WASHING PROCESSES AND THEIR EFFECT OF THE RELEASE OF MICROPLASTICS TO THE ENVIRONMENT

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1 Abstract

This contribution focuses on current issues of microplastics in components from washing processes of the environment. The theoretical part describes the origin of microplastics in terms of history from the discovery of plastic as a universal tool for a variety of applications in practice to its mass production, which for the future caused a new and difficult-to-degrade environmental problem. It focuses more deeply on the current impacts of increased occurrence in various areas of the environment that are linked to microplastic resources, such as industry and households, and describes their distribution and transport to specific sites, especially wastewater, surface and drinking water, but also soil and air. The work also pays attention to the toxic effects on primary consumers of microplastics, which include mainly marine animals and mammals. A special area is the occurrence of microfibers (ie synthetic fibers originating from the textile industry), which are among the most common types of micropollutants in both aquatic and terrestrial environments. The practical part of the work focuses on the just mentioned microwaste from textiles. As a demonstration experiment proving this statement, a washing process of sportswear was introduced, followed by the capture of outgoing waste using 3 types of filters. Each filter was weighed before and after washing, the difference being the weight that was later included in the calculation of the average microfiber concentration for a given filter type and wash program. One of the aims of this work was to determine the concentration and amount of micro waste released during a particular type of washing.

Key words: microplastics, textile industry, environment, washing processes

2 Introduction

The first discovery synthetic, bacelite, started evolution of plastic industry. This development is dated from beginning of 20th century (De Falco, 2019). Since the start of its mass production, in 1950 (UNEP, 2016), the global plastic production has turned from inexpressive 1.7 million tonnes (Plastic Europe, 2013) to 300 million tonnes in 2014 (Plastic Europe, 2015) (Hernandez, 2017).

The product of plastic materials are microplastics or microfibers. Microplastics are defined like particles in the size range 1 nm to < 5 mm (Hernandez, 2017). Microplastics are now present in every part of environment. They also represent sources for toxins (Germanov, 2018).

Figure 1: Plastic size classification

Generally, MPs are classified as primary or secondary on the basis of their production. Primary MPs are originated from textiles, medicines, toothpaste, and variety of other personal care products like facial and scrubs. The range of primary MPs and its types mainly consists of fragments fibers, films and foams (Lei, 2017; Raza, 2018) Plastic pellets and plastic particles manufactured for particular applications, such as cosmetic products and abrasives. As one of the main sources of MPs in the environment, primary MPs are made of polypropylene, polyethylene (Lei, 2017).
They are also added to cosmetics, soaps, and toothpaste, among other products, used on a daily basis. Shampoo, eyeliner, lip-gloss, deodorant, and sunblock sticks may also contain MPs (Raza, 2018). Secondary MPs can be originated by the fragmentation of big plastic materials degradation. They are derived from the degradation of larger plastic debris through mechanical forces, thermal degradation, photolysis, thermo-oxidation and bio-degradation processes. For example synthetic fibers from washing clothes. Secondary MPs arising by washing clothes are generally polyester, acrylic, and polyamide which can be more than 100 fibers per liter of effluent (Raza, 2018).

