

Microplastic emissions from laundry in Sweden

- An actor analysis including the drivers, barriers, possibilities and responsibility of actors upstream and downstream Mimble AB towards reducing the microplastic emissions.

Mikroplastutsläpp från klädtvätt i Sverige

- *En aktörsanalys bestående av de drivkrafter, barriärer, möjligheter och det ansvar som aktörer uppströms och nedströms Mimble AB har för att bidra till minskade mikroplastutsläpp.*

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Abstract

The usage of plastic is continuously growing with an increasing amount spreading to the environment. This entails potential negative effects on both the human health and on animals, for example by animals starving due to mistaking plastic for food. A concerning issue is that larger fragments of plastics break down to microplastics (< 5 mm) by which the impact is yet to be fully established, but studies have shown that there is a potential harmful impact on the environment. In Sweden, the largest sources of microplastics, created by abrasion, are tyres followed by artificial turf, laundry and road markings. Laundry is however the largest source in connection with sewage water. The EU commission has set a target to reduce the amount of microplastics released into the environment by 30 % to 2030. It is thus called for to implement measures to reduce microplastic emissions from laundry.

Based on a Swedish context, this thesis aims to identify what actors can reduce the microplastic emissions from laundry as well as what their potential drivers, barriers, possibilities and responsibility are. This way it is possible to fill the knowledge gap concerning what barriers need to be overcome before it can be expected of actors to implement measures and regarding tendencies on which actor/-s should take responsibility. The aim is fulfilled by conducting an actor analysis where the actors, who affect and, in some cases, are affected by microplastic emissions from laundry in Sweden are mapped, and their perspectives and context are analysed. This analysis is centred on the company Mimby AB, including actors either downstream or upstream the company. The data used for the analysis is gathered from interviews and a survey.

The study identified eight different types of actors that can affect, and who in some cases also are affected by, microplastic emissions from laundry in Sweden, namely: designers, textile producers, retailers, consumers, washing machine producers, industrial laundries, filter solutions and wastewater treatment plants (WWTPs). Some actors had already implemented measures, the identified drivers for these measures were categorised as knowledge, health & environmental concerns, organisational/mindset, stakeholder encouragement, technical or economic. The most common driver was organisational, e.g., that actors have sustainability strategies. The result showed that all actors have some possible measures to implement but have not done it yet due to that their barriers are too significant and drivers too weak. The barriers identified in the thesis were categorised as knowledge, environmental, organisational/mindset, stakeholder resistance, technical, economic, temporal and legislative. The most mentioned barriers were knowledge and technical, e.g., lack of standardised methods for sampling and analysis of microplastics as well as a lack of measures. Overall, designers and WWTPs have among the highest number of already implemented measures, barriers, drivers and possibilities. The reason for this could be that they are conducting more research on the topic as a response to being increasingly viewed as the actors that can provide the most proactive and reactive solution. In turn, the research they have conducted has led them to identify more measures to implement and more barriers than other actors. It is, however, difficult to conclude if this is due to that they simply have more knowledge or that other actors do have more barriers but are not aware of them since they lack knowledge. This further justifies for the need of establishing more knowledge.

The perception of all actors was that designers should be allocated most responsibility for reducing the microplastic emissions since they place the garments on the market. However, the thesis concludes that it is of priority to enable further technical innovations and to establish more knowledge before actors can be blamed for not acting. Continuing, the thesis concludes that the filter solution offered by Mimby AB will most likely be needed in the future.

Sammanfattning

Som följd av en ökande plastanvändning ökar även nedskräpningen av plast i naturen. Detta påverkar såväl människors hälsa som djur och natur, till exempel genom att djur svälter till följd av att de misstar plast för föda. Ett oroande problem är att större plastfragment bryts ner till mikroplaster (<5 mm) vars påverkan ännu inte är helt fastställd, men studier har visat att det potentiellt kan ge en skadlig inverkan på både människor och natur. De största källorna till mikroplaster i Sverige, uppkomna genom nötning, är däck följt av konstgräs, tvätt och vägmarkeringar. Tvätt är dock den största källan sett till spridning via avloppsvatten. EU-kommissionen har satt upp ett mål om att minska mängden mikroplastpartiklar som släpps ut i naturen med 30 % till år 2030.

Detta examensarbete syftar till att i en svensk kontext identifiera vilka aktörer som kan bidra till minskade mikroplastutsläpp från klädtvätt samt vad deras potentiella möjligheter, drivkrafter, barriärer och ansvar är. På så sätt är det möjligt att fylla kunskapsgapet gällande vilka barriärer som behöver övervinnas innan det kan förväntas av aktörerna att genomföra åtgärder samt gällande tendenser om vilken eller vilka aktör/-er som bör ta ansvar. Syftet uppfylldes genom en aktörsanalys där perspektiven och kontexten av de aktörer som påverkar, och i vissa fall påverkas av, mikroplastutsläpp från klädtvätt i Sverige kartlades. Aktörsanalysen fokuserades på företaget Mimby AB, där de inkluderade aktörerna antingen är nedströms eller uppströms Mimby AB. Aktörsanalysen genomfördes genom en litteraturstudie, intervjuer och en enkätundersökning.

I detta examensarbete identifierades åtta olika typer av aktörer som kan påverka, och som i vissa fall också påverkas av, mikroplastutsläpp från klädtvätt i Sverige: designers, textilproducenter, försäljare, konsumenter, tvättmaskinstillverkare, industritvättar, filterlösningar och avloppsreningsverk. Resultatet visade att några aktörer redan genomfört åtgärder. Drivkrafterna bakom kategoriserades som kunskap, hälso- och miljöhänsyn, organisatorisk/inställning, intressenters stöttning, teknisk eller ekonomisk. Den vanligaste drivkraften var organisatorisk, till exempel att aktörerna hade en hållbarhetsstrategi. Resultatet visade att samtliga aktörer hade åtminstone några möjliga åtgärder att implementera men att de inte har gjort det än på grund av alltför stora barriärer. De barriärer som identifierades i examensarbetet kategoriserades som kunskap, miljö, organisatorisk/inställning, intressenters motstånd, tekniska, ekonomiska, tidsmässiga och lagstiftningsmässiga. De vanligaste barriärerna var kunskapsmässiga och tekniska, till exempel brist på standardiserade metoder för provtagning och analys av mikroplaster samt brist på tillgängliga åtgärder. Sammantaget visar resultatet att designers och avloppsreningsverk är de aktörer som har flest genomförda åtgärder, barriärer, drivkrafter och möjligheter. Anledningen till detta kan vara att de drivs till att bedriva forskning inom ämnet eftersom de lätt kan tilldelas ansvar av andra aktörer eftersom de kan ses som den mest proaktiva respektive reaktiva lösningen. Att de efterforskat mer kan ha lett till att de har identifierat möjliga åtgärder men också till att de stött på fler barriärer än andra aktörer. Det är därför svårt att dra slutsatsen om resultatet beror på att dessa aktörer helt enkelt har mer kunskap och att de andra aktörerna har fler barriärer, men inte är medvetna om dem. Detta motiverar ytterligare till att mer kunskap måste till.

Samtliga aktörer ansåg att designers borde tilldelas det största ansvaret för att minska mikroplastutsläppen eftersom de placerar plaggen på marknaden. I examensarbetet dras dock slutsatsen att det är av stor vikt att möjliggöra ytterligare tekniska innovationer och att fastställa mer kunskap innan aktörerna kan klandras för att de inte agerat mer. Fortsättningsvis dras även slutsatsen att det med största sannolikhet kommer att finnas ett behov i framtiden för Mimby AB:s filterlösning.

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1 Introduction

The usage of plastics is continuously increasing due to contributing with considerable benefits to society (de Wit et al., 2019). However, the use of plastics have negative impacts on the environment and the human health and contributes to climate change, spread of toxic chemicals and littering (European Environment Agency, 2021). Plastic litter in our oceans is one of today's largest environmental challenges (Regeringskansliet, 2020). Over 150 million tonnes of plastic currently exist in our oceans and its degradation can take hundreds of years (Naturvårdsverket, 2020). Even if the inflow of plastic to the oceans would stop today, the size of this sink would keep increasing due to large plastic fragments such as plastic bags continuously degrading to so called microplastics (GESAMP, 2015). Microplastics are plastic particles < 5 mm (GESAMP, 2015).

Studies have shown that animals can starve due to mistaking microplastics for food (Moore et al., 2001). It has also been shown that microplastics can cause stress and inflammation in animals (Koelmans et al., 2019) as well as have a negative impact on animals' reproductive success (Cole et al., 2013) and growth (Sjollema et al., 2016). Microplastics might also have an impact on the human health by causing inflammation in the intestines (Bouwmeester et al., 2015) and affecting fetuses during pregnancy (Leslie, 2011).

Microplastics can either be emitted to the environment via (manufacturing and use of) products in which they are intentionally added or by abrasion of larger plastic fragments (Hann et al., 2018; Naturvårdsverket, 2017). The estimated main sources of microplastic emissions in Sweden, caused by abrasion, are tyres followed by artificial turf, laundry and road markings (Magnusson et al., 2016). Laundry is however the main source to microplastics in sewage water while the main sources to storm water are tyres, artificial turf and road markings. The microplastic particles released during laundry will enter the influent to the WWTPs and about 99 % (Carr et al., 2016; Murphy et al., 2016; Simon et al., 2018) of it are removed from the effluent during the treatment processes. However, it has been shown that up to 40 % of the removed microplastics end up in the sewage sludge and the remaining is believed to possibly be removed in the different treatment stages at the WWTPs (Ljung et al., 2018).

The microplastics released during laundry originate from synthetic textiles made from plastic. The interest in synthetic fibres is continuously rising. Between 1975 and 2019, the global production of synthetic fibres increased by almost 750 % (Textile Exchanges, 2020) and in 2019 the yearly global production of textile fibres amounted to 111 million tonnes, of which almost 68 % were synthetic fibres. By 2030 the global production is expected to reach 146 million tonnes per year where synthetic fibres will stand for 67 % (Textile Exchanges, 2020).

As a part of the EU Green deal and the EU zero-pollution vision for 2050, the EU Commission has published an action plan. The action plan includes actions and reduction targets for microplastic emissions (European Commission, 2021). One of the set targets is to reduce the amount of microplastics released to the environment by 30 % to 2030.

Since laundry is one of the main sources to microplastics it is called for to act to reduce the microplastic emissions of that origin. However, there is at present a lack of measures being implemented towards reducing the microplastic emissions from laundry. To enable this, the actors who can reduce the emissions need to be involved which can be done by for example conducting actor analysis. Actor analysis centred on actors who can contribute to reduced microplastic emissions from laundry has previously not been conducted and is an important knowledge gap to fill. It is necessary to know which actors that have an influence, what actions they can take, what their drivers and barriers for introducing different measures are as well as how to overcome the identified barriers. By identifying this, it can also be understood which actors have the responsibility to act. Without such an understanding it is difficult to mobilize the actors to achieve a reduction in microplastic emissions from laundry.

1.1 Mimby AB

This study is focused around the company Mimby AB. They are a Swedish company that was established in 2017. They offer an add-on solution for laundry machines, the Mimbox, which filters out microplastics, reduces energy usage and reduces water usage by up to 70 % (Mimby AB, n.d.). The solution is, as of today, focused on shared laundry rooms but in the future it is on the agenda to offer it for households. At present Mimby have ongoing pilot projects with customers in Gothenburg testing out the solution.

By conducting an actor analysis, it is possible to highlight Mimby's significance as a part of reducing the microplastic emissions. This analysis can provide an insight to if actors, both upstream and downstream Mimby, will be able to implement measures to reduce the emissions. With this knowledge it is possible to conclude if there will be a need for Mimby's filter solution in the future.

1.2 Aim and research questions

The aim of this thesis is to identify what actors can reduce the microplastic emission from laundry as well as what their potential possibilities to act and influence, and their drivers and barriers to introduce different measures are. This way it is possible to fill the knowledge gap concerning what barriers need to be overcome before it can be expected of actors to implement measures and regarding tendencies on which actor/-s should take responsibility.

To fulfil the aim of the thesis the following research questions will be answered:

1. What actors can affect and, who in some cases also are affected by, microplastic emissions from laundry in Sweden?
2. What potential possibilities, barriers and drivers do the identified actors perceive that they have to contribute to a reduction in microplastic emission from laundry and how can the identified barriers be overcome?
3. How do the identified actors allocate the responsibility for reducing microplastic emissions from laundry?
4. How is Mimply affected by the actors upstream and in what way is Mimply affecting the actors downstream in terms of the need for their solution?

These research questions have been approached via an actor analysis, mapping the perspectives and context of actors who affect and, in some cases, are affected by microplastic emissions from laundry in Sweden. The analysis is focused on the company Mimply with the included actors either being downstream or upstream Mimply. Upstream actors include the design to the washing of the garments while downstream actors include those who are handling the microplastics released from the garments during laundry.

1.3 Delimitations

The work is delimited to a Swedish context, including actors either situated in Sweden or having an established market in Sweden. Continuing, the work will only include machine washing of clothes. The reason for these delimitations is partly due to time constraints and partly due to the master thesis being based on the context of Mimply, which is a Swedish company providing solutions for washing machines.

2 Background

This chapter presents the background of this thesis and introduces microplastics, their impact on the environment and the human health, their sources and sinks, microplastic release during laundry and the regulations including policy instruments regarding microplastics.

Microplastic particles are small fragments of plastic and are categorized as either primary or secondary (GESAMP, 2015). Primary microplastics have been specifically manufactured for use in for example cosmetic products, whereas secondary microplastics refer to larger pieces of plastic which have degraded into smaller fragments, for instance from tyres and plastic litter (Naturvårdsverket, 2017). There is no established definition of the size of a microplastic particle. However, a range of $1 \text{ nm} < 5 \text{ mm}$ is commonly used, for example by GESAMP (2015) and Magnusson et al. (2016).

2.1 Impact on the environment and the human health

The environmental impact of microplastics is still not fully established (GESAMP, 2016). However, once microplastics are released to the environment, they are practically impossible to remove (ECHA, 2020).

Microplastic particles have been found in different animals (Gall & Thompson, 2015; Lusher, 2015), for example it has been shown that over 80 % of a population of lobsters contained microplastics (Murray & Cowie, 2011). There is some evidence to trophic transfer of microplastics but it has only been shown in laboratory tests conducted by for example Cedervall et al. (2012) and Watts et al. (2014). Microplastics have been shown to cause stress and inflammation in organisms (Koelmans et al., 2019; Naturvårdsverket, 2017), blockages of channels to absorb nutrients (Koelmans et al., 2019) as well as negatively affect the animals' growth (Sjollema et al., 2016) and reproduction (Horn et al., 2020). Microplastics can also be used as transport material by invasive species to allow further transport distances (Caruso, 2019). Organisms can mistake the microplastic particles for food and in some areas the amount of microplastics are six times higher compared to that of plankton (Moore et al., 2001). The study by Pauly et al. (1998) has shown that microplastic particles (mentioned as plastic fibres by Pauly et al.) can affect the human health by contributing to the development of cancer if inhaling the fibres. Microplastics can possibly cause inflammation in the intestines and be transported with the blood circulation (Bouwmeester et al., 2015) where there is a risk of microplastics reaching the placenta, potentially affecting the foetus (Leslie, 2011). The effects of microplastic emissions are expected to increase with a decreasing size (Jeong et al., 2016, 2018) and studies have shown that it is more difficult to determine the effects the smaller the particles are (GESAMP, 2016).

Further research is however needed to fully understand the direct and long-term effects of microplastics on the environment and the human health. The amount of microplastics will probably increase in the future and it is therefore difficult to determine the long-term effects that microplastics may have on the

environment (J. Li et al., 2018). There is no standardised method for sampling and analysis of microplastics (João et al., 2020; SAPEA, 2019) and because of this, there is today a lack of data regarding the levels of microplastic particles spread in the environment (GESAMP, 2016). The existing research on the environmental impact caused by microplastics is also inconsistent and speculative, which shows the complexity of these emissions (SAPEA, 2019).

2.2 Sources and sinks of microplastics

It is difficult to investigate the exact sources of microplastics since the particles are created by all sorts of activities where plastic is present (Naturvårdsverket, 2017). The largest source is abrasion of tyres followed by artificial turf, laundry and road markings (Magnusson et al., 2016). After they have been emitted to the environment, microplastics can travel far by wind and water (Magnusson et al., 2016; Naturvårdsverket, 2017). Due to the various sources and ways of transportation it can be difficult to determine the final sink. Microplastics have been detected in many different areas around the world (Kärroman et al., 2016); in all oceans at different depths (Fischer et al., 2015; Fossi et al., 2012; Frias et al., 2014; Law et al., 2010; C. Li et al., 2021; Martins & Sobral, 2011; Reisser et al., 2013; Thompson et al., n.d.) as well as in more remote areas such as the Arctic ice (Amélineau et al., 2016; Obbard et al., 2014), the Himalayas (Napper et al., 2020), the rain forest of Mexico (Álvarez-Lopezello et al., 2021) and on Antarctica (Van Cauwenberghé et al., 2013). However, according to Kärroman et al. (2016) the final sink of microplastics is, the bottom sediments in seas and oceans, which also Thompson et al. (2014) claim is the largest sink.

2.3 Microplastic release during laundry

Laundry is a significant emission source of microplastics to sewage water which end up in the WWTPs (Magnusson et al., 2016). The washing process tears the textiles and fibres are released from the garments. If the textiles are of synthetic origin, the released fibres are considered microplastics. The textiles that release microplastics are made from synthetic materials containing plastic, e.g. polyester, elastane and acrylic (Naturvårdsverket, 2017). Materials such as cotton, linen and wool also release fibres but since they are of natural origin and do not contain plastic, they do not contribute to microplastic emissions.

Magnusson et al (2016) states that the total amount of released fibres vary depending on the amount of laundry per cycle, washing temperature, centrifugation, and detergent. It has been found that, during the 2nd - 5th washing cycle, 20-500 mg of microplastics can be emitted per kg laundry made from polyester (Zilla & Marc, 2020). The released microplastic particles flow to the WWTPs via the sewage water from the washing machine, 176 – 1 995 tonnes of microplastics are estimated to reach the influent of Swedish WWTPs per year (Magnusson et al., 2016). Most of the microplastics, 96 – 99.9 %, are retained at the WWTPs and can be captured in the sewage sludge (Habib et al., 2020). In Sweden, it is estimated that between 3.5 and 40 tonnes of microplastics originating from laundry remains in the effluent (Magnusson et

al., 2016). The sludge from WWTPs can be used as a fertiliser on farmland. In 2018, 39 % of the sludge from the Swedish WWTPs was used on farmland (SCB, 2018).

2.4 Regulations

As of today, there are no policy instruments implemented in Sweden nor in the EU to reduce the microplastic emissions from laundry, the focus has instead been to limit the usage of primary microplastics. Since July 1st, 2018 it has been forbidden in Sweden to use primary microplastics in some cosmetic products (Regeringen, 2018).

In the EU Green Deal from 2019, it is stated that the plastic strategy from 2018 will be followed up by discussions regarding measures concerning primary microplastics as well as secondary microplastics originating from for example textiles (European Commission, 2019). Since the EU Green Deal was launched, the Zero Pollution action plan has been adopted which presents targets set by the EU Commission to reduce pollution (European Commission, 2021). One of these targets is to reduce the amount of microplastic particles released into the environment by 30 % to 2030. As a part of the action plan, key actions for the period of 2021-2024 are presented. Among these are that the Drinking Water Directive will be revised and present stricter water quality standards which, among other pollutants, will include microplastics. Further, other water and marine laws will be reviewed to better support the reduction of microplastics.

3 Theoretical background

This chapter presents theories and concepts regarding actor analysis that is a part of the method used in this thesis.

An actor analysis aims to understand the actors' perspectives and different interactions regarding a specific area of interest (Rees et al., 2018; van der Lei, 2010) and can be used as a policy and decision-making tool in a broad range of domains (Hermans & Thissen, 2009). It has been applied in for example supply chain management, transport policy, economics, machine learning (van der Lei, 2010) as well as in the environmental field (Bendtsen et al., 2021; Brunklaus et al., 2010; Clausen et al., 2020; Colvin, Bradd Witt, et al., 2020; Lyon et al., 2020). What is considered as an actor varies between studies and greatly depend on the contexts and aims of the studies. No established definition of the term 'actor' was found by the authors.

There are several different methods for conducting actor analysis (Hermans & Thissen, 2009; van der Lei, 2010). For example, Hermans et.al (2008) used actor analysis in the field of water management to understand the actors' perceptions and to identify how to reduce pollution. In this study the aim was to include actors that affect and are affected by an environmental policy, being environmental experts, decision makers and local actors. In this case local actors involved representatives from e.g., the civil society and the private sector.

Some consider stakeholder analysis as one common type of actor analysis (Bryson, 2004; MacArthur, 1997). Stakeholder analysis originates from business management and has been used for the purpose of identifying stakeholders and understanding how they can affect the performance of a firm (Brugha & Varvasovszky, 2000). The definition of a stakeholder is commonly based on the work by Freeman (1984) who stated a stakeholder as being "*any group or individual who can affect or is affected by the achievement of an organization's purpose*" (p.54). There are three different approaches to conduct a stakeholder analysis: normative, instrumental and descriptive (Donaldson & E.Preston, 1995). The main differences between the approaches are that the instrumental is used for identifying connections, the normative for interpreting different processes while the descriptive is solely used to describe relations and usually acts as a complement to the instrumental and normative approaches.

Recently stakeholder analysis is being translated and adopted to use in the field of environmental management. Among others, it has been done by Reed et.al (2009) who defines stakeholder analysis as "*a process that: i) defines aspects of a social and natural phenomenon affected by a decision or action; ii) identifies individuals, groups and organisations who are affected by or can affect those parts of the phenomenon (this may include non-human and non-living entities and future generations); and iii)*

prioritises these individuals and groups for involvement in the decision-making process” (p.1). Stakeholder analysis has been translated to be used in environmental and resource management (ENRM) by replacing the firm with an ENRM issue (Colvin, Witt, et al., 2020). Often this type of analysis is used to involve stakeholders in decision-making and the creation of policies (Lyon et al., 2020).

Achieving sustainability transformations is another area where stakeholder analysis can be conducted. Lyon et al. (2020) mention that individual and collective action are some factors that enable a sustainability transformation. Continuing, they state that stakeholders who can affect or is affected by a specific sustainability problem are central in its transformation. Thus, pointing out the need to understand and involve relevant stakeholders to enable such sustainability transformations.

Environmental stakeholder analysis has been conducted specifically related to microplastics by Clausen et.al (2020) studying the EU restriction proposal on the usage of primary microplastics. They mention different ways of identifying stakeholders to include in the analysis, for example by reviewing literature and brainstorming to name a few. This study listed the identified stakeholders, sorted them into different groups of similar interest and categorised these as either primary, secondary, or tertiary stakeholders. *Primary stakeholders* included direct beneficiaries such as producers and consumers. The *secondary stakeholders* involved those who provided support to the primary stakeholders, for example researchers and local authorities, while the *tertiary stakeholders* consisted of the government and national authorities.

To summarize, actor analysis is a broad method for analysing the perspectives and opinions of different actors. Stakeholder analysis can be considered as one type of actor analysis and involves stakeholders who affect or are affected by the performance of a firm. Stakeholder analysis can be adopted to environmental management by replacing the firm with an environmental issue, which would imply that the stakeholders included are either affected by or can affect the said environmental issue.

4 Method

This chapter presents the method chosen to fulfil the aim and to answer the research questions of the thesis. The method consists of an initial literature review and an actor analysis conducted through a literature review, semi-structured interviews and a survey.

