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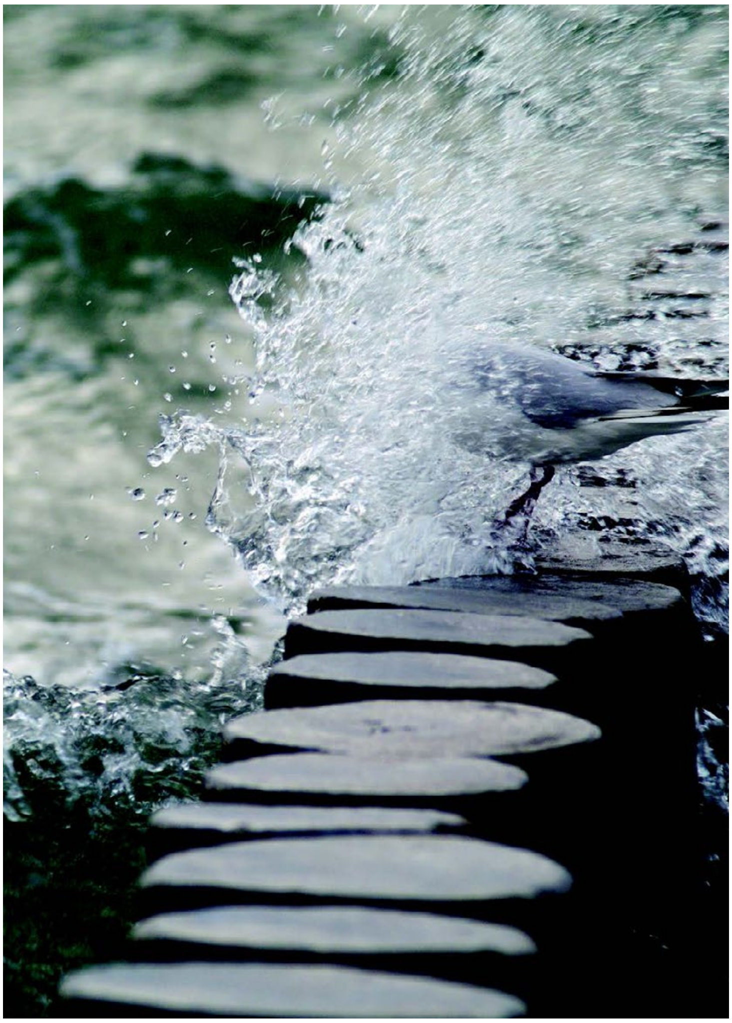
Microplastics

Presentation of government commission on sources of microplastics and proposed measures for reduced emissions in Sweden



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Foreword

In August 2015, the Swedish Environmental Protection Agency (EPA) was commissioned by the Government to "identify major sources in Sweden for the emission of plastic microparticles into the sea, work to reduce the generation and emission of microplastics from these sources, and, if necessary, propose regulatory changes to reduce emissions" (Reg. no. M2015/2928/Ke).

This report from the Swedish EPA presents the results of its work on the commission. The commission was active between August 2015 and May 2017.

Members of the working group varied over time. In total, the following persons at the Swedish EPA participated in the working group: Emelie Aurell, Kerstin Bly Joyce, Tomas Chicote, Sanna Due, Petter Larsson Garcia, Britta Hedlund, Jenny Hedman, Linda Linderholm, Larsolov Olsson, Anna Maria Sundin, Metta Wiese, Cecilia Ångström, Elisabeth Österwall, Elisabeth Öhman (acting project manager), and Kerstin Åstrand (project manager). Johanna Eriksson and Frida Åberg from the Agency for Marine and Water Management participated in the working group.

We would like to thank the people in different agencies, universities, research institutes, municipalities, interest groups and companies who have contributed to the work in different ways. We would like to express our special thanks to the Agency for Marine and Water Management for its good collaboration and to the Swedish Chemicals Agency, the Swedish Consumer Agency, the Swedish Transport Agency, the Swedish Energy Agency, the Swedish Transport Agency, the Swedish National Road and Transport Research Institute, and the National Agency for Public Procurement for their contribution to the work.

Stockholm, 1 June 2017

Björn Risinger, Director General

Innehåll

Summary

Introduction

In August 2015, the Swedish Environmental Protection Agency (EPA) was commissioned by the Government to identify major sources in Sweden for the emission of microplastics into the sea and to work to reduce emissions from these sources. The Swedish EPA presents its commission in this report. We present the results of the first comprehensive survey of the sources and dispersal of microplastics in Sweden, an assessment of which of the identified sources should be primarily addressed, and the steps to be taken to prevent emissions and reduce the releases of microplastics into the sea, lakes and streams from these sources.

The presence of microplastics in the marine environment has been increasingly recognised in recent years, not least at global level. Microplastic is a generic term for small plastic fragments measuring from 1 nm to 5 mm. The microplastics found in the oceans, but also in freshwater systems, have different origins. Microplastic can be unintentionally formed when plastic items deteriorate and plastic particles are emitted, or when we do not re-use, recycle or dispose of plastic materials properly so that the plastic becomes debris that is successively degraded down into smaller and smaller pieces in nature. There is also plastic that is originally fabricated as small pellets or beads.

The basis of this work has been the Swedish environmental quality objectives *A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos* and *A Non-toxic Environment*. Reduced releases of microplastics into seas, lakes and streams will contribute to achieving these objectives.

The commission was conducted by the Swedish EPA in cooperation with the Agency for Marine and Water Management other relevant authorities, and with the participation of relevant organisations and other stakeholders between August 2015 and May 2017. The conclusions are those of the Swedish EPA.

Results

Mapping of sources and dispersal pathways

IVL Swedish Environmental Research Institute has, on behalf of the Swedish EPA, mapped possible sources and dispersion routes for microplastics in Sweden. Focus has been placed on onshore sources. The survey gives a first, consolidated picture of the origin of microplastics and their transport to the sea. Knowledge of how microplastics disperse from source to sea, lakes and streams remains limited. Possible pathways are via air, rainwater and snow dumping, as well as through wastewater treatment plants and slurry spreading.

It has not been possible to calculate the proportion of microplastic transported to sea, lakes and streams for the majority of the mapped sources due to the lack of available data. The volumes that can be calculated are dispersion from sources where emissions occur directly to water, such as washing boat hulls, and the loss that occurs via wastewater treatment plants. The amount of microplastic that reaches Swedish coastal waters from various sources has thus not been estimated.

Major sources of microplastics in Sweden

In the light of the survey, the Swedish EPA has considered that the following sources should be addressed primarily in Sweden: Tyre and road wear, artificial grass pitches (AGPs), industrial production and handling of primary plastics, synthetic fibre laundry, boat hull paints and litter. In total, these sources account for the largest emissions of microplastics in Sweden.

Assessment of the possibilities for moving towards reduced emission of microplastics in Sweden

Today, there is not enough scientific knowledge to enable certain conclusions to be drawn about how microplastics from tyre and road wear, artificial grass pitches, industrial production and handling of primary plastics, textile laundry, boat hull paint and litter in Sweden are released to the seas, lakes and streams and what environmental impact they have there. We have therefore considered that the possibilities for preventing emissions and reducing the releases of microplastics are limited in the short term. At the same time, the presence of microplastics in the oceans – including in Swedish coastal waters and fresh waters – is a fact. In view of the precautionary principle, the Swedish EPA therefore calls for measures that can be implemented at reasonable costs and consequences for the stakeholders concerned, despite the uncertainties that exist.

In this respect, it is important to note that there are already instruments for reducing emissions of microplastics, albeit indirectly. Many of the behaviours that cause emissions and the releases of microplastics are the same as those that cause particulate emissions in general. For example, there are instruments aimed at reducing particulate emissions to air and water. Therefore, the synergies between possible measures to reduce microplastic emissions and ongoing or planned measures in other areas, such as clean air work and non-toxic everyday life, should be exploited.

Proposals for action

Knowledge building is central to the prevention of emissions of microplastics in the longer term and reduction of their releases, as is dialogue and information to raise awareness of the problems of microplastics. We have therefore drawn up proposals for measures aimed primarily at raising both knowledge and awareness of microplastics through research and development, guidance, dialogue and information. In parallel with national measures, work in the EU and internationally to reduce the releases of both macro- and microplastics to seas, lakes and streams continues.

KNOWLEDGE BUILDING

The knowledge gaps and methodological difficulties identified during the work on the commission constitute an important contribution to further work with microplastics in Sweden.

We propose, among other things, that VTI (the Swedish National Road and Transport Research Institute) be commissioned by the Government to develop knowledge of microplastic emissions from road traffic. Further examples of R&D measures include evaluation of highway stormwater purification techniques, a knowledge-based review of measures to reduce losses and leakage of granulate from artificial grass pitches, screening of microplastics and measuring of plastic particles in boat hull washes. In addition, the Swedish EPA will make an inventory of the need for knowledge of microparticles, including microparticles made from plastic.

PRE-PURCHASE PROCUREMENT GROUPS

A pre-purchase procurement group is a multiple year collaboration between the various procurement agencies aimed at improving the quality of procurement through joint knowledge-building and collaboration on requirements and procurement methods. We have found that pre-purchase procurement groups are an efficient way to gather and build knowledge and to create new solutions for the development of primarily artificial grass pitches, but also for the development of advanced treatment techniques for purification of wastewater treatment plants and stormwater. The Swedish EPA will initiate a pre-purchase procurement group to discuss reduced environmental impact from artificial grass pitches during 2017 and will investigate the possibilities of initiating additional pre-purchase procurement groups for, among other things, advanced wastewater treatment.

GUIDELINES

Guidance for supervisory agencies and companies has several objectives, such as creating the conditions for equally applied and effective supervision, clarifying rules and contributing to better self-inspection. The Swedish EPA will provide guidance for increased control of spill flows (untreated or incomplete treatment of water from sewerage systems or wastewater treatment plants), partly for the application of the legislation governing the use of rubber granules in artificial grass pitches, and partly for measures to minimise material losses during manufacture and processing of primary plastics.

INFORMATION

A number of information measures are proposed, notably in the field of textile laundry, such as providing information for consumers about the measures they can take to reduce the emission of microplastics from the use and laundry of synthetic fibres, and to reduce the amount of litter. The Swedish EPA is also planning to hold a workshop with the Swedish Chemicals Agency to consider microplastics that are caused by synthetic fibres.

PARTICIPATION IN THE EU AND INTERNATIONALLY

A number of initiatives are under way at EU and international level to prevent and manage the presence of microplastics in the oceans. Sweden needs to continue to participate in the relevant EU and international contexts, both to benefit from the knowledge presented there and to participate in, and influence, the development of measures that have bearing on both national and global environmental and sustainability targets.

Measures at EU level have been assessed as most relevant in the reduction of tyre wear and for microplastics produced by the use of textiles. Together with the Swedish Energy Agency, we propose that Sweden investigate the possibility of developing the EU’s energy label for tyres to include wear resistance and work to develop the ecodesign rules for washing machines. We also propose that the Swedish EPA, in connection with the revision of the reference document for textile manufacture under the EU Industrial Emissions Directive, works within the EU to produce data on the emission of microplastics from manufacturing processes in the textile industry.

Sweden should use the knowledge generated in international processes to increase its knowledge base and develop measures nationally. We can also contribute our own experience, for example, in building efficient waste management schemes, because insufficient waste management and onshore litter is the largest global source of marine refuse and microplastics in the oceans. The work of the HELCOM and OSPAR regional marine conventions is identified have been identified as important arenas for this commission.

Conclusions

This report has compiled existing knowledge of the origin of microplastics and transport to the sea, lakes and streams in Sweden. We demonstrate the steps that need to be taken to prevent emissions and reduce the release of microplastics from land-based sources to seas, lakes and streams. The knowledge compiled here forms a springboard from which to work. The proposed measures are a first step along the way and need to be developed and supplemented as our knowledge of microplastics increases.

Microplastics are an environmental problem that transcends societal sectors to which there is no simple solution. At the same time, there are many parallels with measures that aim at reducing emissions and discharges of undesirable substances in general. The Swedish EPA therefore believes that it is of great importance to take advantage of the synergies that exist. Further investigation will need to be made of potential target conflicts that may arise.

Work on this government commission has put microplastics on the agenda. A number of voluntary activities are already under way at various levels in Sweden with a view to both increasing knowledge about microplastics and how their emission is best prevented and reduced. To reduce the presence of microplastics in seas, lakes and streams, stakeholders at all levels of society need to contribute to knowledge building and measures to reduce their emission.

1. Introduction

The presence of microplastics in the marine environment has been increasingly recognised in recent years. Microplastic is a generic term for small plastic fragments measuring from 1 nm to 5 mm. The microplastics found in the oceans have different origins. Microplastic can be unintentionally formed when plastic items deteriorate and plastic particles are emitted, or when we do not re-use, recycle or dispose of plastic materials properly so that the plastic becomes debris that is successively broken down into smaller and smaller pieces in nature. There is also plastic that is originally fabricated as small pellets or beads. These pellets are used as raw material in the manufacture of plastic products. The beads are added to cosmetic and body-care products or used for abrasive blasting. These two forms of plastic can also be dispersed to the environment.

Microplastics are found globally, including in the North Sea and the Baltic Sea. There is growing concern that the problem of microplastic is not confined to the marine environment but is also a problem for freshwater systems and terrestrial environments. Microplastics have been found in the Swedish lakes Mälaren and Vättern. The risks associated with the prevalence of microplastic in the sea, but also in lakes and rivers, are many and complex. For example, intake and accumulation have been demonstrated in plankton, mussels, fish and birds.

Plastic is a very useful, durable and comparatively inexpensive material that is found everywhere in our daily lives: in health care, in packaging, in textiles, in building materials, in toys, in vehicles and so on. The durability itself causes plastic to break down very slowly. Degradation can take up to several hundred years, and is usually incomplete. Because plastic does not disappear in the environment and large amounts of plastic debris are added annually, among them microplastics, it is likely that the amount of microplastic in the sea will increase over time.[1]

The effects of marine litter on both the environment and the economy have been widely recognised at global level in the last decade and a vigorous mobilisation of the world's policy bodies is under way. In 2016, the UN declared microplastics to be an 'emerging issue of environmental concern' (UNEP 2016). In June 2017, the UN will organise a global ocean conference that will focus heavily on marine litter and microplastics. The UN and its agencies have adopted several resolutions, developed knowledge bases and created a global programme for marine litter. The regional marine conventions HELCOM and OSPAR have developed regional action plans for marine litter. In 2008, the EU adopted the Marine Strategy Framework Directive that uses marine litter as one of eleven descriptors for a good marine environment. The European Commission also intends to present a plastic strategy in 2017, within the framework of the EU's circular economy package. The strategy is likely to include measures to reduce marine littering. In May 2017, the Nordic environment ministers adopted a Nordic programme for plastics, which presents targets for reducing the

[1] The growing global demand for plastic poses major challenges for the sustainable use of resources and waste management. Last year, world production of plastic amounted to 322 million tonnes (Plastics Europe 2016). According to estimates, almost the same amount of plastic waste (275 million tonnes) is generated, of which 5–13 million tonnes annually end up in the world's seas (Jambeck et al. 2015).

amount of plastic waste and microplastic in the environment.[2] The Swedish Government has taken initiatives to reduce the amount of plastic that enters the sea and to manage the plastic that has already ended up there.[3]

The Swedish EPA presents the government commission in this report. The aim of the report is to increase knowledge about sources and the emission of microplastics in Sweden and about the steps that need to be taken to prevent and reduce the emission and release of microplastics into seas, lakes and streams, now and in the longer term.

1.1 The government assignment

The Swedish EPA was commissioned by the Government to "identify major sources in Sweden for the emission of plastic microparticles into the sea, work to reduce the generation and emission of microplastics from these sources and, if necessary, propose regulatory changes to reduce emissions" (Reg. no. M2015/2928/Ke). See Appendix 1.

The order issued by the Government includes the following:

- Identify and prioritise the sources and dispersal pathways in Sweden that need to be prioritised to reduce emissions.
- Work to reduce the generation and emission of microplastics from prioritised sources through national measures, such as amendments to regulations and guidance, stricter supervision, industry dialogue about voluntary measures and/or regulatory changes as necessary.
- Analysis of the advantages and disadvantages of international/EU instruments if national measures are not considered appropriate or possible.
- Follow and take into account developments in this field in the EU and internationally (EU, MS, OSPAR, HELCOM, NMR, UNEA and UNEP).
- Compile existing knowledge of the state of research into the best possible technologies in wastewater treatment systems and propose measures if necessary.
- Make knowledge generated within the assignment easily accessible to relevant institutions within and outside Sweden.

A report on the assignment is to be submit by 15 June 2017.

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[2] Annex 3 summarises ongoing international, regional and EU activities related to microplastics.

[3] See http://www.regeringen.se/artiklar/2017/02/plast-i-haven--ett-omfattande-miljoproblem/

1.2 Starting points and boundaries

1.2.1 Balanced Marine Environment, Flourishing Lakes and Streams and a Non-toxic Environment

A starting point for the work on the assignment has been the Maritime Environment Ordinance (2010:1341), which implements Sweden's commitment under the Marine Strategy Framework Directive.[4] The overall objective of the directive is to ensure that all EU marine areas have achieved good environmental status by 2020, in 11 thematic areas, known as descriptors. Descriptor 10 indicates the status of marine litter. The Member States develop their own more specific definition of good environmental status and adopt an action programme to achieve this. The Swedish action programme *Good Marine Environment 2020. Marine strategy for the North Sea and the Baltic Sea. Part 4: The action programme for the marine environment* has been developed by the Agency for Marine and Water Management and is aimed at agencies and municipalities. The starting point for the actions in the programme that focus on marine litter are as follows. Plastic is the most common litter in the oceans (60–90%). The action programme highlights the presence of both micro and macro-litter made up of plastic as a major problem for the environmental status of the North Sea and the Baltic Sea. The action programme includes both measures to combat the litter already present in the marine environment and measures to prevent the formation of marine litter, especially focussing on macro-litter.

Achieving good environmental status in accordance with the Marine Environment Ordinance (2010:1341) is part of the environmental quality objective *Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos*.[5] Reduction of microplastic emissions is part of ensuring a good environmental status for coastal and marine waters in terms of physical, chemical and biological conditions, as specified in the environmental quality objective.

The work of the government commission has been done in line with several of the environmental quality objectives. In addition to the objective of *Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos*, there are most obvious links to the objective of the environmental quality objective of *Flourishing Lakes and Streams* and the objective of a *Non-toxic Environment*. Microplastics are also found in freshwater systems. Reduced emissions of microplastics from land-based sources could help improve the ecological and chemical status of lakes and streams. Plastics also contain a range of chemical additives, some of which may be hazardous to the environment. Emissions of microplastics need to be reduced to achieve the objective

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[4] The Marine Strategy Framework Directive (2008/56/EC) is the environmental pillar in the EU's integrated maritime policy. Its aim is to achieve or maintain good environmental status in Europe's seas by 2020. The basic provisions of the Directive provide for good environmental status to be achieved through ecosystem-based management. The Directive makes a distinction between marine regions and sub-regions. Sweden falls under two of these: the North Sea sub-region and the Baltic Sea sub-region. The Maritime Strategy Framework Directive was incorporated into Swedish legislation in November 2010 through the Maritime Environment Ordinance (2010:1341).

[5] The national environmental quality objectives describe the strived for state of the environment and set the framework for Swedish environmental work. The 16 environmental quality objectives represent a comprehensive picture of policy objectives in the environmental field, while at the same time including the environmental requirements Sweden must comply with in the form of EU legislation and international agreements. Several of the marine-related environmental quality objectives include requirements laid out in the Marine Environment Ordinance and the Agency for Marine and Water Management regulations.

of levels of non-natural substances being close to zero and their impact on human health and ecosystems being negligible.

The work also has a bearing on the global sustainability targets and Agenda 2030. In particular, Objective 14 "Life below water" has an intermediate objective of significantly reducing the amount of marine litter from land-based sources by 2025.

1.2.2 OSPAR and HELCOM Action plans for marine litter

The regional marine environment conventions, HELCOM (Baltic Sea) and OSPAR (North-East Atlantic) marine litter action plans provide a framework for regional efforts to reduce litter and microplastics in the seas and guideline documents for contracting parties. The measures will be implemented partly through regional cooperation and partly through voluntary national measures to be implemented in each country, for example through the countries' action programmes under the EU's Marine Strategy Framework Directive. In addition to the measures aimed at plastic litter, there are several measures specifically targeting microplastics. Both action plans set out measures like mapping sources of microplastics, compiling and developing available technologies for purification of microplastics from wastewater and stormwater, and dialogue with relevant sectoral bodies to obtain voluntary commitments to reduce the use of microplastic beads in cosmetics. In addition, training and information are identified as important national initiatives. OSPAR also has a commitment to reduction of the emission of primary plastic pellets from industrial production. As regards to microplastics, Sweden has undertaken to make a particular contribute to regional work with wastewater and stormwater treatment techniques and the mapping of sources.

1.2.3 Delimitations and uncertainties

The Swedish EPA's commission is very broad in that possible sources of microplastics covers all plastic use in society. Microplastics can be generated in principle from all activities in society where plastic is present.

This assignment has been limited to land-based sources of microplastics. Microplastics already present in the sea and microplastics resulting from the fragmentation of plastic litter in the sea are only marginally touched upon.

Lack of waste management opportunities and land-based litter are the largest sources of marine litter and microplastics in the sea globally (GESAMP 2016). Not only are the ecosystems affected but also the billions of people who have the sea as a source of income and food. Two billion people worldwide do not have access to any form of organised waste management. Five countries in Asia account for more than half of all waste that reaches the seas, much of it due to poor or non-existent waste management opportunities and litter. At the same time, the amount of plastic used per person is nearly four times higher in Europe than in Asia. The global problems of litter play a central role in microplastics in the sea. However, this assignment is limited to Sweden's contribution to the presence of microplastic in the sea.

The presence of microplastic in the sea is the main starting point for the Government's commission. In dialogue with the Ministry of Environment and Energy, the Swedish EPA has broadened the assignment's examination to include the presence of microplastic in lakes and streams.

A significant difficulty in this work has been both the lack and the quality of data. Estimates about emissions from various sources in Sweden are generally quite rough.

We know even less about how much of these microplastic emissions actually reach the sea and the impact of emissions from a specific source on the environment.

Despite these shortcomings, the knowledge gathered in the framework of this government commission provides an initial, comprehensive picture of the origin and transport of Swedish microplastics to the sea. The knowledge gaps and methodological challenges identified in the study constitute an important contribution for further work with microplastics in Sweden.

Overall impact assessments have been made on the proposed measures where possible.

1.2.4 The precautionary principle

The uncertainties in the databases have posed challenges in assessing the possible and appropriate actions needed to reduce the emission of microplastics into the sea. We have chosen to base our approach on the precautionary principle, which is one of the general precautionary regulations if the Swedish Environmental Code, and the proportionality principle in Chapter 2 of the Environmental Code. The precautionary principle and the proportionality principle mean that preventive measures should be taken as soon as there are grounds to believe that a measure or activity may cause damage to the environment, as long as it is feasible to comply with the preventive measures.

1.3 Completion of the assignment

The commission was conducted by the Swedish EPA in cooperation with relevant authorities, and with the participation of relevant organisations and other stakeholders between August 2015 and May 2017.

The Swedish EPA formed a project working group (consisting of employees with relevant expertise, legal competence and socio-economic analysis skills) and a steering group. The project steering group consisted of managers of the units and sections that participated in the project team. The Agency for Marine and Water Management has been represented in both the working and steering groups.

1.3.1 Methodology

The project was conducted in three, partially parallel stages. Stage 1 mapped the sources and pathways of microplastics in Sweden. This was done at IVL Swedish Environmental Research Institute on behalf of the Swedish EPA. Additionally, Örebro University conducted a review of the state of knowledge on the exposure and effects of microplastics on marine wildlife on behalf of the Swedish EPA.

In stage 2, the Swedish EPA, in consultation with relevant authorities and other stakeholders, assessed the results of the IVL Swedish Environmental Research Institute survey. The purpose of the assessment was to identify major sources of microplastic in Sweden.

In stage 3, we analysed the potential for and suitability of actions to deal with microplastic emissions on a national basis.

To assess national governance, we conducted conceptual analyses. "Conceptual analysis" in this context means an extended analysis of problems to: (i) clarify the problem and its causes, the behaviours, choices and decisions that are behind the problem, (ii) identify drivers for these environmentally damaging behaviours and (iii) analyse different ways of governance.

Furthermore, we assessed the advantages and disadvantages of measures to reduce microplastic emissions at international and European level. We assessed whether reducing emissions from the selection of sources is controlled more effectively internationally or in the EU than nationally, or whether the issue should be pursued at both national and international/EU level.

In all, we conducted three analyses to identify important sources and dispersal pathways that should be addressed in Sweden.

1.3.2 Supporting documentation

The commission covers a large and complex area. The studies conducted within the framework of the commission were based on existing material, primarily existing published data. In other words, no empirical studies were conducted. It has not been possible to collect primary data, such as the measurement of microplastic quantities from various sources and pathways of microplastics.

Three studies were developed within the framework of the work on the commission. Other written sources have also been used and are presented in the reference list. Published data has not always been available. In those cases, data were collected through personal contacts. These are listed in the reference list.

The following reports were prepared and are published on the Swedish EPA's website:

- Kärrman, A., Schönlau, C. and Engwall, M. (2016). *Exposure and Effects of Microplastics on Wildlife – A review of existing data*. Örebro: Örebro University
- Magnusson, K., Eliasson, K., Fråne, A., Haikonen, K., Hultén, J., Olshammar, M., Stadmark, J. and Voisin, A. (2016). *Swedish sources and pathways for microplastics to the marine environment*. Stockholm: IVL Swedish Environmental Research Institute, report C 183. Revised March 2017.
- Baresel, C., Magnér, J., Magnusson, K., Olshammar, M. (2017). *Tekniskalösningar för avancerad rening av avloppsvatten* [Technological solutions for advanced wastewater treatment]. IVL Swedish Environmental Research Institute, report C 235. On assignment from the Swedish EPA.

1.3.3 Dialogue and consultation

The following agencies have participated in various parts of the work on the commission: The Swedish Agency for Marine and Water Management, the Swedish Chemicals Agency, the Swedish National Agency for Public Procurement, the Swedish Transport Agency, the Swedish Energy Agency, the National Board of Housing, Building and Planning, the Swedish Consumer Agency, VTI (the Swedish National Road and Transport Research Institute) and the Swedish Transport Agency.

Representatives of academia, municipalities, county councils, trade organisations (such as the water and wastewater industry, the waste industry, the textile industry, the chemical and tyre industries) and other organisations (such as the Swedish Football Association and the Keep Sweden Tidy Foundation) have also contributed with expertise and input.

A reference group was appointed that included the following authorities and organisations for assessing which of the sources identified by IVL Swedish Environmental Research Institute (from here on referred to as IVL), can be described as "more important" in this context: The Swedish Agency for Marine and Water Management, the Swedish Chemicals Agency, the Swedish Medical Products Agency, the Swedish National Board of Housing, Building and Planning, the Swedish Transport Agency, University of Gothenburg, Stockholm University, Örebro University, KTH Royal Institute of Technology, SP Technical Research Institute of Sweden and IVL Swedish Environmental Research Institute.

Three workshops and seminars were held as part of the assignment. In November 2015, the Swedish EPA held a workshop on possible sources and dispersal pathways. The results of the workshop have provided IVL with the selection of sources and dispersal pathways for mapping emissions of microplastics. Approximately 65 representatives from relevant agencies, county councils, trade organisations, other stakeholder organisations (environmental organisations), universities, university colleges and research institutes participated and contributed with their knowledge and opinions.

In March 2016, a seminar was held on the results of Örebro University's review of the state of knowledge on the exposure and effects of microplastics on marine wildlife and on IVL's survey. There were approximately 60 participants at the seminar, including representatives of relevant agencies, county councils, trade organisations, other stakeholder organisations (including environmental organisations), universities, university colleges and research institutes.

In April 2017, a final seminar presented the preliminary overall results. Approximately 65 representatives of relevant agencies, county councils, trade organisations, other stakeholder organisations (including environmental organisations), universities, university colleges and research institutes participated in the seminar.

1.4 Further reading

The next chapter introduces the microplastic problem. Chapter three presents the results from the mapping of sources and pathways of microplastics in Sweden, conducted by IVL. We explain our assessment of which of the mapped sources and pathways could be regarded as important in Sweden. On the basis of this selection, we describe these sources and pathways in more detail in Chapters 4–9. Chapters 4 to 9 also include assessments of the potential for reducing the emissions of microplastics from each source and proposals for measures. In Chapter 10 we focus more closely on three dispersal pathways for microplastics. We conclude in Chapter 11 by summarising all the proposals for measures.

2. Microplastic - definition and description of the problem

2.1 What is microplastic?

As yet, there is no generally accepted definition of "microplastic" in the research literature, but it generally refers to small pieces of different types of plastic (GESAMP, 2016; European Commission, 2013). The definition of microplastic is a subject that is widely discussed, both in scientific and policy contexts. Questions about size, types of plastic and the origin of raw materials are among the subjects for discussion.

In this government commission, we have chosen to use a broad definition of "plastic": The term includes man-made polymers made from either oil or by-products from oil, or from biomaterials (bio-based plastics). Non-synthetic polymers, such as natural rubber and polymer modified bitumen, are also included. There is an ISO standard that defines plastic. The standard does allow rubber to be defined as plastic, for example. According to Verschoor (2015), the fact that rubber is often included in the definition of microplastics is because the material can produce solid particles with a high polymer content. We have also chosen to include latex and bio-based plastics since they have similar properties from an environmental point of view to plastic microparticles. Furthermore, this broad definition of 'plastic' in the microplastic context is the usual use of the term internationally.

Plastic particles between 1 nm and 5 mm are regarded here as being microplastic. Industrially manufactured plastic pellets are included as a group even if they are sometimes slightly larger than 5 mm. The upper limit of 5 mm is common[6]. However, the lower limit varies. For example, the UN Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) has set a lower limit of 1 nm, although such small particles cannot be detected in the environment except in exceptional cases (GESAMP, 2015), as it is difficult to measure these particles today. On the other hand, OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) has not set a lower limit in its Regional Action Plan for Marine Litter, which includes microplastics, but rather defines microplastics as being less than 5 mm in size (European Commission 2013; OSPAR 2014). Regardless of the limit used, a wide spectrum of small particles is included in the different definitions. The width reflects both the lack of an unambiguous, agreed definition and the practical difficulties involved in collecting and measuring particles. Many studies of microplastic presence in the sea were conducted with plankton nets that neither capture the smallest particles nor sieve out different sizes.

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[6] The upper limit of 5 mm is said to be derived from a NOAA (National Oceanic and Atmospheric Administration) workshop in 2008, at which the researchers chose a definition that would make it possible to distinguish other types of effects on biota than effects of large plastic litter that had been in focus until then (GESAMP 2015; Verschoor 2015).

When we refer to "microplastic particles" or "microparticles made of plastic" in this commission, "particle" refers to solid particles, regardless of their form, such as beads, flakes and fibres.

Microplastics are often divided into two groups, primary and secondary microplastic. Primary microplastic is intentionally produced plastic pellets, such as the plastic pellets produced as raw material in the plastic industry. Primary microplastic is also used as scrubber material in various products, as an ingredient in cosmetics and in other products.

Secondary microplastic is formed when plastic objects fragment into microscopic particles, for example from plastic litter and during the use of different plastic and plastic-like products. Plastic debris breaks down and fragments in the environment from exposure to sunlight and other external forces. Microplastics are also generated by, for example, car tyre wear and leakage from artificial grass pitches.

2.2 The presence of microplastics in seas, lakes and streams

The research report *Exposure and Effects of Microplastics on Wildlife* was compiled by the Örebro University on behalf of the Swedish EPA. The report provides an overview of current state of knowledge about exposure and effects of microplastics on animal life. The following sections are based on this study unless otherwise noted.

Plastic particles can be transported long distances by wind and water currents. Studies show a global dispersion of microplastics in the oceans from densely populated areas to remote areas of the Arctic and Antarctic, see Figure 1. Estimates of the amount of floating macro- and microplastics in the oceans vary widely, from 14,400 tonnes to 268,940 tonnes. The broad range reflects the uncertainties and gaps in knowledge about presence and distribution in the environment. Different methods are used to collect microplastics in the sea, both in surface water and in sediments, and there has been no standard for how and where to sample. This means that it is difficult to compare measurement results and to get a correct overall picture of the presence of microplastics in the sea (Kärrman et al. 2016; Magnusson et al. 2016).

Microplastics have been found in surface water, sediment and freshwater systems, see Figure 1. Sediment is considered the most significant sink for microplastics. Up to 2,000 particles/m^2 have been reported from deep-water sediment. Microplastics are often a problem that is being discussed in connection with marine environment and marine litter. Researchers have also recently begun to take an interest in freshwater systems. For example, microplastics have been found in both the Mälaren and Vättern rivers. In other words, microplastics may be an even more complex environmental problem than was previously feared (Kärrman et al. 2016).

The release of microplastics in the marine environment depends on the density of the particles, the location of the sources, waves and ocean currents and biological processes. Accumulation zones for the particles have been identified (ibid.).

The complete degradation of plastic polymers in natural environments can take centuries. Degradation in the environment depends, for example, on the type of plastic, temperature and exposure to sunlight. The large amount of plastic litter in the sea and the long degradation time mean that the accumulation of microplastic in the marine environment will increase, even if all emissions were to cease now (ibid.).

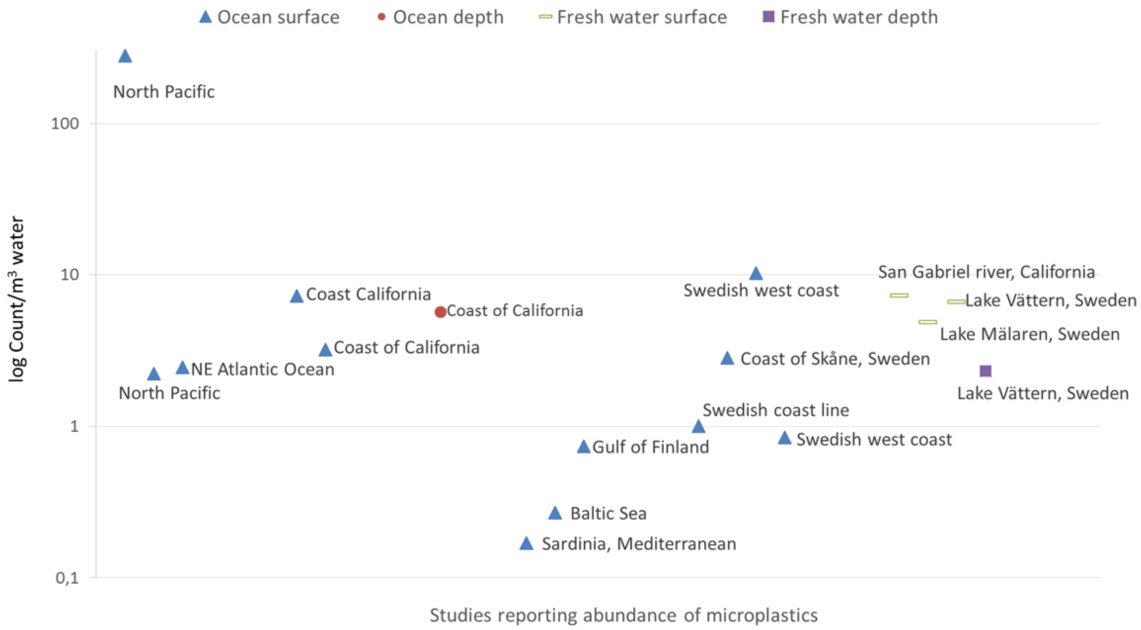

Figure 1. The presence of microplastics in the sea and fresh water is ≥300 µm (number of particles/m³ water, logarithmic scale). Source: Kärrman et al. 2016.

The international studies of macro- and microplastics in water from lakes and oceans show that polypropylene (PP), polyethylene (PE) and polystyrene (PS) are the most commonly found polymer types (Kärrman et al. 2016). This is due both to their common use in packaging materials but also to their density, which keeps them floating in the water column. As different types of plastic have very different characteristics, the composition of polymers may differ depending on how and where samples are taken and the type of sample examined. Heavier particles will settle more quickly and will probably be found in the sediment near the source, while lighter particles will be found in the water column where they can be transported long distances, depending on ocean currents and other factors. The accumulation, chemical change or degradation of a polymer can cause its physical/chemical properties to change over time, which can cause a floating microplastic particle to eventually sink to the bottom (Magnusson et al. 2016).

2.3 Effects of microplastics on animal life

There are many possible risks posed by plastic, which contributes to the complexity of the problem. Animals can experience physical stress when they become tangled in, or eat, macro- and microplastics. The latter can cause suffocation, infections or even starvation. Microplastics can be easily ingested by many organisms and thereby transferred between trophic levels. Ingestion and accumulation of macro- and microplastics has been demonstrated for a wide range of filter organisms, invertebrates, fish, mammals and birds. Plastic litter in the sea can also transport alien species into new environments and act as a hard transport ground for organisms.

Nanoparticles have been shown to be ingested from the gastrointestinal tract. Effects from the ingestion of plastic have been observed for phyto- and zooplankton, mussels, marine worms, crustaceans, fish and birds. Biological effects can also be caused by additive chemicals, which are used to give certain properties to the plastics, leaching out and being ingested. In the same way, monomers and by-products that remain in the plastic from the manufacturing process can leak out. In addition, chemicals from the surrounding environment, such as persistent organic pollutants that often have high affinity with plastics, can also be adsorbed by the particle surface.

In a study from the Pacific Ocean, six times higher levels of microplastics compared to plankton have been measured (Moore et al. 2001). The high proportion of plastic fragments in relation to animal plankton could affect the energy balance of animals living on plankton, but this is probably only one of the ecological problems of microplastics. Unfortunately, we do not currently have a link between dosage and response, and at which concentrations adverse effects occur. Scientific literature also contains few publications on ecological consequences and effects at population level. Other areas where there are gaps in knowledge include, for example, the presence and loss of synthetic fibres, the formation process of nanoparticles and the presence and effects of microplastics in the land environment. However, there is a great deal of research going on in this area, so knowledge of both the occurrence and impact of microplastics will increase significantly in the coming years.

3. Sources of microplastic in Sweden

In the Government commission, the Swedish EPA has been tasked with "identifying major sources of emissions of plastic microparticles into the sea in Sweden, and working to reduce the formation and emission of microplastics from these sources". In a first step in this work, the Swedish EPA commissioned IVL to map possible sources and dispersal pathways for microplastics in Sweden. The survey *Swedish sources and pathways for microplastics to the marine environment – a review of existing data* has formed a central basis for work on the government commission. This chapter will provide a brief description of the results of the survey, our assessment of the results and state which of the sources in the survey can be described as more important in this context.

3.1 Sources and dispersal of microplastics – results from IVL's survey

Microplastics can, in principle, be generated by all human activities where plastic is present. A study of all possible sources of microplastics has therefore not been possible. The selection made by IVL is based on the results of a workshop held by the Swedish EPA in November 2015 on possible sources and dispersal of microplastics in Sweden, which was attended by a large number of stakeholders from different sectors of society. The results of IVL's survey are summarised in table form in Annex 2. All the data in this section comes from this survey.

The survey is not a total study, but gives a first, consolidated picture of the origin of Swedish microplastics and their transport to the sea. It also points out gaps in knowledge and methodological difficulties, which is an important contribution to further work on microplastics in Sweden.

3.1.1 Sources of microplastic

IVL has surveyed both intentionally produced microplastics and microplastics generated through onshore and offshore activities. The largest microplastic emissions in Sweden – that are possible to calculate – come from onshore sources. The single biggest source is wear of vehicle tyres. Approximately 8,190 tonnes of microplastics per year are estimated to originate in road traffic, of which about 7,670 tonnes are due to tyre wear. Emissions from artificial grass pitches and from washing of synthetic textiles are estimated to be 1,640–2,460 tonnes and 800–950 tonnes per year, respectively. Losses related to painting buildings are estimated at 130–250 tonnes per year.

The survey also includes emissions of microplastics arising from activities at sea. Of these, boat hull paint is the largest source, with emissions of 160–740 tonnes of microplastics per year. The amount of microplastic created by degradation of plastic litter has not been calculated. However, IVL makes the assessment that litter is a significant source.

Of intentionally produced microplastics, emissions from industrial production and handling of primary plastics account for the largest volumes, 310 to 530 tonnes per year. Microplastic added to hygiene products accounts for a small proportion, 66 tonnes per year.