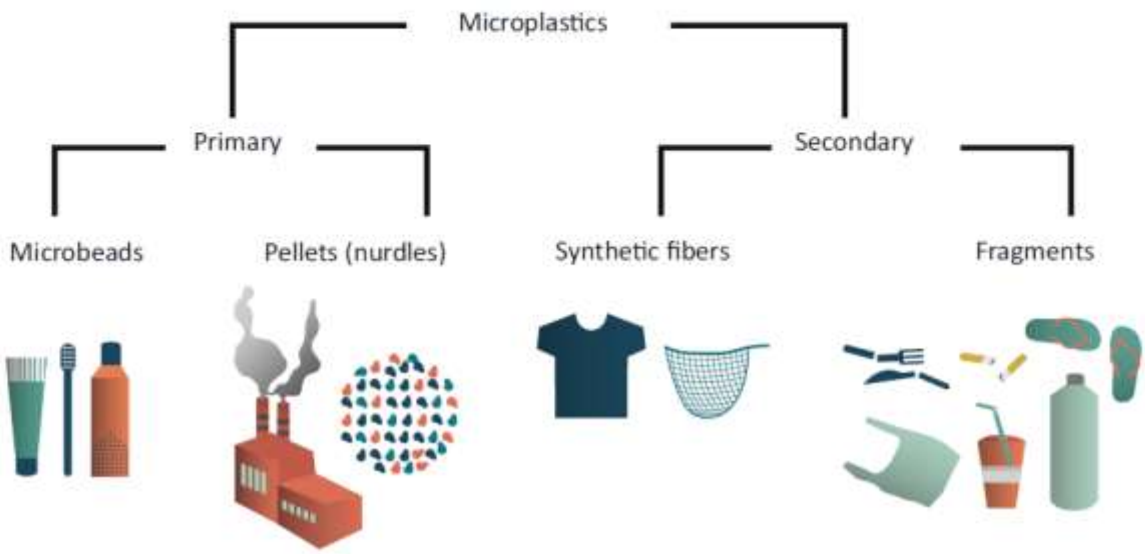

Figure 2: Types of microplastics (Germanov, 2018).

Microfibers, which are tiny threads of polyester, nylon, acrylic, and other synthetic textiles) released from synthetic garments during washing but do not have any other use. Polyester is the dominant microfiber pollutant among all marine environment pollutants. The amount of polyester production increased annually from 5.3 million tones in 1980 to 70 million tones in 2018.

Table 1
Types of synthetic microfiber pollutants present in the ocean (Alok, 2019).

Sl. No.	Different kinds of fabrics	Sources	Percentage
1	Polyester	Textile industry	56%
2	Acrylic	Textile industry	23%
3	Polypropylene	Textile industry	7%
4	Polyethene	Textile industry	6%
5	Polyamide	Textile industry	3%

In the environment, plastics can be distributed to the water sources from rivers-based or land-based, included the particles from WWTPs, because that were not specifically designed to retain them. The main quantity of plastics in WWTPs is from personal care products, textile fibers releasing during washing processes or pellets from many industries (Hernandez, 2017). The wastewater treatment plants is in many studies defined like the source of releasing microplastics to the environment. Here is the question, is WWTPs really like source or just barrier from companies, household and environment (Gatidou, 2018). The major source of microplastics in wastewater treatment is from various industrial companies but also from household from washing processes. The not small source of microplastics is also from industrial laundry (Dris, 2017). The textile industry uses high volumes of water throughout its operations, from the washing of fibers to bleaching, dyeing and washing of finished products. On average, approximately 200 liters of water are required to produce l kg of textiles (Parvathi, 2009). The large volumes of wastewater generated also contain a wide variety of chemicals, used throughout processing. These can cause damage if not properly treated before being discharged into the environment. Of all the steps involved in textiles processing, wet processing creates the highest volume of wastewater (Venkatsan, 2019; Parvathi, 2009).

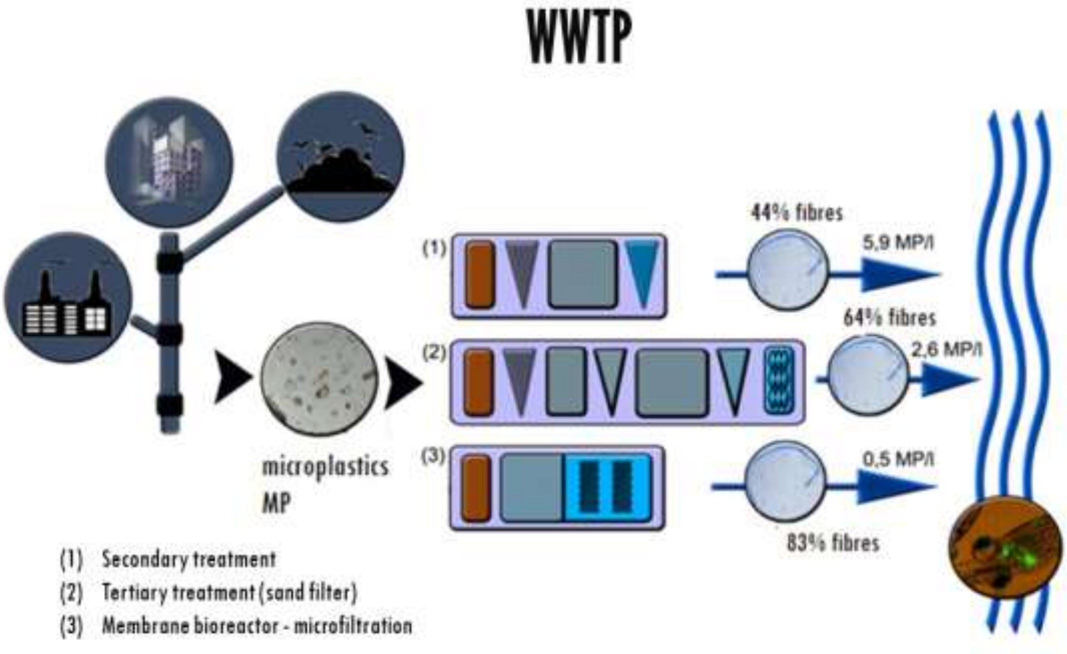

Figure 3: Waste water treatment plant like source of microfibers in environment (Michielssen, 2016).