To fulfil the aim and to answer the research questions of the thesis we developed an actor analysis based on inspiration from existing research which have used actor analysis and environmental stakeholder analysis (see 3). The reason for developing our own version was that we did not find the identified studies that had used stakeholder analysis or actor analysis sufficient to fulfil our aim. For the analysis we decided to use the term actor instead of stakeholders since we considered the definition of an actor to be more versatile with no set definition and the term stakeholder to be more established and specific. It could be justified to use either of the terms but by this choice we aim to avoid misunderstandings.

The major difference between our work and actor analysis methods in general is that they are often used for policy analysis in connection with decision-making. Our work aims to map the perspectives of actors and is not directly meant to be used for taking further decisions. Further, it is relevant to apply the descriptive approach to our analysis since our overall aim is to map the actors and describe their barriers, drivers and possibilities which do not apply to the normative and instrumental approach.

Since our work concerns microplastic emissions we found that environmental stakeholder analysis, which focuses on an environmental issue, suits better than the traditional stakeholder analysis, which focuses on an organisation. Therefore, we also conducted our actor identification based on the stakeholder definition by Reed et al. (2009) who states that the included stakeholders are individuals, groups and organisations who are affected by or can affect parts of the phenomenon - in our case 'phenomenon' refers to the microplastic release from laundry in Sweden. Further, our work partly consists of actors' possibilities to reduce microplastic emissions, thus we found it relevant to take inspiration from the work of Lyon et al. (2020) which includes actors who can contribute to achieving a sustainability transformation - in our context the transformation was to reduce microplastic emissions from laundry in Sweden. Inspiration was also taken from the analysis made by Clausen et al. (2020) who categorised stakeholders as primary, secondary, and tertiary. In our study we only included actors related to the primary category, that is, those groups or individuals who can affect the issue and who, in some cases, also are directly affected by it.

To enable the actor analysis, a literature review was conducted to retrieve an initial background on the studied topic. The literature review continued partly parallel to the actor analysis. The actor analysis consisted of deciding the system, identifying actor categories and actors to include in the studied system as well as collecting data through semi-structured interviews and a survey. Lastly the collected data was analysed. See Figure 1 below for a visualisation of the approach of this thesis.

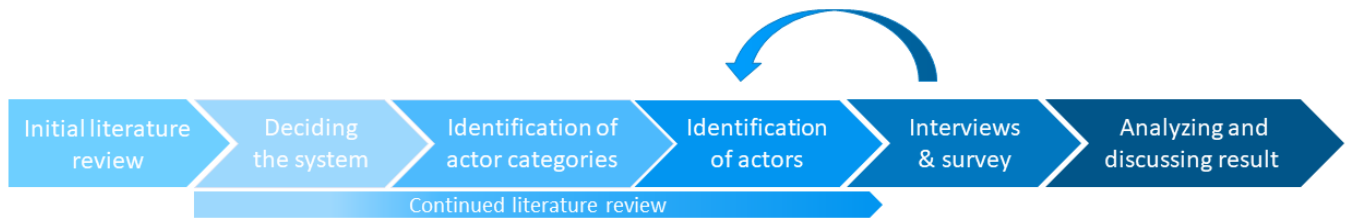


Figure 1. Visualisation of the overall approach of the thesis.

4.1 Literature review

The literature review was conducted in two parts. The first part focused on developing an understanding of the microplastics issue and the second part on finding previous studies regarding actor analysis. The latter was a part of the actor analysis (4.2), and also provided inputs for deciding which approaches to use, which actors to include in the system as well as to learn about the actors' context in regard to microplastic emissions. The purpose of this part of the literature review was to gain insight and understanding about the subject as well as to aid in the preparation of the interview guides and the survey. and it gave important inputs to answering research question 1.

We used the databases Scopus and Web of Science for the literature review. Using a variety of databases enabled us in finding a wide range of documents, such as scientific articles and reports from different institutions. The initial literature review included search terms such as “microplastic” in combination with for example “environment”, “environmental impact”, “health”, “laundry”, “textile”, “design” and “synthetic clothing”. The second part of the literature review included search terms such as “microplastic emissions” and “laundry” in combination with “actors”, “drivers”, “barriers” as well as “actor analysis”, “stakeholder analysis” and “environmental stakeholder analysis”. The articles were filtered to show the most cited articles. We were aware that recently published articles had not yet reached a high citation and therefore also took these into consideration by filtering on newest date.

4.2 Actor analysis

After completing the initial literature review the actor analysis was initiated. The actor analysis consisted of establishing the system and its delimitations, identifying actor categories, identifying actors within each actor category as well as data collection through interviews and a survey. Lastly the collected data was analysed. See Figure 2 below for a visualisation of the structure of the actor analysis.

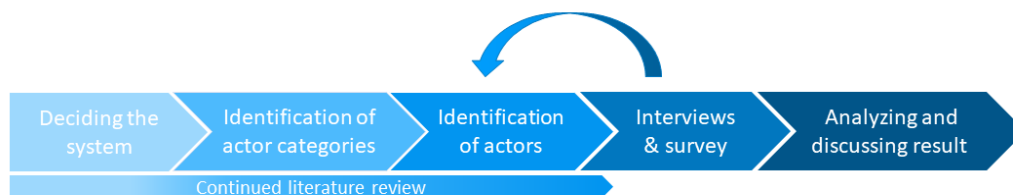


Figure 2. Visualisation of the structure of the actor analysis.

4.2.1 The system and its delimitations

The first part of the actor analysis was to establish the system in which the main actor categories were to be identified. This was done based on the knowledge retrieved from the literature review. The included

actor categories are both upstream and downstream Mimby. The actor categories upstream considered those handling textiles: starting with the design of a synthetic garment and ending with it being bought and used (worn and washed) by the consumer. The actor categories downstream included actors that received the microplastics emitted from the garments during laundry. Figure 3 presents a visualisation of the system. In this thesis the microplastic emissions from laundry is limited to those originating from textiles and not from the detergent nor from the potential plastic released from the washing machine itself.



Figure 3. Visualisation of the system used for the identification of actor categories, including actor categories both upstream and downstream Mimby.

4.2.2 Identification of actor categories and actors

The first step consisted of identifying the actor categories. This identification was based on information from (the) literature (review), on e.g., the fashion value chain, as well as our previous knowledge concerning different relevant actor categories.

The actor category of textile recycling and second-hand stores was at first included in the studied system, but later excluded, since their contribution to the microplastic emissions was not sufficiently significant in comparison to the other included actor categories. An important reason for this was that the only identified Swedish textile recycling company solely recycled natural fibres and not synthetic fibres. Neither does it contribute to the production of synthetic textiles like the other identified actor categories in the fashion industry (designer - consumer) do.

The competitors to Mimby were initially also included in the actor analysis as an actor category but were later removed. The reason was that no competitors with a product (in terms of microplastics) that is similar to Mimby's was found on the Swedish market, only internationally. Since the study was delimited to Sweden, international competitors were excluded from the analysis.

The second part of the actor analysis was to identify actors within each actor category. This was mainly done by examining companies who are members of the trade organisations for each actor category. See Table 1 below for an example of the identification of different actors within one actor category.

Table 1. An example of the two stages of identification: identification of actor category and identification of actors within said actor category.

Identified actor category	Designer
Identified actors within the actor category	HM, Lindex, Filippa K

The aim was to include varied actors of varying size and focus area in each actor category to receive a result that was broad and generalizable. This is validated by Brinkmann & Kvale (2018) who state that it is difficult to generalize the result if too few actors are included in the analysis. The main aim was to include two large and two small actors, with one of each size having a sustainability profile and one that had not, thus at least four actors per actor category.

For some actor categories, additional factors were incorporated in the identification of actors to assure an as great variation as possible among the analysed actors. For example, both e-commerce and physical stores were included in the category of retailers due to the large number of possible actors in that specific industry.

After the identification of actors was completed, we contacted representatives from the actors to schedule interviews. Due to some actors not responding or not wanting to participate in the interviews, some supplementary actors were needed to be identified. When identifying the new additional actors, the same process as explained above was used. These complications resulted in that not all actor categories included the variety of actors which was strived for. Some interviewees suggested other types of actor categories that they considered to have a key role in why the actor experienced, for instance, certain barriers to implement measures. These suggestions were after consideration by us, included in the analysis. The new actor categories were not included in the focused system and were therefore not given the same space in the study as the original actor categories. The new actor categories are therefore considered as an external force on the focused system and are further on categorised as secondary actor categories in this thesis.

4.2.3 Data collection

The data for the analysis of the selected actors were collected through interviews and a survey. The main purpose of these were to identify the actors' possibilities, drivers, and barriers to contribute to reduced microplastic emissions from laundry, as well as how the different actors allocate responsibility for reducing pollution among the actor categories. In this thesis we define drivers as both internal and external factors that has enabled actors to implement measures while we define barriers as internal and external factors that prevent actors from implementing measures. Further, we define possibilities as theoretical measures that an actor could implement if there were no barriers. The following sections provide more details on the interviews and the survey.

4.2.3.1 Interviews

Interviews were conducted with representatives from the identified actors. This method was deemed appropriate as this study required the different actors' perspective on microplastic emissions. Semi-structured interviews were chosen as it allows the researcher to ask open-ended questions as well as supplementary questions if needed to clarify certain thoughts from the interviewee (Adams, 2015).

The goal was to interview representatives from the identified actors that had a sustainability manager role with the intention of them possibly being aware of microplastics, which would enable a deeper discussion. If a sustainability manager was not available we were redirected to another representative, for example a quality manager, a process engineer, or the chief executive. The representatives were contacted by e-mail, telephone and LinkedIn. If we had not received an answer within 3 days, we sent out a reminder. If there was still no answer the actor was removed from the actor analysis. See Appendix B for general information regarding the interviewees.

When a sufficient number of interviews were scheduled for each actor category, the rest of the contacted actors in that specific actor category who had not answered were no longer considered due to time constraints. What was deemed as a sufficient number of actors depended on the actor category. Some actor categories had a limited number of Swedish actors and were in general difficult to get in contact with. Therefore, we had to be satisfied to only include one actor in that specific actor category.

Figure 4 below presents the number of contacted actors and their responses.

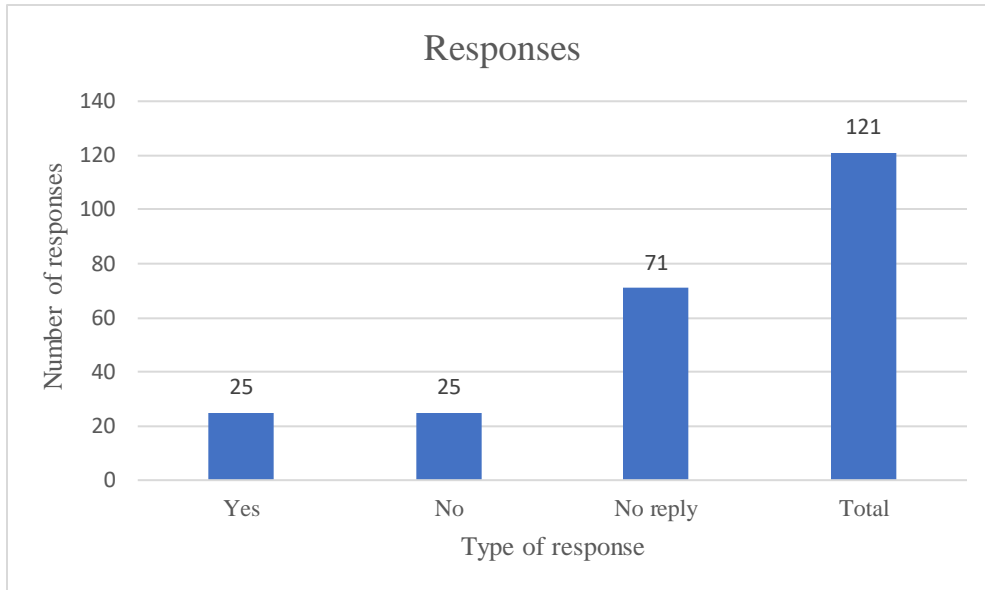


Figure 4. The number of actors contacted for scheduling interviews and their response.

In total 25 interviews were conducted. The number of interviews held per actor category is presented in Table 2 below.

Table 2. Number of interviewees per actor category.

Actor category	Number of interviewees
Designer	5
Textile producer	1
Retailer	2
Consumer	3
Washing machine producer	2
Laundry detergent producer	1
Filter solution	1
Industrial laundry	1
Wastewater treatment plant	5
Secondary actor categories	4

Interview guides were prepared for each interview and were based on the research questions and the background of the actor categories retrieved from the literature review. All the interview guides consisted of the same main questions but were slightly adjusted by adding specific questions for each actor category, see Appendix E. The interview guides were arranged in five parts. The first part of the interview was an

introduction where we presented the background and aim of the master thesis as well as stating the terms of the interview. The second part included introductory questions to gain insight in how much knowledge the interviewee had on microplastics in general and in relation to their industry. The third part consisted of questions related to research question 2 which concerns the actors' possibilities, barriers and drivers of implementing measures to reduce the microplastic emissions. The fourth part of the interview consisted of questions related to research question 3 regarding the allocation of responsibility among the actor categories. For this part, the actor categories which we had identified were shown, visualised as a chain, and explained to the interviewee. We asked if they agreed with the chain or if they thought that an actor category should be added or removed, and thereafter asked the interviewee to rank the different actor categories in terms of how much responsibility they have in order to reduce the microplastic emissions from laundry. This was done by using a responsibility scale, see Figure 5 below.



Figure 5. The scale which was used during the interviews for the interviewees to allocate responsibility between actor categories as a part of the actor analysis.

The interviewee had seven placements to choose from when allocating actor categories on the scale, either on top of an option or between two. For example, either above 'All responsibility' or in the middle of 'No responsibility' and 'Some responsibility'. This was done to facilitate the compilation of the result. Multiple actor categories could be allocated to the same placement on the scale. The interviewee also had the opportunity to not include an actor category on the scale if they did not know where to put it. Lastly, in the fifth part of the interview, the interviewee was given the opportunity to provide additional thoughts and opinions.

The interviews lasted for 40 – 60 minutes and were, due to the COVID-19 restrictions, held online using Microsoft Teams. When interviewing a new actor, recommended by an interviewee, new interview guides were created following the same structure as the previous ones. Additional questions were sometimes added to find out in what way they influence the previously interviewed actor. If we wanted to use quotations from the interviews, we contacted the concerned actor for them to approve the quotation and to adjust if wanted. The interviews were anonymous except for some of the interviewed secondary actor categories who did not want to be anonymous. One interviewed secondary actor category regretted their participation and did not want to be a part of the study when asked to be quoted. Consequently, all the data and result gathered from that interview was thus deleted.

4.2.3.2 Survey

A survey was conducted to gather data from the actor category ‘Consumers’. The reason for choosing to conduct a survey was because this actor category consists of a great number of actors and having interviews would be too time consuming. Conducting a survey was viewed as an appropriate way of reaching out to consumers of varying kind and therefore eventually acquiring a more qualitative result. The result from the survey was also later used to contact some consumers for complementing interviews. The survey consisted of primarily short questions with multiple choices, see Appendix E. It was possible for the respondents to create their own alternative if they did not consider any of the existing alternatives to be suitable. A few questions requested solely written answers but were optional. According to Van Selm & Jankowski (2006) it is important to keep surveys simple and short to respect the respondents’ time constraints. They also mention that the longer a survey is the less likely it is to retrieve many respondents, which was kept in mind when designing the survey.

Questions regarding the respondents age, gender and occupation were included to ensure there was enough variety among the respondents for the result to be as representative as possible for the actor category. It is important to note that the respondents had the opportunity to submit their answers completely anonymous by not submitting their email. However, this meant that no follow up interview could be conducted with that specific respondent.

As recommended by Kylén (2004), the survey was tested on three people to ensure it was comprehensible to the respondents. Their input was considered and thereafter the survey was launched. Platforms such as Facebook and LinkedIn were used to spread the survey. In total, the survey was open for two weeks and gathered 119 respondents. To attract more respondents, they had the possibility to win a prize¹ if responding to the survey.

To complement the data gathered from the survey, three follow-up interviews were conducted with consumers who during the survey chose to sign up for it. The interviewees were chosen based on their awareness, on a scale from one to five, of microplastic emission, which was asked in the survey. We included one consumer who chose a five, one who chose a three and one who chose a one on the scale. With this selection, we aimed to get data which was representative for the actor category. Kylén (2014) mentions that surveys with few open-ended questions can, to some extent, limit the answers of the respondents. By complementing with follow-up interviews, the goal was to obtain deeper analysis and reasoning instead of only answers based on given alternatives. When doing this, the result also became

¹ A laundry bag removing microplastics from the washing machine drum.

more comparable to the results from the other actor categories since the same in-depth questions could be asked.

4.2.4 Method of analysis

After the interviews were conducted the analysis of the data was initiated with the transcription being the first step. Only the parts of direct concern for the analysis were transcribed. The interviews were recorded and easily accessible afterwards if needed to clarify the transcription. The remaining steps of the analysis are presented in the following sections of this chapter.

4.2.4.1 Possibilities, barriers and drivers

The transcribed interviews were analysed to identify the actors' already implemented measures, possibilities, barriers and drivers. The analysis started with colour coding each transcription with one colour indicating implemented measures, another for drivers et cetera. The reason why we chose to code the transcribed interviews was since it gave an overview to base the continued analysis on and is said by Thomsson (2014) to be a good way for the researcher to sort the data and identify themes. Thereafter, each identified possibility, driver and barrier was summarised to shorter sentences and placed in a table, one table for each interviewed actor. The next step was to gather all information per actor category. New tables were created for each actor category and all possibilities, drivers and barriers from each actor was gathered. If several actors within the same actor category had mentioned the same driver or barrier it was only mentioned once in the tables presenting the drivers and barriers for each actor category. The reason for this was that it would facilitate the comparison between actor categories with varying the numbers of actors. Afterwards, the identified drivers and barriers were categorised into themes. The reason for not doing this with the possibilities was because they were perceived as being too specific for each actor category and that generalising them would result in a loss of interesting results. The categorising identified similarities among all drivers and among all barriers. Having themes facilitated comparison of the result between actor categories. Table 3 below presents the general themes in which the drivers and barriers were categorised as. *Knowledge* barriers and drivers relate to research, spread of information and awareness. *Health and environmental concerns* entail that some actors act due to a feeling of responsibility for their environmental impact while *environmental* barriers concern that some measures which reduce microplastics instead increases other types of environmental impact. *Organisational/mindset* concerns drivers and barriers related to organisational structures and approaches as well as the mindset of individuals. The themes *stakeholder encouragement* and *stakeholder resistance* include that actors are affected by their surroundings, for example by customer demand and the action of competitors. *Technical* drivers and barriers involve factors related to the function of, for example, processes and materials, while *economic* can be that a measure is costly or, the opposite, that it results in an economic gain. Barriers referring to *temporal* is for example that

implementing some measures takes a lot of time. *Legislative* barriers can entail that there are no policy instruments supporting the transformation.

Table 3. The themes in which the drivers and barriers, identified from the transcribed interviews, were categorised as.

Drivers	Barriers
Knowledge	Knowledge
Health and environmental concerns	Environmental
Organisational/mindset	Organisational/mindset
Stakeholder encouragement	Stakeholder resistance
Technical	Technical
Economic	Economic
	Temporal
	Legislative

4.2.4.2 Responsibility allocation

The data retrieved from the responsibility allocation was converted to a numerical scale. This way the resulting responsibility allocation from each actor category was based on an average of the result from the actors within each actor category. Some actor categories only consisted of one actor and consequently no average needed to be calculated. Figure 6 below illustrates the scale when the placements were numbered. Some actors chose to abstain from allocating certain actor categories since they did not know where to place them, and these were not included in the calculated average. However, they are still presented in the text.



Figure 6. The numbered placements used for calculating the average value for the responsibility allocation.

The following example aims to clarify how the average responsibility scales per actor category were made:

Actor category B consists of three actors who have made their individual responsibility allocations of actor categories A - C. All three actors placed actor category A as having 'Some responsibility' meaning the average value is a 3 $((3+3+3)/3)$ which indicates a placement at 'Some responsibility'. Regarding actor category B, two of the actors placed it at 'Significant responsibility' while the third actor placed it at 'All responsibility', meaning the average value to be 5.7 $((5+5+7)/3)$ and a placement between 'Significant responsibility' and 'All responsibility'. For actor category C one actor placed it at 'No responsibility', one placed it at 'Some responsibility' while the third one chose to abstain. The average value is calculated to be a 2 $((1+3)/2)$ indicating a placement between 'No responsibility' and 'Some

responsibility'. This calculation does not consider the actor who abstained, instead that actor's opinion is only presented by text.

5 Results

In this chapter the results from the analysis of the interview and survey are presented. First, the results regarding the identified actor categories are presented, continuing with the actor categories' possibilities, drivers and barriers to reduce the microplastic emissions from laundry as well as the responsibility allocated among the actor categories.

5.1 Initial actor category chain

Figure 7 below illustrates the actor categories which were identified before the data collection was conducted. Based on the system boundaries and the actor definition, the actor categories were decided by conducting the literature review, brainstorming and discussion with the supervisors.

The actor category 'Designer' includes the ones designing a garment, deciding what should be produced and sometimes also how it should be produced. All the identified designers were a part of larger clothing chains and no stand-alone designers were included. The following actor category, 'Textile producer', entail the actors that produce the garment in terms of both the fabric and the yarn. The third upstream actor, 'Retailer', includes the actors who sell the garments: physical and online shops as well as resellers. 'Consumer' is the next actor category and includes those who purchase and use (wear and wash) the clothes. The data collection from this category consisted of answers from the survey and three in-depth interviews. 'Laundry' consists of 'Washing machine producer' (WMP), 'Industrial laundry' and 'Laundry detergent producer' (LDP). 'WMP' include the actors that produce washing machines, 'Industrial laundry' involve the ones who wash clothes as their business and 'LDP' include the producers of laundry detergent. The actor category 'Filter solution' entail the actors that provide filters that remove microplastic particles from the washing machine wastewater. The last actor category in the chain is 'Wastewater treatment plant' (WWTP) and include the ones that treat the wastewater. To get a deeper insight about the actors in each actor category, see Appendix B.

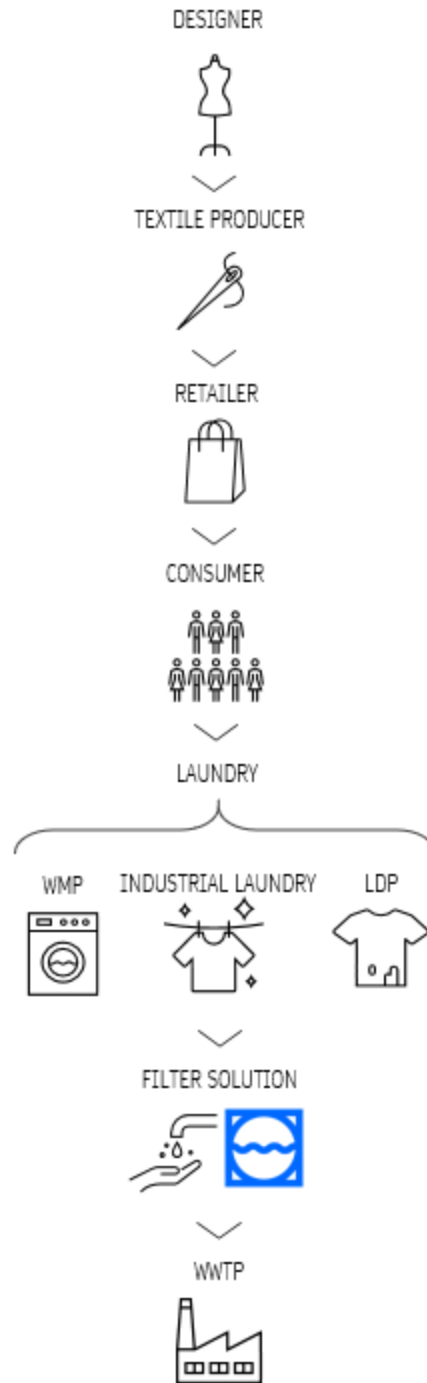


Figure 7: Illustration of the initial actor category chain including the identified actor categories before the data collection.