Calculation of microplastic emission has been based on existing data to the extent that such data have been available. It should be noted that the calculations are theoretical. Collection of new primary data, such as the measurement of microplastic volumes at source and in the dispersal pathways, has not been possible within the scope of this government commission. All in all, this means that the emission calculations are approximate. For some sources, a range of maximum and minimum calculated values is specified depending on the available data. For several sources, there is so little data that it is not possible to quantify the volumes involved, for example, in the case of litter and agriculture. The difficulties in calculating emissions of microplastics have led IVL to revise the survey. The figures above and in Annex 2 come from the revised version, dated March 2017.

3.1.2 Dispersal pathways

Knowledge of how microplastics disperse from different sources to sea, lakes and streams remains limited. Factors, such as particle size, density and source location, are likely to affect transport. IVL has identified stormwater, effluent from wastewater treatment plants, sludge from wastewater treatment plants, snow dumping and atmospheric deposition as possible dispersal pathways in Sweden.

It has not been possible to estimate the proportion of microplastic transported to sea, lakes and streams for most of the surveyed sources due to the lack of available data. The volumes that can be calculated are dispersion from offshore sources where releases occur directly to water, such as wear and washing of boat hulls, and the leakage that occurs via wastewater treatment plants. For these sources, the amount of microplastic estimated to reach the sea has been assumed to be the same amount discharged from the source in question (Magnusson et al. 2016).

In summary, it is possible to demonstrate that microplastics can be found in Swedish coastal waters and lakes, (Kärrman et al. 2016; Magnusson et al. 2016). It has not been possible to estimate the total amount of microplastic derived from the various Swedish sources. Knowledge of the actual concentrations of microplastics in Swedish waters or, for that matter, in the oceans, is still limited. Many research projects are ongoing both in Sweden and internationally.

3.2 The Swedish EPA's assessment of major sources

In the second phase of identifying and prioritising which sources and dispersal pathways should be addressed primarily to reduce the release of microplastics to the sea, the Swedish EPA has assessed the results of IVL's survey. The purpose of the assessment was to identify major sources of microplastic in Sweden.

3.2.1 Assessment criteria

The Swedish EPA has entered into a dialogue with a reference group consisting of researchers and other experts that has defined major sources as the sources that are most harmful to the environment. However, it transpired that it was very difficult to assess the harmfulness due to the uncertainty of the data we have had to base the assessment on. The assessment has instead been based on a balance between the size of the emissions, the risk of local emissions and the likelihood that emission of microplastics from the source reaches seas, lakes and streams. See the assessment criteria in the fact box below.

The criteria for assessment of major sources:

- **The severity of harm from the source**, with regard to its impact on the environment and health, depending on:
  - type of particle (e.g. flake, grain or fibre)
  - particle size
  - plastic type
  - presence of hazardous substances (additives)
  - Ability to adsorb and transport environmental toxins
- **Documented (measured) presence** of microplastic from source in the sea (and lakes)
- **The probability** that the emission of microplastics from the source reaches seas, lakes and streams.
- **Quantity** (volume)
  - The total national emission per year from each source. A qualitative assessment is made when a quantitative estimate is not possible.
- **Source causing large local emission** of microplastic (may cause problems locally).

Due to the uncertainties in the survey, these considerations have not been possible for all sources, and it has not been possible to assess several sources at all. A significant difficulty has been that the data have changed and been added during the course of the work, which has meant that we have revised the assessments several times. In other words, there are also significant uncertainties in the assessments made here. As knowledge of microplastic emissions from various sources develops, the assessment of major sources should also be revised. A source that has not been considered to be important in this report may well prove to be so in the future.

3.2.2 Identified major sources

This section presents the results of the assessment of major sources, based on IVL's survey of sources and dispersal pathways. The box below summarises the sources that were judged to be more important without being in any internal order.

Important sources of microplastic emissions in Sweden:

- Industrial production and handling of primary plastics
- Roads and tyres
- Artificial grass pitches
- Textile laundry
- Boat hull paint
- Littering

INDUSTRIAL PRODUCTION AND HANDLING OF PRIMARY PLASTICS

Of the intentionally manufactured microplastics, material losses from industries producing plastic or plastic products have been identified as one of the major sources of microplastic emission in Sweden. Plastic raw materials, in the form of plastic pellets, are used in the manufacture of plastic products. Material losses of plastic pellets can occur as local emissions to water and air, both from industrial plants producing pellets or plants using pellets as raw materials. Material losses can also occur as diffuse emissions when transporting plastic pellets between these plants.

IVL estimates the total annual material losses of plastic pellets in Sweden at 310–533 tonnes. Although the actual total annual losses of plastic pellets from these plants are unknown, as is the amount of material losses that end up in seas, lakes and streams, this source has been considered to be important. The reasons for this are that the estimated emissions are relatively high, that there is a risk of local emissions and that several of the large industrial plants are located close to the sea.

ROAD AND TYRE WEAR

According to IVL's survey, road and vehicle tyre wear is the largest source of microplastic emissions in Sweden, 8,190 tonnes of microplastics per year It is not known how much of the emissions reach seas, lakes and streams. We have estimated that at least part of the microplastic particles from road traffic are likely to reach streams, lakes and seas, primarily via water drainage. Tyre particles can also contain hazardous substances that should not be released to the environment. All in all, it has been difficult to assess to what extent this source should be judged as important or not. Because the estimated emissions from road traffic are almost as high as all the other emissions combined and because of the probability that part of emissions from road traffic can reach seas, lakes and streams, road traffic is identified as an important source, despite the uncertainties.

LOSSES FROM ARTIFICIAL GRASS PITCHES

According to the survey, artificial grass pitches are the second largest source of microplastic emissions. There are currently about 1,200–1,300 artificial grass pitches in Sweden and about 100 new artificial grass pitches are being built annually (Wallberg et al. 2016; Magnusson et al. 2016). To ensure that the surface of an artificial pitch has the desired properties, the pitch is filled with large quantities of rubber granulate. Regular use and care of the pitch will lead to the loss of granules from the pitch and they need to be replaced. For example, granules are lost during snow clearance, by rain and on the players' shoes and clothing. There are several uncertainties regarding artificial grass pitches as a source of microplastic in the sea. There are no reliable figures on the extent of the granulate loss and on the extent of the loss that is released through various dispersal pathways to sea, lakes and streams. The Swedish EPA notes that large quantities of granulate is lost from artificial grass pitches every year and that some of these losses are released to the environment. For this reason, artificial grass pitches should be considered as an important source.

LOSS DURING LAUNDERING

Microplastics are leached when textiles are laundered. Synthetic fibre textiles experience wear when laundered, creating microplastics that, during laundry, are conducted with the wastewater from both households and from professional laundries. Emissions were initially estimated at 176–1,995 tonnes per year in the IVL survey. The estimates of emissions have subsequently been adjusted downwards by IVL to 800–950 tonnes per year Microplastics from this source are transported by wastewater to treatment plants. Most of the larger particles are filtered out in the treatment plants. IVL estimates that emissions of microplastics into seas, lakes and streams that originate from laundering textiles that are disseminated by wastewater treatment plants are estimated at 0.2–19 tonnes per year. The remaining quantities end up in sludge. As laundering textiles is the largest upstream source of microplastics to wastewater treatment plants, it is considered to be an important source. Several international summaries and national studies in other European countries have identified synthetic textile fibres as one of the largest sources of microplastic in the seas, affecting the priority given to textile laundry as a source of microplastics.

BOAT HULL PAINT

Some boat hull paints contain polymers as a binder. It is assumed that some of these polymers form microplastic particles when the paintwork of the boat wears gradually away or when the boat is washed, scraped or rubbed down during maintenance. These microplastic particles are most likely to end up in the water. Release of microplastics from boat hull paints was originally identified as one of the larger sources of microplastic emissions in Sweden (Magnusson et al. 2016). IVL estimated the emission of microplastics from boat hull paint to be 484–1,364 tonnes of microplastics per year. The estimates for these emissions were later revised to 160–740 tonnes of microplastics per year. Although boat hull paint is likely to account for a relatively small proportion of total microplastic emission in Sweden, the Swedish Agency for Marine and Water Management and the Swedish EPA have considered that there are still reasons to work on the reduction of these emissions. This is both because there is a risk of microplastics accumulating at boat maintenance sites and because the paint flakes and plastic particles from the hull and maintenance tools are released directly into the sea. In addition, boat hull paints often contain toxic substances that are, in themselves, a reason to reduce emissions.

LITTERING

It has not been possible to calculate the amount of microplastic that is caused by litter, as large plastic objects are fragmented, but IVL believes that litter is likely to be a significant source in Sweden. Globally, due to lack of waste management schemes, plastic litter is considered the largest source of microplastic in the sea (GESAMP 2016). In northern Europe and North America, studies suggest that on-shore sources (excluding litter) are larger or roughly equal to the sources of microplastics as litter. This can be explained by the comparatively better waste management systems in these regions (Boucher and Friot 2017). However, both Norway and Denmark have concluded that microplastic input to the sea is mainly also due to fragmentation of plastic litter in these countries (Sundt et al. 2014; Lassen et al. 2015).

Although the size of the emissions in Sweden is not known, it is highly likely that some of the plastic disposed of in the environment will end up in seas, lakes and streams where the debris is gradually degraded into microplastics. The risk is obviously greatest when litter is left on beaches or in other environments in the vicinity of sea, lakes and streams, although plastic litter can also be brought there via rainwater and streams. Plastic litter may also be fragmented on land and then be subsequently dispersed through air or water pathways to streams and lakes, and then on to the sea. Taking everything into account, we have assessed litter as an important source of microplastic in the sea.

3.2.3 Microplastics from other potentially important sources

IVL has also surveyed other sources of microplastics, such as waste management, the generation of microplastics from construction and maintenance and from agriculture. Of these, only emissions from rot and paintwork in buildings were quantified. The assumptions on which the emission calculations are based are considered to be very uncertain. We do not have data on the emissions of microplastics from agricultural plastic. The lack of data combined with uncertainties has meant that we were unable to assess these sources. Hygiene products are also a source of microplastic that has been surveyed. The government is already pushing the issue of measures to prevent microplastics from being released to seas, lakes and streams from hygiene products, so we will not address it for further evaluation in this report.

Below follows a brief description of what is being done about hygiene products and about waste management as a source of microplastic.

HYGIENE PRODUCTS

Microbeads made from plastic that are used as an abrasive material in various hygiene products and as an additive in cosmetics, are another source that IVL has identified. Microplastic emissions from hygiene products have been recognised both internationally and in Sweden, with bans, proposals for bans and voluntary commitments in the industry after much attention from consumers. For example, UNEA's resolution (2/11) called for the phasing-out of microbeads. Cosmetics and hygiene companies have pointed out that the industry reported an 82% reduction in microplastic beads from 2012 to 2015 as a result of voluntary commitments (Jansson 2017). Sweden has pushed the issue of a ban, both in the EU and internationally, and has, among other things, initiated a proposal for a joint commitment by the countries of HELCOM and OSPAR to ban microplastics in cosmetics. The Swedish Chemicals Agency has proposed, on behalf of the Government, a ban on the use of plastic particles in cosmetic products that are washed off, such as shower creams and toothpaste, to remove plastic from products where it is unnecessary. The Government Offices have referred a somewhat revised proposal for a national ban for consultation. The Government has also commissioned the Swedish Chemicals Agency to investigate whether plastic particles should be banned in additional products.[7]

As preventive measures to prevent the emission of microplastics are being developed in the context of other assignments, we have not considered hygiene products as a source here. However, according to IVL's survey, hygiene products are a less significant source in Sweden, in terms of the number of tonnes of microplastics per year[8]. The microplastics from hygiene products that are transported to wastewater treatment plants and sludge are highlighted in Chapter 10 on dispersal pathways.

MICROPLASTICS FROM WASTE MANAGEMENT

Releases from processes for waste management and recycling of plastic have been identified in IVL's survey as one of the sources of microplastic emissions in Sweden. However, data for assessment of these sources is lacking. Even so, we will discuss waste management and recycling here. This is because waste management, or the lack of such management, is a significant cause of the presence of both macro and micro-litter in all seas around the world.

Facilities that could potentially be important sources in Sweden include, for example, landfill leachate and recycling facilities that fragment plastic. Relatively small volumes of microplastic are considered to be emitted via digestate that is spread on agricultural land (Magnusson et al. 2016).

Landfills

Leachate from landfill sites can be a source of microplastics. In addition, handling of plastic waste can lead to plastic littering both inside and outside the landfill area. However, there is no data on the quantities involved (Magnusson et al. 2016).

In 2012, the volume of leachate from Swedish landfills amounted to 14 million cubic metres, which was processed to different degrees (Swedish EPA 2014).

Since 2002, sending of combustible waste to landfill has been prohibited and in 2005 the ban was extended to cover all organic waste. The landfill tax and the ban on landfill have resulted in a reduction in combustible and organic waste in landfills. However, large quantities of plastic were deposited before the bans were introduced. The amount of waste in municipal landfills has been estimated at around 30 million tonnes, of which approximately 8 per cent is plastic, corresponding to 2,400,000 tonnes of plastic. However, organic waste is still being disposed of under licence or through exemptions from the landfill bans. Significant amounts of so-called

[7] Read more about the Government's initiatives at http://www.regeringen.se/pressmeddelanden/2016/12/regeringen-vill-minska-plast-i-haven/

[8] Representatives of the cosmetics and hygiene companies have pointed out that the figure is probably excessive.

fluff from fragmentation are also still being deposited. The fluff is largely made of plastic. This plastic originates from plastic in cars and electrical equipment that has not been dismantled before fragmentation.

Further studies are needed to find out whether emissions of microplastics from landfills are important and what measures would be most appropriate. The Nordic Council of Ministers' Waste Group is funding a project that investigates the emission of microplastics from landfills in the Nordic countries.

Fragmentation of plastics for recycling

Plastic is fragmented for recycling at some 30 licensed plants in Sweden.[9] There are no data on microplastic emissions from this type of facility. However, they are considered to be interesting because plastics are processed and refined through fragmentation at these plants. When plastic is fragmented, it is finely divided into smaller pieces of plastic that can be of different size and shape. Understandably, fragmentation can also lead to very small plastic particles, which can potentially be dispersed by water and air from the fragmentation plants.

The Swedish EPA has conducted a review of the licences for some 30 Swedish plants that have permits for mechanical processing of plastics (so-called B plants). The purpose of the review was to examine whether provisions exist that govern the emission of microplastics from these plants. The review shows that there are no specific provisions regarding emission of microplastics, but that several provisions may still have bearing on these emissions as well. For example, there are provisions that say that the working area should be kept clean and that there should be routines for regular cleaning of the property and surrounding area. Operations must be conducted in such a way as to prevent littering and generation of dust and so that the ground is not contaminated. Other requirements are that plastic fractions should be processed and temporarily stored on a hard surface and that rainwater should be collected.

There is no information about the size of the volumes of microplastics that could be dispersed from fragmentation plants. Volumes are probably relatively small compared to the production and handling of plastic pellets, for example. In spite of this, the Swedish EPA considers that the issue of the emission of microplastics could be addressed through testing and supervision of plants authorised for mechanical processing of plastics. For example, a first step could be to monitor whether current conditions and precautions can be expected to limit the loss of microplastics from the plants. The Swedish EPA intends to provide guidance to companies and agencies on how emissions of microplastics can be limited from facilities manufacturing plastic. Such guidance may also include fragmentation facilities, see section 6.4.1.

Anaerobic digestion

Digestate from food waste may contain plastic. This plastic is mainly made up of soft plastic from packaging. If plastic bags are used for collection of the food waste, for example in optical sorting, they also become a source of plastic in the digestate.[10]

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[9] The plastic that is fragmented comes from, for example, packaging waste, operating waste, construction and demolition waste, electrical waste and cars.

[10] Catering waste can be collected in different ways. Plastic bags are used for collection in some local authorities, while others use paper bags. Plastic bags can facilitate collection, for example, in the municipalities that use optical sorting to separate the different fractions of household waste.

The plastic that comes with the food waste into the facility is largely separated in pre-processing, but some will accompany the waste into the digestion chamber. The plastic does not decompose during the digestion stage but remains in the digestate. Almost all digestate produced is used in agriculture to fertilise agricultural land. IVL's survey estimates that there are relatively small amounts of microplastic that are dispersed via digestate. We have not considered digestate as an important source of microplastic in the sea today. There is, however, a need for more knowledge regarding the loss of microplastic by means of digestate.

3.2.4 Dispersal pathways

As far as dispersal pathways are concerned, we have chosen to proceed with a survey of the dispersal pathways that we know something about and that may be a transport route for several different sources of microplastic. We have therefore chosen to highlight wastewater treatment plants, sludge and stormwater. Textile laundry and hygiene products containing plastic beads are examples of upstream sources of microplastics that are passed on to wastewater treatment plants. This also applies to indoor dust and pharmaceuticals. However, these latter are considered by IVL to be less significant.

A large proportion of the microplastics that accompany the wastewater are separated in the treatment plants and do not end up in the sea, but in the sludge. Sludge is used or handled in different ways. Our current very limited knowledge about microplastics in sludge is presented in connection with the survey of wastewater treatment plants. We highlight snow dumping as a possible pathway for microplastics in Chapter 4 under the generation of microplastics from road traffic.

The following chapters present the sources of emissions of microplastics assessed as important.

4. Microplastic emissions from tyre wear

4.1 Loss of microplastic from road and tyre wear

Road traffic is the largest source of microplastic emissions in Sweden, according to IVL's survey of microplastic sources. Losses are primarily due to wear of vehicle tyres. IVL has estimated that 7,674 tonnes of microplastic per year is due to tyre wear. Microplastic emissions are also caused by wear of road surfaces and road markings (Magnusson et al. 2016).

The loss of microplastics from tyre and road wear in Sweden were calculated on the basis of the existing traffic management data (km per year), emission data for tyres, asphalt wear, etc. (Magnusson et al. 2016). However, the data we have available is not complete. In other words, the data concerning the emission of microplastics from road and tyre wear is approximate. Nevertheless, studies from Norway, Denmark and the Netherlands, among others, also point to tyre wear as the largest known source of microplastic emissions in each country (Sundt et al. 2014; Lassen et al. 2015; Verschoor 2014).

4.1.1 Release of rubber particles from tyre wear

Friction between a vehicle's tyre and the road surface causes wear while driving. Approximately 20 per cent of a tyre's mass is worn off during the lifetime of a tyre (Renberg 2014). According to IVL's survey, the emission of rubber particles from tyre wear is 7,674 tonnes per year. This can be compared with Norway, where the emissions from tyre wear were calculated at 5,000 tonnes per year (Sundt el al. 2016). The calculation in IVL's report is based on data from traffic management work on Swedish roads and emission data (Magnusson et al. 2016). According to data from the agency Transport Analysis (2016), traffic on public roads in Sweden amounted to 80,714 million vehicle kilometres in 2015, of which passenger cars accounted for the largest share (65,854 million vehicle kilometres).[11] According to estimates, wear of passenger car tyres and tyres on heavy trucks accounts for the largest emissions, 3,293 tonnes per year and 3,248 tonnes per year, respectively, see Table 1. IVL has calculated emissions based on emission data from VTI. According to this study, wear from car tyres amounts to 0.05 g per vehicle kilometre in Sweden and 0.7 g per vehicle kilometre from buses (Gustavsson 2001).

[11] Sweden has an extensive road network. There are 105,000 km of public roads, 42,000 km of municipal roads and 433,035 km of private roads. The private roads are mostly forest roads with a low volume of traffic (Magnusson et al. 2016).

Table 1. Rubber particulate emissions per vehicle type (tonnes per year).

Vehicle type	tonnes/year	Comments
Motorcycles	17	Release factor like cars/2
Cars	3,293	Release factor for cars
Buses	688	Release factor for buses
Light trucks	429	Release factor as for cars
Heavy trucks	3,248	Release factor as for buses
Total	7,674	

Source: Magnusson et al. 2016

4.1.2 Losses of microplastic from road wear

Roads consist of several layers of gravel and rock substrate for stability and strength. The surface layer that is subject to traffic wear is called the pavement. The pavement usually consists of asphalt. Asphalt paving comprise 95% aggregate and the rest, about 5%, is a binder, usually bitumen. Bitumen is produced from crude oil and consists mostly of high molecular hydrocarbons. Polymers (PMB) are sometimes used as an additive in bitumen. It is these polymers that are assumed to cause emission of microplastics from road wear.

Road wear is caused by traffic loads, winter road maintenance, road cleaning and climatic factors such as rain, snow and temperature changes. In particular, cars fitted with studded tyres in winter lead to extensive road wear. Road deformation problems are mainly caused by heavy traffic.

IVL's calculations of the microplastic emissions are based on data for the percentage of polymer modified bitumen in asphalt and road wear assumptions (Magnusson et al. 2016). IVL has assumed that about 5% of the asphalt-paved road network contains polymer modified bonding agent (PMB), which results in 15 tonnes of microplastics per year. The Swedish Transport Agency has pointed out that the polymer content in PMB is on average about 4% of bitumen (percentage by weight).[12] The Swedish Transport Agency has also pointed out that about half of PMB is not worn in the same way because it is in the lower layers, that is, under the pavement. If this is considered in conjunction with the lower PMB content of asphalt, the emissions from road surface wear will be approximately 6 tonnes of microplastic per year.

It should be noted that PMB does not exist as separate microplastic particles but is "dissolved" in bitumen. In practice, asphalt particles that are worn away consist mainly of gravel and stone and a small percentage, bitumen and, where applicable, polymers.

It is unclear whether, and in such a case how, the polymer additive in the eroded asphalt with PMB is emission to form microplastic particles.

[12] A recalculation from 5% to 4% would further reduce the estimated emissions from road wear from 15 tonnes to around 12 tonnes per year

4.1.3 Release of microplastics from wear of road markings

As with the road surface, road markings wear due to traffic loads, winter road maintenance, road cleaning and climatic factors. Wear of road markings can cause microplastic emissions. The annual emissions of microplastics from wear of white road marking paint are estimated by IVL at 504 tonnes per year. The figure is based on assumptions made for Norway as conditions in the two countries' are assumed to be similar (Magnusson et al. 2016).[13] In addition to the white road marking paint, red painted bicycle crossings (cold plastic laid on) are used in Sweden. Wear of red-painted bicycle crossings has not been calculated in the survey.

The estimated emissions of microplastics from wear to road markings are likely to be slightly more. According to Sundt et al. (2014), the polymer content of road marking paints is 1–5%. According to a later Danish report, the polymer content is actually 0.5–2% (Lassen et al. (2015). The latter figure has been confirmed by Swedish manufacturers in Jannö (2016). In addition, the Norwegian figures on road marking wear from 2014 have been commented upon by the authors themselves. In Sundt et al. (2014), one hundred per cent wear was assumed, which is likely to be too much because all paint is not worn in the same way, due to traffic volume and other conditions, or is not worn at all, if, for example, it is removed in connection with road works (Sundt el al. 2016). A Danish study calculated the emission factor as 23–43% (Lassen et al. 2015). Given that both the polymer content and the emission factor are lower than in IVL's calculations, wear of road marking paint is likely to result in less than 504 tonnes of microplastic per year in Sweden.

4.2 Dispersal of microplastic from road and tyre wear to seas, lakes and streams

Microplastics from road traffic are likely to spread mainly to the immediate surroundings as splashes or accompany rainwater. The size and density of the particles are decisive for how they are dispersed and how far away from the source they end up, but the shape is also likely to affect how they are spread (Magnusson et al. 2016). The extent of microplastic particles generated from road traffic transported to sea, lakes and streams has not been calculated (Magnusson et al. 2016).

Grigoratos and Martini (2014) have estimated that less than 10% of the particles from tyre wear are dispersed via air as PM_{10}.[14] Of the larger particles, the largest are probably deposited in the top layer of the soil in the immediate vicinity of the roads, while smaller particles can be transported with surface water or stormwater to the nearest streams and then on to lakes and seas.

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[13] In Sundt et al. 2014) the emission calculation was based on data on annual consumption of road marking paint and the Norwegian road network. IVL has adapted the calculation to the longer Swedish road network (Magnusson et al. 2016).

[14] PM_{10} refers to particles less than 10 μm (1,000th of a millimetre). These particles are small enough to pass through the human upper respiratory tract (nose and throat). Even smaller particles that can reach the end of the lungs are called $PM_{2,5}$ (less than 2.5 μm). Inhalable particles have a negative impact on human health, including increased incidence of cardiovascular diseases and respiratory diseases. Particles from road surface wear, tyres and brakes, as well as from road gritting and salting (i.e. road dust) contribute to high levels of inhaled particles in the air. There would appear to be a particle effect, in which whatever the particles consist of, they result in similar negative effects on the population (Gustafsson 2005).

4.2.1 Dispersion through stormwater

When it rains, particles deposited on the road are mixed with the run-off water and spread through stormwater drainage or as splashes. The way and distance the particles are dispersed depends on factors that include their size, shape, wind conditions, vehicle speed and rain intensity. The stormwater running off urban roads flows into either ditches or roadside gutters. The stormwater is then directed out to the receiving water body. In some cases, stormwater passes through a purification plant before it reaches the receiving water body or is led to a wastewater treatment plant, see section 10.2 on stormwater.

Outside urban areas, stormwater can either be infiltrated into the hard-edge strip or into the road shoulder or be led away through ditches that run directly off the roads. The route taken by the water depends, among other things, on the intensity of the rain, the permeability of the soil, the degree of saturation, the structure of the hard-edge strip and shoulder, etc. The amount of pollution leaving the road through run-off stormwater varies depending on several factors, but usually a significant portion leaves the road as splash off to the shoulders. Water can splash up to 10 metres from the road network to surrounding land. No follow-up has currently been conducted for this water, so the fate of the microplastic particles that accompany is not known, according to the Swedish Transport Agency.

There is no data that shows how much of the microplastic that comes from road traffic that is dispersed via stormwater to seas, lakes or streams in Sweden. So-called black particles have been found in both stormwater and seawater. The black particles may originate from asphalt and tyres, but they may also come from, e.g., peat (Norén and Naustvoll 2010; Norén et al. 2016; Jannö 2016). These studies have not been able to determine the origin of black particles. Jannö (2016) has compared tyre particles with black particles from stormwater samples under a microscope and found that they are very similar in their appearance.

4.2.2 Dispersion through the air

The smaller the particles, the more likely they are to be dispersed in the air. Airborne particles can be between a few nanometres up to about 100 micrometres. The smaller they are, the farther they can be transported by air (Thorpe and Harrison 2008). Airborne particles that have fallen on the ground are largely flushed away by rainwater. They can, for example, be transported to a body of water via stormwater. Airborne microplastic particles can also be deposited on the surface of the sea.

According to Magnusson et al. 2016) there are no available data to calculate the generation of microplastic particles via air from road traffic in Sweden, nor the total load from this dispersal pathway to the sea. Based on the Grigoratos and Martini (2014) estimate that 0.1–10 per cent of tyre particles are dispersed via air as PM_{10}, a rough estimate based on IVL's survey would mean that approximately 8–770 tonnes of microplastics generated from tyre wear are dispersed via air per year in Sweden.

4.2.3 Dispersion through snow dumping

Losses of microplastics from tyre and road wear are a relatively diffuse emission that takes place along Sweden's roads. One exception is snow that has been displaced by snow ploughs. Ploughed snow that is dumped directly on open or ice-covered water as a result of lack of alternative suitable spaces may cause a local emission of pollution, including microplastics.[15]

Dumping of waste, such as snow, in lakes and seas is prohibited. It is, however, possible to apply for an exemption from the county administrative board.[16] About ten major cities in Sweden are allowed to dump waste snow directly into water, the majority of which are located in southern Sweden (Magnusson et al. 2016). For example, the City of Stockholm is permitted to dump 800,000 m^3 snow following extreme snowfall due to a lack of alternative space. According to the City of Stockholm Traffic Office, such quantities have not been dumped in recent years because a lack of heavy snowfalls requiring removal of snow. Before the winter of 2016/2017, the City of Stockholm Traffic Office applied for funds from the Swedish EPA to investigate alternatives to dumping for snow disposal. The City of Gothenburg dumped 900 m^3 of snow in the Göta river in the winter of 2010–2011 (City of Gothenburg 2016). No dumping has taken place since then. The volumes actually dumped annually depend, of course, on the amount of precipitation. The city of Gothenburg is investigating the possibility of increasing the number of dump sites for snow, although this is considered a challenge as the city grows. The City of Gothenburg Traffic Office believes that it will still be necessary to dump snow in the river after extreme snowfall (ibid.). In Sweden, snow is not currently cleaned before being dumped in water.[17]

The concentration of microplastic particles in snow removed by ploughing is not currently known.[18] Research on pollution in snow and on how snow dumping affects marine environments is being conducted, for example, at Luleå University of Technology. However, microplastics do not currently form part of these studies.[19] Municipalities measure pollution in ploughed snow, but microplastics are not currently included in the measurements. During the winter of 2016, the City of Stockholm Traffic Office has produced a literature study to gain more knowledge of microplastics in snow and a sampling programme. Its aim is to be able to investigate the volumes of microplastics in snow during the winter of 2017/2018. Standardised analysis methods and comparative values would have to be developed to get a better picture of the extent of the microplastic content in removed snow, according to representatives of the City of Stockholm Traffic Office (Nitzelius 2017).

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[15] Snow is usually dumped from a quay, from which a truck or other road vehicle tips snow into the water.

[16] According to Chapter 15, Section 1 of the Environmental Code, waste is defined as "any object, material or substance that is regarded as being a category of waste and that the holder disposes of or intends to dispose of or is obliged to dispose of". Snow from streets and squares normally contains traffic pollution. Snow from streets and squares falls into category 20 03 03 Waste from street cleaning.

[17] In Norway, for example, a technology for cleaning particles and debris in snow is used for all snow dumped in Oslo harbour that has been collected from central Oslo. It cleans all snow in several stages before the water from the melted snow enters Oslo fjord. The technology is based on particle separation and does not involve chemical purification of substances. The City of Stockholm Traffic Office has evaluated the technology and found that it does not have sufficient capacity for the needs that exist (Nitzelius 2017).

[18] Whether or not microplastics are spread from onshore snow dump sites has not been investigated within the framework of this commission. There are methods, such as ground absorption that prevent drainage directly into streams (City of Gothenburg 2016).

[19] Dialogue with Stefan Marklund, LTU (23/03/2017).

4.3 Causes of emissions

Release of microplastics from road traffic occurs when we drive on the roads and result from the friction between tyres and the road surface. The extent of the friction and effects depend on both tyre and road characteristics. Factors such as tyre, vehicle and road characteristics, driving style and traffic volume affect emissions (Grigoratos and Martini 2014; Sundt et al. 2016). Since wear of vehicle tyres is judged to be such a much larger source of microplastics than wear of road markings and road surfaces, tyres and tyre wear are the focus here.

4.3.1 Tyre characteristics

A tyre consists of a complex mixture of both organic and inorganic substances, see example in the fact box below. According to ETRMA (European Tyre and Rubber Manufacturers' Association), more than 200 types of raw material can be used in the manufacture of a tire. There are a variety of different tyre types whose contents vary because they are adapted for different vehicle types and sizes (Thorpe and Harrisson 1998). Some substances in tyres, such as PAH (polycyclic aromatic hydrocarbons), are more hazardous than others to health and the environment. The presence of PAH and other chemicals in tyres is regulated by the REACH Regulation (EC 1907/2006).

Vehicle tyres are primarily designed to meet safety requirements for braking, grip and severe weather conditions. Tyres with good grip can reduce the consequences of an accident by reducing speed before an accident occurs. Different types of tyres differ in terms of safety, but also in terms of their environmental characteristics, such as how much noise they make and the volume of particles they create (Swedish Transport Agency 2015).

Tyre manufacturers work continuously on development of tyre properties, such as life and grip, but also rolling resistance, comfort, noise, temperature sensitivity and freedom from maintenance. Tyre wear depends on several factors such as grip and rolling resistance. The highest developed tyres today, compared to previous tyres, have better traction, lower rolling resistance and are quieter, according to the Association of Tyre, Rim and Accessory Suppliers. Tyre wear is also due to other factors, such as road design, vehicle technological development (e.g. power train and brakes) and vehicle weight (Åman and Ardefors 2017).

Components of passenger car tyres

According to STRO, tyres are "made of a textile cord. These so-called cord threads are held together by several rubber layers. The soft core is stiffened by several belts that lie diagonally and across the core threads to create stability in the tyre structure. These belts may be made of steel (steel radial tyres) and/or textile materials, such as polyester, rayon, nylon, Kevlar, etc. The wear tread consists of a combination of synthetic and natural rubber, depending on the characteristics desired. The rubber, together with the tyre tread, must provide a secure grip. Many of today's tyres also have much lower rolling resistance than earlier tyres, thanks to special silicon-based (silica) rubber mixtures and other belt designs."

Source: STRO:s (The Scandinavian Tire & Rim Organization) tyre school[20]

[20] See http://www.stro.se/information/dackskola/

4.3.2 Vehicle characteristics affect tyre wear

Vehicle weight and torque affect the emission factor: The heavier the vehicle and the stronger the torque, the greater the wear on the tyres. Engine power has increased on most vehicles over the years (Åman and Ardefors 2017). The Swedish Transport Agency has also pointed out that the wear on the front wheels of front wheel drive vehicles with high torque may be higher than normal if the vehicle is driven aggressively.

4.3.3 Road characteristics affect tyre wear

Choice of road surface affects how much a tyre wears. Road surfaces are designed to cope with road wear and tear, while being as far as possible adapted to such parameters as friction, noise, durability and stability and various weather conditions (Swedish Transport Agency 2014). The surface design and material contained in the pavement will vary according to the traffic density of the road and the speed of the vehicles. More durable stone materials, such as porphyry and quartzite, are generally laid on roads with a high traffic density to withstand wear caused by studded tyres.[21] However, harder rock types can increase tyre wear. The texture of the coating may also play a part in wear. On the other hand, roads with a softer surface may lead to more rapid road wear, which can result in increased particulate emissions, generally, from the road surface. Further studies are required to gain a better understanding of the relationship between road surface, tyre wear and generation of microplastic.[22]

4.3.4 Use of studded tyres erodes road surfaces

Our climate means that summer and winter tyres are required to get good grip on different types of road surfaces. Studded and non-studded winter tyres are available. Studded winter tyres have been noted as particularly significant for particle emissions to the air. Studded tyres rough up the road surface and can cause approximately 100 times more emissions of PM_{10} particles than summer tyres, and approximately 10 times more emissions than stud-free winter tyres (Gustafsson et al. 2009). It is therefore possible that the use of studded tyres leads to increased emission of the microplastics that are bound in the road material, in so far as microplastics are emission from bitumen particles in asphalt.

In total, use of studded tyres has decreased by a few per cent since the Swedish Road Administration/Swedish Transport Agency started measurement in 2005. The share of stud-free winter tyres has increased accordingly. The use of studded tyres has decreased most in those metropolitan areas that have or have had problems meeting the environmental quality standard for inhaled particles (PM_{10}), for example in Stockholm and Gothenburg. Local measures, in the form of a ban on studded tyres, were introduced on certain streets (Swedish Transport Agency 2015). Although use of studded tyres has decreased, traffic on Swedish roads has increased slightly (Transport Analysis 2016). A qualified guess is that road wear can be assumed to be currently at around the same level as before.

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[21] Paved roads with a lower traffic density roads often have a surface consisting entirely of a locally-occurring rock. In Sweden, the most common rocks used in road surfaces are granite, gneiss, quartzite and porphyry. Of these rocks, porphyry is the most durable and granite and gneiss the least durable.

[22] Dialogue with the Swedish Transport Agency (03/05/2016).

Whether different types of winter tyres cause more or less wear than summer tyres is unclear. Stud-free winter tyres are likely to wear down faster than summer tyres due to their softer rubber compound. At the same time, there are significantly more summer tyres and they drive in total significantly more kilometres than winter tyres (including studded tyres).[23] Further studies will be required to find out whether summer tyres are generally a bigger problem than winter tyres from a microplastic point of view.

4.3.5 Driving style

Release of microplastics is also affected by the way we drive. Tyre wear is greatest under heavy acceleration and braking (City of Gothenburg 2016). Particle formation also increases at higher speeds (Gustafsson 2005).

4.3.6 Traffic volume

The emission levels of microplastics from road traffic are naturally affected by the amount we drive. The rate of increase in road traffic has shown signs of stagnation for several years. However, traffic management on the Swedish roads has increased slightly again in 2014 and 2015 (Transport Analysis 2016).

The Swedish road network is divided into the state road network, municipal and private road networks. Three-quarters of all traffic drive on the state road network and just over 20% on the municipal road network. A small percentage drives on the private road network. Public road network traffic is mainly rural (80%), while the opposite is true for the municipal road networks, where 85% of the traffic is in urban areas. Two thirds of traffic in Sweden is in rural areas, 34% is in urban areas and a tenth of traffic is in cities. Research shows that residents in urban areas drive less than others (WSP 2015).

4.4 Assessment of the possibilities for moving towards reduced emissions of microplastic from road traffic

This section assesses the conditions for steering towards reduction of microplastic emissions from road traffic at a national level, with a focus on emissions caused by wear of vehicle tyres. The assessments were conducted in dialogue with the Swedish Transport Agency, VTI (the Swedish National Road and Transport Research Institute), the Swedish Energy Agency and the Swedish Transport Agency.

4.4.1 Tyre manufacture – development of tyre characteristics

Tyres are not manufactured in Sweden and our tyre market is limited compared to many other countries. The opportunity to influence tyre manufacturers by applying national measures is therefore deemed to be small. However, it would be possible to work towards the development of more durable and sustainable tyres in the EU, for example through the development of EU's mandatory energy label for tyres (EC/1222/2009).

[23] Dialogue with VTI (04/04/2017).

4.4.2 Consumer's choice of tyres

There are a variety of tyres available on the market for different vehicle types. For consumers, the EU tyre energy label (EC/1222/2009) is available to support tyre selection. The label shows energy efficiency, grip on wet road surfaces (wet grip) and external noise. The label is common to EU countries and will be applied to new tyres for passenger cars, light trucks and heavy vehicles. The aim is to make it easier for the consumer to choose tyres that offer lower fuel consumption and lower noise levels, to contribute to reducing CO2 emissions and traffic noise. The combination of choosing energy-labelled tyres and an economical driving style gives an average petrol-fuelled car a saving of SEK 1,700 per year, according to the Swedish Energy Agency.

Today, wear resistance is not included in the energy labelling of tyres. However, many tyres have a Tread Wear Rate (TWR) label, which is used primarily for the US market. The relevance of this label for Swedish conditions is unknown. It could be possible to drive towards the development of more durable tyres through the development of labelling. However, investigation is required to ascertain whether this is a suitable route to take. The Swedish Energy Agency is responsible for Sweden's energy labelling system. The energy authority considers that knowledge building is first needed to assess suitability. This is partly to determine the extent to which the microplastic emissions from tyre wear are due to the characteristics of the tyres and not to other factors, and partly to enable a balance to be struck between wear resistance and tyre noise, grip and other safety aspects. In a second stage, robust measurement methods need to be developed to extend the energy labelling for tyres. The European Commission has recently conducted an evaluation of the energy labelling on tyres in which the consultant has concluded that it is not appropriate to add mileage to the label at present, mainly due to the lack of measurement methods and uncertainty regarding environmental benefits (Viegand Maagøe A/S 2016).

4.4.3 Choice of road surface affects tyre wear

Choice of road surface affects how much a tyre wears. A poorer rock quality has been allowed for some years, which has increased rutting and other surface damage as a result. Requirements have been made stricter and an aggregate with higher wear resistance is now being used on roads with high traffic levels.

Construction work is conducted under contract and is governed by specifications issued by the Swedish Transport Agency, including requirements for bituminous layers (TDOK 2013:0529).[24] At present, tyre wear is not considered when choosing road surfaces. According to the Swedish Transport Agency, choice of road surface almost always involves several conflicting targets, such as climate, friction, noise, durability and stability. The choice of aggregate is primarily dependent upon the estimated number of vehicles. Roads with high levels of traffic need to resist abrasion caused by studded tires. Reducing the requirements would mean that the surface would almost certainly have a shorter life span and thus have to be resurfaced earlier.

[24] These requirements will be used in conjunction with the so-called AMA Anläggning 13. AMA Anläggning is a reference document used in the preparation of descriptions and execution of works. AMA Anläggning is published in new generations every third year. The latest is AMA Anläggning 13.

This is likely to involve high costs, as well as additional environmental impact in the form of increased CO2 emissions, according to the Swedish Transport Agency.

