Tampere University of Applied Sciences

WASHING MACHINE MICROPLASTICS

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BACHELOR'S / MASTER'S THESIS
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Energy and Environmental Engineering

ABSTRACT

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Washing machine microplastics

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Microplastic are pieces of plastic which are smaller than 5 mm. They are toxic for the environment due to their disruptive ability of the intestines, grills, reproductive system, metabolism and animal growth.

The aim of this thesis is to gain insight on microplastic problem from the textile washing machine aspect and analysis methods to finally introduce treatment. In this work, literature review of books, journal article and publications are done with work extension of hypothetical works.

Garment fragments are also microplastic since most of garment product are plastic originated. The most considerable categories of garment material are Polyester, Nylon, Polypropylene, Acrylic and Spandex. On average of 6kg wash, 700 000 fibres could be released per wash. Samples can be collected by filtering (in the outflow water) or sampling large amount of discharged water to filter with special filter paper for further analysis. The paper then is dried and analysed by electronically scanning, weighting, counting or FTIR measurements. During the measurement process, there are numerous factors contributing to errors which could be minimized with careful preparation.

Removing microplastic and its additives can be done by collecting microfiber pieces during wash, filter them or treating them in the discharged water before entering the environment. Further research is required to encounter microplastic before they accumulate and become a significant issue for human.

Key words: microplastic, toxic, measurement, removal.

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GLOSSARY or ABBREVIATIONS AND TERMS (choose one or other)

DRIFT	Diffuse reflectance infrared Fourier transformed
FTIR	Fourier Transform Infrared
MB	Membrane bioreactor
MP	Microplastic
PET	Polyethylene terephthalate
PA	Polyamide
PP	Polypropylene

1 INTRODUCTION

Since 1930s, numerous objects have been detected to caught around Callorhinus ursinus neck and shoulder part which later on found as plastic litter in early 1970s. (Fowler, 1987). Followed by in the next decades, these observed debris have accumulated research interest of scientists through increasing the amount of data and evidences. The majority of data is collected from marine study from species entangled by fishing net fragment and birds with plastic ingestion in an extensive worldwide scale documentation. Studies has shown that at least half of the marine bird species are victim of plastic ingestion and particularly occurrence concerning plastic debris including invisible one to naked eye, also known as microplastic (MP). (Mallory, 2008)

In definition, MP are puny pieces of plastic causing harm to environment and living being. Rather than being a specific kind of plastic, it is a plastic fragment smaller than five millimetre in length. They come from various source such as cosmetic, clothing, industrial processes, etc…According to latest information, two types of MP have been classified. Primary MP plastic fragment that has the size of 5mm or less when entered the environment and secondary MP are created from bigger plastic product discharged into the environment and degrading. (Boucher et al. 2017) Primary MP are microfiber from garment, microbeads and nurdles. Secondary MP sourced from plastic bottles, fishing net and plastic bags degrading in the water due to their exposure of UV light, freezing, heat, wind and physical abrasion. Another important source of secondary MP is the breakdown of synthetic fibre through washing machine and their discharge to the wastewater system (Kontrick, 2018). Since they are plastic, they are durable and accumulate throughout the food chain, particularly in aquatic ecosystem.

According to the global evaluation of MP sources, 34.8% of MP are released from laundry of textiles and 28.3% are erosion of car tyres while driving. City dusts are also computed for its contribution of 24,2% of MP pollutions while the minority but significant contributions are road making, marine coating (Coating of ship, tank, vessels in marine environments as protective layer from corrosion), personal cares products and plastic pellets all account for the remaining 12,7%.

For MP to end up in the oceans, there are various pathways originated from human activities. Plastic pellets and marine coating cause MP to be released while in the ocean as a direct pollution. Personal care products and synthetic textile release MP to the wastewater stream to be transferred to the oceans. Once the MP are formed, from tyres, roads or fabric frictions, they can be in the atmosphere and carried by the wind to eventually end up in the ocean. An estimate figure of MP global release corresponds between 0,8 to 2,5 million tons per year and the largest portion are from laundering of synthetic textiles (Bouncher, 2017).

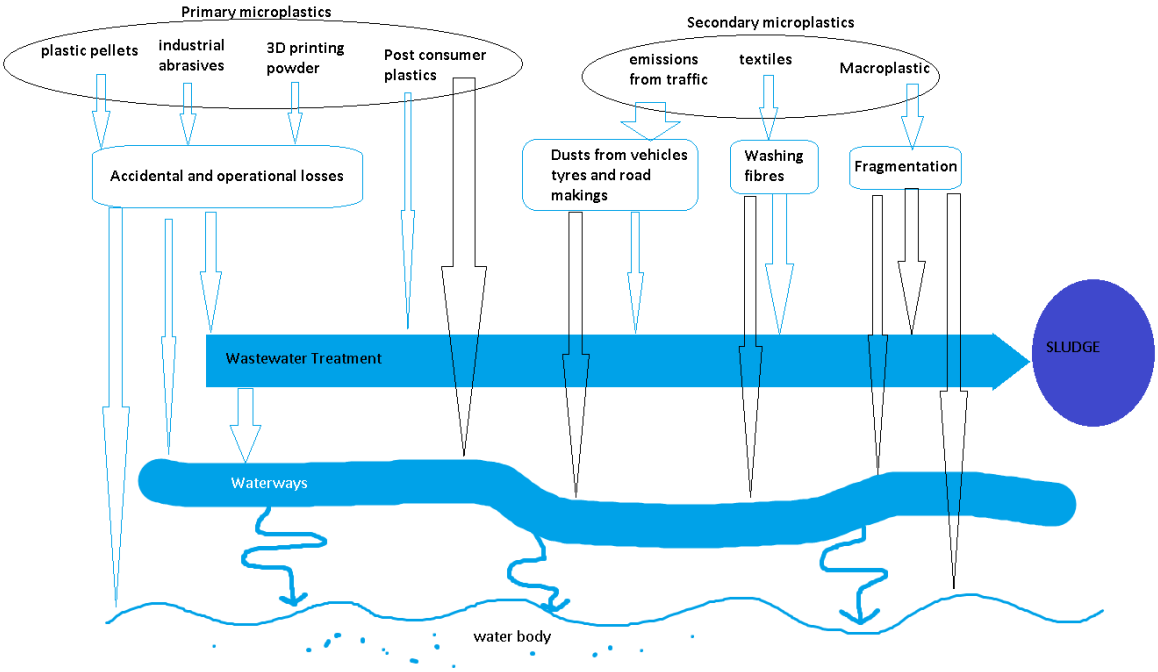


Figure 1. Source and pathways of MP to aquatic ecosystem

According to Kontrick in 2018, the danger of MP posed are cleared as the first physical impact created is the injuries of marine life form as they accumulate in intestines and grills, leading to unnatural death from eating habits. Second, plasticizers in MP are found to be endocrine disrupter intervening with marine animal growth and reproductive system. Thirds, studies have shown that MP are delivering deadly pollutant into its new ecosystem causing from irritation to disturbance in metabolism. Throughout the food web, MP's bioaccumulation could create a loss of biodiversity with continuous impact. (Deudero & Alomar, 2015).