5.2 Possibilities, barriers and drivers

Below, the actor categories' implemented measures, possibilities, drivers and barriers are presented. The drivers and barriers have been categorised into themes. For more detailed information about the drivers and barriers, see Appendix D.

5.2.1 Designer

As mentioned, the actors in this category consisted of designers of larger clothing chains, see Appendix B. This entailed that the following gathered data to some extent surpassed the perspective of designer. In the actor category 'Designer', the interviewed companies had already implemented some measures: participation in research projects, communication with customers to wash their clothes less, offer laundry bags in their range, dialogue with their suppliers about fleece, research monitoring and participation in meetings with the Swedish Chemicals Agency. The reasons for these measures, categorised as *organisational drivers*, have been that the interviewed actors view it to be their responsibility to do better and increase their knowledge, the actor itself is sustainability focused and works proactively to meet future regulations. *Health and environmental* aspects were that they care for the environment and want to reduce harmful substances from their products. The actors mentioned, with reference to *stakeholder encouragement*, that they want to share knowledge with customers to enable them to do better choices and that they do not want to lose customer trust.

The most common reason as to why they have not done more is, according to the designers, lack of *knowledge*. This mainly refers to there being a lack of information and research, for example that there is no standardised method to measure and analyse the results. This makes it difficult for the 'Designer' to implement measures since there are no guidelines to follow. *Organisational* factors are also common. Some of these are that the actor is a small business and therefore lacks resources, the complexity of the supply chain and that the actor prioritises other sustainability issues, e.g., climate change, since they are deemed more acute. Some actors also mention, with reference to *technical* barriers, that synthetic material, as of today, cannot be replaced by other materials. One actor explains it by the following:

“Our synthetic fibres are actually quite amazing with all the properties that can be achieved, you can get garments that are water repellent - you can wear skiwear without getting wet, you can sail without getting wet, and while you're running the material breathes without you getting chafed. So synthetic materials are amazing in many ways except that they release microplastics, so I think you must find another solution there, because the benefits outweigh the negatives.” – Designer B

A reason categorised as *stakeholder resistance* refers to customer demand ruling the business. There are also factors categorised as *economic*: e.g., it is costly to implement measures, *environmental*: e.g., there are other environmental impacts associated with other materials and therefore a substitution may be difficult, as well as *temporal*: lack of time.

The designers mentioned that if the barriers would be overcome, the possible measures to implement would mainly regard affecting the production phase. Laser cutting, increasing the yarn density of the garment and adjusting the spinning of the yarn would decrease the number of fibres released from the garment during laundry. One actor also mentioned coating the fibres as a possible measure but was not seen as preferable as it would increase the usage of chemicals and energy, thus it would result in the garment contributing with another environmental impact. Another possibility would be to produce their own laundry bag as well as to evaluate which product groups (outdoor, active wear, fashion garments etc.) that must be in synthetics to ensure a certain function of the garment, for example a t-shirt does not necessarily need to be in synthetics while a running shirt does.

The implemented measures, possibilities, drivers and barriers for the actor category ‘Designer’ to reduce the microplastic emissions from laundry are summarised in Table 4 below. See Appendix D for more details.

Table 4. Already implemented measures, possibilities, drivers and barriers for the actor category ‘Designer’ to contribute to reduced microplastic emissions from laundry, gathered from the interviews. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Measures	Possibilities	Drivers	Barriers
<ul style="list-style-type: none"> ○ Taken part in research projects ○ Offer laundry bag in their product range. ○ Inform customers to wash their clothes less ○ Frequent meetings with the Swedish Chemicals agency ○ Dialogue with suppliers ○ Continuously staying up to date with the latest research ○ Performing small-scale tests 	<ul style="list-style-type: none"> ○ Increase yarn density ○ Ultrasonic cutting ○ Spinning of the yarn ○ Coating fibres ○ Produce own laundry bag ○ Evaluate which products groups need to be in synthetics 	<ul style="list-style-type: none"> ○ Knowledge (1) ○ Health and environmental concerns (2) ○ Organisational (7) ○ Stakeholder encouragement (1) 	<ul style="list-style-type: none"> ○ Knowledge (2) ○ Organisational (5) ○ Technical (3) ○ Economic (1) ○ Environmental (2) ○ Stakeholder resistance (3) ○ Temporal (1)

5.2.2 Textile producer

The interviewed textile producer had not implemented any measures to reduce microplastic emissions since the actor is not using synthetic materials in their production as of now but has the opportunity to. Therefore, the textile producer does not have any direct drivers towards reducing microplastic emissions and the drivers presented in Table 5 below are more of a general character. Reasons categorised as *organisational* drivers: the interviewed actor has sustainability goals to influence their customers to choose more organic alternatives, and *stakeholder encouragement*: their customers drive the development forward. Reasons to why measures had not been implemented mostly regarded *economic* factors such as high costs and *stakeholder resistance* such as the customer demand. The textile producer produces what the customer

(designer) wants and even if other materials are suggested by the textile producer, the customers have a budget where it is not always possible to consider fabrics with less environmental impact. The actor said the following:

“Because most of the time it's a question of cost, if a fleece sweater costs 60 SEK or 50 SEK, you can't use environmentally friendly alternatives in it.” – Textile producer A

The interviewed actor said that there is biodegradable polyamide on the market today but that it costs five times as much as usual polyamide. The actor mentioned, with reference to the *legislative* barrier that there is a lack of policy instruments. However, if there were no barriers, the possibilities they do have would be to develop biodegradable fibres and communicate with different types of NGOs about the topic.

The measures, possibilities, drivers and barriers for the actor category ‘Textile producer’ to reduce the microplastic emissions from laundry are presented in Table 5 below. See Appendix D for more details.

Table 5. Already implemented measures, the possibilities, drivers and barriers for the actor category ‘Textile producer’ to contribute to reduced microplastic emissions from laundry, gathered from the interview. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Measures	Possibilities	Drivers	Barriers
N/A	<ul style="list-style-type: none"> ○ Develop biologically degradable fibres ○ Dialogue with different NGOs 	<ul style="list-style-type: none"> ○ Organisational (1) ○ Stakeholder encouragement (1) 	<ul style="list-style-type: none"> ○ Stakeholder resistance (1) ○ Legislative (1) ○ Economic (2)

5.2.3 Retailer

One of the two interviewed retailers had implemented measures to reduce microplastic emissions in the form of offering laundry bags to their customers that catches the microplastics released from the garments. Reasons categorised as *organisational* drivers for this measure were that the actor felt partly responsible for the microplastic emissions and wanted to do something about it as well as wanting to be at the forefront to meet future regulations. As barriers to introducing further measures, the retailers brought up that they did not have enough *knowledge* about the topic. One actor mentioned that since the environmental impact is still not measurable, microplastics will probably not be acknowledged to a great extent by the actor’s suppliers. Another reason categorised as a *knowledge* barrier, was that is difficult for ‘Retailer’ to make the right choices since it is not established which materials that are problematic when it comes to microplastic emissions. The other actor was not aware of microplastics releasing from textiles. However, even if the retailers would have more knowledge, it was mentioned that there is a considerable *organisational* factor. The retailers as physical shops are controlled by the brand and cannot decide what information to provide to the customers nor the layout of the shop since all the stores need to look the same. One of the actors said:

“We are all controlled and we are not allowed to expose the garments exactly how we want. As we are a chain store it is decided from the top. The garments should be hung in a certain way, all the customers should have the same experience when shopping in our stores and so on.” – Retailer A

However, the retailers have the possibility to inform customers in the shops and online about microplastics and how one’s laundry habits and choice of fabric can help to reduce the emissions. Customer demand in terms of requesting synthetic materials was brought up as a barrier and categorised as *stakeholder resistance*. Some customers only want clothes in synthetic materials and the reasons are many. For example, synthetic garments do not shrink or break as easily as materials made from natural fibres and are usually also cheaper. A reason categorised as a *technical* barrier was that synthetics are needed to obtain certain properties of the garment, being waterproof for example. Another reason, categorised as an *environmental* barrier, was that to implement measures concerning climate change is of higher priority.

The implemented measures, possibilities, drivers and barriers for the actor category ‘Retailer’ to reduce the emissions from microplastics is presented in Table 6 below. See Appendix D for more details.

Table 6. Already implemented measures, possibilities, drivers and barriers for the actor category ‘Retailer’ to contribute to reduced microplastic emissions from laundry, gathered from the interviews. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Measures	Possibilities	Drivers	Barriers
<ul style="list-style-type: none"> ○ Developed a laundry bag 	<ul style="list-style-type: none"> ○ Inform customers about microplastics (which garments are releasing microplastics) and to wash garments less often 	<ul style="list-style-type: none"> ○ Organisational (3) ○ Technical (1) 	<ul style="list-style-type: none"> ○ Knowledge (2) ○ Organisational (1) ○ Economic (1) ○ Environmental (1) ○ Stakeholder resistance (1) ○ Technical (1)

5.2.4 Consumer

This chapter includes results both from the interviews and from the survey. An overview of the consumers’ implemented measures, possibilities, drivers and barriers to reduce the microplastic emissions from laundry is presented in Table 7 below. See Appendix D for more details.

Table 7: Already implemented measures, possibilities, drivers and barriers for the actor category ‘Consumer’ to contribute to reduced microplastic emissions from laundry, gathered from both the interviews and the survey. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Measures	Possibilities	Drivers	Barriers
<ul style="list-style-type: none"> ○ Changing laundry habits ○ Use laundry bag ○ Purchase less garments made from synthetics 	<ul style="list-style-type: none"> ○ Laundry less often 	<ul style="list-style-type: none"> ○ Technical (1) ○ Health and environmental concerns (2) ○ Mindset (2) 	<ul style="list-style-type: none"> ○ Knowledge (3) ○ Technical (4) ○ Economic (2) ○ Temporal (1) ○ Mindset (2) ○ Stakeholder resistance (1)

5.2.4.1 Interviews

One of the interviewed consumers had implemented a measure in the form of buying less clothes made from synthetic materials. The reason for this, with reference to *mindset* driver, was that the consumer has a personal interest for the topic. The main aspect, brought up by the consumers, as to why more measures have not been implemented and why the other consumers have not implemented any measures was lack of *knowledge* about microplastics. They stated that it is a difficult issue for the consumer to know what sustainable choices to make. One consumer phrase it like following:

“I think this issue of materials is a tough one, growing cotton or other types of natural materials requires a lot of water and energy. If you look at lyocell and fabrics that come from wood fibres, it takes a lot of chemicals to make those types of fibres whereas a fleece sweater can be made from recycled PET bottles. So, I think it’s a hard task as a consumer balancing what’s good and what’s bad” – Consumer A

With reference to *mindset* barriers, the consumers lack the personal interest and they have other priorities. One consumer said that laziness is one reason to why measures have not been researched and implemented. Reasons categorised as *technical* barriers refer to the properties of the materials, it was for example mentioned by some consumers that they want the specific functions synthetic materials provide, such as stretch and the garment being waterproof.

One of the consumers mentioned one possible measure that could be implemented and that was to laundry less frequently. It was claimed that the consumers would implement more measures if they were provided with more information, if there were regulations and if there was an increased level of accessibility of consumer-based measures such as laundry bags. The consumers also pointed out that the measure must be easy to implement and cannot be too time consuming.

5.2.4.2 Survey

The results of the analysis of the survey data consisting of implemented measures, drivers and barriers are presented below. No data regarding the possibilities was retrieved, see the above result from the interviews for that perspective. There were in total 119 respondents to the survey, for more detailed information about the statistics of the respondents’ gender, occupation and age, see Appendix E.

Out of the 119 respondents, 44 % stated that they consciously purchase less synthetic clothing while 56% did not. Out of those who did purchase less synthetic clothing some explained that the reasons, categorised as *technical* drivers, were that garments made from natural fibres are believed to offer a different function, for example being more comfortable, more exclusive as well as of higher quality than synthetic.

About 18 % of the respondents had implemented a measure to reduce the microplastic emissions from laundry. More than half of these respondents had changed their washing habits by for example washing

less, washing at lower temperatures, airing the clothes instead of washing and using less centrifugation. 27 % of the respondents said that they include a laundry bag in their washing routine. The reasons for incorporating these measures, categorised as *health and environmental concerns*, were claimed to be that they wanted to reduce the microplastic emissions and to act more environmentally friendly in general. Another mentioned reason, categorised as a *technical* driver, was that they want to reduce the tear of the garment and therefore wash their clothing less often.

Some of those who did not buy less synthetic clothing stated that this was because of lack of *knowledge*: they did not have any knowledge about microplastic emissions from synthetic clothing, as well as *stakeholder resistance*: that it was not easily accessible for them to purchase clothing with less synthetic material because the retailers (considered a stakeholder) do not offer a high proportion of clothes made from natural fibres. *Technical* reasons for wanting synthetic clothing were because it lasts longer, dries quicker, is vegan, its function is needed for outdoor activities and it is stretchy. A reason categorised as a *mindset* barrier was that the material of clothing was not anything they cared about. Furthermore, it was claimed that the consumer will not sacrifice comfort and functionality for sustainability. Additionally, an *economic* reason was that sometimes synthetic clothing is more affordable than clothing made from natural fibres.

Most of the respondents have not implemented a measure. According to the consumers this is primarily because of lack of *knowledge*: 89 % stated that they are not aware of any measures and 2 % said that it is due to a general lack of knowledge regarding microplastics. A few mentioned, with reference to *economic* barriers, that measures are expensive, *temporal* barriers: they do not have the time to research potential measures, *technical* barriers: they find the measures to be complex and using a shared laundry room is believed by the respondents to be limiting since they cannot fully decide which measures to implement, and *mindset*: they have not taken the time to research measures.

5.2.5 Washing machine producer (WMP)

One producer mentioned that they are taking part in research projects regarding microplastics. The reason to why they did this was partly since they have sustainability strategies, a proactive work ethic and think they should take responsibility within the company and partly since it is profitable for them to work with sustainability measures. The other producer had not implemented any measures but said that they strive to deliver the best possible washing machine. One of the possibilities for 'WMP' is to develop and implement a filter solution into their washing machines for removing microplastic emissions, which was discussed by one of the actors:

" We've looked into the possibility of adjusting factors of the washing cycle such as time and temperature. The microplastics from the washing machine released with the drain, are mainly originating

from the wear of the garments when used. This knowledge makes it relevant to develop some solution that separates the microplastic particles from the drainage water”- WMP B

The reason to why a filter had not been implemented in their machines was explained with reference to *organisational* barriers. As wished by one of the producers their trade organisation APPLiA was contacted to get a further explanation regarding these *organisational* aspects. The trade organisation mentioned that there is no washing machine production in Sweden with sites producing via assembly lines with no distinction being made as to which country the washing machine is being sold to. The following was stated:

“No company can make changes to their products solely for the Swedish market.”– APPLiA

Producers will not install filters solely for Sweden, only if a bigger share of the market like EU demands it. Further mentioned organisational aspects to why measures had not been implemented was that other topics are of higher priority than microplastic emissions, for example energy and water usage. Other stated reasons were *technical*; it is complex to make sure the user handles the filter correctly and empties it in the garbage and not in the sink, *legislative*; there is no legislation on having filter solutions and therefore there is no direct incentive and *knowledge*; there are no standardised analytical methods for microplastic emissions and thus it is difficult to conclude what amount of microplastic emission is harmful, and *economic*; adding a new component to the washing machine in the form of a filter increases the total cost of a washing machine. Lastly *stakeholder resistance* was brought forward as hindering measures, for example one of the producers believed that the media has not highlighted the issue of microplastics enough and if they would then producers would probably more likely implement measures:

“Something will first happen when a discussion takes place that goes beyond scientific articles. If this would be mentioned and debated on the news then there would be a bigger effect and pressure on us to act, but as long as that dialogue isn’t happening there won’t be a demand for it [a filter solution] on the market” – WMP A

The implemented measures as well as possibilities, drivers and barriers within the actor category ‘WMP’ are summarised in Table 8 below, see Appendix D for more details.

Table 8. Already implemented measures, the possibilities, drivers and barriers for the actor category ‘WMP’ to contribute to reduced microplastic emissions from laundry gathered from the interviews. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Implemented measures	Possibilities	Drivers	Barriers
<ul style="list-style-type: none"> ○ A part of research projects ○ Conducted master thesis 	<ul style="list-style-type: none"> ○ Develop filter solution ○ Adjust laundry programs ○ Initiate dialogue with suppliers 	<ul style="list-style-type: none"> ○ Organisational (4) ○ Economic (1) 	<ul style="list-style-type: none"> ○ Organisational (3) ○ Knowledge (2) ○ Technical (2) ○ Legislative (1) ○ Stakeholder resistance (1) ○ Economic (1)

5.2.6 Laundry detergent producer (LDP)

The interviewed actor in this category had not done anything to reduce microplastic emissions from laundry but had removed microplastic as an intentionally added ingredient in laundry detergent. It was claimed that laundry detergent is not associated with increased levels of microplastic release from laundry and that only the mechanical process of laundry is the cause. Therefore, drivers and barriers of laundry detergent producers are more directed to the use of microplastics as an ingredient rather than the possible abrasion effect that the detergent could have on the garments. The LDP did therefore not bring up any specific drivers and barriers. The interviewed actor said the following when asked how microplastics is discussed in their industry:

No, I don't think it has been discussed or even seen that it could be a problem. The laundry detergent's function is to loosen or break down the dirt. [...] I don't think the laundry detergent in itself would cause more fibres to be released from textiles during the washing process, but rather it is the mechanical work that does so. – LDP A

The general drivers of LDPs were categorised as *organisational*: they want to work proactively and want to be seen as a sustainable company, and *stakeholder encouragement*: internal and external pressures as well as that microplastics have been acknowledged by media. Reasons as to why more have not been done were categorised as *technical* barriers: there are no adequate alternatives on the market today, *temporal*: long lead times and that it takes time to replace ingredients, *stakeholder resistance*: limited raw materials and limited amount of suppliers and *organisational*: do not think they have a lot of responsibility since the primary function of laundry detergent is to make the garments clean.

The possible measures to reduce microplastic emissions would be to potentially change the formula of the laundry detergent, as well as to develop washing cloths that, at present, are used to avoid discoloration of garments but could potentially be used to also attract microplastics.

The implemented measures, possibilities, drivers, and barriers for the actor category 'LDP' to reduce microplastic emissions from laundry are summarised in Table 9 below. See Appendix D for more details.

Table 9. Already implemented measures, the possibilities, drivers and barriers for the actor category 'LDP' to contribute to reduced microplastic emissions from laundry, gathered from the interview. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Measures	Possibilities	Drivers	Barriers
N/A	<ul style="list-style-type: none"> ○ Maybe change the formula ○ Washing cloths for discoloration could potentially be used for microplastics 	<ul style="list-style-type: none"> ○ Organisational (2) ○ Stakeholder encouragement (2) 	<ul style="list-style-type: none"> ○ Technical (1) ○ Stakeholder resistance (1) ○ Temporal (2) ○ Organisational (1)

5.2.7 Industrial laundry

Within the actor category ‘Industrial laundry’, no already implemented measures to reduce microplastic emissions from laundry were identified. However, there were some possible measures mentioned by the interviewees, more specifically to investigate potential technology which could remove the microplastic particles from their effluents (e.g., filter solutions) and to possibly adjust the material composition of their textiles. It was mentioned that the CEO of the company gave sustainability issues a high priority which can be categorised as an *organisational* driver. The reasons as to why no measure had been implemented yet mainly concerned *technical* and *knowledge* aspects. For example, their processes deal with large volumes of water and therefore they need technologies that are specifically adopted to their industry. Existing filter solutions would therefore potentially not be suitable, and even if they would be, there is a risk that the filters quickly would be clogged by dirt and fibres from the water. Connected to *knowledge* it was mentioned that there are no guidelines for measures to implement and that they in general lack knowledge regarding the microplastic emissions. The industrial laundry said that they need to meet requirements set by their customers, for example hospitals that demand that the garments are washed in such a way that it fulfils their hygiene requirements. In that case, hygiene is of a higher priority than washing in a way that reduces microplastic emissions. This can be categorised as a barrier connected to *stakeholder resistance* and was explained by the actor as follows:

“Our mission is to deliver clean and intact garments on right time to our customers who pretty much solely consist of hospitals and health care centres. They expect a certain standard on the clothing they receive.” – Industrial laundry A

The implemented measures, possibilities, drivers and barriers to reduce the emissions from microplastics is presented in Table 10 below. See Appendix D for more details.

Table 10. Already implemented measures, the possibilities, drivers and barriers for the actor category ‘Industrial laundry’ to contribute to reduced microplastic emissions from laundry, gathered from the interview. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Implemented measures	Possibilities	Drivers	Barriers
N/A	<ul style="list-style-type: none"> ○ Research for filter systems or other technology removing microplastics ○ Adjust material composition 	<ul style="list-style-type: none"> ○ Organisational (1) 	<ul style="list-style-type: none"> ○ Knowledge (2) ○ Economic (1) ○ Technical (3) ○ Stakeholder resistance (1)

5.2.8 Filter solution

The actor category ‘Filter solution’ distinguishes from the others in the sense that their implemented measure is the company itself. They mention that it is a business opportunity for them to reduce the microplastic emissions and there is a growing market demand and no competition. These aspects can be categorised as drivers relating to *economic* and *stakeholder encouragement*. One mentioned possibility they

have is that they could engage in collaborations with more established companies who could contribute to more sales of their product, thus increasing the spread of the filter solution. They did mention some reasons that hinders their work, for example in terms of *knowledge*. This concerns for example that the microplastic issue is not well known among the public and that the environmental impact of microplastic emissions is not fully established. This might hinder potential customers to want to implement the filter solution. Further it was brought up that there currently is no economic gain in solely removing microplastics, which can be categorised as a barrier of an *economic* character. The filter solution company explains this as following:

“The discussion regarding water is much easier to understand. Water has a price and if you save water, you will also save money. The price of water is believed to rise and therefore you want to take proactive measures. Regarding microplastics it is still unclear, both concerning how much we can remove, what damage it causes and the fact that it does not have an economic value.” – Filter solution A

The measures, possibilities, drivers and barriers for the actor category ‘Filter solution’ to reduce the microplastic emissions from laundry is presented in Table 11 below. See Appendix D for more details.