Taking into account the target conflicts and uncertainties as to how much choice of road surface affects tyre wear, and therefore the emission of microplastic in the form of tyre particles, it is currently considered that knowledge of the contribution of various road surfaces to tyre wear needs to be developed before control of the contribution of surfaces to microplastic emissions can be discussed.

4.4.4 Use of studded tyres affects road wear

In the interest of improvement of road safety in the winter season, the Winter Tyre Act requires passenger cars to have winter tyres (studded or stud-free) from 1 December to 31 March, when driving on winter roads.

The choice and use of winter tyres have an impact on road safety as well as on the environment. The use of studded winter tyres is a problem in terms of wear and particulate emissions from road surfaces in general. The extent of this problem from a microplastic point of view is unclear, as described in section 4.3.4.

Control of use of studded tyres has been used to reduce both costly road wear and levels of inhalable particulates. Speed limits and bans on the use of studded tyres have been introduced locally. In Sweden, Stockholm, Gothenburg and Uppsala have introduced local bans on studded tyres on roads that have problems in meeting EU limit values for content of inhalable particles.

A tax on the use of studded tyres in urban areas has been considered in the Particle Content Review (SOU 2015:27). The review submitted its report to the Government in March 2015. Its conclusion was that the introduction of a tax was not yet justified on the grounds that measures such as a ban on use of studded tyres, dust-binding and suction cleaning were available. Should current measures not be sufficient to meet the EU Air Quality Directive's particulate concentration limit (PM_{10}), the study produced a draft law on the taxation of studded tyre use in urban areas.[25] The Government has not proceeded with the review's proposal.

In addition, there are recommendations for the type of winter tyres that are best suited for different winter conditions. STRO (The Scandinavian Tire & Rim Organization) has developed a winter tyre guide to facilitate tyre selection under different driving conditions, such as ice, powdery snow and bare ground.[26] Studded tyres usually have better grip than stud-free winter tyres on icy roads, but when driving in southern Sweden on wet and dry winter roads, stud-free winter tyres are more suitable for mid-European conditions. Information about particle formation and rolling resistance is not included in this guide. The possibility of supplementing the recommendations with such information has not been investigated here.

Overall, reduced road wear is desirable from several points of view. Airborne particles from road wear are a health problem and the cost of surface damage is high. In particular, wear caused by studded tyres on road surfaces causes increased particulate emissions in general. In view of the uncertainty around estimates for emission of microplastics from wear of road surfaces and markings, the Swedish EPA considers that no justification is currently present for strengthening the existing controls on

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[25] The review proposed that if a studded tyre tax were to be introduced, the tax would be paid per calendar day (SEK 50), per month (SEK 600) or for the whole winter season (SEK 2,000).

[26] See http://www.stro.se/information/val-av-vinterdack/.

use of studded tyres. However, the microplastic issue may further justify measures focusing on, for example, studded tyres, and it would be useful if ongoing work on air quality in Sweden was also aware of this.

4.4.5 Smoother driving style reduces particle formation

Of the voluntary measures available, the effects of a smoother driving style have been highlighted earlier as a means of reducing fuel consumption and emissions to the air from road wear. As tyre wear is likely to be greatest under heavy acceleration and braking, a smoother driving style results in reduced particulate emissions, including microplastic emissions. "Eco-driving" is a voluntary choice and is encouraged through information and training by various stakeholders.

The Swedish EPA considers that the emission of tyre particles as a result of the microplastic problem is a further factor strengthening the need for voluntary measures that will ensure a smoother driving style.

4.4.6 Collecting particles from the state road network

The efforts discussed share a common aim of preventing particles from forming through wear and tear. In parallel with such measures, measures aimed at preventing the release of particles into the environment need to be discussed.

The Swedish Transport Agency is responsible for the generation of pollution from the state transport system, including the emission of microplastics. The Swedish Transport Agency considers that, at least in theory, there is a system for dealing with microplastic particles from the state road network, because the pollutants are particulate-bound.[27] Collection of pollutants from run-off road water takes place today, although the Swedish Transport Agency has not previously considered microplastic from tyre wear in this context. The standard principle is that there should be a natural filter system in the hard edge strip, to hold sediment there and then remove it during road maintenance. The Swedish Transport Agency has guidelines for when the sediment can be reused and when it should be treated as hazardous waste. Samples are conducted on the sediment mass, which is then reused as a filler material, depending on the level of contamination content.[28] How well the current treatment technique for road stormwater works with regard to microplastics is unclear and something that requires further investigation.

The Swedish Transport Agency is working on knowledge-building projects for the emission of microplastics from the transport system in international, Nordic and national forums with the aim of increasing knowledge of the issue. For example, the Transport Administration cooperates with other EU countries on aquatic pollution and works continuously on collecting knowledge about pollution in water. Among other things, the Swedish Transport Agency is a member of CEDR (Conference of European Directors of Roads – the Member States' "Transport Agency"), which has been running a project, TG water quality, since 2013. TRV has participated in the project, which has resulted in a report and identified research needs.[29] A decision has been made to move the identified research need forward in a so-called "Research

[27] Dialogue with the Swedish Transport Agency (03/05/2016, 04/04/2017).
[28] Dialogue with the Swedish Transport Agency (03/05/2016).
[29] See http://www.cedr.eu/management-contaminated-runoff-water-report/

Call 2016". One of the four identified areas is "New and emerging chemicals" (including microplastics). The aim is to increase knowledge of these substances, levels, origin, occurrence, etc. and to find out whether current road design/treatment methods are working satisfactorily or whether new methods need to be developed. At the time of writing, a review of the research proposals received is ongoing.

The Swedish Transport Agency is also participating in a joint Nordic research project, NordFoU/REHIRUP (Reducing highway run-off pollution) with the aim of reducing pollution to water from roads, which has also recognised the contribution of microplastics. Project plans are available for microplastics, where they are found in stormwater, wider dispersed in the environment and the potential to clean them out by sedimentation. REHIRUP complements the CEDR package.[30]

The Swedish EPA's assessment is that, within the framework of its responsibility for the emission of pollutants from the state transport system, the Swedish Transport Agency has a platform for both building up knowledge of microplastics' dispersal from the state roads and, in the next stage, working actively to prevent proliferation. The Swedish EPA recommends that the Swedish Transport Agency be given a clearly identified responsibility for the emission of pollutants from the state transport system.

4.4.7 Collecting microplastic particles from the municipal road network

In urban environments, there is no room for hard edge strips as described above on the state road network. Instead, there are collection systems for stormwater or for water treatment services. Based on the knowledge we have today about microplastics, stormwater is likely to be a significant factor in the dispersion of tyre particles in urban areas.

In Stockholm's inner-city districts, for example, stormwater is connected to the wastewater treatment system. This means that microplastic particles originating from road traffic are led to wastewater treatment plants where they are filtered out. In the outer districts of the city the stormwater is led into nearby lakes and streams. In total, only about 8% of stormwater is currently treated in urban environments, of which about half is processed in wastewater treatment plants and half is processed in stormwater treatment plants. This means that the largest percentage of microplastic particles in stormwater will reach local receiving water bodies sooner or later (Magnusson et al. 2016).

The dispersion of microplastics by stormwater has been recognised at both municipal and county level. For example, in its report "Mikroplast i Göteborg", the City of Gothenburg recommends the introduction of analysing microplastic in rainwater coming from trafficked areas. The aim is to find effective methods to prevent the dispersion of microplastics through stormwater. In addition, the City of Gothenburg is proposing an investigation into how much microplastic is present in sand and grit that are swept up by road sweeper machinery in municipal streets. The aim is to propose further measures to separate the microplastic, should the quantity be significant (City of Gothenburg 2016). The Östergötland County Administrative Board has a three-year project that will lead to increased knowledge of the amount of pollutants, including

[30] Dialogue with the Swedish Transport Agency (March–April 2017).

microplastics, that are flushed with stormwater into the Baltic Sea, and of the measures that are most cost-effective.
Our assessment is that knowledge needs to be developed to better understand how, and how much, microplastic from the road network is dispersed via stormwater and which methods are best suited to prevent the dispersion of microplastic through stormwater.

4.4.8 Road cleaning

Road surfaces collect eroded material from road paving, tyres, brakes, various road works, etc. in the form of road dust. So close to the source, this dust is an important source of information for the content of microplastics from dust generated by road traffic and as reference material to what is found downstream of the dispersal pathways. Studies of the amount and properties of road dust are ongoing, including by VTI, but there is currently no knowledge of its significance as a source of microplastics. One way of preventing the spread of this dust to adjacent ground and water is through effective cleaning. The effects of cleaning on road dust have also been studied, but once again the microplastics aspect is missing from these studies.

The Swedish Transport Agency is responsible for cleaning public roads and municipalities are responsible for the municipal road network. Roads are cleaned by being swept. For example, in the spring roads are cleaned using special road sweepers to sweep up gravel (or so-called grit – crushed rock) that has been used to make the surface less slippery. Some of the collected material is usually reused; that is, the gravel is recovered and used for road gritting again. It is currently unknown how much microplastic accompanies the gravel and what subsequently happens to it. Roads, cycle paths and pedestrian paths are then more or less regularly swept during the summer months. It is likely that both micro- and macro-plastics form part of the sweepings, see Chapter 9 on litter.

In addition, roads are cleaned to reduce the dispersal of airborne particles. For this to be effective, cleaning techniques are needed that are capable of taking up and retaining particles less than 10 µm, which few standard machines today can handle. In these cases, the cleaned material contains a larger proportion of fine dust, which may require special processing during emptying, transport and disposal. The extent to which this dust is a source of microplastics is unknown.

4.4.9 Snow dumping

Snow that is dumped in lakes, rivers or the sea is a local emission of microplastics. Data will be needed to be able to discuss possible revision of granting exemptions from the ban on dumping snow. There is currently no data on how much snow is dumped directly into water in Sweden each year or on the microplastic concentrations in the snow being dumped.

4.4.10 Traffic volume

If traffic volumes on our roads were to decrease, emissions from road traffic to air and water in general would also decrease, as would microplastic emissions from road traffic.

In June 2016, the Environment Objective Committee presented a proposal to reduce greenhouse gas emissions from domestic transport by 70% by 2030 compared to the 2010 level (SOU 2016:47). This objective is included as part of a proposal for a climate policy framework for Sweden, which the Government presented in March 2017. In addition to more energy-efficient vehicles and an increased share of renewable fuels, the proposal pointed out that measures to enable more efficient transport work are an important precondition for achieving the target. According to the Swedish Transport Agency's basic road traffic management development forecast between 2010 and 2030, passenger car traffic is expected to increase by 25% and goods traffic by 45%. Achievement of the target of a 70% reduction in emissions from domestic transport would require a zero increase in passenger car traffic and a 20% increase in heavy goods traffic instead of 45%.[31]

One example of an existing instrument that reduces local traffic is congestion tax, which is used in the cities of Stockholm and Gothenburg. In Stockholm, the volume of traffic has decreased over the congestion tax period with reductions of around 20% since the tax was introduced. There are also proposals for a distance-based road wear tax for heavy goods vehicles (SOU 2017:11) that were submitted by the Road Wear Committee in February 2017. The purpose of the tax is primarily to ensure that heavy goods traffic bears its socio-economic costs to a greater extent. A road wear tax could reduce the environmental impact of the transport sector and thus also have an effect in the form of reduced emission of microplastics. Another effect may be that transport moves from road to rail or sea, for example. This could result in a reduction in road traffic volumes and thus in reduced wear and particulate emissions.

Within the framework of this commission, the impact of general measures for the reduction of traffic on microplastic emissions has not been studied. Given that traffic in Sweden will increase in accordance with the Transport Administration's baseline forecast, reduced road traffic would also have an even greater effect on the emission of microplastics from road and tyre wear.

The Swedish EPA considers that it is not reasonable to take further measures to reduce road traffic solely on the basis of the risks associated with the emission of microplastic particles from tyre and road wear. On the other hand, the synergies between ongoing or planned measures to reduce road traffic and potential measures to reduce micro-plastic emissions could be usefully recognised by stakeholders.

4.4.11 Overall assessment of national governance possibilities

Many of the behaviours that cause emission of microplastics are the same as those that cause particulate emissions from road traffic in general. There are in place instruments that directly or indirectly reduce particulate emissions to air and water from road traffic. As there are so many uncertainties about the emission volumes and about the release of microplastic particles from tyre and road wear to seas, lakes and streams, we believe that tighter control of emissions from road traffic is not justified at present for this reason alone. In addition, there is a risk of conflict of objectives with other environmental areas (air quality, climate impact, noise), as well as with aspects of road safety and accessibility. Any potential target conflicts need to be further investigated. On the contrary, the synergies between possible measures to reduce microplastic emissions and ongoing or planned measures in other areas should be exploited. Many of the measures taken today to reduce emissions to water and air from road traffic are also considered to have an effect on microplastic emissions.

[31] In addition, there are several proposals for instruments and measures that could lead to more efficient transport in the Environment Committee's climate and air-care strategy, such as investment in urban environmental agreements for investment in walking, cycling and public transport, changes in travel deductions to promote low-emission travel and travel-free communication.

At first sight, it would of course be most effective to direct governance toward preventing the emission of tyre particles, as tyre wear is the main source of microplastic emissions in Sweden, according to IVL's survey. Due to the considerable uncertainties in the evidence and in our assessments, there are very limited possibilities to prevent tyre wear from occurring in the short term. Knowledge building is central to the prevention of emission in the longer term, as is dialogue and information to raise awareness of the problems of microplastics. Research efforts are also needed for increased and more reliable knowledge of how and how much microplastics from road traffic are released to seas, lakes and streams.

4.4.12 Action at international and EU level

Release of microplastics from road traffic occurs when we drive on the roads and result from the friction between tyres and the road surface. Tyre/road friction depends on both tyre and road characteristics. We control road characteristics in Sweden ourselves, but we have no preconditions for national development of tyre characteristics. We believe that the governance of the development of more durable tyres should take place at EU level, for example through the EU's energy labelling of tyres, see the proposed measures below.

Neither HELCOM nor OSPAR's action plans for marine litter, tyre and road wear treat them specifically as a source of microplastics. Tyre particles form part of the concept of secondary microplastics within both conventions. There are still no proposed measures within the framework of the convention work. The Nordic Council of Ministers' Working Group on the Sea and the Coast (Marine Group, HAV) funds an ongoing project to increase knowledge of road wear. The results are expected to be ready in 2017 and will be able to provide input to both the convention work and national measures.

4.5 Proposals for measures

The scientific knowledge that is available is insufficient to reach a safe conclusion as to whether there is a potential risk to the environment or health due to the emission of microplastics from road traffic. The proposed measures are therefore primarily aimed at increasing knowledge and raising awareness of microplastic emissions from road traffic. These measures should be seen as a first step so that it will be possible in the next stage to steer more effectively towards the reduction of microplastic emissions from road and tyre wear.

4.5.1 Government commission to the National Road and Transport Research Institute (VTI)

A fundamental problem for proposing relevant national instruments and measures is the lack of knowledge of road microplastics and several uncertainties. Release of microplastics from road traffic has been judged as a significant, perhaps the largest, source of microplastics in the sea. They are judged primarily to be linked to tyre wear and, secondly, to wear of road markings and surfaces, but there is insufficient knowledge about the amount of emissions and how much comes from the various sources. Moreover, it is not clear what should be defined as microplastics. Knowledge is also needed, among other things, about the properties of these microplastics, how emissions are affected by road surfaces, tyres, vehicle technology, driving style, type of vehicle etc. and the percentages of these emissions that reach streams, lakes and seas.

The State Road and Transport Research Institute (VTI) has long experience in research and development commissions regarding wear of both tyres and road surfaces, as well as sampling near the source. Laboratory resources have been built up and now include a test-road machine, where the impact of different surfaces and tyre types on wear can be studied. The activities normally have a highly applied and action-oriented nature, with the aim of studying how different materials or environmental parameters affect wear and particle formation. Therefore, the Swedish EPA, together with VTI, proposes that VTI be commissioned to develop knowledge of microplastic emissions from road traffic.

The gaps in knowledge concerning microplastics and road traffic need to be identified and clarified. We propose that VTI is commissioned to carry out a pilot study and a full-scale study. The purpose of the pilot study is to:

- identify and describe key knowledge gaps for which more research is needed to make proposals and take relevant measures;
- propose and justify which of these knowledge gaps should be prioritised,
- propose appropriate research and investigation to fill the gaps.

The main study aims to carry out the proposed studies in cooperation with relevant complementary research communities and finally to propose effective instruments and measures to limit the environmental and health risks related to microplastics from road traffic.

Furthermore, VTI's commission should also include following relevant research into microplastic particles from road traffic at national and international level.

4.5.2 Knowledge building on the emission of microplastics from roads

A better understanding of the dispersal pathways is needed to gain a better understanding of how the loss of microplastic particles from road and tyre wear are spread and how much of the emissions from road traffic reach seas, lakes and rivers. Knowledge of both air- and water-borne microplastic particles needs to be built up, but we also need to understand what happens to the microplastic particles that are assumed to be deposited and form sediment near the road. We currently know nothing about microplastic that is contained in water that splashes off roads and onto surrounding ground from roads that do not have hard edge strips or other areas where water collects. Research into the fact that microplastic particles are not only a problem for marine environments but also for freshwater systems and terrestrial environments means that this can be a problem, especially in connection to agricultural land.

The Swedish EPA's assessment is that, within the framework of its responsibility for the generation of pollutants from the state transport system, the Swedish Transport Agency has a platform for both building up knowledge of microplastics' loss from the state roads and, in the next stage, working to prevent proliferation. The Swedish EPA recommends that the Swedish Transport Agency be given overall responsibility for knowledge building and analysis of measures suitable for reducing the loss of microplastics from the state transport system.

Swedish municipalities are also important stakeholders in building up knowledge about the spread of microplastics from the municipal road network. The Swedish Transport Agency should cooperate with them and other interested parties as part of the knowledge-building process on the generation of microplastics from road traffic. Cooperation with VTI in their government commissions as proposed above is of course central.

4.5.3 Evaluate stormwater purification technologies

Methods for collecting pollution from run-off stormwater from the public roads already exist. How well the current treatment technique for road stormwater works with regard to microplastics is unclear and requires further investigation. The Swedish Transport Agency is participating in a collaboration within the organisation of European national road administrations, CEDR, as well as in the Nordic research collaboration NordFou to investigate, among other things, the suitability of treatment techniques for microplastics. The Swedish Transport Agency is therefore expected to be able to deal with this issue within the framework of its existing work on protecting water from pollution.

As regards the emission of microplastics from the municipal road network via stormwater, we encourage the ongoing local and regional efforts to measure pollution, including microplastics, and to install purification technologies.

4.5.4 Exploring the development of the EU tyre energy label

Wear resistance is not currently a criterion in the EU Energy Label for Tyres (EU Regulation 1222/2009 on Tyre labelling). The development of the energy label could not only provide consumers with better support in the choice of tyres with regard to particulate emissions, but also send a signal to tyre manufacturers on the importance of developing more hard-wearing tyres. To work towards the introduction of wear on the energy labelling of tyres, robust measurement methods need to be developed and established. This requires the development of knowledge and commitment to the work of the standards bodies. The Swedish EPA, in consultation with the Swedish Energy Agency, proposes that the Swedish Energy Agency be given responsibility for investigating the possibilities and suitability of working for the development of the energy labelling of tyres to include tyre wear.

CHANGE COMPARED TO CURRENT SITUATION

As a first step, this can take place within the Energy Agency's existing work on the energy labelling of tyres, which will not lead to major changes. If the proposal to introduce particulate emissions/wear on tyre labelling becomes a reality, it may hopefully lead to better choices for consumers and, by extension, this may lead to fewer particles and microplastics released in nature.

STAKEHOLDERS

In a first step, the Swedish Energy Agency, Swedish tyre manufacturers and distributors, VTI and the Swedish EPA are affected. If the Energy Agency finds it appropriate, the issue will be discussed with the other EU countries and at the European Commission.

CONSEQUENCES

As a first step, this can take place within the Energy Agency's existing work on the energy labelling of tyres and is not expected to have any major consequences. However, should participation in standardisation work and/or undertaking specific studies on particles from tyres become relevant at a later stage, additional resources will be required.

5. Microplastic loss from artificial grass pitches

5.1 Microplastic loss and dispersal pathways from artificial grass pitches

Release of microplastics from artificial grass pitches has been identified as one of the sources of microplastic emissions in Sweden (Magnusson et al. 2016). There are currently about 1,200–1,300 artificial grass pitches in Sweden and about 100 new artificial grass pitches are being built annually (Wallberg et al. 2016; Magnusson et al. 2016, SKL 2016). To ensure that the surface of an artificial pitch has the desired properties, the pitch is filled with large quantities of filler material in the form of rubber granulate. The granulate used in artificial grass pitches is so small that it is considered to be microplastic in this report. Regular use and care of the pitch will lead to the loss of granules from the pitch and they need to be replaced. The Swedish EPA notes that there are uncertainties about the volumes of granules that are released annually from Swedish pitches, but that the different knowledge bases show that there is a loss and a release of rubber granulate into the environment. The box below summarises the assessment of artificial turf as a major source of microplastics.

Swedish artificial grass pitches are filled with about 2–3 tonnes of rubber granules per year and pitch (Magnusson et al. 2016) indicating that a corresponding amount is lost from the pitches annually. The total amount of rubber granules that can potentially be spread annually from Swedish artificial grass pitches is thus 1,640–2,460 tonnes (Magnusson et al. 2016). There are various reasons why granulate disappears from artificial grass pitches plans. For example, granules are lost during snow clearance, by rain and on the players' shoes and clothing.

Particle type: Rubber granulate

Particle size: Approximately 3 mm, meaning that the rubber granulate used on artificial grass pitches can be considered to be microplastic particles at time of their initial use.

Plastic type: SBR, EPDM, TPE

Presence of hazardous substances: Uncertainties exist for the different materials. Substances that may be present include PAHs, phthalates and heavy metals.

Ability to adsorb and transport environmental toxins: Unknown

Documented (measured) presence of microplastic from the source in the sea: Unknown

Probability that the emission of microplastics from the source reaches seas, lakes and streams: Disperal to the environment via various pathways. Direct to the environment, via stormwater and possibly via wastewater passing through treatment plants. The extent to which discharges are made to seas, lakes and streams is uncertain. The location, design and care of the facility will affect the likelihood of microplastic proliferation.

Quantity (volume): 1,640–2,460 tonnes of rubber granules per year are added to Swedish artificial grass pitches. This entire amount is likely not to be spread, because a certain amount will be compacted in the pitch and a certain amount will be collected as waste off the pitch. The volume that reaches the sea, lakes and streams is unclear.

Source causes large local emission of microplastic: Yes

Granules that are in snow when it is cleared are to some extent collected and returned to the pitch or are disposed of as waste. Granulate is also compacted on an artificial pitch, which means that the amount of granulate that needs to be added may be greater than the amount that was actually removed from the pitch (Magnusson et al. 2016). Other estimates show that approximately 1–2 tonnes of rubber granules per year and pitch can be released to the environment, which means a total of about 630–1,264 tonnes per year in Sweden (Wallberg et al. 2016).

Estimates on the number of artificial grass pitches in Sweden and the volumes of granules released to the environment vary. This is because, in part, the estimates are done in different ways and that they are based on different underlying data about the number and size of different types of artificial grass pitches. It is not possible for the Swedish EPA to determining which figures are most representative.

The report "Tyre material in artificial grass pitches" from Sweco Environmental AB on behalf of the Swedish EPA, has a flow model for the loss of granulate from pitches, see Figure 2. The quantities in the figure below refer to four pitches over a one-year period and are based on information from a football club.

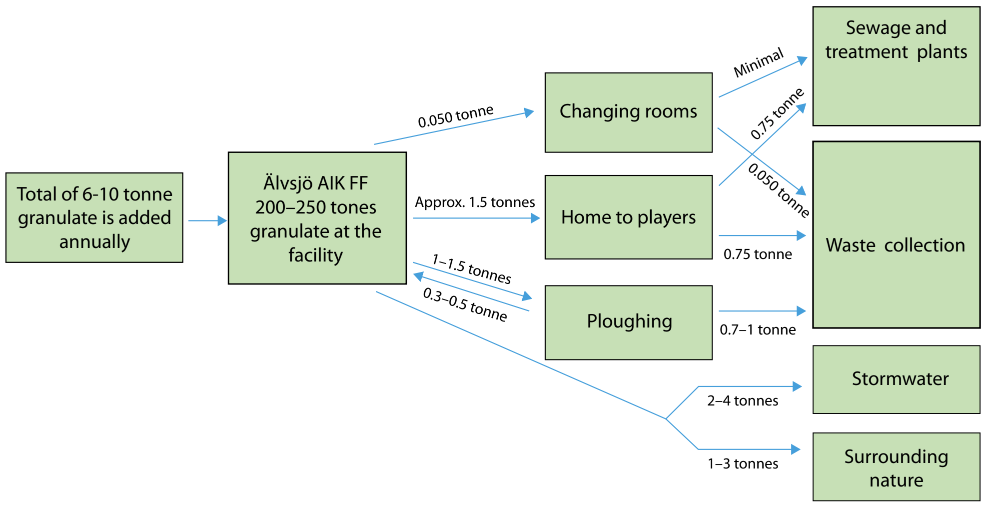

Figure 2. Flow model of the dispersal pathways for granulate from artificial grass pitches. The flow model is based on information from a football club and estimates from four pitches over a one-year period
Source: Wallberg et al. 2016.

5.2 Underlying causes of emissions – stakeholders, behaviours and drivers

There are behaviours, choices and decisions at different levels that result in the loss of granulate from artificial grass pitches:

- Municipalities and other stakeholders choose to build artificial pitches.
- The clients/manufacturers choose to use rubber granulate as the filling material.
- The design and care of the pitches affect the loss of rubber granulate from the pitches.

5.2.1 Municipalities and other stakeholders choose to build artificial pitches.

The artificial grass pitches are regarded as being very positive by football organisations. Swedish municipalities have been sensitive to the needs of the sports movement and have evaluated opportunities for greater use of the pitches throughout the year. This is why the number of pitches has increased. The Swedish Football Association (SvFF) is actively pursuing a quest for more artificial grass pitches in Sweden, both to make all-year training possible and to ensure that there is equality of conditions throughout the country.

The number of artificial grass pitches has grown rapidly and the number of football teams playing on artificial turf has increased significantly over the past four or five years, while the use of/construction of natural grass pitches has decreased at approximately the same rate. The main advantage is that it is possible to get more playing time from an artificial pitch than a natural grass pitch, which requires rest periods. It can also be used all year round. This will make it cheaper in cost terms per game hour (Lundqvist 2016; Zethrin 2016).

5.2.2 The clients/manufacturers choose rubber granulate as the filling material.

The filling materials used in artificial grass pitches are SBR (recycled car and machine tyres), EPDM (newly manufactured vulcanised industrial rubber), TPE (newly manufactured thermoplastic) or organic filling material (such as cork, bark and coir). SBR is the most common filling material today and is used on 60–70% of all artificial grass pitches. SBR is popular because the material has good properties and is considerably cheaper than other materials such as TPE and EPDM, although these materials are also commonly used. There is no aggregated information indicating differences in the risk of release depending on the type of rubber granulate used. For this reason, this report will regard the different types of rubber granules as being equivalent from a microplastic perspective.

Organic filling material is currently uncommon but has increased recently (Magnusson et al. 2016). Above all, the use of cork has increased. However, the use of these materials may present some difficulties compared to rubber granules. For example, they may be more difficult to use in winter conditions or more expensive to purchase. There is no available information about the total environmental impact of the various materials in a life cycle perspective.

Development of completely new types of pitches is also ongoing. One such example is hybrid grass, a combination of natural and artificial turf, which is currently being laid in several major football stadiums in Sweden.

There are uncertainties about the content of hazardous substances in the various types of rubber granulate and the possible risks that this could entail. As far as health risks are concerned, existing studies indicate that the use of SBR in football pitches does not entail an increased risk of negative impact on human health (ECHA 2017, Wallberg et al. 2016). However, there is still uncertainty whether the studies cover all relevant substances and potential health effects, which implies a need to continue to build up knowledge in this area. In terms of environmental risks, leachate from artificial grass pitches, depending on the stormwater system and conditions in receiving water bodies, can have a local environmental impact (Wallberg et al. 2016).

5.2.3 The design and care of the pitches affect the loss of rubber granulate from the pitches.

Pitches need to be maintained to optimise the use of the artificial turf and extend its service life. Raking, snow clearance, or other pitch maintenance means that granulate can be carried from the pitch to surrounding ground where it is usually heaped up. Normally, the granulate is returned to the pitches as far as possible or collected and sent for disposal. However, some granulate will remain on the ground, be released to adjacent areas and also dispersed by stormwater. Another dispersion pathway is via those who use the artificial grass pitch and take the granulate from the site to changing rooms, surrounding areas and/or their homes. In homes, granulate may be swept up by vacuum cleaners and then be disposed of together with the household waste, or disposed of in a yard/back garden or laundered out in a washing machine.

Various weather events will also contribute to the loss of granulate from artificial turf. During the winter months, snow and subsequent snow clearing can cause a wide dispersion of granulates, as the snow cleared from pitches contains large amounts of granulates and is often piled at the side of the artificial grass pitches. When the snow melts, part of the granulate remains by the side of the pitch, while some of it spreads with meltwater to stormwater drains or is blown into stormwater from these sources.

Stormwater has been shown to be a transport pathway for microplastics to the environment. It is also released to aquatic environments via drains. A common path for rubber granulate to the drain is the granules that players carry on them from the artificial pitch. This release occurs, for example, from changing rooms, from homes and during laundry.

There are various types of measures that may be applied that can limit the loss of granulate from artificial grass pitches.

5.3 Assessment of possibilities for reducing emissions of microplastic

5.3.1 Current governance in Sweden of emission of microplastics

There are no instruments that regulate the number of artificial grass pitches built that use rubber granulate as filler material. There are also no existing instruments specifically aimed at reducing the loss of granulate (i.e. microplastics) from these pitches. Several of Sweden's municipalities and county councils are working on environmental issues related to artificial grass pitches. There are examples of county councils and municipalities that have developed guidance for supervision and procurement guidelines. There is no guidance and guidelines are lacking at a national level.

The Swedish Football Association (SvFF) has developed recommendations for the construction of artificial grass pitches (Swedish Football Association 2017). In its recommendations, SvFF states that it is important for the pitch owners to shoulder high levels of responsibility for ensuring that the rubber granulate does not end up in the environment, but is returned as far as possible to the artificial pitch. SvFF further states that great importance should be attached to the handling of rubber granulate when planning pitches and that the following points are important to consider:

- Rubber granulate that is moved off the pitch should be returned. Plan the facility to have areas, preferably paved, where snow swept from the artificial pitch can be heaped. After the snow has thawed, the granulate can then be returned to the pitch. A gravel surface covered with ground fabric, or an end-of-life artificial turf mat, can be an alternative to asphalt.
- The principle of the pitches' drainage and surface-dewatering piping is that they are connected together to form a closed system and then led to a cistern in which any filter solutions can be placed and the quality of the stormwater measured before being passed on to the public stormwater system, or another receiving water body.
- Filters should also be fitted to stormwater cisterns to trap granulate that has entered the drainage system.
- If a large amount of granulate is washed off in a shower room, consider inserting a granulate filter there as well.
- Players should be encouraged to brush off the granules at a specific location from which they can be collected and returned to the pitch.

SvFF also organises artificial turf courses for grounds staff who work for clubs and municipalities and conferences for pitch maintenance staff, facility managers and other stakeholders. SvFF states that environmental issues, including the loss of granulate from pitches, are included in these courses and conferences.

5.3.2 EU and international processes

The debate around artificial grass pitches is ongoing both internationally and in Sweden. The discussion is mainly about the choice of granulate with the aim of avoiding unwanted substances that can affect human health and the environment (EPA et al. 2016, DHI 2013, Nilsson et al. 2008). In June 2016, the European Commission commissioned the European Chemicals Agency (ECHA) to investigate the health risks associated with the use of recycled tyre granules in artificial grass pitches. ECHA published the results of the report in February 2017 with the conclusion that exposure is very low, both for adults and children playing on pitches with recycled tyre granulate and for those involved in the installation and care of such pitches (ECHA 2017).

There is limited data on the loss of granulate from artificial grass pitches to the environment in the form of microplastics. Some countries have investigated the issue (Sundt et al. 2014, Lassen et al. 2015), and proposed local measures such as better design and maintenance (Sundt et al. 2016).

In HELCOM and OSPAR, acquisition of knowledge about sources and dispersal pathways for microplastics is ongoing and regional summaries will be developed within both of the conventions by 2017. Sweden, as well as other countries within the conventions, contributes to the work through, among other things, national surveys, which provide input to regional summaries and the development of measures.

The International Football Federation, FIFA, has an environmental programme, Football for the Planet, which aims to help reduce the environmental impact of FIFA's activities. FIFA has recently decided to conduct a life-cycle analysis of all its artificial grass pitches around the world[32]. Microplastics spread is one of the main elements of the project.

[32] http://www.eunomia.co.uk/eunomia-investigating-how-green-football-turf-is-for-fifa/

5.3.3 ASSESSMENT OF THE POSSIBILITIES FOR MOVING TOWARDS REDUCED NATIONAL EMISSIONS

It is difficult to see that it is possible to control/divert the driving forces away from the trend of building artificial turf plans. The benefits to society are probably too great. The governance will then be more focused on one of the following options:

- finding substitutes for rubber granulate as filler material or pitches constructed entirely without filler material
- to reduce the loss and despersal the rubber granulate from the pitches
- and/or to prevent waste from ending up in the environment.

SUBSTITUTES FOR RUBBER GRANULATE AS FILLER MATERIAL OR PITCHES CONSTRUCTED ENTIRELY WITHOUT FILLER MATERIAL

Substitutes for rubber granulate as filler material are already on the market but are more expensive than SBR. The Swedish EPA welcomes initiatives to develop and test new filling materials for artificial grass pitches to find the best alternatives from a health and environmental point of view. However, there is no basis for the Swedish EPA to recommend one type of filler material over another. Comprehensive analysis of potential environmental and health impacts throughout the life cycle of the material would be required to assess whether one material is better than another. Such an assessment would also require extensive knowledge of the technical characteristics of the material and its suitability for use as filler material in artificial grass pitches. We also currently believe that it is not the role of the Swedish EPA to recommend one specific material over another available on the market. The responsibility for safe use of materials lies with companies. This type of steering mechanism could also inhibit the development of new materials.

There is also the development of completely new types of pitches, such as hybrid grass. The Swedish EPA lacks the knowledge and expertise to assess how the construction of this type of pitch can and should be developed.

REDUCING THE LOSS AND DESPERSAL OF RUBBER GRANULATE FROM THE PITCHES

The loss is partly made up of local emissions from each artificial pitch and partly made up of diffuse emissions from individual players who carry the material on their footwear and clothing. The diffuse emissions from players are difficult to do anything about because it comes down to a very large number of individuals' behaviours. This is why the focus should be on targeting the local emissions from the pitches. The size of the loss will depend on how the pitch and its surrounding environment are designed and on how the pitch is managed and maintained.

Design

Improved design of pitches and their surroundings can reduce loss, for example by creating hardened surfaces adjacent to the pitch, special snow containment areas and equipment for the treatment of stormwater and wastewater. Pitch design is set at the time of its order. Most pitches are ordered by municipalities through public procurement procedures. The development of procurement criteria could therefore have a steering effect on the design of the pitches.

Care and maintenance

Care of artificial grass pitches, such as snow clearance in the winter, causes a large part of the loss of rubber granulate, partly due to a lack of knowledge of how to care for and clear an artificial pitch. This lack of knowledge can be addressed by information or by training pitch operators how to optimise management and minimise loss. Another tool to reduce the amount of waste is to have a specific plan for how each artificial pitch should be managed and maintained.

The Swedish EPA considers that existing studies and data show that there is a loss of rubber granulate from artificial grass pitches. We also believe that there are relatively simple measures that can be applied to reduce the level of the loss. As rubber granulate is a relatively inexpensive material, the financial incentives to reduce loss are limited. Further steps need to be taken to reduce the level of loss.

PREVENT THE LEAKAGE FROM SPREADING TO THE ENVIRONMENT

As a complement to measures to reduce loss, measures may also be needed to reduce the loss of granulate to the environment. Where possible and appropriate, technological actions should be taken to prevent the granulate that is lost from the pitch from entering the (acquatic) environment. Collection in stormwater cisterns, drainage systems, purification facilities and dewatering are examples of technological solutions that can be used.

5.3.4 Gaps in knowledge

As described above, there are still several uncertainties regarding artificial grass pitches as a source of microplastic and the risks that they may entail. The uncertainties include:

- There are no reliable figures on the amount of granulate that is lost
- There are no definite figures on how much of the leakage is spread through different dispersal pathways and where it ends up
- There are uncertainties about hazardous substances in the various types of rubber granulate and the potential risks that they could entail.

5.3.5 Overall Assessment

The Swedish EPA notes that large quantities of granulate is lost from artificial grass pitches every year and that some of these losses are released to the environment. This loss may pose environmental risks both through the release of microplastics into the environment and by the fact that different types of granulate may contain hazardous substances.

There are measures that can reduce the amount of granulate lost from artificial grass pitches and prevent the release of granulate into the environment. There is no collective information about these measures and their efficacy. There is also no overall assessment of what measures are reasonable to take in the construction and maintenance of an artificial pitch from a cost perspective. The actions that are reasonable and effective to take are likely to vary between pitches, for example, depending on the age and location of the pitch. However, our assessment is that there are relatively simple and inexpensive measures that should be taken by anyone who owns and/or operates an artificial pitch.

Most existing and expected new artificial grass pitches are owned, or will be owned, by municipalities or municipally-owned companies. This means that the purchase and construction of the pitches, as well as the purchase of filler materials and, in some cases, the management of the pitches must take place in accordance with the Swedish Public Procurement Act (2016:1145). Municipalities face similar challenges, and there is a demand for solutions that reduce the environmental impact of the pitches, for example leakage of granulate. Suppliers of artificial grass pitches, both established and potential, should therefore have incentives to develop new solutions that meet the demands. Artificial grass pitches are a fairly new phenomenon in this context, which means that one can expect that completely new concepts can be developed and existing solutions developed further.

The Swedish EPA has, in consultation with the Swedish National Agency for Public Procurement and Swedish local and regional authorities, made the assessment that many of the challenges that exist regarding both the construction, maintenance and maintenance of artificial grass pitches can now be addressed by improving the quality of procurement.

5.4 Proposals for measures

5.4.1 Pre-purchase procurement groups to reduce the environmental impact of artificial grass pitches

In the light of the fact that public procurement is a central tool for purchasing, construction and, to a certain extent, management of artificial grass pitches, the Swedish EPA recommends that work to reduce the loss of microplastics and other pollutants from artificial grass pitches be conducted within the framework of public procurement.

There is currently no comprehensive and evaluated knowledge of the best possible design, care and maintenance that will reduce the loss of rubber granulate and other pollutants, while the number of artificial grass pitches is increasing rapidly. The Swedish EPA, together with the National Agency for Public Procurement, therefore considers that problems with the procurement and management of artificial grass pitches can be solved in a relatively efficient way by a so-called pre-purchase procurement group.

A pre-purchase procurement group is a multiple year collaboration between the various procurement agencies (and on individual occasions also others who carry out procurement under similar terms) aimed at improving the quality of procurement through joint knowledge-building and collaboration on requirements and procurement methods. [33] The Swedish Energy Agency, which has worked with pre-purchase procurement groups and innovation procurement since the 1990s, considers that pre-purchase procurement groups are an effective way of achieving new solutions.

In the case of artificial grass pitches (AGP), a pre-purchase procurement group could work on the requirement to purchase solutions that prevent the loss and dispersal granulate from artificial grass pitches, as well as other types of measures

[33] In the 2016 national procurement strategy, the Government calls on procuring authorities and entities to promote the use of innovation procurement, including by providing support to pre-purchase procurement groups. The Government has also given the National Agency for Public Procurement a special government mandate to promote the creation of pre-purchase procurement groups.

that reduce the environmental impact of AGPs. By agreeing on methods, requirements and criteria, procurement can be conducted more effectively and will lead to better competition in the market. A possible result of the pre-purchase procurement group's work is that the municipalities will initiate an innovation procurement process for new solutions for artificial grass pitches. A potential pre-purchase procurement group presupposes that there is sufficient interest among the municipalities. We have been in dialogue with Swedish Association of Local Authorities and Regions (SALAR) and several municipalities and believe that such an interest exists.

