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COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Combatting microplastic pollution in the European Union

Accompanying the document

Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on preventing plastic pellet losses to reduce microplastic pollution

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Annex 15:
Preliminary analysis of the main sources of microplastic emissions

This Annex reflects the initial analytical work that was undertaken while developing this impact assessment. While six major sources of unintentional releases of microplastic were identified (paints, tyres, pellets, textiles, detergent capsules and geotextiles), pellets were the only source retained for further legislative action in this impact assessment. The preliminary analysis showed that subject to further analysis of cost-effectiveness, and the impacts of alternatives, **existing or forthcoming legislative instruments were better suited to tackling microplastic releases from paints, tyres, textiles, detergent capsules and geotextiles**. This Annex outlines the preliminary analysis of these five sources in view of guiding any future analysis.

1 THE ORIGINALLY IDENTIFIED SOURCES OF MICROPLASTIC EMISSIONS

A UN Environment study[1] identified as many as 74 sources for the release of microplastics (both primary and secondary microplastics) into the environment. Depending on the literature source, the importance and share of sources contributing to the unintentional release of microplastics vary widely. Microplastics are released in different stages of the product life cycle, such as production, transport, use, and end-of-life. Regarding industrial sources, the plastic and textile industries are considered to be the major contributors.

It is to note that the present monitoring data lacks harmonization of sampling and analytical methods, and data is difficult to compare. Different approaches were used to estimate the emissions from sources because of the heterogeneity of the available data or data unavailability. Several studies have indicated tyres, textiles and pellets as the main sources of the unintentional release of microplastics[2]. Further desk research and stakeholder consultation[3] pointed to three additional sources, as the preliminary analysis estimated them as main sources of unintentional releases of microplastics:

- Paints, probably the largest emitter, including also road markings and marine paints;
- Geotextiles;
- Detergent capsules (comprising laundry and dishwater capsules).

For pellets, textiles, detergent capsules and geotextiles, reliable estimates were not available on the quantity of material or for the microplastic emission rate, and therefore researchers have estimated

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1 UN Environment (2018): Mapping of global plastics value chain and plastics losses to the environment with a particular focus on marine environment

2 Germany (2014) Sources of microplastics relevant to marine protection, Report for Federal Environment Agency.
Norway (2014) Sources of microplastic pollution to the marine environment, Report for Norwegian Environment Agency.
Denmark (2015): Occurrence, effects and sources of releases to the environment in Denmark, Report for The Danish Environmental Protection Agency.
Sweden (2016): Swedish sources and pathways for microplastics to the marine environment, Report for Swedish Environmental Protection Agency
OSPAR (2017): Assessment document of land-based inputs of microplastics in the marine environment
Eunomia (2018): Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not Intentionally added in) products: Final report.
Ryberg et al. (2019): Global environmental losses of plastics across the value chains. Resource, conservation and Recyling.

3 A dedicated website https://microplastics.biois.eu was maintained to ensure constant interaction with stakeholders

varying emission levels. A range of possible emissions scenario was provided for these four sources, which varies significantly for some sources such as textiles.

For tyres, on the other hand, in the absence of data, a modelling approach was used for estimating the potential microplastic emissions, resulting in an average figure. On the basis of the uncertainty of the input data and the modelling parameters, an uncertainty factor of about 20% was applied to calculate the upper and lower ranges. For paints, a confidence interval for the micro-plastic leakage to the environment was estimated using a Montecarlo approach. The first step is to set confidence intervals for the input parameters. Since the data availability surrounding plastic losses from paint is scarce, a qualitative approach rather than a data-driven approach is used to set the intervals on the input parameters[4]. Ultimately, the 95% confidence interval for the total paint micro-plastic leakage to the environment in EU-27 is 231 - 863 kt a year. Estimated releases from these six sources are captured in Table 1.

Table 1: Estimated releases from the six sources of unintentional microplastics release to the EU environment

Source	Quantity (tonnes/year), 2019*
Paints	231 000 – 863 000 (average 482 000)
Tyres	360 000 – 540 000 (average 450 000)
Pellets	52 140 – 184 290
Textiles	1 649 – 61 078
Geotextiles	6 000 – 19 750
Detergent capsules	4 140 – 5 980
TOTAL of the selected six sources	654 929 – 1 674 098 (90-93% of total emissions)
TOTAL of all sources	729 087 – 1 808 198

(*) Estimations based on the supporting study for this Impact Assessment

Other sources were also considered and summarised in Annex 14. It also includes further information on each of these other sources that we did not retain in the analysis because they were considered as microplastics coming from the intentional use of microplastics added to products or due to a lack of sufficient information.

2 INTRODUCTION TO THE PRELIMINARY ANALYSIS OF THE FIVE SOURCES

In this chapter, we present the preliminary analysis undertaken for five of the originally identifiedmajor sources: tyres, textiles, paints, detergent capsules and geotextiles. These sources were analysed by identifying measures to tackle the following two interlinked problem areas:

- **The negative environmental and (potential) health impacts associated with the unintentional releases of microplastics into the environment from the five sources into the environment.** Most of the problems are associated with microplastics in general,

[4] Paruta et al. (2022) Plastic Paints the Environment, EAEnvironmental Action 2022, ISBN 978-2-8399-3494-7

irrespective of their source. Specific impacts are explained when discussing the most relevant sources.

- **Insufficient data / information on unintentional microplastics releases from five sources.** There is an absence of comprehensive information on the unintentional releases of microplastics from different sources (thus a high uncertainty). While existing information might be sufficient to take action in some cases, also in line with the precautionary principle, in other cases more information and research is needed in order to understand the sources of microplastics and their impacts so that effective policies can be designed.

Although microplastics is an active field of research and the number of publications on microplastics has increased rapidly in recent years, a standardised procedure for identifying/quantifying microplastics from different sources is still lacking. Investigations are generally conducted using different methods, covering differing particle sizes and expressed in different units that cannot be converted, overall making it difficult to compare results across studies. Hence, the reported abundance of microplastics and respective sources in the environment have high variability and may differ by several orders of magnitude.

Data Uncertainties

This IA identifies, **for each of the five sources**, different uncertainties and data gaps that are explained in more detail in the baseline of this Annex. Some salient features include:

Tyres: Several factors influence the release of Tyre Wear Particles (TWP) into the environment, e.g. tyre material and design (which consists of many components), road composition, and driving behaviour. Analysing tyre abrasion in environmental samples is challenging, and an interpretation of the analytical data should reflect the external conditions. Additionally, reproducible quantification of particles in the environment depends on the laboratories' sampling and analytical techniques, where weaknesses and knowledge gaps exist. The ongoing work to develop a harmonised test method and standard to measure TWP emissions should help. In addition to uncertainties with the overall emission factors for tyre abrasion, there is also a lack of data on the mix of tyres currently in use and how they vary in terms of abrasion rates. A number of studies have demonstrated significant variation in abrasion rates between different tyre models and types both across different categories (i.e. tyre sizes and types) as well as within categories.

Textiles: the uncertainty of the microplastic estimations is high. In the baseline, they vary between 2 058 and 74 111 t per year in the EU. The data quality is low for production and wearing life-cycle stages. There is no data for the end-of-life. The uncertainty comes from the limited data to quantify microplastic emissions and not from the baseline extrapolation.

Paints: Some uncertainties and data gaps exist relative to market statistics of paint sold per paint sector and the plastic content within it. For wear and tear losses, the lifetime of the paint system is not a subject that is systematically researched and assessed, but its assessment is key in order to determine microplastic pollution during the use phase of the object.

Detergent capsules: The estimated amount of potential microplastic losses through capsules to the environment bears several uncertainties. The principal uncertainty results from the fact that this source relates to a water soluble and biodegradable polymer. There is a lack of information on the composition of PVOH and related mixtures used for detergent capsules due to trade secrets and the subsequent lack of data on whether all PVOH-based grades are fully degradable in all environmental media.

Geotextiles: There are several uncertainties and data gaps, in particular concerning the quantities installed and for which application they are used, along with the related microplastic emissions. Depending on the application, geotextiles do not represent the same microplastic emission potential, e.g., geotextiles used to stabilise the soil during road construction are not exposed to UV, air, or abrasion in the same way as geotextiles used for coastal protection. However, limited data is available.

Table 2: Problem evolution and objectives of EU actions

Problem area	How would the problem evolve without action?	Why is action needed at the EU level?	Objectives for remediation
Tyres	The trends show an increase in tyre wear emissions, with increases of around 20-30% expected by 2030. Whilst a test method for measuring TWP emissions is under development, this alone will not necessarily drive any reductions.	Type approval testing for tyres with a standard on tyre abrasion is foreseen and then needs to be implemented at a European and international level to ensure harmonisation of tyre quality and characteristics. EU action is required to set limits also for tyre abrasion in order to limit the emissions of microplastics from tyres, as well as to ensure a consistent implementation of measures and to avoid distortions in the market and between Member States.	To reduce emissions from tyres through actions targeted at the tyres themselves as well as other factors impacting emissions.
Textiles	The trends show an increase in microplastic emissions from textiles, around 22% expected by 2030.	EU action is required to improve the understanding of microplastic emissions over the life cycle of synthetic textiles. EU action will also ensure a consistent implementation of measures and avoid distortions in the market and between Member States.	To improve the knowledge base and bridge the data gaps through better source characterisation. To reduce microplastic emissions from textiles through actions targeted at the life-cycle (production, washing, etc.) of textiles.
Paint	Paint is the key to asset protection as it extends objects' lifetime. How polymer-based paint is used, though, is the source of microplastic pollution in the environment. Without action, the business-as-usual scenario is a never-ending accumulation of microplastic pollution in all environmental compartments.	In order to prevent microplastic emissions from paints, mandatory action is needed to make sure that measures are applied in different sectors which use paints. Action at EU level would create a coherent framework from which every Member state will benefit.	To improve the knowledge base and bridge the data gaps through better source characterisation. To reduce microplastic emissions from paints and incentivise the development of new technologies for paint application, maintenance and capture.
Detergent Capsules	The general increase in the use of PVOH and related blends in detergent capsules could raise concerns regarding their possible emissions in wastewater. There is a lack of data on whether all available PVOH-based grades are fully degradable in all environmental media.	EU action would ensure a consistent implementation of measures to tackle microplastic release from detergent capsules and create a coherent framework from which every Member state will benefit.	To improve the knowledge base and bridge the data gaps through better source characterisation. To ensure that PVOH does not cause any adverse environmental impacts, the objective of the remediation is to actively reduce the release of PVOH into the European environment.
Geotextiles	The geotextiles market is seeing significant growth (expected to grow by 2.5 times by 2029 compared to	An EU-wide action on tackling microplastic emissions from geotextiles will ensure deeper insight into the problem and	To improve the knowledge base and bridge the data gaps through better source characterisation.

Problem area	How would the problem evolve without action?	Why is action needed at the EU level?	Objectives for remediation
	2019). This would result in a significant release of microplastics (particularly from coastal erosion and river margins applications).	create a coherent framework from which every Member state will benefit.	The reduction of microplastic emissions from geotextile use.

3 RELEVANT LEGISLATION FOR REDUCING MICROPLASTIC EMISSIONS & ONGOING INITIATIVES

The following legislation and ongoing initiatives were identified as relevant to the reduction of microplastic emissions. This overview aims to provide insight into the EU's and Member States' current approach to microplastics and point to any regulatory gaps. This section only contains the legislation relevant to the five sources discussed and not to pellets. The legislation relevant to pellets, such as the REACH restriction, is explained in Annex 6 of this IA on legislation related to pellets.

Several EU policies and instruments (waste management, air quality, industrial emissions legislation, tyre labelling, motor vehicle type approval legislation) affect or could affect directly or indirectly the generation and release of microplastics in the environment. The Fertilising Products Regulation contains a provision on 'Controlled Release Fertilisers' targeting microplastic releases used for fertilisers. But none of these has already taken decisive action.

3.1 Ecodesign for Sustainable Product Regulation

In March 2022, the European Commission adopted a proposal[5] for Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC. This proposal is the cornerstone of the Commission's approach to more environmentally sustainable and circular products. The proposal builds on the existing Ecodesign Directive[6], which only covers energy-related products.

This proposal will set **harmonised rules on environmental sustainability** for products, including textiles and paints, to make them more durable, reliable, reusable, upgradable, reparable, easier to maintain and refurbish, and energy and resource-efficient. A preliminary assessment of the products to be included in the first Working Plan for the ESPR is currently ongoing. Textiles, detergents, tyres and paints may be part of the working plan in the framework of the ESPR proposal – this is to be determined at a later stage. The implementation of the ESPR is expected to include information and performance requirements on products at the source of microplastic release and using the corresponding testing and measurement method.

The Implementing Regulation on **eco-design for washing machines and washer-dryers**[7], adopted in 2019, recognises the need to consider, in the next review of the Regulation foreseen by 2025, the feasibility of new requirements for reducing micro-plastics in the water outlet, such as filters.

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5 European Commission, Commission Proposal for a Regulation establishing a framework for setting eco-design requirements for sustainable products and repealing Directive 2009/125/EC, COM(2022)142 final, 2022.

6 See Energy label and ecodesign (europa.eu)

7 Commission Regulation (EU) 2019/2023 of 1 October 2019 laying down ecodesign requirements for household washing machines and household washer-dryers pursuant to Directive 2009/125/EC of the European Parliament and

3.2 Tyres labelling and EURO 7

In the recent revision of the Tyre Labelling Regulation[8], the co-legislators agreed to empower the Commission to adopt delegated acts in order to include parameters or information requirements for tyre "abrasion and mileage" (as soon as a suitable method is available). The co-legislator had clearly in mind how an indicator of abrasion alone was not going to be effective in orienting consumer purchase choice, and a complementary indicator, possibly combined and highly "valued" by consumers, such as mileage, was necessary. The type approval legislation refers to the same testing methods for the same parameters and sets the minimum requirements for efficiency, safety and health protection. The Euro 7 standard adopted by EC in November 2022 has a placeholder to introduce the abrasion limits for tyres once the emissions' measurement methodology is developed.

3.3 Construction Products Regulation

The revised Construction Products Regulation introduces the requirements for construction products, such as cement, steel, aluminium and plastics, to improve the protection of health, safety and the environment, in line with the new Ecodesign for Sustainable Product Regulation.

3.4 EU Strategy for Sustainable and Circular Textiles

The EU strategy for sustainable and circular textiles[9], adopted on 30.03.2022, sets the vision for a more sustainable textile sector by looking at the entire life-cycle of textile products and proposing actions to change how to produce and consume textiles. The Strategy identifies microplastics releases as one of the main issues to be addressed and refers to the current initiative. The Strategy also mentions that "the Commission will propose harmonised EU extended producer responsibility rules for textiles with eco-modulation of fees, as part of the forthcoming revision of the Waste Framework Directive in 2023".

3.5 Research

Besides the policy and legislative activities, the EU is dedicating substantial resources to better understanding and combating marine litter (including microplastics) through a number of projects funded by the LIFE, EMFF/EMFAF, Horizon 2020 and Horizon Europe Programmes or other projects, including enlargement neighbourhood funding and regional (e.g. Interreg) funding.

3.6 Member state and international actions on microplastics

Several EU member states have implemented measures to tackle microplastic emissions, particularly in recent years. If most of these measures are aimed at banning intentionally added microplastics (such as in cosmetics) or single-use plastics, there are examples of initiatives taken on unintentionally released microplastics that are presented in

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of the Council, amending Commission Regulation (EC) No 1275/2008 and repealing Commission Regulation (EU) No 1015/2010, OJ L 315, 5.12.2019, pp. 285-312.

[8] Regulation (EU) 2020/740 of May 2020

[9] European Commission, Commission Communication – EU Strategy for Sustainable and Circular Textiles, COM(2022)141 final, 2022.

Table 3.

Table 3: Selected actions in Member States

Countries	Sources	Measure
France	Textiles	Mandatory requirement for all new washing machines to be equipped with microfiber filters by January 1st 2025.[10]
Denmark	Microplastics	Monitoring program of Danish Marine Strategy including monitoring of marine litter, analyses of microplastic in sediments, as well as analyses of macro and microplastics in stomachs of two fish species.[11]
Netherlands	Microplastics	Research program on mitigation measures to avoid microplastic emissions from pellets, tyres, textiles and paints. Investigation on the supply chain by January, mainly on spills. Developing a plan with a focus on small companies.[12]
Sweden	Microplastics	Research program in 2017 to identify the main sources of microplastic emissions in Sweden.[13]

Similarly, outside of the EU, several countries have started actions against microplastic emissions, which are summarised in Table 4.

Table 4: Selected international actions

Countries	Sources	Measure
Chile	Microplastics	National Strategy for Marine Waste and Microplastics Management, launched in 2021, with the objective for sustainable plastic waste management throughout their life cycle, preventing and reducing the discharge of plastic waste in aquatic ecosystems.
Commission for Environmental Cooperation (CEC)	Microplastics	Transformation of recycling and solid waste management in North America" brings Mexico, Canada, and the US together to accelerate the adoption of circular economy and sustainable management practices regarding materials (plastics and microplastics) in North America.
UK	Microplastics	The UK government commissioned research projects to better understand the issue of microplastics losses from tyres and clothing. A Rapid Evidence Review has been commissioned to gather the evidence to progress approaches to more consistent definition, sampling and assessment methodologies for monitoring and reporting microplastics in water. Collaboration is also ongoing with the water industry to establish methods to detect, characterise and quantify microplastics in waste water and evaluate the removal efficiency of treatment processes.

[10] LOI n° 2020-105 du 10 février 2020 relative à la lutte contre le gaspillage et l'économie circulaire (1) [Law n°2020-105 of 10 February 2020 related to the fight against waste and the circular economy (1)], Journal official "Lois et Décrets" no. 0035 du 11 février 2020 [JORF] [Official journal "Laws and Decrees" no. 0035 of 11 February 2020], 11 February 2020, Fr.

[11] Ministry of Environment and Food of Denmark; Microplastics: Occurrence, effects and sources of releases to the environment in Denmark, Environmental project No. 1793, 2015

[12] Dutch Government, Policy Programme on (micro) plastics – European Marine Strategy Framework Directive, 2020 (https://g20mpl.org/partners/netherlands).

[13] Swedish Government, 'Microplastics', 2022 (https://www.naturvardsverket.se/amnesomraden/plast/om-plast/mikroplast/).

Countries	Sources	Measure
Australia	Textiles	The National Plastics Plan 2021 announced that the Australian Government will work with industry to phase in microfibre filters on new residential and commercial washing machines by 1 July 2030[14]
Canada	Textiles Research	Under the Zero Plastic Waste strategy, Canada is implementing a comprehensive approach to reduce plastics pollution, which includes investing in science to close research gaps on macro and microplastics. The government provided funding to support research on microfibre release occurring during washing, to design dedicated test methods and to develop sampling methods for microfibres in laundry effluent and wastewaters.
Norway	Tyres, Textiles, Turfs	The Norwegian Climate and Environment Ministry commissioned a review on microplastics pollution, which includes measures to target wear and tear of vehicle tires and textiles and losses from artificial turfs. Norway has implemented speed limits to reduce local air pollution caused by road dust will likely also reduce microplastic emissions.
USA (Connecticut)	Textiles Research	Development of research programs, awareness-raising campaigns and best consumer practices to reduce microfibre shredding and microplastics emissions during laundering House Bill 5360 (2018) to target microfibres emitted during laundering. The bill mandated further research on microfibres, awareness-raising initiatives and the development of best consumer practices and industry efforts to prevent microfibre shedding.
USA (California)	Textiles	Microfiber bill AB 129: development of a standard methodology to assess the efficiency of microfiber filtration in washing machines Bill AB 1952 (under preparation): launch of a pilot program on microfibre filters
USA (New York)	Textiles	New York State proposed Assembly Bill A01549 in 2018. This would require the following labelling for all products containing more than 50% synthetic material: “This garment sheds plastic microfibers when washed”.
USA (NASA)	Monitoring	Using a new technique relies on data from NASA’s Cyclone Global Navigation Satellite System (CYGNSS), a constellation of eight small satellites that measures wind speeds above Earth’s oceans and provides information about the strength of hurricanes, the NASA team looked for places where the ocean was smoother than expected given the wind speed, which they thought could indicate the presence of microplastics. Then they compared those areas to observations and model predictions of where microplastics congregate in the ocean.

3.7 Industry initiatives

Selected voluntary initiatives are presented in Table 5.

[14] Australian Government, ‘National Plastics Plan 2021’, 2021 (https://www.agriculture.gov.au/sites/default/files/documents/national-plastics-plan-2021.pdf).

Table 5: Selected voluntary initiatives (Industry and NGO)

Name	Sources	Details
Microfibre Consortium	Textiles	Development of practical solutions for the textile industry to minimise microfibre release to the environment from textile manufacturing and product life cycle.
Voluntary Cross Industry Agreement	Textiles	Several industry associations (International Association for Soaps, Detergents and Maintenance Products, Comité International de la Rayonne et des Fibres Synthétiques, European Outdoor Group, Euratex and the Federation of the European Sporting Goods Industry) have formed a voluntary Cross Industry Agreement. The partnership aims to contribute to the development of international standardised test methods to identify and quantify microfibres, share information on the progress of research, knowledge gaps, options and priorities and support and participate in industrial research for the development of feasible and effective solutions
Clothing Industry initiative	Textiles	Patagonia, Arc'teryx, REI and MEC and MetroVancouver commissioned Ocean Wise's Plastic Lab to investigate microfibers, the tiny textile particles that shed from garments over their lifetime.
Tire Industry Project	Tyres	This project, launched by 11 major tyre manufacturing companies under the umbrella of the World Business Council of Sustainable Development (WBCSD), aims to identify and implement feasible measures in order to reduce the impact of the life cycle of tyres on the environment, also in the context of microplastics pollution. [15]
European Tyre and Road Wear Particle Platform	Tyres	The European Tyre and Rubber Manufacturers Association (ETRMA) initiated this multi-stakeholder platform aimed to facilitate research, encourage stakeholder cooperation and knowledge-sharing and explore mitigation options to reduce TRWP pollution.
European Tyre and Rime Technical Organization (ETRTO)	Tyres	ETRTO is working on assessing the feasibility and accuracy of a standard test method for the tyre abrasion rate to propose to the European Commission.
Plastic soup foundation	Textiles Cosmetics	With their Beat the Microbead app, one can scan all your personal care and cosmetic products for yourself to see if they contain plastic ingredients. Their Ocean Clean Wash campaign additionally raises awareness about microfibers and the relationship between clothes and plastic in the ocean.
Race for Water Odyssey	Microplastics	Raise awareness about microplastics[16]
Rethink plastic alliance	Microplastics	Awareness raising, policy lobbying
Seas at Risk	Microplastics	Awareness raising, policy lobbying

[15] https://tireparticles.info/our-research
[16] https://www.raceforwater.org/en/news/microplastics/

3.8 Multilateral Actions

In March 2022, the second session of the 5th United National Environment Assembly unanimously adopted resolution 14: End Plastic Pollution: towards an international legally binding instrument[17] (hereafter referred to as the resolution). The preamble to the resolution highlights that "plastic pollution includes microplastics". This inclusion indicates that the intergovernmental negotiating committee (INC) will have to consider how to address microplastics in a forthcoming global agreement.

In May 2019, the Conference of the Parties to the Basel Convention adopted a decision by which it amended Annexes II, VIII and IX of the Convention in relation to plastic waste. A Plastic Waste Partnership was created with the aim, among other things, to significantly reduce and eliminate the discharge of waste plastics and microplastics in the environment. The OECD Council Recommendation on Water calls for Adherents to prevent, reduce and manage water pollution from all sources while paying attention to pollutants of emerging concern, such as microplastics. UNEP's Clean Seas campaign raises awareness on microplastics, such as on cigarette filters, textiles and cosmetics.

4 PROBLEM DEFINITION BY SOURCE

4.1 Problem definition for tyres

Tyre wear is caused by the friction process between tyres and the road surface. Accordingly, tyre wear is emitted wherever and whenever vehicles travel. From the point of origin, it can either be transported directly into the three environmental compartments (soil, air, water) or indirectly through remobilisation and deposition. Most tyre wear is initially deposited on or near the road surface. The finer fractions (PM2.5 and PM10) can be transported much further by airborne drift[18]. As exhaust emissions of particular matter continue to decline due to legislation such as Euro 6, the contribution that tyre wear and other non-exhaust emissions make to total PM emissions from road transport are increasing significantly. For example, in the UK, non-exhaust emissions (i.e. particles from brake wear, tyre wear and road surface wear) have been estimated to contribute around 60% and 73% (by mass) of primary PM2.5 and PM10 emissions, respectively, from the road transport sector (and 7.4% and 8.5% of total primary UK PM2.5 and PM10 emissions, respectively)[19]. In the EU, non-exhaust PM, emissions from brake, tyre or road wear, have all increased and become the dominant transport emission source for PM10 (since 2012) and PM2.5 (since 2018)[20].

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[17] United Nations Environment Assembly, Resolution – End plastic pollution: towards an international legally binding instrument, UNEP/EA.5/Res.14, 02.03.2022.

[18] Air Quality Expert Group, Report for UK Department for Environment, Food and Rural Affairs, Scottish Government, Welsh Government, and Department of the Environment in Northern Ireland, 'Non-Exhaust Emissions from Road Traffic', 2019 (https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf).

[19] Air Quality Expert Group, Report for UK Department for Environment, Food and Rural Affairs, Scottish Government, Welsh Government, and Department of the Environment in Northern Ireland, 'Non-Exhaust Emissions from Road Traffic', 2019 (https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf).

[20] Vanherle, K. et al., 'ETC/ATNI Report 5/2020: Transport Non-exhaust PM-emissions. An overview of emission estimates, relevance, trends and policies', *Eionet Portal*, 2021 (https://www.eionet.europa.eu/etcs/etc-

4.1.1 Pathways to the environment and the scale of their impact

The impact of tyre wear on individual environmental compartments and the organisms living there is not sufficiently understood. However, there are already many studies that have estimated the total emissions of tyre wear for a region or country. These have typically been developed by combining activity rates (generally vehicle kilometres) with emission factors (i.e. the rate of microplastic release per vehicle kilometre), sometimes disaggregated by road and/or vehicle type, although other approaches have also been taken. A comprehensive literature review on tyre wear has been prepared by Baensch-Baltruschat et al.[21] This provides estimates of the mass losses of the tyres. In some cases (e.g., in Sundt et al.), the calculated TWP (total) is supplemented by the polymer shares (polymer).