Table 11. Already implemented measures, the possibilities, drivers and barriers for the actor category ‘Filter solution’ to contribute to reduced microplastic emissions from laundry, gathered from the interview. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Implemented measures	Possibilities	Drivers	Barriers
○ Developed a filter solution for laundry machines	○ Collaborate with other more established companies who could spread their solution to a wider market	○ Stakeholder encouragement (3) ○ Economic (1)	○ Knowledge (2) ○ Economic (1) ○ Legislative (1)

5.2.9 Wastewater treatment plant (WWTP)

Several representatives for WWTPs mentioned that they had implemented measures, for example taking part in research projects concerning microplastic emissions. Two mentioned that they work with upstream actors to reduce the amount of microplastic emission reaching the influent to the WWTP. One is building a new site and is going to implement a disc filter which will remove more microplastic than their previous technology. The reasons to why these measures had been implemented have mainly been due to *health and environmental concerns*; continuously improving the water quality and reducing the number of particles in the effluent. This was pointed out by one of the actors:

“I don’t think the focus is to implement measures to specifically reduce microplastic emissions. [...] Instead, we want to reduce the number of particles in our effluents overall, as well as to increase the capacity to remove phosphorus and nitrogen.” – WWTP D

Some reasons were also of an *organisational* character; proactive work ethic, strive to be in the forefront of the industry and have a goal to contribute to a sustainable society. Several possible measures were mentioned by the interviewees: new technologies that would reduce the amount of microplastics retained in both the effluent and the sewage sludge, informing households on microplastics and setting higher

requirements on actors who are connected to the WWTP. They also brought up several factors hindering the WWTPs to implement these measures, being mainly *organisational*, such as it being prioritised to remove pharmaceutical residues and to remove microplastics from stormwater. Also, hindering aspects related to *knowledge* were mentioned e.g., that there are no standardised methods for sampling and analysis of microplastics and that knowledge about microplastics is not fully established. Other mentioned reasons to why they have not implemented these measures are *technical*; it is difficult to remove microplastic particles when it has reached the sludge and that is it is a complex undertaking to implement a new process in an existing plant, *economic*; new processes usually have high investment costs, *legislative*; there are no laws requiring microplastics to be removed in WWTPs and *environmental*; it is not motivated to implement new processes since it takes a lot of natural resources to construct. According to one actor:

“Installing more advanced technology can result in a higher impact on the environment since it requires more concrete and sand. And another reason for higher impact is that it would take up more land, more space in the city.” – WWTP E

The implemented measures as well as possibilities, drivers and barriers within the actor category ‘WWTP’ are summarised in Table 12 below, see Appendix D for more details.

Table 12. Already implemented measures, the possibilities, drivers and barriers for the actor category ‘WWTP’ to contribute to reduced microplastic emissions from laundry, gathered from the interview. The number in parenthesis indicates how many unique drivers and barriers were categorised for each theme. See Appendix D for more details.

Implemented measures	Possibilities	Drivers	Barriers
<ul style="list-style-type: none"> ○ A part of research projects ○ Work upstream ○ Install disc filter 	<ul style="list-style-type: none"> ○ Install membrane technology ○ More discussion with Swedish Water and Wastewater Association (trade organisation) ○ Engage in more research projects ○ Spread information to households ○ Require connected enterprises to reduce their microplastics emissions ○ Implement sand filter ○ Improve primary screen 	<ul style="list-style-type: none"> ○ Technical (1) ○ Stakeholder encouragement (1) ○ Health and environmental concerns (1) ○ Organisational (4) 	<ul style="list-style-type: none"> ○ Knowledge (4) ○ Organisational (1) ○ Technical (3) ○ Legislative (1) ○ Economic (1) ○ Stakeholder resistance (1) ○ Environmental (1)

5.2.10 Overall barriers and drivers

Table 13 summarizes the drivers mentioned by each actor category. The most common type of drivers was by far *organisational*. Many also brought up *stakeholder encouragement* and *health and environmental concerns*, while the least common drivers were *economic* and *knowledge*. The actor categories ‘Designer’ and ‘WWTP’ mentioned most drivers while ‘Industrial laundry’ and ‘Textile producer’ the least.

Table 13. The number of unique drivers, for each theme, identified for each actor category. The table also presents the total number of unique drivers among all themes for each actor category as well as the total number of unique drivers for each theme among all actor categories. TP stands for textile producer.

	Designer	TP	Retailer	Consumer	WMP	LDP	Industrial laundry	Filter solution	WWTP	Total/driver
Knowledge	1									1
Health and environmental concerns	2			2					1	5
Organisational/mindset	7	1	3	1	4	2	1		4	23
Stakeholder encouragement	1	1				2		3	1	8
Technical			1	1					1	3
Economic					1			1		2
Total/actor category	11	2	4	4	5	4	1	4	7	

Table 14 shows the mentioned barriers in the different actor categories. The most common barriers were *knowledge* and *technical* followed by *organisational/mindset* and *economic*. The least common drivers were *environmental* followed by *temporal* and *legislative*. The actor category ‘Designer’ brought up the most barriers followed by ‘Consumer’ and ‘WWTP’ while ‘Filter solution’ and ‘Retailer’ has the least.

Table 14. The number of unique barriers, for each theme, identified for each actor category. The table also presents the total number of unique barriers among all themes for each actor category as well as the total number of unique barriers for each theme among all actor categories. TP stands for textile producer.

	Designer	TP	Retailer	Consumer	WMP	LDP	Industrial laundry	Filter solution	WWTP	Total/barrier
Knowledge	2		2	3	2		2	2	4	17
Environmental	2		1						1	4
Organisational/mindset	5		1	3	3	1			1	14
Stakeholder resistance	3	1	1	1	1	1	1		1	10
Technical	3		1	4	2	1	3		3	17
Economic	1	2	1	2	1		1	1	1	10
Time	1			1		2				4
Legislative		1			1			1	1	4
Total/actor category	17	4	7	14	10	5	7	4	12	

5.2.11 Overcoming the barriers

All interviewed actors were asked what they thought must happen to overcome the mentioned barriers. Common answers to this question were that more research should be established, especially concerning the environmental impact of microplastics as well as to standardise sampling and analytical methods. Additionally, it was argued that innovation and creating more technical solutions should of focus. Further it was mentioned that policy instruments should be implemented and if they are, it should be done at an EU level to avoid that Swedish companies are disfavoured. Examples of policy instruments was to decide on

requirements for limit values, to implement filters in the Eco-design criteria for washing machine and to implement taxes. Some actors pointed out that they would prefer to not have taxes since it might not be effective.

Diffusion of information to more actors was also argued to be an important next step. This could be done through increased media coverage and by NGOs forming opinion. Regarding information it was mentioned by a few actors that they wished to receive guidelines providing them recommendations on measures to implement. Since they might not have the resources to research on their own this is a preferable solution for them. It was suggested by some actors that such guidelines could for example be provided by trade organisations and governmental agencies.

Another mentioned way of overcoming the barriers was by implementing labels on garments to guide the consumer. Further it was stressed that it is important to map what materials are sustainable, avoid fleece material, reduce the level of mixed fibres in garments, standardise materials and to establish a database concerning all materials and their microfibre release.

It was stated that it is important to act proactively by implementing measures upstream, but end-of-pipe measures will be necessary since the smallest particles are difficult to eliminate. However, the approach should be to work upstream to reduce the number of particles which needs to be treated in the WWTPs. Lastly it was pointed out that ways of having a better and more frequent communication between actors are needed since it can enable sharing of knowledge and experiences.

5.3 Responsibility allocation

In this part, the results of how the actor categories allocated the responsibility among the actor categories are presented. See Appendix C for more detailed information on how each actor category allocated the responsibility among different actors. The overall allocated responsibility among the actor categories is shown in Figure 8 below.

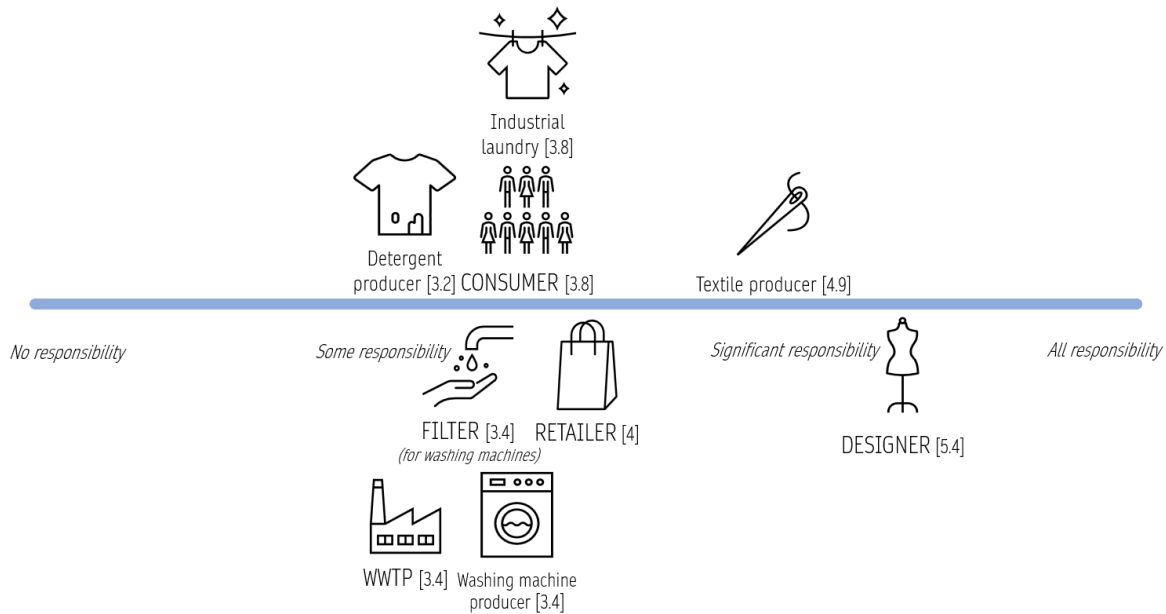


Figure 8. The overall responsibility allocation based on the average allocation of all actor categories. The number in the brackets indicates the calculated average value for the placement. See Figure 6 for how the placements on the scale were numbered.

The results show that all the actor categories have some responsibility, meaning that no one in the actor chain can place themselves outside the problem of microplastic release from laundry. The upstream actor categories are shown to in general have higher responsibility than the downstream actor categories. The actor category 'LDP' has the lowest responsibility while 'Designer' have the highest responsibility followed by 'Textile producer'. 'Designer' and 'Textile producer' are rather separated from the other actor categories which are fairly lumped together. What differs the lumped actor categories from one another is that the more upstream actor categories are shown to have a bit more responsibility than the downstream actor categories. Two of the interviewed actors in 'Designer' placed all the actor categories on 'Significant responsibility'. The explanation for this was that they argued that all actor categories have responsibility and that they all need to collaborate.

5.3.1 Designer

The actor category 'Designer' was placed the highest on the overall responsibility allocation scale, see Figure 8. Many of the actor categories including themselves, agreed that the designing phase initiates the

issue of microplastic emissions. Therefore, it was believed that the actor category should ensure to design garments that release less microplastics. Both ‘Filter solution’ and ‘Consumer’ said that ‘Designer’ is the actor category initiating the problem and has the largest opportunity to reduce microplastic emissions. The reason being that if they would stop designing garments made from synthetic materials then the problem could be eliminated. It was added by ‘Consumer’ and ‘WWTP’ that ‘Designer’ is also dependent on fulfilling the customer demand. This makes their work complex since, as stated by the actor category itself, one cannot get the same material characteristics by using natural fibres instead of synthetic fibres. Further, ‘Retailer’ said that since the ‘Designer’ is the one who orders and designs the clothes, they could be a driver in finding new solutions and innovations.

Only one actor category, ‘Industrial laundry’, placed ‘Designer’ on the lower part of the scale. The reason being that ‘Designer’ is affected by the consumers to a great extent but that they should be aware of and research new materials. One of the interviewed actors in the actor category ‘WWTP’ left ‘Designer’ unallocated since the actor believed that all materials have some type of environmental impact and it is difficult to decide which material should be of priority to produce. For example, synthetic materials release microplastics while producing cotton has a high water usage.

5.3.2 Textile producer

The actor category ‘Textile producer’ was placed among the highest on the overall responsibility allocation scale, see Figure 8. All actor categories except the interviewed consumers and ‘Industrial laundry’ placed the actor category high on the scale, see

Appendix C. Some of the reasoning was similar as to why ‘Designer’ was placed high on the scale i.e., that they are initiating the problem and are responsible for choosing a good material and quality of the garment. Additional thoughts were that ‘Textile producer’ is responsible for producing in ways that decrease the microplastic emissions and is responsible for informing its customers (e.g., designers). One interviewed consumer also said that ‘Textile producer’ is handling large volumes and that a slight adjustment in their production will have a great impact on the environment. However, the interviewed consumers, ‘Industrial laundry’, ‘WWTP’ and a few actors in ‘Designer’ placed ‘Textile producer’ on the lower part of the scale. The reason being that they consider the actor category to only produce what the customer (designer) wants and is therefore dependent on the customer demand. ‘Industrial laundry’ added that they are however responsible for innovating new materials.

One interviewed actor in the actor category “WWTP” chose to abstain from allocating ‘Textile producer’ responsibility because of the same reason mentioned in ‘Designer’; that all materials have some type of environmental impact and that it is difficult to decide which material should be prioritised.

5.3.3 Retailer

The actor category 'Retailer' was placed the highest among the actor categories that were fairly lumped together in the overall responsibility allocation scale, see Figure 8. Some actor categories, 'LDP', 'Textile producer' as well as some of the actors in 'Designer' and 'Retailer' placed the actor category 'Retailer' higher on the scale. The actor categories 'LDP' and 'Retailer' considered that they have a responsibility in affecting other actor categories in the chain to for instance implement measures. 'Textile producer' argued that 'Retailer' has a responsibility in choosing what they want to sell, whereas 'Designer' thought they have a responsibility to inform customers about microplastics, how to take care of garments and laundry habits. Further, it was considered that they have responsibility since they are the ones deciding what is available for the customers to purchase.

Some actor categories, 'WMP' and 'WWTP' placed 'Retailer' in the middle of the scale with the reason being that retailers can recommend certain materials to their customers and guide customers in their purchase by offering a certain range of clothing. Another reason mentioned by 'WWTP' was that they push for the development of labels. The interviewed consumers argued that 'Retailer' can decide what garments to sell but are affected by the customer demand.

Some actor categories, 'Industrial laundry', 'Filter solution' as well as some actors in 'Retailer' and 'Designer', placed 'Retailer' on the lower part of the scale. 'Industrial laundry' considered 'Retailer' to be affected by the customer demand to a great extent, but that they should be aware of, and research, new materials. 'Filter' said that 'Retailer' can affect the discussion but, in the end, they are not the ones who have created the issue. Both the actor category itself and 'Designer' argued that 'Retailer' cannot do much since they are very limited as to what measures they can implement. They for example often have little to say when it comes to advertisement and purchase since it is controlled by the headquarters.

5.3.4 Consumer

The actor category 'Consumer' was placed the highest among the actor categories that were fairly lumped together in the overall responsibility allocation scale, see Figure 8. 'Textile producer', 'WMP', respondents from the survey and some actors in 'Designer' placed the actor category high on the responsibility scale. 'Designer' said that 'Consumer' have a responsibility in buying products that are less harmful, and that the consumers can change their laundry habits. Continuing, 'Textile producer' and the respondents from the survey said that the consumers are the ones buying the garments and creating the demand. 'WMP' said that the consumer demand can influence what materials are produced. The respondents from the survey continued by saying that if there is no other option for the consumers to choose another material, then the responsibility for 'Consumer' is limited. The consumers are simply buying what the designers are making. It was also pointed out that responsibility is often placed on consumers to change their behaviour

but that it can be considered an excuse for producers to not take responsibility for the impact caused by their product. Additionally, 'WMP' stated that consumers need to be provided with correct information to make sustainable choices.

'Retailer', 'LDP', 'WWTP' and the interviewed consumers placed 'Consumer' in the middle of the scale. The opinions were that the consumers have a responsibility concerning their washing and consumption habits as their demand is affecting what is available on the market. However, the consumer cannot be given all the responsibility since it takes a lot of effort to be a conscious consumer, they are dependent on receiving information and guidance (e.g., through labels). It was also mentioned that it is difficult for them to find the time and the interest to do research about the environmental impact of all products they buy.

The other actor categories, 'Filter solution', 'WMP', 'Industrial laundry' and some actors in 'Designer' placed the actor category 'Consumer' on the lower part of the scale. 'Filter solution' said that consumers are affected by trends and that they are not the ones who have created the problem from the start. 'WMP' argued that consumers mostly buy garments for the sake of fashion and do not consider buying less of a certain material. Regarding the consumers' washing behaviour, the actors within 'WMP' mentioned that it can be difficult to change their behaviour and that the change needs to happen in the washing machine instead. Following, 'Industrial laundry' said that it is probably only a small portion of consumers that are aware of microplastics and that it is today unreasonable to demand responsibility from the consumers. Additionally, 'Designer' thought that the consumers do have a responsibility when it comes to washing but added that all responsibility cannot be placed on consumers due to their unawareness. They also believed that even though consumers would do every possible measure, the microplastic emissions will still exist and measures need to be taken further up the chain to eliminate the problem.

5.3.5 Washing machine producer (WMP)

As seen in Figure 8, 'WMP' was on average allocated to have just above 'Some responsibility' on the responsibility allocation scale, being in the middle of all actor categories.

'Designer', 'Textile producer', 'Filter solution', 'Retailer' and 'LDP' placed 'WMP' on the lower part of the scale. Some argued that they are not causing the microplastic emissions since they are not the ones putting the textiles on the market. However, it was said that they should strive towards innovation and if they have a solution, for example filters, they should implement it. It was mentioned that having filters in washing machines could be a short-term solution until the problem is solved upstream. The interviewed consumers agreed that 'WMP' should not have too much responsibility since they provide a basic human need by washing clothes but could implement filters as a short-term measure. The respondents to the survey agreed on the latter and added that a technical solution would be more reliable than individuals changing their washing behaviour.

‘WWTP’ allocated ‘WMP’ in the middle of the scale, having the same opinions as the previous mentioned actor categories, but it was added by some of the WWTPs that it is unsure whether a filter would have a big effect on reducing the emissions or not. The actor category ‘WMP’ allocated themselves in the middle of the scale as well. It was for example argued that they are not responsible for the consumer washing behaviour, but they do take responsibility to search for possible solutions that would reduce microplastic emissions. ‘Industrial laundry’ allocated ‘WMP’ higher up on the scale pointing out that they can implement filters or come up with other innovative solutions.

5.3.6 Laundry detergent producer (LDP)

The actor category ‘LDP’ was placed the lowest among the actor categories that were fairly lumped together in the overall responsibility allocation scale, see Figure 8. All actor categories except ‘Industrial laundry’ placed ‘LDP’ on the lower part of the scale. ‘WMP’, ‘WWTP’, ‘Designer’ and ‘Filter solution’ argue that laundry detergent does not have a significant effect on the microplastic release from laundry, only a possible minor abrasion effect. ‘WWTP’ and the interviewed consumers added that laundry detergent is necessary for the washing process.

‘Textile producer’ and ‘Designer’ considered that ‘LDP’ is not causing the problem but, as stated by ‘Textile producer,’ ‘LDP’ can still try to come up with innovations regarding reducing microplastic release. Further, ‘Designer’ and ‘Retailer’ argued that there is not much evidence showing that the laundry detergent causes abrasion on the textiles.

The actor category ‘Industrial laundry’ placed ‘LDP’ higher on the scale because as there is laundry detergent especially manufactured for industrial laundries, there should be laundry detergent manufactured to release less microplastics from the garments.

5.3.7 Industrial laundry

As seen in Figure 8, ‘Industrial laundry’ was on average allocated to have just above ‘Some responsibility’ On the responsibility allocation scale, being in the middle of all actor categories.

They were placed by ‘Designer’ and ‘LDP’ at the lower part of the scale arguing that the actor category ‘Industrial laundry’ are not the reason to why microplastic emissions exist. However, some additional opinions were that industrial laundry should do something since their business is to wash clothes. The actor category ‘Retailer’ also placed them on the lower part of the scale arguing that ‘Industrial laundry’ is dependent on washing machine producers and others to provide them with the technology. The consumers agreed to allocate them as having lower responsibility, stating that the actor category ‘Industrial laundry’ cannot always choose what garments they are washing but that they could filter their wastewater.

‘Textile producer’ allocated ‘Industrial laundry’ in the middle of the scale with the reason being that there is no solution for industrial laundries today. They could refuse to wash certain types of materials, but that is not reasonable. The actor categories ‘WMP’ and ‘WWTP’ placed them in the middle as well, stating that industrial laundries should take responsibility for their effluents to limit the amount of microplastic emission they pass on to the WWTPs.

The actor category ‘Industrial laundry’ themselves perceived that they have among the highest responsibility since they can put demands on the washing machine producers to implement filters.

5.3.8 Filter solution

As seen in Figure 8, ‘Filter solution’ was on average allocated to have just above ‘Some responsibility’ on the responsibility allocation scale, being in the lower part of all actor categories.

The actor categories ‘Designer’, ‘Filter solution’ and ‘LDP’ placed ‘Filter solution’ on the lower part of the scale. One general thought was that they are not causing the microplastic emissions. It was also said that filters could be a measure to consider but only short-term. The interviewed consumers, and the respondents to the survey, allocated low responsibility to ‘Filter solution’ agreeing that they are not responsible for the occurrence of the emissions and that the aim should be to implement measures further upstream in the chain. It was also mentioned that the ‘Filter solution’ has a low responsibility since they are dependent on other actors implementing their filter solution.

‘Industrial laundry’ allocated ‘Filter solution’ in the middle of the scale meaning that their solution is important but that it is difficult to ensure that every household has a filter installed in their washing machines, therefore it is a complex requirement to set. The actor category ‘WMP’ also allocated them in the middle and argued that it is an important solution and that they should contribute with their knowledge.

‘Textile producer’ placed ‘Filter solution’ on the higher part of the scale meaning that their filter is an important solution. However, it was argued that they could be considered to not have responsibility since they are simply trying to find a solution to the problem and, in contrast to the other actor categories, they are not contributing to the microplastic emissions. The actor categories ‘Retailer’ and ‘WWTP’ had the same reasoning but placed ‘Filter solution’ lower on the scale.

5.3.9 Wastewater treatment plant (WWTP)

As seen in Figure 8, ‘WWTP’ was on average allocated to have ‘Some responsibility’ on the responsibility allocation scale, being placed among the lowest of all actor categories.

The consumers allocated ‘WWTP’ to the higher part of the scale arguing that they are a reactive solution and the last actor category that can act before the microplastics are emitted into the nature. Therefore, it

was considered that ‘WWTPs’ should take short term responsibility in the meantime as the system is shifting to proactive measures.

‘Designer’ placed the actor category ‘WWTP’ in the middle of the scale. The reason being that WWTPs have a societal responsibility for treating the wastewater and should therefore take part in reducing the microplastic emissions. However, it was considered that they do not have the highest responsibility among all the actor categories since they are not initiating the problem. The actor category ‘Textile producer’ stated that the WWTPs solely have the responsibility to treat the wastewater and allocated them lower on the scale. ‘Industrial laundry’ also placed ‘WWTP’ in the middle of the scale arguing that they can gather all wastewater meaning that it would be easier to implement measures at WWTPs than installing filters at multiple places. The actor categories ‘Filter solution’, ‘LDP’ and ‘WMP’ placed ‘WWTP’ on the lower part of the scale with the explanation that WWTPs have a societal mission to fulfil but not much responsibility otherwise. However, if a requirement regarding microplastic emissions was introduced, the WWTPs must work accordingly. It was added by ‘WMP’ that WWTPs are not responsible for the pollution in the influent but if they can remove it, they should. ‘WWTP’ allocated themselves on the lower part of the scale but the opinions within the actor category varied. Some argued that they have responsibility to work upstream, conduct research and to continuously improve their water quality. One actor stated that since there is no requirement to remove microplastics they do not have responsibility, but if there was, they would implement measures. They agreed that measures by upstream actors should be prioritised as they are the ones creating the polluted influent.

5.3.10 Other

Several actors wished to add additional actor categories when conducting the responsibility allocation. ‘Designer’, ‘Textile producer’, ‘Filter solution’ and ‘WMP’ wanted to add legislators and the government/EU, allocating them among the highest responsibility. The reason was that they considered them as being able to affect the issue by implementing policy instruments, for example by subsidising the technology needed or setting requirements demanding actors to implement measures. It was added by some that if there are no policy instruments regarding microplastic emissions no actor will implement measures.