The Swedish EPA will initiate a pre-purchase procurement group to discuss reduced environmental impact from artificial grass pitches during 2017 and will investigate the possibilities for long-term funding of pre-purchase procurement groups. SEK 1 million has been set aside for 2017. The funding requirement for running a pre-purchase procurement group for AGPs is, however, approximately SEK 1.9 million per year over at least a three-year period. This includes a permanent secretariat function and funding of several pre-studies.

A budget is required for (see also impact assessment below):

- co-financing of a secretariat function up to 50% of the cost. The remainder will be co-funded by the members of the pre-purchase procurement group. SEK 900,000 per year over a 3-year period is expected to be required for the proposed pre-purchase procurement group for AGPs.
- Full funding of pre-studies (100%) of SEK 1 million per year for 3 years for the proposed pre-purchase procurement for artificial grass pitches.

IMPACT ASSESSMENT

Stakeholders

Pre-purchase procurement groups usually consist of representatives from activities in municipalities, county councils and the state, but companies can also participate. In this case, a procurement group should be made up of those responsible for the municipalities' leisure administrations/real estate companies, sports facilities, etc. A central aspect is that the municipal representatives have a mandate and an opportunity to influence future investments and procurement of artificial grass pitches in their respective municipalities.

We also believe that the following authorities should play a supporting part for a pre-purchase procurement group based on their areas of responsibility: The Swedish EPA, the Swedish National Agency for Public Procurement, the Swedish Chemicals Agency, the Swedish Agency for Marine and Water Management and the County Administrative Boards. In addition, Sweden's municipalities and county councils should be included as a collective organisation in a pre-purchase procurement group for artificial grass pitches.

Costs

A permanent secretariat function will be needed for the pre-purchase procurement group to function efficiently over time, as well as funding for pre-studies and projects. In addition, there are additional costs for the Swedish EPA to initiate work with pre-purchase procurement groups, as well as administrative costs for the municipalities, agencies and other stakeholders who participate in the pre-purchase procurement group.

- *Secretariat function*
  The task of a secretariat is to organise meetings, produce decision-making data, manage administration around pre-studies and write applications for major development projects. The function can be performed by one of the members of the pre-purchase procurement group, a trade association, consultant company or similar. The most appropriate role for a secretariat in this case remains to be examined.
  A pre-purchase procurement group should operate over several years to achieve results. The secretariat function for the Energy Agency's small pre-purchase procurement groups is usually granted funding for 3 years at a time with funding of approximately SEK 900,000 per year The Energy Agency applies the Block Exemption Ordinance, Article 27 Innovation Clusters, as its basis for support. The funding level is 50% and the working hours of members is counted as co-funding.
- *Pre-studies*
  Pre-studies may include surveys, small studies and tests, as well as various forms of decision-making data. The results of the pre-studies may include proceeding and starting a development project, initiating an innovation contract or developing new requirements or criteria for procurement. Experience from, among other things, the National Agency for Public Procurement is that funding for pre-studies should be available in order not to lose pace and maintain commitment among those involved in the pre-purchase procurement group. It has also been shown that the pre-studies should receive 100% funding. The reason is that these are projects in early stages that can be difficult to link to a direct benefit for an individual stakeholder. For example, the Swedish Energy Agency has set aside a budget of approximately SEK 1 million per year for pre-studies for its newly started pre-purchase procurement group "Small houses".[34]
- *Projects*
  The costs of the pre-purchase procurement group projects, such as development projects and innovation procurement, vary and cannot be determined precisely. Funding of the projects is proposed via public authorities and other institutions' regular call-offs, see below.

If more is required, members of the group need to seek additional funding for larger projects. Any pre-purchase procurement groups in the Swedish EPA should be able to search in, for example, the Swedish EPA's own report Urban Innovations - Funding for cutting-edge technologies and advanced system solutions. It is also possible to seek funding from other stakeholders such as Vinnova, the Swedish Energy Agency, industry organisations and other research and innovation centres.

[34] Since the level of funding for pre-studies is 100%, the Block Exemption Ordinance does not apply. The Energy Agency has solved this by signing framework agreements with 2 companies. The Swedish Energy Agency can thus easily call off the pre-studies requested by the pre-purchase procurement groups. A simpler way (without a procurement procedure) for the Swedish EPA could be to make use of the ordinance governing De Minimis aid.

5.4.2 Guidance on legislation for the use of rubber granulate in artificial grass pitches

The Swedish EPA intends to produce guidance on how the legislation is to be applied to granulate in artificial grass pitches. The assessment of whether a granular material should be classified as waste or product is an important issue because it determines whether it is the waste or chemical legislation that must be complied with by the vendor and user of the granular material. The guidance will not focus on loss of granulate from artificial grass pitches. Correct application of the legislation is nevertheless considered to contribute to better handling of the granulate.

The Swedish Chemicals Agency intends, in cooperation with the Swedish EPA, to follow and participate in further work within the EU on risk assessment and regulatory development concerning hazardous and particularly hazardous substances in rubber granulate.

5.4.3 Summary of knowledge

The Swedish EPA has initiated a compilation of knowledge of existing measures to reduce leakage of granulate from artificial grass pitches and intends to complete and publish it. In its work on the compilation, the agency will seek the views of other agencies through cooperation in the Environmental Objectives Council.

THE IMPACT OF THE PROPOSALS FOR GUIDANCE AND SUMMARY OF KNOWLEDGE

More operators should know what legislation they are required to comply with and also take measures to reduce loss and the dispersion of granulate by following the Swedish EPA's guidance and disseminated information. The issue can also be addressed by the supervisory authority, which means that operators will be guided to acquire knowledge and take action.

The stakeholders concerned are the Swedish EPA as the guiding authority, the Swedish municipalities and county councils as the collective organisation and the municipalities as active operators. Other organisations such as the Swedish Football Association and the tyre recycler, Svensk Däckåtervinning AB may also be affected.

Issuing guidance and dissemination of information mean increased administrative costs for the Swedish EPA. At the same time, the guidance and information will facilitate both procurement and construction for municipalities and other operators.

6. Microplastic emissions from industrial production and handling of plastics

6.1 Emission and dispersion of microplastic from industrial production and handling

Material losses from industries producing plastic or plastic products have been identified as one of the sources of microplastics emissions in Sweden. Plastic raw materials, in the form of plastic pellets, are used in the manufacture of plastic products. Material losses of plastic pellets can occur as local emissions to water and air, both from industrial plants producing pellets or plants using pellets as raw materials. Material losses can also occur as diffuse emissions when transporting plastic pellets between these plants. IVL estimates the total annual material losses of plastic pellets in Sweden at 310–533 tonnes. The estimate is based on total production and use of plastic pellets in Sweden multiplied by an emission factor from studies in Denmark and the USA. The extent of these losses that end up in water is unknown (Magnusson et al. 2016).

There are two manufacturers of plastic pellets in Sweden, both located on the coast at Stenungsund. Together, they are authorised to manufacture more than 1,000,000 tonnes of plastic pellets per year. One of the facilities has a license to discharge 6 tonnes of PVC annually to water, but measured discharges to water at the facility amounted to 0.9 tonnes in 2015. There are no measured values for the second facility. There are about 90 manufacturers of plastic products in Sweden that use significant amounts of plastic pellets as raw materials. The extent of material loss from these facilities or during transportation to them is unknown.

Particle type: Plastic pellets

Particle size: Usually 2–5 mm but also smaller beads are found

Plastic type: PVC or polyethylene

Presence of hazardous substances: May be present as additives in the plastic

Ability to adsorb and transport environmental toxins: Unknown

Documented (measured) presence of microplastic from the source in the sea: Unknown

Probability that the emission of microplastics from the source reaches seas, lakes and streams: High – production takes place at coastal facilities. Discharges have been quantified by measurement

Risk of high local emission of microplastic: Yes – from the two manufacturers of plastic

6.2 Causes of emissions

There are behaviours, choices and decisions by various stakeholders that can result in uncontrolled emission of microplastics from industrial production:

- Loss of material from facility manufacturing plastic pellets
- Material loss during transport
- Material loss from a facility using plastic pellets as raw materials.

6.2.1 Material loss from a plastic pellet manufacturing plant

There are currently only two companies in Sweden manufacturing plastic pellets. Inovyn Sverige AB, which manufactures pellets from PVC, and Borealis AB, which manufactures pellets from polyethylene. Both are located on Askerö fjord in the south-west part of the Stenungsund industrial area.

Inovyn Sverige AB is Sweden's only manufacturer of polyvinyl chloride (PVC) plastic raw material. The company has facilities for the manufacture of PVC in the form of suspension PVC (S-PVC) and paste PVC (P-PVC). S-PVC has a grain size of around 0.1 mm, while P-PVC is 0.02–2 µm. The company holds permits in accordance with the Environmental Code. Decisions and judgements regulate the quantities of production and emissions into air and water, information on the measures to be taken and precautions to be taken. The facility has a licence to manufacture a maximum of 260,000 tonnes of PVC per year. The requirements of the licence allow discharge to water of 6 tonnes of PVC per year. Actual production in 2015 was 21,978 tonnes and measured PVC discharge to water was 0.9 tonnes. The wastewater from PVC production is channelled to the company's PVC recycling system and 401 tonnes of PVC were recovered from it in 2015. The largest environmental improvement project in 2015 was the installation of a large bag filter in the PVC factory. At the end of the year, a project was started to minimise dust when loading bulk and container vehicles (Environmental Report 2015 Inovyn Sverige AB).

Borealis AB is the only polyethylene manufacturer in Sweden. Customers make, among other things, pipes and cable insulation from the polyethylene (PE) produced by Borealis AB. The environmental licence granted to the polyethylene plant in 2007 allows production of 750,000 tonnes of polyethylene per year. Actual production in 2015 amounted to 532,000 tonnes. There are no requirements governing how much plastic can be discharged with wastewater or into the air. However, the company is subject to the condition that it must investigate how emission of plastic particles can be minimised. In a separate judgement dated 05/06/2015 (case no. M 2292-06) the Land and Environment Court at Vänersborg passed the decision that particle filters with 10 µm pore size for stormwater and process water must be installed and operational no later than 1 August 2016. Borealis has invested in two new filters to purify microparticles from water. One will filter stormwater, the other the factory's process water. Under trial conditions the filters captured more than 99 per cent of the microparticles (Environmental Report 2015 Borealis AB).

Borealis (2015) has identified three risk areas for leakage of plastic pellets and microplastics, as well as the measures that can be taken:

- Plant water (purification of stormwater and process water)
- Snow removal (storage of all snow at the site)
- Goods vehicles (No use of open vehicles).

6.2.2 Material loss during transport

Material loss can also occur during transport, i.e. after it has left the manufacturing plant and before it reaches the facility that will use plastic pellets as a raw material. All plastic pellets are packed in bulk and leave the facilities in Stenungsund by road, but significant parts are then transported further by sea, ferry or rail. There is a risk of loss, both during transport and transshipment to another mode of transport. Transport can be conducted either by the manufacturer itself or by an independent transport company and the carrier will be responsible for any leakage during transport. We have no information about to what extent material losses occur during transportation at present.

6.2.3 Material loss from a facility using plastic pellets as raw materials

Plastic in the form of plastic pellets is used as a raw material in the manufacture of various plastic products. Plastic in the form of plastic pellets is used as a raw material in the manufacture of various plastic products. However, facilities that are subject to licensing under the Environmental Code are registered in the Swedish Environmental Reporting Portal (SMP). Company code 25.20 applies to facilities that use more than 20 tonnes of plastic raw material per year[35] There are approximately 90 facilities within this company code that therefore use significant amounts of plastic pellets. At present, there is no aggregated data on loss of plastic pellet material from these facilities or on the actions taken by companies to prevent such loss (Magnusson et al. 2016). There are also facilities subject to a notification requirement. These are registered in the respective municipalities, but there is no nationwide record showing them all.

[35] Company code 25.20 applies to a facility that manufactures products using further polymerisation 1.) polyurethane without the use of toluene diisocyanate, if production is based on more than 200 tonnes of plastic raw material per calendar year; (2) polyurethane using toluene diisocyanate, if production is based on more than 20 tonnes of plastic raw material per calendar year; or 3.) other plastics, for which production is based on more than 20 tonnes of plastic raw material per calendar year.

6.3 Assessment of the possibilities for moving towards reduced emission of microplastic to the sea

6.3.1 Current governance in Sweden of emission of microplastics

FACILITIES FOR THE MANUFACTURE OF PLASTIC PELLETS

Existing instruments in the form of licences and conditions pursuant to the Environmental Code are in place to govern the two Swedish manufacturers of primary plastics. The conditions include limits on microplastic emission and/or requirements for specific technology/measure to limit the emission of microplastics. The stakeholders seem to be focusing on the issue of the emission of plastic pellets.

FACILITIES USING PLASTIC PELLETS AS A RAW MATERIAL

The industries that use large quantities of plastic pellets, that is, more than 20 tonnes per year, as raw materials in their production of plastic products are also governed by permits and conditions under the Environmental Code. There are currently about 90 such licensed plants in Sweden and the Swedish EPA has conducted a review of the environmental conditions for all of them. The review shows that no conditions directly regulating the emission of plastic pellets or measures to prevent such emissions are present in any of these cases. Only a few operators have conditions that may have bearing on the emission of microplastics.

6.3.2 EU and international processes

Plastic production is regulated in the EU under the Industrial Emissions Directive with a reference document on best available techniques. Within the framework of this description there is some scope for addressing parameters relating to the formation and emission of microplastics from the manufacture of plastics and plastic products respectively. A developed adaptation of plastic production to the problem of microplastic beyond the reference document may be made in the national trials. A revision of the reference document is required for the EU as a whole, but there are no plans for that.[36]

The European Commission has agreed to come up with a plastic strategy within the framework of the Circular Economy Action Plan. The strategy is planned for presentation during 2017. The plan is to address the conditions for disconnecting plastic production from dependence on fossil raw materials, reuse of plastic and reduction of leakage of plastic to the environment.[37]

The HELCOM Marine Litter Action Plan contains no activity specifically directed at plastic pellets from production. The pellets are part of the concept of primary microplastics. OSPAR addresses plastic pellets through a dedicated activity aimed at encouraging the industry to participate in voluntary initiatives and exchange

[36] BREF document Reference Document on Best Available Techniques in the Production of Polymers, August 2007.
[37] COM(2015)614, 2.12.2015.

good experiences to reduce emissions across the chain.[38] One such international initiative is Operation Clean Sweep, which was launched by the plastic industry in the USA in the 1990s. The companies that join the initiative undertake to set up systems and train staff so that pellets are handled in such a way as to minimise emission to the environment (zero pellet loss). The initiative has authored manuals and good examples to support companies. However, there are no publicly published data on the effectiveness of these measures, nor any quantification of the volumes of pellets that are prevented from being released to the environment.

The global transport of plastic pellets is widespread, especially at sea, and there is a high risk of emissions. Loss of cargo, particularly containers, is relatively frequent. MARPOL prohibits deliberate dumping of plastic, including pellets, from ships and offshore structures in international waters[39]. Enforcement is, however, very difficult.

6.3.3 Assessment of the possibilities for moving towards reduced emission in Sweden

The two major stakeholders in the manufacture of plastic pellets are currently governed by licences and requirements that regulate emission of plastic pellets/microplastics are a factor in the licensing process. The companies are also working on voluntary initiatives to minimise the emission of microplastics. At present, the Swedish EPA considers that no further control is justified to reduce emission of microplastics from manufacture of plastic pellets.

According to the primary plastic manufacturers, transport is conducted largely using enclosed vehicles, so it can be assumed that material loss during transport is relatively small. However, it can be assumed that at least some loss of material occurs in connection with transport. As many operators are involved – although we do not know how many – in the transport chain and the emissions of microplastics are diffuse, the possibilities to direct towards a reduction of microplastic emissions are considered to be limited. Therefore, no further governance is proposed at present.

For the approximately 90 facilities that use large quantities of plastic pellets to manufacture plastic products, and which are therefore subject to requirements under the Environmental Code, there are currently no requirements that affect material loss of plastic pellets. Future development of such requirements is considered to be useful. The requirements are normally only reviewed when the companies in question make an application for a review of the activities. The Swedish EPA may initiate a review by guiding the review authorities, but at present it does not consider that there is a factual basis that would justify a review of requirements. However, the Swedish EPA is a referral body when requirements are reviewed and can thereby exert influence on the requirements.

In addition, the Swedish EPA could guide the review authorities to include the issue of microplastics in their requirements for facilities that use large volumes of plastic pellets. The supervisory authorities also have the opportunity to focus on the issue of microplastics in their supervisory work. One way of achieving this could be

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[38] Action 52 (zero pellet loss) promotes initiatives and exchange of best practice aiming at zero pellet loss (for example operation Clean Sweep) along the whole plastics manufacturing chain from production to transport. OSPAR Marine Litter Regional Action Plan.

[39] International Convention for the Prevention of Pollution from Ships, Annex V. Implemented in the EU via Directive 2000/59/EC.

for the Swedish EPA to include the issue of microplastics in its guidance. The guidance could also include operators in matters such as inventory of material losses, handling methods and examples of effective measures.

6.3.4 Gaps in knowledge

We have no current information about to what extent material losses occur during transportation.

Nor do we know the extent to which material losses are incurred from facilities using plastic pellets as raw material. We have identified about 90 facilities whose operations are governed by permits, but there is also an unknown number of plants who only have a notification requirement. Although it can be assumed that these facilities handle relatively small volumes of plastic pellets per facility, emissions may be significant if there are many facilities of this type.

6.4 Proposals for action

6.4.1 Guidance to authorities and operators

To draw the attention of review authorities, supervisory authorities and operators to the issue of microplastics, the Swedish EPA intends to include the issue of material losses of microplastics in the guidance to these three stakeholder groups. The aim is to raise awareness among review authorities, supervisory authorities and operators of the material loss issue and provide examples of appropriate measures.

The guidance will also enable facilities who are required to make notifications to be reached when the municipalities are the supervisory authorities for these. Guidance should be developed in line with the emergence of new knowledge of microplastics. It is difficult to justify more stringent instruments in view of the current state of knowledge about environmental problems. However, the knowledge gaps identified here are not seen as a problem as guidance will focus on best practice regarding measures to minimise material losses.

Another type of facility that could have similar emissions to those described above is recycling facilities that are authorised for mechanical processing of plastics, which means that plastics are being refined through fragmentation to make new plastics material that can be used in manufacturing. There are about 30 such facilities in Sweden. We have little knowledge about material losses from these fragmentation plants, but as the same types of issues and measures are relevant to these plants, they should be encompassed by the guidance provided under the above proposal. See also section 3.2.3.

6.4.2 Impact of the proposal

CHANGE COMPARED TO THE CURRENT SITUATION

The Swedish EPA is developing guidance to bring the issue of microplastics to the attention of review authorities, supervisory authorities and operators. If the guidance is accepted, these issues will be addressed in future review and supervision, which may mean that companies not currently checked for microplastic emissions may be influenced to take measures to prevent such emissions.

STAKEHOLDERS

- The proposed guidance will be directed at the following review authorities, supervisory authorities and operators: The Swedish EPA as the guiding authority.
- County Administrative Boards that carry out supervision.
- Municipalities carrying out assess permit applications and carry out supervision.
- Facilities using plastic pellets as a raw material.
  (About 90 facilities with a permit requirement B and unknown number with notification requirement C
- Fragmentation plants (approx. 30 facilities)

IMPACTS

- Increased administrative costs for the Swedish EPA due to the inclusion of the issue of emission and measures for microplastic in the guidance. 4-8 pv.
- Increased administrative costs for County Administrative Boards due to the inclusion of the microplastic aspect when setting requirements and supervision.
- Increased administrative costs for Municipalities due to the inclusion of the microplastic aspect in supervision.
- In the long term, increased costs of environmental measures for facilities that need to introduce measures after testing and/or supervision.
- In the long run, lower material losses of plastic pellets from these facilities and therefore lower introduction of microplastics to aquatic environment.

The extent to which these impacts are realised depends on the extent to which guidance has an impact among review and supervisory authorities. However, the Swedish EPA's experience is that the existing guidance is used by most authorities and operators.

7. Microplastic emissions from textile laundry

7.1 Microplastic in textiles

Several national and international assemblies have identified synthetic textile fibres as one of the largest sources of microplastic in the oceans.[40] In the survey of the sources supplying Swedish wastewater treatment plants (ARV), emissions of microplastic from laundering textiles[41] are estimated to be the largest upstream source (see Chapter 10.1). The emission of microplastics is mainly due to wear of textile synthetic fibres that occurs during use and laundering. In total, the microplastic emissions from synthetic fibres that go to Swedish wastewater treatment plants are estimated to be between 8–945 tonnes per year (Magnusson et al. 2016). The corresponding figure for Norwegian wastewater treatment plants is estimated at around 600 tonnes per year (Sundt et al. 2014).

In Sweden we consume around 128,000 tonnes of textiles per year, of which approximately 30–40% are estimated to be made of synthetic fibres (Schmidt et al. 2016). Synthetic fibres are usually made from petroleum products. The most common synthetic fibre is polyester fibre, followed by nylon, acrylic and polypropylene fibres (Technon OrbiChem 2014). Demand has risen sharply since the first man-made fibres were developed in the 1930s. Man-made fibre production increased by almost 300% between 1992 and 2010, from 16 to 42 million tonnes globally (Boucher and Friot 2017). Global synthetic fibre production in 2015 amounted to 60 million tonnes and accounted for about 65% of total fibre production[42], indicating that over 50% of all textiles used in the world (clothing, home textiles, technical textiles, etc.) are at least partially synthetic fibres (Magnusson et al. 2016).

The biggest increase in man-made fibres is in developing countries, where the demand for such fibres is also highest. The world's population today stands at 7 billion and is expected to be close to 9 billion by 2050. By 2030, another 3 billion people are expected to be among middle-class income earners, probably with the desire to be able to consume to the same extent that we in the Western world do today. In combination with the fact that cotton production is considered to have reached its peak and is not expected to increase, this means that demand for alternative materials and synthetic materials is expected to increase to meet the growing global textile demand (Oglund et al. 2015).

[40] E.g., Boucher and Friot (2017), Sundt et al. 2014, and Lassen et al. 2015).

[41] Textile fibres can be divided into natural fibres (cotton, wool, silk) and manufactured fibres (man-made fibres). Man-made fibres can have a natural or synthetic origin (synthetic fibres). Synthetic fibres include elastane, acrylic, polyamide, nylon and polyester. The natural artificial fibre group includes viscose. (Nationalencyklopedin 2016)

[42] Fibres in synthetic, cellulose, wool and cotton (The Fiber Year Consulting 2016; CIRFS 2016).

7.2 Release to sea and streams

All textiles, regardless of fibre and material, get worn and torn during use and washing, resulting in microparticles in the form of small fibres that are shed from the textiles. In the case of man-made fibre textiles, wear means that microparticles made of plastic are shed during laundry and are then carried away by the wastewater. A small proportion of this is estimated to reach sea, lakes and streams, as most of it is deposited in the slurry. Polyester microparticles prove to be the most commonly found synthetic fibre from textiles in sediments and wastewater worldwide, followed by acrylic and polyamide fibres (Browne et al. 2011). Natural fibres, such as cotton or wool, degrade in the environment. However, synthetic fibres are problematic because they degrade very slowly. Chemicals present in wastewater, such as plasticisers or flame retardants, can also be adsorbed onto particles (stick to the surface) and are then dispersed further (Wilcox et al. 2016). The amount of particles generated varies depending on many parameters, including the type of textile fibre. Most of the larger particles (larger than 300 µm) are filtered out to the sludge in the wastewater treatment plants[43] (see Chapter 10.1). The emissions to seas, lakes and streams released by wastewater treatment plants from textile laundry are estimated to total 0.2–19 tonnes per year (Magnusson et al. 2016).

7.3 Causes of emission of microplastic from textile laundry

There are several behaviours, choices and decisions that cause emission of microplastic from textile laundry:

- *Material composition* - textiles are designed and manufactured in man-made materials.
- *Construction* - textiles are made in such a way (knitted/woven) that causes man-made fibres to be released from textiles during laundry.
- *Choice of consumption* - consumption of synthetic fibre textiles contributes to emissions.
- *Laundry method* - textiles are washed in a way that causes more synthetic fibres to be released during laundry.

7.3.1 Production and design

As stated above, man-made fibre manufacture constitutes a substantial part of total global fibre manufacture. Textiles can also be designed in such a way that microplastic synthetic fibres can easily be emission from the textiles during laundry. However, designers, manufacturers, buyers (or consumers) have not been aware of the microplastics issue for very long. A fundamental problem is that environmental costs, in this case environmental costs caused by emissions of microplastics, are not included in the final

[43] A study at three Swedish treatment plants has shown that incoming water can contain more than 20,000 microplastic fibres per m^3. Exhaust water had concentrations of between 150–3,300 microplastic fibres per m^3 (Magnusson and Wahlberg 2014)

price of textiles. Manufacturers do not, therefore, pay for the environmental impact of the products they manufacture and market. There are therefore problems with external effects.

Releases are dependent on the large quantity of man-made textile fibres and on the quantity of micro-plastic fibres emission when the material suffers wear during use and laundry (see also 7.3.3). Material composition (fibre mix, fibre type, i.e., filament fibres or short fibres) and construction (spin, weave, or knitting technique) affect the volume of microplastic fibres that are emission during laundry. Carney Almroth et al. (under review) have quantified the precipitation of synthetic fibres from textiles for three synthetic materials: acryl, nylon and polyester. Different knitting techniques have also been studied. The study finds that different types of material and construction generate different quantities of microplastic fibres during laundry, where, for example, a product made of PET fleece material[44] can precipitate up to 110,000 fibres in a single wash. The study shows that products made from loose structures precipitate more than products made from a tightly knitted construction. The proportion of plastic microfibres emission during laundry can be reduced by changing the design of the products, according to the authors of the study (Carney Almroth et al. under review). This is also supported by EU research results (MERMAIDS Consortium et al. 2017).[45]

7.3.2 CoNsumption

On average, we consume more than 13 kg of textiles per person per year in Sweden, of which 30–40% are produced from man-made fibres (Schmidt et al. 2016). High consumption of newly produced man-made fibre clothing leads to higher microplastic emissions as garments have been shown to emission the most microfibres from the first washes (Folqueue 2015). Problems at the consumption stage include a lack of information to consumers about the way in which the product has been manufactured and the fact that the material can contribute to the emission of microplastics. This means that consumers cannot make informed choices based on full information about the environmental and health impacts. The prevailing behavioural culture also has an influence, because price and fashion largely govern the choice of consumption at the time of purchase.

There is also a lack of knowledge about how we care for our clothes (e.g., wash gently, not so often, air instead, use low temperatures etc.). Since the actual environmental costs (emissions of microplastic particles) are not included in the price, access to inexpensive textiles is high. The result is high levels of consumption and low incentives to change behaviour. Consumers base their purchases on inadequate information and buy more than is optimal for the economy (Swedish EPA 2016).

[44] Fleece can be derived from recycled PET bottles.
[45] See also www.life-mermaids.eu

7.3.3 Textile laundry

The largest proportion of laundry is conducted in domestic households.[46] In Sweden we generate about 200–300 kg of laundry per person per year (Pakula and Stamminger 2010). The amount of synthetic fibres shed per kilogram of textile during laundry varies and there is currently insufficient data on the volume of man-made fibres emission by an average household (Magnusson et al. 2016). There are several studies that have analysed the proportion of man-made fibres that are shed during laundry. For example, Napper and Thompson (2016) show that a wash of 6 kilograms of synthetic material can shed between 138,000 and 729,000 fibres. However, analysis methods differ between the studies and it is therefore difficult to compare the results. A new report from the pilot project "Microplastics shedding"[47], in the research project "Mistra Future Fashion" 2011–2019[48], highlights that there is currently no standardised test method for emission of textile microplastics. The authors argue that a more standardised method would improve the ability to compare the shedding of microplastics between different materials (Roos et al. 2017). In addition, the volume of textile fibres shed during laundry depends on several factors such as the number of washes, the type of material, washing temperature, the use of detergent/softener, washing machine and spin drying (see for example Napper and Thompson 2016; Folqueue 2015).

7.4 Assessment of the possibilities for reducing emission of microplastic from textile laundry

This discusses the possibilities for preventing the emission of microplastic that is leaked by wastewater treatment plants as a result of washing textiles containing synthetic fibres at both the production and consumption stages.

7.4.1 Current governance in Sweden of emission of microplastics from textile laundry

THE PRODUCTION STAGE

To reduce the emission of synthetic fibres from microplastics during laundry of textiles, the main focus is on the ability to control composition/content (fibre mix/fibre type) and design (e.g. how densely woven). There is no direct governance today in Sweden for the above from a microplastic perspective. However, Sweden has limited control since the manufacture of man-made fibre textiles sold in Sweden is almost exclusively conducted in other countries and outside the EU. Our domestic textile production is small, even smaller than in the other Nordic countries (Palm 2015). In 2013, Swedish production of garments and home fabrics amounted to about 450 tonnes, compared with 2014 when imports to Sweden were 128,000 tonnes (Swedish EPA 2016).[49]

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[46] Based on the assumption that of the 13 kg of textiles put on the market, the largest consumption is by the private consumer.

[47] http://mistrafuturefashion.com/sv/nytt-projekt-undersoker-mikropartiklar-fran-polyestertyg/

[48] http://mistrafuturefashion.com/sv/hem/

[49] The inflow of textiles increased by almost 40% in the early 2000s and then plateaued but is now still at a high level (Swedish EPA 2016).

However, the above-mentioned research programme “Mistra Future Fashion” aims to improve the environmental performance of fashion and clothing, and part of the programme examines sustainability and alternative fibre materials and design. Within the framework of the programme, the pilot project “Microplastics shedding” was recently launched to examine the relationship between textile properties and the shedding of microplastics from polyester fabrics. The project thus contributes to filling a knowledge gap in existing research. In the longer term, there may therefore be opportunities to reduce emissions if more knowledge can be obtained regarding the effects of material compositions and design. However, to achieve better governance that contributes to reducing emissions, a holistic approach will be needed, including the life cycle perspective from design, technology and choice of process and fibre to use, care and waste management (Boucher and Friot 2017).

THE CONSUMPTION STAGE

Household

There is currently no governance directed at Swedish consumers to address the problem of microplastics from textiles during laundry. There have been several information campaigns linked to the chemicals problem, pushing the message that chemicals do not belong in the drains, including the subject of textile chemicals, but not directly linked to microplastics. The knowledge that some textiles cause emission of microplastics during laundry has been reported in the media for the last two or three years, but awareness that all synthetic products contribute to the release of microplastics into the environment is still considered to be limited in many consumers. Information can increase awareness among private consumers, which can have an impact on emissions in the longer term.

There are some studies that suggest that an effective and simple measure to reduce the percentage of microplastics that is emission with laundry water is to use so-called washing bags.[50] The bags are advertised as being able to reduce wear and tear of the synthetic products during laundry and to collect loose fibres, thereby preventing the microplastic particles from being discharged with the wastewater. However, it is uncertain how much effect washing bags can have on emissions.

Procurement authorities

Environmentally-friendly procurement of goods and services in the public sector have been identified as an important instrument. By utilising their purchasing power, public authorities play an important role in promoting the development of a more sustainable direction in the procurement of both textiles and services involving the handling of textiles, such as laundry and textile services. The National Agency for Public Procurement supports purchasers in setting both environmental and social requirements in public procurement. Sustainability criteria are part of this support. Criteria have been developed for procuring textiles and laundry and textile services.[51] Microplastics are not currently included in these criteria.

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[50] For example ”The Guppy Friend” washing bag http://guppyfriend.com

[51] The criteria are drawn up in consultation with stakeholders from both the public and private sectors, such as purchasers, suppliers, trade associations, environmental organisations and authorities. Criteria are developed at three levels, where possible: basic, advanced and leading edge (National Agency for Public Procurement 2017a and 2017b).

Laundries

In Sweden there is currently no direct governance connected to water-based laundries related to the microplastic issue. However, it is probably more important to control different types of laundries due to their use of chemicals, rather than have a one-sided focus on the loss of microplastics. Wastewater from major water-based laundry facilities is normally sampled and analysed for e.g. BOD, COD, oil, phosphorus, nitrogen and metals (Svenskt Vatten 2012). Chapter 31, Section 1 of the Swedish Ordinance on Environmental Licensing (2013:251) places notification obligations (C) on laundry facilities that do not use solvents, if the facility handles more than 2 tonnes of laundry per day. The notification obligations does not apply if discharges of water from the operation are directed to a wast- water treatment plant that is subject to authorisation in accordance with Chapter 28, Section 1 or if the company is subject to registration according to Chapter 19, Section 3. For laundries that are subject to reporting requirements, the notification must be made to the municipality, which is therefore also responsible for supervision. There are examples of municipalities that have produced guidelines for new establishments and changes to laundries, such as the City of Stockholm.

7.4.2 Governance and relevant processes in the EU and internationally of emission of microplastics from textile laundry

Negative effects of textile manufacture have long been widely recognised globally, but mainly at general level linked to chemical and water use, for example. There are a large number of initiatives and processes in place regarding sustainable manufacture and consumption of textiles in the Nordic countries and the EU, and also globally.[52] For example, the UN leads the implementation of a 10-year framework of programmes for sustainable consumption and manufacture (called 10YFP). The Swedish EPA is a focal point in Sweden, which means that we should inspire action by spreading good examples and raising awareness of the need to switch to more sustainable consumption and manufacture. Sustainable textile chains are an area that is under discussion for being given priority in the future within the programme.[53]

However, microplastic is generally a relatively new concept and few processes include the shedding of microplastic fibres during laundry as an environmental parameter. However, microplastic is generally a relatively new concept and few processes include the shedding of microplastic fibres during laundry as an environmental parameter. The commission handed to the Swedish EPA's by the Government's concerning handling of textiles[54] also highlights that EU legislation may need to be developed to address design issues for textiles in particular because Sweden has limited opportunities to influence textile manufacturing issues due to EU rules on the free movement of goods (Swedish EPA 2016). This could also have an effect on emission of microplastics.

[52] For example, work is under way with "'conscious textile and garment manufacturing chains, which are run by, for example, the Sustainable Apparel Coalition (http://apparelcoalition.org/the-higg-index/).

[53] http://www.naturvardsverket.se/Miljoarbete-i-samhallet/sverige-i-varlden/Hallbar-konsumtion-och-produktion/Internationell-satsning-pa-att-bryta-ohallbar-konsumtion-och-produktion/

[54] http://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Regeringsuppdrag/Redovisade-2016/Hantering-av-textilier/

In 2015, the Nordic Council of Ministers adopted an action plan for sustainable fashion and textiles. The vision of the action plan is for the Nordic fashion and textile industry to become a leader in sustainable design, manufacture and handling of textiles and contribute to sustainable development and green growth in both the Nordic countries and around the world (Nordic Council of Ministers 2015). Shedding of microplastic fibres during laundry is not mentioned as an environmental parameter, but there are several proposals that could contribute to reducing shedding, such as the development of fibres and design for more durable textiles and advice to consumers on the handling and washing of clothes. The principles of the EU's Circular Economy Action Plan also cover textiles and several EU projects have been funded to support developing the textile industry toward a circular economy. Two examples are the projects RESYNTEX[55] which will develop a method for recycling man-made fibres and the European Clothing Action Plan (ECAP)[56] which focuses on creating a sustainable chain for clothing, from manufacture and design to waste management. None of the projects currently have any particular focus on the shedding of microplastic fibres during laundry. However, in the context of increased awareness of the environmental impact of microplastics, it is possible that awareness of the subject will be raised during these initiatives.

The "Ocean Clean Wash" campaign is[57] a global coalition initiated by "The Plastic Soup Foundation"[58], which includes the EU Life + MERMAIDS[59] project. The MERMAIDS project aims to examine the volume of microplastic fibres shed by textiles during laundry and has studied various methods for reducing shedding, such as the type of detergent, pre- and post-treatment for laundry and filter solutions in washing machines. The results from MERMAIDS that were presented in May 2017 include consumer information, results from filter solutions in washing machines and policy recommendations (see press emission[60]). There are also several international initiatives by the industry and private operators to develop various filter solutions[61] or microplastic collectors for washing machines, such as the "Guppy friend" and the "Rozalia ball"[62]. Initiatives on how to wash clothes to reduce fibre shedding have also been introduced on the initiative of both the clothing industry and environmental organisations.

The EU Ecodesign Directive[63] is often referred to as a possible instrument that could be developed to address microplastic shedding from textile laundry. In the EU, requirements for the performance of washing machines are regulated by the Directive, i.e. energy efficiency, washing efficiency and water consumption. The Directive is also open for the regulation of other parameters. However, it must be possible to monitor the requirements under the Directive. A review of the requirements for washing

[55] http://www.resyntex.eu/

[56] http://www.ecap.eu.com/

[57] http://oceancleanwash.org/campaign/

[58] http://www.plasticsoupfoundation.org/en/

[59] "Mitigation of microplastics impact caused by textile washing processes" (http://life-mermaids.eu/en/about/this-project/).

[60] http://www.plasticsoupfoundation.org/en/2017/05/fibers-from-synthetic-clothing-disastrous-for-mankind-and-the-oceans/

[61] For example, see Bruce et al. 2015.

[62] http://rozaliaproject.org/stop-microfiber-pollution/

[63] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products.

machines is currently under way, but microplastics have not yet been discussed in the EU consultation Forum, which deals with this. However, 'requirements' other than energy use in the user phase will be introduced for washing machines in the ongoing revision, such as resource efficiency requirements. The Swedish Energy Agency participates in this consultation forum as the responsible authority in Sweden, and regularly reconciles its position with the Swedish cooperation group for the Ecodesign Directive. The Swedish EPA, the Swedish Chemical Agency, the Swedish National Board of Housing, Building and Planning, the National Electrical Safety Board and the National Agency for Public Procurement participate in the national group.

HELCOM and OSPAR are primarily focused on an ongoing process of knowledge gathering. Synthetic textile fibres are mentioned as a part of microplastics in the regional action plans, but any direct measures to reduce emissions to the marine environment have yet to be developed. Both HELCOM and OSPAR intend to produce an overview of sources of microplastics and how they can be regulated in 2017.

A general difficulty in regulating emissions of microplastic fibres from textiles is the lack of standardised definitions and measurement methods (Roos et al. 2017; Sundt et al. 2016). In Norway, a proposal has been made for the development of a standard method for analysing volumes of textile fibres shed during laundry. Although this does not directly lead to reduction in emissions, it is considered that such a common tool fulfils a basic need for follow-up and also an incentive for textile manufacturers to change the design and composition of textiles (Sundt et al. 2016).

Textile manufacture in the EU is covered by the EU Industrial Emissions Directive (2010/75/EU). The work on the Directive will review the EU reference document BREF Textile 2003[64] on best available techniques (BAT) for the textile industry in the coming years. BAT covers the manufacture of all textiles including man-made fibres. Updated BAT conclusions and reference documents concern all new industries in all EU countries and will also form a starting point for the examination and review of both new and existing textile industries in the EU. The revision of the EU reference document could also include data on the emission of microplastics from production processes in the textile industry. Future revisions of BREF Textile may also have some impact on production facilities outside the EU, as many manufacturers already refer to BREF's compliance with emission regulations (EU Commission 2003).

7.4.3 Overall assessment of national governance possibilities

The Swedish EPA considers that the solutions should focus primarily on dialogue with industry, information and consumption guidance. The Agency also notes that there are gaps in knowledge regarding the properties of textiles and that more research is needed to help reduce shedding of microplastics from textile laundry.

In the production stage, the Swedish EPA considers that the possibility of limiting the formation of microplastics that occurs in washing as a result of wear of synthetic fibres is limited in the short term. This is because textile manufacture is almost exclusively conducted in other countries and Sweden therefore has no control over the introduction of instruments to tackle environmental problems effectively in the short term in a socio-economic way.

[64] http://eippcb.jrc.ec.europa.eu/reference/txt.html

In addition, the Swedish EPA considers that there is currently a general lack of knowledge of the microplastic issue among both purchasers and manufacturers. For example, there is no knowledge of how the problem can be solved through choice of fibre, production process and design techniques. The Swedish EPA considers that there is a need to get a comprehensive grip on available information and knowledge and to identify further gaps in knowledge, in addition to those already identified. Existing knowledge and information also needs to be shared between stakeholders, such as researchers, designers, manufacturer and other relevant textile stakeholders. The same applies to existing knowledge of measures that could minimise the shed of microplastics from textile fibres.

