after repeated real-life use (Y) plus one and two washes of used microfibre cloths. The number of microplastics on the largest filter (250 µm) has been estimated.

Graph 3.3 Real-life microfibre cloths: number of microplastics after repeated + 1x and repeated + 2x washing [log number of microplastics per wash]

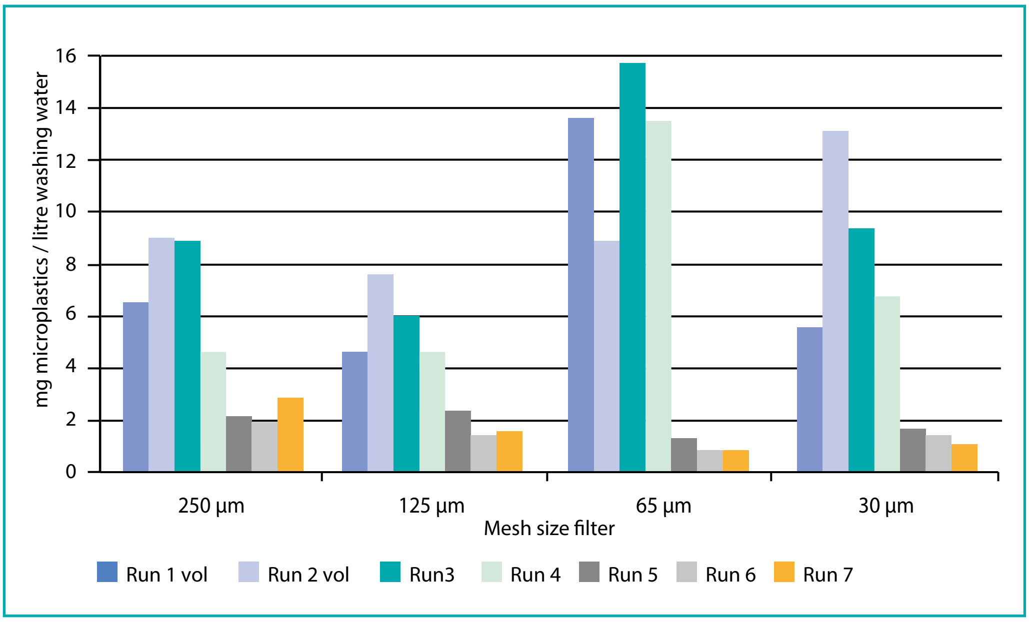


The release of microplastics from real-life microfibre cloths is high on all filters (between 285,000 and 425,000 per wash). In the 'second' wash, the number of microplastics released is often smaller than in the 'first' wash.

3.3 AMOUNT OF MICROPLASTICS AFTER REPEATED WASHING

3.3.1 Microfibre mops

Graph 3.4 shows the amount of microplastics after repeated washing of new mops.

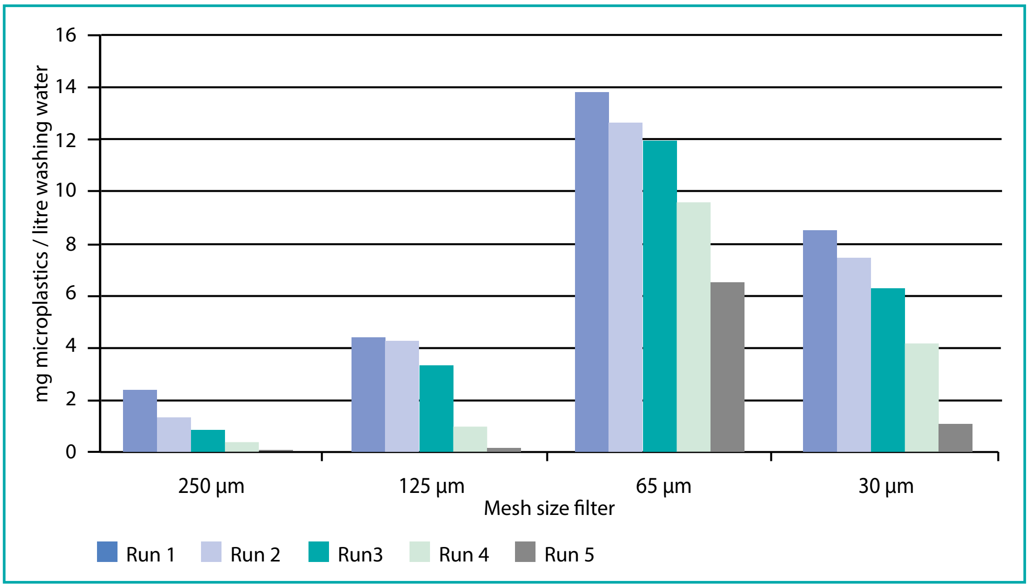


Graph 3.4 Microfibre mops: amount of microplastics after several washes [mg/ litre washing water]

The amount of released microplastics decreases more or less gradually as the number of washes increases. This is especially the case after halving the load. In the first washes, most microplastics are found on the smallest filters (65 µm and 30 µm).