The actor category ‘Textile producer’ wanted to add NGOs (e.g., certifications) as an actor category and allocated them to have the highest responsibility. It was argued that they can influence and that they could include microplastics in their requirements for the actors to receive the label. It was also mentioned that NGOs can contribute to the industry regulating itself without the need of policies. See 5.4.1 for the perspective of one NGO that was interviewed as wished by the ‘Textile producer’.

‘Industrial laundry’ wanted to include the county administrative board and allocated them the highest responsibility since they could develop guidelines providing recommended measures.

5.4 Secondary actor categories

In this chapter we will present the result gathered from the interviews held with the actors who had been recommended by the primary actor categories. It is important to note that these actors were clearly pointed out that they should be interviewed but were not in all cases added by actors during the responsibility allocation, thus not all secondary actor categories are included in 5.3.10. Since these were not initially included in the actor analysis, nor did they fit in the decided system, they are separated from the rest of the chain and named secondary actor categories.

5.4.1 NGOs

An interview was held with an NGO that offers labelling and standards that companies within the fashion industry can receive by fulfilling certain requirements based on different limit values.

During the interview, the NGO stated that they, as of today, do not have any labels or standards which includes microplastic emissions from laundry. The barriers as to why was mostly connected to *knowledge*: research is new and there is no limit value regarding what levels of microplastic emissions that is harmful. Since their labels and standards are based on limit values it is clearly a significant barrier. Further it was stated that if these barriers would be overcome, they would most likely include limit values regarding microplastics in their labelling. Another mentioned possibility was that they could provide qualitative recommendations on actions that the companies could take.

5.4.2 Trade organisations

Some actors wished for their respective trade organisation to be included. This section includes result gathered from two trade organisations.

Svenskt Vatten (the Swedish Water and Wastewater Association) which is the trade organisation for Swedish WWTPs mentioned that they are a part of and initiating research regarding microplastic emissions. The driver as to why was said to be that they are working long-term with the aim of having higher water quality and to be a part of the circular economy. It was stated that there might be a possibility to include more treatment technologies in the WWTPs that could remove more microplastics than today – but focusing more on the removal of microplastics from untreated storm-water or minimising microplastics in the sludge. Further, it was mentioned that probably more than 99 % of the microplastics are removed today from the effluent in Swedish WWTPs. It was however pointed out that the increasingly stricter requirements on WWTPs to remove phosphorus results in a synergy effect where microplastics are also removed. To clarify, measures with the intention to remove phosphorus also removes microplastics. Due to this, it was said that there is a possibility that measures directed to specifically reduce microplastic emissions might not be needed. Nevertheless, it was said that they either way will continue to take part in research projects regarding the topic, discussing with governmental agencies, supporting research with data and spreading

knowledge to their members. The mentioned barriers were that the knowledge regarding microplastics is limited and that there is no standardised method for analysis.

APPLiA, the trade organisation for home appliances, was also interviewed. They mentioned that no measure has been implemented within the industry to reduce microplastic emissions. A stated possibility was to implement filters in all produced washing machines. As mentioned earlier, the barriers as to why this has not been done is that the washing machine production is global which makes it difficult for producers to adapt to solely the Swedish market. A lot of the production is done by assembly lines and it is not known what washing machine will be sold to what country. This adds to the difficulty of adapting a low number of washing machines to one specific country. Due to this, it was argued that the discussion regarding filters should be taking place at an EU level. It was also mentioned that Brexit, 'Januariavtalet' (Swedish governmental agreement) and the COVID-19 pandemic has slowed down the work. Further, it was said that there is at present no effective solution on the market and there is a long way until filters are implemented in all households. It was argued by the organisation that it can take many years, about 15-25 years, before a full effect of this measure is shown. Therefore, it was believed that other measures need to be taken that can have an effect in the shorter term, for example at WWTPs.

5.5 Final actor category chain

Figure 9 illustrates the actor category chain created after the data collection.

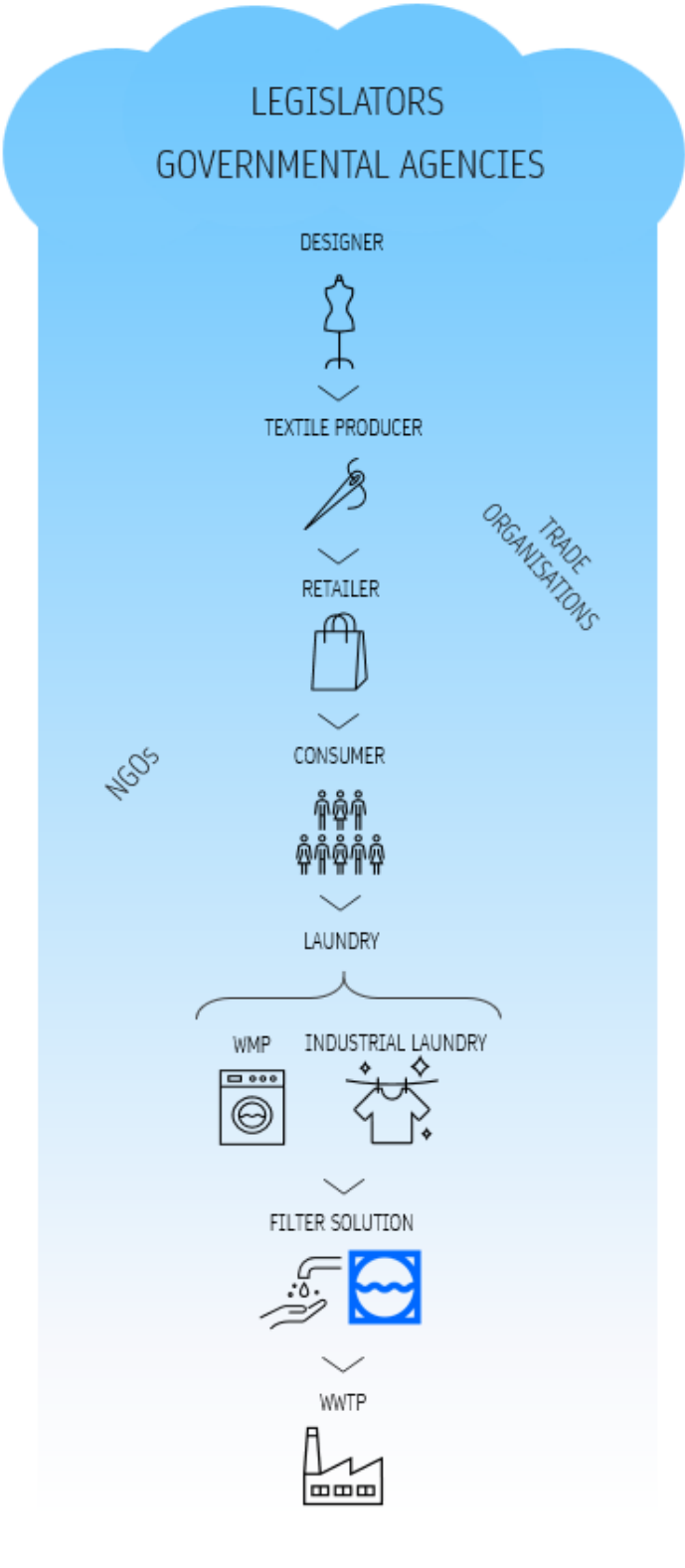


Figure 9: Visualisation of the final actor chain, including the identified actor categories after the data collection meaning that some changes have been made to the original actor categories and that secondary actor categories have been added around the chain to symbolise their external effect on the system.

Compared to the initial identification of actor categories (Figure 7) some changes have been made. In the final actor category chain, the actor category 'LDP' has been removed and the secondary actor categories have been added. The 'LDP' was excluded since most of the interviewed actors argued that laundry detergent probably does not affect the microplastic emissions to a great extent, and that the abrasion effect on the garments caused by detergent is probably small. The actors also believed that laundry detergent does not have a significant role in the chain holistically. The reason is that a change regarding the laundry detergent would not be as strong of a measure as a reformation in other actor categories.

The added secondary actor categories were included since several interviewed actors said that they have a great influence to reduce the emissions. The government and legislators can implement policies and control measures to force the primary actor categories in the chain to change or implement measures. It was said by some actors that the trade organisations can inform the actor categories in the same industry about microplastic emissions, create guidelines and convey opinions from the primary actor categories to political actors. NGOs were also considered to have a major impact as they can push the primary actor categories to change, for example by having higher demands for labelling different types of materials.

6 Discussion

The following chapter discusses the results of this thesis as well as the method. The first part consists of a discussion about the actor categories' implemented measures, possibilities, drivers and barriers followed by discussion concerning the responsibility allocation as well as the affect actor categories might have on Mimby and vice versa. The last part discusses the method.

6.1 Possibilities, barriers and drivers

Among all actor categories, the most commonly occurring barriers were *knowledge* and *technical* followed by *organisational/mindset* and *economic* while the most common driver was *organisational* followed by *stakeholder encouragement*.

Regarding the *knowledge* barrier, several actors mention how they are hindered by no standardised analytical methods existing. It leads to that it is difficult to know what amount of microplastic emissions is harmful and naturally it is therefore not always possible to decide whether a measure is needed. To overcome this, more research needs to be established and possibly also an increased collaboration between industries to standardise methods. Some actors lack information regarding microplastic emissions and/or are unaware that measures even exist. Therefore, they have neither implemented measures nor do they know what possible action to take. This could be overcome by trade organisations and governmental agencies providing guidelines informing about the topic as well as recommending measures for specific actor categories to take. It is also stated by some actors that they are awaiting established research regarding the environmental impact of microplastic emission - why implement a costly measure that is later shown to not be needed? *Technical* barriers are commonly perceived, such as measures not being compatible to all sites, that new processes are not suitable to implement at existing sites and there are no alternatives to synthetic materials. There is thus a need for further technical innovation. Implementing policy instruments that provide economic incentives or that demands limit values to be fulfilled would probably facilitate innovations.

As an *organisational/mindset* barrier it was frequently pointed at how other topics are of higher priority than microplastic emissions from laundry. For example, implementing measures that reduce the impact on climate change and WWTPs focusing on removing pharmaceutical residues as well as prioritising to treat microplastic emissions from stormwater. The reason why microplastic emissions are less of a priority is partly because its environmental impact is not fully established and partly since there is yet no legislation in place. Prioritising issues which have a stated effect can therefore be considered reasonable.

It is often argued that possible measures entail high costs which hinder the actors from implementing them. Several actors, especially those within the fashion industry, mention how they are hindered by the fact that their business is dependent on fulfilling the customer demand. If garments made from synthetics is

demanded by customers, they will offer it. Eliminating synthetic materials is hence not an option. Frequently mentioned by the actors is that most textiles contribute with some type of environmental impact, for instance that the production of cotton requires a substantial amount of water. It is at present therefore difficult to point out what materials are sustainable and what to recommend. It was argued by the actors that synthetic materials are durable, resulting in garments lasting longer, which is an important sustainability aspect. In that sense it is justified to uphold the usage of synthetic materials. Another aspect was that the environmental impact from textiles usually decreases along with a decreased consumption, that goes for most materials except for synthetics. The reason is that microplastic release can occur when wearing the garments and having less clothes will therefore still result in microplastic release, assuming that the consumer still owns clothes in synthetic material. The concept of slow fashion can thus be thought to not have a significant effect on microplastic emissions. However, even if synthetic materials will exist, the fashion industry still have possible measures to implement that would decrease the microplastic release during laundry, for example increasing the material yarn density and pre-washing garments at production. If pre-washing is implemented it is important to still have filters since microplastics will still be emitted, only that the microplastic emissions have been moved to being emitted during the production phase instead of the user phase.

The mentioned *organisational/mindset* drivers often concern the fact that actors have sustainability strategies, have a proactive work ethic and want to be in the forefront of the industry. It can be believed that they think that microplastic emissions will be increasingly acknowledged in the future as well as it is a business advantage to have been among the first in their respective industry to have implemented measures. Another explanation is that they forecast that policy instruments regarding microplastics will be implemented and therefore it is for their own survival to find measures proactively before it is demanded. Many actors are simply aware of the environmental issues and want to help, thus they implement measures accordingly with no other explanation except for having sustainability strategies. Several actors have drivers connected to *stakeholder encouragement*, often meaning the customer demand, and therefore will act according to what is wanted by their customers.

If comparing the number of drivers and barriers (see 5.2.10) between upstream and downstream actor categories no significant difference is observed, it does not appear as if the placement in the system affects the possibilities of an actor to reduce microplastic emissions. What can be noted is that ‘Designer’ have the most drivers and barriers out of all the actor categories. A reason as to why they might have more barriers than the others is partly mentioned to be due to the fashion industry being global, which might entail that it can take time to implement measures, and partly because clothing is a basic human need involving an emotional attachment for many consumers. That ‘Designer’ has the most drivers and barriers could also

indicate that the topic of microplastic emissions is more acknowledged within their actor category and possibly that they have more pressure from stakeholders to act, thus more drivers were identified. Since this actor category, due to their many drivers, probably working with microplastics to a greater extent they have most likely discovered more barriers than others who have not done the same research. It is likely that this reasoning applies to some of the other actor categories as well, for example 'WWTPs' that also have several barriers. All actor categories had more barriers than drivers, which implies that measures first need to be taken to overcome the said barriers, and thereafter it is possible to implement measures to reduce the microplastic emissions from laundry.

At first, it can be considered that those who have the least number of barriers, such as 'Textile producer' and 'Filter solution', clearly have the biggest opportunity to act since they have less barriers to overcome. However, this is opposed by the fact that they also have among the lowest number of drivers. Important to note is that some barriers and drivers can have different levels of effect on the categories. An actor that only has one barrier could be more limited than another actor that has several. Conclusions should therefore not be based solely on the quantity of drivers and barriers, but also by analysing what each driver and barrier entail. For example, 'Retailer' does not have that many barriers but one they do have is that they are not free to plan their shops, it is controlled from the headquarters, which is greatly limiting.

Regarding already implemented measures it can be concluded from the result that 'Designer', by far, has done the most out of all actor categories followed by 'WWTPs' and 'WMP' while several have not implemented any measures. This further adds to the discussion that 'Designer' and 'WWTPs' might be those who are the most informed and aware of the issue and are trying to do what they can despite the barriers. An explanation as to why 'Designer' stands out regarding implemented measures can be, and has also been stated by the actors, that they are aware that the action of them designing and placing these garments on the market is what initiates the chain in where the microplastic emissions later are created. They therefore know that they will probably be given some responsibility for it and it can be thought that they have addressed this by increasing their research to identify potential measures. Considering the 'WWTPs', their work is based on governmental demands and fulfilling limit values. As microplastic emissions have been increasingly addressed and after governmental research projects have been conducted it has been natural to spread this information to the WWTPs. They are the only actor category in the identified chain which is not privately owned and are also working based off a societal mission. This could possibly affect the measures they take and result in them wanting to stay updated on the research to be aware of new requirements that might come. To summarise, it seems easy to be blamed by others and to believe that you must implement measures as the actor placing the product on the market and as the last end of pipe solution. They are drastically the two actor categories who offer the most proactive solution

versus the most reactive. Concerning those who have not implemented measures the barriers have been too significant, and the actors need the barriers to be overcome before they can act. Most of these barriers are factors that several of the actors cannot overcome on their own. For example, regarding policy instruments and the need for standardised sampling and analysis methods. Since these issues are on a larger scale it is for example of need that the trade organisations and politicians act.

All actor categories brought up that they had at least one possible measure to implement if all barriers would be overcome. 'WWTP' closely followed by 'Designer' had the most while 'Retailer' and 'Consumer' had the fewest. It is difficult to conclude if this is due to some actor categories not having any possibilities to contribute with, and that action should be taken by others, or if the knowledge barrier is that significant that it limits the actor categories from knowing what possible measures they can implement. This motivates for the need of prioritising to overcome barriers connected to knowledge since there might be several possible measures existing, but many are not aware of them. It is also important to establish more research to clearly motivate why measures are important to take. This was stated to be the reason to why few measures had been implemented in the actor category 'Consumer', several had for example not heard about microplastics before they responded to the survey. It is understandable that consumers are not aware since it cannot be expected of them to research the environmental impacts of all products they consume. It can be considered that they should be provided accessible information to facilitate sustainable choices. For the remaining of the actor categories it can be thought that as a company they should strive to be aware of what impact their business causes and act accordingly. Since there is no legislation regarding microplastic emissions that can however not be expected. Concluding, the possibility which all actor categories to at least some extent has is to actively stay informed on the topic, follow the latest research and, if possible, also contribute with innovations or data to support research.

Knowledge barriers were identified as among the most significant barriers in this study. The research is relatively new, the environmental impact of microplastics is not fully established and there are no standardised methods for sampling nor analysis. This, combined with there not being any legislation that demands actors to contribute to reduce microplastic emissions results in actors not implementing measures. Many actors state how the topic has not been addressed to a great extent by stakeholders, such as the media. If the topic would have been given more attention they would have heard about the issue and felt the need to act to sustain a good reputation. There are therefore no real incentives to implement measures. An exception would be if the actor has strong sustainability strategies and therefore works proactively to acknowledge issues before it is done by the media and legislators. It can be discussed that having this type of approach might be rare and something that only actors who have a lot of resources can adopt. Usually, other topics have been mentioned to be more alarming to the actors, such as simply keeping the business

going but also other environmental issues where the impact is established. To summarise, not much speaks for that the actors should have already implemented measures. There are several barriers that needs to be overcome before that can be expected and before actors can be held responsible for not acting.

6.2 Responsibility allocation

The overall allocated responsibility is shown in Figure 8 where it can be noted that all actor categories were perceived to have some level of responsibility. It also shows that the more downstream actor categories are placed lower and the more upstream actor categories higher. No tendencies were shown concerning actor categories placing themselves as having low responsibility, instead they were objective and had often no issue with allocating themselves high. The actor category with the highest responsibility, according to the actor categories, was 'Designer'. The actor categories in general argue that designers have the possibility to proactively design the garment with the choice of material in mind as well as arguing that the designers, as being the ones placing the product on the market, should take responsibility. Working for reducing or eliminating the problem from the start will contribute to a reduction in the microplastic release further down the chain. However, one actor category did place 'Designer' lower on the scale based on that the customer demand is too significant for the actor category to be able to implement measures. In turn, one barrier regarding 'Consumer' is that they depend on the range of clothing that is being offered. The barriers between the two actor categories contradict and it becomes a vicious cycle where neither can be blamed more than the other. If either the consumers or designers would change their behaviour/production, the vicious cycle could come to an end. If the consumers would purchase less synthetics, the industry will automatically shift to other materials. The same regards if the designers start using other materials as well. However, if the designers are waiting for the consumers to change their consumption behaviour, there is a risk that nothing will happen since the consumers are mainly buying what is being offered. In a sense, waiting for the consumers to change their consumption behaviour could equal the designers handing over their responsibility as producers to someone else. Important to note is that the actor category 'Designer' placed themselves as having the highest responsibility (

Appendix C) and are therefore acknowledging their impact. Nevertheless, it is important to note that designers have significant barriers and if the responsibility is shifted to them, it could be motivated for to implement policy instruments to enable the actor category to implement measures.

The actor category 'Textile producer' was also placed on the higher end of the overall responsibility scale, but lower than 'Designer'. The argued reason was that 'Textile producer' only produces what the customer (designer) wants and is driven by their demand. A similar discussion as the one above could be applied for the relationship between 'Textile producer' and 'Designer' and it should therefore be the responsibility of the 'Textile producer' to change. However, the difference between the relationship regarding 'Designer'

(customer) – ‘Textile producer’, and ‘Consumer’ (customer) – ‘Designer’ is that the ‘Designer’ is a part of large companies that are well-informed in the process of producing clothes. It is also possible that there is a relationship of power between ‘Textile producer’ and ‘Designer’ which affects the textile producers’ ability to change. For instance, the textile production is commonly based in developing countries where the textile producers do not have the ability to counter the demands of the designer. Worth mentioning is that the ‘Textile producer’ however still has a responsibility in producing the garments in ways so that the microplastic release from garments is minimal. Nevertheless, it could be wished for that the two actor categories collaborate to construct new innovative materials that could be an alternative to synthetics to release no/less microplastics.

The actor category ‘Retailer’ was placed the highest among the actor categories grouped in the middle and is the actor category which has the closest interaction with consumers. As many consumers lack knowledge about microplastics and are in general dependent on receiving information to make sustainable choices, ‘Retailer’ provides a very important function in terms of spreading information. However, they face a significant barrier in terms of that the actions of physical shops are often controlled from headquarters. ‘Retailer’ could act as the place where information regarding materials can be easily accessed. For instance, they could have dedicated sections in the store for sustainable alternatives, provide information about microplastics on their webpage or have a label stating what garments release no/less microplastics. Some actor categories consider ‘Retailer’ in the role as re-sellers to have a responsibility in offering garments that are not made from synthetic materials and/or release less microplastics. As of today, when the research is not fully established and it still unknown if certain materials release less or more than others, the latter is difficult for the ‘Retailer’ to implement.

The remaining actor categories are fairly lumped together in the overall responsibility scale. The reason is that they are not considered to cause the microplastic emissions in the first place. The ‘LDP’ was allocated to have the lowest responsibility. As explained in 5.5 this actor category has been removed from the actor category chain and will therefore not be further discussed in this chapter. With that said, the actor categories ‘Filter solution’, ‘WWTP’ and ‘WMP’ were allocated to have the lowest responsibility. Regarding ‘WMPs’ it was argued by the actor categories that they do not have a responsibility of what is being washed since their primary function is to wash clothes. However, it was mentioned that they do have a responsibility in implementing filter technology since it is the process of washing that contributes to the microplastic emissions, whether it is a good solution can be discussed. It will take several years before most washing machines in Swedish households have a filter installed. It can also be argued that if the washing machines should have a filter, then all other outlets from the household should also have a filter. The reason is that there are other sources of microplastics from households than from laundry, such as dust and washing

dishes, but are probably not causing microplastic emissions to the same extent as laundry. There are also several other sources to microplastic emissions outside the household (e.g., artificial turfs and tyres) and therefore, along with the argument of having filters in every outlet, it could be motivated for to remove microplastics at WWTPs where most of the microplastic emissions are gathered instead of having several minor filters in every household. For this reason, it could be argued that the ‘WMP’ has lower responsibility than the ‘WWTP’. Since the ‘WWTP’ is one actor receiving flows from several outlets, it could also be perceived as more resource efficient to solely remove microplastics at the WWTPs. However, the wastewater treatment performed in the ‘WWTP’ is also quite energy demanding due to more pollutants than microplastics being removed from the wastewater. It is probably easier to develop technology for treating wastewater from washing machines than developing technology focusing on treating several different pollutants at WWTPs. The actor category ‘WWTP’ itself, along with other actor categories, said that they have a responsibility in working upstream since if there were no synthetics in the first place, there would be no microplastic emissions in the WWTP influent. If the number of pollutants in the wastewater decrease, it will decrease the pressure on the WWTPs’ to implement measures to treat the wastewater. The WWTPs have, as earlier mentioned, several barriers to overcome and it is therefore motivated for that both ‘WWTP’ and ‘WMP’ have the same level of responsibility. Another point worth mentioning is that the WWTPs could demand to receive treatable water from the actors that are producing wastewater. If the WWTPs were to receive further requirements about having to remove microplastics, it could potentially lead to the WWTPs demanding the upstream actor categories to implement measures to increase the water quality of the wastewater. Allocating responsibility to ‘WWTPs’ can therefore in the long-term result in upstream actors still having to implement measures.