Although there have been some studies, the Swedish EPA notes that there is currently a lack of research into the properties of textiles. Existing research notes that there is a clear correlation between the amount of synthetic fibres shed during textile laundry due to wear and tear and the design of fibres and materials. However, there is still a need to study and analyse different fibre designs, as well as various spin, weave and knitting methods, to identify whether existing methods minimise the proportion of microplastic particles shed during washing. Although there is some research into different materials (e.g. polyester), there is still a need to study whether there are any differences between different man-made materials such as polyester, polyamide, elastane, acryl etc.

In the consumption stage, the Swedish EPA considers that, in the short term, the possibility of limiting the occurrence of microplastics, as a result of wear of synthetic fibres that occurs during laundry, is limited. The Swedish EPA's assessment is that there is no knowledge at the consumption stage about whether specific fibres and materials give rise to microplastics and whether this is a quality issue and how textiles can/should be used/washed to reduce the emission of microplastics. Domestic knowledge can be increased through provision of information on how more gentle washing of textiles can help to reduce the amount of microplastic particles (linked to parameters above such as wash temperature, use of detergents, etc.).

In the longer term, increased knowledge of the environmental problem and practical advice can influence consumption choices and change behaviours, thereby contributing to reduced microplastic shedding during laundry. The Swedish EPA further believes that more information can be provided to commercial laundries, partly general information about microplastics that are released by washing and partly the practical measures that laundries can introduce to minimise microplastic released, for example, by using gentler washing methods. For the same reasons, procurement authorities need more information and, potentially, guidance about microplastics released by washing and about the appropriate requirements for choice of materials in textiles, but also on laundry and textile services in the procurement process. There is a lot of material that can be compiled and communicated to the various stakeholders.[65]

Finally, it is clear that even if some information is available, few studies have looked at the volumes of synthetic fibres emission during textile laundry. So, there is little data. The Swedish EPA estimates that there is currently too little knowledge about the sources and nor is there any standardised method for measuring the presence of microplastic in the laundry water.

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[65] For example from the results of the EU Life + project MERMAIDS.

7.4.4 Gaps in knowledge

A number of gaps in knowledge have been identified. First of all, there is a need for a standardised measurement method to better analyse the amount of textile fibres that are shed during laundry. The different methods of measurement used today should also be compared. This is expected to be an important first step toward more comparable data that can show the amounts of microplastic that is shed during textile laundry over time.

Further analysis of various materials and fibre design, as well as various spin, weave and knitting techniques, is needed to better identify how the proportion of synthetic fibres shed during laundry can be minimised. It is important to communicate the results of studies of materials and design to designers, manufacturers, procurement bodies and buyers, to contribute in the long term to minimising the proportion of microplastics generated by textile products during laundry. This could help identify whether new, more efficient designs need to be developed, or new materials developed to help minimise the emission of microplastics.

The possibilities and effects of using wash bags for private households and for larger commercial laundries needs to be investigated more closely. The extent of the effect of washing bags should be investigated, as well as the material and design that is suitable for a washing bag. If it appears that washing bags are a good solution for reduction of the emission of microplastics from textile laundry, the information needs to be disseminated to consumers and manufacturers, as well as to commercial laundries, to achieve fast and effective minimisation of the volumes of microplastic that are being released in the environment. This could have a rapid effect on minimising the proportion of microplastics generated by textile products during laundry.

7.5 Proposed measures

The Swedish EPA proposes that measures should be taken in connection with the implementation of the measures proposed in the Swedish EPA's commission concerning the handling of textiles, presented in autumn 2016 (Swedish EPA 2016). The proposed measures are deemed to contribute mainly to achieving the following environmental quality objectives: Balanced Marine Environment and Flourishing Coastal Areas and Archipelagos, Flourishing Lakes and Streams and Non-toxic Environment.

7.5.1 Information

INFORMATION FOR TEXTILE OPERATORS

The Swedish EPA proposes a workshop on the topic of man-made fibre microplastics. The workshop should be directed primarily at stakeholders who are part of the textile dialogue group initiated by the Swedish EPA and the Swedish Chemicals Agency to create sustainable and resource efficient and non-toxic cycles (Swedish EPA 2016). As a result, stakeholders such as researchers, designers, manufacturers and other relevant textile operators are expected to share existing knowledge of synthetic fibre microplastics and of appropriate measures to minimise their proliferation. The Swedish EPA and the Swedish Chemicals Agency are proposed as the responsible authorities for the measure. Planning should take place in autumn 2017 and the workshop will be held in the spring of 2018.

Stakeholders: The Swedish EPA and the Swedish Chemicals Agency, who are responsible for the workshop. Stakeholders involved in the dialogue group participating in the workshop.

Consequences: Increased administrative costs for the Swedish EPA and the Swedish Chemicals Agency, primarily for planning and conducting the workshop. Increasing knowledge for the above-mentioned stakeholders to reduce the leakage of microplastics caused by textile fibres.

PUBLIC/HOUSEHOLD INFORMATION

The Swedish EPA proposes that the Swedish Consumer Agency, under the two commissions Hallå konsument[66], an information service for consumers, and the Forum for Environment-smart Consumption[67], include information about microplastics produced from man-made fibre textiles during use and laundry, and what measures consumers can take to minimise the emission of microplastics. The information should be produced in consultation with the relevant coordination authorities in "Hallå konsument", including the Swedish Chemicals Agency and the Swedish EPA. The result is expected to be that consumers will be informed of the products that are environmentally preferable for the reduction in emission of microplastics and of how products can be washed to reduce wear and tear, thereby minimising the loss from laundry of man-made textiles. New results from the EU project MERMAID's consumer information can be used, for example. If the use of washing bags is found to be efficacious, they could also be recommended. The information measure will be included among the existing tasks of the Swedish Consumer Agency. Implementation of the measure is proposed for between 2017 and 2018.

Stakeholders: In particular, the Swedish Consumer Agency, the Swedish EPA and the Swedish Chemicals Agency, which are responsible for producing the underlying documentation for the "Hallå konsument" project. Consumers, who are the target group for information tasks concerning more environmentally-smart consumption with a view to reducing emissions of microplastics.

Consequences: Increased administrative costs for the above authorities for the production of supporting documents and promotion for the "Hallå konsument" consumer information. The resources are part of already existing responsibilities. Increasing knowledge for consumers that can contribute to reduction of the loss of microplastics caused by textile fibres;

INFORMATION TO COMMERCIAL LAUNDRIES

The Swedish EPA proposes that information be disseminated to the commercial laundries that are members of the Swedish Textile Service Association. The aim is to raise awareness both of the emission of microplastics into the environment caused by laundries and of specific and practical contributions that the laundries can make to minimise emission of microplastics. For example, new results from the EU MERMAIDS project can be compiled and communicated. The result is expected to contribute to knowledge of the washing methods that are better to

[66] http://www.hallakonsument.se/

[67] https://www.konsumentverket.se/aktuella-konsumentproblem/nyheter-och-pressmeddelanden/pressmeddelanden/2017/nytt-uppdrag-konsumentverket-startar-forum-for-miljosmart-konsumtion/

choose from an environmental point of view to help reduce the loss of microplastics when washing man-made textile products. The Swedish EPA has been proposed as responsible for the development of information in cooperation with the Swedish Agency for Marine and Water Management. It has also been proposed that the Swedish Laundry Association should disseminate information via its channels (email, website, meetings). This is expected to be possible in autumn 2017 or spring 2018 depending on when information is available.

Stakeholders: The Swedish Environmental Protection Agency and the Agency for Marine and Water Management that will produce the supporting material. The Swedish Textile Service Association, which will be responsible for dissemination of the information. Members of the Laundry Association who receive the information.

Consequences: Increased administrative costs for the Swedish EPA and the Agency for Marine and Water Management for compilation of material and the human resources required for participation in any meetings. Increased administrative costs for the Swedish Textile Service Association for the dissemination of information. Increasing knowledge for laundries that can contribute to reduction of the loss of microplastics caused by textile fibres.

INFORMATION TO PROCUREMENT AUTHORITIES

The Swedish EPA proposes that, within the framework of existing contracts, the National Agency for Public Procurement should examine whether there is a possibility for public sector stakeholders to contribute to reducing the release of microplastics into the environment from textiles by imposing public procurement requirements. In future revisions, existing information and sustainability criteria for procurement of laundry and textile services, and textiles may be reviewed. There may also be grounds for taking a closer look at the need for training and guidance. If, when revising the criteria, it is possible to impose procurement requirements, procurement authorities will, as a result of the measure, receive information about environmental preferences for textiles that can contribute to the reduction of microplastic emissions. The study of the appropriateness of introducing criteria from the microplastic perspective should be conducted over the period 2017–2018.

Stakeholders: The Swedish National Agency for Public Procurement, in the first instance, which carries out the study.

Consequences: Increased administrative costs for the National Agency for Public Procurement related to the study into sustainability criteria from a microplastic perspective. In the longer term, procurement authorities may be informed of possible environmental requirements, but this depends on the outcome of the study.

7.5.2 EU level

ECODESIGN RECOMMENDATIONS

The Swedish Energy Agency (the authority responsible for implementing the Ecodesign Directive) has been proposed to work with the Swedish EPA and the Swedish Chemicals Agency to ensure that the European Commission evaluates the EU project MERMAIDS on the effects on microplastic emissions of filters on washing machines, and to encourage the European Commission to examine whether filters should be introduced as an ecodesign requirement. In the future, the Energy Agency may consider investigating washing machine filters, which requires special studies and resources. The result is expected to be increased knowledge of the effects of filters on washing machines on microplastic emission during laundry and recommendations from the European Commission on ecodesign requirements. Work on the measure should take place in autumn 2017 or spring 2018.

Stakeholders: The Swedish Energy Agency, the Swedish EPA and the Swedish Chemicals Agency are primarily responsible for producing relevant data and attending international meetings.

Consequences: Primarily, administrative costs for the above-mentioned agencies that are deemed to be part of the regular work of each agency.

NEW BEST AVAILABLE TECHNIQUES FOR TEXTILE MANUFACTURE

In connection with the revision of the EU reference document on best available techniques (BAT) for textile industries (BREF textile 2003), the EU Industrial Emissions Directive (2017/75/EU) proposes that the Swedish EPA should work within the EU to produce data on the emission of microplastics from manufacturing processes in the textile industry. It may be a question of highlighting, in the forthcoming negotiations, the need to start measuring emissions of microplastics (developing a common methodology for measurement). It may also be a matter of collecting data on to what extent there are microplastic emissions from textile industries manufacturing man-made fibres. The information can then form the basis for further negotiations on updated BAT conclusions and reference documents. The result is expected to have an impact on emissions from manufacturing plants within the EU but also on plants where textiles are produced for export to the EU. This is because many manufacturers already refer to compliance with BREF's emission regulations.

Stakeholders: The Swedish EPA is responsible for Industrial Emissions Directive (IED). Swedish textile manufacturers and importers have key roles to contribute to the production of data. The stakeholders will mainly have administrative costs, but these are expected to be met within ordinary operational budgets..

Consequences: Small, included in the framework of the implementation of the Industrial Emissions Directive. In the longer term, the measure is expected to have an effect on emission of microplastics from synthetic fibres from the textile industry and thus also on discharges to Swedish wastewater treatment plants.

8. Microplastic emission from boat hull paints

8.1 Emission and dispersal of microplastics from boat hull paint

Some boat hull paints contain polymers as a binder.[68] It is assumed that some of these polymers form microplastic particles when the paintwork of the boat wears gradually away or when the boat is washed, scraped or rubbed down during maintenance. These microplastic particles are most likely to end up in the water.

Release of microplastics from boat hull paints was originally identified as one of the larger sources of microplastic emissions in Sweden (Magnusson et al. 2016). IVL estimated the emission of microplastics from boat hull paint to be 484–1,364 tonnes of microplastics per year. The estimates for these emissions were later revised to 160–740 tonnes of microplastics per year. However, further estimates of the emission of microplastics from boat hull paint by the Swedish Chemicals Agency (Kemi) and the Agency for Marine and Water Management (HaV) have shown that emission volumes are likely to be significantly lower. According to these calculations, it is more likely that boat hull paints contribute about 10 tonnes of microplastics per year.

The large differences in the calculations reflect the wide range of uncertainties in the assumptions made. IVL's calculations are based, among other things, on estimates of paint volumes extrapolated from sales statistics in other European and Nordic countries to the Swedish market and on an assumption of the amount of polymer in paint. The lower figures from the Chemicals Agency and the Environmental Protection Agency are based on the polymer content in boat hull paint reported by manufacturers and paint importers to the Chemicals Agency's product register. The amount of plastic-forming polymer in paints for leisure craft is usually lower than assumed in IVL's calculations, as many paints are based on other binders (Isaksson 2016). Another difference is that IVL has assumed that the entire paint particle is to be considered as a microplastic particle for those paints that were not anti-fouling paints. The corresponding estimates from the Chemicals Agency and the Agency for Marine and Water Management include only those polymers that are deemed to be capable of forming microplastics.

[68] In regulations and maintenance, the boat paints used to protect the hull of the boat are sometimes distinguished from boat paints in the sense of all paint intended for paintwork on boats. In product registers it may be difficult to determine the paint type concerned, since only those hull paints that contain biocides to prevent fouling require special approval and are therefore reported separately.

Particle type: Paint flakes

Particle size: Unknown

Plastic type: Acrylates

Presence of hazardous substances: Copper, zinc and possibly other biocides from anti-fouling paints. TBT may be present in older layers of paint.

Ability to adsorb and transport environmental toxins: Unknown

Documented (measured) presence of microplastic from the source in the sea: Unknown

Probability that the emission of microplastics from the source reaches seas, lakes and streams: High – maintenance is done in or close to water.

Source causes large local emission of microplastic: Local emissions can occur from shipyards, marinas and harbours.

8.2 Causes of emissions

There are behaviours, choices and decisions at various levels that affect the emission of microplastics from marine paints to the marine and aquatic environment:

- Paint manufacturers choose polymer as a binder in the paint.
- Boat owners and craft owners choose to paint the hulls of their boats.
- Boat owners/shipyards wash/scrape off paint so that it ends up in the water.

Here we distinguish between leisure craft and commercial vessels, as both maintenance procedures and regulations distinguish between them.

8.2.1 Paint manufacturers choose polymer as a binder in the paint

There are many different types of paints used in the maintenance of leisure craft and vessels. Those containing polymeric materials may also release microplastics. Polymers are used as a binder (colour matrix) in the paint film. The binder holds together the various inorganic particles present in the paint, such as pigments, fillers and biocides, so that they form a covering layer when paint is applied. The binder usually makes up about 5–20% by weight of the paint. In ship paints, various polyacrylates, known as synthetic resins, are more common as binders, while leisure craft paints use a natural resin, such as resin or carbon-ofonium, derived from conifers (Hellio and Yebra 2009) to a greater extent.

According to the Swedish National Association of the Marine Industries Federation, Sweboat, there are about ten major manufacturers of boat hull paint. The industry is international (Eriksson 2016).

8.2.2 Leisure craft

There are about 800,000 leisure crafts in Sweden, most of which are taken ashore every year to be sanded and painted. The work is to a large extent conducted at one of the country's approximately 1,500 leisure boat harbours (Swedish Transport Agency 2016).

BOAT OWNERS CHOOSE TO PAINT THE HULLS OF THEIR BOATS

Many hull materials need to be protected from moisture and sunlight, and painting the boat can be a way to provide that protection. If the boat is in seawater, algae, barnacles and other organisms grow on its hull. This growth reduces the manoeuvrability of the boat and increases fuel consumption. To prevent fouling, hull paints often use chemical or physical means to prevent organisms from attaching, so-called anti-fouling paints. Anti-fouling paints based on biocides are commonly referred to as biocide paints. Today, copper compounds, often combined with zinc, are used to inhibit growth.

THE BOAT IS WASHED OR SCRAPED SO THAT PAINT FLAKES END UP IN THE WATER

During washing, scraping and sanding, flakes and particles of paint and scrap material are formed that, depending on the way the work is done, may end up directly in or near the water.

When leisure craft are lifted out of the water, the boat hull is usually washed with a high pressure washer. If a boat is painted with a biocide paint, it should be washed in a facility where the washing water is collected and cleaned according to the relevant guidelines (Agency for Marine and Water Management 2015). If such washing is conducted in accordance with the guidelines, the risk of emission of microplastic is considered to be low. However, many boats are currently being washed in a way that does not comply with the guidelines, which may lead to the emission of both biocides and plastic particles.

Boats whose hulls have not been painted with a biocide paint are often washed while lying in the water, for example using a brush or a hand tool.[69] During washing, paint flakes and other surface coatings may be dislodged and the washing tools will wear out to different degrees. These particles then end up in the water. A permanently established brush washing facility[70] must be provided with a collecting basin to prevent washed off material from entering the water. Existing mobile facilities do not have a basin.

8.2.3 Ships

Commercial vessels are docked for painting at intervals of 2.5–5 years and approximately 25 shipyards in Sweden carry out such work (Svenska Varv 2012). In between, the vessels are washed while in the water.

SHIP OWNERS CHOOSE TO PAINT THEIR VESSELS' HULLS

There are two types of hull paint for vessels, one of which protects the vessel against corrosion of the vessel's hull plating and the other paint that prevents growth of aquatic organisms on the hull. Anti-fouling paints, as for those on leisure craft, often contain copper or a combination of copper and zinc.

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[69] In the 2015 Boating Survey, 16% of boat owners report that they use biocide paint, making it the most common method of avoiding fouling. The most common alternative methods are seasonal washing, or the prevention of growth with hull cloths or removal of the boat from the water when not in use.

[70] In 2016, around 20 such brush washing facilities were in service in Sweden, and the number is rising every year Most facilities are listed at www.batmiljo.se

There is also a small proportion of vessels, especially those that ply ice-filled waters such as the Baltic Sea, that use hard epoxy paint, also known as ice-breaker paint, which is biocide-free. Another alternative is for vessels to use silicone-based paints, which concept is for organisms to be dislodged at sufficiently high speeds (Granhag 2017).

THE VESSEL IS WASHED OR SANDED SO THAT PAINT FLAKES END UP IN THE WATER

Ships are docked for maintenance at intervals of 2.5–5 years. Between docking intervals, hull washing is conducted in the water, 1–2 times a year if anti-fouling paints are used (Tyvik 2017). For some vessels painted with ice-breaker paint, hull wash is done at intervals of about every three weeks (Hanse 2017). The need for hull washing depends on the season and the vessel's stage in the maintenance cycle.

During docking, the vessel is washed, sand-blasted and painted. Cleaning with high pressure flushing means that both possible fouling of the hull and residues of anti-fouling paint end up in the dock's flushing water. The waste water can then be taken care of and transported to a treatment plant, cleaned on site, or simply pumped directly into the receiving water body without cleaning. The extent to which the flushing water is cleaned or disposed of is unknown because each yard is governed by unique conditions set by the local regulatory authority.

There are about 25 yards that perform this type of work in Sweden. According to Svenska Varv, several shipyards have taken measures on their own initiative for collecting and purifying waste water without any requirement from their respective supervisory authorities. Other yards have conducted or started similar operations after a requirement has been set. The association claims that investment in their own wastewater treatment plants is only economically feasible for larger shipyards with a high turnover of ships (Svenska Varv 2012).

Cleaning in water can be done by robot and water jet or by divers with brushes. Different techniques for collecting and cleaning the washing water exist or are under development, but also washing without collection is common.

8.3 Assessment of the possibilities for reducing emissions of microplastic from boat hull paint

8.3.1 Current governance in Sweden of emission of microplastics

Today, there is no governance that focuses directly on the emission of microplastics from boat hull paints. The existing instruments are aimed at reducing the impact of biocides that are harmful to the aquatic environment.

LEISURE CRAFT

Governance of which paint may be used

Marine hull paints that chemically or biologically prevent barnacles, mussels and algae from sticking to the hull are considered to be pesticides. They must therefore be investigated and approved by the Chemicals Agency before they can be sold or used. The boat hull paints that prevent fouling only on a physical basis, for example through a surface structure on which growths cannot grip, do not need this type of approval to be sold.

Governance of how maintenance may be conducted

The prevailing rules in the subject of boat hull cleaning are 'Guidelines for boat hull washing of leisure craft' from HaV (The Agency for Marine and Water Management 2015). Each municipality may then interpret and direct demands toward its recreational boat ports. Under the guidelines, a boat painted with a biocide paint should be washed in a way that collects and purifies flushing water. A boat that is not painted with a biocide paint can be washed lying in the water. A brush wash should be provided with a collecting basin to prevent large amounts of dislodged material from contaminating the surrounding environment.

Promoting alternative methods

The Projekt Skrovmålet[71] initiative is working on review of existing regulations for boat hull paints and methods for cleaning and removing paint. Its main aim is to reduce the negative environmental impact of biocides in paint, but also sources of microplastics will be taken up by the project and included in the proposed measures. These will be presented in 2020 in the framework of the Marine Environment Action Programme.

SHIPS

Governance of which paint may be used

The Swedish Chemicals Agency approves which anti-fouling paints may be used on vessels painted at shipyards in Sweden. For commercial shipping, the International Maritime Organization (IMO) has developed the International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS) (IMO 2001). Under the same regulatory framework, merchant ships of 400 GT or more must have an anti-fouling certificate that confirms that the vessel has a bottom coat that meets the requirements in force (EU Regulations 782/2003 and 536/2008). However, the content of plastic in binder is not included in this control.

8.3.2 Overall assessment of national governance possibilities

Boat hull paint is likely to account for a relatively small proportion of total microplastic emissions in Sweden. The Agency for Marine and Water Management and the Swedish EPA consider that there is still reason to work on reduction of these emissions from boat hulls. This is both because there is a risk of microplastics accumulating at boat maintenance sites and because the paint flakes and plastic particles from the hull and maintenance tools released directly into the sea (in contrast to other major sources for which we have no information about the extent to which they are released to the

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[71] Skrovmålet is run by the Swedish Transport Agency and is one of the cooperative measures initiated by the Swedish Environmental Objectives Council. The main aim of the project is to reduce the environmental impact of boat bottom paints and environmentally hazardous paint residues. https://www.transportstyrelsen.se/sv/sjofart/Fritidsbatar/Batlivets-miljofragor/Ren-batbotten/skrovmalet/

sea). In addition, boat hull paints often contain toxic substances that are, in themselves, a reason to reduce emissions.

As there is so much uncertainty both about what should actually be classified as microplastic in hull paint and about the actual emission volumes, we believe that tighter control of emissions from boat hull paints is not justified at this time. Instead, the synergies between possible measures to reduce microplastic emissions and ongoing work against biocide emission from anti-fouling products should be exploited.

In the case of ships, the use of hull paint and the cleaning of ships' hulls is governed by EU regulations and international guidelines. In the context of this commission, we have been unable to assess whether microplastics are an issue that should be addressed, for example by the IMO. We have, however, national authority over, among other things, the cleaning of flushing water during washing and docking. We believe that there is a need to investigate the conditions for the disposal of flushing water that are imposed on operators. There may also be a need for guidance to local regulatory authorities to obtain more uniform conditions regarding the disposal requirements for flushing water.

8.4 Proposals for measures

8.4.1 Measurement of plastic particles during boat hull washing

The Agency for Marine and Water Management is planning sampling at one or a few brush-washing facilities. The aim of the survey is to obtain knowledge to evaluate the best possible techniques for leisure boat hull washing and, if necessary, to plan more extensive sampling.

8.4.2 Include microplastics in the overview of the regulations for boat hull paints

The Agency for Marine and Water Management intends to review the guidelines for leisure boat hull washing as part of its ongoing work to review existing regulations for boat hull paints and methods for cleaning and removing paint within the scope of the Skrovmålet project. If necessary, these could be developed to include methods to minimise the emission of microplastics. Proposals for amendments will be presented in 2020 under the framework of the Marine Environment Action Program.

9. Micro-plastic emissions from litter

9.1 Release and dispersion of microplastics from litter

Plastic is the most common type of litter in the world's seas. The microplastic found in the sea, which originates from plastic debris, may have reached the sea in different ways. Macro litter (larger pieces of plastic litter) can be thrown overboard from both leisure craft and merchant vessels, but can also come from other maritime activities, such as fishing gear (Magnusson et al. 2016). Macro litter may also have been thrown away on beaches or transported to the sea from shore via stormwater, streams, winds and snow (Keep Sweden Tidy Foundation 2016). Approximately 80% of all marine litter originates from land (Eunomia 2016).[72] The plastic macro litter that ends up in the sea eventually breaks down into microplastic. Fragmentation of plastic can take a long time, up to several hundred years. Globally, due to lack of waste management schemes, plastic litter is considered the largest source of microplastic in the sea (GESAMP 2016).

Plastic macro litter can also be broken down on land, for example on beaches, and released to the sea as microplastics. For example, a survey of beach litter along the Baltic Sea found small, unidentified plastic pieces that came from degraded plastic products. These accounted for just over 25 per cent of all the beach litter found by the project.[73] However, many of the small pieces of plastic can be attributed to packaging such as lids, bags, fast food packaging and sweet paper, which indicates that consumer goods are the source (Blidberg 2017).

It has not been possible to calculate how many tonnes of microplastics per year are generated from littering of plastic articles in Sweden. There is data from litter surveys[74] conducted on both the west coast[75] and in urban environments. However, IVL has judged that the uncertainties associated with scaling up the results of these surveys and calculating the amount of microplastic generated from marine litter are so many and extensive that it is not possible to do so. For example, there are methodological problems linked to the measurements and uncertainties about how much

[72] The UN defines marine litter as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment.". This report includes both direct and coastal pollution.

[73] MARLIN was a project that intended to create a harmonised method of measuring marine litter in countries around the Baltic Sea, while at the same time taking public opinion-forming initiatives.

[74] Litter surveys on beaches are a way of assessing marine littering. Beach litter gives a picture of both the land-based litter that has been transported there in different ways or is a result of litter discarded on the beach, and the litter that the sea washes up on the beach. Every year, the anti-litter organisation Keep Sweden Tidy Foundation (HSR), together with several municipalities, carry out litter surveys in urban areas, parks and green areas and along the coasts and beaches, using a method developed by Statistics Sweden (SCB).

[75] Problems with beach litter occur throughout the country but are considerably greater on the west coast than in other parts of the country, especially on the Bohus coast. One reason is that around 80% of all litter on the west coast's shores is litter that has been washed up and has therefore probably been transported sea currents from the whole of the North Sea. Between 4,000 and 8,000 cubic meters of litter are washed up on the Swedish west coast every year Most of this consists of plastic.

litter reaches the sea from land (Magnusson et al. 2016).[76] This means that it is not possible to estimate emissions of microplastics from litter discarded in Sweden.

The litter surveys that have been conducted show that the amount of litter at first reduced in the seven urban areas that have surveyed litter since 2012, but that the 2016 deposits are back to the same levels as in 2012. Since 2012, the amount of waste along the coasts has decreased on the east coast, while it has increased on the west coast, partly because the survey method has changed and the volume of small litter has been calculated more accurately. However, the reason for the decline on the east coast is not clear.

9.2 Underlying causes of emissions

9.2.1 Modern consumption patterns, values and knowledge

Litter is a consequence of modern consumption patterns and people's attitudes and behaviour. It often results from multiple minor acts by individuals, such as throwing away a single-use package, a bus ticket or similar, which, taken together, contribute to a more extensive and serious litter problem. Behavioural research shows that group pressure and social standards play a major role in how we act, for example, it is easier to discard rubbish in a place that is already littered.

9.2.2 Cleaning, waste disposalanddrainage

Litter can also be caused by poor cleaning routines, waste management or sewage and stormwater runoff so that litter reaches the sea.

9.3 Assessment of the possibilities for moving towards reduced discards of litter

9.3.1 Governance of litter in Sweden today

Littering has been forbidden in Sweden for a long time. The ban is aimed at all and applies in locations to which the public has access. "Normal" litter, that is, large objects or large quantities, can be punishable by a fine or even imprisonment for a maximum of one year. Less severe littering may incur a fine.

The Swedish Environmental Code, the Street Cleaning and Signage Act and, to a certain extent, also the Planning and Building Act and the Roads Act regulate littering. The laws set the framework for banning littering and who is responsible for cleaning up a littered location. The Swedish EPA has investigated and described the national work, including prevention of littering in, among other things, two government commissions: Specific efforts to reduce litter (2013) and Measures to reduce littering (2016).

[76] Of the plastic litter found during beach litter surveys, it is unclear how much has come from onshore litter and how much is marine litter washed up on the beaches.

Litter levels are also affected to some extent by producer responsibility for packaging[77], including plastic packaging and plastic carrier bags[78]. Manufacturers are responsible for collecting and disposing of end-of-life products, which should motivate the manufacture of products that are more resource-efficient, easier to recycle and do not contain hazardous substances. Recycling materials from packaging means reduced waste and better management of natural resources.

9.3.2 Current governance in Sweden of marine litter

The EU's Marine Strategy Framework Directive (2008/56/EC) was incorporated into Swedish legislation via the Maritime Environment Ordinance 2010 (2010:1341). Its overall objective is to achieve a good environmental status in the Baltic Sea and the North Sea in accordance with established environmental quality standards by 2020. Good environmental status linked to marine litter is characterised by 1) the amount of litter, including its degradation products, is not causing damage to the marine environment, and 2) Reduction of litter that affects or is likely to adversely affect marine organisms (HVMFS 2012:18). The EU Member States themselves decide on an action programme for the marine environment to achieve the objectives of good environmental status. The Swedish action programme includes five measures aimed at reducing the amount of marine litter (responsible for implementation): [79]

- Promote efficient and sustainable collection and reception of lost fishing gear and prevent the loss of new (Agency for Marine and Water Management).
- Targeted national information campaign against marine litter by the Agency for Marine and Water Management in cooperation with the Swedish EPA.
- Support initiatives to promote, organise and carry out beach cleaning in particularly affected areas (the Agency for Marine and Water Management).
- Strategic work through the inclusion of marine litter in relevant waste plans and programmes (Swedish EPA).
- When reviewing municipal waste plans, identify and highlight how waste management can help reduce the occurrence of marine litter and set targets for such work (Municipalities).

As land-based littering has a significant impact on the marine environment, water management under the EU Water Framework Directive (2000/60/EC) is also important for achieving good environmental status under the Maritime Environment Ordinance.[80] In December 2016, new action programmes for water management were adopted in Sweden.[81] However, there are no parameters for good status linked to litter or microplastics within the Water Framework Directive, and therefore no measures to reduce the transport of litter amount to the aquatic environment.

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[77] At present, there are two current packaging ordinances, 2006:1273 and 2014:1073. Both regulations contain provisions that are in force now and Ordinance 2014:1073 contains provisions that have not yet come into force. The Packaging Ordinance has been created on the basis of the EU Directive 94/62/EC on packaging and packaging waste.

[78] At the end of 2016, an Ordinance (2016:1041) regarding plastic carrier bags was adopted pursuant to the provisions of the EU Packaging Directive 94/62/EC. The aim of the legislation is to reduce the use of plastic carrier bags, thereby reducing the amount of waste they cause and promote more efficient use of resources.

[79] The Swedish action programme *Good Marine Environment 2020. Marine strategy for the North Sea and the Baltic Sea. Part 4:* An action programme for the marine environment has been developed by the Agency for Marine and Water Management.

[80] Marine litter under the Marine Environment Ordinance also includes materials transported to the marine environment from land via streams and sewage systems or by winds.

[81] http://www.vattenmyndigheterna.se/Sv/atgarder-for-battre-vatten/Pages/default.aspx

9.3.3 International activities

REGIONAL ACTION PLANS FOR MARINE LITTER

Both HELCOM (2015) and OSPAR (2014) have adopted regional action plans for marine litter. They serve as a framework for coordinating work on marine litter and microplastics in the respective regions (Baltic Sea and North-East Atlantic respectively) and are indicative documents for the contracting parties. The measures will be implemented partly through regional cooperation and partly through voluntary national measures to be implemented in each country, for example through the countries' action programmes under the Marine Strategy Framework Directive.

Sweden has been actively working for the adoption of HELCOM and OSPAR action plans against marine litter and implementation of the measures listed in the plans is now under way. Most of the stated regional measures are currently ongoing in project form and are about developing knowledge and data that will form the basis for further decisions on how best to implement the measures.

THE EU'S CIRCULAR ECONOMY PACKAGE

The EU's 2015 Circular Economy proposal contains two elements: An action plan for a circular economy and a waste package with proposals for revisions of six EU directives in the field of waste. The Waste Directive (2008/98/EC) lays down the framework for waste management and waste prevention. The old directive does not contain any provisions concerning littering. However, the current revision mentions marine litter as a target area, and in several places litter has been mentioned in the directive during the negotiations. The Action Plan proposes specific measures to reduce marine litter, and refers to a preferred reduction target for marine litter on beaches and for fishing gear found in the sea of 30% by 2020. However, it is difficult to assess at present whether the proposals on litter will remain in the final draft.

Under the Circular Economy Action Plan, the EU decided in 2015 that all Member States should reduce their consumption of lightweight plastic carrier bags, inter alia with a view to reducing litter and preventing bags from entering the sea. It is up to the Member States themselves to devise instruments and measures so that no more than 90 thin plastic bags per person are used in 2019, and no more than 40 in 2025. From 1st of June 2017, consumers will be given information when buying a plastic carrier bag. Anyone who gives or sells plastic carrier bags must provide information about the environmental impact of the plastic carrier bag, the benefits of reduced bag use and the measures that consumers can take to reduce their bag use.

Furthermore, the EU is developing a plastics strategy as part of the Circular Economy, in which the leakage of plastic into the environment is one of three main problem areas. It is to be expected that the strategy will present several proposals for measures relating to littering, for example from single-use plastic articles. The strategy will be presented by the end of 2017.

9.3.4 Overall assessment of national governance needs

Governance to prevent the build-up of and reduction of the leakage of litter, including plastic litter, in the environment is available today. The Agency for Marine and Water Management has developed an action programme for a good marine environment in 2020. Proposals for measures have also been prepared in the Swedish EPA's report on the government commission "Measures to reduce litter" (2016). The Swedish EPA proposes funding for one of the measures in the action programme in the form of funding for beach cleaning on the Bohus Coast. More measures are laid out in the regional action plans for marine litter around the Baltic Sea and the North-East Atlantic. The Swedish EPA and the Swedish Agency for Marine and Water Management consider that the national action programme contains several important measures of great relevance to Sweden from a littering perspective. The Swedish EPA and the Agency for Marine and Water Management assess the need for intensified work concerning all of the measures in the parts of the Swedish Action Programme that are about disturbing littering and, by extension, microplastics.

LOST FISHING GEAR

One of the measures (AAM 19) in the Agency for Marine and Water Management's action programme concerns the loss of fishing gear. The formation of microplastics from fishing gear is due to the degrading of lost and discarded fishing gear, which can also occur on land, and wear from fishing gear. In the case of measures against lost and discarded fishing equipment, the Agency for Marine and Water Management is working on the issue through ÅPH19. In terms of wear and tear of fishing gear, the agency considers that the fishing industry uses durable materials as much as possible for reasons of cost. According to SLU Aqua, for example, dolly ropes are not used in the Swedish fishing industry. This is a form of protective device to protect the gear in certain forms of bottom trawling and which wears and becomes easily detached from the trawl. The agency therefore does not intend to go further on this issue, beyond the work that is being done, and will be done, over the next few years within the framework of ÅPH19.

INFORMATION CAMPAIGN

Another measure in the Agency for Marine and Water Management's action programme is to develop a targeted national information campaign about marine pollution. This measure will enacted in cooperation with the Swedish EPA.

Today, both agencies are primarily working on campaigns on marine litter by providing funding to the Keep Sweden Tidy Foundation through existing grants. This year, the Agency for Marine and Water Management has given Keep Sweden Tidy Foundation a three-year grant totalling of SEK 6 million to run two campaigns aimed at reducing marine litter. The campaigns are intended to comply with Action 20 (APAH 20) of the Agency for Marine and Water Management action programme. In the light of the issue of microplastics and the negative environmental impact of litter on marine life, both the Swedish EPA and the Agency for Marine and Water Management consider that there is a need to develop campaign work on marine litter to reach the public more widely. A campaign specifically dealing with microplastics also needs to be conducted. The campaign is part of the compliance with the agreed action programme for the marine environment and would best be implemented nationwide, but will probably have a lesser impact on the amount of litter on the Bohus coast because that litter is predominantly of international origin and has washed ashore on the west coast.

Keep Sweden Tidy Foundation is the national, external stakeholder that most clearly deals with attitudes and behavioural issues. The foundation is well-established and already has a comprehensive contact network to work on these issues. In 2016, the Swedish EPA stated in its government commission Åtgärder för minskad nedskräpning [Measures for the reduction of littering] that the national litter prevention project has been guaranteed. However, as far as the work on attitudes and behavioural issues is concerned, funding has not been guaranteed for longer periods. Keep Sweden Tidy Foundation has also recently started the Håll Havet Rent [Keep the Sea Clean] network, which is aimed at organisations and companies that want to participate in creating a long-term commitment to reducing litter.

In the Government commission, the Swedish EPA also confirms that the attitude and behaviour issues are currently being conducted primarily by others than the national authorities. The work is funded in many different ways, including state funding, membership fees and corporate sponsorship. The Swedish EPA has described several possible options for funding national work on attitude and behavioural changes in its report. Within the EU, negotiations are under way to fund information to the public, with a view to preventing litter through producer responsibility. However, these negotiations are not yet completed and the Swedish EPA therefore considers it less appropriate at present to propose funding for this work that may prove difficult to change at a later time. As one of the founders of Keep Sweden Tidy Foundation, the Swedish EPA has a responsibility for the foundation's funding as long as the agency has a finance that permits it to do so.

SUPPORT INITIATIVES TO PROMOTE BEACH CLEANING IN PARTICULARLY AFFECTED AREAS

In addition to measures to prevent the occurrence of marine litter, measures are needed to clean up the litter that has arrived on the beaches. The Bohus coast has a special issue with marine litter. Results of surveys conducted show that, every year, there is as much litter on the beaches of the Bohus coast as in the rest of Sweden. This stretch of coast is heavily affected by litter that is washed ashore and its costs for beach cleaning are estimated to be very high, compared to other municipalities. The Swedish EPA and the Agency for Marine and Water Management therefore consider that there is a need for extra funding for cleaning the beaches along the Bohus coast.

In the present situation, the Swedish EPA considers that state funding for beach cleaning within existing forms of funding is the most feasible way because the problem is regional and the litter is largely international. The proposal has been sent out for consultation and the matter is currently being dealt with by the Government Offices.

INCLUSION OF MARINE LITTER IN WASTE PLANS AND PROGRAMMES

Two of the measures in the Swedish action program concern the inclusion of marine litter in national and municipal plans and programmes to:

- Work strategically by including marine litter in relevant waste plans and programmes.
- When reviewing municipal waste plans, identify and highlight how waste management can help reduce the occurrence of marine litter.

The issues are in hand as they stand today, but future developments are more uncertain. Litter has been mentioned in several places in the Waste Directive during the negotiations for the circular economy package, which is currently being negotiated within the EU. Article 9 of the Waste Directive deals specifically with waste prevention and there, as recently as April 2017, targets and measures to prevent litter have been included in the negotiations. At the time of writing, however, we do not know what the end result will look like.

Litter prevention is a priority area in the national waste plan. Work is currently under way to develop a new waste plan. The Swedish EPA has also revised the current regulations for what municipal waste plans should contain. As of June 2017, the municipal plans must contain both targets and measures to reduce litter. The guidance to the regulations states that local authorities should prioritise measures to prevent and reduce plastic littering that can lead to marine litter and the formation of microplastics.

9.4 Proposed measures

The Agency for Marine and Water Management has considered the current instruments to be insufficient to address the problem of marine litter. Future work needs to focus on both legal, economic and information instruments and on knowledge-oriented measures. The problem of marine litter has received a lot of attention in recent years, and there is much happening in the area of research and policy, both internationally and nationally. However, to achieve a reduction in the amount of marine litter, measures and regulations need to be implemented more quickly.

9.4.1 Government funding of beach cleaning

The Swedish EPA and the Agency for Marine and Water Management consider that there is a need for extra funding for cleaning the beaches along the Bohus coast.

In its government commission, Measures for reducing littering, the Swedish EPA considers that state funding for beach cleaning is the most feasible way because the problem is regional and the litter is largely international. If a different funding solution, for example funding from producers, is to be considered, a holistic approach will be needed to fund the costs of littering that also includes land-based litter. However, such consideration of a holistic solution was not within the framework of the declared government commission.