Table 6: Annual tyre wear emissions for different countries and regions from Baensch-Baltruschat et al.[22] supplemented by Hann et al.[23] and ETRMA.[24][25][26]

Country	Tyre wear emissions in total (referring to tyre tread) tonnes/years	Calculation method	Emission Factor applied	Remarks	Reference
EU28	572,157		own data		(ETRMA, 2018)
EU28	503,586	b	k		(Hann, 2018)
EU28	1,327,000	b		Estimates based on EU Registered LDV and HDV X Total vehicle km derived from data of Germany / no differentiation of road type	(Wagner, 2018)
Germany	61,000	b	own data	Derivation of EF is not explained	(Baumann, 1997)
Germany	111,420	b	i		(Hillenbrand, 2005)
Germany	60,000-111,000	c			(Essel, 2014)

atni/products/etc-atni-reports/etc-atni-report-5-2020-transport-non-exhaust-pm-emissions-an-overview-of-emission-estimates-relevance-trends-and-policies).

21 Baensch-Baltruschat, B. et al., 'Tyre and road wear particles – A calculation of generation, transport and release to water and soil with special regard to German roads', *Science of the Total Environment*, Vol. 752, 2021, Elsevier BV.

22 Baensch-Baltruschat, B. et al., 'Tyre and road wear particles – A calculation of generation, transport and release to water and soil with special regard to German roads', *Science of the Total Environment*, Vol. 752, 2021, Elsevier BV.

23 Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.

24 Data provided by the European Tyre & Rubber Manufacturers Association (ETRMA) in: Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.

25 Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.

26 Data provided by the European Tyre & Rubber Manufacturers Association (ETRMA) in: Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.

Country	Tyre wear emissions in total (referring to tyre tread) tonnes/years	Calculation method	Emission Factor applied	Remarks	Reference
Germany	133,000	b	i		(Wagner, 2018)
Germany	75,200	b	j		(Baensch-Baltruschat, 2020)
Germany	98,400		k		(Baensch-Baltruschat(b), 2020)
Germany	125,188	b			(Kole, Wear and Tear of Tyres in the Global Environment: Size Distribution, Emission, Pathways and Health Effects, 2019)
Denmark	6514 – 7660	b	l	Recalculation of data estimated by Lassen et al. 2015	(Kole, Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment. , 2017)
Denmark	4200 – 6600	d			(Lassen, 2015)
Denmark	7310	d			(Kole, Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment. , 2017)
France	37 646	d			(Unice, 2018)
Seine River basin (FR)	13 804	e			(Unice, 2018)
Italy	50 000	n/a			(Milani, 2004)
Netherlands	15452 (total)	b	n		(Sherrington, 2016)
Netherlands	7726 (polymer)	b	n		(Sherrington, 2016)
Netherlands	17300 (only tyre wear)	b	o		(Verschoor, 2016)
Netherlands	15030	b	p		(Kole, Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment. , 2017).
Netherlands	8768 (corrected for amounts trapped in	b	p		(Kole, Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment. , 2017)

Country	Tyre wear emissions in total (referring to tyre tread) tonnes/years	Calculation method	Emission Factor applied	Remarks	Reference
	open pore road surface)				
Norway	7500 (total)	b	l, m		(Sundt, 2014)
Norway	4500 (polymer)	b	l, m		(Sundt, 2014)
Norway	9600 (total)	f			(Sundt, 2014)
Norway	5700 (polymer)	f			(Sundt, 2014)
Norway	7100 (total)	b	l,k		(Vogelsang, 2020)
Norway	4300 (polymer)	b	l,k		(Vogelsang, 2020)
Sweden	13000	b	q		(Magnusson, 2016)
Great Britain	38000 – 75000	d			(UK, 1999)
Great Britain	42000 – 84000	d		Update of data given by EA UK	(Kole, Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment. , 2017)

A Own calculation, data source for number of inhabitants: total Europe (Eurostat, 2020), others (CIA, 2018).
B Estimation based on emission factors and total vehicle km.
C Data based on (Gebbe, 1997) and WDK (Association of German Rubber Manufacturing Industry, reporting year 2005)
D Estimation based on consumption of tyres and abrasive loss (weight loss during use).
E Derived from data for entire France based on population density and lengths of urban and rural roads in the Seine river basin
F Estimation based on the number of tyres collected for retreading and weight loss during use.
G Estimation based on the number of registered vehicles, life expectancy of tyres and loss during life time
H Extrapolated from the emission data for DEU, DNK, GBR, ITA, NLD, NOR, SWE, AUS, BRA, CHN, IND, JPN, and USA, and the world's number of vehicles
I Emissions factors compiled by (Hillenbrand, 2005)
J Emissions factors compiled by (Gebbe, 1997)
K Emission factors by (Deltares-TNO, Emissieschattingen Diffuse bronnen Emissieregistratie. Remslijtage., 2016).
L (Luhana, 2004)
M (Anonymus, 2012)
N (Deltares-TNO, Emissieschattingen Diffuse bronnen Emissieregistratie. Remslijtage. , 2014)
O (Klein, 2015) (Dutch Pollutant Release and Transfer Register).
P Van Duijnhove et al. (2014)
Q (Gustafsson, 2008)
R (Aatmeeyara, 2009)
S Unified EF: 50 mg/km.

The total amount for the EU28, as shown in the table, is in the range of about 500 000 – 1 300 000 t/a (with the UK included). If the amount of emissions from the UK is excluded, according to Kole (2017)[27], the emissions from the EU27 based on these studies would be about 460,000-1,220,000 t/a (a specific quantification has been developed for this study and is described later in in the baseline. Where tyre wear ends up in the environment is the subject of current research. The tyre wear mapping study[28] has calculated the input pathway after more direct emission of tyre wear for Germany and selected regions in a comprehensive model. According to this, in Germany as a whole, tyre abrasion is emitted in approximately 57% in urban areas, 43% to open spaces and forests. Direct input into water bodies is only 0.4%, but indirect input from precipitation drainage must be considered.

The tyre wear deposited on the road surface can be flushed into surface waters via the road runoff after precipitation, depending on the sewer system. Figure 1 shows the two possible sewer systems "separate system", where the road runoff is discharged directly into a surface water body, and the "combined sewer system", where the road runoff is discharged to a wastewater treatment plant. During heavy rainfall events, the combined sewer system may be overloaded and drain directly to a surface water body by means of a sewer overflow. Figure 2 shows volume flows based on the example of Berlin and shows that about 78% of precipitation water is discharged untreated into surface waters. The discharge via the sewer overflow amounts to 7% (15 million m^3) and thus represents a pathway that also needs to be taken into account.[29] Sustainable drainage systems can be an efficient measure to reduce emissions from tyre wear into the surface water, but such systems are mainly used on motorways due to the space required. Further measures are discussed later in this section. WWTP is not seen as a sink because microplastics from tyre wear will typically end up in sludge which is either applied to fields as fertiliser and thus contributes to microplastic accumulation in the soil, or it is incinerated or landfilled.

[27] Kole, P.J., Löhr, A.J., Van Belleghem, F.G.A.J. and Ragas, A.M.J., 'Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment', *International Journal of Environmental Research and Public Health*, Vol. 14, No. 10, 2017.

[28] German Federal Ministry of Traffic and Digital Infrastructure (BMVI), 'Schlussbericht 19F2050A-C: TyreWearMapping: Reifenabrief – ein unterschätztes Umweltproblem?' [Final report 19F2050A-C: TyreWearMapping: Tyre abrasion – an underestimated environmental problem?], 2021 (https://www.umsicht.fraunhofer.de/content/dam/umsicht/de/dokumente/kompetenz/prozesse/tyrewearmapping-schlussbericht.pdf), De.

[29] TyreWearMapping - Digitales Planungs- und Entscheidungsinstrument zur Verteilung, Ausbreitung und Quantifizierung von Reifenabrieb in Deutschland. Final report 19F2050A-C

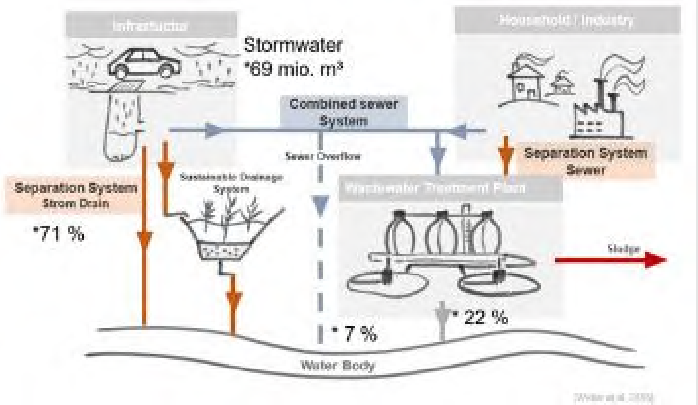

***Figure 1: Volume shares of storm water in separations system and combined sewer system in Berlin*[30]**

Baensch-Baltruschat et al.'s study defines the total release of tyre and road wear particles in Germany. Up to 20% of tyre abrasion was estimated to enter surface waters depending on the sewer systems. According to Baensch-Baltruschat et al., 74% ends up in the soil, which is within the range of the studies[31,32] (49% - 85%). There is a lack of data on how microplastics behave once they enter soil and surface water and the extent to which degradation occurs.

***Figure 2: Releases of microplastics from tyre wear into the environment for Germany*[33]**

4.1.2 Factors affecting the scale of the problem

This section discusses the key parameters influencing tyre wear, building on the problem drivers identified in the figure above. A comprehensive overview of the key parameters influencing tyre wear, according to Boulter et al.[34] presented in figure below.

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[30] Wicke, D. et al., 'Projekte: Relevanz organischer Spurenstoffe im Regenwasserabfluss Berlins (OgRe)' [Project: The relevance of organic trace substances in Berlin stormwater runoff], organischer Spurenstoffe im Regenwasserabfluss Berlins. Hg. v. Kompetenzzentrum Wasser Berlin. Kompetenzzentrum Wasser Berlin.

[31] Unice et al., Characterizing export of land-based microplastics to the estuary – Part II: Sensitivity analysis of an integrated geospatial microplastic transport 250odelling assessment of tire and road wear particles, 2018

[32] Hann, S., Sherrington, C., Jamieson, O., Hickman, M., Kershaw, P., Bapasola, A., & Cole, G. (2018). Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products. Report for DG Environment of the European Commission, 335.

[33] Baensch-Baltruschat, B. et al., 'Tyre and road wear particles – A calculation of generation, transport and release to water and soil with special regard to German roads', *Science of the Total Environment*, Vol. 752, 2021, Elsevier BV.

[34] Boulter, P. G. „A Review of emission factors and models for road vehicle non-exhaust particulate matter." Project Report PPR0065, Department for the Environment, Food and Rural Affairs, Scottish Executive, Welsh Assembly Government, and the Department of Environment in Northern Ireland, 2006

Tyre characteristics

- Size (radius/width/depth)
- Tread depth
- Construction
- Tyre pressure and temperature
- Contact patch area
- Chemical composition
- Accumulated mileage
- Set-up (*e.g.* tracking, toe-in and camber)

Vehicle characteristics

- Vehicle weight and distribution of load
- Location of driving wheels
- Engine power
- Power/unassisted steering
- Electronic braking systems
- Suspension type and condition

Road surface characteristics

- Material: bitumen/concrete
- Texture pattern
- Texture wavelength - micro/macro/mega
- Porosity
- Condition, including rutting and camber
- Road surface wetness
- Silt loading of road surface
- Surface dressing

Vehicle operation

- Speed
- Linear acceleration
- Radial acceleration
- Frequency and extent of braking and cornering

Figure 3: Influences on the emission factor of tyre wear

Possible influencing variables are divided into driving behaviour, tyre, road surface and vehicle characteristics. From a technical measurement point of view, it is very difficult to evaluate the individual influencing factors separately. The RAU project “Tire wear in the environment” has identified the factors (Figure 4) that influence tyre wear[35]. According to this, road topology and driving behaviour have the most significant influence on tyre wear emissions. The road topology describes the road layout and can be divided into different driving situations such as curves, intersections, slopes and straight roads etc. Changing the topology (e.g. increasing the curve radius) is certainly not technically feasible on a large scale. But a reduction of the permitted maximum speed could be an agreed adjustment here. In addition, hot spots can be identified with the description of the topology so that specific measures, such as the treatment of road runoffs or optimised road cleaning, can be implemented. The driving behaviour can be described, for example, by acceleration behaviour. An aggressive driving behaviour (high accelerations) leads to more tyre wear than a moderate driving behaviour (low accelerations).

Also, the project team carried out road dust studies that underlined the influence of road topology. In the local investigations, traffic lights, curves, gradients and straight roads were considered and compared. In the analysis of the road dust samples, increased SBR (styrene-butadiene rubber) contents were found at the locations of curves and traffic lights.

[35] Barjenburch, M. and Venghaus, D., ‘Präsentation: Reifenabrieb in der Umwelt’ [Presentation: Tyre abrasion in the environment], Abschlusskonferenz "Plastik in der Umwelt" [Conference "Plastic in the environment"], 2021 (https://bmbf-plastik.de/sites/default/files/2021-05/Session-B_Venghaus_RAU.pdf).

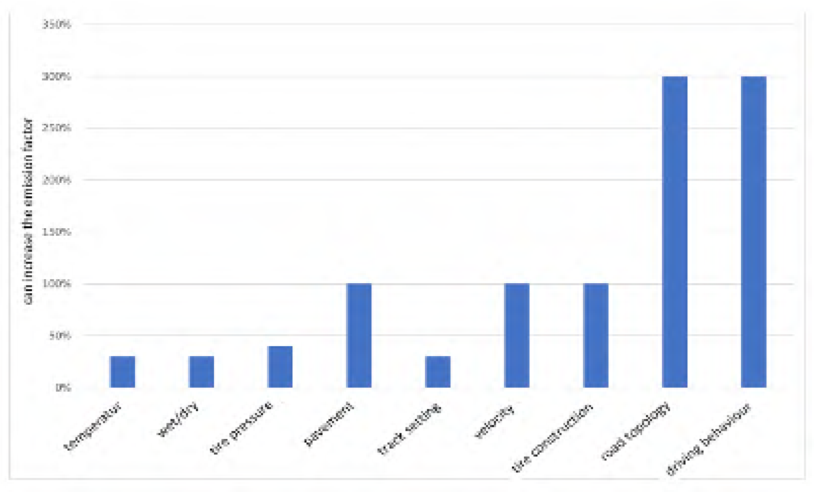

Figure 4: Factors influencing the formation of tyre wear and maximum influence[36]

Development in transport volume and mode of transport

In the OECD report[37], a reduction of PM10 emissions from road traffic by 252 approx. 40 % from 2000 to 2014 was determined (Figure 5). However, the decrease is only caused by exhaust emissions; the emissions from non-exhaust (tyres, brakes, roads) remained constant. With further internal combustion engine vehicles (ICEVs) optimisation and progressive replacement of ICEVs by electric vehicles (EVs), a further reduction in exhaust emissions can be expected, and the non- exhaust emissions will become the main source of PM10 emissions in road traffic.

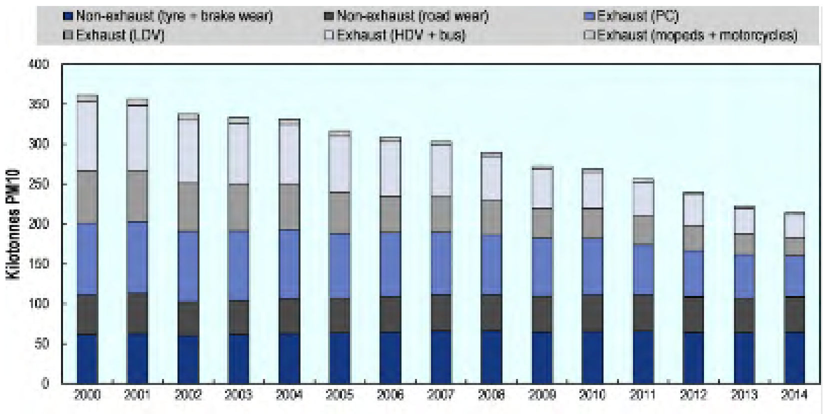

Figure 5: Annual PM emissions from road transport, EU-28, 2000-2014

A key driver of tyre wear emissions is driving mileage. It is expected that there will be a significant increase in road transport volumes over the next decades. The JRC estimates (Figure 6) show a 16%

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[36] Barjenburch, M. and Venghaus, D., 'Präsentation: Reifenabrieb in der Umwelt' [Presentation: Tyre abrasion in the environment], Abschlusskonferenz "Plastik in der Umwelt" [Conference "Plastic in the environment"], 2021 (https://bmbf-plastik.de/sites/default/files/2021-05/Session-B_Venghaus_RAU.pdf).

[37] OECD, *Non-exhaust Particulate Emissions from Road Transport: An ignored environmental policy challenge*, 2020, OECD Publishing, Paris.

increase in passenger road transport between 2010 and 2030 and 30% for 2010-2050. Freight transport is estimated to increase by 33% by 2030 and 55% by 2050[38].

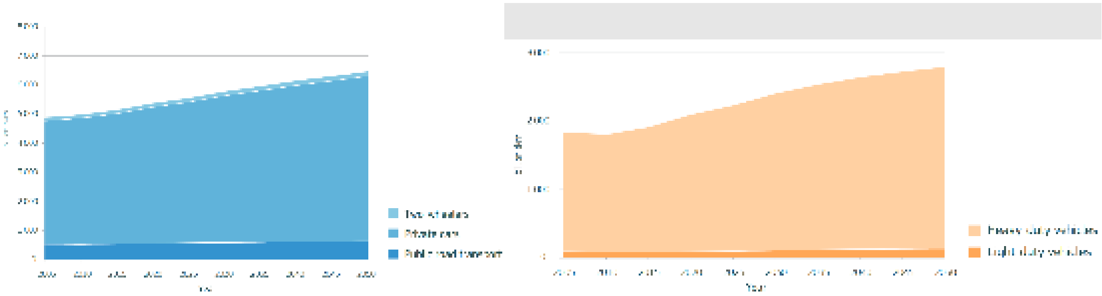

Figure 6: Estimated passenger and freight transport on roads in Europe[39]

Tyre characteristics

The influence of tyre characteristics and construction was investigated in detail by the German Automobile Association (ADAC). Under representative conditions, car tyres from various manufacturers were tested for emission factor (EF) and driving safety. A distinction was made between the three tyre types: summer, winter and all-season tyres with different tyre dimensions. Due to the limited data available, all-season tires are only listed for one dimension. Driving safety was assessed for dry and wet road surfaces and on snow for winter tyres. The figure below shows the tyre wear emissions in mg/vehicle km, as an average of all four vehicle tyres.

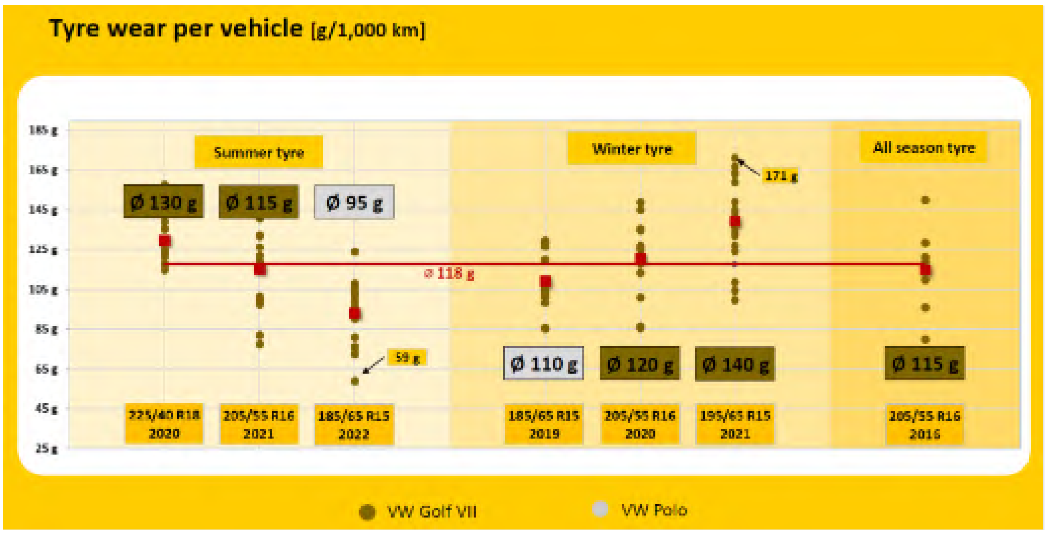

Figure 7: Emission factors of different tyres[40]

Figure 7 shows a significant difference in EF due to the tyre dimension. As the tyre dimension increases, it also increases the average EF. However, the scattering of the EF within a tyre dimension is particularly interesting, where the deviations between the manufacturers are up to 100% apart. A

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[38] Alonso Raposo, M. and Ciuffo, B., *The Future of Road Transport: Implications of automated, connected, low-carbon and shared mobility*, JRC116644, 2019, Publications Office of the European Union, Luxembourg.

[39] Barjenburch, M. and Venghaus, D., 'Präsentation: Reifenabrieb in der Umwelt' [Presentation: Tyre abrasion in the environment], Abschlusskonferenz "Plastik in der Umwelt" [Conference "Plastic in the environment"], 2021 (https://bmbf-plastik.de/sites/default/files/2021-05/Session-B_Venghaus_RAU.pdf), De.

[40] ADAC, 'Tyre wear particles in the environment' / 31940 RMU

significant correlation between EF and driving safety was not observed in the study. Both low-emission tyres achieved good results in driving safety and tyres with high EF, and vice versa. The study identified tyre models in all categories that have low tyre wear and do not compromise on safety. There are data gaps in terms of the volumes of each of these tyre models that are sold each year as well as the distances driven, which, combined with the emission factors, influence overall emissions from tyres. The challenge in tyre development is to move the composition (and construction) towards higher abrasion resistance while ensuring the same driving safety. Nevertheless, as shown in the ADAC study[41], there is a large potential for tyre manufacturers to produce TWP emission-optimized tyres that also provide driving safety.

The ADAC study also highlighted the need to adopt good practices, such as shaving tyres (i.e. removing fine rubber protrusions or pins that might be left over from the production process) before putting them in the market to avoid releasing them into the environment during the first kilometres of their use. Fine rubber pins are created when the rubber is injected into the tyre mould through fine channels. Many manufacturers remove these residues in a further production step in order to return the material directly to the material cycle. However, it appears that some manufacturers do not remove the residues and directly place the tyres on the market with these rubber residues. However, it is highly uncertain exactly what proportion of tyres placed on the market include these rubber pins. They seem to be more commonplace for budget tyres than more premium brands and potentially more frequent for winter tyres where the injection channels are necessary due to the fine tread structure compared to summer tyres. Whilst it is very challenging to quantify the exact contribution that they may make to overall tyre wear emissions, some initial estimations appear to indicate that their overall impact is expected to be very low, less than 0.5% and potentially closer to 0.1% of the total wear from a tyre[42].

In materials science and R&D, innovations are also reported, such as the use of dandelions[43] or moss[44]. One possibility would be using innovative additives such as nanotubes (TUBALL[45]), which should be effective for improved performance. However, the effect on tyre wear emission is unclear. A test method covering tyres for both light and heavy-duty vehicles is currently being developed by the European Commission through a study led by IDIADA. The study is expected to propose and validate appropriate test methods, evaluate the performance of current tyres in Europe with these methods and perform a cost-benefit analysis of possible tyre abrasion limits by third quarter of 2022. The results of the project will allow the inclusion in the future of abrasion limits in Euro 7 emission standards for motor vehicles and their components (such as tyres) adopted in November 2022. The UNECE WP.29 established a joint Task Force between its Working Party on Noise and tyres (GRBP)

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41 ADAC, ‘Tyre wear particles in the environment’ / 31940 RMU

42 Personal communication with the JRC, May 2022.

43 Continental, ‘Erste Versuchsreifen aus Löwenzahn-Kautschuk’ [First test tyres made from dandelion rubber] (https://www.continental-reifen.de/specialty/unternehmen/sustainability/taraxagum/continental-tires-dandelion-taraxagum), De.

44 Goodyear, ‘Der internationale Reifenhersteller Goodyear stellt heute auf dem Autosalon in Genf seine jüngste Mobilitätsvision für die Städte von morgen vor: den neuen Konzeptreifen „Oxygene“, der dazu beiträgt, dass urbane Mobilität in Zukunft sauberer, komfortabler, sicherer und nachhaltiger wird’ Kautschuk’ [International tire manufacturer Goodyear is presenting its latest mobility vision for the cities of tomorrow at the Geneva Motor Show today: the new concept tyre "Oxygene" will help make urban mobility cleaner, more comfortable, safer and more sustainable in the future], 2018 (https://www.goodyear.eu/de_de/consumer/why-goodyear/geneva-motor-show.html), De.

45 OCSiAl, ‘TUBALL: Revolutionary Carbon Nanotubes for the Tyre Industry’, 2017 (https://ocsial.com/de/news/-tuball-revolutionary-carbon-nanotubes-for-the-tyre-industry-/).

and its Working Party on Pollution and Energy (GRPE) in February 2022 to develop the tyre abrasion test method and a Global Technical Regulation. This is expected by 2024.

In general, a standardized test method and limit should consider the physical properties and chemical composition of the emitted tyre wear. The physical characteristics include the emitted particle mass, number and size distribution. It is essential to prevent an increase in the potentially toxic particulate matter fraction (especially PM2.5).[46] A limit value based only on mass may lead to less tyre wear being emitted in general, but it does not reflect a shift from large/few particles to small/many particles. Furthermore, it is assumed that larger particles are better retained during emission treatment. However, the consideration of chemical composition is also highly relevant from the point of view of environmental protection. Until now, tyre manufacturers have not been required to disclose the components used. In the Emission Analytics/PEW report[47], 100 different tyres available on the European market were analysed for tyre wear rate and chemical composition. More than 400 organic components were found in an average tyre, with 49% of the organic mass consisting of often-carcinogenic aromatic and polycyclic hydrocarbons. In this study, there is a factor of 4 between the highest and lowest emitting tyre manufacturers. In order to regulate or prevent the use of environmentally harmful substances, disclosure of the ingredients by the tyre manufacturers would be recommended.