Despite the evidence of the damage caused to marine life, currently there is no available information supporting the effect of MP uptake to human body throughout the food chain. The most common path for MP to enter human body is via oral, such as eating, drinking

or consuming drugs. After oral administration, MP are taken into blood from gut and from there into liver and bladder. Plastic can contain mixtures of their additive in order to boost the physical ability which can be leached into the surrounding. The additives that has significant affect to human health are: phthalates, bisphenol A, brominated flame retardants, triclosan, bisphenone and organotin. While the information of additive leaching directly into tissues is insufficient to state, the damage of bisphenol A to human health is significantly negative as it is an endocrine disrupting chemical. (Galloway, 2015)

Out of all those problems, one major pollution source of MP that lie in our house is the washing machine. Our clothes are made of plastic and can be shredded into fragments. When washing, the high-speed rotation causes the cloth to fragment to MP and discharge them to wastewater system. If not carefully treated, the MP could pollute when discharged into streams and rivers. And ultimately, come to our body via the food chain.

2 AIM OF THE THESIS

The aim of this thesis is to review the problem and solutions of microplastic from the washing machine point of view as source when every household contribute to this problem and most does not know. The work consists of introduction to the problem, methods of performing the work, results and discussion of the articles reviewed with possible solutions. And finally draw the conclusions.

The content reviewed are listed as follow:

- To gain insight on microfiber's components
- To quantify the concentration of MP in washing machine
- To collect existing analysis methods and develop standard of MP's measurements
- Finally introduces removal methods and possible treatment ideas for further research.

3 MATERIAL AND METHOD

Since this is a reviewing work, everything will be done in front of the computer and internet connections. Search engines are used as tools for data searching. These sites are categorized by:

www.google.com	https://www.sciencedirect.com/
https://scholar.google.com	https://link.springer.com/
https://tamk.finna.fi/	https://www.theseus.fi/
https://www.researchgate.net/directory/publications	

Table 1. Websites for literature research

From the sites, the literatures are aimed to use variety of sources which includes but not limited to:

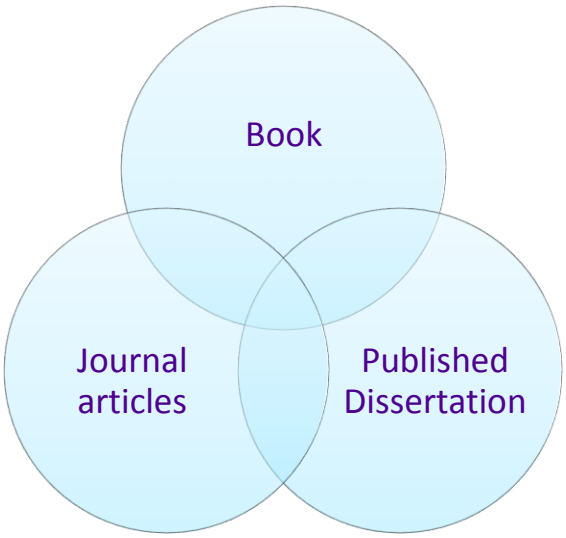


FIGURE 2. Correlation between literature sources

The main idea of this thesis is discussion and analysis of the literatures, several steps are proceeded as follow:

Step 1: Selecting literatures topics for reviewing (microplastic types, concentrations, analysis methods, data, treatment methods)

Step 2: Select keywords for search, alternative keywords are applied to widen the literature range of the topic reviewing.

Step 3: Selecting the Articles based on the relevant, popularity, detail and transparency of the work.

Step 4: Categorize the articles by sections and topics

Step 5: Read, Evaluate, synthesize and theorize research findings to create writing pattern and subtopic of the thesis.

Step 6: Develop the thesis.

Step 7: Revising the work for its relevant and delete the work with the exact same context.

In addition to the literature review, the author also discusses, summarises and concludes the research finding by topics. An extension work of Microplastic Standards and Treatment methods are included as a hypothetical work based on similar work.

4 RESULTS AND DISCUSSION

After a long search of information on MP from washing machine, the results and information are gathered to systematically reviewed.

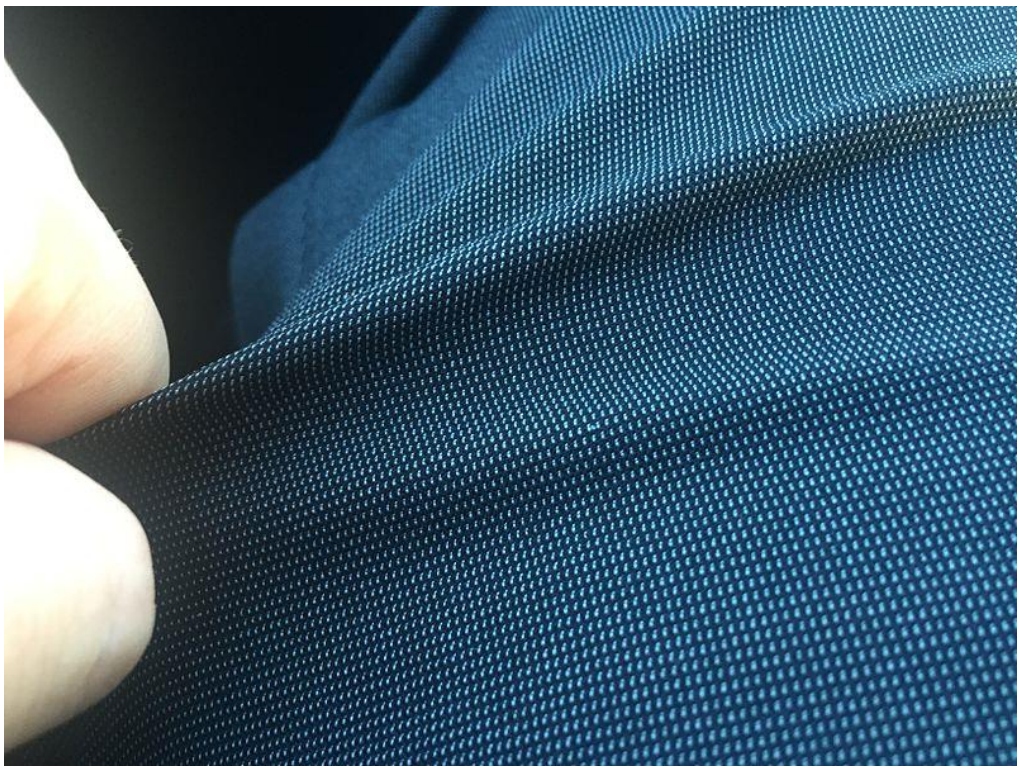
4.1 Types of plastic/microplastic

It is no mystery that our clothes are a source of MP pollution for the environment and our self. As the garment could fragmented to MP during wash, the type of MP will be identical to the original synthesised material as the garment being washed. According to Oerlikon Corporation (OC) report survey in 2010, the polymer garment that is not biodegradable are: polyester, polyamide, polypropylene, acrylic, spandex and aramid, apart from natural made and biodegradable material of cotton (cellulose), wool (cellulose/protein) and carbon fibre (OC, 2010).