3.3.2 Consumer textiles

Graph 3.5 shows the amount of microplastics after repeated washing of consumer textiles.



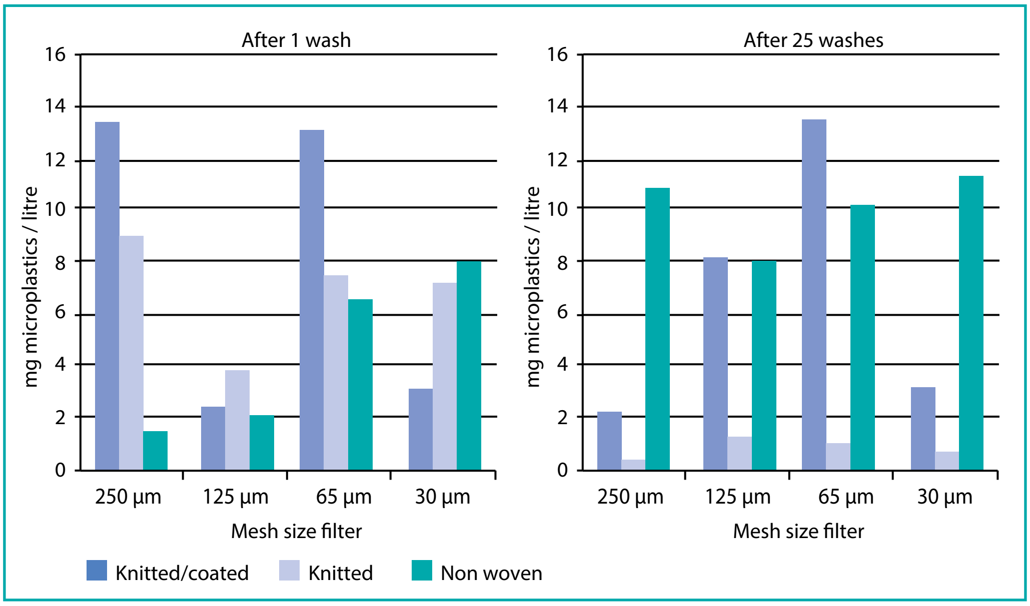
Graph 3.5 Consumer textiles: amount of microplastics after several washes [mg/ litre washing water]

As the number of washes increases, the amount of microplastics released on all filters gradually decreases. It is clear that the most microplastics were found on the smallest filters (65 µm and 30 µm).

3.4 Type of microfibre materials

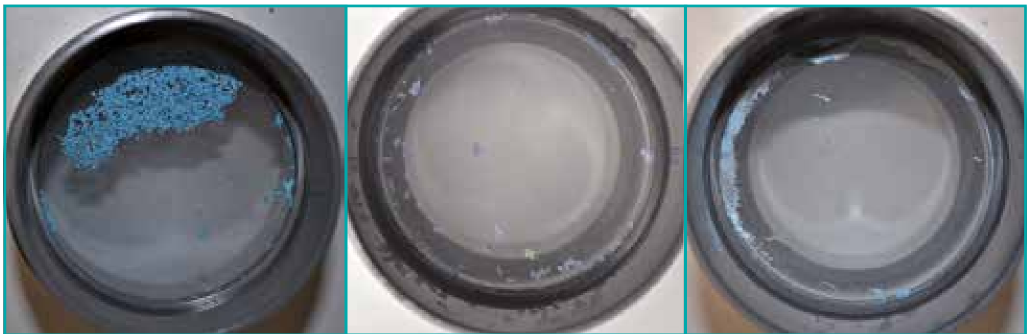
Graph 3.6 shows the amounts of microplastics after washing different types of microfibre cloths. Figure 3.1 shows the amounts of microplastics on the largest filter (250 µm) after filtration of the first wash.

Graph 3.6 Amount of microplastics in the wash water per type of microfibre cloth after 1 and after 25 washes [mg/ litre washing water]



Both after the first wash and after 25 washes, differences were found between the types of microfibre cloths. The increase in the amount of microplastics after 25 washes of the non-woven cloth is remarkable for all filters. The same applies to the decrease in quantities in case of the knitted microfibre cloths.

Figure 3.1: Microplastics on a 250 µm filter after 1 x washing of new microfibre cloths



Knitted with coating; 70% PE, 30% PA	Knitted: 100% PE	Non-woven: 70% PE, 30% PA

CHAPTER 4 DISCUSSION

4.1 Method

Several methods exist for the separation of microplastics from an aqueous solution [4]. Liquid filtration was used because this method was found to be practical in a preliminary study. This has been confirmed in this study. In addition, the method is simple and inexpensive.