Tyres are also sold with only part of the vent spews shaved off: sometimes, even those on the tread are left there. Vent spews, also known as “tyre hairs” or “Tire hairs” (or vent sprue, nibs, or nippers), are the result of excess rubber expelled through air channels in the tyre mould (needed because of the intense heat and pressure used during curing).

Vehicle characteristics

A shift of passenger vehicles from internal combustion engine vehicles (ICEVs) to electric vehicles (EVs) is assumed[48], whereby the influence of EVs on tyre wear emissions is controversially discussed. The absolute vehicle weight of an EV may increase when directly comparing the same vehicle model available as ICEVs and EVs due to the weight of the batteries. In this case, tyre wear emissions will also increase. It is expected that future development of the batteries (higher energy density for the same weight or volume) might decrease this weight difference

Another factor to consider is the engine power or drive torque. EVs bring full torque to the road already at start-up. Although efficient traction control (anti-slip control) is possible, there is still a higher point-to-point power transfer. The negative influence on tyre wear emissions due to engine power has been studied, among others, in Gebbe et al[49]. In the OECD report[50], the focus is on airborne non-exhaust particulates, with EVs classified into light weight (driving range up to 160 km) and heavy weight (driving up to 480 km or more). The OECD report’s assessment shows:

- Light weight: 11-13% less non-exhaust PM2.5 and 18-19% less PM10 than ICEVs;

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[46] ETRMA (in Hann et al. 2018)
[47] Emission Analytics / PEW report (2022) - Research report - Tire chemical composition and wear emissions
[48] Venghaus et al. 2021 RAU - "Reifenabrieb in der Umwelt" Abschlusskonferenz "Plastik in der Umwelt" (20./21.04.2021)
[49] Gebbe et al., ‘Quantifizierung des Reifenabriebs von Kraftfahrzeugen in Berlin’ [Quantification of tyre wear of motor vehicles in Berlin], *Technische Universität Berlin* [*Technical University of Berlin*], 1997, De.
[50] OECD, ‘Policies to reduce microplastics pollution: Focus on textiles and tyres’, 2021 (https://www.oecd-ilibrary.org/environment/policies-to-reduce-microplastics-pollution-in-water_7ec7e5ef-en).

- Heavy weight: reduce PM10 by only 4-7% and increase PM2.5 by 3-8% relative to conventional vehicles.

There is a trend towards heavier vehicles and with bigger wheels and tyres, which has a negative effect on tyre wear emissions. A market share analysis by the International Council on Clean Transportation (ICCT)[51] shows the significant development of demand for Sport Utility Vehicles (SUV) in Europe over the last 20 years. Since EV variants are also offered for these SUV models, a decline in the trend is not expected.

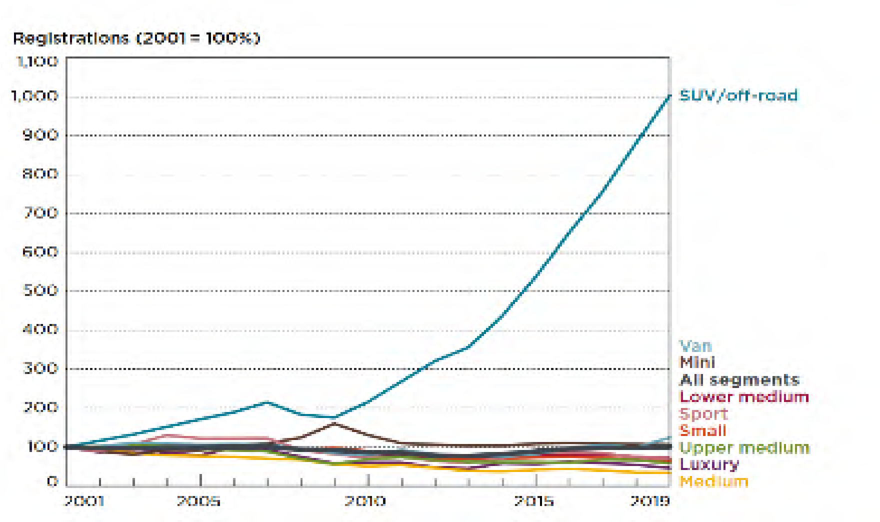

Figure 8: Passenger car registrations by vehicle segment[52]

Road surface characteristics

Although porous asphalt can have a negative impact on the tyre wear emission rate, porous asphalt is seen as a positive influence due to its retaining effect.[53] In order for the retaining to be effective, regular cleaning of the road surface is needed. The use of this asphalt is currently planned primarily for motorways. The use of rubber asphalt also needs to be considered. Although the addition of tyre material results in a reduction potential of CO_2 emissions and noise and contributes to the recycling process of waste tyres, it also improves the temperature properties and fatigue resistance of the asphalt.[54] Nevertheless, it must be critically examined whether additional tyre material from the asphalt is emitted into the environment during the use phase.[55]

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51 The International Council on Clean Transportation, 'European vehicle market statistics: Pocketbook 2021/22', 2021 (https://theicct.org/wp-content/uploads/2021/12/ICCT-EU-Pocketbook-2021-Web-Dec21.pdf). Diaz et al. 2020 European vehicle market statistics 2020/21

52 Ibid.

53 European Tyre and Road Wear Particles (TRWP) Platform, 'Way Forward Report', 2019 (https://www.etrma.org/wp-content/uploads/2019/10/20200330-FINAL-Way-Forward-Report.pdf).

54 Wang, Q.Z. et al., 'Waste Tire Recycling Assessment: Road Application Potential and Carbon Emissions Reduction Analysis of Crumb Rubber Modified Asphalt in China', *Journal of Cleaner Production*, Vol. 249, 2020, Elsevier BV.

55 Bhashyam, S.S. et al., ‚Microplastics in the marine environment sources, impacts and recommendations', *Research@THEA*, 2021.

Collection and treatment of road run-off is a challenge, especially in urban areas. Due to the high investment costs, no significant use is assumed without regulatory intervention. There is also a crossover with some elements of the Urban Wastewater Treatment Directive.

Vehicle operation

Speed limits (motorways) are under discussion because of their impact on exhaust emissions. Germany is the only country in the EU27 without a general speed limit. Whether a speed limit will be introduced is currently the subject of political discussions. According to the UBA, a speed limit could reduce CO_2 emissions by 6.7% at 120 km/h and 13.8% at 100 km/h.

In several Member States, there is a growing tendency to limit speed in urban areas for both safety and environmental reasons (in particular, for air quality and climate change reasons). For example, Spain has introduced a 30 km/h speed limit in urban areas for roads with one lane in each direction. Similarly, Paris implemented a general speed limit of 30 km/h in 2021.

The significance of an urban speed limit of 30km/h in Germany and its federal states in terms of tyre abrasion emissions has been investigated by the TyreWearMapping project[56]. With the physical model, a reduction of about 50% was calculated for both passenger cars and heavy-duty vehicles, considering 50 km/h as the maximum permitted speed in urban areas.[57]

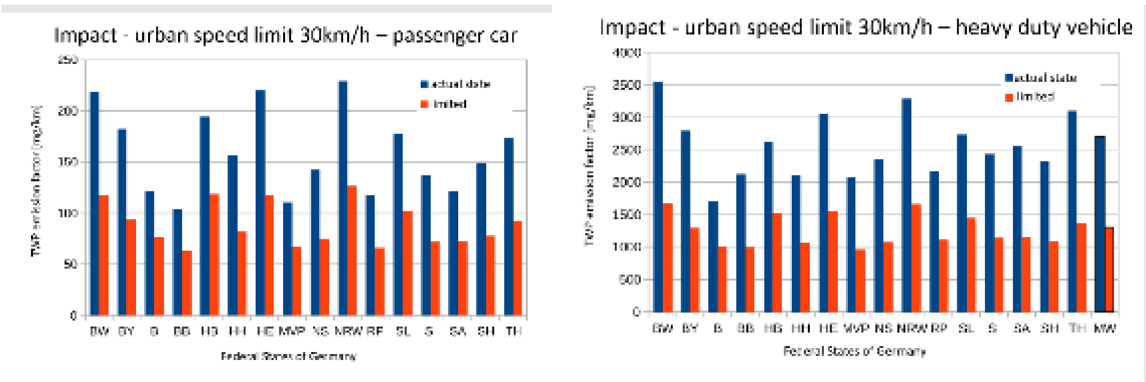

Figure 9: Impact – urban speed limit 30 km/h

An increase in the proportion of autonomously driving vehicles could have a reducing effect on tyre wear emissions. Autonomous driving makes it possible to optimise the flow of traffic and thus reduce braking and starting manoeuvres and moderate the driving style, for example.[58] Moreover, autonomous driving is expected to have vehicles move more smoothly and calmly. The development

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[56] German Federal Ministry of Traffic and Digital Infrastructure (BMVI), 'Schlussbericht 19F2050A-C: TyreWearMapping: Reifenabrief – ein unterschätztes Umweltproblem?' [Final report 19F2050A-C: TyreWearMapping: Tyre abrasion – an underestimated environmental problem?], 2021 (https://www.umsicht.fraunhofer.de/content/dam/umsicht/de/dokumente/kompetenz/prozesse/tyrewearmapping-schlussbericht.pdf), De.

[57] German Federal Ministry of Traffic and Digital Infrastructure (BMVI), 'Schlussbericht 19F2050A-C: TyreWearMapping: Reifenabrief – ein unterschätztes Umweltproblem?' [Final report 19F2050A-C: TyreWearMapping: Tyre abrasion – an underestimated environmental problem?], 2021 (https://www.umsicht.fraunhofer.de/content/dam/umsicht/de/dokumente/kompetenz/prozesse/tyrewearmapping-schlussbericht.pdf), De.

[58] Center of Automotive Management 2021 https://auto-institut.de/automotiveinnovations/emobility/elektromobilitaet-in-europa/

of the share of fully autonomous driving vehicles, for which the impact is most effective, in the total number of autonomous vehicles is shown in the following figure.[59]

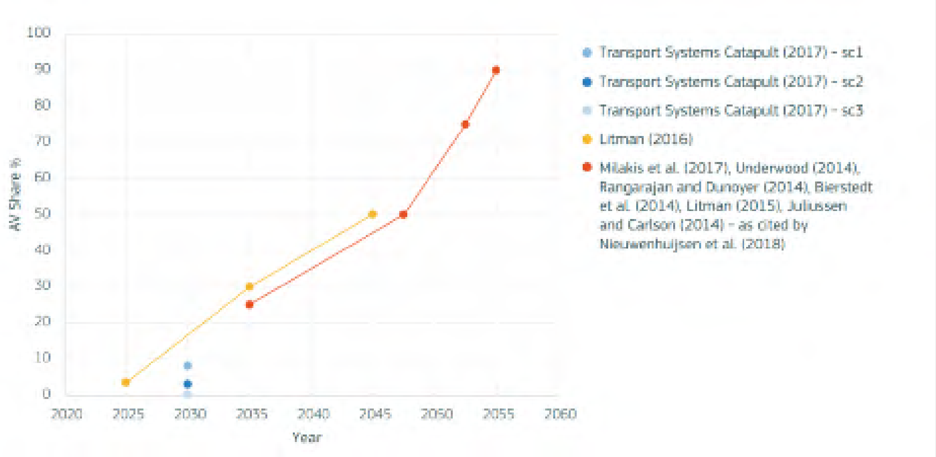

Figure 10: Range of sales projections for AVs (fully automated) until 2055 (as% of AV of total vehicles sold) (sc=scenario)

Other factors

On-board information on driving behaviour or awareness campaigns (e.g. "deadly dust"[60] initiated by the tyre wear collective and how&how) can positively influence driving behaviour or even reduce vehicle kilometres in general. Furthermore, on board tyre pressure monitoring systems (TPMS), which warn drivers when tyre pressure is dangerously low, can also help to reduce microplastic emissions as tyre pressure is an important factor in abrasion rates. Such systems are currently calibrated from a safety perspective but could be adapted to also optimise for tyre wear.

The alignment of the wheels can also play an important role in tyre wear as well as tyre lifetime. Directive 2014/45/EU on periodic roadworthiness tests[61] sets minimum requirements (and frequencies) for periodic testing of road vehicles which includes specific technical elements that are to be covered. These include wheels and their alignment. However, the requirements for checks on wheel alignment are indicated to be "…*not considered essential in a roadworthiness test*", so may not be applied uniformly across the EU.

4.2 Problem definition for textiles

Most scientific papers discuss the unintentional release of microplastics from textiles used in clothing with a focus on the emission of microplastics during the use phase and, more specifically, on textile washing. Due to the lack of data on microplastic emissions from polycotton (used in household and professional textiles/furnishing), and the amount of polyester contained in the polycotton blend, no estimation could be made. According to the first approximations made by RDC Environment,

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[59] Center of Automotive Management 2021 https://auto-institut.de/automotiveinnovations/emobility/elektromobilitaet-in-europa/

[60] How & How and The Tyre Collective, 'Deadly Dust Campaign, 2020 (https://how.studio/work/deadly-dust).

[61] European Parliament and Council of the European Union, Directive 2014/45/EU on periodic roadworthiness tests for motor vehicles and their trailers and repealing Directive 2009/40/EC, OJ L 127, 29.4.2014, pp. 51.

microplastic emissions from professional textiles would represent less than 5% of the emissions from clothing. The focus is, therefore, on the **microplastic emissions of clothing from households**.

It is known that synthetic textiles are prone to release microplastics in water during washing because of abrasion. The water is then treated in WWTP. According to the Swedish Environmental Protection Agency, most of the microplastic (around 98%) is removed from water in WWTP and retained in sewage sludge[62]. About half of the sewage sludge is then spread on agricultural land[63], used in soil production, or incinerated. However, microplastic releases can occur during the entire lifetime of textiles, including production, wearing, washing, drying and end-of-life. Consequently, the fibres may not only enter the environment via WWTP discharges but also via airborne emissions, landfill leakages, etc. Fibrous microplastics have been found in freshwater, seas, soils, air and remote ice and polar regions[64]. The figure below presents the different pathways followed by unintentionally released microplastics from textiles.

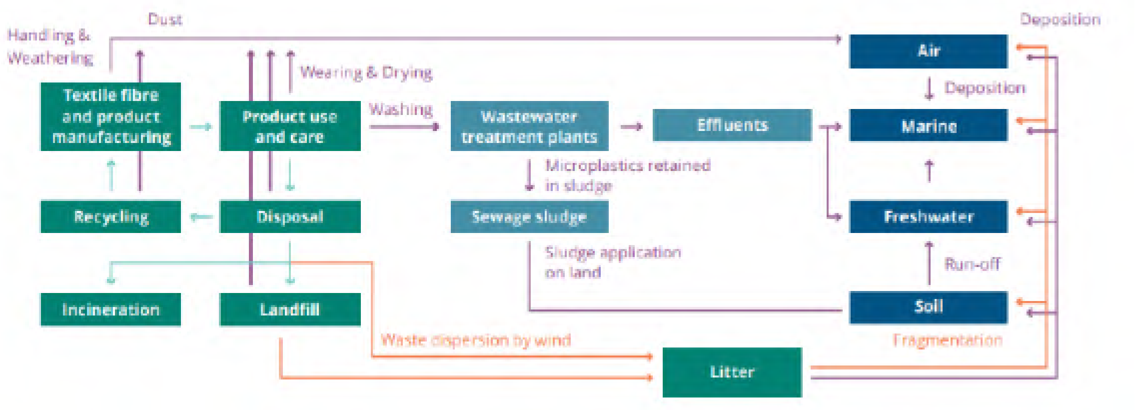

Figure 11: Emission pathways for secondary microplastics from synthetic textile in the air, water and soil (ETC/WMGE, 2021)

4.2.1 Factors affecting the scale of the problem

Three general problem drivers impact the unintentional release of microplastics from textiles:

- Increase in production and use of synthetic textiles;
- Regulatory failure as the microplastic release from textiles is an externality;
- Lack of knowledge and practice (for consumers and producers).

These general problem drivers can be divided into several specific problem drivers, discussed further.

Increase in production and use of synthetic textiles

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[62] Magnusson et al. (2017) Swedish sources and pathways for microplastics to the marine environment, Report for Swedish Environmental Protection Agency.

[63] When sewage sludges are applied to soil, the microplastics end up back in the environment and can be washed away by rain. Some sludge is also incinerated.

[64] Zhang, Y-Q., et al., 'Microplastics from textile origin – emission and reduction measures', *Green Chemistry*, No. 15, 2021.

Since microplastics from textiles are emitted during production as well as during use, an increase in production necessarily implies a bigger release of microplastics from textiles. More intensive use of textiles, such as an increasing washing frequency, will also lead to more microplastic emissions.

Problem driver 1: Increase in demand for textiles

Between 1996 and 2012, there was a 40% growth in the number of clothes purchased per person in the EU[65]. This trend is expected to increase in the future, as at a global level, the consumption of clothing and footwear is expected to increase by 63% between 2019 and 2030. This increase in textiles consumption leads to an increase in textiles production, thus increasing microplastics emissions from textiles (both from production and in use). In practice, this increase in consumption is accompanied by a decrease in the number of uses per piece[66,67]. A higher renewal rate also means more textiles being thrown away and more emissions at the end-of-life stage, especially if the textiles are recycled (shredding can cause a lot of microplastic emissions[68]).

Several factors and drivers explain the increase in textile consumption, including production trends based on low-cost and fast fashion, a respective decrease in the price of clothing, the increasing affluence of consumers, and further trade liberalisation. Beyond the increase in textiles consumption, the growing population in Europe also implies an increase in the use of textiles. This will lead to more microplastic emissions in the air (because of wearing and drying) and water (because more washing cycles will be performed). According to OECD statistics, the EU population is expected to increase by 1.3% by 2030[69]. The European Commission has recently adopted the EU strategy for sustainable textiles[70]. As summarised by Interreg Europe[71], "the new strategy sets out the vision and concrete actions to ensure that by 2030 textile products placed on the EU market are long-lived and recyclable, made as much as possible of recycled fibres, free of hazardous substances and produced in respect of social rights and the environment. Moreover, consumers will benefit longer from high-quality textiles -fast fashion should be out of fashion- and economically profitable re-use and repair services should be widely available." Regarding microplastics, the European Commission plans to address the unintentional release into the environment by a set of prevention and reduction measures at the different life-cycle stages.

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[65] ETC/WMGE, 'Textiles and the environment in a circular economy', 2019 (https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/textiles-and-the-environment-in-a-circular-economy/).

[66] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) [German Agency for International Cooperation], 'Study for the German Federal Ministry for Economic Cooperation and Development (BMZ): Circular Economy in the Textile Sector', 2019 (https://www.adelphi.de/de/system/files/mediathek/bilder/GIZ_Studie_Kreislaufwirtschaft_Textilsektor_2019_final.pdf).

[67] European Environment Agency (EEA) (2019) Textiles and the environment in a circular economy

[68] RDC Environment assessment based on experts' estimates literature review

[69] OECD, 'Population projections: evolution forecasts of EU (28 countries) population between 2021 and 2030', 2022 (https://stats.oecd.org/Index.aspx?DataSetCode=POPPROJ#).

[70] European Commission, Commission communication - EU Strategy for Sustainable and Circular Textiles; COM(2022)141 final, 2022.

[71] Interreg Europe, 'New EU Strategy for sustainable and circular textiles', 2022 (https://www.interregeurope.eu/news-and-events/news/new-eu-strategy-for-sustainable-and-circular-textiles#:~:text=The%20new%20strategy%20sets%20out,social%20rights%20and%20the%20environment).

Problem driver 2: Increase in use of plastic as raw materials for textiles

The figure below shows the evolution of the split of world fibre production[72] between 1980 and 2030. Synthetic fibres represent 75% of total fibres in 2020, a share that will reach 85% in 2030 (with 70% for polyester alone).

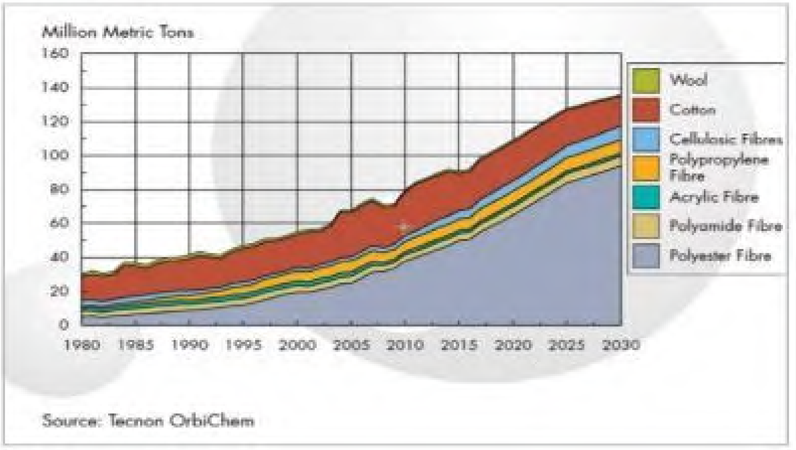

Figure 12: World fibre production per fibre between 1980 and 2030

According to Fibre2Fashion[73], the increase in the use of synthetic fibres will probably continue for the next few decades because of the relatively low cost of synthetic fibres compared to natural fibres and the availability of raw materials. Viscose staple fibres are an alternative to cotton fibres because of their physiological performance. Cellulose fibres have specific properties that make them difficult to substitute with petroleum-based synthetic fibres. Given the limited production of cotton fibres, the share of viscose is likely to increase to cover the increase in textile consumption and the increase in population. In terms of environmental impact, the CO2 equivalent of producing viscose staple fibre is similar to that of cotton fibre. However, the impact on ecosystem diversity is better in the case of cotton, see next figure.

[72] Yang Qin, M. (2014). Global fibres overview. Tecon OrbiChem: Synthetic Fibres Raw Materials Committee Meeting at APIC 2014.

[73] Fibre2Fashion, 'Man-made fibres driving growth', 2017 (https://www.fibre2fashion.com/industry-article/7895/man-made-fibres-driving-growth).

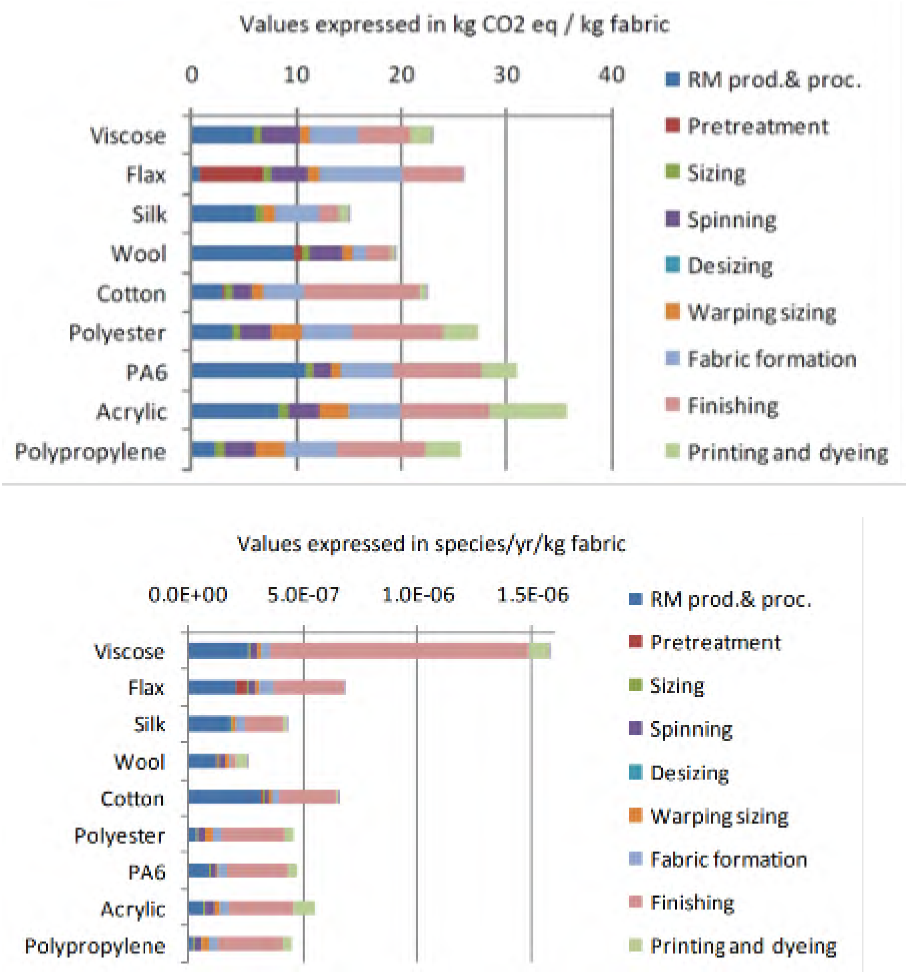

Figure 13: Environmental impact of fibre production processes[74]

Problem driver 3: Increase in textile washing frequency

According to AISE, the average amount of washing cycles in the EU is staying relatively stable at around 3.5 washes a week per household (a slight decrease was observed between 2008 and 2017, followed by a slight increase between 2017 and 2020), as well as the average load, which remains around 80%. However, the capacity of the average washing machine sold in the EU has been increasing: while in 2004, 97% of washing machines sold in the EU had a capacity of less than 6 kg, in 2014, 60% of them had a capacity of 7 kg or more. This means that there is an average increase in the quantity of textiles washed per washing cycle and thus an increase in textile washing frequency.

Regulatory failure as the microplastic release from textiles is an externality

Problem driver 1: No eco-design requirements on the unintended release of microplastics

No eco-design requirement is currently defined at the production level to reduce microplastic emissions from textiles. Furthermore, no document or information has been developed to guide producers on this matter, which is not tackled in the main guides. For instance, the BREF (Best Available Techniques Reference Document) for the Textiles Industry developed under the Industrial

[74] JRC, Environmental Improvement Potential of textiles (IMPRO Textiles), January 2014. (https://publications.jrc.ec.europa.eu/repository/handle/JRC85895)

Emissions Directive groups microplastic emissions with TSS (Total Suspended Solids), and does not provide specific solution or guidance for reducing microplastic emissions during the production phase[75]. The Textiles BREF mentions that there is currently a lack of information about microplastic emissions[76].

The implementation of eco-design criteria is limited by knowledge gaps and the lack of standardised measurement methods to quantify microplastic emissions. These methods are currently under development and could be used in the future to set a threshold on microplastics released from textiles.