3 Materials and methods

As a research object, we used textiles, in the form of sports jerseys, with a structure of 100% polyester. The washing process was realized in laboratory model of washing machine (Camry CR8052) in two washing programs – 45-minutes and 30-minutes without the washing powder. The temperature of washing process was 40 °C and the volume of washing water was 6 liter. Wastewater collection from the wash cycle was realize on filters with size 1, 25 and 100 µm.
Repetition of individual programs, resp. capture on individual filters were performed in 3 identical experiments. Every filter we used later during the experiment; it was primarily weighed on analytical balances. The waste water was collect to the tank, through a filter. Waste (fibers from textile) was trapped on the filter. Also the textile we moved to the right part of washing machine (spin-drier) and the waste water was collect and filtered through a filter. The filters were covered dry at the room temperature for 48 hours and then dried in an dryer (60 °C, 2 hours) to the unchanged weight.

Figure 4: The laboratory model of washing machine (Camry – CR8052) and filter (1, 25 100 µm) used for catching wastewater from washing machine.

Subsequently, the waste filtered water was additionally filtered by vacuum filtration, with a filter size of 0,22 µm (MCE Membrane -Nitrocellulose membrane). The filters after vacuum filtration were dried for 2 hours at 105 ° C in an dryer and subsequent considered. The difference between the weight of the filter before and after washing process resp. before and after vacuum filtration we further stated when calculating the microfibers concentration (mg/l). Water sample after vacuum filtration with a 0.22 µm filter as well as after filtration with filter sizes of 1, 25 s 100 µm, was microscopied using fluorescence microscope (Nikon Eclipse Ci-L with LED radiation source and Nicon Plan Fluor 10x0.30 OFN25 DIC L / N1 lens). Images were processed using IC measure and IC capture programs.

4 Results

Table 2 Parameters of washing process cycle of blue blanket (100 % PET); concentration of fibers mg/l on the filters after washing process.

Temperature of washing process [°C]		Time of washing process [min]	Filter size [µm]	Weight before washing [g]	Weight after washing [g]	Weight difference [g]	Concentration of fibers [mg/l]
40 °C	A	15 min	100	36,4664	36,4795	0,0131	**2,2**
	B	30 min	100	36,4515	36,4733	0,0218	**3,6**
	C	45 min	100	36,4795	36,7703	0,2908	**48,5**

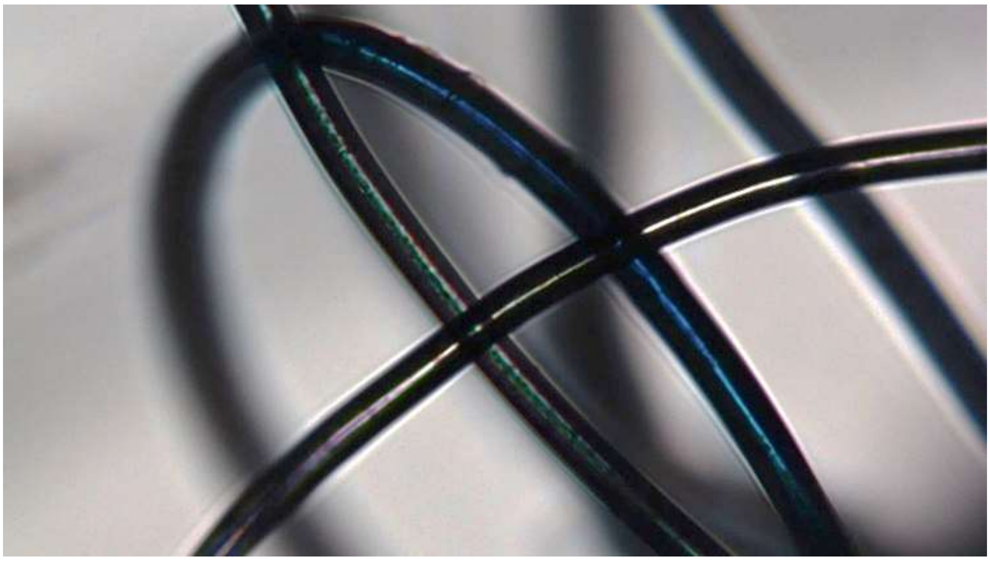

Figure 5: Microfiber (from blue blanket 100% PET) released during a washing process with a temperature of 40 °C and a washing time of 30 minutes.