The actor category ‘Filter solution’ was placed among the lowest on the overall responsibility scale and the opinions were that they only provide a possible solution to the problem and are not responsible for creating the emissions, which most other actor categories are. They simply exist to decrease the microplastic emissions and their responsibility could therefore only be related to the technology itself: that it must work properly and that the actor category itself can contribute with knowledge about their technology. They do not, in that regard, have the same type of responsibility as the other actor categories, due to this difference it could be discussed whether they should be allocated responsibility at all.

Regarding ‘Industrial laundry’, it was stated by most of the actor categories that washing clothes is their business, and that they therefore could have a responsibility in either choosing what to wash or treating their wastewater. Choosing what to wash would be difficult since many of the industrial laundries today wash clothes used in certain businesses where synthetics are needed, for example in hospitals. The argument “it is their business” can be seen as contradicting as WMP’s business is to offer the possibility of washing

clothes. However, sometimes the industrial laundries use conventional washing machines and as previously mentioned, it is the process of washing that contributes to the microplastic emissions and therefore it could be considered that the 'WMP' should have responsibility. It could be that the arguments for the 'WMP' and 'Industrial laundry' are contradicting and that they do have the same level of responsibility. Industrial laundries are dependent on external technologies to do their business and it is difficult for industrial laundries to change washing behaviour since the garments need a certain level of cleanliness. In this sense, industrial laundries can be equalled with consumers in terms of changing behaviour. Both 'Industrial laundry' and 'Consumer' are dependent on that technology exists and more responsibility could thus be considered to be allocated to 'WMP'. Another point worth mentioning is that industrial laundries are in a sense more able to treat their own wastewater compared to every individual household, since they can act as a point source where the wastewater could be treated before reaching the WWTPs.

An actor category that was mentioned and added during several of the interviews was legislators. It is perceived by most of the interviewed actor categories that they have the highest responsibility as they have the possibility to enable actors to implement measures of various kinds. For instance, they could enable a continued development of innovation regarding new materials and filtering technologies. Many actor categories also mention that the issue of microplastics is something that should be dealt with on EU-level. If policy instruments would only be implemented in Sweden, it could disfavour companies on the Swedish market. This could concern and complicate the situation for the actor categories within the fashion industry as well as 'WMP', since both their sectors are global. If policy instruments were to be implemented on an EU or global level, more textile producers would need to take responsibility. This would entail that more measures would be implemented upstream, resulting in less microplastic release downstream. Another advantage of having policy instruments on a broader level is that standardised sampling and analytical methods will probably be established, which is one of the main mentioned barriers.

Another actor category that was mentioned during the interviews was NGOs, especially those offering labels. It was perceived that they have great responsibility in highlighting the problems and working towards reducing them by, for example, setting higher standards. If the NGOs would set higher requirements regarding microplastics, the industry would probably adjust accordingly. For example, it can be a business opportunity for companies in getting their fabric labelled.

The time perspective is a factor worth mentioning regarding the responsibility allocation. As of today, downstream actor categories have more responsibility allocated to them than they might have in the future. While awaiting the upstream actor categories to implement measures the downstream measures are of great importance since they are the last chance to remove the microplastic emissions before they reach the environment. The goal is probably that downstream actor categories should not have a significant role in

the future even though downstream measures will always be needed since microplastic emissions most probably will exist to some extent. However, if better materials are produced that do not release as much microplastics, the pressure of innovating advanced measures downstream decreases. A possible consequence with downstream measures playing a greater role could be that upstream actor categories do not implement measures to a great extent since there are already measures taking care of the microplastic emissions downstream. With policy instruments directed to the upstream actor categories this could be prevented from occurring.

Another aspect that is worth mentioning is the costs. Many actor categories both upstream and downstream, have an economic barrier in terms of measures being costly. However, it might be that the further down in the system the actor category chain is placed, the costlier the measures become. For instance, for the WWTPs to implement a new treatment process solely for microplastics requires a substantial amount of resources, both economically and in terms of time. In comparison, designer can in theory choose to not use synthetics or move towards slow fashion, which does not entail the same amount of resources. This could motivate for responsibility being allocated upstream rather than downstream.

Both wearing and washing clothes is a basic human need and is something that hinders the problem from being solved. It is unreasonable to stop producing and washing synthetic material since its function will always be needed. As earlier mentioned, decreasing the consumption of synthetic materials will not have a significant effect on the microplastic emissions since they mainly occur during the user phase. As mentioned by some actors, microplastic emissions can however be reduced by washing less and by airing the clothes more. It can be thought that ‘Consumer’ and ‘WMP’ therefore should act since it is essentially their behaviour and technology that causes the spread of microplastic emissions. On the other hand, one could argue that the emissions are moved. Instead of microplastics being released during the washing process they are released to the air. The same can be argued for filter solutions, the microplastics are moved from the wastewater to waste. However, this discussion exceeds the system of this thesis but is an important aspect to keep in mind.

6.3 Mimbley

Synthetic fibres will most probably not disappear due to synthetic material having certain demanded properties that, as of today, cannot be found in any other materials. This aspect combined with the need for washing clothes, entails that microplastic emissions will still exist in the future. All actor categories have mentioned that they have barriers for implementing measures. The upstream actor categories are dependent on customer demand, have various organisational barriers, lack knowledge and information, consider that measures are costly and that there is a lack of policy instruments whereas the downstream actor category has significant technical, economic and organisational barriers. Additionally, if policy instruments are

implemented, it will probably take several years before they are in place due to the research not being fully established. For these reasons, and that filters will most likely be needed to remove microplastics from wastewater, there will be a demand for Mimibly's filter solution.

It could be thought that it is only when policy instruments, giving economic incentives, are implemented that one can expect actors to implement measures. If the policy instruments will target for instance the WWTPs, Mimibly's filter solution will not be needed to the same extent compared to if the policy instruments would be implemented in the fashion industry. The reason is that if the WWTPs receive a new demand for treating the water for microplastics, the WWTP must develop and implement measures that successfully do that. That means that the priority of installing filters in, for example, washing machines might drastically decrease since the incentives will be low – why implement a measure when the problem is already taken care of downstream? Worth mentioning is however that the WWTPs have a significant upstream work and are continuously working with the precautionary principle even when policy instruments are directed to the WWTPs. The reason is that if the influent is of better quality, the WWTPs can more easily meet the requirements. In this sense, Mimibly will be an appreciated innovation since the WWTPs, despite having more requirements, will still strive for increasing the quality of the influent by working upstream. The WWTPs have many barriers as of today, and some barriers will still exist in the future, for example that the water treatment system is complex and that the WWTPs have limited space for adding treatment steps. Having innovations like Mimibly will therefore facilitate for the WWTPs to reduce the microplastic emissions.

Regarding the fashion industry, the actor categories as earlier mentioned also face significant barriers that hinder the implementation of measures towards reducing microplastic release. The actor categories also have more barriers than drivers, which further decreases the chance of implementing measures in the fashion industry. If policy instruments will be implemented in the fashion industry, there will still be a need for filtering technology downstream since synthetic fibres, as previously mentioned, will probably still be produced in the future. Hence, with policy instruments targeting the upstream actor categories, there will still be microplastic release from laundry that will need to be taken care of. The reason is that it is unlikely that the policy instruments will aim to eliminate microplastics from the fashion industry. It is more likely that it will focus on reducing textile consumption and production in general, which has probably no significant effect on microplastic emissions as previously mentioned. Therefore, no matter what measures are implemented in the fashion industry it will positively affect Mimibly since microplastic emissions will still exist and thus there will be a need for filtering solutions.

If Mimibly's product is used by the upstream categories, it enables the actors to continue their business and/or behaviour as usual. In that sense, the upstream actor categories could perceive themselves as having

less responsibility as they already have implemented a measure (the Mimbox) that decreases microplastic emissions. This could lead to upstream actor categories not implementing further measures.

‘WMPs’ mention that a filter might have to be installed in solely newly produced washing machines in the future. They also mention that policy instruments are potentially being implemented in other countries regarding microplastics and washing machines. If this happens, the need for the Mimbox may decrease at first sight. Since it will take several years before an effect of installing filter technology in newly produced washing machines can be shown, it however means that the Mimbox can assist in facilitating the transition. Having a filter solution is also motivated for from a sustainability standpoint. The Mimbox can be used with already existing washing machines, meaning that the need to replace old washing machines (because they do not have a filter) decreases. Old washing machines can thus be in use for a longer period.

The discussion above depends on if the research will conclude that microplastics have a harmful effect on the human health and the environment. If the research settles for the opposite, there will be no need for the microplastic filtering technology in the Mimbox. If that were to happen, it will however probably not affect Mimbox since, filtering microplastics is not the main function of the Mimbox. In conclusion, it can be said that Mimbox, in terms of microplastics, will most likely be needed in the future if the research settles that microplastics are harmful. With regards to microplastics being more acknowledged and the reduction targets set by EU, it can be believed that the need for measures will still exist.

6.4 Discussion of method

Regarding the system boundaries it could be discussed whether it is reasonable to include the actor category 'Filter solution'. In contrast to the other actor categories, they are not causing the microplastic emissions, they are rather a potential measure some of the other actor categories could implement. The same could be discussed for 'WWTP', with the difference that they have a societal responsibility to treat the wastewater whereas the filter solutions do not have the same level of responsibility. However, the definition of which the actor category identification is based on solely mentions that the included actor categories should affect, and in some cases be affected by, the issue and does not concern the responsibility of creating said issue. Therefore, it was found reasonable to include 'Filter solution' and 'WWTP' as actor categories.

The Swedish context used in the system boundaries could also be discussed since a large amount of clothing used in Sweden is produced internationally. From this perspective it would have been interesting to research international producers to get a more realistic picture but this was not done due to time constraints. It was decided that the Swedish context would imply the inclusion of solely Swedish actors. To get a more representative result for Sweden, a possible change could have been to reconsider the Swedish context to imply that the textiles should be designed, purchased and used in Sweden. That would have enabled the inclusion of international producers.

During the process of actor identification, it was understood that the number of actors within the categories varied greatly. For example, there are many designers but only a few textile producers in Sweden since most of the textile production is situated outside of Europe. This had a significant impact on the number of actors included in the analysis and is important to note. This for example explains why only one actor is included in the actor category 'Textile producer' while there are five actors included in 'Designer'.

Contacting representatives from the actors was time consuming since it was difficult to get in touch with a representative. Because of this, many actors were contacted as more interviewees were still needed. This affected the project by having to spend more time on this than planned for. This could have been avoided by deciding to aim for only one to three actors within each actor category instead of four since it would still have represented the system to some extent.

The secondary actor categories were solely added based on what was mentioned by the primary actor categories. Therefore, there are certainly further actor categories that could have been included as secondary actor categories. For example, it could have been suitable to add actor categories such as influencers and the media. However, they are not a part of the established system and it is not the aim of this thesis to research secondary actor categories, therefore we did not include secondary actor categories we ourselves believed could have an effect.

The interviews were successful, we were satisfied with the gathered data and it seemed as if the questions were of good quality since the interviewees understood the questions and their relevance. All interviews were semi-structured, meaning that some additional questions that were not included in the interview guides were asked. In a few cases we had to ask the interviewee for clarifications and additions via e-mail if an answer was unclear to us, if questions had mistakenly not been asked or if the interviewee had time constraints limiting the interview. It was also stated in the end, by all the interviewees, that they were satisfied with the interview and thought relevant questions had been included. When asked if there was something the interviewee wanted to add, only a few of the interviewees made additions. This implies that the interviews managed to cover the most relevant topics. However, there was one error being made during the interviews. When analysing the interviews, we realised that some of the interviewed actors interpreted the actor categories 'Designer' and 'Retailer' differently, even though explanations were given. They thought of 'Designer' and 'Retailer' as one brand, which may have affected the placement of 'Retailer' on the responsibility scale. Also, all the interviewees were not fully aware of the other actor categories' context. For example, many considered that 'Retailer' easily can implement measures when, they generally, cannot. This might also have affected the result concerning the placement on the responsibility scale. However, it is yet a result to map the perspective of the other actor categories and how they perceive the responsibility to be. Maybe two actor categories allocate most responsibility to each other and therefore no one implements measures?

Regarding the survey, a couple of points should be noted. Firstly, the survey was spread on our social media and was shared by our supervisors to their networks. This might have had a slight effect on what types of people the respondents were. Since we are students, a concern was that we would have most of the respondents being students. However, we were glad to see that only 45 % of the respondents were students which was a lower number than expected. Thus, we have reason to believe that the results are representative for a greater group of people. Secondly, having an online survey demanded the respondents to have access to internet as well as being active on social media. Therefore, a large group of people – the elderly – did not respond to the survey. Due to time constraints, it was not possible to search for representatives from this group of people in other ways than what was done.

The survey might have been slightly biased when asking about barriers. Regarding the textile consumption, we directly asked why the respondents did not buy less synthetics while regarding laundry we asked more generally about why they have not implemented measures. We should have asked for barriers regarding the textile consumption in the same general way as for laundry since we later learned that there are other measures to take than just buying less synthetics, for example buying materials of higher quality. However,

this was compensated for by the in-depth interviews that were conducted with some consumers where the topic could be discussed further.

There are also some things to be pointed out regarding the analysis of the interviews. Firstly, the work was split between the two of us and there is a risk that the analysis, for instance the colour coding of the transcription, was not performed in the exact same way. For example, one of us could have acknowledged a part of the interview as a barrier while the other did not. We were aware of this risk beforehand and therefore ensured that we had discussed our method for the analysis thoroughly and clarified any doubts. After the analysis was completed, we checked each other's work to identify potential aspects that had been missed. As much as we are aware, no major difference should therefore exist if the analyses are compared. Secondly, the created themes for the drivers and barriers can be discussed. The aim was to make the themes general so they could be applied to most actor categories despite them often having barriers and drivers that are specific to their respective industry. Therefore, some drivers and barriers fit better in their assigned theme than others. If more themes would have been included, it could have resulted in a greater variation and a different result. However, it was found of greater priority to make the themes general to enable a comparison between actor categories and to reach conclusions for the system. Lastly, there is a risk that the actors might have perceived the responsibility allocation scale differently. For example, that the word 'Significant' was thought of differently and that two actors could consider an actor category as having the same amount of responsibility but placed them differently on the scale. Our perception is that this did not seem to occur, but it is important to be aware of since it could influence the result. Regarding the responsibility allocation we are happy that we visualised the scale for the interviewees. By illustrating the scale, it made it more comprehensible for the interviewees to do the allocation and for us to conduct the analysis. We therefore think the result has been affected positively by this choice. Using average values for the result can however be discussed since some more uncommon ways of allocating the responsibility are not shown. However, the aim was to show the opinions of the whole system and what was thought by the majority, therefore it was justified to use average values.

7 Conclusions

What actors can affect and, who in some cases also, are affected by microplastic emissions from laundry in Sweden?

The thesis identified eight different actor categories that can affect, and that in some cases also are affected by, microplastic emissions from laundry in Sweden: ‘Designer’, ‘Textile producer’, ‘Retailer’, ‘Consumer’, ‘WMP’, ‘Industrial laundry’, ‘Filter solution’ and ‘WWTP’.

What potential possibilities, barriers and drivers do the identified actors perceive that they have to contribute to a reduction in microplastic emission from laundry and how can the identified barriers be overcome?

All actor categories had possibilities to contribute to reducing the microplastic emissions from laundry. These possibilities are often specific for the context of each actor category (see 0), but the more common types of possibilities are measures of a technical character, e.g., designers increasing yarn density and ‘WMP’ implementing filters, and organisational character, e.g., increased research and initiating collaborations with other actors. ‘WWTP’ closely followed by ‘Designer’ had the most possibilities while ‘Retailer’ and ‘Consumer’ had the fewest. An explanation to this could be that ‘WWTP’ and ‘Designer’ are generally perceived to have more responsibility and that they therefore have done more research, thus identified more possibilities. Further, the reason to why some actor categories have few possibilities could be due to a lack of information and a need for more research.

The identified types of barriers were *Knowledge, Environmental, Organisational/mindset, Influence by stakeholders, Technical, Economic, Temporal* and *Legislative*. Knowledge barriers were concluded to be the main type of barrier identified in the system. This highlights the need to prioritise knowledge creation to enable the actors to implement reduction measures. Important ways of overcoming the knowledge barriers are to standardise analytical and sampling methods, establish the environmental impact of microplastics and thereafter that trade organisation and governmental agencies provide guidelines are important ways of overcoming the knowledge barriers. Technical barriers were also common, for example that there are no existing measures to implement nor alternatives to synthetic materials. An increase of innovations is thus needed and can be facilitated by implementing policy instruments that provide economic incentives. Some actor categories have already implemented measures with the identified drivers being *Knowledge, Health and environmental concerns, Organisational/mindset, Influence by stakeholders, Technical and Economic*. *Organisational* drivers were the most frequently perceived: that the actor has sustainability strategies, proactive work ethic and wants to be in the forefront of their respective industry. However, all actor categories have more barriers than drivers. For introducing measures to reduce the

emissions these barriers need to be overcome. Overall, 'Designer' and 'WWTP' are the actor categories that have the highest number of already implemented measures, barriers, drivers and possibilities. 'Designer' and 'WWTP' are aware of their perceived central responsibility to influence which has driven them to conduct more research on the topic. In turn, the research has led them to identify more measures and barriers.

How do the identified actors allocate the responsibility for reducing microplastic emissions from laundry?

The actor category 'Designer' was allocated the most responsibility since they are in the start of the actor category chain and can make certain decisions regarding design and material for the garment to release less microplastic particles. 'Textile producer' was also allocated high responsibility. These types of actors are often dependent on what the 'Designer' wants but do have a responsibility to produce the products in ways that release less microplastics. They also, along with 'Designer', have a responsibility to develop new materials that do release less/no microplastics. 'WWTP', 'WMP' and 'Filter solution' were allocated the lowest responsibility and were not considered to cause microplastic emissions. They do however have some responsibility, 'WWTP' and 'WMP' are responsible for implementing technologies that remove microplastics and 'Filter solution' has a responsibility in securing the function of their solution. 'Retailer' has a responsibility in spreading information to customers as well as to offer garments in different materials and/or less synthetics. Regarding the last two actor categories, 'Industrial laundry' and 'Consumer', they were placed between 'Retailer' and the lowest allocated actor categories. 'Industrial laundry' is responsible for choosing what they wash and/or to treat their wastewater with regards to microplastic emissions. Further, it can be considered that it is not possible to allocate much responsibility to 'Consumer' since they are dependent on receiving information as well as being dependent on what the other actor categories do, for instance the way 'Textile producer' produces the materials. However, 'Consumer' do have a responsibility in making sustainable choices regarding their consumption and washing behaviour. The overall conclusion that can be made regarding the responsibility allocation is that all actor categories have some level of responsibility. Lastly, the potential harmful effects of microplastic emissions need to be established to a greater extent before different actors are given formal responsibility to act.

How is Mimby affected by the actors upstream and in what way is Mimby affecting the actors downstream in terms of the need for their solution?

It can be concluded that Mimby's filter solution will be needed in the future. The main reasons as to why, are that synthetic materials most likely will exist and clothes will still need to be washed. This entails that there will still be microplastic emissions occurring during laundry. It can be considered that 'Consumer'

and 'WMP' should take responsibility, but probably with Mimply as a complement. It is not reasonable to solely trust consumers to change their washing behaviour since it should be easy for them to contribute. This can be done by offering a technical solution, such as the Mimbox or by washing machine producers incorporating filters. If filters are implemented in washing machines they will most likely solely exist in newly produced machines and the transition to all Swedish households having a washing machine with a filter solution could therefore take a long time. Mimply's solution can be implemented on existing machines, therefore they could play an important role to accelerate this transition. Additionally, Mimply's solution can also have a positive effect on the WWTPs. The WWTPs often work with upstream actors to reduce the amount of pollution in their influent. If they would receive requirements in the future to treat microplastic emissions, they would probably appreciate upstream solutions such as Mimply since it decreases the pressure on them to implement costly treatment technologies. Important to note is that it is not yet established how harmful microplastics are, and depending on what is concluded, Mimply's filter solution might not be demanded. However, the microplastic emissions are increasingly being acknowledged with EU setting targets to limit the release into the environment by 30 % to 2030. Consequently, it can be concluded that measures to reduce microplastic emissions from laundry, like the Mimbox, will most probably be needed in the future.

7.1 Suggestions for future research

To develop the work further and to understand a few aspects in greater detail, an international perspective could have been used. This is called for since the fashion industry is global and significant parts of the industry being based outside Sweden. The textile production in Sweden is minimal compared to other textile producing countries, meaning that many possibilities, drivers and barriers that would regard textile production were not included in this work. In this regard, more sub-actor categories could be included in the actor category chain regarding textile production, such as the gathering of raw materials. A suggestion would be to include theoretical possibilities, drivers and barriers in further studies. That way it would for example be possible to identify knowledge gaps between what possible measures an actor believe they have compared to what they in theory could do. It would also be interesting to include more secondary actor categories that were not included in this thesis, for example influencers and various opinion-formers. Even tertiary actor categories, i.e., those who are solely affected by microplastic emissions, such as the environment and future generations, could be of relevance to include in further research.

8 References

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9 Appendix

Appendix A

Statistics about the respondents

In total, 119 respondents answered the survey, see Figure 10 for specific statistics regarding the age, gender and occupation of the respondents.

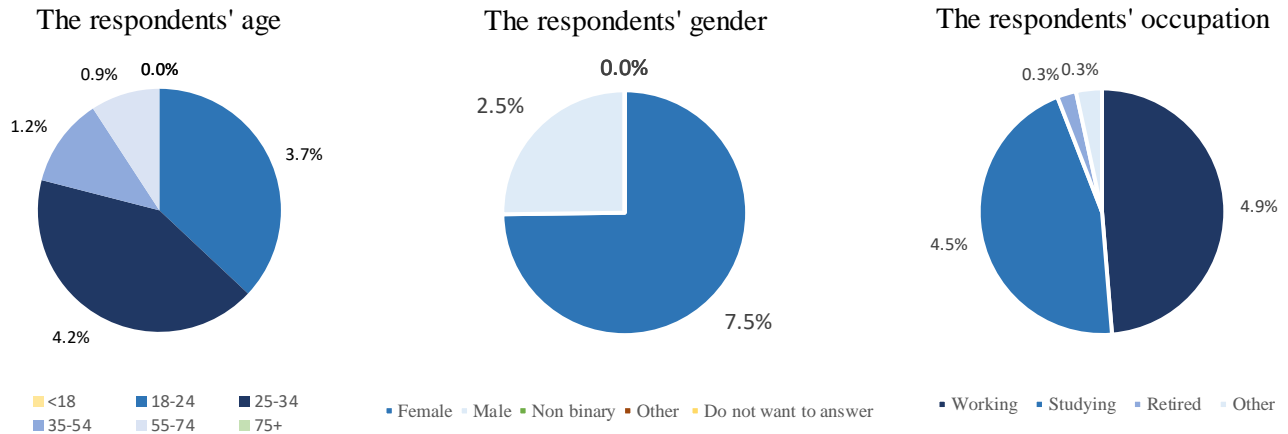


Figure 10. Statistics regarding the age, gender and occupation of the respondents to the survey.

To get a perception of how aware the respondents were about microplastics they were asked to rank their awareness on a scale from one to five. The average answer was a 3.3 which indicated that most respondents were aware of microplastics and their sources to some extent. Most respondents chose a 3 or higher. The same was done regarding the respondents' awareness of synthetic textiles. The average value was 3.4 which states that most respondents were aware of synthetic textiles to some extent. Most respondents chose either a 4 or a 5.

Appendix B

Table 15 below presents general information about the interviewed actors.

Table 15. General information about the interviewed actors.