4.1.1 Polyester

Polyester, by the name is the polymer of ester functional group (-CO-O-). In textile industry, it is usually referring to PET (Polyethylene terephthalate). It comprises the most synthesized polymer in the world, account for 75% of all manmade fibre and most of them are PET. PET is made from terephthalic acid and ethylene glycol. Normally it is synthesized by polycondensation reaction, of acid and alcohol to form ester bond. (Eichhorn, 2009).

Fabric made of polyester are strong, elastic and wrinkle resistance. It is cheap and easy to make, form and last. Which is why PET is preferred in textile industry. due to its durable characteristic, its microfiber is also durable and require long duration to degrade. A zoomed in look for polyester fabric as bellow:



PICTURE 1. Polyester fibre zoomed in (Bearas, CC BY SA 4.0)

4.1.2 Polyamide (Nylon)

Polyamides (PA), are macro compound with polymer chain of amide bond, between carboxyl group (-COOH) and amine group (-NH_2), that could be naturally and artificially made. (Palmer, 2001). PAs or nylon are one of the first synthesized polymers applied in textiles. It can be categorized into aromatic (ring) and aliphatic (straight) polyamides, although many more categories could be named based on the 2. Most of the aliphatic Pas can be polymerized by condensation or ring opening polymerization. Aromatic PAs are harder to synthesize due to the inert reactivity of the aromatic ring, therefore they are usually synthesized by diamine and diacid chloride. (Bunsell, 2009). PA fibre can be used as waterproof clothes:

PICTURE 2. Polyamide fabric example (Eyesighter, CC BY AS 3.0)

4.1.3 Polypropylene

Polypropylene (PP) is a synthetic fibber derived form 85% propylene. It is a linear structure of monomer C_nH_{2n} manufactured by propylene with the presence of catalyst such as $TiCl_4$. PP fibres have softening point of 140°C and lies to chain degradation of above 100°C. It is the lightest synthesized fibre, excel in chemical resistance due to its linear polymer bond. Its low melting temperature prevent it from being ironed like PET, hard to be dyed, poorer resilience compares to PET and flammable. PP fibres has high surface area and is oleophilic, which can be used to transport sweat away (Mandal, 2019). PP fibre are usually used for woven clothes, which are viewed as:

PICTURE 3. Polypropylene fibre example (Wovenplacemat, CC BY AS 4.0)

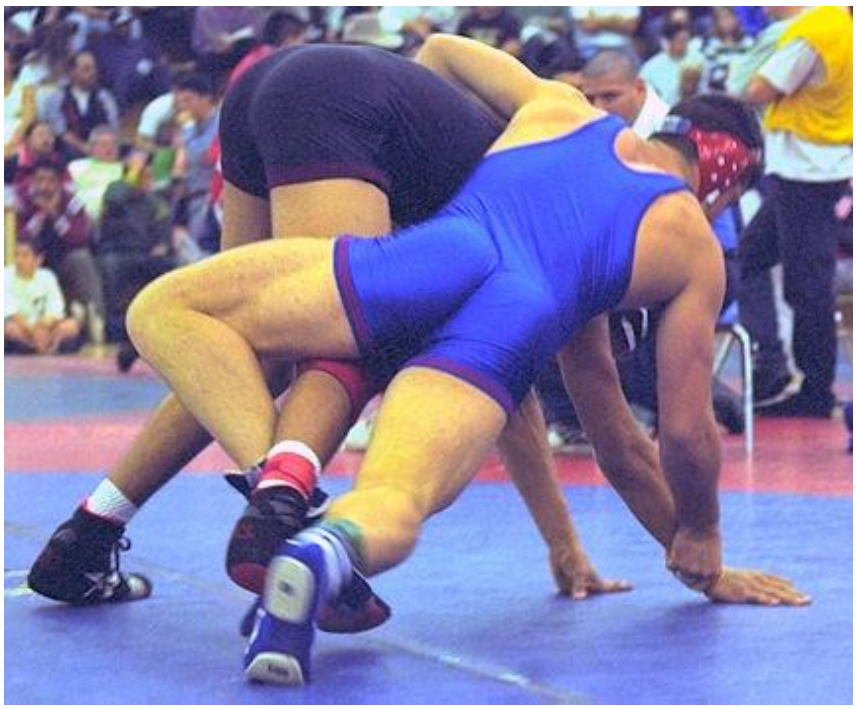
4.1.4 Acrylic

Acrylic fibres are synthesized from polyacrylonitrile(C_3H_3N) by addition polymerization of acrylonitrile (vinyl cyanide). They are produced by dry or wet spinning extrusion process, where they dissolve the polymer in solvent of N, N-dimethylformamide or aqueous sodium thiocyanate, measuring it though a multi-hole's spinnerets and the resulting fibres will be consolidated in the same solvent solution (wet spinning) or evaporate the solvent with heated inert gases (dry spinning). Acrylic fibre is resistant to moth, oil, chemicals or sunlight degradation which could be used to manufacture garment of all seasons. (Shishir, 2015). Acrylic fibre is seen as:

PICTURE 4. Acrylic fabric example (GiFontenelle, CC BY AS 4.0)

4.1.5 Spandex yarn

Spandex, also known as Lycra or elastane is a fibre known for the elasticity. It is a copolymer of polyether(R-O-R) and polyurea (-$(NH_2)_2$CO-R-). It is made to withstand high temperature and stretch to 500% for athlete. Spandex is made by reacting monomers to form prepolymer, and further react in various ways to produce the fibre. In its macromolecular structure, the rubbery segment is linked to the rigid segment and repeating in different length and composition order. (Turksoy, H. G. 2007). Stretching spandex cloths are seen as:



PICTURE 5. Spandex pant (Eddgaard, CC BY AS 2.0)

4.2 Concentration of the microplastic

Synthetic MP fibres are repeatedly reported from samples in sediments, water column and biota as they travel from washing machine to sewage treatment plant. Experiments has shown that a single garment can produce over 1900 fibres per wash and an average 6kg wash could release 700,000 fibres pieces (Browne et al. 2011). To measure the result, Browne sample discharged effluent of treatment plant and the sediments of sewage sludge disposal site. With the accumulation of human discharge water, the concentration will increase in the environment every discharge. The composition of the MP is shown in the figure bellow:

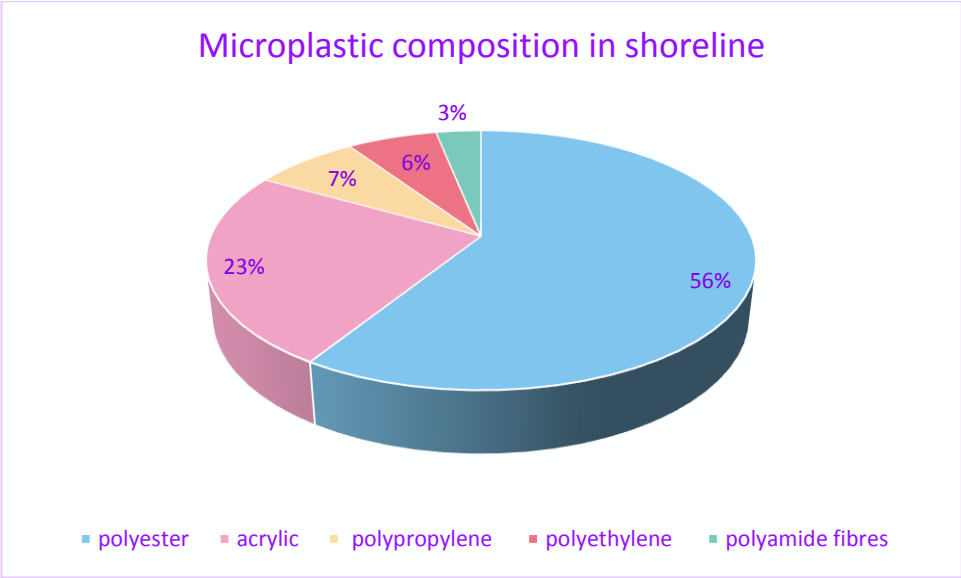


FIGURE 3. Illustration of microplastic composition found in shoreline in Browne's report

On another study made by Napper and Thompson in 2016, Acrylic fibre could give 763130 fibres/mg of fibre collected in the effluent (2.63 mg in the first wash) while polyester fibre gives 475988 fibre pieces/mg of fibre collected in the effluent (2,79 mg in the first wash). After 5 times of washing, the amount of MP drops to produce less MP in the wastewater yet the number is still significantly large.

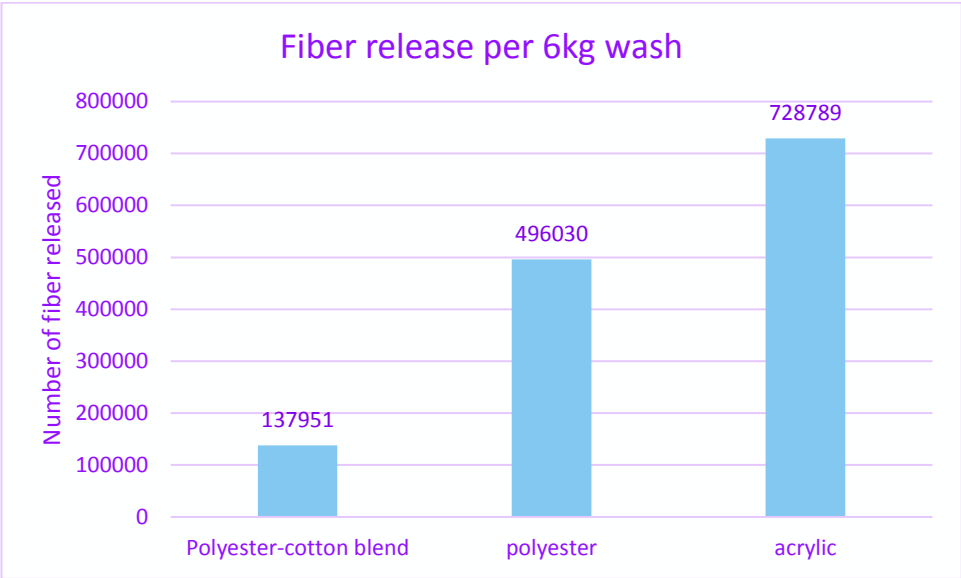


Figure 4. Representation of Napper and Thompson Fibre release

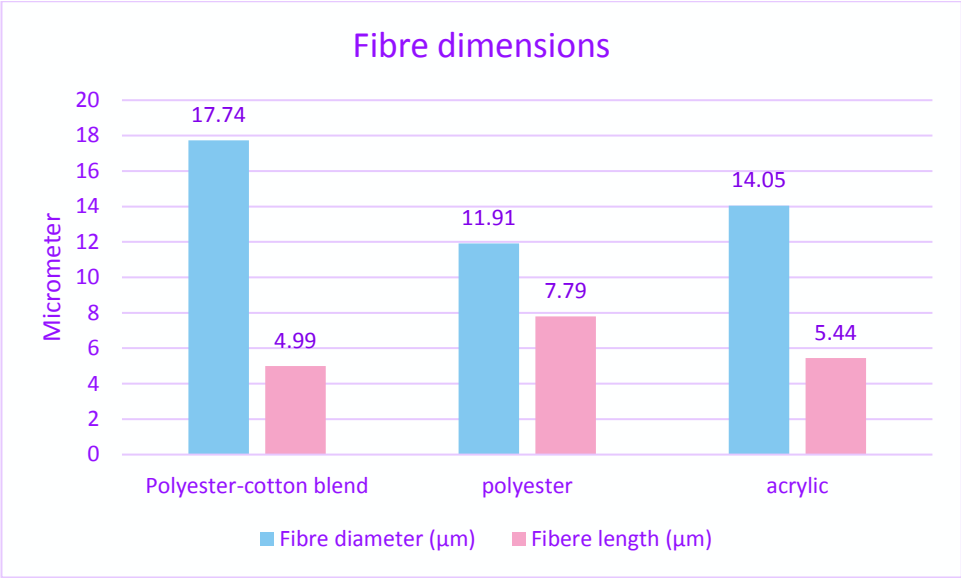
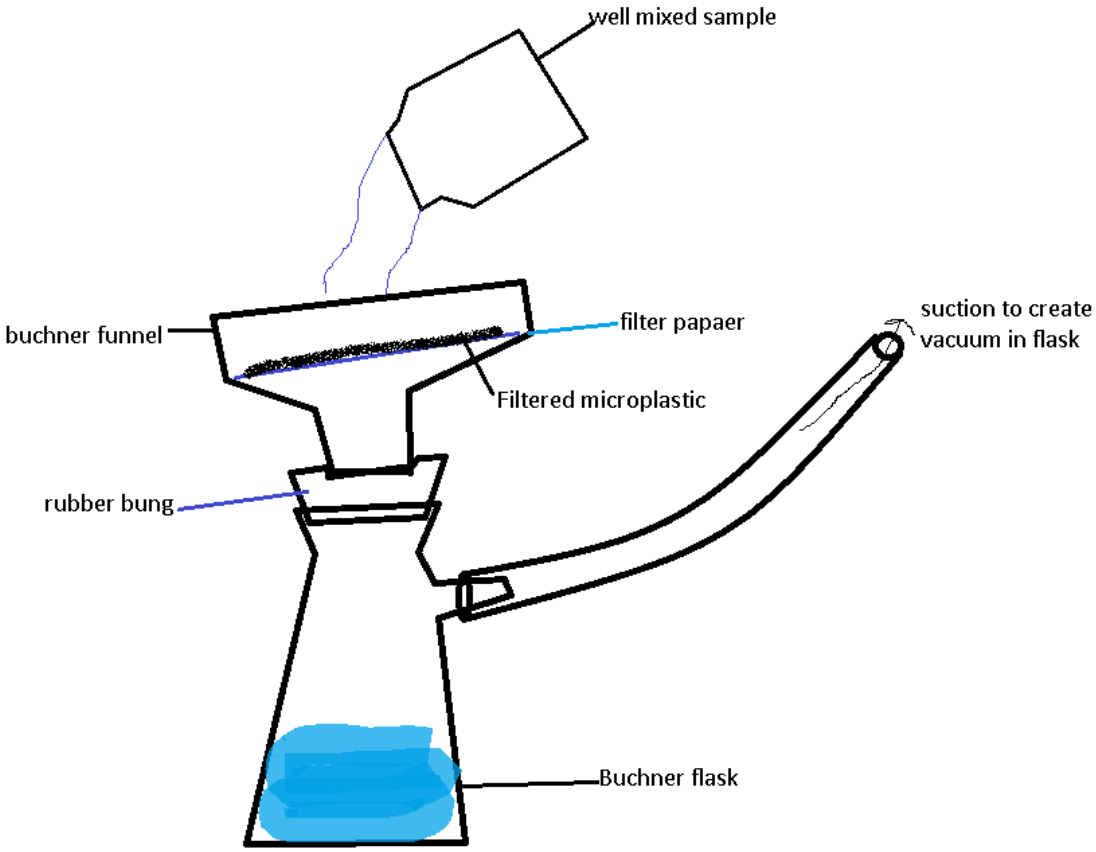