Table 3a Parameters od washing process cycle of red blanket (100 % PET); concentration of fibers mg/l on the filters after washing process.

Temperature of washing process [°C]		Time of washing process [min]	Filter size [µm]	Weight before washing [g]	Weight after washing [g]	Weight difference [mg]	Concentration of fibers [mg/l]
40 °C	A	15 min	100	36,6077	36,6091	0,0014	0,23
	B	30 min	100	36,1264	36,1282	1,8	0,30
	C	45 min	100	36,6662	36,7032	37	6,20

Table 3b Parameters of filtrations (classic CF and vacuum VF) of waste water form washing processes (15, 30, 45 minutes, used filter 100 μm of red blanket (100 % PET); concentration of fibers mg/l on the membrane filters 0,22 MCE - Membrane – Nitrocellulose membrane

Temperature of washing process [°C]		Time of washing process [min]	Filter size [μm]	Concentration of fibers (CF) [mg/l]	Filter size [μm]	Concentration of fibers (V F) [mg/l]	Total weight of microfibers [mg]
40 °C	A	15 min	100	0,23	0,22	1	0,43
	B	30 min	100	0,3	0,22	7	3,20
	C	45 min	100	6,2	0,22	27,5	11,70

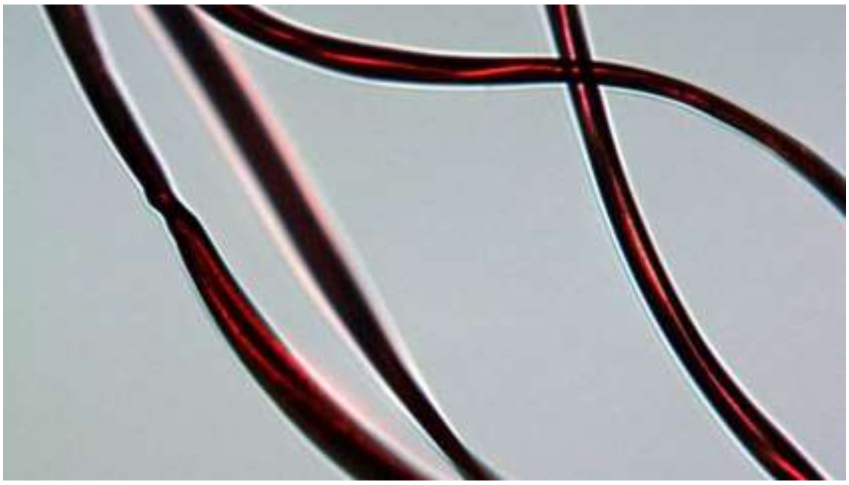

Figure 6: Microfiber (from red blanket 100% PET) released during a washing process with a temperature of 40 °C and a washing time of 30 minutes.

Figure 7: Microfibers in waste water under fluorescence microscopy from washing process (filter 100 μm).

a, b,

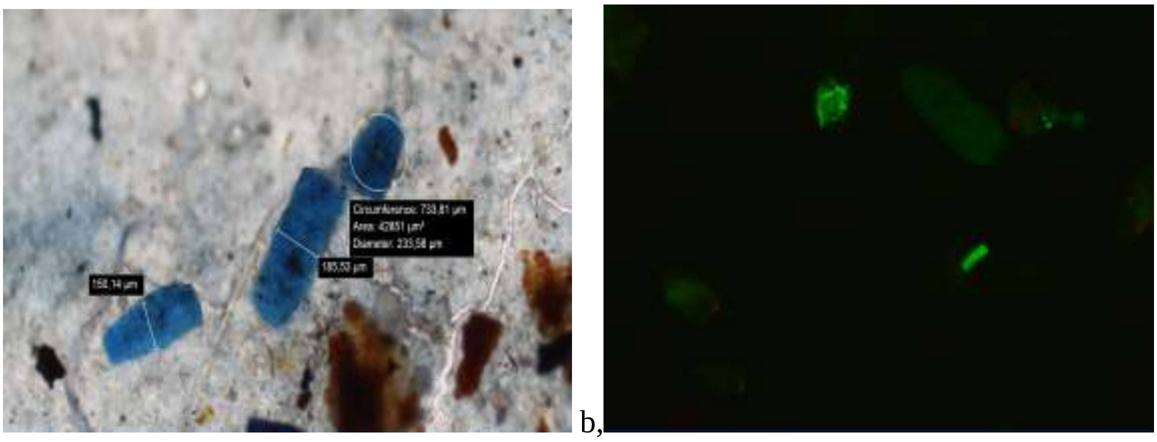

Figure 8: The picture of microplastics on the filters under optic (a) and fluorescence (b) microscopy after washing process (blanket 100 % PET).