However, as shown in figure below, nearly 80% of textiles consumed in Europe are imported and produced outside of Europe. Regulation at the producer level would then require developing an international approach and commitment. In addition, to effectively enforce ecodesign measures and avoid barriers to free trade inside the EU as a result of the implementation of national measures, ecodesign measures should be implemented at the EU level. The European Commission proposed a new Ecodesign for Sustainable Products Regulation (ESPR) in 2022. This framework aims to set ecodesign requirements for specific product groups to significantly improve their circularity, energy performance and other environmental sustainability aspects. Textiles are identified as a priority in this framework.[77]

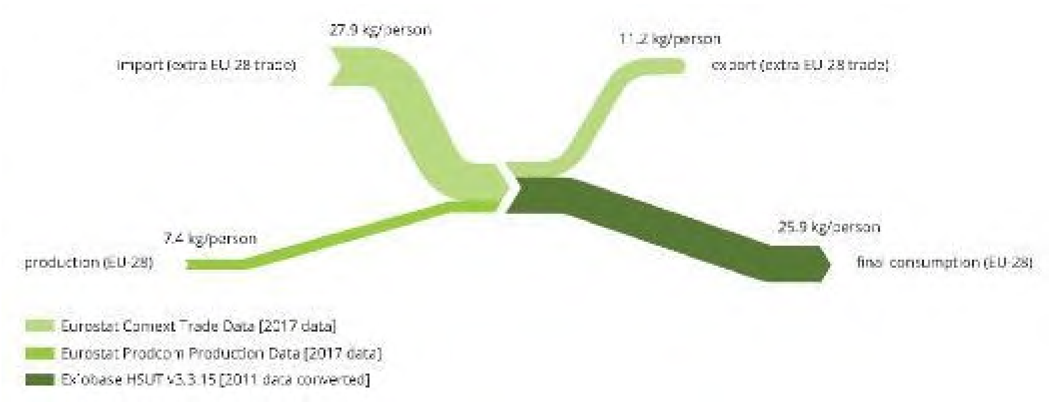

Figure 14: Overview of the import, export, production and consumption flows of textile products, EU, 2017, kg per person[78]

Problem driver 2: No legal requirements to prewash textiles

High microplastic emissions occur during pre-washing due to loose fibres resulting from the manufacturing process. No prewashing step is required at the producer level before selling the textiles. A pre-wash step could be added during production to specifically remove microplastics and must be associated with the obligation of having a proper wastewater treatment plant. This could also

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75 JRC, 'Best available techniques (BAT) Reference Document for the Textiles Industry', 2023 (https://eippcb.jrc.ec.europa.eu/sites/default/files/2023-01/TXT_BREF_2023_for_publishing%20ISSN%201831-9424_final_1_revised.pdf).

76 Textiles BREF "In conclusion, at the time of drafting this document, there was little information available as to the emissions of microplastics to water from textile production facilities, in terms of emissions actually monitored and therefore in terms of the significance of these emissions."

77 European Commission, Commission Proposal for a Regulation establishing a framework for setting eco-design requirements for sustainable products and repealing Directive 2009/125/EC, COM(2022)142 final, 2022.

78 ETC/WMGE, 'Textiles and the environment in a circular economy', 2019 (https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/textiles-and-the-environment-in-a-circular-economy/).

be an ecodesign requirement. Currently, pre-washing can be done by consumers to eliminate certain chemical residues before wearing clothes.[79] With the goal of eliminating pre-washing for consumers, the pre-wash should cover both functions: removing microplastics and removing chemical residues.

Problem driver 3: No legal requirements for washing machines and tumble dryers to reduce the release

In France, a law was approved in February 2020 mandating that, as of January 2025, all washing machines sold in France be equipped with a filter for synthetic microfibres. An amendment to this law was adopted in June 2021, enabling the implementation of other technologies[80] (alternative to filters) such as capturing bags or absorbing balls to reduce microplastic emissions from washing.[81]

The use of filters in washing machines was also studied in Sweden, but there does not appear to be any such initiative in other EU countries.[82] Ecodesign requirement on washing machines and tumble dyers could also facilitate the use of filters. However, particular attention should be paid to how consumers handle the filters. If they are eventually washed or rinsed in a sink, there will be no decrease in microplastic release.

Problem driver 4: Very costly to invest in end-of-pipe wastewater treatment (including preventing microplastics in sludge)

Most wastewater treatment plants contribute to reducing microplastic concentration in water efficiently. However, decreasing the amount of microplastics in sludge is more challenging. Almost half of this sludge is usually spread on soil, which leads to microplastic releases into the soil. Implementing an additional treatment step to treat sludge would be costly, and there do not yet appear to be commercially available techniques to do so effectively.

Lack of knowledge and practice

There is a lack of knowledge and practice, both at the consumer and producer level. At the consumer level, the awareness is low, and there is no communication or guidance on how to reduce releases, while at the producer level, there is a lack of knowledge on eco-design measures and how to improve manufacturing processes in order to reduce emissions.

Problem driver 1: No or limited awareness among consumers

There is very limited awareness of the microplastics issue among consumers. According to a survey in the US in July 2020, 57% of the population had never heard of microplastics before. It means that the aware public represents around 40% of the population. About 50% of those who do know about

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[79] Time, 'Why You Should Always Wash New Clothes Before Wearing Them', 2019 (https://time.com/5631818/wash-new-clothes/).

[80] Alternatives to the filters.

[81] Sénat français [French Senate], Amendement n°2143 au projet de loi relatif à la lutte contre le dérèglement climatique [Amendment n°2143 to draft legislation on the fight against climate change], 10.06.2021 (http://www.senat.fr/amendements/2020-2021/667/Amdt_2143.html), Fr.

[82] Australia also announced its intention to "Work with the textile and whitegoods sectors on an industry-led phase-in of microfibre filters on new residential and commercial washing machines by 1 July 2030".

microplastics have learned about them in the past year[83]. According to this study, around 30% of US consumers think microplastics need to be addressed urgently.

Problem driver 2: No guidance to consumers on how to avoid or reduce unintentional releases

Information on how to reduce microplastic emissions from household washing machines is available online for consumers already aware of the issue. Several websites list the different existing options available for consumers (laundry bags, balls or filters, and general information on washing).[84,85] However, this information is directed to an aware public (representing around 40% of the population, see section above). At the same time, there is no or limited communication on this issue to the general public. If filters become mandatory or more widely used, particular attention should be paid to how consumers handle the filters or other devices to avoid microplastic releases. If they are eventually washed or rinsed in a sink, there will be no effect on overall microplastic emissions.

Problem driver 3: Lack of knowledge on eco-design measures and how to improve manufacturing processes in order to reduce emissions among producers

At the producer level, no or few technical solutions are defined. The implementation of eco-design criteria is limited by knowledge gaps and sometimes contradictions in the literature, as well as the lack of standardised measurement methods to quantify and compare microplastic emissions. At this stage, it is hard for producers to efficiently change the design of their textiles to reduce microplastic emissions.[86]

Producer voluntary initiatives reported so far are limited in terms of market shares; some examples of initiatives include the following:

- TextileMission project[87]: project carried out with several partners such as Adidas AG (retailer of sporting goods) and VAUDE Sport GmbH & Co (retailer of mountain equipment). The main work areas are the microplastic output of marketable textiles, retention capacity of different cleaning or purification steps in wastewater treatment plants, sustainability aspects of alternative materials, biodegradable materials and new cutting and processing possibilities, and production and testing of prototypes.
- Cross Industry Agreement (CIA)[88]: voluntary collaboration for the prevention of microplastic release into the aquatic environment during the washing of synthetic textiles of five European industry associations representing the global value chain of garments and their associated maintenance, namely AISE, CIRFS, EOG, EURATEX and FESI

[83] The Nature Conservancy and Bain & Company, 'Toward eliminating pre-consumer emissions of microplastics from the textile industry', 2021 (https://www.bain.com/globalassets/noindex/2021/tnc_bain_white_paper_eliminating_microplastics.pdf).

[84] The New York Times, 'Your Laundry Sheds Harmful Microfibers. Here's What You Can Do About It', 2021 (https://www.nytimes.com/wirecutter/blog/reduce-laundry-microfiber-pollution/).

[85] Irish Examiner, 'Green washing: How to reduce microplastic in your laundry', 2022 (https://www.irishexaminer.com/property/homeandgardens/arid-40951550.html).

[86] Opting for natural fibres would stop microplastics emissions but would also increase other environmental impacts (CO_2 emissions, land use, etc.).

[87] TextileMission, Project: Microplastics of Textile Origin - A Holistic View: Optimized Processes and Materials, Material Flows and Environmental Behavior, 2017-2021 (https://bmbf-plastik.de/en/joint-project/textilemission).

[88] Euratex, 'Cross Industry Agreement' (https://euratex.eu/cia/).

- Patagonia (retailer of outdoor equipment and clothing)[89]: the company initiated two studies. The first study focused on measuring the amount of microfibers that come off the products in the wash (and comparing them to lower-quality items). The objective of the second study is to understand better the fibre and fabric characteristics that lead to microfiber release and to develop a rapid test method to assess the potential of fabrics to shed during laundering. Both studies are conducted to enable the research and development of new materials.

4.3 Problem definition for paints

Generally, paints are made from the following components: pigments (absent in the case of varnishes), solvents (organic solvents and/or water), various additives and a binder. With few exceptions (e.g., pure mineral paint, which contains inorganic binders), the binder is a polymer, most commonly a synthetic resin, which binds all the other ingredients together and influences durability, and flexibility, and it is responsible for the general mechanical properties of the film (*Bierwagen et al., 2017*). Common binders are alkyls and epoxies, but paint might also contain polyurethanes, polyesters, polyacrylates and polystyrenes (*C. Gaylarde et al. 2021*). After the paint has been applied, the solvents (and/or water) evaporate, leaving binder, additives and pigments behind, forming the solid content.

The majority of paint formulations do not contain microbeads as an ingredient[90]; however, due to their resin content, paint particles (dried together with additives or in liquid form as polymers) are considered as microplastic[91]. Out of the 52 Mt of paint produced globally in 2019, 19.5 Mt are synthetic polymers[92], representing 5% of total world polymer production (*368 Mt - PlasticsEurope, 2020*). Paint has, in fact, a high polymer content - on average 37% - and can be found on a wide range of objects and infrastructures used in our society: cars, boats, indoor walls, buildings, and bridges, among others. It is not without reason, as paint delivers value by protecting objects from environmental degradation and corrosion. Thus, by increasing the lifetime of objects, paint eliminates the need for frequent replacement or maintenance that would otherwise be necessary, with the associated environmental impacts. But since paint is often applied on exterior surfaces to protect them from wear and tear and corrosion, it should come as no surprise that paint lost during the application, wear and tear, or removal will eventually find its way to the environment.

Many studies have already pointed out that paint particles are part of the increasingly important microplastic source in our oceans. Ingredients of the paint binders such as polyurethanes, polyesters, polyacrylates, polystyrenes, alkyls and epoxies have been increasingly identified in environmental

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[89] Patagonia, 'An update on microfiber pollution', 2018 (https://www.patagonia.com/stories/an-update-on-microfiber-pollution/story-31370.html).

[90] Microbeads are intentional added microplastics which are covered by the REACH restriction: European Chemicals Agency, Bakcground Document to the Opinion on the Annex XV report proposing restrictions on intentionally added microplastics, 2020 (https://echa.europa.eu/documents/10162/b56c6c7e-02fb-68a4-da69-0bcbd504212b).

[91] Verschoor, A. et al., 'Emission of microplastics and potential mitigation measures: Abrasive cleaning agents, paints and tyre wear', Dutch National Institue for Public Health and the Environment, 2016 (https://rivm.openrepository.com/bitstream/handle/10029/617930/2016-0026.pdf?sequence=3)

[92] Market research from MarketsandMarkets Research Private Limited

samples all over the globe[93],[94],[95],[96],[97],[98], highlighting the importance of better assessing the contribution of paint to plastic pollution.

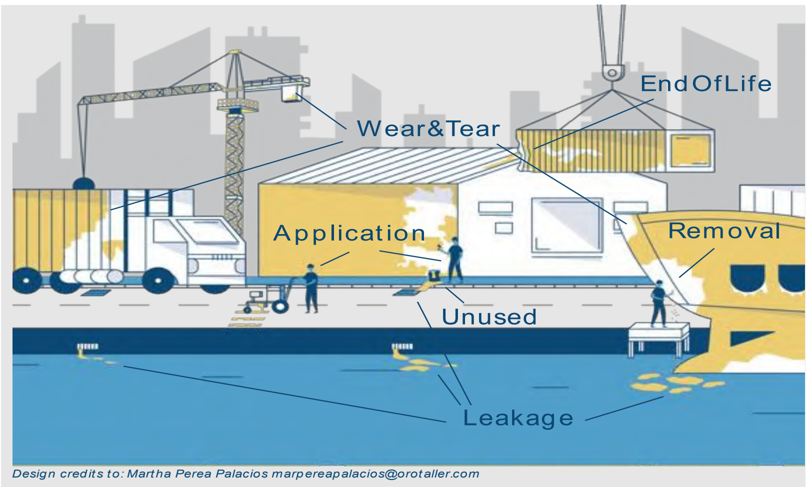

Figure 15: Different ways of microplastic release from paints

From the EA-Environmental Action analysis published in January 2022[99], a large part of the paint is mismanaged in the EU (40%) and thus leaks to the environment. The majority (63%) of this leakage occurs in the form of microplastics emitted during paint application, maintenance and wear and tear. The remaining 37% of the leakage (mostly microplastics) stems from unused paint or is associated with the end-of-life of the painted objects. The leakage occurs predominantly on land (63%) and in oceans and waterways.

If one looks in more detail, this 37% of the global leakage is the result of different forms of solid waste mismanagement and the leakage occurring directly in the ocean (e.g., through wear and tear or maintenance of commercial ships or offshore rigs), the latter accounting for 18% of total leakage.

Paint leakage is geographically ubiquitous, with leakage rates ranging from 22% in high-income North America to 50% in low and middle-income Europe. This means, for instance, that half of the

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[93] Turner, 2021, Paint particles in the marine environment: An overlooked component of microplastics, https://doi.org/10.1016/j.wroa.2021.100110)

[94] Dibke et al. Microplastic Mass Concentrations and Distribution in German Bight Waters by Pyrolysis–Gas Chromatography–Mass Spectrometry/Thermochemolysis Reveal Potential Impact of Marine Coatings: Do Ships Leave Skid Marks? https://doi.org/10.1021/acs.est.0c04522

[95] Schell, T., Hurley, R., Buenaventura, N. T., Mauri, P. V., Nizzetto, L., Rico, A., & Vighi, M. (2022). Fate of microplastics in agricultural soils amended with sewage sludge: Is surface water runoff a relevant environmental pathway?. Environmental Pollution, 293, 118520;

[96] Turner, A., Ostle, C., & Wootton, M. (2022). Occurrence and chemical characteristics of microplastic paint flakes in the North Atlantic Ocean. Science of The Total Environment, 806, 150375;

[97] Cardozo, A.L.P., Farias, E.G.G., Rodrigues-Filho, J.L., Moteiro, I.B., Scandolo, T.M., Dantas, D.V. (2018). Feeding ecology and ingestion of plastic fragments by Priacanthus arenatus: What's the fisheries contribution to the problem? marine Pollution Bulletin 130: 19-27;

[98] Herrera, A., Ŝtindlová, A., Martínez, I,. Rapp, J., Romero-Kutzner, V., Samper, M.D., Montoto, T., Aguiar-González, B., Packard, T., Gómez, M. (2019). Microplastic ingestion by Atlantic chub mackerel (Scomber colias) in the Canary Islands coast. Marine Pollution Bulletin 139: 127-135)

[99] Paruta, P., Boucher, J., Pucino, M. (2022). Plastic Paints the Environment, EA- Environmental Action, ISBN 978-2-8399-3494-7

paint applied in European low-income countries will eventually leak into the environment in one way or another. Because of its larger population, the highest contribution to total leakage in absolute terms comes from the Asia Pacific region (54% of total leakage).

The six paint sectors analysed in the EA's global study are architectural, marine, automotive, road markings, industrial wood and general industrial. They contribute to the total leakage with individual leakage rates ranging from 28% (automotive sector) to 74% (road markings sector). The architectural sector is the largest contributor to the total leakage (48%), and the road markings sector is the smallest contributor (2%). In terms of leakage specifically to ocean and waterways, the contribution from architectural paint is similar to that of marine or general industrial paints. EA-Environmental Action's report[100] shows that the paint industry is potentially the sector with the highest contribution to microplastics leakage to ocean & waterways (1.9 Mt/year), higher than tyre dust, synthetic textile and other known sources combined (less than 1.5 Mt/year in total[101,102] . This finding does not imply that these other sources are not part of the problem, as the paint leakage identified in the EA study only adds up to the leakage from these other sources, which was already high in absolute value. To understand the reasons behind this change in the methodology, one needs to look at the previous research focusing on other sources of microplastics. Some of the previous studies on plastic leakage have included paint but under "other sources" of primary microplastic release in the environment. The contribution of paints to the total microplastic leakage was estimated to range from 9.6% to 21% in different studies (see Table 1). Although none of the studies takes into account all paint sectors and all geographies, this alone is not enough to explain the difference with the EA's assessment.

The root differences are rather that not all loss types are accounted for in previous studies, and that wear and tear and removal rates are very different. For example, the Eunomia report[103] excludes all losses due to overspray. Furthermore, most studies base their wear and tear and removal rates on an OECD report[104] or on values provided by CEPE (the association representing the interests of the coatings sector at European level)[105]. For instance, Eunomia estimates that only 0.5% of the antifouling marine paint will be lost to the environment due to wear and tear during the lifetime of the boat, even when most antifouling paint is meant to "erode" or "peel off" in order to prevent fouling on the boat hull. The EA study assumes that within 4 years, 35% of the antifouling paint will be lost and thus is an important source of microplastics release. This is a conservative estimate, as according to a paper by paint manufacturer International Paint Ltd.[106], CEPE considers all the biocide contained in the antifouling paint to be released during the antifouling coating lifetime (100% loss rate). The same paper claims that the actual emission is a factor 2.9 smaller (34% loss rate).

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[100] Paruta, P., Boucher, J., Pucino, M. (2022). Plastic Paints the Environment, EA- Environmental Action, ISBN 978-2-8399-3494-7

[101] Boucher, J., & Friot, D. (2017). Primary microplastics in the oceans: a global evaluation of sources (Vol. 10). Gland, Switzerland: IUCN

[102] Lau, W. W., Shiran, Y., Bailey, R. M., Cook, E., Stuchtey, M. R., Koskella, J., & Palardy, J. E. (2020). Evaluating scenarios toward zero plastic pollution. Science, 369(6510), 1455-1461

[103] Hann, S., Sherrington, C., Jamieson, O., Hickman, M., Kershaw, P., Bapasola, A., & Cole, G. (2018). Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products. Report for DG Environment of the European Commission, 335.

[104] OECD (2009). Emission scenario document on coating industry (paints, lacquers and varnishes). OECD Health and Safety Publications, Series on Emission Scenario Documents, 22: 201.

[105] CEPE, 2021. About us. Accessed on 19/11/2021. https://cepe.org/about-us/who-we-are/

[106] Finnie (2006) Improved estimates of environmental copper release rates from antifouling products. Biofouling : The Journal of Bioadhesion and Biofilm Research

Table 1: Comparison of studies on plastic leakage from paints

Source	Geography	Sectors	Paint microplastic leakage (kt/yr)	Per capita equivalent (g/cap/yr)	Paint share of micro-plastic leakage (%)
IUCN *Boucher & Friot, 2017*	Global	• Marine • Road markings	156 (to ocean & waterways)	23 (to ocean & waterways)	10,7%
EUNOMIA *Hann et al, 2018*	EU	• Architectural • Marine • Automotive • Road markings	20 (to ocean & waterways)	40 (to ocean & waterways)	11.6%
MEPEX *Sundt, Schulze & Syversen, 2014*	Norway	• Architectural • Marine • Road markings	1.1 (to environment)	214 (to environment)	14%
UNEP *Ryberg et al., 2018*	Global	• Architectural • Marine • Road markings	640 (to environment)	84 (to environment)	21%
Swedish EPA *Magnuson et al., 2016*	Sweden	• Architectural • Marine • Road markings • General Industrial	1.8 (to environment)	186 (to environment)	9.6%
EA *Paruta et al. 2021*	Global	• Architectural • Marine • Road markings • General Industrial • Automotive • Industrial wood	1857 (to Ocean & Waterways)	267 (to Ocean & Waterways)	58%

4.4 Problem definition for detergent capsules

Industry claims that detergent capsules have revolutionised the world of household care and professional cleaning and hygiene industry within the last ten years. They afford several key advantages by being more convenient for consumers (easy and correct dosing), avoiding skin contact with active ingredients like detergent, salt and rinse aid and optimising resource use and packaging. The cornerstone of these detergent capsules relies on using a water-soluble plastic film that must be dissolved during the washing cycle. The water-soluble plastic films are mainly composed of polyvinyl alcohol (PVOH). The typical thickness for these water-soluble plastics is between 30 and 50 µm. For instance, in the case of liquid laundry detergent capsules, the volume of each liquid laundry detergent capsule is considerably lower than that of an equivalent dose of traditional detergent. Yet, it cleans the same full load of laundry. All active ingredients are contained in a single unit dose capsule, which dissolves after contact with water inside the washing machine and then releases the detergent. In addition to this convenience, the high concentration level leads to lower product amounts/job needed to be transported through the supply chain, which is a sustainability advantage by reducing CO2 emissions. Additionally, the film performs the containment function, enabling high-efficiency cleaning agents that facilitate low-temperature and low-water wash cycles (which directly improves sustainability, as a significant portion of the carbon emissions from a laundry cycle comes from the use phase of heating water). As a unit dose, precise portion control is a key feature to dispense only the quantity needed per load, effectively reducing excessive use and consumer/end-user overdosing.[107] The key enabler of this capsule is a water-soluble film, which holds the concentrated detergent solution. This film is generally based on PVOH, with polymer backbone modifications and specific performance additives such as salts (e.g., calcium carbonate) and plasticizers (e.g., glycerol). The films are developed to readily dissolve as intended in the washing process, including in sustainability-driven cold-water cycles, and meet the technical challenges of mass volume production and regulatory compliance.

The definition of "microplastics" of the REACH restriction might not be applicable to PVOH, either because it is in the form of a film (then not complying with the size limits of the definition) or because it fulfils the solubility criteria set in the restriction. However, even if PVOH is water-soluble and as such not in the scope of the REACH restriction, it may adversely impact the environment (see Rolsky[108]). Detergent capsules frequently contain multiple compartments, allowing the formulators to separate ingredients which at the elevated concentrations of liquid laundry detergent capsules would not be compatible with each other. To ensure consumer safety and avoid spillage, the film is designed not to dissolve and rupture during routine transport and handling (e. g. when touched with wet hands); to resist compression (e. g., during transport or dosing); and to trigger an aversive reaction in case of oral contact. These features are required for liquid laundry detergent capsules in the EU under Regulation (EU) No. 1297/2014 (amending the CLP Regulation (EC) 1272/2008), which was put in place to help reduce accidental exposures involving young children observed in the market. With respect to their powder analogues, these detergent capsules provide better protection against any allergic issues related to skin contact and any accident related to misuse by children.

As far as water-soluble films are concerned, more particularly related to their water-solubility feature, the use of PVOH can be expanded to other applications as a sizing and finishing agent in the textile industry and as a thickening or coating agent for paints, glues, packaging of meat, pharmaceuticals and paper and food industries. The fate of PVOH relating to these different applications remains uncertain.

With a yearly global production of 650,000 tonnes, PVOH is becoming increasingly popular, with an annual growth rate of 4% from 2018 to 2023. In Europe, the use of PVOH is estimated to be around 100 000 tonnes per year, of which 20 000 tonnes are used as protective films for detergent capsules (see further in the calculation of the baseline).[109] Other uses are papermaking, textile warp sizing, as a thickener and emulsion stabilizer in polyvinyl acetate (PVA) adhesive formulations, in a variety of coatings, and 3D printing. As aforementioned, the PVOH films can be used for all relevant

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[107] AISE report on SOLUBLE FILMS IN SINGLE-DOSE DETERGENT PRODUCTS: Information on their purpose, technical characteristics, testing and usage (April 2022, Provided by A.I.S.E. in support of the study for the European Commission on "Microplastics pollution – measures to reduce its impact on the environment")

[108] Rolsky, C. and Kelkar, V., Degradation of Polyvinyl Alcohol in US Wastewater Treatment Plants and Subsequent Nationwide Emission Estimate', *International Journal of Environmental Research and Public Health*, Vol. 18, no. 11: 6027, 2021.

[109] Renewable Carbon, 'BioSinn – Products for Which Biodegradation makes sense', 2021 (https://renewable-carbon.eu/publications/product/biosinn-products-for-which-biodegradation-makes-sense-pdf/).

products (capsules filled with detergent for the washing machine and all chemicals for the household and garden, such as chlorine tablets for the garden pond). However, in the case of PVOH-based capsules, they have a direct environmental impact as these capsules are directly delivered into grey water before wastewater treatment plants.

The common way to obtain PVOH is through a hydrolytic deprotection process conducted on polyvinyl acetate (PVA). To facilitate the processability window, PVOH can also be used as blends or mixtures (PVAI, Polyviol, Alcotex, Covol, Gelvatol, Lemol, Mowiol, Mowiflex, and Rhodoviol) when used as a protective film for laundry and dish detergents[110]. For the sake of clarity, the term "PVOH types" indicates the generic composition of these protective films.

As reported by Rolsky[111], the general increase of PVOH and related blends used in capsules and others could be more and more considered as one of the most ubiquitous pollutants in wastewater. Some reports[112] highlight that when PVOH is discharged into water bodies, PVOH and related blends likely have an adverse effect on the environment. Due to its surface properties, it has been reported that PVOH's ability to foam can inhibit oxygen transfer, causing irreparable harm to aquatic life at high concentrations. In addition, PVOH can potentially adsorb dangerous chemicals or contaminants, such as antibiotics or heavy metals, at high concentrations, posing a threat to the environment and our food chains, similar to traditional polluted plastics at high concentrations.