Actor	Information
Designer A	Offering mainly fashion garments, ~ 200 stores, E-commerce. A part of a bigger brand.
Designer B	Offering mainly activewear, ~ 50 stores, E-commerce. A part of a bigger brand.
Designer C	Offering mainly fashion garments, ~ 1 500 stores, E-commerce, A part of a bigger brand.
Designer D	Offering mainly fashion garments, ~ 400 stores, E-commerce, A part of a bigger brand.
Designer E	Offering mainly activewear, ~ 400 stores, E-commerce, A part of a bigger brand.

<i>Textile producer A</i>	Does not produce synthetic material as of today but have the possibility to. Stand-alone company.
<i>Retailer A</i>	Offering mainly fashion garments, E-commerce, A part of a bigger brand.
<i>Retailer B</i>	Offering mainly activewear, E-commerce, A part of a bigger brand.
<i>Consumer A</i>	Most aware, working
<i>Consumer B</i>	Some awareness, student
<i>Consumer C</i>	Least aware, student
<i>Industrial laundry A</i>	Main customer is within healthcare
<i>LDP A</i>	Global company
<i>WMP A</i>	Offering both household and industrial washing machines
<i>WMP B</i>	Offering both household and industrial washing machines
<i>Filter solution A</i>	Offering a solution which among other functions filters out microplastic particles released during laundry
<i>WWTP A</i>	Situated in a town of ~ 30 000
<i>WWTP B</i>	Situated in a city of > 150 000 inhabitants
<i>WWTP C</i>	Situated in a town of ~ 15 000
<i>WWTP D</i>	Situated in a city of > 150 000 inhabitants
<i>WWTP E</i>	Situated in a city of > 150 000 inhabitants
<i>NGO</i>	Offering labelling on textiles
<i>APPLiA</i>	Trade organisation of the Swedish electrical home appliance industry
<i>Svenskt Vatten (the Swedish water and wastewater association)</i>	Trade organisation of Swedish WWTPs

Appendix C

Figure 11- Figure 20 below presents the responsibility allocation for each actor category. The numbers in brackets indicate the calculated average placement.

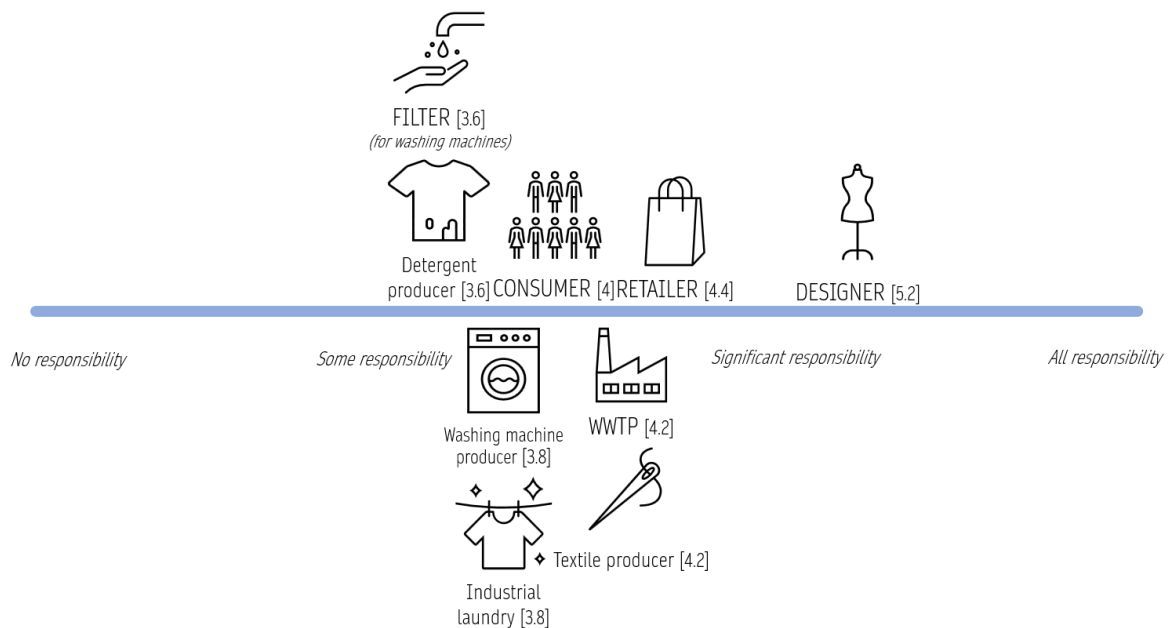


Figure 11. Responsibility allocation by actor category 'Designer' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets shows the average value for the respective placement calculated from all actors within the category.

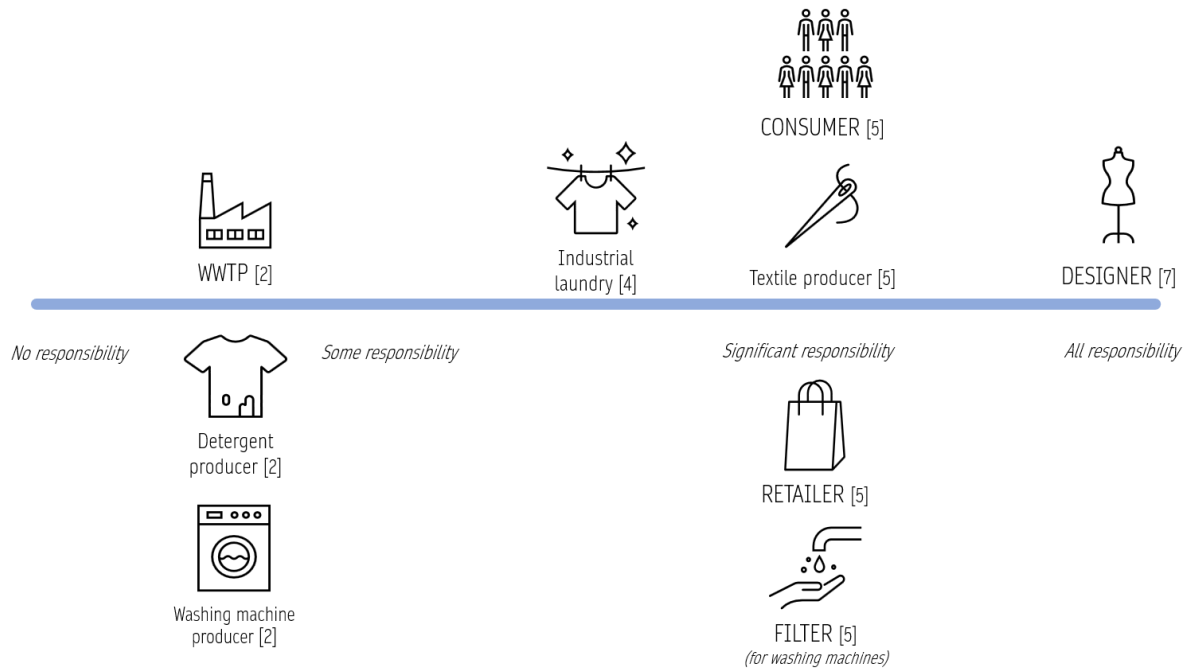


Figure 12. Responsibility allocation by actor category 'Textile producer' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets shows the average value for the respective placement calculated from all actors within the category.

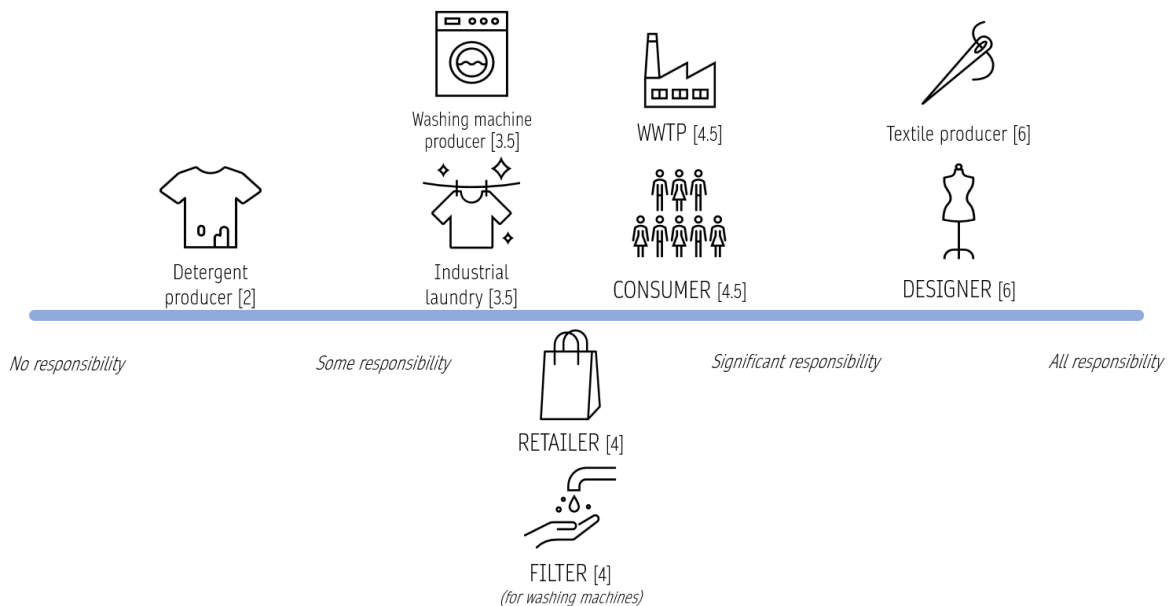


Figure 13. Responsibility allocation by actor category 'Retailer' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets shows the average value for the respective placement calculated from all actors within the category.

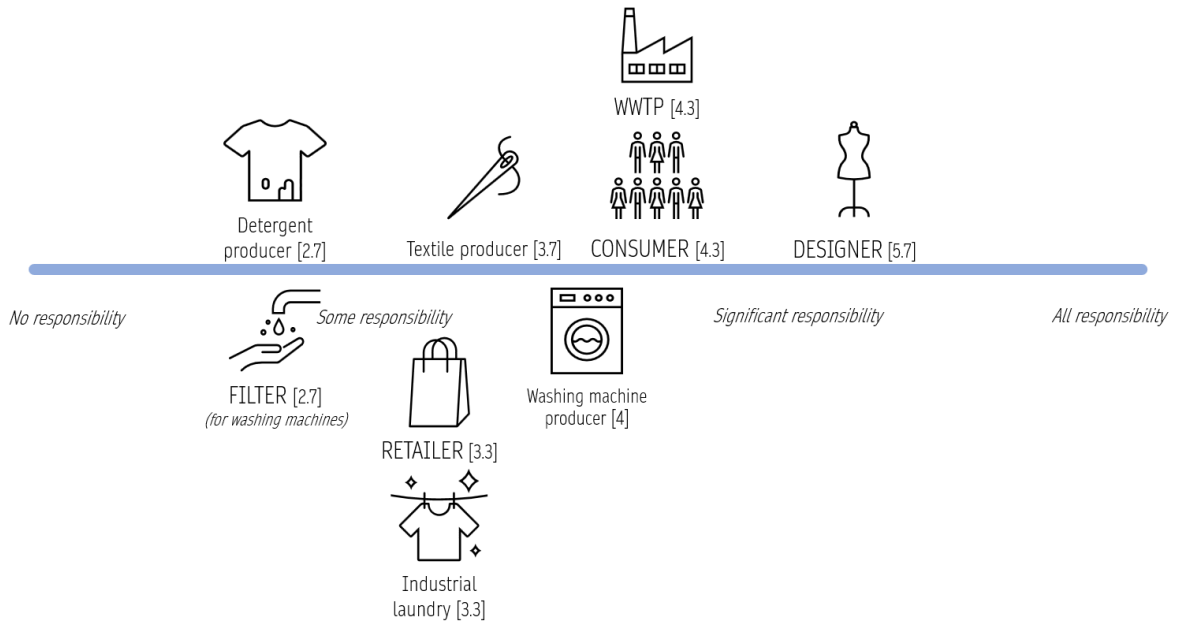


Figure 14. Responsibility allocation by the actor category 'Consumer' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets show the average value for the respective placement calculated from all actors within the category.

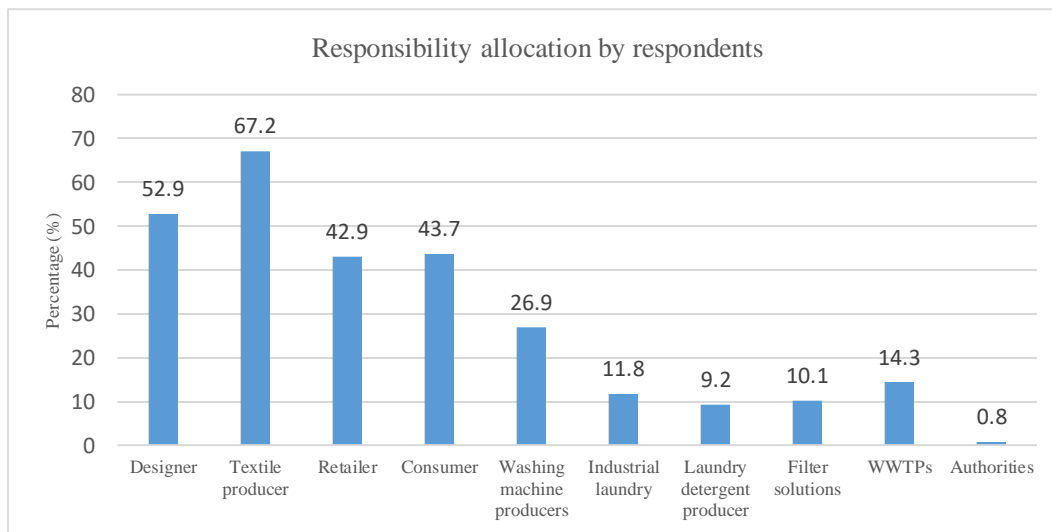


Figure 15. Respondents allocating responsibility to the different actor categories.

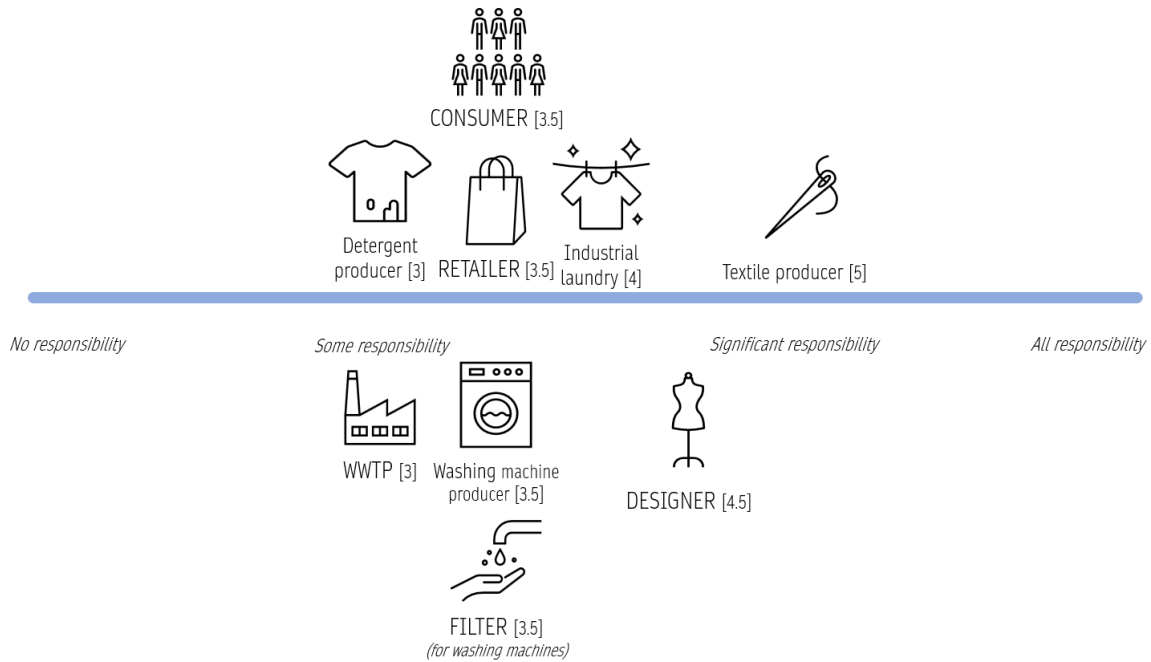


Figure 16. Responsibility allocation by actor category 'WMP' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets show the average value for the respective placement calculated from all actors within the category.

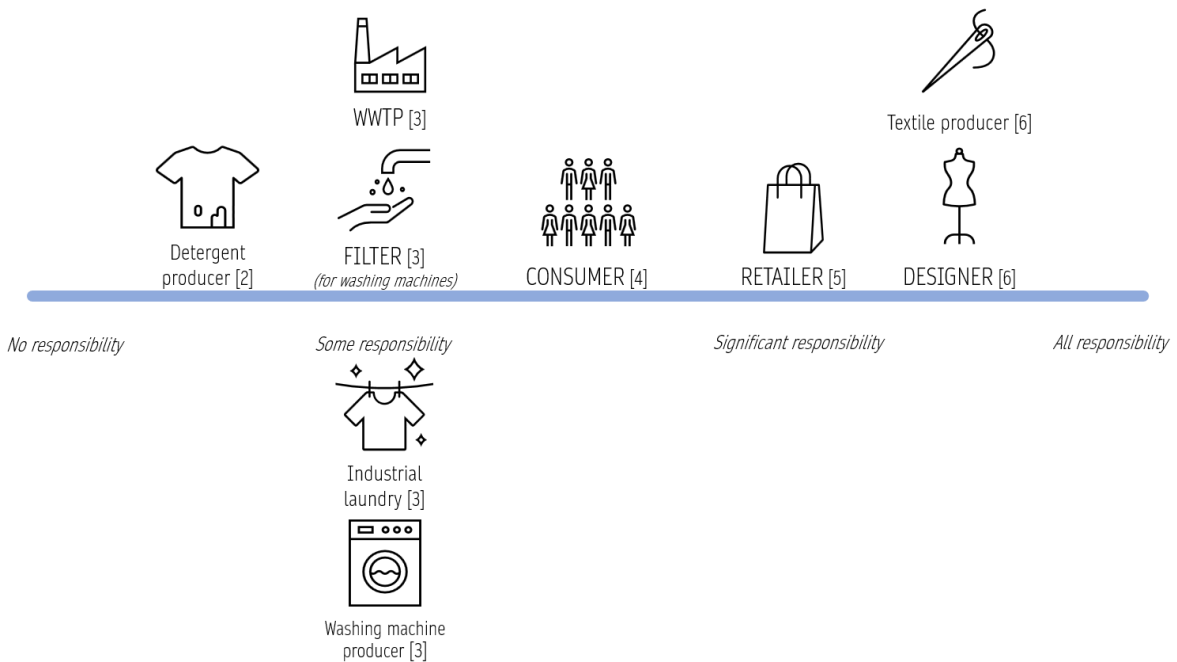


Figure 17. Responsibility allocation by actor category 'LDP' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets show the average value for the respective placement calculated from all actors within the category.

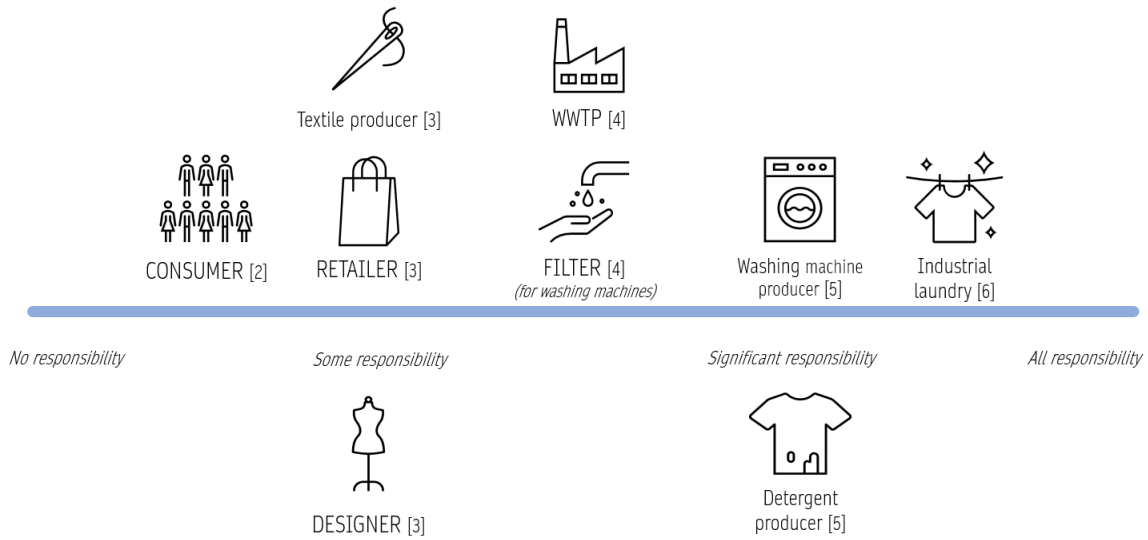


Figure 18. Responsibility allocation by actor category 'Industrial laundry' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets show the average value for the respective placement calculated from all actors within the category.

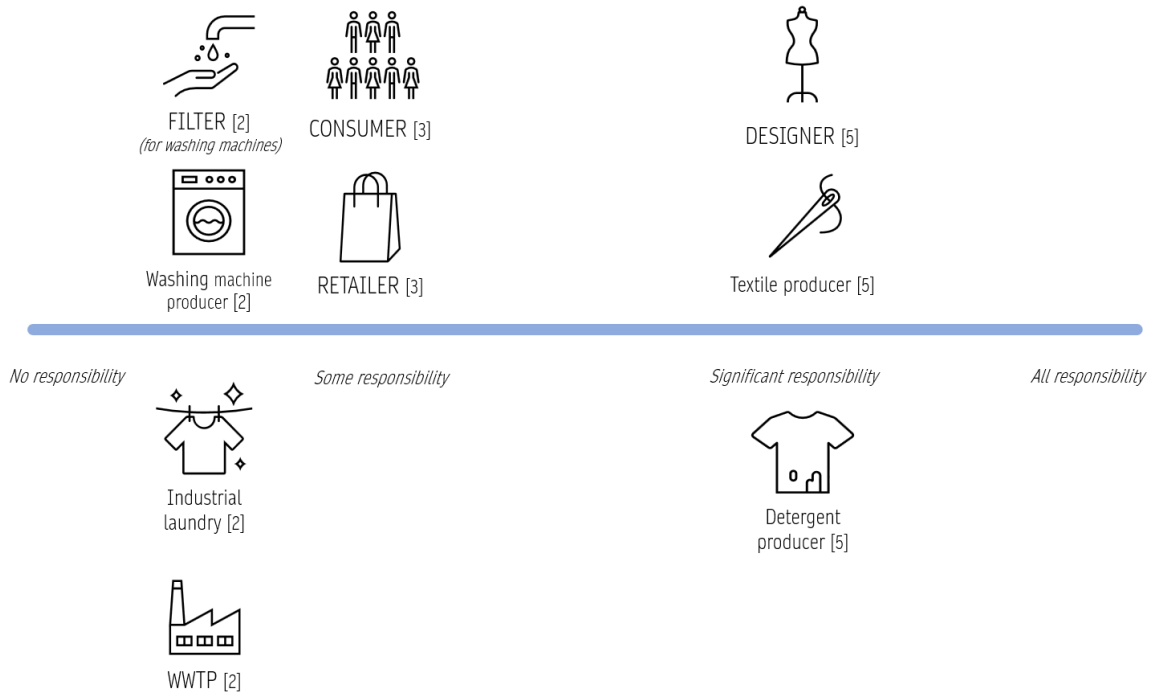


Figure 19. Responsibility allocation by actor category 'Filter solution' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets show the average value for the respective placement calculated from all actors within the category.