5 Discussion

The wastewater treatment plants (WWTPs) is in many studies defined like the source of releasing microplastics to the environment. Here is the question, is WWTPs really like source or just barrier from companies, household and environment (Gatidou, 2018). In our study we detected synthetic materials, released during washing processes and analysed, how many of microfibers releasing during household duties.

The first variable of this experience was the washing time. Indeed, the washing time has an impact on the quantity of microplastics of the wash water. The longer the washing time will be and there will be more microplastics in the end. The longest the washing time will be, the more microplastics there will be in the end. The second variable of washing processes was used materials. .

In the Table 2 we can see concentration of microfibers mg/l on the filters after washing process. During longer washing process 45 minutes, the concentration of releasing microfibers (from blue blanket (100 % PET)) was 13 – times more than during 30 minutes washing program and 22 – times more than during 15 minutes washing program. We can evaluate that, during longer washing program is greater mechanical abrasion.
On the Figure 5 and 7 we can see microfibers (Figure 5, 7a – optical microscope
100 x magnification, Figure 7 – Fluorescence microscope), from 150 -180 µm. On the Figure 7b we can see microfibers under fluorescence microscope.

In the Table 3a we can see concentration of microfibers mg/l on the filters after washing process. During longer washing process 45 minutes, the concentration of releasing microfibers (from red blanket (100 % PET)) was 27 – times more than during 30 minutes washing program and 20 – times more than during 15 minutes washing program. We can evaluate that, during longer washing program is greater mechanical abrasion. After classic filtration of waste water from washing processes, we did vacuum filtration (used 0,22µ MCE - Membrane – Nitrocellulose membrane) in samples of waste water after filtration through 100 µm filters. In the Table 3b we can see comparison of the concentrations. The total weight of microfibers released from washing processes of 100 % polyester red blanket

was the higher after 45 minutes (11,70 mg), after 30 minutes (3,2 mg) and after 15 minutes (0,43 mg). On the Figure 6 we can see microfibers (optical microscope) 100 x magnification.
Also we can evaluate, that red blanket is more stabile that blue blanket, because quantity of release microfibers from blue blanket is higher. Materials of every blanket what we use were from 100 % polyester fibers, but on this experiment we can see, that stability of materials are various.

This experiment can be part of the research about how textile industry or washing processes can influence environment and occurrence of microplastics/microfibers in environment.

If in one way researches dominate discussions, that reveal domestic laundering as microplastic sources are scarce, although growing. Trying to combine both environmental with textile sciences, general knowledge gaps were highlighted; firstly those directly related to fibers and later those influencing fibers as a source of microplastics, mainly from domestic washings. Fabrics with higher abrasion resistance, low hairiness, and higher yarn breaking strength have a lower tendency to form fuzz and/or release microfibers during the mechanical action of washing. Despite the fact that the cellulose-based fabrics shed more microfibers (Zambrano, 2019) than the polyester fabric, cotton and rayon fibers degrade in aquatic conditions whereas polyester fibers do not and are expected to persist in the environment for a long time.

6 Conclusion

Every day we meet with a large amount of various plastic materials (synthetic/natural). These materials are daily distributed widely through out to the freshwaters, seas, oceans including sediments in the environment, plastics can be distributed to the water sources from rivers-based or land-based, included the particles from WWTPs, because that were not specifically designed to retain them. The main quantity of plastics in WWTPs is from personal care products, textile fibers releasing during washing processes or pellets from many industries (2). In our study we focused on textile industry and washing processes like source of microplastics and microfibers in environment. We can evaluate that washing processes has a effect on fiber release. One of the main parameters of releasing microfibers is time of washing process and stability of textile, when is less stability the quantity of microfibers is higher. When the time of washing process is longer, also during washing processes occurs to mechanical disability and abrasion and the amount of microfibers is also higher.

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