The fate of PVOH in wastewater treatment systems[113] has been explored (using radio-labelling to have a clear follow up about the complete biodegradation), with some studies indicating the degradation of PVOH-films during the wastewater treatment process even if the complete degradation has not been established following this process. For instance, some claims have highlighted that the PVOH and related mixtures used as detergent capsules are fully biodegradable, but they require additional investigations to confirm this statement. The biodegradation of PVOH occurs under specific circumstances, which may not be present during wastewater treatment or in the natural environment (river, seas, and oceans). The PVOH biodegradation is usually conducted in the presence of oxidative bacteria in which they oxidize the tertiary carbon atoms, leading to the main endo-cleavage of PVOH molecules and ultimately to the formation of hydrolysable by-products (hydroxy ketone and 1,3-diketone). Other microorganisms such as bacteria Pseudomonas can utilize

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[110] Julinova, M. et al., 'Water-soluble polymeric xenobiotics - Polyvinyl alcohol and polyvinylpyrrolidon - And potential solutions to environmental issues: A brief review', *Journal of Environmental Management*, No. 228, 2018, pp. 213-222.

[111] Rolsky, C. and Kelkar, V., Degradation of Polyvinyl Alcohol in US Wastewater Treatment Plants and Subsequent Nationwide Emission Estimate', *International Journal of Environmental Research and Public Health*, Vol. 18, no. 11: 6027, 2021.

[112] (a) Cole, M., Lindeque, P., Halsband, C. and Galloway, T. S., 'Microplastics as contaminants in the marine environment: A review', *Marine Pollution Bulletin*, Vol. 62, 2011, pp. 2588-2597.

(b) Li, J., Zhang, K. and Zhang, H., 'Adsorption of antibiotics on microplastics', *Environmental Pollution*, Vol. 237, 2018, pp. 460-467.

(c) Brennecke, D., Duarte, B., Paiva, F., Caçador, I. and Canning-Clode, J, 'Microplastics as vector for heavy metal contamination from the marine environment', *Estuarine, Coastal and Shelf Science*, Vol. 178, 2016, pp. 189-195.

(d) Lei, L. et al., 'Oxidative degradation of poly vinyl alcohol by the photochemically enhanced Fenton reaction', *Journal of Photochemistry and Photobiology A: Chemistry*, Vol. 116, No. 2, 1998, pp. 159-166.

(e) Sun, W., Chen, L. and Wang, J., 'Degradation of PVA (polyvinyl alcohol) in wastewater by advanced oxidation processes', *Journal of Advanced Oxidation Technologies*, Vol. 20, No. 2, 2017.

(f) Hollman, P.C.H., Bouwmeester, H. and Peters, R.J.B., 'Microplastics in Aquatic Food Chain: Sources, Measurement, Occurrence and Potential Health Risks', *RIKILT-Institute of Food Safety*, 2013 (https://edepot.wur.nl/260490).

[113] Wheatley, Q. and Baines, F., 'Biodegradation of polyvinyl alcohol in wastewater', *Textile Chemist & Colorist*, Vol. 7, No. 2, 1976, pp. 28-33.

PVOH as a carbon source, and many of these processes can take place simultaneously to begin the degradation of the polymer. While several bacterial species have been documented degrading PVOH, they are present in soils and not usually in natural water compartments.[114] In the case of old sludge, the microorganisms are usually acclimatised and could effectively biodegrade these PVOH and related mixtures. Knowing that these PVOH and related mixtures used as water-soluble films can contain certain additives (e.g. salts and plasticizers), the related additives could likely modify and to some extent, inhibit their biodegradation ability.[115] To clearly demonstrate the full biodegradation of these PVOH after wastewater treatments, specific procedures and related characterization techniques must be employed, such as radiolabelling PVOH in order to follow up the ultimate fate of these PVOH types.

A recent report has highlighted that the PVOH films used for detergent capsules were shown to be potentially biodegradable in OECD screening test conditions.[116] The OECD 301 series of biodegradation tests are commonly used by manufacturers and users of these water-soluble films. They are considered stringent screening tests, conducted under aerobic conditions, in which a high concentration of the test substance (in the range of 2 to 100 mg/L) is used and ultimate biodegradation is measured by non-specific parameters like Dissolved Organic Carbon (DOC), Biochemical Oxygen Demand (BOD) and CO2 production. These tests are also used under existing EU legislation to measure the biodegradability of mixtures (surfactants under Regulation (EC) No 648/2004 on detergents) and polymers (under the recently adopted REACH restriction on intentionally added microplastics). These tests are considered stress tests for the test chemical since the system does not have an environmentally realistic ratio of a test chemical to microbes (which in an actual WWTP would be orders of magnitude higher). The inoculum is sourced from a well-operated domestic wastewater treatment plant with a diverse and robust microbial population, and no pre-exposure to the test chemical is allowed. In these studies, the test material is the sole carbon and energy source for the population of microorganisms to use and grow. Using 6 representative PVOH and related mixtures, the extent of biodegradation after 28 days was estimated at 60.4% on average, but the full biodegradation has not been demonstrated except on the basis of extrapolation models.

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[114] Yamatsu, A., Matsumi, R., Atomi, H. and Imanaka, T.: Isolation and characterization of a novel poly(vinylalcohol)-degrading bacterium, Sphingopyxis sp. PVA3. Appl Microbiol Biotechnol 72 (2006), 804 – 81. PMid:16583228; DOI:10.1007/s00253-006-0351-4

[115] Byrne et al., Biodegradability of Polyvinyl Alcohol Based Film Used for Liquid Detergent Capsules, *Environmental Chemistry*, (2021)

[116] Byrne et al., 'Biodegradability of polyvinyl alcohol based film used for liquid detergent capsules', *Tenside Surfactants Detergents*, Vol. 58, No. 2, 2021.

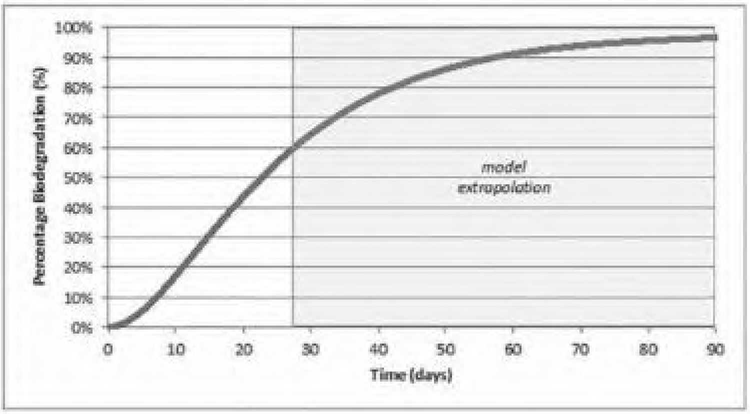

Figure 16: Model extrapolation beyond 28 days

There are some international standards (e.g., ISO standard 14593: 1999) that can be used to demonstrate the complete biodegradation of biodegradable plastics, such as some microbial polyesters in natural aqueous compartments (marine), *i.e.*, the complete metabolisation of C-substrate into CO_2. However, the standards are commonly conducted at temperatures above room temperature and do not correspond to the real environmental situation. Therefore, PVOH removal during wastewater treatments is still in question due to a lack of comprehensive research and must be even experimentally demonstrated in some natural compartments, such as in marine conditions in which the rate of biodegradation can be slowed down due to a low temperature (e.g., 4°C in oceans).

4.4.1 Value chain of water-soluble plastics

The main actors in the value chain are:

- Detergent manufacturers
- Water-soluble plastic producers
- Water-soluble plastic processors
- Wastewater management companies

Below is a description of their respective roles.

- **Detergent manufacturers** belong to the European household care and professional cleaning and hygiene industry, particularly those manufacturing detergent capsules for laundry and dishwasher capsules. More than 1700 companies are active in the domains of soaps, detergents or maintenance products.
- **Water-soluble plastic producers** are manufacturers of virgin PVOH materials for water-soluble productions. Historically, air Products and DuPont were among the first PVOH manufacturers of PVOH, but today Kuraray (Japan) is one of the largest manufacturers of PVOH resins.
- **Water-soluble plastic processors** transform PVOH pellets by mixing them with plasticizers and salt to alter their physical properties, particularly water-solubility. Such activities are related to compounders. The major supplier in Europe is Kuraray under the brand name monosol.
- **Wastewater management companies** are treating urban and industrial wastewater with a fundamental role in ensuring public health and environmental protection by removing suspended solids, harmful bacteria, and pollutants of emerging concern. They can be of

private and public bodies. Urban wastewater treatment in Europe has improved over recent decades, largely above 80% of wastewater treated since 1995.

4.4.2 Routes of water-soluble plastics loss

Related to its inherent water-solubility, the major release of PVOH and its blends as detergent capsules occur through conventional water treatments in the form of greywater from domestic, public, and industrial sources. One might not exclude that other PVOH fractions not used as detergent capsules, such as chlorine tablets, can be found elsewhere, such as in soils. In this respect, the major route of PVOH and its blends is related to water discharges of greywater from domestic, public, and industrial sources, mainly reaching most wastewater treatment plants in Europe. There are different wastewater treatment levels (primary, secondary, sludge, and disinfection) before leaving the wastewater treatment plant. The primary treatment based on mechanical treatments (stirring, filtration, etc.) and the secondary treatment based on biological actions (digestion, etc.) are compulsorily implemented in the EU and in the case of sensitive areas (coasts, etc.), additional treatments (tertiary treatments based on advanced filtration, etc.) are even considered. For instance, for discharges to sensitive waters, the wastewater treatment plant directive requires that all urban areas populated by more than 10 000 people provide primary, secondary and tertiary treatment. In a highly dense EU country such as The Netherlands, more than 90% of wastewater treatment is based on a tertiary treatment, consisting of a disinfection chamber and a filtration unit. [117] [118] [119] [120]

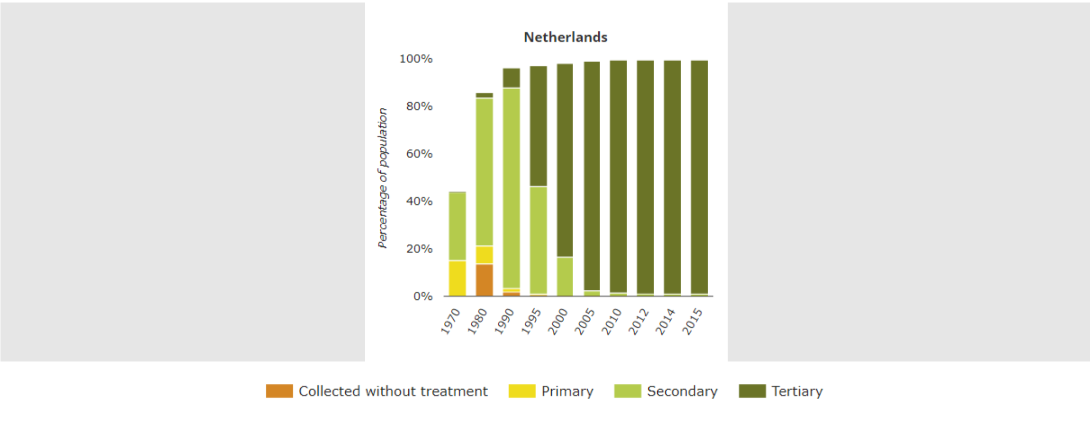

Figure 17: Collection rate of urban wastewater in the Netherlands

Related to the misuse or non-intentional release of PVOH in some natural compartments (e.g. soil), we may not exclude that all PVOH cannot reach the facilities related to wastewater treatment plants. Therefore, PVOH residues could be likely found in both treated sludge and water.

Water-soluble plastics used for detergent capsules have been recently extended to other types of more environmentally friendly resins, such as the LACTIPS company[121]. They propose a casein-based

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[117] European Environment Agency, 'Urban wastewater treatment in Europe', consulted March 18th 2022 (https://www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment).
[118] European Environment Agency, 'Urban wastewater treatment in Europe', consulted March 18th 2022 (https://www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment).
[119] European Environment Agency, 'Urban wastewater treatment in Europe', consulted March 18th 2022 (https://www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment).
[120] European Environment Agency, 'Urban wastewater treatment in Europe', consulted March 18th 2022 (https://www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment).
[121] Lactips, 'Polymère naturel et biodégradable en milieu aquatique', consulted on March 18th 2022 (https://www.lactips.com/).

packaging film for dishwasher tabs claimed as "OK bio-degradable WATER" by the private company TÜV Austria, but are not endorsed by any CEN or ISO standard. However, at this moment, these alternatives are still unsuitable as these LACTIPS products derived from milk protein are non-VEGAN products and could not be widely accepted as water-soluble films. Another issue is related to their poor transparency as water-soluble films. Some suppliers in Germany can provide biodegradable films based on natural products (starch) with the EU Ecolabel. The EU-Ecolabel recognised the biodegradability of these products, in which the water-soluble films were a part of the overall composition.

4.5 Problem definition for geotextiles

Geotextiles are a type of geosynthetics used for various civil engineering applications. They are primarily made of polymers such as polypropylene or polyester and are mostly manufactured in two different forms woven and nonwoven. Figure 18 below shows various examples of geosynthetics.

Figure 18: Various samples of geosynthetics

From bottom to top: the rough black surface of high-density polyethylene (HDPE) geomembrane, white carrier nonwoven geotextile, black geonet, white nonwoven filter geotextile (folded back), black woven geogrid and a white.[122]

There is a real environmental advantage in using geotextiles as their mechanical properties enable civil engineers to significantly increase the tensile strength of soils. They are lightweight materials, so they have lower carbon emissions than equivalent concrete or metal. Furthermore, they weigh significantly less than other materials which can be used to stabilise soils, e.g., gravel and rock. As a result, the CO_2 balance when using geotextiles versus gravel or more traditional stabilising materials is in favour of geotextiles[123,124]. Indeed, rising sea levels and increasing storm strength are disrupting European coasts to a greater extent than before, and geotextiles are used for protecting coasts. Although geotextiles are, in theory, designed to withstand the harsh conditions to which they are exposed in these applications, there are examples of these geotextiles failing and not serving their

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[122] Müller, W.W. and Saathoff, F., 'Geosynthetics In Geoenvironmental Engineering', *Science And Technology Of Advanced Materials*, Vol. 16, No. 3, 2015.

[123] Dixon, N., Raja. J., Fowmes, G. and Frost, M., 'Sustainability Aspects Of Using Geotextiles', *Geotextiles*, 2016, pp. 577-596.

[124] Edana, 'Why use nonwovens in geosynthetics and civil engineering?', Consulted 6 January 2022 (https://www.edana.org/nw-related-industry/nonwovens-in-daily-life/geosynthetics-and-civil-engineering).

intended purposes nor being removed (after use) from coastal areas where they can become hotspots for macro and microplastics emissions.

The issue seems to stem from two main factors: first, the materials may not have sufficient resistance to the environmental conditions they are exposed to (temperature variation, exposure to water, salt water, UV light, abrasion, etc.) and second, the extreme weather events such as storms which the material can be exposed to. Some autoclave tests performed in 2021[125] exhibit good life expectancies (a half-life of 330 years for mechanical properties retainment) for different geotextile types. However, the mechanical wear of the materials was not taken into account, which is unfortunate considering that mechanical wear in coastal erosion protection applications is a very destructive force.

The industry has estimated the longevity of geotextiles by studying the influence of thermal and UV ageing on the reduction in mechanical properties of the geotextiles. Their results showed that for an unexposed 1.5 mm thick HDPE geomembrane, the life expectancy for the retention of 50% of mechanical capacity could be up to 450 years, whereas it was 97 years for the exposed membranes. [126] A study indicates that the successive exposure of polypropylene geotextile to UV degradation, sea water and thermal cycle "showed the existence of relevant interactions between the degradation agents and the reduction factors obtained by the traditional methodology were unable to represent accurately (by underestimating) the degradation occurred in geotextiles."[127]

The tests performed[128] to evaluate the life expectancy of these materials emulated the thermal, radiative and chemical processes to which geotextiles are exposed. However, they did not consider the mechanical abrasion which happens when geotextiles are exposed to the outside environment. One can infer that adding mechanical abrasion to the three degradation tests discussed would reduce the life expectancy of these materials even more for the geotextiles used in harsh environments, such as when used for coastal erosion protection. The general problem drivers for the microplastic emissions from geotextiles are similar to other sources, viz. market failure, regulatory failure and information/knowledge failure.

Scale of microplastic emissions from geotextiles

Estimations of the emissions of microplastics from geotextiles are scarce, but there are no lab results or experiments conducted, except the Bai, Xue et al. experiment in China. There are several explanations for this; first of all, geotextile weathering and environmental impact because of microplastics is a newly studied subject. Moreover, in-situ sampling is extremely difficult because these materials are either directly exposed to harsh environments and water (e.g., coastal erosion protection) where any microplastic particle emitted is extremely difficult to sample from the environment, either they are buried in the foundations of roads, building, or any other large construction works where to sample any microplastics; one would need to dig up the surrounding

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[125] Scholz, P. et al., 'Environmental Impact Of Geosynthetics In Coastal Protection', *Materials* (Basel), Vol. 14, No. 3, 2021, pp. 634.

[126] Koerner, R. M., Hsuan, Y.G. and Joerner, G.R., 'Lifetime Predictions Of Exposed Geotextiles And Geomembranes', *Geosynthetics International*, Vol. 24, No. 2, 2017, pp. 198-212.

[127] Carneiro, J.R., Almeida, P.J. and De Lurdes Lopes, M., 'Laboratory Evaluation Of Interactions In The Degradation Of A Polypropylene Geotextile In Marine Environments', *Advances In Materials Science And Engineering*, Vol. 2018, 2018, pp. 1-10.

[128] The thermooxidation tests were carried out according to method A of EN ISO 13438 and the damage suffered by the geotextile (during the degradation tests) was evaluated by tensile tests according to EN 29073-3 [33] (the method specified in EN 12226 [19] for determining the changes in the tensile properties of aged nonwoven geotextiles).

soil. The fate of geotextiles buried underground and potential microplastic emissions are also not known.

5 BASELINE BY SOURCE

5.1 Baseline for tyres

A key driver of tyre wear emissions is driving mileage. It is expected that there will be a significant increase in road transport volumes over the next decades. The JRC estimates a 16% increase in passenger road transport between 2010-2030 and a 30% increase for 2010-2050. Freight transport is estimated to increase by 33% by 2030 and 55% by 2050[129]. Most recently, in the context of preparing the Fit for 55 Package[130], the Commission assumed the increase in passenger car transport will grow by around 30% and around 20% for road freight transport[131]. Additionally, climate change effects, e.g. more frequent heavy rainfall events, will exacerbate the problems linked with releases of those microplastics from urban runoff and stormwater overflows (SWO). Finally, the increasing electrification of vehicle fleet may negatively influence tyre wear emissions and abrasion since 'electrified vehicles' (i.e. hybrid ICE) are generally heavier compared to their conventional counterparts. Battery electric vehicles are not necessarily heavier than conventional ICE vehicles of comparable class and power, particularly the larger ones[132]. Moreover, energy density (in weight and volume) is predicted to improve, so longer-range battery electric vehicles (BEVs) are expected in the future without an increase in weight. The possible effects of the introduction of electrified vehicles on non-exhaust emissions have been summarised in a recent OECD report[133].

With regards to tyre abrasion, important improvements could be expected since the proposal for a Euro 7 Regulation includes a review clause and related empowerments in order to include tyre abrasion limits in the type approval process. An ongoing Commission study and work performed in the UN Forum for Harmonisation of vehicle regulations on tyre abrasion test method will provide the basis for a tyre abrasion standard. The Tyre Labelling Regulation[134] included the possibility of a delegated act on tyre abrasion when the standard on abrasion (and mileage) becomes available.

5.1.1 Analytical approach

It is still a challenge to collect representative environmental samples of tyre wear, whether in water, soil or air.[135] Due to a lack of reliable methodologies, measurement uncertainties and incomplete databases, no reliable results can be quantified. An analytical or a top-down approach is possible.

Analytical problems hamper the environmental monitoring of emitted TWP. Emitted TWP cannot be analysed using FTIR or Raman spectroscopy, commonly used for other microplastics. Since tyre

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[129] Alonso Raposo, M. and Ciuffo, B., *The Future of Road Transport: Implications of automated, connected, low-carbon and shared mobility*, JRC116644, 2019, Publications Office of the European Union, Luxembourg.

[130] European Council and Council of the European Union, 'European Green Deal - Fit for 55', 2022 (https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/).

[131] European Commission, 'Policy scenarios for delivering the European Green Deal', 2022 (https://energy.ec.europa.eu/data-and-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en#scenario-results).

[132] E.g. A Tesla Model 3 LR, 4x4, 441 HP weighs 1726 kg, while a BMW 330e, 4x4 292 HP weighs 1820 kg.

[133] OECD, *Non-exhaust Particulate Emissions from Road Transport: An ignored environmental policy challenge*, 2020, OECD Publishing, Paris.

[134] European Parliament and Council of the European Union, Regulation (EU) 2020/740 on the labelling of tyres with respect to fuel efficiency and other parameters, OJ L 177, 5.6.2020, pp. 1–31.

[135] Peter Tromp et al., Presentation on the 'Comparison and improvement of analytical techniques for quality data on TWP in the environment', *Conference Setac Europe*, 2021 (https://globe.setac.org/tire-wear-and-microrubber-particles/).

tread and emitted TWP have a complex chemical composition and emitted TWP are difficult to separate from environmental matrices, markers are needed to detect the particles in environmental samples. In general, chemical compounds that are additives in tyre tread materials in sufficiently high concentrations are used as markers. A reliable marker should i) be specific to tyre rubber polymer, ii) be present in comparable concentrations, preferably independent of tyre brands, iii) not easily leach out or be transformed under environmental conditions and iv) be easily and precisely detectable. Typical markers used are inorganic Zn, benzothiazoles such as 2-(4-morpholinyl)benzothiazole (24MoBT) and N-cyclohexyl-2-benzothiazolamine (NCBA) (components of vulcanization accelerators), NR (natural rubber) and SBR/BR (styrene butadiene rubber/ butadiene rubber). For all markers, a sample preparation to separate emitted TWP from other particles is useful to reduce the background concentration, prevent matrices effects and concentrate emitted TWP to get a representative sample. By using thermoanalytical methods, a fractionation in several size classes is useful. The reason is that bigger particles have a high influence on the total mass, but in general, the number of particles is less than for smaller particles.[136] Furthermore, by analysing the air samples, the particle size <10µm is more relevant to evaluating health hazards.

Top-Down approach

Based on a mileage approach, tyre abrasion emissions can be estimated theoretically. An emission factor (EF) is defined and multiplied by the distance travelled. The resulting quantity corresponds to the losses on the tyre tread and represents the emitted TWP. The EF can be made dependent on various influencing variables, which are explained below.

Quantification of emissions

By differentiating between vehicle types (motorcycle, passenger car, HDV, etc.) and road types (urban, rural and motorway), the influencing variables from Boulter et al.[137] - tyre and vehicle characteristics, road surface characterisation and vehicle operation - can be taken into account, i.e. emission factors of the vehicle types are adjusted according to the driving situation (urban/rural/motorway). Based on the methodology for determining the emission rate described above and considering influencing factors, emission factors (EF) can be determined.

The figure below shows an overview of EF from various studies[138]. It is clear that the EF for motorcycles, passenger cars and light/medium vehicles show hardly any deviations. The EF for heavy-duty vehicle (HDV) and buses, on the other hand, fluctuate strongly.

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[136] Venghaus, D. et al., Report on project RAU (Tyre abrasion in the environment) – ‘Tire Wear in the environment – RAU’, 2021, Funded by the German Federal Ministry of Education and Research (BMBF).

[137] Boulter, P.G., Thorpe, A., Harrison, R.M. and Allen, A.G., ‘Road Vehicle Non-exhaust Particulate Matter: Final Report on Emission Modelling’, *TRL*, 2006.

[138] Peano, L. et al., ‘Plastic Leak Project. Methodological Guidelines’, *Quantis*, 2020 (https://quantis.com/report/the-plastic-leak-project-guidelines/).

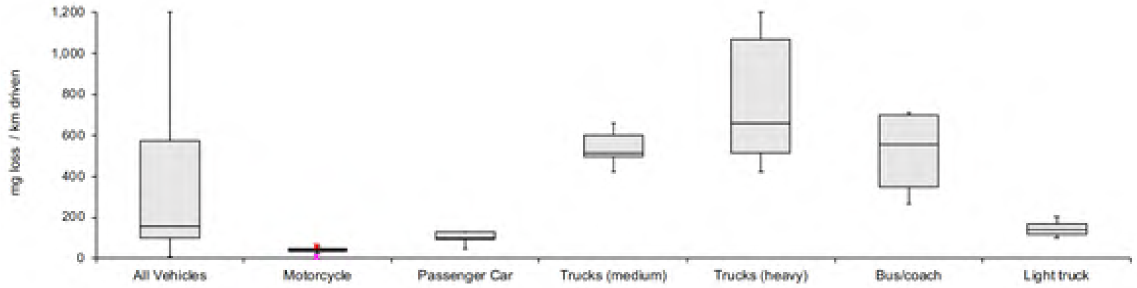

Figure 19: Emission rates according to vehicle type in various studies[139]

The EF, according to Deltares and TNO[140], has already been used several times in the calculations of the Netherlands Environmental Agency[141,142,143]. Furthermore, the EF served as a basis for the TWP emissions calculations in numerous studies[144]. To estimate TWP emissions for the EU27, the most recent road traffic data from the Eurostat database were used (Table 2).

Taking into account the given data and assumptions, this results in an annual emission quantity of **450,000 t/a TWP** for the entire EU27 for 2020, which is at the bottom end of the range from other studies (460,000-1,220,000 t/a) discussed previously. The shares of the road sectors (urban/rural/motorway) in the total emissions can be estimated on the basis of the available mileage data. According to this, most tyre wear is emitted on urban (39%) and rural (38%) roads. The share of motorways is 23%.

[139] Ibid.

[140] Deltares and TNO, 'Emissieschattingen Diffuse bronnen Emissieregistratie - Bandenslijtage wegverkeer' [Emission estimates Diffuse sources Emission registration - Tyre wear road traffic], 2016 (https://docplayer.nl/22104153-Bandenslijtage-wegverkeer.html), Nl.