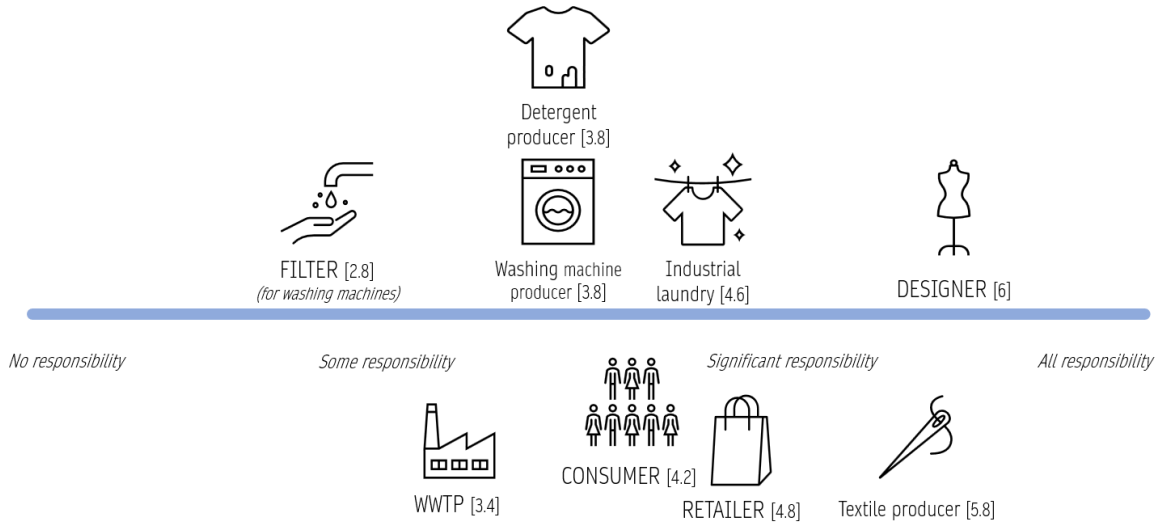


Figure 20. Responsibility allocation by actor category 'WWTP' on a scale from 'No responsibility' (1) to 'All responsibility' (7). The brackets show the average value for the respective placement calculated from all actors within the category.

Table 16 below presents the responsibility allocation made by each interviewed actor. The numbers indicate a specific placement on the scale (explained in 4.2.4.2.) and were used for calculating the average values when creating the responsibility scales.

Table 16: Presents how each interviewed actor placed the actor categories on the responsibility scale. The numbers indicate a specific placement on the scale. If there is no number, it indicates that the actor abstained from allocating responsibility to that specific actor category.

Actor	Actor category								
	Designer	Textile producer	Retailer	Consumer	Industrial laundry	LDP	WMP	Filter solution	WWTP
Designer A	6	3	6	3	2	2	2	1	4
Designer B	5	5	5	5	5	5	5	5	5
Designer C	5	5	2	2	4	3	4	4	4
Designer D	5	3	4	5	3	3	3	3	3
Designer E	5	5	5	5	5	5	5	5	5
Textile producer A	7	5	5	5	4	2	2	5	2
Retailer A	6	6	3	5	4	1	1	5	4
Retailer B	6	6	5	4	3	3	6	3	5
Consumer A	5	4	4	4	5	3	5	3	3
Consumer B	6	2	5	3	4	3	5	4	5
Consumer C	6	5	1	6	1	2	2	1	5
Industrial laundry A	3	3	3	2	6	5	5	4	4
Detergent A	6	6	5	4	3	2	3	3	3
Laundry machine A	4	5	3	2	4	2	3	3	3
Laundry machine B	5	5	4	5	4	4	4	4	3
Filter solution A	5	5	3	3	2	5	2	2	2

WWTP A	5	5	4	5	5	4	5	3	5
WWTP B	6	7	5	4	4	3	3	3	4
WWTP C	7	7	5	3	5	3	3	2	3
WWTP D	-	-	4	5	6	4	5	-	4
WWTP E	6	4	6	4	3	5	3	3	1

Appendix D

Table 17 - Table 25 below presents the specific drivers and barriers identified for all actors within each actor category. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Table 17: Presents the identified drivers and barriers for each interviewed actor in the actor category 'Designer'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Actor	Drivers	Barriers
Designer A	<ul style="list-style-type: none"> ○ High proportion synthetic materials. (3) ○ Desire to know how they can improve/Want to know what they can do. (3) 	<ul style="list-style-type: none"> ○ Purchases already made clothes, supplier source the materials. (3) ○ Many different materials. (5) ○ Relatively small business. (3) ○ Customer comfort and demand. (4) ○ Difficult to change customer behaviour. (4) ○ Fashion is an emotional choice, and therefore difficult to influence the customer. (4) ○ Synthetic materials are needed to create a specific look. (5)
Designer B	<ul style="list-style-type: none"> ○ Want to provide the customers with a tool to decrease the wear and tear of more frequent washing. (1) ○ Views it as their responsibility to inform the customer. (3) ○ Want to learn more. (3) 	<ul style="list-style-type: none"> ○ Lack of time. (7) ○ Lack of information. (1) ○ Small business, not enough resources. (3) ○ Have other things to do concerning the sustainability area. (3) ○ Customer demand rules the business. (4) ○ Need a specific function in the garments that only synthetics can provide. (5)
Designer C	<ul style="list-style-type: none"> ○ Be at the forefront before policies. (3) ○ Synthetic materials are the second biggest fibre group. (3) ○ Environmental concerns. (2) ○ Sustainability strategies at the company. (3) 	<ul style="list-style-type: none"> ○ Lack of research. (1) ○ Lack of standardized measuring tool. (1) ○ It is not possible to replace synthetic materials today and get the same function it provides. (5) ○ Lack of knowledge. (1) ○ Costly. (6) ○ Complexity of supply chain. (3)
Designer D	<ul style="list-style-type: none"> ○ Continuously working with removing toxic element and substrates. (2) 	<ul style="list-style-type: none"> ○ Lack of standardized measuring tool. (1) ○ Lack of knowledge. (1) ○ Costly to implement laser cutting. (6) ○ Prefer to invest in climate change measures (it is proven) (3) ○ It is not motivated to coat fibres since it requires a lot of chemicals, energy and water. (2) ○ Synthetic materials are great in terms of durability and longevity. (5) ○ Lack of consistent research findings. (1) ○ The research today is still very new and we can simply not implement measures based on incomplete research. (1)
Designer E	<ul style="list-style-type: none"> ○ Very sustainability focused. (3) ○ Want to be at the forefront to avoid unpleasant future situations. (3) ○ Do not want to lose customer trust (4) ○ Believe they have the responsibility to stay informed (3) 	<ul style="list-style-type: none"> ○ Synthetics materials cannot be replaced. (5) ○ Limiting since they work with functional clothing. (5) ○ Lack of information. (1) ○ Lack of research. (1) ○ Another environmental impact with natural fibres. (2)

Table 18: Presents the identified drivers and barriers for the interviewed actor in the actor category 'Textile producer'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Drivers	Barriers
<ul style="list-style-type: none"> ○ Have sustainability goals to influence their customers to more organic alternatives. (3) ○ Their customers are driving the development forward. (4) 	<ul style="list-style-type: none"> ○ Customer demand. (4) ○ Lack of policy instruments. (8) ○ The market is cost driven. (6) ○ Costly to buy biologically degradable synthetics materials. (6)

Table 19: Presents the identified drivers and barriers for each interviewed actor in the actor category 'Retailer'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Actor	Drivers	Barriers
Retailer A	<ul style="list-style-type: none"> ○ Sustainability strategies. (3) 	<ul style="list-style-type: none"> ○ Customer demand. (4) ○ Lack of knowledge. (1) ○ We are controlled by the rest of the company and do not have any choice regarding the store's layout. (3)
Retailer B	<ul style="list-style-type: none"> ○ Feel as they are partly responsible for the microplastic emissions. (3) ○ Want to be at the forefront if there will be new regulations. (3) ○ Making their own filtering laundry bag seemed like an easy measure. (5) 	<ul style="list-style-type: none"> ○ Customer demand. (4) ○ Want a specific function only synthetic materials provide. (5) ○ No measurable environmental impact, nothing to say to suppliers. (1) ○ Climate change is more important. (2) ○ Not knowing which materials are problematic when it comes to microplastic emissions. (1)

Table 20: Presents the identified drivers and barriers from the survey and for each interviewed actor in the actor category 'Consumer'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Actor	Drivers	Barriers
Consumer A	<ul style="list-style-type: none"> ○ Partly working within the topic of microplastics. (3) ○ Personal interest. (3) 	<ul style="list-style-type: none"> ○ All materials have some environmental impact, difficult to know what to do. (1) ○ Need the function that synthetic materials provide. (5) ○ Measures are not easily accessible. (1) ○ Lack of knowledge. (1) ○ Lack of research. (1)
Consumer B	N/A	<ul style="list-style-type: none"> ○ Lack of interest. (3) ○ There are other things to do. (3) ○ Feels difficult, need to research a lot on your own for a little impact. (1) ○ Need the function that synthetic materials provide. (5) ○ Personal preferences. (3)
Consumer C	N/A	<ul style="list-style-type: none"> ○ Lack of knowledge. (1) ○ Have other priorities. (3) ○ Too lazy to research measures. (3) ○ Need the function that synthetic materials provide. (5)
Survey	<ul style="list-style-type: none"> ○ Want to reduce microplastics emissions. (2) ○ Act environmentally friendly. (2) ○ Washing clothes less often to reduce the tear of the garment. (5) 	<ul style="list-style-type: none"> ○ Natural materials provide other functions. (5) ○ Measures are complex. (5) ○ Using a shared laundry room is limiting in terms of implementing Measures. (5) ○ Other materials than synthetics are not easily accessible because the stores do not offer a large share of them. (4)

	<ul style="list-style-type: none"> ○ Do not want to sacrifice comfort and functionality for sustainability. (3) ○ Clothes made from synthetics are cheaper (6) ○ Measures are expensive (6) ○ Don't have the time to research measures (7)
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Table 21: Presents the identified drivers and barriers for each interviewed actor in the actor category 'LDP'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Drivers	Barriers
<ul style="list-style-type: none"> ○ Internal and external pressures (4) ○ Microplastics have been acknowledged in media (4) ○ Want to be seen as a sustainable company (3) ○ Works proactively (3) 	<ul style="list-style-type: none"> ○ Lead times (7) ○ Limited raw materials and suppliers (4) ○ Takes time to replace complete ingredients (7) ○ The primary function is to make the clothes clean (3) ○ No adequate alternatives on the market today (5)

Table 22: Presents the identified drivers and barriers for each interviewed actor in the actor category 'WMP'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Actor	Drivers	Barriers
LMP A	<ul style="list-style-type: none"> ○ Strives to deliver the best possible laundry machine to the best price. (3) 	<ul style="list-style-type: none"> ○ The laundry machines are only manufactured globally and is difficult to impact as one country alone. (3) ○ Other topics are of higher priority. (3) ○ There are no regulations. (8) ○ It has not been given attention in media. (4) ○ Will not implement measures as one actor alone. (3)
LMP B	<ul style="list-style-type: none"> ○ Wants to be a company with sustainability strategies. (3) ○ They profit from working with Sustainability. (6) ○ Has a proactive working ethic. (3) ○ Believe it is partly their responsibility to solve. (3) 	<ul style="list-style-type: none"> ○ No standardized analytical methods exist. (1) ○ Implementing a filter would increase costs. (6) ○ Having a filter is complex – must ensure that the user handles it correctly. (5) ○ Difficult to convey knowledge to their customers. (1) ○ Limitations in what can be conveyed in the laundry machine display. (5)

Table 23: Presents the identified drivers and barriers for each interviewed actor in the actor category 'Industrial laundry'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Drivers	Barriers
<ul style="list-style-type: none"> ○ Their CEO priorities sustainability questions. (3) 	<ul style="list-style-type: none"> ○ No adequate replacement of synthetic material. (5) ○ There are no guidelines recommending measures. (1) ○ All the fibres and dirt in the water would clog a filter if it was to be implemented. (5) ○ Lack of knowledge. (1) ○ Large volumes of water with complicated processes. (5) ○ The customers a certain type of textile and level of cleanliness. (4) ○ Measures would be costly. (6)

Table 24: Presents the identified drivers and barriers for each interviewed actor in the actor category 'Filter solution'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Drivers	Barriers
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<ul style="list-style-type: none"> ○ A business opportunity to solving the lack of water and lowering microplastic emissions as an added value. (6) ○ Not a lot of competitors. (4) ○ Their customers are driven by environmental policies. (4) ○ Are detached from the rest of the chain meaning they do not hinder and compete with the other industries (e.g., laundry machine producers). (4) 	<ul style="list-style-type: none"> ○ No economic gain to solely remove microplastics. (6) ○ No established environmental impact of microplastics. (1) ○ Knowledge of microplastics is not spread. (1) ○ Regulations regarding technology involving water. (8)
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Table 25. Presents the identified drivers and barriers for each interviewed actor in the actor category 'WWTP'. The numbers in parenthesis indicate what type of barrier/driver they were categorised as following the order seen in Table 3.

Actor	Drivers	Barriers
WWTP A	<ul style="list-style-type: none"> ○ Building a new plant. (5) ○ Media brought attention to it. (4) ○ Practices the precautionary principle. (2) ○ Proactive work ethic. (3) 	<ul style="list-style-type: none"> ○ No standardized analytical methods exist. (1) ○ No standardized measuring methods exist. (1) ○ Removal of pharmaceutical residues is of higher priority. (3) ○ Removal of microplastics from storm water is of higher priority. (3) ○ Complex to implement a new process in an already existing plant. (5) ○ There is no legislation on removing microplastics. (8)
WWTP B	<ul style="list-style-type: none"> ○ Continuously work to improve the water quality. (2) ○ Strive to be in the forefront of industry. (3) ○ Strive to contribute to a sustainable society and therefore wants to eliminate as much contaminants as possible. (3) 	<ul style="list-style-type: none"> ○ Not a lot of existing technology for removing microplastics. (5) ○ No standardized analytical methods exist. (1) ○ Removal of microplastics from storm water is of higher priority. (3) ○ Knowledge is not fully established. (1)
WWTP C	N/A	<ul style="list-style-type: none"> ○ Removing metals from the sludge is of higher priority. (3) ○ Removal of pharmaceutical residues is of higher priority. (3) ○ Complex to implement a new process in an already existing plant. (5) ○ High investment cost. (6) ○ Has not been brought attention to in media. (4)
WWTP D	<ul style="list-style-type: none"> ○ Takes on responsibility since they are a pathway for the spread of emissions. (3) ○ Proactive work ethic. (3) ○ Strive to have an effluent with lowest number of particles in it as possible. (2) 	<ul style="list-style-type: none"> ○ New area of research. (1) ○ No standardized analytical methods exist. (1) ○ No measures exist. (1) ○ Other things are of higher priority. (3)
WWTP E	N/A	<ul style="list-style-type: none"> ○ Measuring methods are inadequate (1) ○ New area of research. (1) ○ Complex to remove microplastics from sludge. (5) ○ Removal of microplastics from storm water is of higher priority. (3) ○ Implementing new purification processes is costly (6) and not always environmentally motivated for. (2)

Appendix E

Results from the survey

In this chapter the extended result from the survey is presented. Table 26 below presents the questions asked in the survey.

Table 26: Presents the questions asked in the survey.

No.	Introductory questions	Why the question was asked
1	Age	Information about the respondent
2	Gender	Information about the respondent
3	Occupation	Information about the respondent
4	How many people live in your household?	Information about the respondent
5	How aware are you of microplastics and its origin?	To give us an idea of the respondent's awareness about microplastics before asking more in-depth questions
6	How aware are you of synthetic textiles?	To give us an idea of the respondent's awareness about synthetic textiles before asking more in-depth questions
Consumption of clothes		
7	How often do you buy newly produced garments?	Information about the respondent
8	How often do you buy second hand?	Information about the respondent
9	What characteristics determine what clothes you buy?	To know the characteristics that are important for the respondent
10	How often do you think about what material a garment is generally made of before you buy it?	Information about the respondent
11	Do you consciously buy garments that consist of a small amount/no synthetic material?	Direct question to identify implemented measures
11.1	<i>If yes:</i> What makes you buy garments made of a small amount of/any synthetic material?	Direct question to identify drivers
11.2	<i>If no:</i> What makes you NOT buy garments made of a small amount of/any synthetic material?	Direct question to identify barriers
12	What would make you more likely to buy garments made from a small amount of/any synthetic material than you do today?	Overcoming barriers
13	Would marketing/other information influence you to buy garments made of less/no synthetic material?	To know if the respondent would act after receiving information about microplastics
13.1	Please briefly explain your answer to the previous question (optional)	To know if the respondent would act after receiving information about microplastics
14	Would you have wanted shops/retailers to provide more information on which garments release less microplastics?	To know if the respondent would want to receive more information about microplastics
14.1	Please briefly explain your answer to the previous question (optional)	To know if the respondent would want to receive more information about microplastics
Laundry		
15	Do you have access to your own laundry machine at home or do you do laundry in a shared laundry machine?	Information about the respondent
16	How many washing machines do you run per month?	Information about the respondent
17	Have you implemented any measures/new washing habits to consciously reduce microplastic emissions when washing clothes?	Direct question for identifying measures
17.1	<i>If yes:</i> What is the action/washing habit?	Direct question for identifying implemented measures

17.2	If yes: How did you come to introduce this measure/washing habit?	Direct question for identifying drivers
17.3	If no: Why is it that today you are NOT using a measure that reduces microplastic emissions from laundry?	Direct question for identifying barriers
17.4	If no: Would you consider introducing any measure/new washing habit that would reduce the amount of microplastic emissions when washing? *	Information regarding personal interest
17.4.1	*If yes: What is the reason why you would introduce such a measure/washing habit?	Potential driver
17.4.2	*If no: What is the reason why you would NOT implement such a solution?	Potential barrier
17.4.3	*If no: What would make you introduce a solution?	Overcoming barrier
Final questions		
18	Which of these actors do you think bears the greatest responsibility for reducing microplastic emissions from laundry? (Max 3)	Responsibility allocation
18.1	Please explain briefly why you think the 3 actors you chose above bear the greatest responsibility (optional)	Justifications for the ranking of actor categories regarding the responsibility allocation scale
19	How much responsibility do you think you have as a consumer (buying/washing clothes) to reduce microplastic emissions from laundry?	To know what responsibility the respondent consider himself/herself to have
19.1	Please briefly explain your answer to the previous question (optional)	To know what responsibility the respondent consider himself/herself to have

The following part of this chapter provides the overall answer to the main questions from the survey.

Question 11: Do you consciously buy garments that are made from less/no synthetic material?

For question 11, 56 % of the respondents answered ‘No’ while 44 % answered ‘Yes’.

Question 11.1: Why do you purchase garments made from less/no synthetic material?

This question was answered by the respondents writing freely, hence no given options were provided for them to choose from. To get an overview, the types of answers were categorised as reasons connected to personal preference (e.g., prefers cotton), environmental, comfort, quality. The share of respondents for each type of answer is shown in Table 27 below. Since the respondents could write their answer freely some gave several reasons, for example both quality and comfort, in one answer and therefore the share of respondents does not add up to 100 %.

Table 27. Answers to question 11.1 and the share of respondents choosing each answer.

Type of answer	Share of respondents
Personal preference	17 %
Environment	38 %
Comfort	50 %
Quality	19 %

Question 11.2: Why do you NOT purchase garments made from less/no synthetic material?

The answers to the question and the share of respondents who chose a specific answer is presented in Table 28 below.

Table 28. Answers to question 11.2 and the share of respondents choosing each answer.

Answer	Share of respondents
Have no knowledge about it	58 %
It is not easily accessible to purchase	13 %
Do not care about material	10 %

The remaining answers were only given by one respondent each and are therefore not presented in the table since it is not representative for the whole actor category.

Question 17: Have you implemented any measures/new washing habits to consciously reduce microplastic emissions when washing clothes?

For question 17, 82 % of the respondents answered ‘No’ while 18 % answered ‘Yes’.

Question 17.2: How did you come to introduce this measure/washing habit?

This question was answered by the respondents writing freely, hence no given options were provided for them to choose from. 59 % answered that they want to reduce microplastic emissions and 18 % said that they in general have an environmentally friendly mindset. The remaining answers were only provided by one respondent each and is not presented since it is not considered representative for the actor category.

Question 17.3: Why is it that today you are NOT using a measure that reduces microplastic emissions from laundry?

For question 17.3, 89 % of the respondents answered that they are not aware of any measures, 2 % said that they think measures are too expensive while 2 % answered that they find measures difficult to use. The The remaining answers were only provided by one respondent each and are not presented since they are not considered representative for the actor category.

Question 18: Which of these actors do you think bears the greatest responsibility for reducing microplastic emissions from laundry?

The answers to question 18 and the share of respondents who chose a specific answer is presented in Table 29 below. The respondents could provide three answers and therefore the shares do not add up to 100 %. ‘Authorities’ and ‘All categories’ were added by respondents and were not a provided option.

Table 29. Respondents allocating responsibility to the different actor categories.

Actor category	Textile producer	Designer	Retailer	Consumer	WMP	WWTPs	Industrial laundry	LDP	Filter solutions	Authorities	All categories
Share of respondents	67 %	53 %	43 %	44 %	27 %	14 %	12 %	9 %	10 %	1 %	1 %

Interview guides

Table 30 below presents the interview guides used for preparing and conducting the interviews.

Table 30: Presents the interview guides used for preparing and conducting the interviews.

No	Introductory questions	Why the question was asked
1	What do you know about microplastics?	To give us an idea how much they know about microplastics before asking more in-depth questions
2	What do you know about your industry in regard to microplastics?	To give us an idea how much they know about microplastics regarding their industry before asking more in-depth questions
In-depth questions		
3	Do you know if measures have been implemented in your industry in general to decrease microplastic emissions?	To know if any measures have been implemented in the industry. Could potentially be a follow up question if the company has not implemented any measures but the industry has.
4	Has [actor] implemented any measures?	Direct question for identifying implemented measures
4.1	If yes: What were the reasons to why [company] chose to implement measures?	Direct question for identifying drivers
4.2	If no: What are the reasons to why you have not implemented a measure as of right now and in the future?	Direct question for identifying barriers
5	What would make you implement a measure/implement more measures?	Overcoming barriers, what needs to be done
6	If the barriers you mentioned earlier were to be overcome, which measures in theory could you implement?	Direct question for identifying possibilities
Responsibility allocation		
7	Do you know which actors (actor categories) regarding microplastic emissions from laundry that should take responsibility?	Introductory question for the responsibility allocation scale
	<i>We show and explain the actor category chain</i>	-
	<i>We show and explain the responsibility allocation scale</i>	-
8	Which of these actors (actor categories) would you say are responsible for reducing the microplastic emissions? Rank the actors (actor categories) on the scale and motivate why you placed them there.	To know which actor categories are considered by the interviewee to have the most responsibility
9	What specifically is their responsibility to do?	To know what they think the actors should do
10	What kind of responsibility do you think you have?	To know what responsibility they consider themselves to have
11	What do you think is the reason why more has not been done overall in the chain?	Potential barriers

12	In general, what needs to happen for there to be a change regarding microplastic emissions from laundry?	How to overcome the barriers
13	What are your opportunities to influence other actors?	To get to know the dynamics between certain actor categories
14	Do other actors (actor categories) influence you?	To know the dynamics between certain actor categories
15	Do you cooperate with other actors (actor categories)?	To know the dynamics between certain actor categories
	Final questions	
16	Something you would like to add/we should have asked about?	If the interviewee has something else to say but did not have the opportunity to say it during the interview