FIGURE 5. Illustration of Napper and Thompson fibre's dimensions

4.3 Sampling

In any measurement, the first step is to collect water sample then measure. The sample collection is varied yet should remain as the average concentration of the whole wash. The sampling method could be collecting all the water then measure of pick multiple point of discharge period to execute the analysis. After sampling period, there are various methods to determine the result. Many experiments require controlling various factors for measuring the result, and Gyrowash machine is popularly used.

A method used by Lamichhane in 2018 used vacuum filtration, built with filtering funnel, filter paper, base, clamp, filtering flask and vacuum. The washing machine tested released 22 litres of water per wash, but only sample 3 litres after well mixing the sample water. After setting up the apparatus, the sample was poured into the funnel and filtered to leave the residue for analysis. The residue is then dried and measured under laboratory scale and microscope. The experiment was picturized as:



PICTURE 6. Representation of Lamichhane's sampling method

In 2016, Napper and Thomson used Whirlpool WWDC6400 washing machine to launder garment sample, the outlet microfiber was recorded using a nylon CellMicroSieve™ (Fisher Scientific), with 25 µm pores, was attached to the end of the drain hose. Once completed the wash, the CellMicroSieve™ was removed to collect microfiber. 2L of water was used to filter again for potential build-up of detergent with Whatman No. 4 filter papers, and then dried at 30 °C to constant weight. Once dried, the fibers are weighted with Cubis® precision balance (Sartorius).

4.4 Analysis methods

4.4.1 Counting and estimation method

a. Manual estimation

After sample is collected, Napper and Thomson filter again and again, and visualized using scanning electron microscopy. The result of SEM is picturized similar to:

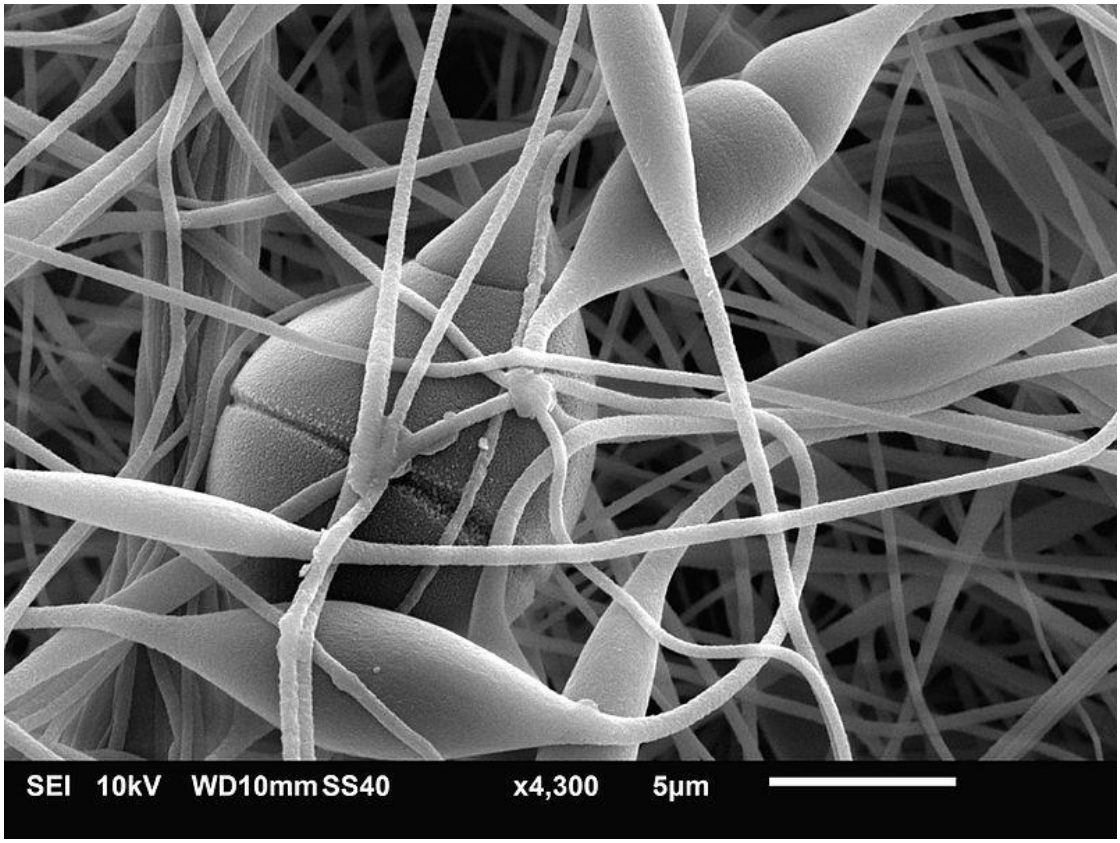


FIGURE 6. SEM image of nanofiber example (Dulnik, J. CC BY AS 4.0)

The number of fibres released N, was estimated from the weight of filtered fibres using the following equations and assuming the fibres were of cylindrical shape:

a) $V_t = \frac{M_t}{D}$

b) V(average fibres) = $\pi * r^2 * l$

c) N= $\frac{V_t}{V}$(average fibre)

Whereas:

V_t is the total volume of fibres collected (m^3)

M_t is the total mass of fibres collected (g)

D is the density (g/m^3)

V(avg.fibre) is the mean volume of one fibre (m^3)

N is number of fibres

l is the length (m)

r is the radius(m)

For each product:

equation a) calculate the total volume of fibres collected

equation b) calculate the average volume of a fibre from each garment

equation c) calculate the approximate number of fibres released in the effluent from each wash.