[141] Geilenkirchen, G. et al., 'Methods for calculating the emissions of transport in the Netherlands', *PBL Netherlands Environmental Assessment Agency*, 2020 (https://www.pbl.nl/sites/default/files/downloads/pbl-2020-methods-for-calculating-the-emissions-of-transport-in-the-netherlands-2020-4139.pdf).

[142] Verschoor, A. et al., 'Emission of microplastics and potential mitigation measures: Abrasive cleaning agents, paints and tyre wear', Dutch National Institue for Public Health and the Environment, 2016 (https://rivm.openrepository.com/bitstream/handle/10029/617930/2016-0026.pdf?sequence=3).

[143] Klein, J. et al., 'Methods for calculating the emissions of transport in the Netherlands', 2019 (https://english.rvo.nl/sites/default/files/2019/05/Klein%20et%20al%202019%20Methodology%20report%20transport%202019.PDF).

[144] Vogelsang, C. et al., 'Microplastics in road dust – characteristics, pathways and measures', 2019 (https://www.miljodirektoratet.no/globalassets/publikasjoner/M959/M959.pdf).

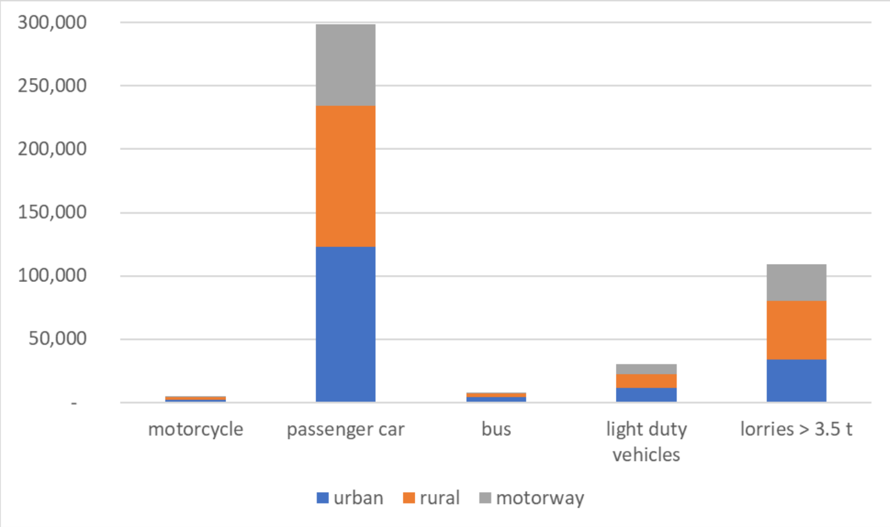

Figure 20: Annual estimated TWP emissions for the EU27, 2020

In order to develop an estimate for the final release of tyre wear (i.e. to which environmental compartments they are released), the methodological guidelines of the Plastic Leak Project[145] were used. The tool published for this project takes all input pathways into account and allows specific parameters to be adjusted. Although there are uncertainties in the data, e.g. the share of separate/combined sewer systems or the recycling of sewage sludge, it nevertheless provides information on how different measures could affect it.

The table below shows the calculated estimates for the final release of tyre wear into the environment.

Table 2: Estimation of the final release of emitted TWP

		FINAL RELEASE COMPARTMENTS					Removed from the environment
	share of roads	OCEANS (sediments and water column)	FRESH-WATER (sediments and water column)	SOILS	AIR	OTHER TERRESTRIAL COMPAR-TMENTS	
Average		2%	14%	59%	5%	9%	12%
Urban	39%	2%	19%	48%	5%	12%	19%
Rural	38%	0%	3%	91%	5%	5%	0%
Motorway	23%	3%	26%	38%	5%	12%	21%

The table shows that the majority of the emission is deposited in the soil (59%), which is the significant input pathway for rural roads in particular. This includes wind drifts to roadside and ditches as well as WWTP sludge agriculture and compost use. With regard to the input into the aquatic environment, urban areas and motorways are of particular importance. Other terrestrial compartments include stormwater sludge and sewage sludge listed in Eurostat as other and unknown. Sludge for incineration is evaluated as "removed from the environment". Although it can be assumed that airborne particles will deposit in the environment over time and thus contribute to the input of

[145] Quantis, 'The Plastic Leak Project' (https://quantis.com/who-we-guide/our-impact/sustainability-initiatives/plastic-leak-project/).

soil, surface waters or oceans, the intention of the pathway estimation is to identify which compartments and the living organisms in them are affected by the emission. The proportion of airborne particles is therefore set to 5%, according to Baensch-Baltruschat et al.

The baseline is the projection of emissions over the assessment period. The different factors that could potentially influence tyre wear emissions in the future have been assessed above. The following table summarises the expected effect of these factors on the tyre wear emissions. In addition to these factors, any future potential regulatory actions on abrasion rates could have a significant positive effect.

***Table 3: Key factors and their effect on tyre wear* emissions.**

Factor	Estimated Impact on TWP Emissions
Development in transport volume and mode of transport	Increase
Tyre material innovations	High effect and high potential
Road material innovations	Limited effect but high potential
Electric vehicles	Increase – depending on battery technology developments which might reduce the effect
Vehicle weight (SUV trend)	Increase
Speed limits	Decrease
Porous asphalt	Limited decreasing effect – but medium potential impact
Driving behaviour	Changes in behaviour can lead to increases (greater acceleration, sharp breaking etc.) or decreases (slower acceleration / speeds, reduced ./ smoother breaking)
Autonomous driving / connected driving	Limited decreasing effect in the short term, but medium potential impact in the longer term

For transport volumes, there are EU projections available that quantify how it is expected to evolve. In preparation of the European Green Deal Package, the Commission carried out a scenario assessment, including projections of the development of the transport sector and transport volumes. The policy scenarios assume continued transport growth. Though they include some reductions compared to the reference scenario, the increase in passenger car transport is assumed to grow by around 30% and about 20% for road freight transport[146]. It means that an increase in emissions can be expected due to the continued road transport growth.

Considering the different factors, it is difficult to quantify the expected change in emissions in the future. The increase in road traffic and the (assumed) higher weight of electric vehicles would all lead to an increase in tyre wear emissions. More restrictive speed limits, better tyres, and improved

[146] European Commission, 'Policy scenarios for delivering the European Green Deal' (https://energy.ec.europa.eu/data-and-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en).

driver behaviour through autonomous driving and awareness campaigns would lead to lower emissions. The following assumptions have been made:

- It is assumed that all factors except the transport volume increase cancel each other out. For example, effects of increases in the weight of passenger cars are offset by the factors that reduce emissions such as speed etc.
- The projected increase in transport volumes by 2030 of 30% for passenger transport and 20% for freight transport lead to proportionate increases in the microplastic emissions by the respective vehicle categories.

In total, the emissions are therefore expected in the baseline to increase from around 450,000 tonnes per year to **570,000 tonnes per year in 2030**.

5.1.2 Uncertainty and data gaps

Several factors influence the release of emitted TWP into the environment, e.g. tyre material and design, which consists of many components, road composition, and driving behaviour. The analysis for the determination of tyre abrasion in environmental samples is a challenge, and an interpretation of the analytical data should be carried out, taking into account the external conditions. In general, these variables' comparison and inclusion are not explored. Additionally, reproducible quantification of particles in the environment depends on the laboratories' sampling techniques and analytical techniques. Currently, there is a knowledge gap which is a combination of sampling techniques and evaluation procedures most suitable for quantification of emitted TWP to get realistic values. This gap should be at least partially filled with the ongoing work to develop a harmonised testing method and standard.

In addition to uncertainties with the overall emission factors for tyre abrasion, there is also a lack of data on the mix of tyres currently in use and how they vary in terms of abrasion rates. Several studies have demonstrated significant variation in abrasion rates between different tyre models and types both across different categories (i.e. tyre sizes and types) as well as within categories.

5.2 Baseline for textiles

The European demand for synthetic textiles is estimated at 8 million tonnes (ETC/WMGE, 2021c), representing almost 14 % of Europe's total plastic consumption. Between 1996 and 2012, there was a 40% increase in the amount of clothes purchased per person in the EU, and, according to the European Environmental Agency (EEA), between 1996 and 2018, clothing prices in the EU dropped by over 30 %, relative to inflation. Since 2000, Europeans have purchased more pieces of clothing but spent less money in doing so. These trends are expected to increase in the future, as at a global level, the consumption of clothing and footwear is expected to increase by 63% between 2019 and 2030. The global consumption of synthetic fibres increased from a few thousand tonnes in 1940 to more than 60 million tonnes in 2018, and continues to rise. Since the late 1990s, polyester has surpassed cotton as the fibre most commonly used in textiles. While the majority of synthetic textile fibres are produced in Asia, Europe stands out as the world's largest importer of synthetic fibres by trade value[147], and also produces and exports such fibres.[148] This increase in consumption leads to an increase in textiles production thus increasing microplastic emissions from textiles. In practice, this increase in consumption is accompanied by a decrease in the number of uses per piece[149]. A higher renewal rate also means more textiles being thrown away and more emissions at the end-of-life stage. Due to their low cost, synthetic materials are one of the levers of fast fashion.

The global increase in textile consumption implies a wider use of synthetic fibres, namely polyester and a consequent increase in fibre production. More than half of the global fibre production is polyester, making it the most common synthetic fibre (55 million tonnes in 2018) (Textile Exchange, 2019)[150], in with a large majority of polyester, which should represent around 70% of the total fibre production in 2030. The growing share of synthetic fibres is linked to the limited production of cotton and its relatively high price, as well as the increasing use of synthetic fibres in industries (synthetic fibres are used in a wide range of technical products: tyres, conveyor belts, reinforcement in composites, etc.).

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[147] Birkbeck, C.D., *Global Governance Brief: Strenghthening international cooperation to tackle plastic pollution: options for the WTO*, The Graduate Institute of Geneva, 2020.

[148] Manshoven, S., Smeets, A., Arnold, M. and Fogh Mortensen, L., 'Plastic in textiles: Potentials for circularity and reduced environmental and climate impacts', European Environment Agency and European Topic Centre on Waste and Materials in a Green Economy, Eionet report ETC/WMGE 2021/1, 2021.

[149] Hemkhaus, M., Hannak, J., Malodobry, P. et al., 'Circular economy in the textile sector', study for the German Federal Ministry for Economic Cooperation and Development, 2019.

[150] Textile Exchange, '2019 Preferred Fiber & Materials Report', 2019 (https://store.textileexchange.org/product/2019-preferred-fiber-materials-report/).

Table 4 sums up current microplastic emissions from synthetic textile per year in the EU. Data quality was assessed according to the number of sources and the uncertainty[151]. Not all emissions to water reach the environment. Indeed, part of the emissions to water will be captured by wastewater treatment plants. A large majority of microplastics are captured in the sludge[152]. However, in Europe, approximately 50% of all sludge are applied in agriculture as fertilizer[153]. So, due to sludge usage as fertilizer (the other half being incinerated, the microplastics are not emitted to the environment), 50% of emissions to water will reach the environment. Outside Europe, all emissions to water are considered to be emitted to the environment.

[151] The data used for calculating the emission ranges are presented in the appendices of the supporting study for this Impact Assessment.

[152] Lares, M. et al., 'Occurrence, Identification And Removal Of Microplastic Particles And Fibers In Conventional Activated Sludge Process And Advanced MBR Technology', *Water Research*, Vol. 133, 2018, pp. 236-246, Elsevier BV.

[153] Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.

Table 4: Microplastic emissions from synthetic textile per year in the EU27 - 2021

	Production	Washing	Drying	Wearing	End-of-Life
Microplastic emissions per year due to EU consumption (tonnes)	[841 ; 22,704] Of which 21% happen in the EU	[635 ; 5506]	[137 ; 7501]	[37 ; 25,367]	NA
Type of emissions	Air / water	Water	Air	Air	Air / water
Data quality	Low	Medium	Medium	Low	NA
Number of sources	1	6	4	2	0

These quantifications need to be refined along with standardised measurement methods in order to understand the influence of each factor and to be able to compare data. Standardisation should specify all the experiment criteria and impose only one measurement method to compare studies with one another. However, these values already underline the need to tackle microplastic emissions and generation directly at the source.

The baseline scenario has been developed for the year 2030. The quantities of microplastics emitted per year in 2030 are estimated by taking into account the evolution of the parameters related to the general problem driver "Increase in production and use of textiles", such as the increase in clothing consumption and the increase in the share of synthetic materials in clothing. The following table lists the parameters used to define the baseline scenario and gives their evolution between the current situation and the foreseen situation in 2030. The values for 2030 are either estimated on the basis of the literature or are assumed (details provided in "Comments" column).

Table 5: Evolution of the parameters of the microplastic emissions from textiles between the current situation and 2030 (parameters marked with an * are used directly in the emission calculations)

Parameter	Sub-category	Unit	Data considered in the state of the art (current value)	Baseline scenario (forecast data)	Comments
Evolution of the population					
Population *	-	million	447	449 [154]	
Households in Europe (1)	-	million households	195	198	Population increase: 1.3% [155]
Market data					

[154] Toute l'Europe.eu, 'A quoi ressemblera l'Europe en 2030' [What will Europe look like in 2030?], 2020 (https://www.touteleurope.eu/environnement/a-quoi-ressemblera-l-europe-en-2030/), Fr.

[155] Calculation according to OECD projections between 2021 and 2030.

Parameter	Sub-category	Unit	Data considered in the state of the art (current value)	Baseline scenario (forecast data)	Comments
Consumption of textile products *	-	million tonnes	7.4 [156]	9.0	Increase in textile production: +23% [157]
Proportion of man-made fibres in clothing sector	-	%	33.9%	38%	Assumption: 38% of man-made materials (cf. section "Increase in production and use of synthetic textiles" / problem driver 2)
Polyester *	Woven	%	8.40%	9.38%	
	Knitted	%	8.60%	9.60%	
Polypropylene *	Woven	%	0.20%	0.22%	
	Knitted	%	1.20%	1.34%	
Acrylic *	Woven	%	0.30%	0.33%	
	Knitted	%	8.40%	9.38%	
Polyamide *	Woven	%	1.50%	1.67%	
	Knitted	%	5.30%	5.92%	
Washing					
Number of washes per household (2)	-	washes a week	3.35	No change	According to 2008, 2017 and 2020 AISE data, no change in frequency[158, 159]
Average capacity of a washing machine (3)	-	kg	6.5	7	Assumption based on (JRC, 2016)
Relative load of one wash (4)	-	%	82%	-	

[156] Calculation based on the following data: 6.4 million tonnes of clothing consumed in the EU in 2015 (source: ECAP, 'Mapping clothing impacts in Europe: the environmental cost', 2017 (http://www.ecap.eu.com/wp-content/uploads/2018/07/Mapping-clothing-impacts-in-Europe.pdf)) and "40 per cent growth in the amount of purchased clothes per person in the EU between 1996 and 2012", which means 2.5% growth per year (source: ETC/WMGE, 'Textiles and the environment in a circular economy', 2019 (https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/textiles-and-the-environment-in-a-circular-economy/))
As in the EC/Eunomia (2018) report, professional textile washing – namely in hospitals or hotels – was not considered. Professional and household linens are mainly composed of cotton or polycotton (polyester/cotton blend) . Due to the lack of data on microplastics emissions from polycotton, the amount of polyester contained in the polycotton blend, no estimation could be made. According to first approximations made by RDC Environment, microplastics emissions from this source would represent less than 5% of the household emissions from clothing.

[157] Calculation based on the following data: "40 per cent growth in the amount of purchased clothes per person in the EU between 1996 and 2012" (source: ETC/WMGE, 'Textiles and the environment in a circular economy', 2019 (https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/textiles-and-the-environment-in-a-circular-economy/))

[158] AISE, 'A.I.S.E.'s pan-European habits survey 2020', 2021 (https://www.aise.eu/our-activities/information-to-end-users/consumer-research.aspx).

[159] AISE, 'A.I.S.E. Pan-European Consumer Habits Survey 2017', 2018 (https://www.aise.eu/documents/document/20180528165059-aise_consumershabitssurvey2017_summary_final.pdf).

Parameter	Sub-category	Unit	Data considered in the state of the art (current value)	Baseline scenario (forecast data)	Comments
Machine load * (3)*(4)	-	kg of textile washed per cycle	5.33	5.33	Calculation based on the average capacity of a washing machine and the relative load of one wash Note: no increase in load despite the increase in capacity.[160]
Number of washes per year * (1)*(2)	-	billion washes	34.0	34.5	Assumption: increase in the number of washes according to the population
Drying					
Number of tumble dryers in use in European households *	-	million	78.0	78.3	Assumption: increase in the number of dryers according to the population
Number of uses per year *	-	times per year	107	No change	
Average load *	-	kg	4.4	No change [161]	

The microplastic emissions per year for 2030 are presented in the following table. It should be noted that emissions of microplastics per year for the year 2030 are calculated using the following assumption, **“there is no change in the quantities of microplastics emitted per kg (kg worn, kg washed or kg dried)”.** This assumption is based on the fact that the time considered is too limited to identify and implement eco-design and research & development actions as a baseline without policy measures fostering changes. No quantified data is available for microplastic emissions related to the end of life of clothing. For these emissions, the evolution of emissions (in % terms) is estimated only based on the increase in clothing consumption.

[160] European Commission, Final report - Review study on household tumble driers, 2019 (https://www.applia-europe.eu/images/Library/Review_study_on_tumble_dryers_06-2019.pdf).

[161] Ibid.

Table 6: Evolution of the quantities of microplastics emitted per year (tonnes/year)

Emissions	Data estimated in state of the art (current value)	Baseline scenario (forecast data)	Evolution	Comments
Production in Europe (emissions to air and water)	159 - 4293	217 - 5869	+ 37%	Emissions in Europe. Evolution estimates based on the increase in textile consumption and increase in the share of synthetic materials
Production outside Europe (emissions to air and water)	682 – 18 411	932 – 25 172	+ 37%	Emissions outside Europe. Evolution estimates based on the increase in textile consumption and increase in the share of synthetic materials
Use phase – wearing (emissions to air)	37 – 25 367	42 – 28 438	+ 12%	Increase due to the increase in the share of synthetic materials and population growth
Washing (emissions to water)	635 - 5506	714 - 6223	+ 12%	Increase due to the increase in the share of synthetic materials and the evolution of washing habits
Drying (emissions to air)	137 – 7501	153 – 8410	+ 12%	Increase due to the increase in the share of synthetic materials and population growth
End-of-life (emissions to air and water)	No quantified data	No quantified data	+ 37%	Evolution estimates based on the increase in textile consumption. The evolution of the emissions linked to the end of life corresponds to an overestimation because no stock is considered.

The evolution of microplastic emissions varies between +12% and +37%, depending on the type of emissions considered. Among the four parameters used to define the baseline scenario, the most influencing parameters are:

- Increase in the consumption of clothing (for production and end of life)
- Increase in the share of synthetic materials (for wearing, washing and drying).

Note: According to CircularInnoBooster Fashion and Textile project, second-hand clothing accounts for 2% of the total weight of the fashion and luxury goods sector in the world[162]. This figure is expected to grow by 15 to 20% over the next five years. At present, the market for second-hand clothes is still limited. The use of second-hand clothes makes it possible to: reduce the consumption of new clothes and therefore reduce production (thus avoiding microplastic emissions at this stage). On the other hand, studies[163, 164] show that microplastic emissions during care increase with the age of the garment. Thus, emissions could increase during washing.

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[162] CircularInnoBooster Fashion and Textile project, 'Second-hand fashion, a new impetus for clothing consumption', 2021 (https://circoax.eu/second-hand-fashion-a-new-impetus-for-clothing-consumption).

[163] Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.

[164] Textile Mission, 'Textiles Mikroplastik reduzieren - Erkenntnisse aus einem Interdsziplinären Forschungsprojekt' [Reducing textile microplastic emissions: Insights from an interdisciplinary research project], 2021 (https://textilemission.bsi-sport.de/fileadmin/assets/Abschlussdokument-2021/TextileMission_Abschlussdokument_Textiles_Mikroplastik_reduzieren.pdf), De.

The following figures show the evolution of microplastic emissions between 2021 and 2030 for the min and max values. In Figure 21, the microplastic emissions are expressed in tonnes/year. In Figure 22: the emissions are represented relative to 2021 emissions (i.e. 2021 = 100%). Microplastic emissions increase by +25% or +21% depending on whether the min and max thresholds are considered. There is not enough data to estimate what is the most plausible between min and max. The average microplastic emissions were used to quantify the impact of the policy measures.

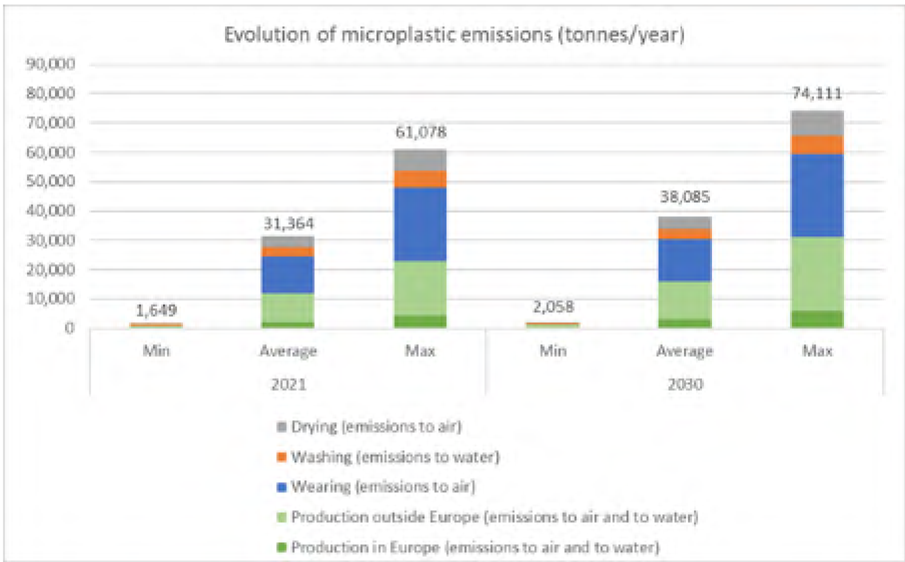

Figure 21: Evolution of microplastic emissions between 2021 and 2030 (in tonnes/year)

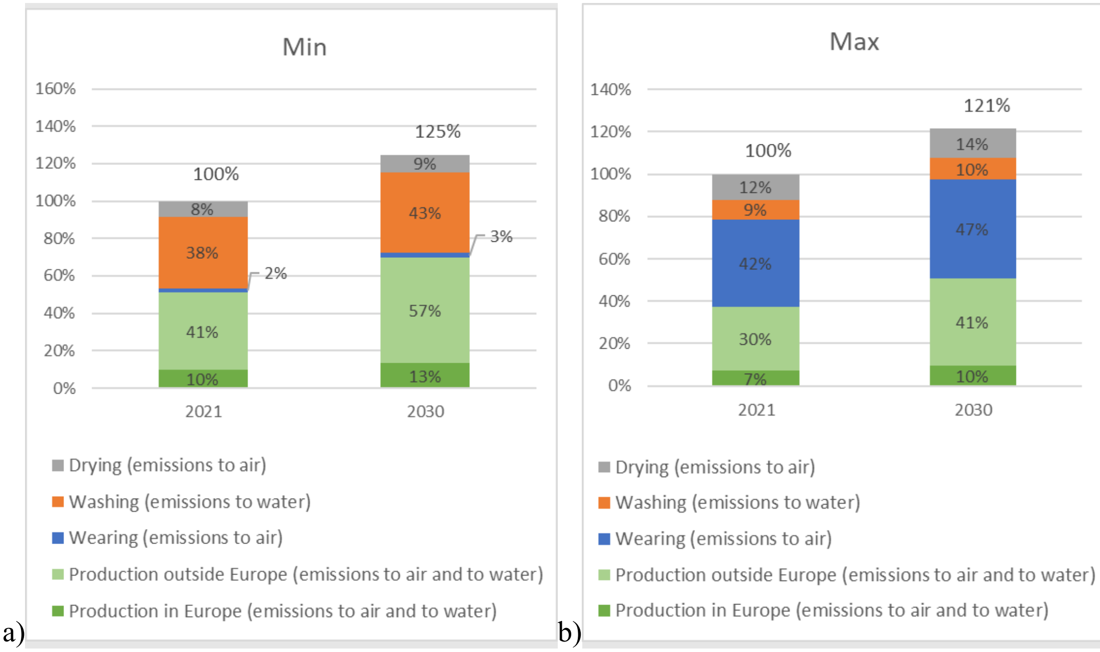

Figure 22: Evolution of microplastic emissions between 2021 and 2030, a) for min thresholds, b) for max thresholds

5.2.1 Uncertainty and data gaps

The uncertainty of the microplastic estimations is high. In the baseline, they vary between 2,058 and 74,111 t per year in the EU. The data quality is low for production and wearing life-cycle stages.

There is no data for the end-of-life. The uncertainty comes from the limited data to quantify microplastic emissions and not from the baseline extrapolation (see following table).

Table 7: Microplastic emissions from synthetic textile per year in the EU27 - 2021

	Production	Washing	Drying	Wearing	End-of-Life
Microplastic emissions per year due to EU consumption (tonnes)	[841 ; 22,704] Of which 21% happen in the EU	[635 ; 5506]	[137 ; 7501]	[37 ; 25,367]	NA
Type of emissions	Air / water	Water	Air	Air	Air / water
Data quality	Low	Medium	Medium	Low	NA
Number of sources	1	6	4	2	0

These quantifications need to be refined along with standardised measurement methods in order to understand the influence of each factor and to be able to compare data. Standardisation should specify all the experiment criteria and impose only one measurement method to compare studies with one another. No quantified data is available for microplastic emissions related to the end of life of clothing. The following figure shows the evolution of microplastic emissions between 2021 and 2030 for the min and max values. There is not enough data to estimate what is the most plausible between min and max. The average microplastic emissions were used to quantify the impact of the policy measures.