Today, beach cleaning is funded from both municipal and state sources and from EU funds. However, the Swedish EPA and the Agency for Marine and Water Management consider that no new forms of funding for marine littering are needed. The costs for cleaning beaches along the Bohus coast have been estimated at approximately SEK 15 million. The funding can be provided by adding funds to the Agency for Marine and Water Management's grant 1.11. In the opinion of the Swedish EPA, funding for beach cleaning would probably not violate state aid rules.[82]

9.4.2 Need for a developed information campaign

The Environmental Protection Agency and the Agency for Marine and Water Management propose that work on the development of information campaigns on marine litter should take place within the framework of the agreed measure no. 20 in the Action Program for the Marine Environment. It is appropriate to strengthen the already existing campaign between 2017 and 2019 on marine littering and to extend it with a campaign on microplastic emission from, for example, textiles and consumer goods. The Agency for Marine and Water Management believes that this issue will

[82] See more about the proposal in Swedish EPA (2016) Åtgärder för minskad nedskräpning – redovisning av regeringsuppdrag [Measures to reduce litter – report from the government commission]. Report 27/10/2016.

require increased funding of SEK 3 million per year from 2018 to 2019 in the Agency for Marine and Water Management grant 1:11 and SEK 5 million extra per year after that, so that the measure is not to charged against to the current budget. It is also necessary to secure long-term funding of attitude and behavioural issues, in accordance with the Swedish EPA's report from the Government's commission Measures to reduce the amount of litter.

9.4.3 Continued regional cooperation

Sweden has actively worked on the development of HELCOM's and OSPAR's Marine Litter Action Plans. The Swedish EPA and the Agency for Marine and Water Management consider that continued work on marine litter within these regional conventions is also central to reducing the incidence of microplastics in Swedish coastal waters.

The HELCOM Marine Litter Action Plan includes several regional measures aimed at improving waste management to reduce the leakage of litter entering the Baltic Sea. Among other things, it will compile a list of good examples of waste management. The current BLASTIC project[83] identifies sources and dispersal pathways of plastic litter from towns and cities to the Baltic Sea. BLASTIC is a flagship project within the EU's Baltic Sea Strategy, coordinated by the Swedish EPA[84]. The results of the project are expected to provide new information and knowledge about sources, dispersal pathways and possible measures that can be implemented for regional work within HELCOM.

The Swedish EPA should develop and increase its contribution to HELCOM's work on waste management related to marine litter. Synergies with, and results from, the BLASTIC project should be considered. The Environmental Protection Agency's efforts in HELCOM would also contribute to similar measures within the OSPAR Regional Marine Litter Action Plan.

As a large part of the litter on the Bohus coast is likely to originate from other countries around the North Sea, efforts linked to OSPAR's work are also highly relevant. The Agency for Marine and Water Management coordinates the Swedish efforts in OSPAR and should continue to contribute actively to the implementation of the Marine Litter Action Plan. In particular, the measures concerning best practices for the management of waste from the fisheries sector to which Sweden has committed itself.[85]

[83] BLASTIC – Plastic waste pathways into the Baltic Sea (2016-2018). Funded by Interreg Central Baltic.. www.blastic.eu

[84] Flagship project under the Hazardous substances policy area of the EU Strategy for the Baltic Sea Region.

[85] OSPAR Action 36 and HELCOM RS5

9.4.4 Impact of the proposals

CHANGE COMPARED TO THE CURRENT SITUATION

- The cleaning of marine litter on the west coast is expected to be improved by the proposal to inject state funds into beach cleaning.
- The information campaign is expected to affect Sweden's attitudes to marine litter and reduce litter on beaches, mainly in the south of Sweden. Within the current budget, the campaign reaches 2.7 million potential consumers during a week-long campaign. With the proposed, increased budget of SEK 1 million, twice as many consumers, about SEK 5.4 million, could be reached and the advertising time extended from one to two weeks.
- Regional cooperation is expected to generate synergies and, among other things, reduce national costs for the reduction of marine litter.

STAKEHOLDERS

- The Agency for Marine and Water Management as a responsible environmental authority.
- The Swedish EPA, as a responsible environmental authority.

CONSEQUENCES

- The potential reduction in microplastic emissions resulting from the measures cannot be assessed, as the amount of microplastic from marine litter has not been established.
- The Agency for Marine and Water Management incurs increased costs for beach cleaning of SEK 15 million per year. The Agency will also incur increased costs of SEK 3 million in 2018–2019, followed by an additional cost of SEK 5 million per year for the development of information campaigns; and continuing administrative costs of 12 person/weeks for participation in regional cooperation on marine litter and microplastics, and administrative costs of 3 person/weeks to deal with decisions, etc. on beach cleaning and information campaigns.
- The Swedish EPA incurs increased administrative costs of about 2 person/weeks to conduct a dialogue with the Agency for Marine and Water Management about the information campaign.
- The Swedish EPA incurs increased administrative costs of about 2 person/weeks for the increase in efforts in the regional cooperation with marine litter, with a focus on waste management.

10. Dispersal pathways: Wastewater treatment plants, sludge and stormwater

In this chapter we describe the knowledge that exists today about how microplastics are released to seas, lakes and streams via wastewater treatment plants, sewage sludge and stormwater. We also discuss the possibility of reducing emissions through these dispersal pathways and propose measures. We also present the results of a study on the best possible techniques for cleaning microplastics in wastewater treatment plants.

There are also other possible dispersal pathways for microplastics, such as through the air and snow clearance. The knowledge of how and to what extent microplastics are released in these ways is very limited today, but we describe these dispersal pathways in Chapter 4, in connection with the emission of microplastics from road traffic.

10.1 Dispersion of microplastics through sewage treatment plants

There are 431 wastewater treatment plants larger than 2,000 person equivalents (pe) in Sweden, which account for approximately 90% of the discharges from wastewater treatment plants (Swedish EPA and Statistics Sweden 2016). According to Statistics Sweden's statistical report on water and wastewater in 2014, barely 60% of the treated wastewater was emission to coastal waters and the rest to inland waters. In total, approximately 1–19 tonnes of microplastic is discharged with the treated wastewater from wastewater treatment plants annually (Magnusson et al. 2016).

The degree of microplastics separation is high in wastewater treatment plants, in the range 95–100% and higher for microplastic particles larger than 300 µm (Baresel et al. 2017; Magnusson and Noren 2014). In addition to the discharge of microplastic via treated wastewater from wastewater treatment plants, a microplastic discharge is conducted by the spill flows[86] of untreated wastewater from the sewer network and at the wastewater treatment plant. This volume is estimated at 1–15 tonnes per year (Magnusson et al. 2016). This means that of the total amount of microplastic that is expected to be discharged from wastewater treatment plants, a significant proportion originates from overflows. Nevertheless, IVL's survey indicates that the total amount of microplastic from wastewater treatment plants represents only a small part of the total amount of microplastic transported to the sea. There are however studies

[86] "Spill flows" are waste water that is discharged untreated or incompletely purified to the receiving water body. This takes place, for example, in situations where the capacity of the wastewater treatment network or the wastewater treatment plant is exceeded.

showing increased concentrations of microplastics in areas close to emission pathways from wastewater treatment plants (Magnusson and Noren 2014). It is therefore important to highlight the possibilities of further reducing discharges from wastewater treatment plants.

The largest surveyed sources of the microplastic entering the treatment plants are from clothes laundry and hygiene products, which contribute between 66 and 910 tonnes of microplastics per year, the larger share of which being from textile laundry (Magnusson et al. 2016). In addition to these sources, microplastics are also entering the wastewater treatment plants via stormwater, but there is currently no data on the size of these volumes. Stormwater enters the wastewater network in areas with combined sewerage systems and where stormwater leaks into the sewerage network in various ways. In combined sewerage systems, stormwater is diverted to the purification plants in the same pipes as sewage water and drainage water. Combined sewerage systems are mainly found in older urban areas built in the mid 20th century. The combined sewerage systems account for about 13% of the sewerage network in Sweden (Svenskt vatten, 2016a). In more recently built urban areas, with separated or duplicate systems, stormwater is drained separately and thus does not burden the wastewater treatment plants. Stormwater management in Sweden is described in more detail in section 10.2 below.

The water entering the treatment plants in addition to the wastewater from households and connected industries is often referred to as additional water (water leakage, drainage water, stormwater). The percentage of additional water varies between plants but can account for as much as 50% or more of the incoming water flow. Large volumes of additional water dilute the contaminated wastewater, which can cause spill flows and cause the treatment plant's degree of purification to be reduced due to lower water temperature, shorter residence time and dilution. In addition to causing spill flows and reducing treatment in wastewater treatment plants, the rainwater discharged in combined sewage systems also affects the quality of the sludge that is separated in wastewater treatment plants.

10.1.1 Microplastic separation in wastewater treatment plants

A conventional wastewater treatment plant consists of a combination of mechanical, chemical and biological treatments, see Figure 3. The mechanical purification separates solid particles such as toilet paper, cotton swabs, sand and gravel at the beginning of purification to avoid getting this into subsequent stages of purification. The biological purification is the work of micro-organisms that clean phosphorus, nitrogen and organic material from the water, often in an active sludge process in which microorganisms live in flocs held in suspension in the tank. During the chemical purification, precipitating chemicals such as aluminium or iron are added to remove phosphorus. The precipitation clumps and deposits to the bottom and can be separated as sludge, which is pumped to the sludge treatment at the treatment plant.

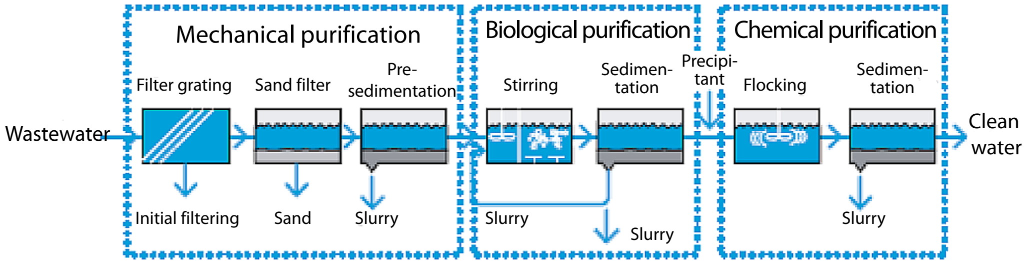

Figure 3. Treatment steps in a conventional wastewater treatment plant. Source: Swedish EPA (2014).

Chemical precipitation can take place both as primary precipitation during primary sedimentation, simultaneous precipitation in biological purification or as a secondary precipitation.

In Sweden it is common that wastewater treatment plants have a sand filter as their final purification step, sometimes combined with post-precipitation. This is because the suspended substance in the outgoing water contains phosphorus.

The purpose of sludge treatment is to reduce the volume of sludge and to stabilise it before sludge dewatering. In Sweden, the most common stabilisation method is anaerobic digestion, in which micro-organisms break down the organic material and form biogas. The sludge is then dewatered to reduce the volume of sludge that is transported away from the wastewater treatment plant. The wastewater that is separated during sludge dewatering is returned to the water treatment stage of the treatment plant.

Wastewater treatment plants are good at separating particles, so the degree of separation of microplastic particles is high despite wastewater treatment plants not being designed to clean such particles. Greater volumes of small particles end up in the sea than the larger fractions of microplastics. Wastewater treatment plants with mechanical, chemical and biological treatment separate more than 97% of particles from ≥ 300 µm. At least 80% of smaller particles, 20 µm are separated (Noren et al. 2016). The separated particles end up in the sewage sludge. It is not currently clear whether anaerobic digestion or other sludge stabilisation has any effect on the content of microplastic in sludge.

A study conducted at the Viksbacka wastewater treatment plant in Helsinki showed that 97.4–98.4% of microdebris particles in size ranges from 20 µm were separated during the mechanical treatment and sedimentation with a chemical precipitate (Talvitie et al. 2017). It is assumed that microdebris is bound to the rinse solution and larger particles in the incoming wastewater, resulting in efficient separation. Further separation was obtained in the active sludge process and the subsequent sedimentation where the microdebris mixes with sludge flocs and separated. An analysis of the size fractions and the type of microdebris showed that the larger size fractions (> 300 µm) were separated more effectively than the smaller size fractions. Examination of output mass from the treatment plant and sludge treatment showed that 20% of the separated microdebris particles were returned to the treatment plant's water treatment as an internal load via the wastewater from sludge dewatering, while 80% were in the dried sludge transported away from the treatment plant.

Based on experience from surveys of microplastic separation in conventional wastewater treatment plants, (Vollertsen and Hansen 2017; Noren et al. 2016a; Magnusson et al. 2016b; Noren et al. 2016b; Magnusson et al. 2014; Magnusson and

Wahlberg, 2014) and statistics from the design and cleaning in existing wastewater treatment plants in Sweden (Swedish EPA and Statistics Sweden 2016), it should be possible to assume that the degree of microplastic cleaning at Swedish wastewater treatment plants is generally high. In conjunction with increased nutrient purification requirements, technologies have been installed that also contribute to increased microplastic separation, as described in section 10.1.3.

10.1.2 Microplastic in sewage sludge

In 2014, 200,000 tonnes of sewage sludge, measured as dry matter (TS), was produced at Swedish wastewater treatment plants. The main areas of use were agricultural land (25%), soil improvement (29%) and landfill cover (24%). The amount of microplastic in sludge originating from households is estimated at from 66 to 909 tonnes per year (Magnusson et al. 2016). This estimate does not contain the contribution of microplastic from stormwater because the volume of this input into wastewater treatment plants was not quantified in IVL's survey.

In a Danish study, the microplastic concentration was estimated at 0.7% of the dewatered sludge, or 2% of the dry weight measured as dry matter (Vollertsen and Hansen 2017). In the Danish study, the concentration of microplastic on arable land was analysed with and without sludge fertilisation. The results showed that the concentration of microplastic in the soil was low, about 10 mg/kg. Soil that was not fertilised with sludge contained more microplastic than that on which sludge had been applied. This may indicate that other sources of microplastic on arable land are larger than those supplied by sludge, e.g., atmospheric deposition. This will require further investigation. Another possible explanation is analytical safety when analysing microplastic in soil (Vollertsen and Hansen 2017).

There are currently few studies of what is happening to microplastics in soil. (Nizetto et al. 2016) have conducted a modelling study in which they assume that the movement of microplastic into soil is similar to the processes contributing to soil erosion. The size and density of the microplastics are important for their movement (Nizetto et al. 2016).

There are few studies of the effects of microplastic on terrestrial organisms. Field trials of sludge fertilisation in Sweden's Skåne region, which have been in progress for more than 30 years, have demonstrated no negative effects of sludge fertilisation on worms (Johansson and Torstensson 1998; Andersson 2015).

10.1.3 Best available techniques for microplastics purification

A study of the best available techniques for the separation of plastic microparticles in wastewater treatment plants has been conducted as part of the Government's commission. The results of the study are presented in their entirety in the documentation report "Technical solutions for advanced wastewater treatment" (Baresel et al. 2017).[87] In addition, the Agency for Marine and Water Management has commissioned a similar report on advanced treatment and technology for the separation of microplastic from wastewater (Noren et al. 2016). This section is largely based on these reports.

[87] The study also includes a review of techniques for the separation of drug residues and other undesirable substances. These results have been reported in the government commission "Advanced wastewater treatment for the separation of drug residues and other undesirable substances, needs, technologies and consequences"

As mentioned earlier, microplastics are largely separated in a conventional wastewater treatment plant, as has been examined in a large number of studies. [88] The treatment processes studied and assessed within the framework of this commission are complementary treatment stages to the already existing treatment of wastewater and can either be integrated into the existing treatment process or be subsequent treatment stages.

The assessment of technical solutions for the treatment of microplastics clearly shows that only ultrafiltration (UF) can provide the complete removal of microplastics from wastewater, according to the current size definition, which is particles between 1 μm and 5 mm. As we have already mentioned, treatment plants are already removing 95–100% of microplastics larger than 300 µm from the aqueous phase and between 70% to 99% of particles larger than 20 µm. The fate of smaller particles is less known, since these were not included in previous analyses. An effective treatment using the UF technique is thus intended to remove the remaining microplastic from wastewater (Baresel et al. 2017).

In addition to the size, the density, texture and loading of microplastics are the main factors in controlling the degree of separation in different treatment steps. Other treatment techniques such as microsieving, sedimentation and flotation techniques can also be used for the separation of high and low density microplastics. However, a single UF can provide a complete purification independent of density (Baresel et al. 2017).

The following are examples of available techniques and process technology solutions that are deemed to have a significant treatment effect on microplastics in addition to the separation that takes place in a wastewater treatment plant (see Chapter 10. 3.1).

MBR/ULTRAFILTRATION (UF)

Ultrafiltration (UF) is one of the various membrane filtration techniques that can be used in water purification for a physical separation of contaminants from the water, and is a technique that results in a complete separation of microplastics (Baresel et al. 2017). Depending on the choice of membrane, ultrafiltration can separate particles down to about 0.1 µm (depending on pore size). UF has a good purification effect on particles, microplastics, pathogens and bacteria, and thus also on multi-resistant bacteria, but not generally on creation of resistance (Baresel et al. 2017). UF does not purify non-particulate impurities, which means that most drug residues are not separated. However, UF, separately or in a membrane bioreactor (MBR), can provide a good pre-treatment before advanced purification techniques such as ozone or activated carbon purification for the separation of drug residues and other contaminants.

Membrane bioreactor (MBR) processes are active sludge processes that use UF as a separation step instead of traditional sedimentation for the separation of suspended material. This enables a higher sludge content in the process and a much less space-intensive separation process than a sedimentation plant, which in total results in a more compact treatment process. UF integrated in the main treatment stage of wastewater treatment plants such as MBR is available in full scale, but is more unusual as separate treatment steps at wastewater treatment plants. After pilot

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[88] Vollertesen and Hansen 2017; Noren et al. 2016a; Magnusson et al. 2016; Noren et al. 2016b; Magnusson et al. 2014; Magnusson and Wahlberg, 2014.

experiments with UF as a separate treatment step, Kalmar Water has plans to include this investment in the direction decision that is to be made regarding investment in a new wastewater treatment plant planned to be operational in 2023 (Ullman 2017).

There are various technical solutions, most commonly filtering in flat-sheet or hollow-fibre membranes, the former using an overpressure on the concentrate side and the latter using a negative pressure on the permeate side (Baresel et al. 2017).

An important aspect of UF operation is that over time the membrane surfaces become clogged, so-called fouling, which reduces permeability and requires more energy to maintain throughput. Clogging of the membranes is a function of both the composition of the effluent and the purification process. For this reason, regular cleaning of membranes is required with different washing solutions. The frequency depends on the operational parameters and membrane design.

In principle, UF can be used for all plant sizes, although the size has an influence on both the technical design and the costs (Baresel et al. 2017). The UF occupies relatively little space and can be integrated in the main station (MBR). It provides a very compact purification technique by allowing the biology to work at higher sludge levels.

UF requires large investment. The total cost is estimated at SEK 0.5–0.75/m^3 for large plants (100 000 pe), with clear economies of scale as the total cost for smaller plants (10,000 pe) is estimated at SEK 1–1.5/m^3 (Baresel et al. 2017). It is an energy-intensive process, both in the manufacture of chemicals and membranes, and for operation. The electricity consumption during operation is 0.1–0.5 kWh/m^3.

MICRO-FILTRATION WITH DISC OR DRUM FILTERS

Filtering techniques separate particles down to a specific size. The main purpose is often to separate suspended particles (SS, suspended solids) and other impurities bound to the particles, which means that the separation of microplastics is an added bonus (Noren et al. 2016). The smaller the pore size of the filter, the greater the particle separation. Micro-filtration is often performed through a woven cloth where the distance between the threads is adapted to produce microsieves of different pore sizes. Microsieves are designed, for example, as disc filters or drum filters and can be used as pretreatment in wastewater treatment plants (replacing primary sedimentation), or as tertiary treatment with post-polishing of phosphorus and suspended material, which is the most common application. Microsieving is also suitable for pre-treatment for ultrafiltration/membrane bioreactor (MBR) or advanced purification for the separation of micropollutants using activated carbon and/or ozone. The pre-treatment separates particles that would otherwise impair the purification efficiency of the advanced purification (Baresel et al. 2017).

The pore sizes range from 10 to 1,000 μm, thus separating particles larger than this. The filters are backflushed regularly and the backflushing water is treated separately or led back to the treatment plant's water inlet. Filters need to be cleaned regularly to maintain filter capacity and avoid clogging.

Väänänen (2017) has shown that for a microfilter of pore size 100 μm used as pre-purification, the degree of separation was 30–60% of the volume suspended material. The same filter, but in combination with chemical precipitation, resulted in a marked increase in efficiency, with > 90% separation of suspended material, and 95–97% separation of total phosphorus.

A disc filter plant has been installed at the Ryaverket facility in Gothenburg as the final cleaning stage. The plant has been in operation since 2010. The disc filter membranes have a pore size of 15 μm and remove particles containing phosphorus, nitrogen and organic matter. However, the main purpose of installing disk filters was to reduce the output of phosphorus below the discharge requirement of 0.3 mg P/L, with a performance-efficient and compact plant. The purification results in particle removal equivalent to 80% and an outgoing phosphorous content of 0.2 mg P/l (Nunes et al. 2013). Microsieves are effective for separating particles larger than the pore size of the microsieve, but do not properly separate smaller particles. Wilen et al. 2016), in a study of Ryaverket microsieves, show that the number of particles < 2–5 μm increases after the disc filter, which is explained by the fact that larger particles are degraded to a smaller size by the shear forces generated by the sieving through the filter membrane. Because these particles are so small, the contribution to the amount of suspended solids in outgoing water is small.

Operating experience has shown the importance of optimising the flushing frequency and cleaning of the disc filters. Best cleaning results have been obtained using hydrochloric acid and sodium hypochlorite. The operating cost of the disc filter plant at Ryaverket is approximately SEK 0.02/m^3, of which the major part is the cost of electricity for the coil pumps (Nunes et al. 2013). Electricity consumption is estimated at 0.013 kW/m^3 filtered water for filtration of water with 15 to 35 mg SS/l. The total cost of cleaning a disc filter in a standard installation is estimated to be somewhere in the range of SEK 0.1–0.2/m^3, depending on the flow conditions of Gryaab. However, Gryaab's own installation at Ryaverket cost more due to complex local conditions (Gingsjö and Mattsson, 2017).

SPILL WATER TREATMENT

The spill flow water treatment, also known as high-flow treatment, can be installed at wastewater treatment plants to purify some of the effluent at times when incoming flow is too high to be treated in the main plant. Instead of letting untreated water pass through, a spill water treatment can be applied, which mainly separates phosphorus and organic matter. The treatment process is often a direct precipitation with chemicals, sometimes with the support of microsand that accelerates the settling rate called the Actiflo process. The degree of purification of phosphorus in this process may be more than 95%. Microsieve treatment in a drum or disc filter can also be used to treat spill water.

An important aspect of the wastewater treatment process is that it must be possible to deploy the technology at short notice, quickly providing high treatment efficiency. Cleaning of microplastic in spill water treatment is uncommon in the reference literature but is similar to the efficient separation of particles and microplastics in conventional chemical-precipitation wastewater treatment plants, and with micro-sieving in spill water treatment should be a means of reducing pollution not only of phosphorus and organic matter, but also of microplastic. Spill water purification technology could also be installed to clean spill water in the drainage system. In Copenhagen, a combination of drum filters, UV treatment and disc filters has been used for spill water treatment in the drainage system (Andersen et al. 2005). A complement to wastewater treatment is to use flow equalisation in the drainage system and into the wastewater treatment plants.

WETLANDS

Additional microplastic particles can be separated if purified wastewater is post-polished in a wetland. A Master's thesis presented a study of stormwater ponds and wetlands, where all facilities showed a microplastic separation of up to 90–100% (Jonasson 2016).

10.1.4 Assessment of the possibilities for reducing emission of microplastic from wastewater treatment plants.

There are several regulations that control discharges from Sweden's wastewater treatment plant today. As with many other sources of and dispersal pathways for microplastics, the problem is relatively new and there is no regulation currently defining requirements for the emission of microplastics from sewage, stormwater or sludge from wastewater treatment plants.

THE URBAN WASTE WATER TREATMENT DIRECTIVE

The EU Urban Waste Water Treatment Directive (91/271/EEC) aims to combat environmental damage caused by urban waste water discharges and certain industrial processes.

Sweden has introduced the Urban Waste Water Treatment Directive into Swedish legislation, partly through the Environmental Code and partly through the Swedish EPA's regulations on the treatment of urban waste water (NFS 2016:6).

The EU Urban Waste Water Treatment Directive (91/271/EEC) is one of the main policy instruments of the EU water management regulatory framework. It covers all the wastewater collected in drainage systems, but quantitative requirements are only imposed for the treatment plants serving more than 2,000 people.

EU SEWAGE SLUDGE DIRECTIVE (86/278/EEC)

The treatment of sludge from wastewater treatment plants is governed by the EU Directive on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (86/278/EEC). The Directive encourages the correct use of sludge in agriculture.

LICENCE TESTING

Waste water treatment plants with a connection of more than 2,000 person equivalents currently require operation licences under the Environmental Code (environmentally hazardous activities according to Chapter 9 of the Environmental Code). Licence testing is required to decide whether the licence is to be granted and the requirements that need to be satisfied to limit the harm and other inconvenience that could be caused by the operation. Sweden sets discharge conditions to control discharges from wastewater treatment plants in accordance with the precautionary principle and best available techniques (BAT) (Swedish EPA and Svenskt Vatten 2013) in accordance with Chapter 2, Sections 2–5 of the Environmental Code.

Discharge reductions can be achieved through the re-examination of existing licences (Chapter 24, Section 5 Environmental Code).

MORE STRINGENT REQUIREMENTS IN GENERAL REGULATIONS

Under Chapter 9, Section 5, the Government can issue general regulations on prohibitions, preventive measures, restrictions and other precautionary measures to comply with Sweden's international obligations. These regulations should then be general and apply to all companies. One such example is SNS 1994:7, the current nitrogen emission requirements for treatment plants serving more than 10,000 person equivalents.

ENVIRONMENTAL QUALITY STANDARDS

Environmental quality standards are a legal instrument introduced with the creation of the Environmental Code in 1999 and regulated in Chapter 5 of the Environmental Code.

Environmental quality standards, derived from environmental quality objectives, are quantitative limits in the environment and must be based on scientific criteria.

THE PUBLIC WATER SERVICES ACT

Local government tasks include the provision of water services, which include water supply and sewerage. The Public Water Services Act entered into force on 1st of January 2007 and aims to ensure that water supply and sewerage are organised in a wider context, if necessary with regard to the protection of human health or the environment. Water services are financed by charges.

HELCOM AND OSPAR

HELCOM's recommendation 28E/5 specifies requirements for municipal wastewater treatment, and recommendation 23/5 specifies requirements for good handling of stormwater. OSPAR contains no decisions or recommendations for municipal wastewater. Both marine conventions' regional action plans for marine litter contain measures to combat the separation of microplastics from wastewater and stormwater. Sweden has, in particular, undertaken to contribute to the compilation of best technology for cost-effective treatment of stormwater and wastewater from microplastics by 2018. The summaries shall be used as a basis for the development of measures at regional level or guidance on measures at national level. For example, this may lead to revision of HELCOM's recommendations. HELCOM recently adopted a new recommendation on sludge, 38/1. OSPAR has not placed much focus on the use of sludge.[89]

10.1.5 Overall assessment of national governance needs

Based on the current understanding of microplastics in the environment it is doubtful whether additional requirements for the separation of microplastics in wastewater treatment plants can be justified based on the Environmental Code or other legislation. This is because microplastics are, for the most part, already separated in a conventional wastewater treatment plant. Of microplastics discharged from wastewater treatment plants most is discharged during spill flows. From a receiving water body point of view, a reduction in the load of both nutrient salts and microplastics could justify a continued focus on minimising the amount of untreated wastewater discharged, and on installing spill water treatment to reduce the load on the receiving water body from this source.

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[89] Two OSPAR recommendations on sludge: OSCOM Recommendation to Take all Possible Steps to Reduce at Source the Contamination of Sewage Sludge with Heavy Metals, 1980; and 1990-2 Methods of Monitoring Dumping Grounds for Sewage Sludge

The water and drainage industry is facing increased strategic measures and investments to ensure long-term sustainability (Svenskt vatten 2016b). These measures cover the whole of the field of water and drainage and relate to the safety of drinking water supply, climate adaptation, regeneration work on the pipeline network, and to meeting stricter and new treatment requirements for wastewater treatment plants. The challenges in the achievement of this are to have strategic investment planning, where resources are required both in the form of money and staff with sufficient time and expertise, which is most difficult for smaller municipalities. The water and drainage industry is in a phase where many operations are given new, more stringent environmental permits. Many plants have been in operation since the 1960s and 1970s and are now undergoing renovation and rebuilding. Synergies between nutrient purification, other pollutants and microplastics should lead to increased knowledge of processing technology and increased separation of microplastics as wastewater treatment plants are converted to meet increased purification requirements.

The aspect of microplastic and technologies that provide a more far-reaching separation can be highlighted in a discussion of technical choice in process modification of a wastewater treatment plant in connection with stricter licensing requirements for nitrogen, phosphorus and BOD. For example, ultrafiltration/MBR has been proven to provide a complete separation of microplastics, and can at the same time be a compact, performance-efficient solution that may be relevant in streamlining conventional small-space active sludge processes. Two of the world's largest MBR plants are now planned for installation at the Henriksdal wastewater treatment plant and the Himmerfjärdsverket plant, both of which are in Stockholm. In Gothenburg, Gryaab has had disk filters for a few years to achieve more extensive phosphorus removal, which also results in further microplastic separation. Ultra- and microfiltration remove microplastics and provide good pre-purification prior to advanced purification technologies, such as ozone or the use of activated carbon, for the removal of drug residues and other contaminants.

A separation of microplastic in wastewater treatment plants means that the microplastics end up not only in the sewage sludge. There are few studies of what happens to the microplastic that ends up on arable land, and whether microplastic can reach the sea that way. This is an area that requires more research.

10.1.6 Proposals for instruments and measures

Efficient and broad upstream work to reduce the inflow of undesirable substances, such as microplastics from such sources as stormwater, textiles and hygiene products is important in the reduction of the amount of microplastics reaching streams, lakes and seas.

Efficient upstream work needs to be conducted through a cooperation process at a local level in specific work aimed at common targets for water and drainage clients, local regulatory authorities and operators. Strategic work also needs to be pursued at regional, national and international levels, with a common vision of objectives and cooperation between agencies, trade organisations and industry.

The upstream work reinforces the need for standardised methods for sampling and analysing microplastics.

PROVISION FOR A PREVENTIVE ACTION PLAN

The Swedish EPA presented a proposal for a draft statute in a government commission on sustainable phosphorus removal: Ordinance on production, marketing, transfer and use of sewage fractions, biofertiliser and compost (Swedish EPA, 2013). In addition to the rules on the use of sludge, bio-fertiliser and compost, the draft statute also included wording on the need for documented preventive measures to improve the quality of fractions. This was proposed to occur by the operator establishing a plan that describes the preventive measures taken to minimise the presence of metals, organic substances and other undesirable substances in the fractions. The Swedish EPA proposes that the agency be authorised to produce instructions defining in more detail what such a plan should contain. One measure could be to include microplastics.

Impact assessment

The work on prevention means that requirements for action will be addressed to industries and other activities, including requirements for the substitution of hazardous chemical products with those less dangerous or requirements for extended cleansing or treatment of wastewater. All this, in addition to higher water and drainage charges, leads to higher costs for the operator. All wastewater treatment plants would eventually be subject to the requirement for preventive measures. The total cost for all wastewater treatment plants was estimated at approximately SEK 100–180 million in the government commission for sustainable phosphorus removal.

GUIDANCE ON INCREASED CONTROL OF SPILL WATER FLOWS

As microplastics are separated so efficiently at wastewater treatment plants, the proportion of microplastics from spill flow water is a significant part of the total discharge of microplastic from wastewater treatment. The Swedish EPA has developed new regulations on the treatment and checks of discharges of urban wastewater (NFS 2016:6), which came into effect on 1st of January 2017. These replace the regulations on the treatment and checks of urban wastewater discharges (SNFS 1994:7 and SNFS 1990:14) which had been in force for more than 20 years.

The new regulation makes requirements for checks of wastewater in both the pipeline network and at or in the wastewater treatment plant. During 2017, the Swedish EPA will produce a written guide to the regulation, and several seminars will be held. The guidance is aimed at regulatory authorities and operators. Clearer guidance and increased checks of spill water flows should increase the possibilities for better mapping of spill water flows, which could ultimately provide the basis for further work on reduction of the amount of spill water, and therefore the emission of microplastics.

PRE-PURCHASE PROCUREMENT GROUP FOR ADVANCED PURIFICATION DEVELOPMENT

As described in Chapter 5, a pre-purchase procurement group is a multiple year collaboration between the various public procurement stakeholders (and on individual occasions also other stakeholders who carry out procurement under similar terms) aimed at improving the quality of procurement through joint knowledge-building and collaboration on requirements and procurement methods. The Swedish Energy Agency, which has worked with pre-purchase procurement groups and innovation procurement since the 1990s, considers that pre-purchase procurement groups are an effective way of achieving new solutions.

With regard to wastewater treatment there is a need to further develop advanced wastewater treatment for the separation of pharmaceutical residues, microplastics and other undesirable substances. A pre-purchase procurement group could be an effective way of working on the requirements for procurement of new technology or system solutions through testing and verification of new technology, and methodology and standard development. By agreeing on methods, requirements and criteria, procurement can be conducted more effectively and will lead to better competition in the market.

The Swedish EPA intends to investigate the possibility of initiating a pre-purchase procurement group for advanced treatment in 2017. The funding requirement for running a pre-purchase procurement group is approximately SEK 1.9 million per year. This includes a permanent secretariat function and funding of several pre-studies.

Impact assessment

Stakeholders

Pre-purchase procurement groups usually consist of representatives from activities in municipalities, county councils and the state, but companies can also participate. In this case, a pre-purchase procurement group should consist of operators, municipalities and Svenskt Vatten.

We also believe that the following authorities should play a supporting part for a pre-purchase procurement group based on their areas of responsibility: The Swedish EPA, the Swedish National Agency for Public Procurement and the Swedish Agency for Marine and Water Management.

Costs

A permanent secretariat function will be needed for the pre-purchase procurement group to function efficiently over time, as well as funding for pre-studies and projects. In addition, there are additional costs for the Swedish EPA to initiate work with pre-purchase procurement groups, as well as administrative costs for the municipalities, agencies and other stakeholders who participate in the pre-purchase procurement group.

- *Secretariat function*
  The task of a secretariat is to organise meetings, produce decision-making data, manage administration around pre-studies and write applications for major development projects. The function can be performed by one of the members of the pre-purchase procurement group, a trade association, consultant company or similar. The most appropriate role for a secretariat in this case remains to be examined.
  A pre-purchase procurement group should operate over several years to achieve results. The secretariat function for the Energy Agency's small pre-purchase procurement groups is usually granted funding for 3 years at a time with funding of approximately SEK 900,000 per year. The Energy Agency applies the Block Exemption Ordinance, Article 27 Innovation Clusters, as its basis for support. The funding level is 50% and the working hours of members is counted as co-funding.

- *Pre-studies*
  Pre-studies may include surveys, small surveys and tests, as well as various forms of decision-making data. The results of the pre-studies may include proceeding and starting a development project, initiating an innovation contract or developing new requirements or criteria for procurement. Experience from, among other things, the National Agency for Public Procurement is that funding for pre-studies should be available in order not to lose pace and maintain commitment among those involved in the pre-purchase procurement group. It has also been shown that the pre-studies should receive 100% funding. The reason is that these are projects in early stages that can be difficult to link to a direct benefit for an individual stakeholder. For example, the Swedish Energy Agency has set aside a budget of approximately SEK 1 million per year for pre-studies for its newly started pre-purchase procurement group “Small houses”.[90]
- *Projects*
  The costs of the pre-purchase procurement group projects, such as development projects and innovation procurement, vary and cannot be determined precisely. Funding of the projects is proposed via public authorities and other institutions’ regular call-offs, see below.
  If more is required, members of the group need to seek additional funding for larger projects. Any pre-purchase procurement groups in the Swedish EPA should be able to search in, for example, the Swedish EPA’s own report Urban Innovations - Funding for cutting-edge technologies and advanced system solutions. It is also possible to seek funding from other stakeholders such as Vinnova, the Swedish Energy Agency, industry organisations and other research and innovation centres.

PARTICIPATION IN THE EU AND INTERNATIONALLY

Contribute to review of the EU Wastewater Treatment Directive

A review of the EU Waste Water Directive is expected to start in 2017. The Swedish EPA, as the responsible agency for the directive, will participate in the review. The problem of microplastics and their separation in wastewater treatment plants will be considered, particularly in the case of spill water flows. The development of better methods for measuring and checking the contents of different types of microplastics in wastewater treatment plants is important for any requirements. Sweden will pursue the same reasoning regarding the demand for increased treatment as at national level (see above). However, it is important that all Member States fully implement and comply with the requirements of the directive.

HELCOM *AND* OSPAR

Sweden will continue to contribute to increasing knowledge about microplastics in wastewater and sludge, as well as about cost-effective, good techniques for the separation of microplastics in wastewater treatment plants. The Agency for Marine and Water Management is responsible for coordinating Sweden’s efforts in the regional

[90] Since the level of funding for pre-studies is 100%, the Block Exemption Ordinance does not apply. The Energy Agency has solved this by signing framework agreements with 2 companies. The Swedish Energy Agency can thus easily call off the pre-studies requested by the pre-purchase procurement groups. A simpler way (without a procurement procedure) for the Swedish EPA could be to make use of the ordinance governing De Minimis aid.

maritime conventions, with the support of other agencies and the Ministry of the Environment and Energy. The Swedish EPA, with the support of the Agency for Marine and Water Management, is responsible for monitoring and contributing to the implementation, reporting and development of HELCOM's recommendation 28E/5 on municipal wastewater, 23/5 on stormwater and 38/1 on sludge, as well as contributing to the actions of HELCOM and OSPAR Regional Marine Litter Action plans covering wastewater treatment and stormwater management (see Annex 3).[91]

HELCOM's Marine Litter Action Plan includes several regional measures aimed at increasing knowledge of microplastics in wastewater and sludge, as well as cost-effective, good techniques for the separation of microplastics in wastewater treatment plants. Sweden has, in particular, undertaken to contribute to the compilation of best technology for cost-effective treatment of stormwater and wastewater from microplastics by 2018 (see Annex 3). The summaries shall be used as a basis for the development of measures at regional level or guidance on measures at national level.

The Swedish EPA should develop and increase its contribution to HELCOM's work on waste management related to microplastics in wastewater and sludge. The results of this government commission should be considered. The Environmental Protection Agency's efforts in HELCOM should also be able to contribute to similar measures within the OSPAR Regional Marine Litter Action Plan.

10.2 Release of microplastic via stormwater to seas, lakes and streams

Stormwater is understood here, as in the proposal for the Public Water Services Act, to mean temporary flows of rainwater,[92] meltwater, flushing water and ground water. In itself, stormwater is not a source of microplastics but can act as a dispersion pathway for microplastics and other pollutants that stormwater can carry to seas, lakes and streams. According to IVL's survey, sources of microplastics for which stormwater can act as a dispersal pathway to the sea are mainly road and tyre wear, artificial grass pitches, industrial production and handling of primary plastics, surface treatment and painting of buildings, etc. and litter, see Table 2 below. In short, wear and outdoor activities that use plastic materials are sources of microplastic where stormwater is a significant dispersion pathway.

However, there are currently no available data about the presence of microplastics in stormwater, which is why it is uncertain to what extent microplastics from these sources are dispersed to seas, lakes and streams. IVL has estimated the amount of microplastic that is released to the sea via rainwater to ~ $70 \cdot 10^9$ microplastic particles per year in Sweden. It should be pointed out that the estimate is based on simplified assumptions and is not intended to give an exact figure but a roughly estimated order of magnitude (Magnusson et al. 2016). Stormwater not only carries plastic and rubber particles caused by wear and tear, but can also carry larger pieces of plastic, i.e., larger than 5 mm to the sea. The larger pieces of plastic may then be broken down into microplastic in the environment.