By running the washing-machine at 30 °C, 1400 R.P.M for 45 min between washes with no fabric present, cross contamination is minimized between washes.

b. Computation estimation

In 2018, a study conducted by using optical microscope Leica DM4000M connected with the software Cleanliness Expert v4.9 after consideration of SEM and previous standard techniques. (Jönsson et al, 2018) This is also considered to be counting method even though it is based on algorithm and computational counting.

PICTURE 7. Representation of the digital microscope connected for counting MP (Zephyris, CC BY AS 3.0)

4.4.2 Fourier Transform Infrared spectroscopic

Infrared spectrometry is a method with molecular vibration theory based, as any molecules with a permanent dipole will be infrared spectrometry active. Homonuclear diatomic as H_2 could not be analysed by infrared spectrometry while CO can. Laser is capable of infrared inducing the dipole changes, when the frequency of radiation matches the molecule's natural vibration frequency, the energy is absorbed to change the amplitude of vibration and appear a peak on the infrared spectrum. The theory is also applied on plastic for identification.

When infrared radiation is applied to sample of the material, FTIR analysis measure the sample absorbance of various infrared wavelength, to determine the sample composition and structures, FTIR work by converting raw information of light source band to absorbance level of wavelength. In the result graph of FTIR spectrum, the horizontal axis represents the infrared spectrum, or the intensity of infrared spectra of 4000 to 400 cm^{-1}. The peak, also known as absorbance band, corresponding with various vibrations of the sample's atoms when it's exposed to the infrared region of the electromagnetic spectrum. the vertical axis represents the amount of infrared light being absorbed or transmit by the sample analyzed. The higher the peak, the more light is absorbed and the more sample there are or higher quantity of the sample. This can be highly effective when measuring sample of microfiber, which are small and easily errored.

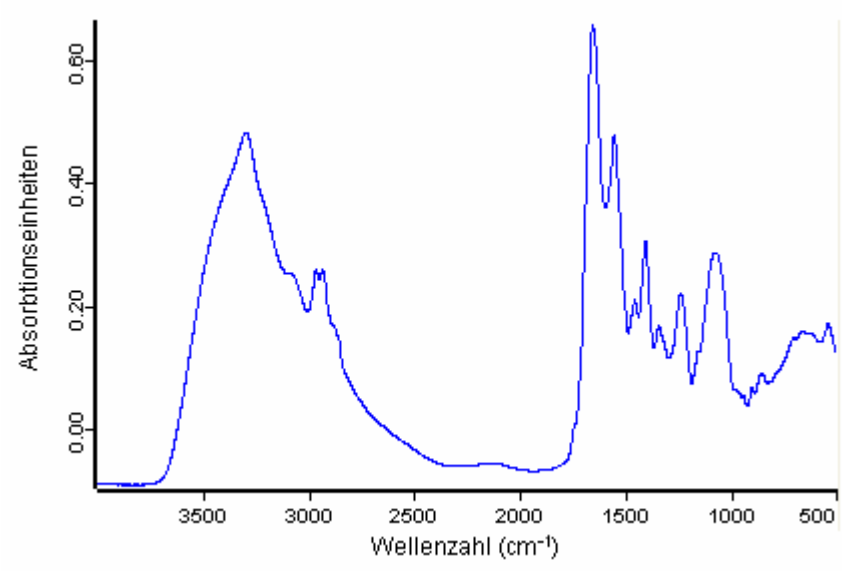


Figure 7. Example of FTIR results (Butenbremer, CC BY AS 3.0)

In a publication by Aalborg University of MP analysis, Fourier Transform Infrared (FTIR) imaging system was used. After samples are taken in nature, Oxidation by H_2O_2

as pre-treatment to preserve the plastic and remove organic matters. The plastic is concentrated by sieving and flushing with ethanol. gravimetric separation was used to separate inorganic and organic content. Afterward, 60 mL of 5 M KOH was added for every 1 g of dry sample and stir for 48 hours at 45ºC. The final concentrated plastic sample was kept in ethanol, with samples bigger than 80 µm, they are deposited onto an infrared reflective glass slide to be analyzed by FTIR imaging reflection mode. If particles are smaller than 80 µm, they are deposited onto CaF_2 infrared transparent window to be dried and analyzed Samples were then analyzed by identification, mass percentage and particle count percentage. (Olesen et al, 2018)

4.4.3 Diffuse reflectance infrared Fourier transformed (DRIFT) spectroscopy

DRIFT is a FTIR spectroscopy localized on surface as it is capable of providing structural and chemical data for all type of solid surface. When infrared light reaches the sample surface, the radiation can be absorbed, reflected or penetrate the sample before being scattered. DRIFT analysis is conducted by focusing infrared light onto a material, and the scattered light is collected and relay to the detector, generating a spectrum. DRIFT is fast and non-destructive, the sample can be analysed in powder form. (Accardo et al.2014). The technique is suited for analysing low signal and sloping baseline in transmission, which may prove to be a great technique for microfiber on filter material.

4.4.4 Errors and difficulties of microfiber analysis

Since microfiber are extremely small that require to quantify, contaminations are easily occurred. A report from Mistra Future Fashion pointed an analysis method of shed fibres by collecting from wastewater in filters and analyse them using optical microscopy technique and scanning electron microscope (SEM). In order to make a distinction of the fibre and filter in SEM, the filter material chosen was fluoropolymer which did not provide the necessary distinction and only 1cm*1cm of the filter was analysed per time. (Roos et al. 2017). The analysis was changed into a more effective way of connecting an optical microscope to an automatic fibre identification software for quantifying the number and describing the material property. In terrible case scenario, the fabric brought along dirt in sample filter and hinder the software from counting and recognizing the MP. Also, when multiple MP crossed, the software counted as one, leading to underestimation.