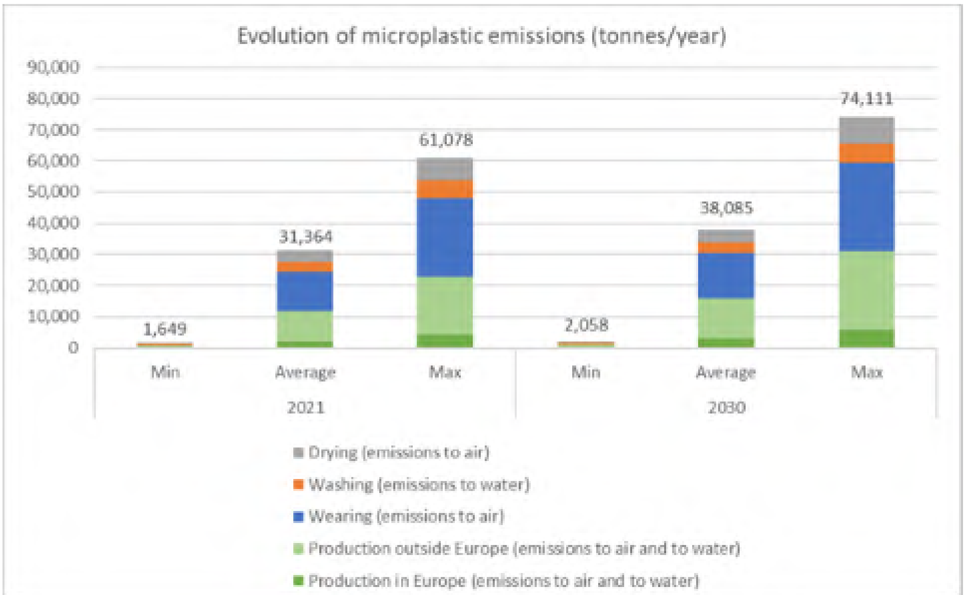

Figure 23: Evolution of microplastics emissions between 2021 and 2030 (in tonnes/year)

5.3 Baseline for paints

Out of the 52 Mt of paint produced globally (in 2019), 19.5 Mt are plastic polymers[165]. This represented 5% of the total global polymer production that year. Paint has a high plastic content - on average, 37% - and can be found on a wide range of objects and infrastructures used in our society: cars, boats, indoor walls, buildings, and bridges, among others.

According to data provided by Statista, citing Kusumgar, Nerlfli & Growney as sources (but without precise reference), paint volumes have grown steadily from 2009-2021, with yearly growth rates of 4%-9%. If we perform a linear fitting of this past trend and extrapolate it to 2030, we can expect that globally 27 Mt of plastic polymer will be used in paint.

The results presented hereafter are an extract from the global EA assessment Paruta et al., 2022. The analysis focuses on paint microplastic release to the environment during the application, wear and tear, removal of paint or handling of the painted object when it reaches its end of life.

It is important to highlight that loss rates are poorly documented both in the scientific and grey literature; therefore, an accurate assessment is not feasible at the moment. The following sections present an estimate of the order of magnitude of the paint leakage to determine whether paint represents a significant contribution to the total plastic leakage. To navigate through this data-scarce environment, expert assumptions have been used for some of the model parameters.

The first thing to estimate is the paint demand by sector. Figure below shows the way plastic polymers were used across the different paint sectors in EU-27 in 2019. The architectural sector ranked first with 42% of the total input, followed by the automotive and marine sectors with 17% and 15%, respectively.

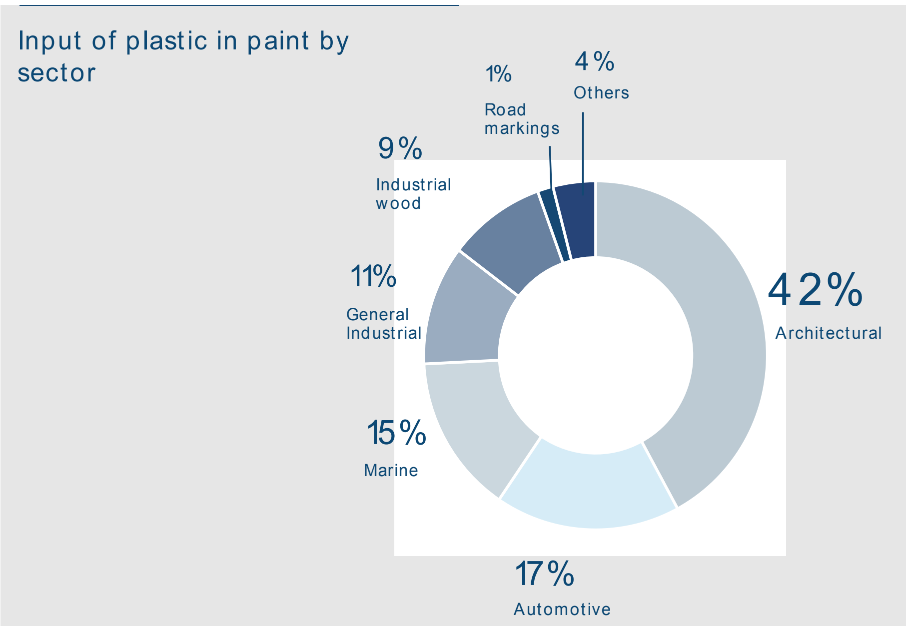

Figure 24: Yearly input of plastic in paint by sector for EU-27, data for 2019.

The total amount of plastic content of paint used in 2019 in the EU was 2,326 thousand tonnes, of which 628 kt/year leaked into the environment. The majority of this leakage was in the form of

[165] Market research from MarketsandMarkets Research Private Limited

microplastics, for a total of 482 kt/year, of which 298 kt/year was leaked to the ocean and waterways and 145 kt/year to land. Despite the uncertainties arising from the leakage calculation, it is clear from this study that the majority of applied paint does not benefit from proper management during maintenance or end-of-life.

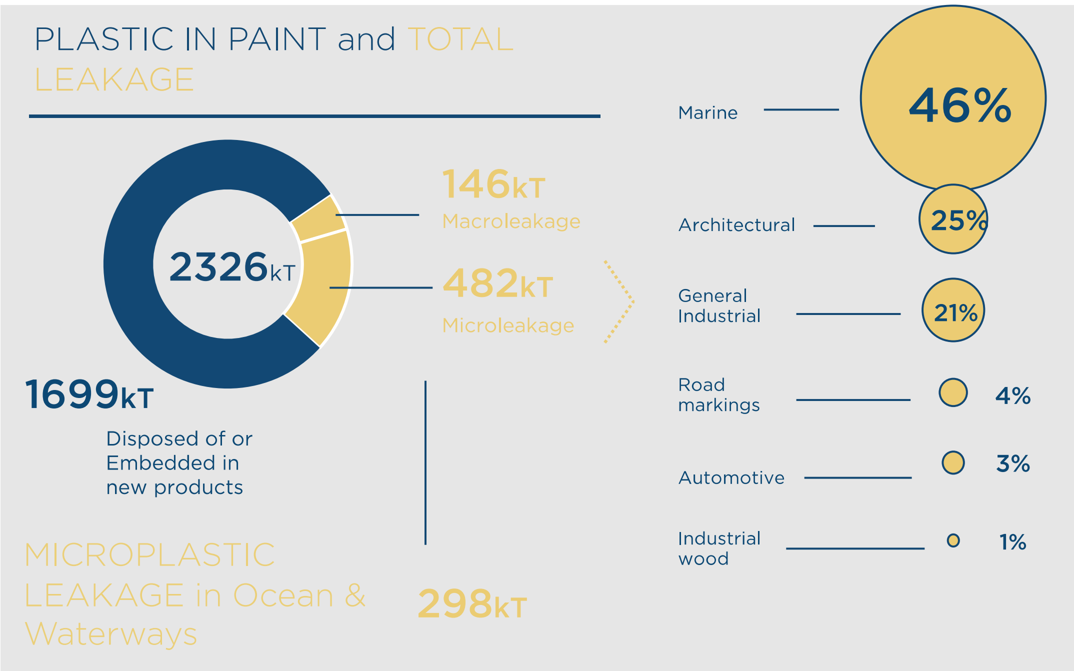

Figure 25: Total amount of plastic in paint each year for the six sectors, EU27

Figure above shows the plastic from paint in leaked and well-managed fractions. The plastic leakage amount is divided into its fractions of micro- and macro-plastics and the amounts that end up in the environment (Ocean & Waterways and Land). On the right side, the picture shows the shares of each sector to the total microplastic leakage. In terms of microplastic leakage to the environment, the marine sector is the largest contributor to the total leakage (46%), while industrial wood is the least important one (1%).

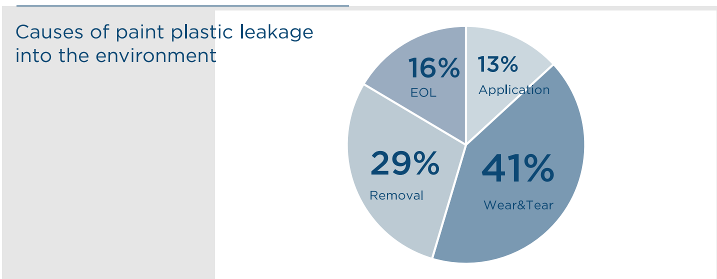

Figure 26: Contribution by loss mechanism of the microplastic leakage to the environment (Land and Ocean & Waterways)

The paint leakage is mainly due to wear & tear (41%) and removal (29%) loss mechanisms (Figure 26). About 16% of the micro-leakage happens at the end-of-life (EoL) of the painted object. In this case, the losses are associated with the practice of shipbreaking of European commercial vessels, which takes place on the beaches of India, Bangladesh, Pakistan, China and for a small part (3.5%) in Turkey (UNCTAD, 2019). All the six sectors contribute to the total leakage, with leakage rates ranging from 2% (industrial wood) to 63% (marine sector) (Table 8), where the leakage rate is defined as the ratio between the microplastic leakage to the environment and the total plastic input.

Table 8 presents the overview of the total leakage contribution for both environmental compartments of each sector and its split between micro- and macro-leakage.

Table 8: Overview of plastic leakage from paint by sector, for EU-27 (2019), in kt

		Unintentional microplastic leakage to the environment				Macroplastic leakage to environment	
Sector	Total input (plastic content)	Leaked to Ocean and Waterways	Leaked to Land	Leakage to the Environment (Ocean & Land)	Leakage rate to Environment	Leaked to Ocean and waterways	Leaked to Land
Architecture	1019.4	28.1	92.7	120.8	12%	20.1	66.5
Marine	356.6	210.2	12.9	223.2	63%	0.5	1.8
General Industrial	268.8	47.0	55.3	102.3	38%	20.5	16.8
Road markings	35.7	9.5	10.5	20.0	56%	0.0	0.0
Automotive	422.1	3.2	9.2	12.3	3%	1.9	7.3
Industrial wood	223.2	0.2	3.2	3.4	2%	1.7	7.4
All paint	*2325.8*	*298.2*	*183.7*	*481.9*	*21%*	*44.8*	*99.9*

The results are obtained following the approach described in Paruta et al. 2022. The values are in thousand tonnes (kt), and they refer to plastic quantities. In the case of marine paints, the microplastic leakage to the environment includes paint lost during maintenance and shipbreaking of European vessels in other countries, for a total of 127 kt. Furthermore, the paint lost while European vessels are at sea has been allocated to the EU – 27 countries, for a total of 68 kt.

In the following sub-sections, we provide an insight into the analysis by sector to illustrate how paint flows across the various stages of its life cycle before reaching its final fate.

5.3.1 Architectural

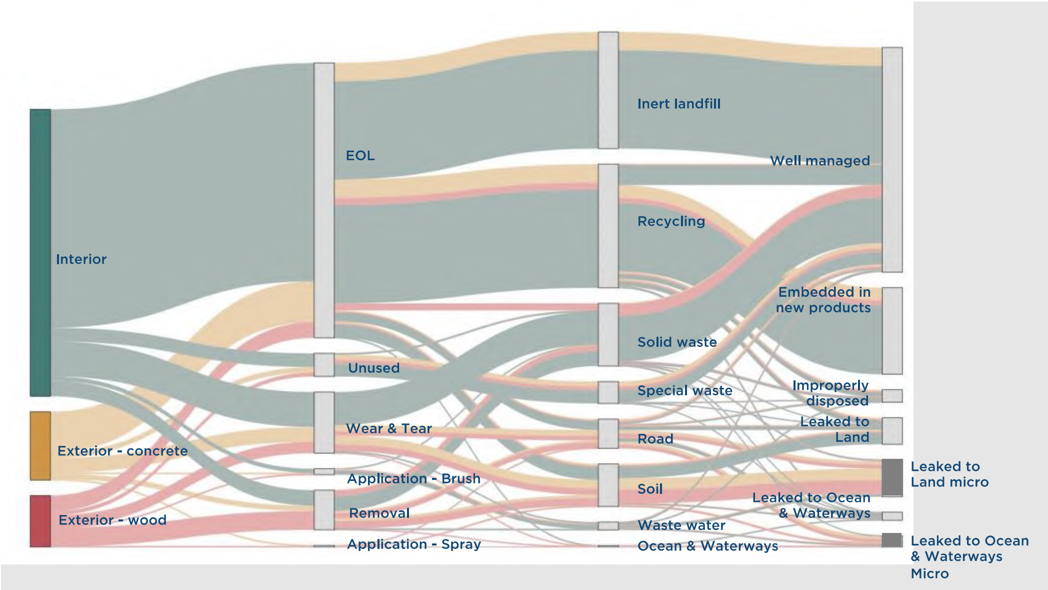

Figure 27: The Sankey diagram of the flow of plastic in architectural paint (2019)

Paint can be lost before reaching its supporting material (application), it can detach from it (wear and tear or removal), or it can be disposed of with or without it (unused or end-of-life). Ultimately, the lost paint can be well managed (disposed to a sanitary landfill or incineration facility), embedded in new products, or leaked to land or oceans and waterways. Here we highlight the part of the leakage that happens in the form of microplastics. In 2019, 1,019 kt of plastic was used in architectural paint within the EU-27 countries. This includes paint used on interior and exterior surfaces. About 71% of the plastic is from paint used on interior surfaces (Hann et al., 2018). The predominance of interior paint is intuitively justified by the fact that there is more interior than exterior surface to paint and that interior paint is re-painted more frequently than exterior due to aesthetic purposes. The amount of architectural paint used in the EU-27 was estimated using the following sources:

- The total amount of plastic used for architectural paint globally, i.e. 10,801 kt according to *MarketsandMarkets Research Limited;*
- The number of households in EU-27 is computed as the total population divided by the average number of people per household (*United Nations, 2019*. Database on Household Size and Composition 2019). Total population by country as reported by the World Bank "What a Waste" database 2.0 (*Kaza, S. et al., 2018*).

The number of households is not the only parameter that impacts the amount of paint used. The income level, the paint type, the weather, and the building material could be additional factors influencing the paint consumption by region. However, they have not been considered here, as no models are available to determine the quantitative impact on the paint used. Nonetheless, according to Hann et al., 2018, 947 kt of plastic was used in architectural paint in Europe in 2018, which is closed to the estimate presented here of 1,019 kt for 2019.

Figure 28: Sankey diagram focusing on the portion of architectural paint that ultimately leaks to the environment in the form of microplastic

Overall, 12% of the plastic in architectural paint put on the EU market leaks into the environment in the form of microplastics, i.e. a total of 121 kt. Of this, 93 kt leaks to land, while 28 kt to oceans and waterways. The leakage is mainly due to exterior paint being lost to the surroundings due to wear & tear and paint removal done without ensuring paint collection. Some of the paint is also lost to the environment during the application, either because of overspray of exterior paint or rinsing brush or rollers for interior and exterior paint. Although losses related to overspray are estimated at 15% (85% transfer efficiency), architectural paint is mostly applied by brush or roller, which accounts for 1.6% of paint losses to wastewater.[166] This assessment assumed that interior paint is always applied by brush or roller and that exterior paint is applied 80% of the time by brush or roller.

We estimate that a large part (68%) of the paint applied to a building will stay on until its demolition (end-of-life). Dust formation during demolition is a known phenomenon, and it has been investigated mostly because fine particles suspended in the air are known to be hazardous to human health[167]. Lacking quantitative estimates, we assume 10% of the paint that is still on the walls during demolition is lost to the environment as dust. The remaining paint follows the end of life of the supporting material. Both concrete, wood and plasterboard (the main support of interior paint) can be recycled. The EU had set a mandatory target of 70% recovery rate of construction and demolition waste by 2020 and concrete is mostly recycled as granulate that is then used in backfilling or road foundations[168]. On average, in the EU, 83% of the mineral waste from construction and demolition was "recycled" in 2016[169]. Plasterboard, which is mainly made of gypsum, can be recycled into new plasterboard through mechanical grinding, and it is then refined to have a uniform texture and be re-used to form plasterboards. According to British Gypsum, a UK manufacturer of interior lining systems, paper flakes (coated with paint) can be separated from gypsum during the recycling process and used as cattle bedding[170]. The hazardous risk to the health of the animals and the food chain safety linked to this practice is still to be investigated. Finally, painted or varnished wood is

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[166] A.J. Verschoor and E. de Valk, RIVM 2017, *Potential measures against microplastic emissions to water,* RIVM Report 2017-0193

[167] Ebadian et al. Technology assessment of dust suppression techniques applied during structural demolition, 1996

[168] Wahlström, M., Bergmans, J., Teittinen, T., Bachér, J., Smeets, A., & Paduart, A. (2020). Construction and Demolition Waste: challenges and opportunities in a circular economy.

[169] European Environment Agency, 2021. Accessed on https://www.eea.europa.eu/publications/construction-and-demolition-waste-challenges/construction-and-demolition-waste-challenges

[170] British Gypsum (2021). Accessed on 21/10/2021. https://www.british-gypsum.com/about-us/csr/environmental-challenges/plasterboard-recycling

sometimes considered recyclable to produce wood chippings for plywood or particle board. In another context, regulation asks for painted wood to be disposed of as waste.

Overall, knowledge of paint losses during demolition and recycling practices of the support material (EoL) is lacking. They appear to be outside the scope of this assessment on the unintentional release of microplastics. However, the proper management of paint at the EoL needs attention since most of the paint is left on the building material until its end-of-life and the management of the construction and demolition waste stream still remains a challenge.

5.3.2 Marine

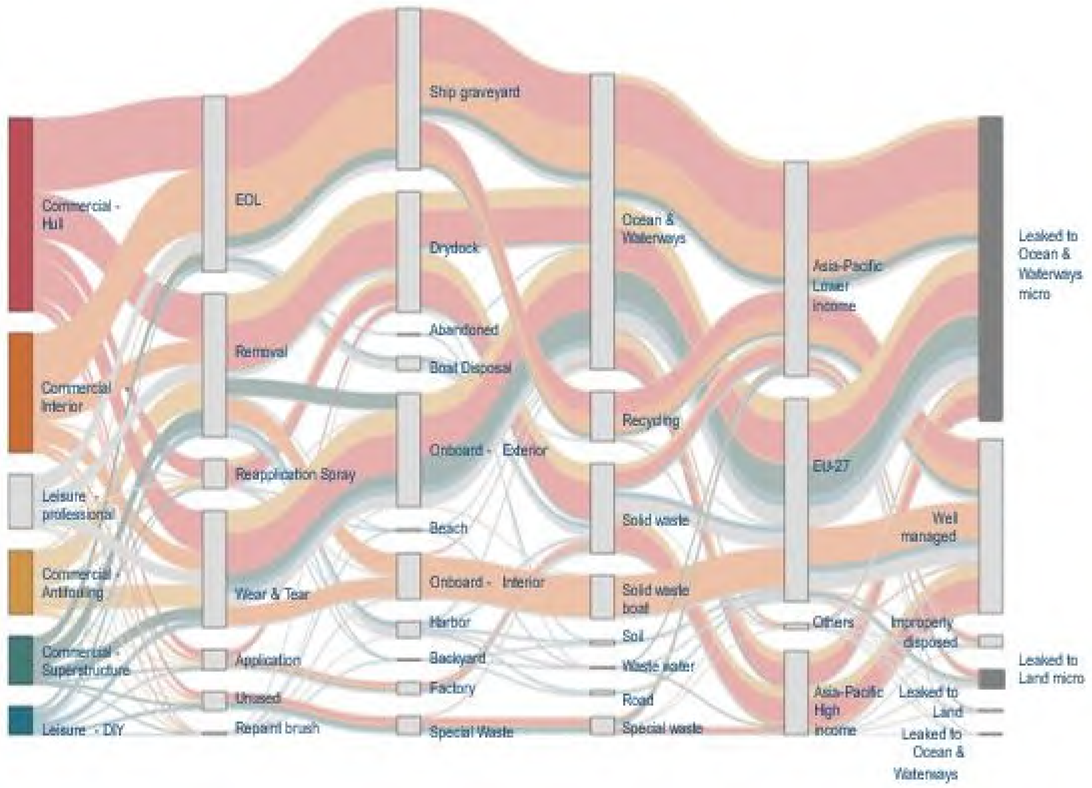

Figure 29: Sankey diagram of flow of plastic in marine paint (2019)

Paint can be lost before reaching its supporting material (application), it can detach from it (wear & tear or removal), or it can be disposed of with or without it (unused, end-of-Life). Ultimately, the lost paint can be well managed (disposed to a sanitary landfill or incineration facility), Embedded in new products, or can leak to land or oceans and waterways. Here we highlight the part of the leakage that occurs in the form of microplastics.

In 2019, 357 kt of plastic was used in marine paint within the EU-27. This includes plastic used in marine paint for commercial vessels (84%) and leisure vessels, both professional and Do It Yourself (DIY)[171]. Marine paint can be applied to the interior of the boat, the superstructure, or the hull, and antifouling paint is applied above the hull and protects the boat from biofouling. The amount of marine paint applied on boats and vessels in the EU-27 was estimated using:

[171] Hann et al. 2018 Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products

- The total amount of plastic used on boats and vessels paint globally, i.e. 10,801 kt, according to *MarketsandMarkets Research Limited*[172]
- The share of commercial vessels and leisure boats that are owned by EU-27

The share of commercial vessels is computed based on the UNCTAD database, which provides the ownership of propelled seagoing vessels of 1000 gross tonnes and above by dead-weight tonnage. Overall, this leads to a 36% share attributed to the EU (2017 data). If we were to base the assessment only on container-carrying vessels, the share would be 45%[173]. Leisure boats share is based on the share of recreational global boat park per country, as provided by *ICOMIA*[174].

It is worth highlighting that most of the paint applied on commercial vessels is not applied in European drydocks but in Asia. In this analysis, we account for all paint that is applied on European vessels independently of where the maintenance takes place. Overall, 63% of the plastic in the paint applied on European vessels will leak into the environment in the form of microplastics, for a total of 223 kt/year, of which 210 kt leaks to land, while 13 kt to ocean and waterways.

There are three main pathways of microplastic leakage to oceans and waterways:

- Wear and tear of exterior boat paint at sea;
- Removal of paint during maintenance of commercial vessels at the dry dock (mostly in Asia), or of leisure vessels, mostly in the EU;
- End of life of commercial vessels at ship graveyards.

Other minor pathways are maintenance of superstructure paint that takes place while the vessel is at sea. Little is known about the waste management of paint at drydocks. If sand blasting is used, paint dust can travel hundreds of meters before depositing[175]. The world commercial fleet is dismantled in ship graveyards on the beaches of India, Bangladesh, Pakistan, China, and for a small part (3.5%). In Turkey[176]. In Bangladesh, India and Pakistan, ships are broken apart directly on the beach instead of on an industrial site (*NGO Shipbreaking Platform, 2021*). Therefore, a portion of the commercial paint that is left on the ships will be lost to the ocean.

About 57% of microplastic leakage to the environment occurs in drydocks or beaches outside Europe, for a total of 127 kt.

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[172] Market research from MarketsandMarkets Research Private Limited

[173] UNCTAD (United Nations Conference on Trade and Development). (2017, October). Review of Maritime Transport 2017. Geneva: United Nations.

[174] ICOMIA (International Council of marine Industry Associations). (2018). Recreational boating industry statistics 2017

[175] Swedish Environmental Protection Agency, Report n° C183 - 'Swedish sources and pathways for microplastics to the marine environment', 2016 (https://www.ivl.se/download/18.7e136029152c7d48c205d8/1457342560947/C183+Sources+of+microplastic_160307_D.pdf).

[176] UNCTAD (United Nations Conference on Trade and Development). (2017, October). Review of Maritime Transport 2017. Geneva: United Nations.

5.3.3 General industrial

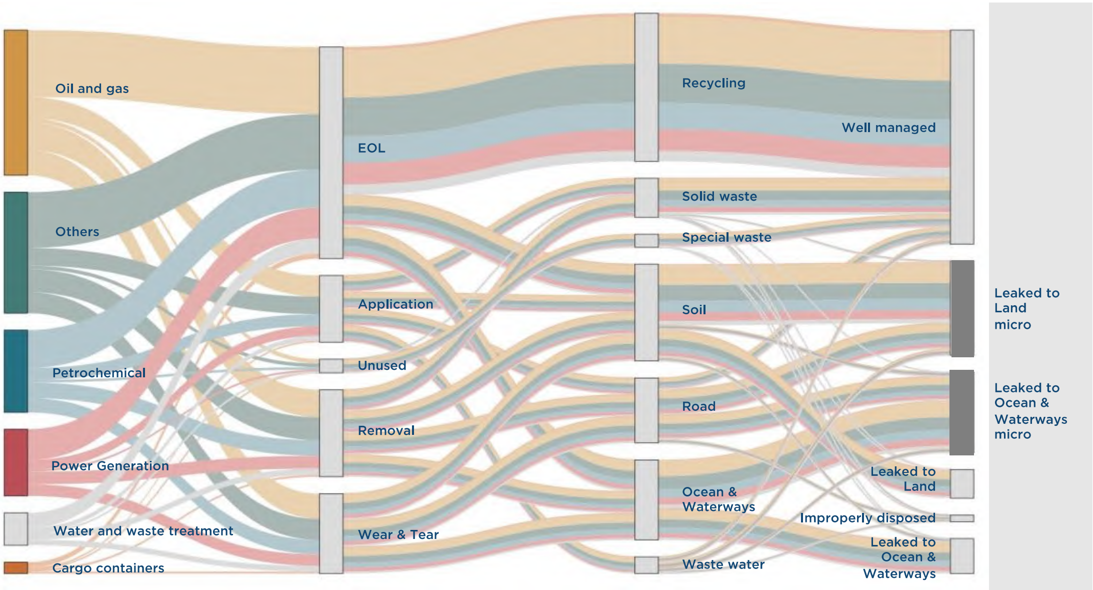

Figure 30: Plastic flow in general industrial paint from the net input to the fates (2019)

In 2019, 269 kt of plastic was used for general industrial paint in the EU-27. General industrial paint is considered here the protective paint used to protect steel or metal surfaces from corrosion. It is used in the oil & gas sector (refineries, pipelines, offshores), petrochemical sector, power generation applications, water and waste treatment, and many other applications.