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91 HELCOM RL4 and RL7, OSPAR Action 42

92 Bill 2005/06:78, General Water Services

Table 2 Sources of microplastics dispersed via stormwater

SOURCES OF MICROPLASTIC	(approx. tonnes/year)	TRANSPORT ROUTE TO THE SEA	(approx. tonnes/year)
Roads and tyres	8,190	Stormwater, wastewater treatment plants (WWP), air	No data
Artificial grass pitches	1640–2,460	Stormwater	No data
Industrial production and handling of primary plastics	310–530	Industrial/WWP waste water, rainwater	No data
Surface treatment and painting of buildings, etc.	130–250	Stormwater, some to WWP	No data
Littering	No data, probably very large source.	Stormwater or directly to the sea	No data
Plastic recycling facilities	No data	Stormwater and airborne	No data

(Source: Magnusson et al. 2016, revised 2017)

10.2.1 Current stormwater management

Urban stormwater is mainly treated in so-called separated or duplicate systems where stormwater is treated separately from wastewater and thus does not burden the wastewater treatment plants. A small proportion, about 13%, of the Swedish urban drainage network consists of combined sewage systems where stormwater, such as traffic stormwater, and wastewater are led to the wastewater treatment plants in the same pipelines. In these areas, the open street drains are connected to the combined sewage systems. These combined wastewater systems were the dominant solution in urban areas up to the 1950s and were mainly found in older communities and town centres (Svenskt Vatten 2016).

According to a survey of municipalities, around 8% of stormwater from urban areas is treated. Four per cent of this is treated in wastewater treatment plants in combined wastewater systems and four per cent in dedicated stormwater treatment plants, such as stormwater ponds and wetlands (Olshammar et al. 2015). A large proportion of urban stormwater is diverted untreated into the environment to the sea, lakes and streams. One explanation for the fact that only a small percentage of the stormwater is being treated is that stormwater has historically been regarded as a being disposal problem, in which the issue was to dewater surfaces and divert water to the nearest receiving water body to avoid water damage and flooding. However, the view of stormwater has changed and is now aimed at achieving more sustainable stormwater management. There are several examples of sustainable stormwater management, including slow drainage, increased infiltration and the construction of measures such as ponds and wetlands as a final step before discharge into receiving water bodies as well as local disposal at the source (Svenskt waters 2016).

The stormwater from roads outside of urban areas is mainly disposed of in ditches that are directly connected to the road network. Ditches can be seen as both dewatering and drainage systems, but also as treatment systems for stormwater, see Chapter 4.

The issue of the release of microplastics through stormwater has only been addressed in recent years. Only a few studies have been conducted on how effective the treatment of stormwater has been in the different stormwater treatment techniques. One of the parameters most often included in studies of stormwater treatment techniques is suspended solids. As microplastics are in particle form, they will form part of the material included in the sampling of suspended substances. Therefore, an approximate indication of how different treatment techniques could work with regard to microplastics separation can be gained (Noren et al. 2016b).

Stormwater treatment plants generally offer effective separation of particulate impurities, and the purification efficiency of systems such as wetlands, ditches, ponds and sand filters is about 70% or more (SVU 2016; Noren et al. 2016b). However, microplastic particle density may differ from other types of particles which may affect their sedimentary ability and thereby be separated by treatment techniques based on sedimentation. However, the conditions for separating microplastics from stormwater are considered to be relatively good. A Masters study from Uppsala University in 2016 studied of the separation of microplastics in several stormwater ponds and artificial wetlands (Jönsson 2016). The systems in the study showed a clear separation of microplastics of up to 90% or more.

10.2.2 Assessment of the possibilities for reducing the release of microplastic via stormwater

The need for stormwater purification varies according to the pollution it contains, which in turn depends on the catchment area and the sensitivity of the recipient. In addition to acting as a dispersal pathway for microplastics, other environmental substances are also dispersed via stormwater, such as metals, oils and PAHs, eutrophication substances and more. All in all, this indicates an increased reason for treating stormwater and thus reducing the release of microplastic to its receiving bodies and then on to the sea.

There are many stakeholders involved in stormwater management, variously municipal, state and private. The stakeholders influence, among other things, the amount of stormwater generated, the way it is transported and its pollution content. There are ambiguities in the current regulations regarding how responsibilities are shared and how far responsibilities stretch. The municipal responsibility is divided between, for example, the road holder, the person responsible for the drainage of municipal streets and the water and drainage principal, who is responsible for the provision of water and wastewater services in the area of operation.

Stormwater is regulated in various legislation, including the Environmental Code, the Public Water Services Act (2006:412) (LAV), the Planning and Construction Act (2010:900) and the Land Code. There is uncertainty here as to whether stakeholders can be targeted by different protection measures, which stakeholders can be targeted and if so by whom they can be targeted and how the measures can be imposed. The lack of clarity about the regulations and the allocation of responsibilities makes it difficult to achieve the effective and reasonable measures that are necessary to reduce the release of microplastics and other pollutants via stormwater. The Swedish EPA is currently working on a shorter government commission with a focus on the problem within the stormwater area – Analysis of the state of knowledge within the stormwater question. The commission is due to be reported by September 30th 2017 and contains three overall parts.

1. A summary of the environmental impact of stormwater (what is in the water, where it comes from, what the environmental impact will result in),
2. Description including analysis of key problem areas (e.g. deficiencies in regulation, planning, technology),
3. Proposals for steps on the way towards further work.

When choosing treatment techniques, it is important to choose the right technique in relation to the expected pollutants and their levels in the stormwater, the status of the receiving water body and the cleaning effect to be achieved. The choice of technique also depends on site-specific conditions such as available space and the possibility of infiltration (Blecken 2016). When they are being built, treatment plants need to be dimensioned in relation to the incoming flow. It is worth noting that the degree of cleansing in a plant generally depends on the initial concentration of a substance. At low concentrations, the degree of cleansing may be low, despite a well-functioning plant (Blecken 2016). If the sources of microplastic dispersal are identified and measures are targeted at actions close to the source, the total need to clean the stormwater can be limited to the water in which the concentrations and needs are highest and the degree of purification of the plant is highest. The total need for purification can then be reduced while reducing the microplastic release of. Actions near the source involve a cost to the operator upstream of the stormwater system. At the same time, this is considered reasonable on the basis of the 'polluter pays' principle.

10.2.3 Gaps in knowledge

There is still a major lack of knowledge about what the dispersal pathways look like and the amounts of microplastics dispersed through stormwater from various sources to seas, lakes and streams. The Swedish EPA considers it important to initiate research, surveys and knowledge collection that increase knowledge in this area. The Swedish EPA can, for example, carry out studies under its screening programme to help increase knowledge in the field.

10.2.4 Proposals for action

In the framework of this government commission, the Swedish EPA has identified the following measures related to the release of microplastic via stormwater.

EVALUATE AND DEVELOP TREATMENT TECHNIQUES

There is need for more knowledge of the effectiveness of current stormwater treatment techniques on removing microplastics. It is also important to develop new cost-effective treatment techniques. To develop new technologies, particular attention should be given to methods suitable for treatment in environments close to the source of microplastics, i.e. road traffic stormwater and surfaces in urban areas with a lack of space. It is important, however, that these treatment techniques consider not only the problem of microplastics but also other substances impacting the environment.

The Swedish EPA intends to investigate the possibility of working with pre-purchase procurement groups for the development of treatment techniques for stormwater during 2017. The work could be set up in a similar way to the proposed pre-purchase procurement group for artificial grass.

REVIEW OF THE REGULATORY FRAMEWORK FOR STORMWATER

Under the current regulations, there are ambiguities as to which stakeholders are responsible for stormwater and how far their responsibilities go. It also means uncertainty as to which stakeholders are subject to the different prevention measures, as well who can set the requirements and how they can be imposed. To achieve necessary but also effective and reasonable measures to reduce the release of microplastics and other pollutants via stormwater, it is important that responsibilities are clear and that are bound by the ability to be able to implement the measures. The 'polluter pays' principle (Chapter 2, Section 8 of the Environmental Code) is central here. The lack of clarity of regulation and the division of responsibilities make it difficult to achieve this.

The Swedish EPA therefore considers that a review of existing legislation with a view to clarifying the responsibility for stormwater needs to be conducted. In this context, it is important to ensure that responsibility follows the ability to implement measures and the possibility of adopting environmental and cost-effective solutions for reducing the release of microplastics through stormwater. In connection with the presentation of the Government commission for an analysis of the state of knowledge in the stormwater issue on the 30th of September 2017, the Swedish EPA intends to return with any proposals regarding revision of the regulatory framework.

INTERNATIONAL WORK WITHIN HELCOM AND OSPAR

The Swedish EPA can work for increased knowledge of microplastics in our international collaborations within Helcom and Ospar. Helcom's current recommendations for stormwater date back to 2002. We can work toward the development of new recommendations within the framework of the collaboration.

11. Overall assessment and proposed measures

The knowledge gathered in this report provides a first, consolidated picture of the origin and release of microplastics to seas, lakes and streams. The primary sources of microplastics that we consider should be addressed are emissions from tyre wear, artificial grass pitches, industrial manufacture and handling of primary plastics, textile laundry, boat hull paint and litter. It presents an overall assessment of the potential for reducing microplastic emissions from these sources and a summary of proposed measures, both national, EU and international.

11.1 Opportunities to reduce microplastic releases

The starting point for the work on this commission has been the environmental quality objective of Balanced Marine Environment and Flourishing Coastal Areas and Archipelagos, but also the environmental quality objectives of Flourishing Lakes and Streams and Non-toxic Environment. To contribute to these objectives, the transport of microplastics from the priority sources to seas, lakes and streams needs to be reduced. Preventive measures need to be taken to prevent emissions from arising, as well as measures aimed at reducing the release of particulate matter to the environment.

Today, there is not enough scientific knowledge to enable certain conclusions to be drawn about how microplastics from tyre and road wear, artificial grass pitches, industrial production and handling of primary plastics, textile laundry, boat hull paint and litter in Sweden are released to the seas, lakes and streams and what environmental impact they have there. We have therefore considered that the possibilities for preventing emissions and reducing the release of microplastics are limited in the short term.

We believe that reducing losses and the release of microplastics into seas, lakes and streams from artificial grass pitches, industrial production and the handling of primary plastics is more feasible in the short term than preventing emission from occurring. The latter would, for example, require a discussion on the choice of filler material for artificial grass pitches, which is problematic because there is currently an insufficient knowledge base for us to be able to recommend one material over another. For tyre wear, textile laundry and boat hull paints, we also estimate that reduction in the loss of microplastics from these sources is more feasible in the short term than prevention of wear of car tyres, man-made fibres and boat hulls. We note, however, that more knowledge of both microplastic dispersal pathways and methods of reducing proliferation is needed to reduce emissions from these different sources.

Litter is not just a microplastic issue. We have considered that previously proposed measures in the presentation of the government commission Measures to reduce the amount of litter (2016) should have an effect on reducing the amount of litter, but that the microplastic issue requires increased information efforts.

Knowledge building is central to the prevention of emission of microplastic in the longer term and reduction of their release, as is dialogue and information to raise awareness of the problems of microplastics.

Although we have assessed the possibility of reducing emissions of microplastics in Sweden as relatively limited in the short term, it is important to emphasise that there are already instruments for reducing emission of microplastics, albeit indirectly. Many of the behaviours that cause emission and spread of microplastics are also those that cause particulate emissions in general. For example, there are instruments aimed at reducing particulate emissions into air and water, as well as instruments for reducing the emission of unwanted substances to the environment. Many of the measures taken today to prevent and reduce emissions of various substances to water and air are also considered to have an effect on microplastic emissions. The synergies between possible measures to reduce microplastic emissions and ongoing or planned measures in other areas should be exploited.

11.2 Summary of proposed national measures

The proposed measures that we have developed are aimed at raising both knowledge and awareness of microplastics through research and development, guidance, dialogue and information. In parallel with national measures, work in the EU and internationally to reduce the emission of microplastics to seas, lakes and streams continues. All the proposed measures are summarised at the end of this chapter, see Table 3.

Measures should be revised as the knowledge base is built up. Potential conflicts of interest between objectives aimed at reduction of microplastic emissions and other objectives, such as road safety and health objectives, linked to sport and leisure, should be addressed in the context of the future development of instruments.

11.2.1 KNOWLEDGE BUILDING

The knowledge gaps and methodological difficulties identified during the work on the commission constitute an important contribution to further work with microplastics in Sweden.

We need an expanded and more reliable knowledge of how, how much and in which way microplastics from the sources and dispersal pathways we have focused on in this commission contribute to the environmental status of coastal and sea waters, as well as in lakes and streams.

There is also a need for further surveys of sources and dispersal pathways. This is partly to capture other, potentially important, sources and partly to ensure the accuracy of the calculations made. Potentially important sources of microplastics are linked, for example, to sports and leisure activities (riding stables, golf courses and fall protection surfaces), the construction sector and agriculture.

There is also a general need to develop harmonised definitions and methods of measurement. This does not mean that measurements of microplastic should wait until standardised methods are available. In parallel to the development of measurement methods, there is a need to continue measurement, using the methods already in place to evaluate both sampling and analysis methods, and to get an idea of the extent of the microplastics issue.

We propose, among other things, that the Swedish National Road and Transport Research Institute be commissioned by the Government to develop knowledge of microplastic emissions from road traffic. Further examples of R&D measures include evaluation of highway stormwater purification techniques, a knowledge-based review of measures to reduce losses of granulate from artificial grass pitches, screening of microplastics and measuring of plastic particles in boat hull washes.

In addition, the Swedish EPA will work with microparticles, including microparticles made from plastic in its inventory of research activities in 2018. The need for increased knowledge of the origin, dispersion and environmental effects of microplastics will be considered.

GUIDANCE

Guidance for supervisory agencies and companies has several objectives, such as creating the conditions for equally applied and effective supervision, clarifying rules and contributing to better self-inspection. The Swedish EPA will provide guidance for increased control of spill flows (untreated or incomplete treatment of water from sewerage systems or wastewater treatment plants), for the application of the legislation governing the use of rubber granules in artificial grass pitches, and for measures to minimise material losses during manufacture and processing of primary plastics.

INFORMATION

A number of information measures are proposed, notably in the field of textile laundry, such as providing information for consumers about the measures they can take to reduce the emission of microplastics from the use and laundry of synthetic fibres, but also to reduce the amount of litter. The Swedish EPA is also planning to hold a workshop with the Swedish Chemicals Agency to consider microplastics that are caused by synthetic fibres.

PER-PROCUREMENT PRE-PURCHASE PROCUREMENT GROUPS

A pre-purchase procurement group is a multiple year collaboration between the various procurement agencies aimed at improving the quality of procurement through joint knowledge-building and collaboration on requirements and procurement methods. We have found that pre-purchase procurement groups are an efficient way of gathering and building knowledge and creating new solutions for the development of primarily artificial grass pitches, but also for the development of advanced treatment techniques for purification of wastewater treatment plants and stormwater. The Swedish EPA will initiate a pre-purchase procurement group on reduced environmental impact from artificial grass pitches during 2017. We also propose a government commission to initiate and run additional pre-purchase procurement groups, see the proposal in 11.4.

11.3 Participation in the EU and internationally

In the case of specific issues and binding regulation, it may be effective and sometimes necessary to operate through the EU, both in terms of the effects on Swedish work with its measures and the impact on microplastics emissions from other countries in Europe. As relevant to the sources identified as more important in the context of this commission, the directives on ecodesign and industrial emissions and the regulation on energy labelling of tyres are considered to be of particular importance in reducing microplastic emissions both in Sweden and in the EU.

The EU's circular economy package and the forthcoming plastic strategy are also likely to have a major impact on both the reduction of plastic litter and the emission of microplastics. The work also includes comprehensive revision of waste legislation, as well as two pending reports on microplastics.[93] Sweden is actively involved in the work on circular economy – that is, sustainable development and an economy based on cycles. We can thus act both as an accelerator and as support in the work on the most relevant parts of the strategy that have a bearing on marine litter and the leakage of microplastics. The Commission's sub-reports on microplastics are expected to be completed in the context of the plastic strategy (late 2017). These may be relevant for national measures.

11.3.1 The Ecodesign Directive

The EcoDesign Directive is often referred to as a possible instrument that should be developed to reduce plastic litter and the emission of microplastics from, for example, textile laundry. The Swedish EPA agrees that, to address the problem of microplastics, there is potential for extending the Ecodesign Directive to more products than the directive currently covers.

The Swedish EPA proposes that Sweden should work to develop the requirements for washing machines, with regard to microplastic emissions from textile laundry, in the ongoing revision of washing machines in the EU Ecodesign Directive. The Swedish Energy Agency, the Swedish EPA and the Swedish Chemicals Agency should be primarily responsible for producing relevant data. The Swedish Energy Agency leads work on the issue and participates in meetings as the responsible authority in Sweden. Work on the measure should take place in autumn 2017 or spring 2018.

In the Circular Economy Action Plan, the European Commission also proposes that the Ecodesign Directive be revised with a view to increasing opportunities for recycling and reducing the use of plastic, thus reducing waste.

11.3.2 ENERGY LABELLING OF TYRES

Tyres are not manufactured in Sweden and the possibilities of influencing tyre manufacturers to manufacture more durable and strong tyres are therefore considered to be small. However, the Swedish EPA considers that it would be possible to pursue the issue at EU level through the EU's mandatory energy labelling for tyres. The labelling sets requirements for energy efficiency, grip on wet road surfaces and external noise. Wear resistance is not currently included.

The Swedish EPA, in consultation with the Swedish Energy Agency, proposes that the Swedish Energy Agency be given responsibility for investigating the possibilities and suitability of working for the development of the energy labelling of tyres to include tyre wear. The Energy Agency considers that robust measurement methods need to be developed and established first, which implies a commitment to the work of the standards bodies and the development of new knowledge.

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[93] http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/amec_tors.pdf, and Eumicroplastics, http://www.eumicroplastics.com/

11.3.3 Industrial Emissions Directive

Under the Industrial Emissions Directive (IED), there is a reference document describing best available techniques (BAT, BREF) for manufacturing in a given industry. Binding BAT conclusions contain mandatory basic requirements for a production facility. Microplastic could be addressed as one aspect of these documents.

The BREF documents are revised by industry according to a rolling schedule of approximately 10-year intervals. BREF for textile industries will be revised in the near future. In connection with this revision we propose that the Swedish EPA works within the EU to produce data on the emission of microplastics from manufacturing processes in the textile industry. The information can then form the basis for further negotiations on updating BAT conclusions and reference documents.

Plastic manufacture in the EU is also regulated under the Industrial Emissions Directive. There is also some scope here for addressing parameters relating to the formation and emission of microplastics from the manufacture of plastics and plastic products respectively. However, the EU has not planned any revision of the reference document.

11.3.4 Other relevant legislation and future processes in the EU

THE MARINE STRATEGY FRAMEWORK DIRECTIVE AND THE WATER DIRECTIVE

On 17th of May 2017, the European Commission adopted criteria and methodology standards for good environmental status in marine waters. These provide that each Member State is to set thresholds for the presence of microlitter, including microplastic, in relation to the risk of damage to the coastal and marine environment by July 2018 or as soon as possible thereafter. This will be done through cooperation at EU level, taking into account regional and sub-regional characteristics. The Water Framework Directive contains no parameters relating to litter or microplastics. A revision of the framework directive is due to take place by 2019. Discussions have been held as to whether microplastics can be interpreted as having an ecological status of particularly polluting substances in the Water Framework Directive.

THE URBAN WASTE WATER TREATMENT DIRECTIVE

A review of the EU Urban Waste Water Treatment Directive is expected to start in 2017. Techniques for separation and methods for measurement and control of discharges should be considered in this process. As the responsible authority, the Swedish EPA will contribute to revision of the directive. The issue with microplastics and their separation in wastewater treatment plants will be considered in that context.

REACH

The EU chemicals legislation REACH is currently subject to a comprehensive review that will be completed in 2018. [94] The current legislation does not apply to polymers. The Commission has commissioned a report on the use of microplastics in products and the possibilities of regulating it within REACH by the end of 2017.[95]

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94 http://ec.europa.eu/DocsRoom/documents/21364

95 http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/amec_tors.pdf,

COLLECTION OF WASTE FROM VESSELS IN PORT

The Directive on port reception facilities for ship-generated waste and cargo residues is currently being reviewed.[96] Several guidance documents have already been published, but further supporting documents are needed to enable the Commission to assess the need for amendments to the Directive.

11.3.5 International processes

The international work on microplastics is generally characterised by continued acquisition and exchange of knowledge. However, the fact that the problem of microplastics in the sea has been elevated to high on the international agenda gives important policy signals and supports regulation at regional and national level. International processes can also contribute, such as coordination of different stakeholders, increased knowledge base and harmonisation of definitions and concepts. Sweden should use the knowledge generated to increase its knowledge base and develop measures nationally. We can also contribute our own experiences to the international processes. The work of the HELCOM and OSPAR regional marine conventions have been identified as important arenas for this commission.

HELCOM AND OSPAR

Sweden has actively participated in the development of HELCOM's and OSPAR's respective Marine Litter Action Plans. The Swedish EPA and the Agency for Marine and Water Management consider that continued work within these regional conventions is also central to reducing the incidence of microplastics in Swedish coastal waters. This should be done through continued good or increased efforts in some defined areas.

The Swedish EPA should develop and increase its contribution to HELCOM's work with actions related to discharge water treatment and stormwater associated with microplastics. In addition, the Swedish EPA should develop and increase its contribution to HELCOM's work on waste management related to marine litter. At present, knowledge gathering is primarily ongoing on sources and dispersal pathways for macro- and microplastics to the Baltic Sea. However, future work involves developing proposals for regional measures, based on the basis of the data produced. The Environmental Protection Agency's efforts in HELCOM should also contribute to similar measures within the OSPAR Regional Marine Litter Action Plan.

The Agency for Marine and Water Management coordinates the Swedish efforts for HELCOM and OSPAR Marine Litter Action plans and should continue to contribute actively to their implementation. This primarily concerns the measures concerning best practices for the management of waste from the fisheries sector to which Sweden has committed itself in particular.[97]

The Swedish Transport Agency should continue to contribute to measures aimed at improving and harmonising port reception of ship waste.[98]

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[96] Directive 2000/59/EC, https://ec.europa.eu/transport/modes/maritime/safety/actions_en

[97] OSPAR Action 36 and HELCOM RS5

[98] OSPAR Action 30, 31 and HELCOM RS3, RS4

11.4 Proposal to the Government

The Swedish EPA proposes that different agencies be given responsibility for implementing most of the proposed measures. It is proposed that the Government decide on the following measures:

- Government commission to the Swedish National Road and Transport Research Institute (VTI) to build knowledge of microplastic emissions from road traffic (see section 4.5.1).
- Authorisation to produce a regulation on preventive measures to minimise the presence of metals, organic substances and other undesirable substances, including microplastics, in incoming wastewater to wastewater treatment plants (see section 10.1.6).
- Grant funding for pre-purchase procurement groups. For pre-purchase procurement groups to work, funding will be required for fixed secretariat functions and several pre-studies. The funding requirement has been estimated at approximately SEK 1.9 million per year for at least a 3-year period and for each pre-purchase procurement group. The Swedish EPA intends to initiate a pre-purchase procurement group on reduced environmental impact from artificial grass pitches during 2017. SEK 1 million has been set aside for the purpose. However, this is a short-term solution. For this pre-purchase procurement group to work over time, an additional amount of approximately SEK 1 million will be required in 2018 and SEK 1.9 million per year for 2019 and 2020. A total of SEK 4.8 million will be required between 2018 and 2020 for a pre-purchase procurement group for a reduced environmental impact from artificial grass pitches. In addition, the Swedish EPA has, in dialogue with the National Agency for Public Procurement, considered that pre-purchase procurement groups are an effective way of gathering and building knowledge and providing new solutions for the development of advanced wastewater treatment techniques and wastewater treatment plants. Funding of SEK 1.9 million per year and per pre-purchase procurement group for at least a 3-year period is required, which means SEK 5.7 million per pre-purchase procurement group. In total, approximately SEK 16 million is required over a 3-year period for the Swedish EPA to be able to initiate and run the pre-purchase procurement groups for artificial grass pitches, stormwater treatment and advanced wastewater treatment (see section 5.4.1 and 10.1.6). Propose that the Government gives the Swedish EPA a three-year task of initiating and running pre-purchase procurement groups with accompanying funding totalling SEK 16 million for work on the task.
- Funding for a developed information campaign on littering and microplastics. The Environmental Protection Agency and the Agency for Marine and Water Management propose that work on the development of information campaigns on marine litter should be take place within the framework of the agreed measure no. 20 in the Action Program for the Marine Environment. It is appropriate to strengthen the already existing campaign between 2017 and 2019 on marine littering and to extend it with a campaign on microplastic emission. The Agency for Marine and Water Management believes that this issue will require increased funding of SEK 3 million per year from 2018 to 2019 in the Agency for Marine and Water Management grant 1:11 and SEK 5 million extra per year after that, so that the measure is not to charged against to the current budget (see section 9.4.2).

- The Swedish EPA would like to take the opportunity to highlight an earlier proposal on government funding for beach cleaning from the government commission Measures to reduce litter (2016). The costs for cleaning beaches along the Bohus coast have been estimated at SEK 15 million. The funding can be provided by adding funds to the Agency for Marine and Water Management's grant 1.11 (see section 9.4.1).

In addition, the Swedish EPA intends to return with details of funding requirements for further efforts to reduce the presence of plastic litter, including microplastics, in the sea, lakes and streams in its budget for 2018.

11.5 Microplastic – a shared responsibility

Microplastic is an environmental problem that affects everyone. Stakeholders at all levels of society need to contribute to the development of knowledge about microplastics in Sweden and to the reduction of emissions from their respective areas of responsibility.

In addition to the national measures proposed in this report, we would also like to highlight the many voluntary commitments already undertaken by municipalities, county councils, trade associations and interest groups.

We would also like to draw attention to the fact that business operators have far-reaching responsibility for preventing the negative impacts of their activities, in accordance with the general precautionary principle in Chapter 2 of the Environmental Code, which applies to everyone and is the basis for all environmental requirements set out in the Environmental Code. The aim of the precautionary principle is to prevent negative impacts and to increase consideration for the environment. It is the person who runs a company, who does or intends to do something that is at risk of having an impact on human health or the environment, who must plan and control their activities on an ongoing basis to counteract or prevent such impacts. The knowledge rule underlines the importance of clarifying in advance the consequences of how human health and the environment could be affected and how they can be protected.

11.6 Conclusions

The measures presented in this report are primarily aimed at increasing knowledge and awareness of microplastic emissions. The measures should be seen as a first step to steer more environmentally and cost-effectively in the long term towards reduced emissions of microplastics to the seas, lakes and streams in Sweden. The measures involve a small step towards achievement of the environmental quality objective of Balanced Marine Environment and Flourishing Coastal Areas and Archipelagos and the environmental quality objectives of Flourishing Lakes and Streams and Non-toxic Environment.

Globally, lack of waste management and on-shore littering are the main source of the presence of macro- and microplastics in the sea. Two billion people worldwide do not have access to any form of organised waste management. In comparison, Sweden's waste management system functions well on an international scale. It is therefore crucial that Sweden continues to contribute to the construction and development of waste systems internationally.

Although our waste management functions comparatively well, our consumption of plastic is high. For example, the amount of plastic consumed per person is nearly four times higher in Europe than in Asia. To reduce the environmental impact of microplastics, they need to be seen as part of our plastic economy. The global plastic economy is not sustainable today (World Economic Forum 2016). It is therefore of great importance to work in parallel to reduce the environmental impact of plastic production and consumption, to make more efficient use of plastic as a resource and to develop plastic that is free from hazardous substances, both in Sweden and globally.

Table 3. Summary of the proposed measures presented in this report.

Source/ Pathways	Type of instrument	Corrective measure	Objective	Responsible party	When
Roads and tyres	R&D	Government commission to the National Road and Transport Research Institute (VTI)	Building knowledge of microplastic emissions from road traffic.	The Government	-
	R&D	Build up knowledge of microplastic dispersion from the roads	A better understanding of how microplastic particles from road and tyre wear are spread and how much of the emissions from road traffic reach seas, lakes and streams.	Swedish Transport Agency	No time specified
	R&D	Evaluate stormwater purification technologies	Investigate how well current stormwater purification techniques work with regard to microplastics.	Swedish Transport Agency	Begun
	EU	Explore development of the EU tyre energy label	Examine the possibilities and appropriateness of driving development of energy labelling of tyres to include tyre wear.	Swedish Energy Agency	Start 2017
Artificial grass pitches	Public procurement	Initiate pre-purchase procurement groups to reduce the environmental impact of artificial grass pitches.	Improving the quality of procurement of artificial grass pitches through joint knowledge-building and collaboration on requirements and procurement methods. Target group: Municipalities.	The Swedish EPA in cooperation with the National Agency for Public Procurement.	2017
	Guidelines	Guidance on legislation for the use of rubber granulate in artificial grass pitches	Facilitate the application of waste and chemical legislation on use of granulate in artificial grass pitches.	Swedish EPA	2017
	Information	Compile measures to reduce losses	Compile existing measures to reduce losses and spread of granulate from artificial grass pitches to assist operators.	Swedish EPA	2017
Industrial manufacture, handling of plastics and fragmentation plants	Guidelines	Guidance to authorities and operators on material losses in the form of microplastics.	Raise awareness among review authorities, supervisory authorities and operators of the material loss issue and provide examples of appropriate measures.	Swedish EPA	2018
Textile laundry	Information /dialogue	Information to textile stakeholders, workshop on the topic of man-made fibre microplastics	Increased knowledge of microplastic emissions caused by man-made fibres at textile operators. Exchange of experience between textile stakeholders,	The Swedish Chemicals Agency and the Swedish EPA	2018

Source/ Pathways	Type of instrument	Corrective measure	Objective	Responsible party	When
	Information	Public/household information on microplastics from textile laundry.	Increased consumer knowledge of microplastic emissions from textile laundry (increased knowledge of the environmental problem and specific advice).	The Swedish Consumer Agency and the Swedish EPA	2017–2018
	Information	Information for the Laundry Association on microplastics from textile laundry.	Increased commercial laundry knowledge of microplastic emissions from textile laundry (increased knowledge of the environmental problem and specific advice).	The Swedish EPA and the Swedish Laundry Association	2017–2018
	Information	Information to procurement authorities on the possibilities of helping to reduce the loss of microplastics from textiles through public procurement requirements;	A review of the possibilities for including microplastics in government information and sustainability criteria for the procurement of laundry and textile services;	National Agency for Public Procurement	2017–2018
	EU: Ecodesign	Promote the evaluation of effects on microplastic emissions of filters in washing machines and promote the development of ecodesign recommendations for filters for washing machines.	Increased knowledge of the effects of filters on microplastic emissions during laundry. Commission recommendations on ecodesign requirements for washing machines.	The Swedish Energy Agency and the Swedish EPA	2017–2018
	EU: BREF, BAT	Promote the development of documentation on the emission of microplastics from manufacturing processes in the textile industry.	Contribute to revised requirements for the best available techniques for textile industries.	Swedish EPA	2017–2019
Boat hull paint	R&D	Measurement of plastic particles during boat hull washing.	Acquire knowledge to evaluate the best possible techniques for leisure boat hull washing and, if necessary, to plan more extensive sampling.	Swedish Agency for Marine and Water Management	2017
	Amendment of regulations	Include microplastics in the list of the regulations for boat hull paints	Review the guidelines for boat hull washing for recreational craft. If necessary, these could be developed to include methods to minimise the emission of microplastics.	Swedish Agency for Marine and Water Management	2017–2020
Litter	Contributions	Government funding of beach cleaning (Previously proposed in the presentation of government commission Measures to reduce littering, 2017.)	Extended cleaning of beaches along the Bohus Coast to reduce litter dispersion, including plastic litter.	The Government	-

Source/ Pathways	Type of instrument	Corrective measure	Objective	Responsible party	When
	Information	Funding for an extended campaign on marine littering with a microplastics campaign.	Influence behaviour to reduce marine litter.	The Government	2017–2019
Wastewater treatment plants	Authorisation to draw up a regulation on preventive measures.	Develop regulations containing preventive measures.	Minimise the occurrence of metals, organic matter and other undesirable substances, including microplastics, in incoming wastewater to wastewater treatment plants.	The Government	-
	Guidelines	Guidance on increased checks of spill water flows	Reduce the amount of spill flow waste water and therefore the emission of microplastics.	Swedish EPA	2017
Stormwater	Review of existing legislation	Review of existing legislation to clarify responsibility for stormwater.	Improve the clarity of legislation.	A number of responsible authorities should be included in such a review, including the Swedish EPA and the Board of Housing.	2017–2018
Overall, general, comprehensive**	Public procurement	Proposed that the Government gives the Swedish EPA a three-year task of initiating and running pre-purchase procurement groups with accompanying funding totalling SEK 16 million for work on the task.	Reduce the environmental impact of artificial grass pitches, including the loss of rubber granulate. Develop advanced wastewater treatment: Separation of drug residues, microplastics and other undesirable substances. Develop stormwater treatment techniques to separate microplastics.	The Government	-
	R&D	Assessment of research activities 2018.	Inventory the need for knowledge of microparticles, including microparticles made of plastic, in order for the next step to be to determine what information is relevant for increased knowledge of the origin, dispersion and environmental effects of microplastics to be considered.	Swedish EPA	2017
	International	Develop the Swedish EPA's regional cooperation in HELCOM.	Increased contribution to HELCOM's work on wastewater treatment and stormwater measures to reduce the incidence of microplastics. Increase the contribution to HELCOM's work on waste management related to marine litter.	Swedish EPA	

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Annex 1. Commission for the Swedish EPA

GOVERNMENT DECISION (M2015/2928/KE) 6 AUGUST 2015

The Government instructs the Swedish EPA to identify major sources in Sweden for the emission of plastic microparticles into the sea, work to reduce the generation and emission of microplastics from these sources and, if necessary, propose regulatory changes to reduce emissions.

The Swedish EPA will submit its final report to the Government Office (Ministry of Environment and Energy) by the 15th of June 2017.

BACKGROUND

Plastic items make up the largest part of marine waste and can consist of anything from microscopic particles to large objects such as barrels, fishing gear and discarded leisure craft. Plastic is particularly problematic because plastic does not decompose in nature, it only fragments into smaller and smaller parts.

Marine litter is an environmental problem that leads to disturbances in the marine ecosystem. The litter poses a threat to various animal species and causes suffering to many animals. In addition, marine litter has major socio-economic consequences, such as damage to fishing gear and vessels and the costs of cleaning beaches and reducing tourism. The ecosystem services on which human beings depend are in danger of being undermined and disappearing.

The presence of microparticles presents a particular challenge in the waste cycle. They are made up of many different materials from a variety of sources. Since their size is similar to that of phytoplankton, marine living animals that filter the water for food will ingest the particles. Because the plastic material is in the water column for a long time, it is likely that the concentration of plastic microparticles, microplastics, will increase gradually. In addition, there are indications that organisms that ingest the microplastics are exposed to increased exposure to environmental toxins because the environmental toxins bind harder to plastic than to natural particles.

Microplastics in the seas occur not only because larger plastic particles have been broken down to smaller ones. Microplastics are increasingly being added to cosmetic products and to household chemical products to provide a scrubbing function. Furthermore, there are studies that show that fleece textiles can emit a significant number of fibres during laundry compared to other materials. Other studies refer to the problem of plastic particles emission from tyres being transported by the stormwater system. Wastewater treatment plants do not have any specific treatment methods to trap plastic particles. A large proportion of the particles will, therefore, probably pass through the treatment plants.

At the Commission meeting for the Convention for the Protection of the Marine Environment of the North-East Atlantic, OSPAR, in Portugal in June 2014, the parties decided to adopt a regional action plan to prevent and manage marine litter. Measures include evaluating all products and processes that include microplastics and, where appropriate, reducing their impact on the marine environment. Sweden has, among other things, undertaken a special responsibility to examine and promote, together with the industry, the use of best available techniques to prevent wastewater, including microlitter, from sewage and stormwater from reaching the marine environment. Similar work on the development of a regional action plan for marine litter is under way within the Convention on the Protection of the Marine Environment of the Baltic Sea, Helcom. Marine litter is an area of action in the implementation of the EU Marine Strategy Framework Directive (2008/56/EC) with the aim of achieving good environmental status in the Baltic and North Sea by 2020. An action plan is to be adopted by December 2015.

The problem of marine litter and microplastics is also a global issue. In June 2014, the United Nations Environment Agency, UNEA, adopted a resolution on marine waste and microplastics, stressing in particular the importance of reducing sources. The UN Environment Program, UNEP, will, in accordance with the resolution, carry out a global study on marine waste and microplastics to be presented to UNEA in May 2016.

The Government prioritises work on a non-toxic environment and a flourishing marine environment. Today's environmental challenges are largely cross-border and work to achieve the environmental quality objectives also requires Sweden to work toward an ambitious environmental policy within the EU and internationally, and to continue to work with countries that are of strategic importance for global environmental and climate cooperation.

In December 2014, the Government instructed the Swedish Chemicals Agency to further develop the action plan for a non-toxic daily life with a view to stepping up efforts to achieve the environmental quality objective of a non-toxic environment. The commission includes, among other things, examining and, where appropriate, proposing national restrictions. Microplastics are mentioned as examples of areas to be examined by the Swedish Chemicals Agency.

MORE DETAILED INFORMATION ON THE COMMISSION

The Government will instruct the Swedish EPA to identify major sources of discharges of plastic microparticles into the sea in Sweden and to propose measures to reduce such discharges. Agencies responsible for protecting the marine and aquatic environment and responsible for regulating products and activities that may lead to the release of microplastics into the environment must contribute to the systematic and coordinated implementation of the commission.

The Agency must monitor and take into account developments and discussions taking place within the EU and its individual Member States, OSPAR, Helcom and the Nordic Council of Ministers, as well as in global work, such as UNEA and UNEP. Where appropriate, the commission must be conducted in dialogue with authorities in other countries as well as regional and global organisations. Knowledge that is generated within the assignment should be made easily accessible to relevant institutions within and outside Sweden. The aim is for Sweden to be a forerunner in developing and implementing measures that reduce the release of microplastics into the environment.

The Agency must identify and prioritise the sources and dispersal pathways in Sweden that need to be addressed primarily to reduce emissions. Sources to be included in the analysis include packaging materials, chemical products, plastic fibres and textiles, building materials, agricultural plastics, tyres and artificial grass pitches.

The proposals will relate to the relevant measures in the forthcoming Marine Environment Action Programme currently being developed by the Agency for Marine and Water Management to achieve good environmental status in accordance with the Maritime Environment Directive.

The Agency must also propose, in addition to actions at sources, measures on the dispersal pathways through which discharges occur, such as textile laundry, collecting and treating plastic waste, litter, dust from plastic production, dust from construction sites, etc. where plastic is ground or cut, maintenance of ships and leisure craft and stormwater systems. The Agency must compile existing knowledge of the state of research into the best possible technologies in wastewater treatment systems and, where required, propose measures. The potential and benefits of simultaneously separating microparticles of non-plastic material should be investigated. The relevant agencies must work primarily to reduce the generation and emission of microplastics from priority sources through national risk management tools, such as regulatory or guidance changes, tighter supervision and/or dialogue with industries on voluntary commitments. If such tools are not sufficient, the agencies should analyse and propose other statutory changes.

Statutory proposals must be accompanied by an impact assessment to be drawn up in accordance with the Sections 6 and 7 of the Ordinance (2007:1244) on regulatory impact assessment. The impact assessment must also include an analysis of the impact on trade with other countries.

If national measures are not judged appropriate or possible, the agencies must analyse the advantages and disadvantages of various instruments at European or international level.

The commission will be conducted in dialogue with municipalities and county councils, trade organisations within the business sector, waste organisations, environmental organisations and other relevant stakeholders.

The Swedish EPA must, in dialogue with the Swedish Government Office (Ministry of the Environment and Energy), agree on the dates and forms of interim reports, based on the deadlines in the processes of various institutions. The Agency must submit its final report to the Government Office (Ministry of Environment and Energy) by the 15th of June 2017.