Two of the most notable sources of error are surrounding environment error and human input error. Except for in a clean room, there are always MP in the air and microfibre in laboratory experiment challenging the analysis of MP. Due to various testing method done by hand, cross contamination can occur during any stage of measurement with such small and easily contaminated samples of MP. Which is why preparation step is crucial for reducing both error factors. Furthermore, there lies risks of contamination between the test rounds, which made it unclear regarding MP occurrence in wastewater.

4.5 Standard

Currently MP are identified by count. As it will be unrealistic to measure them by volume, the MP has tendency to degrade into smaller pieces of nanoplastic. Along with dirt, unwanted particles and nanoplastic, the most probable solutions would be to measure the number of carbon polymer bond in the whole sample. Since it is the lowest quantity that could not shed smaller, quantifying the number of polymer bond. Since there exist numerous MP type and mass number, the mass standard would not be probable imply while measuring microfiber could contain significant amount of contamination.

With the use of FTIR, the MP are measured by infrared radiation absorption, which could be utilized for creating standards of MP in water with higher accuracy. It can represent both absorbance and wavelength of the MP, therefore the software can calculate the concentration and the plastic type. While microplastic can accumulate throughout the food chain, I propose the limit of MP larger than 50 µm is 1 particle per liter and limit of MP smaller than 50 µm is 10 particles par liter. Ideally would be 0 but MP are found everywhere, even inside our water bottle.

4.6 Removal method

Garment in washing machine, when rotate at high speed will create contact and friction shredding fibre in microscopic level, unnoticed by naked eye, will be flushed out with used water. The best way is to switch to natural fabrics or biodegradable one, where MP is not resilient throughout the food chain. There still are other removal method developed.

4.6.1 Cora Ball

Cora ball is a ball designed to catch microfiber during washing. It is a round ball with tiny gap identical to hair comb for catching microfiber thread. The Cora ball can work in all types of washing machine with no negative effect and can be reused repeatedly. (Cora ball team, 2018)

Normally washing machine does not have any filters, the best ones are those keep key and coin from clogging pipe. Therefore, standard filter could not catch microfiber. In nature, coral catches tiny objects from flowing water and inspired by the same principle, Cora ball catches microfiber from flowing water when fragmented during wash. Cora ball behaves similar to coral, allow water to flow and catch MP pieces. The microfibers are captured using Cora ball and can be throw away. Although the ball could not capture 100% of MP in washing machine, some could escape to the discharged water.

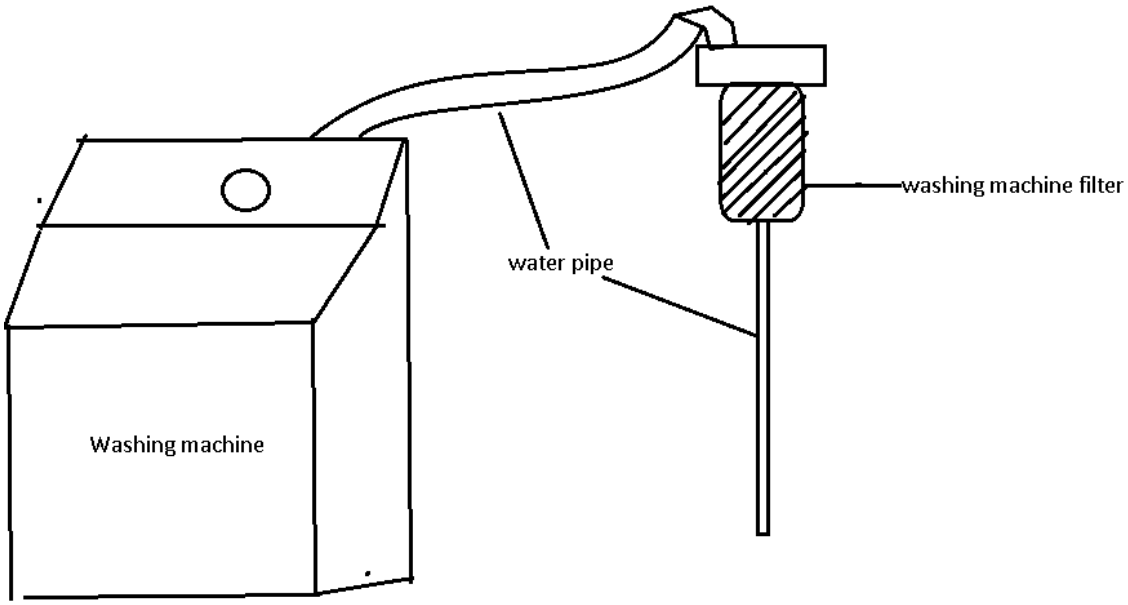
4.6.2 GUPPY friend

GUPPY friend is a washing bag designed for microfiber. It will capture the MP inside the bag to dispose after wash. The MP captured can be removed by hand after each or several add up wash. GUPPY friend is known as a patented product, by putting clothes inside the bag, the tiny microfiber will be filtered at the moment of released from garment during wash. It is a self-cleaning bag specially designed to filter microfiber material. After each wash, the fiber can simply be collected and disposed. (GUPPYFRIEND, 2019)

The instruction is simple, before wash just put synthetic textile into the GUPPY friend bag as normal. Proceed afterward as usual and after washing, take the wet garment out to remove release microfiber inside the bag

4.6.3 Washing machine filter

One method is to filter the washing machine before the wastewater is discharged to the sewage system. An example is as follow:



PICTURE 8. Sketch of washing machine filter.

In the sketch is the microplastic filter in washing machine visualization. The idea is to use filtering material in nano scale which can let water pass but not microfiber. The material should be special made for multiple use and can be remove or replaced.

4.6.4 Wastewater treatment upgrade

Washing machine is only account for a third of MP problem in sewage system. The other part comes from cosmetic and daily products in hygiene. The best way is to upgrade the wastewater treatment system to fully treat MP problem in water.

A photocatalyst such as Titanium dioxide (TiO_2) is widely used for bacterial infection and keeping wall clean from dirt by oxidizing the compound when come to contact (Etacheri et al, 2015). It can be visualized as:

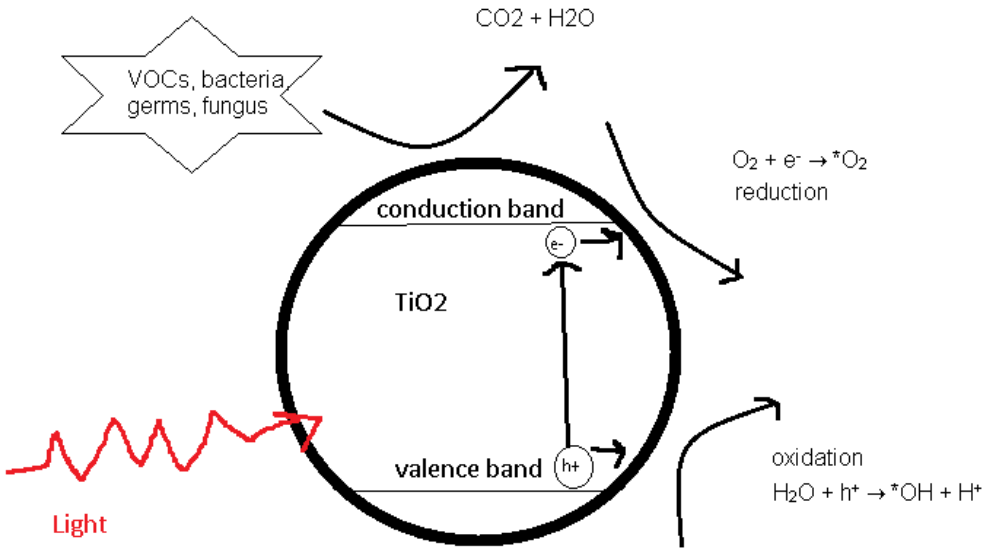


FIGURE 8. TiO_2 Photocatalytic ability representation

Titanium dioxide is a photocatalyst with various applications for its ability and cheap expenses. When expose to sunlight, especially in UV radiation, it shows amazing oxidizing power. Its photocatalyst reaction is explained as follow:

When illuminated, the surface of TiO_2 separate 2 carrier of electron (e^-) and a hole (h^+). For this to occur, sufficient energy must be supplied by photon to excite the electron from valence band to conduction band:

$$TiO_2 + hv \rightarrow h^+ + e^-$$

The recombination of hole and electron of TiO_2 is slow, so hole can oxidize a donor molecule (D) when absorbed on TiO_2 surface:

$$D + h^+ \rightarrow D^+$$

And the electron in the conduction band can reduce and acceptor molecule (A);

$$A + e^- \rightarrow A^-$$

The strong oxidation ability of hole can oxidize contact water to produce hydroxyl radical (*OH):

$$H_2O + h^+ \rightarrow *OH + H^+$$

Oxygen when in contact could be reduced to superoxide ion ($*O_2$) by electron in the conduction band. The super oxide ion is highly reactive, able to oxidize organic materials and has been used to purify water and sterilize:

$$O_2 + e^- \rightarrow *O_2$$ (Castellote, 2011)

With such superb oxidation ability, it might be capable of treating resilient microfibre if applied for wastewater treatment.

4.6.5 Current wastewater treatment technology – Membrane bioreactor

A study has been done to examine the MP removal efficiency from 5 different advanced final stage treatment technology. Membrane bioreactor could remove 99.9% of the MP from the wastewater. Rapid sand filtration could remove 97%, dissolve air flotation could remove 95%, disc filter could remove 40 to 98.5 % and biological active filter could not treat MP at all. During the study, the smallest size of MP (20-100 µm) dominate the size composition and fiber were the most abundant MP type. (Talvitie, J. 2018)

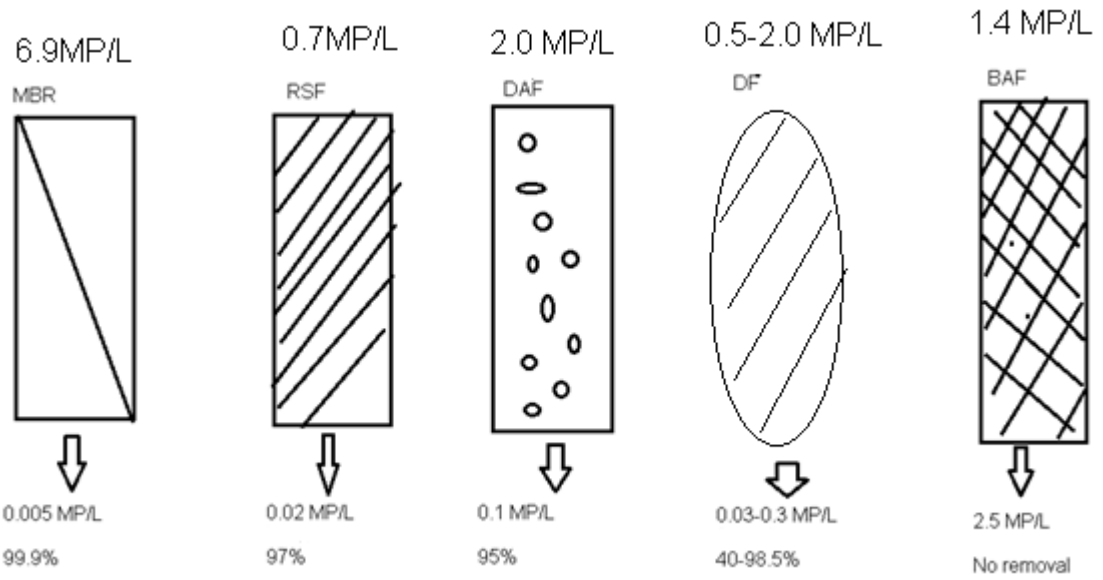


FIGURE 9. Removal of MP from wastewater effluent of the 5 different treatment technologies: membrane bioreactor (MBR), rapid sand filtration (RSF), dissolved air flotation (DAF), disc filter (DF) and biologically active filter (BAF).

In the study, Talvitie also indicate that sand filtration could remove 56% of microliter, cloth media filtration removed up to 95% of MP from secondary effluent. When combined ultrafiltration and biological treatment, 87% of MP was decreased and reverse osmosis later on decrease 25% further. As reverse osmosis is able to remove microscale bacteria and protozoa, even nano scale viruses, how the remaining MP could escape is not clear. In the future, MP pollution should also be taken into consideration when designing advanced final stage of wastewater treatment technology.

5 CONCLUSION

After series of literature reviews, it is safe to concludes that microfibers are causing serious damage to the environment and we are contributing to it every single day. The most popular one that done the damage are non-biodegradable PET, PA, PP, acrylic and spandex.

For every garment, over 1900 pieces of fibres could be produced per wash and two thirds of them are polyester. The number could add up to over 700,000 fibres pieces to be released per wash. Surprisingly, the number of MP decreased after every wash yet the number remaining significant.

In sampling MP, filtration is often used to separate all the MP from water and count afterward, manually or automated. Vacuum filtration is popularly used for its economical inexpensive and easily built. More advanced apparatus could be applied for higher accuracy and smaller sample. When analysing, human factor contributes the most to errors and therefore, computational imaging and counting should be done to ensure high accuracy of the result in micro scale. The best way to minimize the error is careful preparation and pre-treatment before analysis.

Many removal methods of MP in washing machine has been introduced such as Cora ball, GUPPY friend or filtering outflow wastewater. The most efficient one however should be upgrading wastewater treatment plants since not everyone could afford to upgrade their clothes or washing machine.

Further researches are needed to encounter the MP escaping treatment and more efficient in measuring MP in general. In the future, when MP accumulated, it will become a huge pollution problem bigger than plastic pollution in the ocean. To evaluate MP consequences, more information is needed and little do we know about it.

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