This study used two methods to quantify the release of microplastics: counting and weighing. Both methods give an impression of the volume, but differ at the level of detail. Counting the number of microplastics has limitations. It is inaccurate at large numbers. Long fibres can be double counted because they are woven through the meshes of the filter. Small particles may be invisible when accumulated. In such a case, the number of microplastics can only be approximated. Weighing the amount of microplastics then offers a solution. In contrast, weighing small numbers of microplastics is not possible.
In this study, such quantities of microplastics were found on all filters that it would have been best to weigh them. Nevertheless, by counting the numbers of microplastics in part of the study, it is possible to give an indication of the extent to which microplastics are released when washing microfibre materials.

Prior to the study, the presence of microplastics in tap water and in the empty washing machine was investigated. Table 3.1 shows that the quantities found were relatively small and did not play a role in further findings for this study.

4.2 Release of microplastics by washing

On all filters, the numbers and amounts of microplastics found in this study when washing microfibre materials are substantial. To the best of our knowledge, no previous study results have been published to confirm this. The quantities of microplastics found when washing consumer clothing are comparable to previous published data from studies with consumer clothing [3, 5]. A previous study reported numbers between 640,000 and 1,500,000 microplastics per kg of synthetic clothing [5]. These numbers are in the same order of magnitude as those found in this study when washing microfibre materials. It is therefore likely that the microplastics found when washing microfibre materials give a good indication of reality.

It is known from several studies on the release of microplastics when washing clothes that most microplastics are released in the first washes and that as clothes are used and washed more often, the release decreases [1, 2]. This study confirms the decrease in the release of microplastics when washing consumer textiles. For washing microfibre materials, the decrease has not unequivocally established. There are indications that the amount of microplastics decreases with more frequent washing. This does not include the use of microfibre materials. However, when the microfibre materials have been used and washed (whether or not in practice or in the laboratory) before, the numbers of microplastics after multiple washings are at least as high as those after the first washings.

Washing new microfibre mops released more microplastics than after washing new microfibre cloths. This could be explained by the coarser and looser structure of the knit of the mops compared to the cloths. With new materials, it is plausible that they are largely residues from production. After washing and using the materials more often, the differences between microfibre cloths and mops virtually disappear.

The release of microplastics from real-life microfibre cloths is less than that of the cloths mimicked-use in the laboratory. The artificial use process may have led to accelerated wear, causing more fibres to be released in the wash. The type of microfibre cloth could also play a role here; the mimicked-use microfibre cloths are knitted, the real-life ones are non-woven.

TNO advisory report [1] shows that a number of parameters play an important role in the release of microplastics. Material properties and washing conditions are specifically mentioned here. This study found several indications that could confirm this. For example, the fibre type and fabric structure seem to be influential, given the differences between knitted microfibre cloths and non-wovens. The load factor of the drum also seems to be important. Previous research has shown that more microplastics are released in a less full drum [2]. In this study, there is evidence to confirm this.
What role these factors play cannot be determined with certainty based on this study. Additional research is needed for this.

CHAPTER 5
CONCLUSION

In this exploratory study, commissioned by the Technical Committee of VSR (the Association for Cleaning Research), the release of microplastics as part of the process of washing professional microfibre materials was investigated in absolute terms and in relation to washing consumer textiles.

This involved examining three research questions:

How many microplastics are released in the first washes, when washing new microfibre cloths and mops and after consecutive washes of used microfibre cloths and mops?
Large numbers (roughly between 20000 and 660000) of microplastics per wash were found after washing both new and used microfibre cloths and mops. The number of microplastics released tends to be higher in the first wash than those in the second wash. The number of microplastics released increases rather than decreases after (very) frequent washing and using microfibre materials in comparison to the release by new materials. Here, the release of microplastics from real-life microfibre cloths is less than that of the mimicked-use cloths in the laboratory.

How many microplastics are released in repeated washings of new microfibre cloths and mops and how does that compare to consumer textiles?
When washing both microfibre mops and consumer textiles, the amount of microplastics released decreases as the number of washes increases. Most microplastics are found on the smallest filters (65 µm and 30 µm) and the amounts are more or less of the same order of magnitude in microfibre mops and consumer textiles (decreasing after five washes to 1-2 mg/l of washing water on 30 µm filter).

How does the type of microfibre cloth affect the release of microplastics when repeatedly washing new microfibre cloths?
The type of cloth seems to affect the release of the amount of microplastics. This is the case both after the first wash and after the 25th wash. Whether the type of cloth, its composition or a finish play a role here is difficult to determine based of this research.

CHAPTER 6
LITERATURE

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