On behalf of the government

Åsa Romson
Jerker Forssell

Annex 2. Table of sources and dispersal pathways in tonnes/year

Summary table from IVL Swedish Environmental Research Institute's survey, which describes identified sources of emissions of microplastics and the main dispersal pathways in Sweden in tonnes per year In certain cases a range of maximum and minimum calculated values is specified depending on the available data

Source	Quantity of micro-plastic produced (tonnes/year)	Dispersion pathway to the aquatic environment	Estimated amount of microplastic reaching the sea (tonnes/year)
Road traffic	8,190	Stormwater, various discharges	No data
Artificial grass pitches	1,640–2,460	Stormwater	No data
Boat hulls	160–740	Directly to the water	160–740
Laundry water	8–950	Wastewater treatment plants	0.2–19
Industrial production and handling of primary plastics	310–530	Waste-water treatment plants, stormwater	No data
Building painting	130–250	Stormwater, via wastewater treatment plants	No data
Buoys etc.	2–180	Directly to the water	2–180
Hygiene products	66	Wastewater treatment plants	Discharge water: 1.3 Sludge: No data
From fishing gear	4–46	Directly to the water	4–46
Treatment of organic waste	26 (>2mm)	Various discharges to the receiving water body	No data
Household dust	1–19	Wastewater treatment plants	0.02–0.38
Litter	No data	Stormwater or direct to the aquatic environment	No data
Recycling of plastic	No data	Airborne, stormwater	No data
Landfills	No data	Sewage treatment plants, or various discharges	No data
Agricultural cover plastic	No data	Diffuse discharges	No data
Discharges from ships	No data	Directly to the aquatic environment	No data
Abrasive blasting	No data, probably small amounts	Treatment plants, or industrial discharges	No data
Pharmaceuticals	No data, probably small amounts	Sewage treatment plants	No data

(Source: Magnusson et al. 2016, revised 2017)

Annex 3. EU and international regulation and relevant processes linked to microplastics

Plastic has made a quick entry as a flexible and useful material around the world. Last year, global production of plastics amounted to 322 million tonnes, compared with 1.5 million tonnes in 1950 (Plastics Europe 2016). According to estimates, almost the same amount of plastic waste (275 million tonnes) is generated globally, of which approximately 5–13 million tonnes annually end up in the world's seas (Jambeck et al. 2015). The growing global demand for plastic poses major challenges for the sustainable use of resources and waste management.

A number of initiatives are under way at EU and international level to prevent and manage the presence of microplastics in the oceans. Microplastics are often referred to as a fraction of marine litter, and fragmentation of large pieces of plastic litter in the oceans is considered to be the largest source in a global perspective.[99] Knowledge acquisition in recent years has, however, made it clear that there are many different sources that require a wide range of measures.[100]

Working through EU and international processes linked to microplastics

The international work on microplastics is generally characterised by continued acquisition and exchange of knowledge. However, the fact that the problem of microplastics in the sea has been elevated to high on the international agenda gives important policy signals and supports regulation at regional and national level.[101] International processes can also contribute, such as coordination of different stakeholders, increased knowledge base and harmonisation of definitions and concepts. Sweden should use the knowledge generated to increase its knowledge base and develop measures nationally.[102] We can also contribute our own experiences to the international processes. The work of the HELCOM and OSPAR regional marine conventions is identified have been identified as important arenas for this commission.

[99] Boucher, J. and Friot D. (2017). Primary Microplastics in the Oceans: A Global Evaluation of Sources. Gland, Switzerland: IUCN. 43ff.

[100] A rough estimate of the percentage of microplastics in the seas resulting from fragmentation of large items of plastic litter compared to that already reaching the seas as microparticles from land (primary sources) results in between 15 and 31% coming from primary sources. Boucher, J. and Friot D. (2017), IUCN.

[101] For example, microplastics are included in the Marine Pollution Partnership dialogue at the UN Maritime Conference in support of the implementation of sustainable development goal 14 "Life below water" in New York, June 2017. https://sustainabledevelopment.un.org/content/documents/14398Partnershipdialogue1.pdf

[102] For example, Sweden is participating in the update of the UNEP Marine Litter and Microplastics Report (see 11.3)

In the case of more specific issues and binding regulation, work through the EU is more important, both in terms of the effects on Swedish work with its measures and the impact on microplastics emissions from other countries in Europe. As relevant to the sources identified as more important in the context of this commission, the directives on ecodesign and industrial emissions, the regulation on energy labelling of tyres, and work on the circular economy, have particular importance in reducing microplastic emissions both in Sweden and in the EU.

This Annex describes some of the major EU and international regulatory frameworks and initiatives that can be linked to microplastics.[103]

Documents and activities in the EU

A wide range of EU regulations and initiatives are concerned with the problem of marine plastic litter and microplastics, although microplastics have not yet been fully involved in the legislative field. In 2012, the Commission commissioned its own survey of legislation, policies and strategies relevant to marine litter, SWD(2012) 365 final, which notes that this is a complex issue affecting a wide range of sources and areas of influence. The survey was followed by a Green Paper on a European strategy for plastic waste in the environment, COM (2013 123 final), which aimed to launch a broad discussion on what can be done to solve the environmental problem of plastic waste, which is not currently explicitly addressed in EU waste legislation.

Within the EU's Action Plan for a Circular economy, COM (2015) 614 final, plastic is a priority area and a strategy for plastic is planned for autumn 2017, which will include microplastic litter. In support of possible proposals for specific measures, the Commission has decided to identify ways of reducing discharges to the aquatic environment of microplastics deliberately added to products[104] and of microplastics that are not intentionally added,[105] such as emissions from textiles, tyres, artificial grass, etc. A general consultation on the results of the latter project will be held in June-August 2017.

Table 1 lists documents and activities in the EU that may be relevant to microplastics in the sea. Some rules have no relation to current microplastic dispersion but may potentially have it in the future, for example, they may give a regulatory framework that has not been used.

[103] The Annex does not claim to be comprehensive.

[104] http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/amec_tors.pdf

[105] A general consultation will be held during June–August 2017, and a workshop is scheduled for 6 July. See Eumicroplastics http://www.eumicroplastics.com/.

Table 1. Relevant documents and activities in the EU linked to microplastics.

Title	No.,link	Subject/ content/
EU legislation		
Marine Strategy Framework Directive	2008/56/ EC[106] en	Good environmental status for marine litter is: 10.1 The amount of litter, including its degradation products, is not causing damage to the marine environment, and 10.2) Reduction of litter that affects or is likely to adversely affect marine organisms. Litter is labelled as a physical impact. Chemical substances are listed related to dir 2000/60.
The Water Directive	2000/60/ EC en	Aim to preserve and improve the quality of water. Litter is not a criterion of good ecological status.
The Urban Waste Water Treatment Directive	91/271/ EEG[107] en	All urban areas in the EU with more than 2,000 inhabitants must have collection systems and wastewater treatment. But there are exceptions.
The Sludge Directive	86/278/ EEC[108] en	Environmental protection when sewage sludge is used in agriculture. Limit values for seven heavy metals. Nitrogen and phosphorus conditions.
Bathing Water Directive	2006/7/ EC[109] en	The directive applies to the quality of water in all built and natural bathing areas where many people swim. MS monitors water quality with regard to bacteria annually.
Waste Directive	2006/98/EC	General framework with waste hierarchy, targets, etc. But no target for plastic waste.
The Packaging Directive	1994/62/EC, 2015/720/EC	Recycling targets for plastic packaging. The revision required MS to reduce plastic carrier bags. Producer responsibility.
Industrial Emissions Directive	2010/75/EG	Best Available Technique documents, BREF and BAT conclusions, related to plastic manufacturing. They are updated on a decade basis. Current now: LVOC & FDM and TXT.
Classification, Labelling and Packaging Regulation (CLP)	1272/2008	Helps identify hazardous substances. Plastic is a packaging material.
Regulation on the labelling of tyres	EU no 1222/2009	Labelling of tyres in terms of fuel efficiency and other essential parameters, such as grip and noise. Does not include wear resistance.
The Ecodesign Directive	2009/125/ EC en	Groups of products must be CE-marked against step-by-step requirements. Until now, only energy efficiency is dealt with, but the directive leaves room for other aspects.
Energy Labelling Directive	2010/30/ EU[110]	Harmonised criteria for energy-related labelling of energy-related appliances when they enter the market. For example, the washing machine label contains information about water use and spin speeds.
REACH	1907/2006	Comprehensive chemicals legislation. Includes chemical additives in plastics, but not polymers.
Regulation on cosmetic products	1223/2009/ EC	Strengthening market surveillance to ensure, inter alia, a high level of protection of human health. Environmental problems that may be caused by substances in cosmetic products are dealt with under REACH. Contains no restriction on the content of microplastic particles
Directive on port reception facilities for ship-generated waste and cargo residues	2000/59/EG	Requires access to adequate reception and treatment of waste from ships in ports.
Ship Recycling Regulation	1257/2013/ EU	The EU's scrapping of ships will be more environmentally friendly – probably most in China.
EU legislation in the packaging area		
Circular economy	December 2015	Package of proposals for amendments to the Waste directives and the Circular economy Action Plan.
Plastic strategy	Concluded 2017	

[106] OJ L164, 25.6.2008, p. 19.
[107] OJ L 135 30.5.1991, p. 40
[108] OJ L 181, 4.7.1986, p. 6.
[109] OJ L64, 4.3.2006, p. 37.
[110] OJ L 153 18.6.2010, p. 1.

THE MARINE STRATEGY FRAMEWORK DIRECTIVE AND THE WATER DIRECTIVE

The Marine Strategy Framework Directive (2008/56/EC) is the key environmental legislation of the EU's Integrated Marine Policy. The aim is for all EU marine areas to have achieved good environmental status by 2020. The directive will be implemented in six-year cycles in which all EU Member States, starting in 2012, will assess their seas' environmental status, define good environmental status, set environmental quality standards with indicators, develop programmes for monitoring the marine environment and finally establish an action program.

The description of good environmental status is structured in 11 topic areas (descriptors). Descriptor 10 (D10) States "Properties and quantities of marine litter do not cause harm to the coastal and marine environment", which includes microplastics. The Commission recently adopted (17th of May 2017) new criteria and methodology standards for good environmental status in sea waters. [111] These state that each Member State is to set thresholds for the presence of microlitter, including microplastic, in relation to the risk of damage to the coastal and marine environment by July 2018 or as soon as possible thereafter. This will be done through cooperation at EU level, taking into account regional and sub-regional characteristics. The Swedish descriptions of the characteristics of good environmental status can be found in Ordinance 2012:18. This will be updated in 2018 to comply with the new Commission Decision. Current criteria for what characterises good environmental status are 10.1: The volume of waste, including its breakdown products, does not cause damage to the marine environment, and 10.2: Waste that adversely affects or is likely to affect marine organisms must be reduced. The establishment of indicators, monitoring programs and action programmes for microplastics is hampered by the lack of standardised sampling and measurement methods. A technical working group [112] supports Member States in developing, inter alia, indicators and monitoring programmes for marine litter and microplastics and has published several reports for guidance [113].

The Water Directive (2000/60/EC), adopted in 2000, aims to protect and improve all inland and coastal waters in the EU. As with the Marine Strategy Framework Directive, the work takes place in management cycles of six years. The first cycle ended in 2009, the following cycle ended in 2015, and the next will end in 2021. There are no good status parameters relating to litter or microlitter, including microplastic, in the Water Directive. Marine litter under the Marine Strategy Framework Directive also includes materials transported to the marine environment from land via streams and sewage systems or by winds. As marine litter and microplastics are largely from onshore sources, water management under the Water Directive is also important for achieving good environmental status in the seas. A review of the framework directive will be conducted by 2019, and the Commission will make proposals for any changes. Discussions have been held as to whether microplastics can be interpreted as having an ecological status of particularly polluting substances in the Water Framework Directive.

[111] (EU) 2017/848

[112] Technical Group on Marine Litter (TG ML).

[113] https://ec.europa.eu/jrc/en/search/site/marine%20litter

WASTEWATER AND SLUDGE DIRECTIVES

The EU Urban Waste Water Treatment Directive (91/271/EEC) aims to combat environmental damage caused by urban waste water discharges and certain industrial processes. It covers all the waste water collected in drainage systems, but quantitative requirements are only imposed for the treatment plants serving more than 2,000 people. The old EU Member States (EU15) should have fulfilled all the measures under the Directive by the end of 2005, and the 13 new EU Member States in 2015[114]. The latest follow-up (2016) sets good average compliance for EU15 with the Directive's treatment requirements (95% of wastewater received more extensive treatment), while non-compliance is reported for EU13 where only 68% of wastewater received basic treatment[115]. Based on the degree of connection and treatment, a report to the Commission estimates that a maximum of 57% of all microplastics reaching wastewater treatment plants in the EU is separated[116]. In addition to shifting the focus away from the source, the report identifies two obstacles to legislating for microplastics within the Wastewater Directive – upgrading all EU sewage plants with techniques that effectively separate microplastics would cost too much and, even then, no guarantee can be given that no discharges will take place; and that sludge is often used in agriculture from where microplastics can be spread further. The development of infrastructure and new techniques requires substantial investment, which is partly covered by the European Structural and Investment Funds. Investment in innovative technologies is also important and is supported, for example, by the European Innovation Partnership for water and the EU funding program for research and innovation, Horizon 2020. A review of the Wastewater Directive is likely to begin in 2017–2018.

The treatment of sludge from wastewater treatment plants is governed by the EU Directive on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (86/278/EEC). The Directive encourages the correct use of sludge in agriculture. No future revision is planned.

WASTE AND PACKAGING DIRECTIVES

The Commission's proposal to revise the waste directives and the action plan on circular economy deals with plastic and plastic waste.[117] Amendments to the Waste Directive will mainly affect plastics in connection with changes to the Packaging Directive. It is possible to amend the collection and recovery targets and the rules governing producer responsibility. The Commission assessed the impact of this on waste sorting, recycling and re-use and the availability of large volumes of recycled plastics.[118]

The ongoing review of the Packaging Directive provides for a common EU recycling target of 75% of packaging waste by 2030. It requires the implementation of preventive measures, increased producer responsibility, and the development

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[114] http://ec.europa.eu/environment/water/water-urbanwaste/legislation/pdf/transitional_periods_eu10_eu2.pdf Romanian 31 December 2018.

[115] http://eur-lex.europa.eu/legal-content/SV/TXT/PDF/?uri=CELEX:52016DC0105&from=EN

[116] Eunomia, Study to Support the Development of Measures to Combat a Range of Marine Litter Sources, Jan, 2016.

[117] COM(2015) 593, 594, 595, 596 and COM(2015) 614, respectively.

[118] Negotiations in the EU Council and in the EU Parliament started in spring 2016 and have not yet been completed (spring/early summer 2017).

of reusable packaging. In addition, Member States must introduce systems for the collection of used packaging to achieve the targets set. The proposed measures should have a major impact on the reduction of marine litter.

The EU decided in 2015 ((EU) 2015/720) that all Member States should reduce the consumption of lightweight plastic carrier bags. The measure aims not only to help reduce the problems of litter but also to reduce the inefficient use of resources resulting from current consumption of plastic carrier bags.

THE ECODESIGN DIRECTIVE

The Ecodesign Directive (2009/125/EC) covers, with some exceptions, all energy-related products. The aim is to improve the environmental performance of the products throughout their life cycle. The directive is a framework directive, which sets a framework for how requirements are to be developed and what can be regulated. The requirements act as a floor to ban and remove the worst products, from an energy perspective, from the market. The requirements are developed through a life cycle analysis where the product's energy use in the user phase will be the largest criterion for making the product subject to ecodesign. The requirements are introduced either as product-specific EU regulations that are directly applicable in the Member States, or as voluntary agreements. It also regulates when the requirements start to apply and how measurements and controls are to be conducted.

In addition to energy use, properties such as noise, life span or information requirements relating to hazardous substances may also apply. For example, requirements for plastic products and packaging that make them more durable or easier to recycle and reuse, or requirements for the performance of washing machines regarding the emission of microplastics from laundering textiles. The possibility of including such requirements in the Ecodesign Directive, which would be positive for reducing the level of microplastics and their emission, is set out in the Circular Economy Action Plan.

INDUSTRIAL EMISSIONS DIRECTIVE

The Industrial Emissions Directive (IED, 2010/75/EU) aims to control and limit the environmentally hazardous emissions from European industry to protect the environment and human beings. Under the IED there are so-called BREF documents and descriptions of best available techniques, BAT conclusions, for certain industries with mandatory basic requirements at manufacturing facilities. The instruments are statutory for industrial manufacturing technology and can contribute in the long term to the control of plastic emissions from manufacturing and to a certain extent from products. The documents are revised by sector according to a rolling schedule, over a relatively long period of time.[119] Microplastic could be addressed as one aspect of these documents.

Some BREF documents relevant to microplastics are:

- Textile industry covers the manufacture and treatment of textiles. BREF from 2003 will be opened for revision in 2017. Certain aspects relating to the formation and emission of microparticles/fibres from textiles resulting from the manufacturing process should be addressed in the context of the revision of the BAT conclusions. To the extent that such conditions are not known, a starting point may be to pro-

[119] http://eippcb.jrc.ec.europa.eu/reference/

duce a basis which seeks to clarify and prioritise which aspects are critical and what can be done in the context of manufacture to tackle the formation and emission of microparticles. This can then form the basis for negotiations on updated BAT conclusions and reference documents. Imports of textiles into the EU are very extensive and the rules will not directly affect them. However, they may have some impact on manufacturing facilities where textiles are produced for export to the EU.

- *Waste treatment.* Includes the handling and treatment of waste, except landfill and incineration. The revision of BREF from 2006 is currently in its final phase. Microplastics have been the subject of discussion in the negotiations but are probably not included in the BAT conclusions.
- Common Waste Gas Treatment in the Chemical Sector. It includes wastewater and sludge treatment and waste from the chemical industry. BAT conclusions adopted in 2016. Microplastics are not mentioned.
- *Production of polymers.* Includes manufacture of plastic. The revision of this BREF is postponed indefinitely as it was developed under IPPC. The Commission has not decided whether to revise it under the IED. It is waiting to see what happens with BREF WGC (Common Waste Gas Treatment in the Chemical Sector).
- *Surface Treatment of Metals and Plastics.* Regarding BREF from 2006, no revision planned.

REACH

The EU REACH legislation (which regulates the registration, evaluation, authorisation and restriction of chemical substances) aims, among other things, to ensure a high level of protection of human health and the environment. Under REACH, it is the organisation marketing a substance that is responsible for the substance not posing unacceptable risks to human health and the environment.

There is currently no specific regulation of microplastics in REACH. A number of Member States, including Sweden, have therefore examined the conditions for national bans on microplastics in cosmetic products. In its report in 2/16, the Swedish Chemicals Agency concluded that it is possible to argue that a national ban on microplastics, with a view to reducing the amount of marine waste, falls outside Breach's scope.

The process of restricting a substance in REACH may take several years. Initiatives for new restrictions can be taken both by the Commission and by individual Member States. Within the framework of the restriction process, the substance is assessed for its risk and the socio-economic effects of a restriction are evaluated. The Commission is currently carrying out a study of 'Intentionally added microplastics in products' to assess the use of microplastics in products, with particular emphasis on microplastic beads. The study aims to carry out a risk assessment for the environment and human health, and to collect information for a socio-economic analysis of the effects of potential proposed actions concerning the marketing and use of microplastics intentionally added to products. The results will be presented in the form of a dossier under REACH Annex XV, which can be used as a basis for a proposal for restriction(s) under REACH. The study will be completed by the end of 2017.

COSMETICS

The aim of the EU regulation on cosmetic products[120] is to protect consumers from health risks but does not address environmental aspects of the use of the products, which should instead be regulated through REACH. At the meeting of the Environment Ministers in December 2014, Sweden and four other EU Member States called for the ban on microplastic additives in products. [121] These are mainly found in cosmetics and detergents. [122]

CIRCULAR ECONOMY AND PLASTICS STRATEGY

The EU Environment Ministerial Meeting in June 2016, in connection with welcoming the European Commission's Circular Economy Action Plan, underlined the importance of tackling marine litter from plastic. They pointed to ecodesign as a possible instrument and turned to the Commission to come up with robust measures to reduce emissions of microplastics.

The Circular Economy Action Plan includes plans for a plastics strategy for the EU.[123] The intention is to make a proposal in 2017. The strategy focuses on three points: 1. High dependence on new plastic, 2. Low percentage of plastics recycled or reused, and 3. Substantial amounts of plastic waste end up in the environment. The strategy will contribute to reduction in the use of new plastic raw material and thereby reduce its potential for climate impact. It will also improve the conditions for the reuse of plastic. In this case, the economic conditions and quality of recycled materials need to be influenced, for example by improving conditions for investment and innovation. The industry needs to operate in a more circular and resource-efficient manner. The strategy will also help to reduce waste. Proposals for measures are promised for the main sources of marine litter, including microplastic particles in cosmetic products and other plastic products that cause litter. The OSPAR, HELCOM and Barcelona conventions were seen as important.[124] The strategy will propose activities that can be useful at EU level.[125] To date, decisions have been taken to reduce the consumption of lightweight plastic carrier bags (2015/720/EC).

The Commission is also planning a proposal on the re-use of water. The main motive is to tackle the lack of water resources in the EU in a more uniform manner. In particular, minimum quality requirements for agricultural irrigation are being considered. Changes could be made to the Water Framework Directive and the Waste Water Directive.[126]

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[120] (EC) no 1223/2009

[121] Elimination of micro-plastics in products – an urgent need, 17 December 2014, http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2016263%202014%20INIT. European Strategy on Plastic Waste in the Environment, COM (2013)123, See also Conference about microplastics in the EU, May 2015.. http://epanet.pbe.eea.europa.eu/ad-hoc-meetings/workshop-plastics-environment-11-12-may-2015/presentations

[122] See EU-COMs WP for 2016, COM(2015)610.

[123] COM(2015) 614.

[124] OUTCOME OF THE COUNCIL MEETING 3476th Council meeting Environment Luxembourg, 20 June 2016, St 10444.

[125] The Commission Roadmap 2016:39, 26/1/2017.

[126] The Commission Roadmap 2017:6, 07/04/2016. See the most recent consultation from the Commission 2017.

COLLECTION OF WASTE FROM VESSELS IN PORT

The EU Directive on the port reception of ship waste and cargo residues (2000/59/EC) is the most important instrument for combating off-shore littering. It implements MARPOL Annex V on dumping of waste from ships in the EU. The directive requires all EU ports to have sufficient capacity to receive and handle waste from the ships arriving at the port. A system for charging reception costs is also required, so that the costs are in line with the 'polluter pays' principle, but are not so high that motivation is lost to offload waste in port instead of dumping it illegally in the sea. A survey of how the directive is applied in the EU Member States reveals great differences.[127] The directive is currently being thoroughly reviewed.[128] Several guidance documents have already been published, but further supporting documents are needed to enable the Commission to assess the need for amendments to the Directive. However, the Commission has indicated that the issue of marine litter from ships and the importance of compliance with the directive to address the problem should be taken into particular account in the revision.

RESEARCH IN THE EU

Sweden participates in JPI Oceans, a collaborative organisation for EU countries aimed at making better use of national research resources in certain strategic areas. Since 2016, four research projects have been ongoing in a specific initiative targeting microplastics in the European marine environment:[129]

- BASEMAN: Defining the baselines and standards for microplastics analyses in European waters
- EPHEMARE: Ecotoxicological effects of microplastics in marine ecosystems
- PLASTOX: Direct and indirect ecotoxicological impacts of microplastics on marine organisms
- WEATHER-MIC: How microplastic weathering changes its transport, fate and toxicity in the marine environment

Several relevant projects on microplastics in the sea have also been funded by the EU's research programmes FP7 (2007–2013) and Horizon (2014–2020). [130]

MISCELLANEOUS

- **EPA Network** (European Network of the Heads of Environment Protection Agencies).[131] Interest Group Plastics was created in 2016 with thirteen countries participating in the group (not Sweden).[132] The main focus of the group is to prevent plastic litter from reaching the environment.
- **EU Ecolabel** EU Ecolabel Since 2014, theEU´s official EU Ecolabel does not permit microplastics in rinseable cosmetic products from being labelled.[133] It was recently decided to impose even stricter requirements for detergents, which also include a ban on microplastics from June 2017.

[127] http://emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities.html
[128] Directive 2000/59/EC, https://ec.europa.eu/transport/modes/maritime/safety/actions_en
[129] http://www.jpi-oceans.eu/ecological-aspects-microplastics
[130] E.g., Marmicrotox, POSEIDOMM, CosmEthics, FreshwaterMPs (http://cordis.europa.eu/projects/home_en.html)
[131] http://epanet.pbe.eea.europa.eu.
[132] Austria, Denmark, Finland, Iceland, Germany, Netherlands, Norway, Portugal, Romania, Scotland, Slovenia, Spain and Switzerland.
[133] Bes 2014/893/EU.

International conventions

Table 2 is a list of international conventions relevant to microplastics.

Table 2. Relevant conventions associated with microplastics.

Convention	Comments
HELCOM	Regional Convention for the Protection of the Baltic Sea Environment from all types of pollution. A regional action plan on marine litter was adopted in 2015. It includes proposals for action against Microlitter.
OSPAR	Regional Convention for the Protection of the Marine Environment of the North-East Atlantic. A regional action plan on marine litter was adopted in 2014. It includes proposals for action against Microlitter.
London Convention/ London Protocol	The Global Convention to combat marine pollution through dumping of waste and other materials is also known as the Dumping Convention. Under it is the London protocol. Administered by IMO.
International Convention for the Prevention of Pollution from Ships (MARPOL)	Global Convention to combat marine pollution from ships. Annex 5 deals with the discharge of waste, including plastics. Administered by IMO.
Basle Convention	Global convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, includes electronics. Limits shipments of waste to the EU.
Stockholm Convention	Global Convention on restriction of Persistent Organic Pollutants (POPs) in products. The Convention covers both manufacture, use, waste management, accidental formation and environmental monitoring. A panel of experts (POPRC) meets annually to prepare proposals for listing hazardous pollutants.

REGIONAL MARINE CONVENTIONS

The UNEP Regional Seas Programme is an important global instrument for the marine environment.[134] There are 18 regional cooperation programmes, 14 of which are also agreed conventions. Supported by the UNESCO Global Marine Litter Programme, most regional conventions have produced an action plan on marine litter. Sweden is a Member of the OSPAR (North-East Atlantic) and HELCOM (Baltic Sea) marine environmental conventions. In Europe there are also corresponding conventions for the Mediterranean (Barcelona Convention) and the Black Sea (Bucharest Convention).

The OSPAR Regional Marine Litter Action Plan (2014–2021) is a framework for coordinating work on marine litter and microplastics in the region, and a guide document for the contracting parties. The measures will partly be implemented on a regional scale and partly through implementation at national level, for example as measures under the EU's Marine Strategy Framework Directive. The plan is divided into measures targeted at offshore sources, onshore sources, cleaning of existing litter, and training and information. Each action is led by one or more countries, sometimes together with an organisation. The work is coordinated by a specially appointed group of representatives from all the Convention countries responsible for driving the work forward and monitoring results.

In 2015, HELCOM adopted a regional action plan to reduce the incidence and input of marine litter to the Baltic Sea. The plan has been adopted through a recommendation (HELCOM rec. 36/1) and, like the OSPAR Action Plan, consists of regional and voluntary national measures. The goal is to have significantly reduced the amount

[134] http://www.unep.org/regionalseas/

of marine litter by 2025 compared with 2015. The HELCOM Action Plan contains measures targeted at onshore sources, offshore sources, as well as training and information. The regional actions are led by one or more countries, sometimes together with an organisation. Coordination and follow-up are conducted within the framework of HELCOM's PRESSURE working group. The plan will be reviewed and, if necessary, revised in 2021.

In addition to the measures aimed at plastic litter being deposited in the North-East Atlantic and the Baltic Sea, the action plans include several measures specifically targeted at microplastics (see Table 3).

Table 3. Actions aimed at microplastics in OSPAR's and HELCOM's regional Marine Litter Action Plans.

Actions under Regional action plans for marine litter	Comments
OSPAR	
Action 42: Investigate and promote with appropriate industries the use of Best Available Techniques (BAT) and Best Environmental Practice (BEP) to develop sustainable and cost-effective solutions to reduce and prevent sewage and storm water related waste entering the marine environment, including micro particles.	Ireland, Norway and Sweden lead, end date 2017/2018.135 In 2016, Sweden delivered a consultation study 136as a basis for discussion of further measures.
Action 46: Evaluate all products and processes that include primary micro plastics and act, if appropriate, to reduce their impact on the marine environment.	Belgium, Germany and the Netherlands lead, end date 2015. The Netherlands organised a conference137 in December 2015 to discuss possible measures and further initiatives to reduce microplastics discharges to the North-East Atlantic. Based on the results from this report and further information, the Netherlands is developing a knowledge base for microplastics, which is planned to be adopted by OSPAR in 2017. Further work is then needed to develop specific measures.
Action 47: Engage with all appropriate sectors (manufacturing, retail etc.) to explore the possibility of a voluntary agreement to phase out the use of micro plastics as a component in personal care and cosmetic products. Should a voluntary agreement prove not to be sufficient, prepare a proposal for OSPAR to call on the EU to introduce appropriate measures to achieve a 100% phasing out of micro plastics in personal care and cosmetic products.	Germany and the Netherlands lead, with the support of Belgium, the UK and Seas at risk, no deadline. At the first meeting with Cosmetics Europe and Plastics Europe in 2015, the cosmetics industry agreed on a voluntary phase-out of microbeads by 2020 and that the industry would report its progress in a transparent manner. A follow-up meeting was held in March 2017, in which Cosmetics Europe indicated a 82% reduction in the use of microbeads in rinseable products by its members, but was unable to provide any documentation of the calculations. The dialogue process will continue.
Action 52: Promote initiatives and exchange of best practice aiming at zero pellet loss along the whole plastics manufacturing chain from production to transport.	France with the support of Germany, the Netherlands and Seas at Risk lead, end date 2015. France is working on a background paper on plastic pellets, which is expected to be completed by 2018, and will in parallel develop a proposal for an OSPAR recommendation. In addition, OSPAR intends to organise a dialogue with relevant trade organisations in the autumn of 2017 to discuss possible measures.
Action 82: Raising public awareness of the occurrence, impact and prevention of marine litter, including micro plastics.	Proposal for action at national level. The contracting parties will report progress every two years, starting in 2016. This report contributes to increasing knowledge and raising awareness of the problem in Sweden.

[135] Revised from 2017 to 2017/2018 at EIHA meeting April 2017

[136] Norén et al. 2016. Report concerning techniques to reduce litter in waste water and storm water. SMED Report No 193.

[137] Closing the plastic value chain: measures for reducing microplastic emissions. https://www.ospar.org/work-areas/eiha/marine-litter/marine-litter-conference

Actions under Regional action plans for marine litter	Comments
HELCOM138	
RL4: Improvement of stormwater management to prevent litter, including microlitter, to enter the marine environment from heavy weather events.	No country leads but Sweden and the Coalition Clean Baltic (CCB) have committed themselves to contributing, deadline 2018. The aim is for HELCOM to compile available information on the management of stormwater by 2018 to provide guidance on how to prevent the emission of macro and micro-litter to the sea at local level. If relevant, Recommendation 28E/5 on municipal wastewater should also be updated based on the data obtained. The action is similar to OSPAR Action 42 (see above) and the Swedish report provides information. CCB has also provided input.
RL6 Establish an overview of the importance of the different sources of primary and secondary microplastics. Evaluate products and processes that include both primary and secondary micro plastics, such as fibres from clothing, assess if they are covered or not by legislation, and act, if appropriate, to influence the legal framework, or identify other necessary measures.	No country has committed itself to leading, end date 2017. Several countries within HELCOM have in recent years developed national surveys or studies on microplastics (including this one) that can contribute to the regional compilation. The Secretariat is examining the possibility of creating the regional compilation while also being aware of the work on OSPAR Action 46 (see above).
RL7 Investigate and promote best available techniques as well as research and develop additional techniques in waste water treatment plants to prevent micro particles entering the marine environment.	Sweden and Finland lead, end date 2018. The measure links to OSPAR's Action 42 (see above) and the Swedish consultation study that contributed to OSPAR's action can also contribute to this one(SMED 2016). Sweden is also investigating available advanced techniques for treating wastewater for pharmaceutical residues through a government commission to the Swedish EPA (completed May 2017).
NL4 Encourage voluntary reporting of companies on their products formulas (i.e. that they do not contain micro particles) towards HELCOM Contracting Parties. Bring in certification schemes, such as Blue Angel, EU Ecolabel, Nordic Ecolabel, etc. Promote a no-littering policy in national parks and protected areas, i.e. visitors should carry out everything they carry in.	National voluntary action.
NL5 Establish an overview of the importance of the different sources of primary and secondary microplastics. Evaluate products and processes that include both primary and secondary micro plastics, assess if they are covered or not by legislation, and act, if appropriate, to reduce the potential impact on the marine environment and to influence the legal framework. This must include the engagement with all appropriate sectors such as manufacturers and retailers. With regard to the use of primary microplastics in personal care products formulations the possible impact on the marine environment should be reduced by applying substitutes. For other areas of applications appropriate solutions need to be defined. National voluntary action.	This is action is being met by, among other actions this report, together with the Swedish Chemicals Agency's proposal, and the Government's revision, for a national ban on microplastics in cosmetic products
NE5 Raising public awareness, including for children and youths and consumer campaigns, on the occurrence, and prevention of marine litter (e.g. to use ashtrays in public areas inland and along the coast), including micro particles, taking into account existing materials (e.g., Marlisco Project) and accompanied by image campaigns addressing threats/impact to marine life from various harmful litter items, such as cigarette filters.	This is action is being met by, among other actions this report, together with the Swedish Chemicals Agency's proposal, and the Government's revision, for a national ban on microplastics in cosmetic products

[138] RL=Regional Land-based; NL=National Land-based; NE=National Education and outreach

LONDON CONVENTION, LONDON PROTOCOL AND MARPOL (IMO)

The London Convention (Anti-dumping Convention) was signed in 1972 to prevent marine pollution from dumping of waste. The Convention lists various types of waste and substances that cannot be dumped in the sea (black list) and those that may be dumped under certain conditions (grey list). In 1996, the Convention was replaced by a protocol based on the principle that all dumping of any form of waste or substance is prohibited. Sweden is a party to the Convention and the Protocol. EU instruments implementing the Convention are Directive 2006/11/EC and Regulation 1013/2006.

MARPOL is an international convention for the prevention of marine pollution from ships. The Convention was signed in 1973 but only entered into force in 1983. The Convention contains six annexes that regulate various types of pollution. Annex IV deals with discharges of wastewater from ships and Annex V discharges of waste. Under Annex V, all emissions of plastic are prohibited.

The International Maritime Organization (IMO) manages the day-to-day administration of both the London Convention and the Protocol, as well as MARPOL. The IMO leads or participates in several activities to prevent the emission of marine litter and microplastics.[139] In 2016, for example, IMO published the report "Marine Litter in Wastes Dumped at Sea Under the London Convention and Protocol" as part of UNEP's Global Partnership on Marine Litter (GPML). [140] The report mainly identifies dredge waste and sewage sludge, because at present no analysis of the (micro)waste content is required before dumping can be permitted. The conclusion is that more knowledge of incidence and effects is needed, and that there is a need to develop standards for measuring and establishing possible limit values for, for example, microplastics.

11.6.1 The Basel and Stockholm Conventions

For example, implemented in the EU and in Sweden, the Basel Convention means that it is illegal to export waste to countries outside the EU or OECD countries. The meeting of the Parties in April-May 2017 decided to include marine litter in the programme.[141] The Stockholm Convention on Persistent Organic Pollutants (POPs) is relevant for plastics, as it limits the use of commercial flame retardants such as penta- and octabromodiphenyl ethers. This Convention also prohibits the recovery of materials containing persistent organic pollutants, such as certain brominated flame retardants.

International organisations and partnerships

International initiatives and processes are often broad in scope with comprehensive strategies and objectives, wordings such as "significant reduction of marine litter" are common.

[139] http://www.imo.org/en/MediaCentre/HotTopics/marinelitter/Pages/default.aspx

[140] http://www.imo.org/en/OurWork/Environment/LCLP/newandemergingissues/Documents/Marine%20litter%20review%20for%20publication%20April%202016_final_ebook_version.pdf

[141] http://www.basel.int/

The UN and its bodies

The UN has drawn attention to the issue of marine litter from both onshore and offshore sources since the early 2000s and is leading a wide range of initiatives and projects.

Agenda 2030 and seventeen sustainability goals were adopted by UN countries in 2015. Goal 14 "Life below water", has the sub-goal: *By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.* In June 2017, the United Nations, hosted by Sweden and Fiji, will be holding the first conference of implementation of sustainability targets in 14. There will be a strong focus on marine litter and microplastics and a partnership dialogue on land-based sources will include the issue.

The problem also links to several other sustainability goals. For example, Goal 11 Sustainable cities and communities, where target 11.6 states that urban waste management needs to be improved, Goal 12 Sustainable consumption and production patterns, where target 12.5 states that waste generation must be substantially reduced by 2030, and Goal 6 Clean water and sanitation.

The United Nations Environment Assembly (UNEA) was set up in 2012 at the Rio+20 meeting, with the aim of supporting the implementation of sustainability targets and strengthening the UN's environmental work. At its first meeting in 2014, 160 countries adopted Resolution 1/6 on marine plastic debris and microplastics, which, among other things, instructed UNEP to produce a report[142] and invited countries to join the UNEP Global Partnership on Marine Litter (GMPL). The second UNEA meeting in 2016 adopted a follow-up resolution (2/11) which reaffirmed the importance of working with marine plastic debris and microplastics and entrusted UNEP with the task of evaluating the effectiveness of international and regional strategies for marine plastic debris and microplastics. The report will be presented at UNEA's third meeting at the end of 2017.

UNEP's Global Programme of Action has a programme focused on marine litter which, among other things, coordinates the implementation of Resolution 1/6 and 2/11. For example, through the Global Partnership on Marine Litter (GPML) voluntary network, which includes implementation of the Honolulu strategy[143], instructs the development of research studies (e.g. GESAMP WG 40 and IOC UNESCO[144]), and supports the Global Partnership on Waste Management, which has marine litter as a focus area and an action plan 2012 –2016[145] [146]. In 2107, UNEP launched the global Clean Seas campaign, which will run until 2022.[147] Most countries have joined.

[142] Marine plastic debris and microplastics: Global lessons and research to inspire action and guide policy change. UNEP, 2016.

[143] http://www.gpa.unep.org/index.php/global-partnership-on-nutrient-management/publications-and-resources/global-partnership-on-marine-litter-gpml/158-honolulu-strategy-final/file

[144] http://www.gesamp.org/work-programme/workgroups/working-group-40

[145] http://unep.org/gpwm/Portals/24123/images/Work%20Plans/Work%20Plan%20ML%202012-2016.pdf

[146] http://www.unep.org/regionalseas/marinelitter/default.asp

[147] https://cleanseas.org/

THE NORDIC COUNCIL OF MINISTERS

In May, a Nordic programme was adopted to reduce the environmental impact of plastics.[148] The programme commits the Nordic countries to taking measures to prevent the spread of plastic to the sea and increasing their knowledge of microplastics. The Nordic cooperation also provides guidance and documentation for national measures, such as waste management and textile procurement.

Svanen, the Nordic eco-label, prohibits microplastics in cosmetic products.[149]

THE ARCTIC COUNCIL

The PAME (Protection of the Arctic Marine Environment) working group has just initiated work on marine litter, including microplastics. The programme will, among other things, develop knowledge bases.

G7 AND G20

G7 and G20 are annual meetings of heads of state from the world's leading countries at which global issues are discussed.[150] At the G7 meeting in 2015, the countries (France, Italy, UK, USA, Canada, Japan, Germany) adopted a Marine Litter Action Plan covering onshore and offshore sources, cleaning measures and education.[151] Improvements in waster and stormwater treatment are listed as measures to reduce emissions of microplastics. Marine litter is also on the agenda at the G20 summit in 2017 which will be hosted by Germany[152]. Plastics will also be discussed at the G7 environment meeting in Italy in June 2017.[153]

MISCELLANEOUS

- OECD - has a marine litter programme approach under the EPOC working group.
- SAICM (Strategic Approach for International Chemicals Management) - Microplastics have been discussed.
- Standardisation. Work is also being done within the European Committee for Standardization CEN and the International Organization for Standardization, ISO, on plastics and microplastics, on definitions, characteristics and test methods and on degradable qualities.
- There are microplastic-related activities in various interest groups, such as the World Economic Forum and the Ellen McArthur Foundation.

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148 Nordic Programme to Reduce the Environmental Impact of Plastics, Nordic Council of Ministers, 2017.

149 http://www.nordic-ecolabel.org/Templates/Pages/CriteriaPages/CriteriaGetFile.aspx?fileID=2228

150 http://www.g7g20.com/

151 http://www.bundesregierung.de/Content/EN/_Anlagen/G7/2015-06-08-g7-abschluss-annex-eng_en.pdf?__blob=publicationFile&v=1

152 http://www.g7g20.com/publication/priorities-of-the-2017-g20-summit.

153 http://www.g7italy.it/en.

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Microplastics

Presentation of government commission on sources of microplastics and proposed measures for reduced emissions in Sweden

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