The amount of general industrial paint used at the EU - 27 level was estimated using the following sources:

- The total amount of plastic used for general industrial paint globally, i.e. 2,915 kt, according to *MarketsandMarkets Research Limited*[177]
- It is assumed that steel is the main surface on which general industrial paint is applied. The share of paint used in Europe is based on the steel used by country in 2018, as provided by *World Steel Association, 2021*[178]

Overall, 37% of the plastic in general industrial paint put on the EU market leaks to the environment in the form of microplastics, for a total of 102 kt. Of this, 55 kt leak to land, while 47 kt to oceans and waterways. The leakage is mainly due to losses during the application, wear and tear and removal. Many aspects surrounding paint practices by the general industrial sectors are undocumented. It would be crucial to know the paint distribution within the sub-sector in the different EU-27 countries. How much of the paint is destined for structures that are close to aquatic environments (e.g. offshores, underwater pipelines, bridges)? The maintenance frequency and general practices are also not clear. General industrial is the sector where data is the scarcest.

[177] Market research from MarketsandMarkets Research Private Limited
[178] World Steel Association (2021). 2021 World steel in figures

5.3.4 Road markings

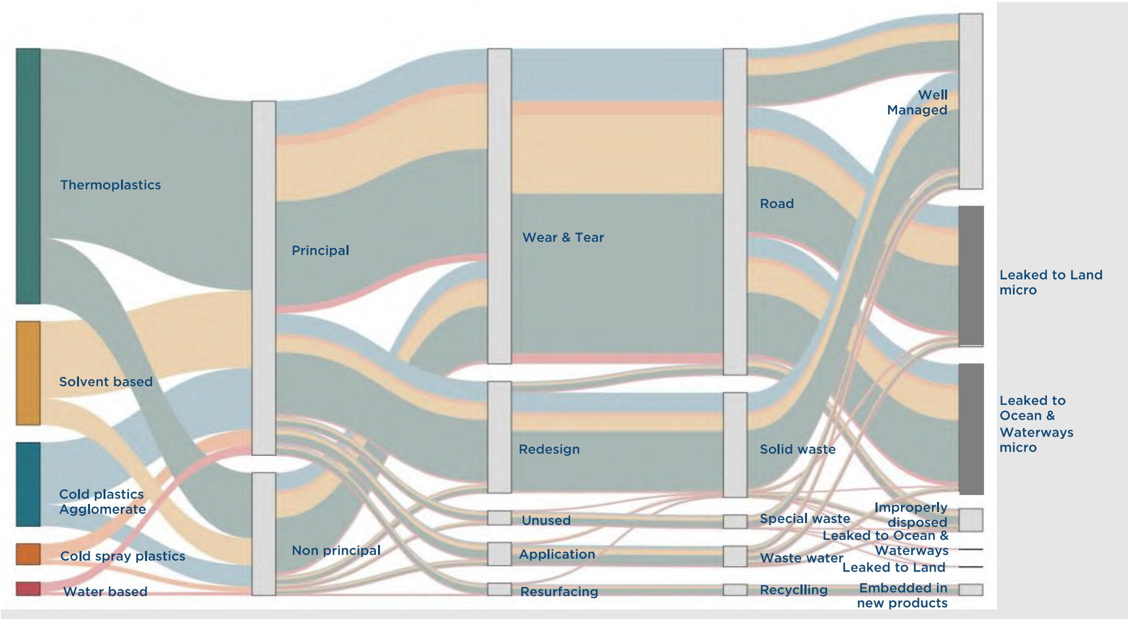

Figure 31: Flow of plastic in road markings paint from the net input to the fates (2019)

In 2019, 36 kt of plastic was used for road markings paint in EU-27 countries. *Hann et al., 2018* lists four different types of paint (solvent-based, water-based, thermoplastics, cold plastics) and provides their demand in the European market. The different paint types have different compositions and plastic content. The amount of plastic used for road markings paint used at the EU-27 level was estimated using the following sources:

- the total amount of plastic used for road markings globally, i.e. 234 kt according to *MarketsandMarkets Research Limited*[179]
- the kilometres of road country, as reported by *CIA*[180]

Overall, 56% of the plastic in the road markings paint will leak to the environment in the form of microplastics, for a total of 20 kt. Of this, 10.5 kt leak to land, while 9.5 kt leak to ocean and waterways. The main pathway for road markings losses to the environment is wear and tear from mechanical abrasion, and this is primarily due to contact with vehicle tyres. Another possible pathway leading to losses of microplastic in the environment could be during the road markings, paint removal to redesign traffic lanes, parking slots, etc. Removal of paint for redesign can be performed in several ways: blasting, grinding, using lasers, chemical methods and even burning[181]. The literature mentions dust formation (in the case of grinding) as a health concern to the removal workers. Still, no evidence has been found of pollution due to the removed paint being uncollected. Interviews conducted with road marking companies in Switzerland affirmed that the removed paint is collected independently from the technique used. Assuming a similar situation in the EU, about 90% of the paint is collected and disposed of as solid waste in EU-27, and 10% is left on the road in the form of finer dust particles and uncollected.

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[179] Market research from MarketsandMarkets Research Private Limited

[180] CIA. (2021). Roadways. Accessed on 9/11/2021. https://www.cia.gov/the-world-factbook/field/roadways/

[181] Pike, A. M., & Miles, J. D. (2013). Effective removal of pavement markings (Vol. 759). Transportation Research Board.

5.3.5 Automotive

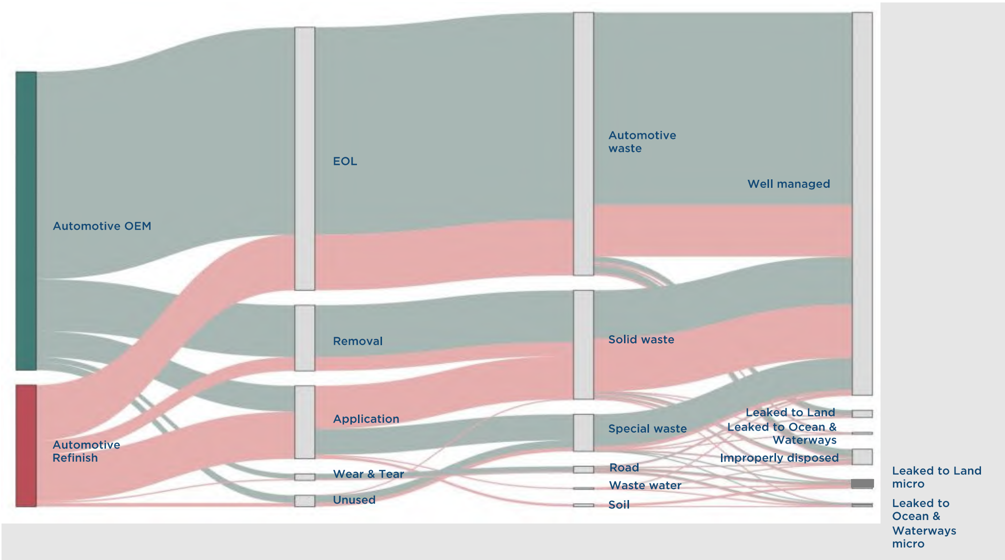

Figure 32: Flow of plastic in automotive paint from the net input to the fates

In 2019, 422 kt of plastic were used for automotive paint in EU-27 countries. About 71% of the paint is used for automotive OEM, applied during the car manufacturing process, and 29% for automotive refinish, applied at a later stage, for example, due to accident damage, damage to the original paint system, or to change the car colour.

The amount of automotive paint used at the EU-27 level was estimated using the following sources:

- the total amount of plastic used for automotive paint globally, i.e. 2'041 kt according to *MarketsandMarkets Research Limited*[182]
- for automotive OEM, the shares of motor vehicles manufacturing by country in 2019, as provided by *OICA*[183].
- the share of automotive Refinish is based on a dataset of motor Vehicles per 1000 people by country. The data set is published on *OurWorldInData*[184], which cites *NationMaster*[185]as the source.

[182] Market research from MarketsandMarkets Research Private Limited

[183] OICA (2022). International Organization of Motor Vehicles Manufacturers. 2019 Production Statistics. https://www.oica.net/category/production-statistics/2019-statistics/

[184] OurWorldInData, 2014. Accessed on 25/10/2021. Motor vehicles per 1000 inhabitants vs GDP per capita, 2014. https://ourworldindata.org/grapher/road-vehicles-per-1000-inhabitants-vs-gdp-per-capita

[185] NationMaster, 2014. Accessed 25/10/2021. Motor vehicles per 1000 people: Countries Compared. https://www.nationmaster.com/country-info/stats/Transport/Road/Motor-vehicles-per-1000-people

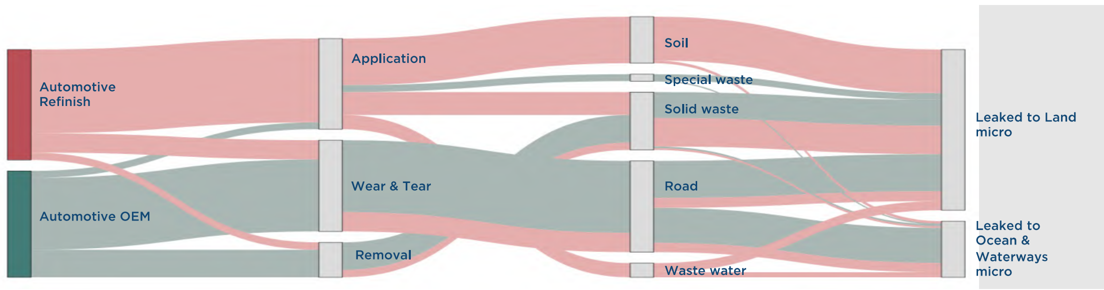

Figure 33: Portion of automotive paint that ultimately leaks to the environment in the form of microplastics

Overall, 3% of the plastic in automotive paint put on the EU market leaks to the environment in the form of microplastics, for a total of 12 kt. Of this, 9 kt leak to land, while 3 kt to oceans and waterways. One of the main pathways for microplastic leakage is the loss at the application of refinish paint.[186] The transfer efficiency of spray guns in body shops is as low as 50%, and an interview with industry experts put the figure closer to 60%. We assume that only a minor part of the over-sprayed paint will be lost to the environment, while the rest will deposit on masking material and will be disposed of with it.

The wear and tear losses include flaking and chipping of the paint due to weathering (such as exposure to ultra-violet sun rays), but also due to accidents and collisions. According to an interview with an automotive paint expert, these types of losses are minimal. Therefore, we assume a 2% loss rate even though, according to *OECD,* flaking and chipping losses of automotive paint are quantified at 10% (after rescaling by the OECD application losses).[187]

5.3.6 Industrial wood

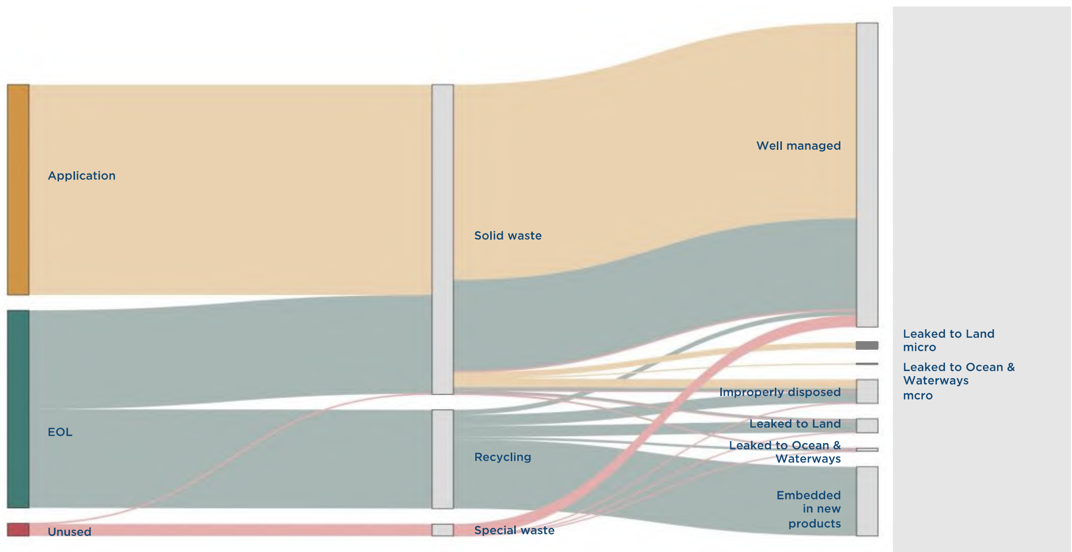

Figure 34: Flow of plastic in industrial wood paint from the net input to the fates

In 2019, 223 kt of plastic was used for industrial wood paint in EU-27 countries. We did not distinguish between the possible direct applications of industrial wood paint. It is typically applied

[186] OECD (2009) Emission Scenario Document On Adhesive Formulation, 2009
[187] OECD (2009) Emission Scenario Document On Adhesive Formulation, 2009

on wooden surfaces such as “joinery, kitchen cabinets, furniture, flooring, millwork, speciality wood products, and exterior building products” (*American Coatings Association, 2018*)[188].

The amount of industrial wood paint used at the EU-27 level was estimated using the following sources:

- the total amount of plastic used for Industrial Wood paint globally, i.e., 1,232 kt, according to *MarketsandMarkets Research Limited*[189]
- the EU-27 share is determined based on the wood consumption by country. FAO online database *"Forestry Production and Trade"* [190]allows to select the specific wood application and track their production and trade around the world. The applications selected for this study are hardboard, MDF/HDF, OSB, other fibreboards, particle board, plywood, sawn wood, and veneer sheet. The reference year is 2019.

Overall, 2% of the plastic in industrial wood paint put on the EU market leaks to the environment in the form of microplastics, for a total of 3.4 kt, of which, 3.2 kt leak to land, while 0.2 kt leak to ocean and waterways. According to *OECD*[191]analysis of the wood furniture sector, around 50% of the paint is lost at the application when using a dry booth (other techniques being wet booth or curtain coating). We assume that application takes place in an industrial setting and that the over-sprayed paint is dealt with as solid waste.

5.3.7 Data gaps and uncertainties

Microplastic pollution from paint has only recently been investigated, for this reason there are still many uncertainties and data gaps.

Some uncertainties and data gaps are relative to market figures of paint sold per paint sector and plastic content within it. In order to estimate microplastic pollution one needs to know on which type of objects the paint is applied, but often market data are split by type of paint sold or sectors such as "coil coatings” which are not easily related to the final painted object. Therefore, a common understanding between scientific community and paint industry is needed in order to gain insight on the paint market in a way that is useful for microplastic calculations.

In terms of paint loss mechanisms (application, wear & tear, removal, unused, at end-of-life), the estimates used in this assessment are mostly conservative. An example of conservative estimate performed in the study are paint losses due to overspray, which are modelled to be at 15%, i.e., 85% transfer efficiency (Paruta et al. 2022). This performance is well above that of some technologies listed in the Best Available Techniques Conclusions document, related to the Industrial Emission Directive, (Chapter 4 of the Directive 2010/75/EU on Industrial Emissions (the Directive)), which have transfer efficiency of 50%-60%. A transfer efficiency of 60% means that 40% of the applied paint is lost to the surrounding environment.

Another example is unused paint. It is believed that, on average, 3%[192]of professional paint and 15% of DIY paint are unused (Verschoor, A., De Poorter, L., Dröge, R., Kuenen, J., & de Valk, E. (et al.,

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[188] www.paintcare.org
[189] Market research from MarketsandMarkets Research Private Limited
[190] Forestry production and trade, 2021. Accessed on 25/10/2021. Forestry production and trade. https://www.fao.org/faostat/en/#data/FO
[191] OECD (2009) Emission Scenario Document On Adhesive Formulation, 2009
[192] OECD (2009) Emission Scenario Document On Adhesive Formulation, 2009

2016,).[193] These are the same values used in this assessment, but, according to a personal communication with ADEME (the French agency for ecological transition), paint cans recovered through an EPR scheme targeting household chemicals are, on average, 40% full. Additionally, an internal paint company document indicates that 30-40% of paint prepared for an offshore maintenance job can end up being unused and subsequently disposed of. Furthermore, this assessment assumes all unused paint to be properly disposed, while a personal conversation with an industry expert revealed that according to their own experience, disposal of paint down the household drainage system is common practice for both professionals and DIYers.

For wear & tear losses, the lifetime of the paint system is not a subject that is systematically researched and assessed, but its assessment is key in order to determine microplastic pollution during the use phase of the object.

From the modelling point of view, a key assumption in Paruta et al. 2022, is that "Wear & Tear" happens in a localized fashion, meaning that if the outmost layer of paint (top-coat) is affected in a certain place, then the deeper layers will also be affected." This has important consequences on the assessment of wear & tear losses. The hypothesis was formulated after discussing with paint industry experts, but it should be validated through testing on the ground. Other sector-specific assumptions that were used to overcome uncertainty and data-gaps are mentioned in the baseline itself, and more can be found in Paruta et al. 2022, but the aforementioned data gaps are believed to be the key ones to investigate in order to improve the baseline assessment, namely:

- Volumes (in mass) of paint sales per sector (with sector split based on final painted object) as well as plastic content (in mass);
- Average transfer efficiency of spraying technologies;
- Volumes of unused paint and its fate;
- Lifetime of paint (see Measure PNT#1);
- Validation of the assumption that wear & tear happens in localised form and affects all paint layers.

5.4 Baseline for detergent capsules

Among the water-soluble plastic films available for the protective film for laundry and dishwasher detergents, polyvinyl alcohol (PVOH) is the most widely used. With a yearly global production of 650 000 tons, PVOH is therefore becoming more and more used with an annual growth rate of 4% between 2018 and 2023. In Europe, around 100 000 tonnes of PVOH is estimated to be used every year, of which 20 000 tonnes are used as protective films for detergent capsules.[194] A similar growth rate is expected for the coming years.

5.4.1 Calculation of the baseline

To define the baseline about the loss of detergent capsules into the environment, we have estimated their contributions following both bottom-up and top-down approaches.

[193] Release of microplastics and potential mitigation measures: Abrasive cleaning agents, paints and tyre wear, OECD, 2009.

[194] Renewable Carbon, 'BioSinn – Products for which biodegradation makes sense', 2021.

In our bottom-up approach, we used the data about the number of washes per household in Europe as provided in our report and this article[195] for data on **laundry** capsules. It roughly estimates the amount of PVOH released into the environment as follows.

Number of wash cycles in the EU: 34 000 000 000

Weight of the shell of a capsule: 0.4g – 1.6g (we will use 1g as the average value)

Share of PVOH in a capsule shell: 65% - 99% (we will use 85% as the average value)

The survey performed in the US study evaluates capsule usage at 70% of all laundry detergent use, but there is no information available regarding the European use of capsules and we assume the EU situation comparable to the US. Upon this assumption, we can use a conservative estimation of 50% capsule usage since, in the EU, powder and liquid detergents are more or less used in the same proportion as the US.

By considering the share of washes done using capsules (50%), the **total amount of PVOH entering wastewater due to detergent capsules** is:

T = 34 000 000 000 * 1g * 0.85 * 0.50 = **14 450 tonnes per year**

To estimate **dishwasher** capsules' contribution, we assumed that 45% of European households are equipped with a dishwasher[196] and the number of cycles per household per year (280)[10]. As there are 195 455 million households in Europe[197], the dishwasher capsule shell weighs 0.3g – 0.7g (we use 0.5g as the average). Moreover, the dishwasher capsule shell has the same composition as detergent capsules.

As no information on dishwasher capsule usage in Europe could be found and considering the US situation, we assumed that the number of dishwasher cycles per year is close to that of Europeans (280 cycles), i.e., 34% of the time.

Thus, the total amount of PVOH entering wastewater due to dishwasher capsules is:

195 455 000 * 0.45 * 280 * 0.34 * 0.5g * 0.85 = **3 559 tonnes per year**

The total microplastics emitted to wastewater from the use of detergent capsules and dishwasher capsules can be estimated at **18 009 tonnes per year.**

This number is a rough estimation but remains close to the value reported by Nova Institute in a bottom-up approach. The EU market for dishwasher tabs with water-soluble film is around 400 000

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[195] Rolsky, C. and Kelkar, V., Degradation of Polyvinyl Alcohol in US Wastewater Treatment Plants and Subsequent Nationwide Emission Estimate', *International Journal of Environmental Research and Public Health*, Vol. 18, no. 11: 6027, 2021.

[196] APPLiA, 'What if all Europeans had a dishwasher?', 2021, Accessed November 19th 2021 (https://www.applia-europe.eu/images/2017-03---DW-campaign-analysis.pdf).

[197] Eurostat, 'How many single-parent households are there in the EU?', 2021 (https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20210601-2#:~:text=In%202020%2C%20there%20were%20195.4%20million%20households%20in,single%20parents%2C%20accounting%20for%204%25%20of%20total%20households).

tonnes annually, corresponding to 20 billion tabs of 20 grams each. The film itself weighs less than 1 g, which puts its total volume in the EU at around 20 000 tonnes.[198]

In another bottom-up approach[199], the recent data provided by International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) indicates that 20.5 ktonnes of dissolved capsules in 2021 were emitted from the use of liquid laundry detergent capsules (8.4 kt), automatic dishwashing tablets (12.1 kt) and WC care products (0.03 kt) in the EU, including Norway (non-EU member) in this estimation. We must highlight that even if Norway as a non-EU member is included in these estimations, the contribution of this country with respect to the EU doesn't impact the overall emission of PVOH grades in the EU. In the case of the first two categories (i.e., liquid laundry detergent capsules and automatic dishwashing tablets), we assumed that 5% of the total capsule or tablet was exclusively derived from PVOH based on the NOVA report[200].

Table 9: Liquid laundry detergent capsules – retail volume (in kilotonnes)*

	2017	2018	2019	2020	2021
EU+Norway	103.2	121.1	137.3	152.6	167.1
PVOH release**	5.2	6.0	6.9	7.6	8.4

* AISE reports that these figures may be slightly underestimated based on their own PVOH consumption. (which may also include internal wastage). The population of Norway is about 1% of that of the EU.

** Based on a conservative assumption of max. 1g PVOH film per capsule (5%).

Table 10: Automatic dishwashing tablets – retail volume (in kilotonnes)*

	2017	2018	2019	2020	2021
EU+NO	197.5	202.0	209.2	237.3	242.9
PVOH release**	9.9	10.1	10.5	11.9	12.1

* AISE member reports that these figures may be slightly underestimated based on their own PVOH consumption (which may also include internal wastage). The population of Norway is about 1% of that of the EU.

** Based on a conservative assumption of max. 1gPVOH film per capsule (1% - values to be confirmed by AISE). However, we made the same assumption as in the case of liquid laundry detergent capsules) to be comparable to the estimations made in the NOVA report, i.e., 5%.

NB. Euromonitor provides sales data for all tablets without differentiation between wrapped/unwrapped or removable/soluble film.

Moreover, WC care products contain a small proportion of toilet cleaning products, such as rim hangers and cistern blocks, corresponding to **an estimated total PVOH quantity of 0.03 kt/annum** in 2021.

In Table 11, a US study[201] indicates that 61% and 18% of PVOH fractions reached the sludge route and the aqueous route (via soil contamination)) respectively. However, the estimations about the 18%

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198 Renewable Carbon, 'BioSinn – Products for Which Biodegradation makes sense', 2021 (https://renewable-carbon.eu/publications/product/biosinn-products-for-which-biodegradation-makes-sense-pdf/).

199 Annex AISE (sent on April 27th, 2022).

200 Annex AISE (sent on April 27th, 2022).

201 Rolsky, C.; Kelkar, V. Degradation of Polyvinyl Alcohol in US Wastewater Treatment Plants and Subsequent Nationwide Emission Estimate. Int. J. Environ. Res. Public Health 2021, 18, 6027.

losses out of wastewater treatment plants must be considered prudently as the study was conducted in India (Kaur et al., 2012)[202] and do not correspond to the situation in the EU. In Europe, we may therefore assume that the situation about the wastewater treatment (even if soil contamination cannot be excluded) is almost optimal, assuming that nearly 50-60% of PVOH and related mixtures shall reach the sludge route and the other fractions 40-50% shall reach the environment, but no studies have addressed this issue after wastewater treatment plants up to now.

Considering the biodegradation level reported in OECD testing, *i.e.*, a simulated degrading environment representative of wastewater treatment plants, 40% of non-biodegradable PVOH could release into the environment using the data reported in the study. Indeed, this study considered a 28-day window while 10 days is the average length of time usually considered for wastewater treatment plants. Other studies have shown that biodegradation of PVOH in acclimated wastewater systems can be even enhanced and reach a degradation rate close to 80% as suggested by Schonberger et al. (1997)[203]. Several conditions must be encountered: (1) steady PVOH influx, (2) sufficiently low food to microorganisms and sufficiently high sludge age and (3) adaptation of the microorganisms (as a rule demands several weeks). The fate of PVOH after wastewater treatment remains challenging as specific approaches (e.g., radioisotope labelling) will have to be developed accordingly. After wastewater treatment, the trace of PVOH has never been reported due to the difficulty of assessing their presence using classical detection techniques to their high solubility in water, and their impact may somehow be underestimated by contrast with microplastics well-identified in sewage sludge[204]. Additional investigations shall be made to assess this.

Table 11: Assessment of PVOH release of detergent capsules into the environment via the sludge route

Source	Geography	Sectors	PVOH leakage to wastewater treatment plants, Tonnes	PVOH release into the sludge in % related to the leakage	PVOH release into sludge, Tonnes	PVOH release into the environment, Tonnes (40% from sludge)
BOTTOM-UP APPROACH Nova Institute, 2021 Byrne 2020	EU-27	Protective films for laundry and dish detergents Garden pond	20 000	20-40%	4 000-8 000	1 600-3 200
BOTTOM-UP APPROACH* AISE	EU-27	Liquid laundry detergent capsules Automatic dishwashing tablets	20 500	20-40%	4 100-8 200	1 640-3 280
TOP-DOWN APPROACH	EU-27	Protective films for laundry and dish detergents	18 000	20-40%	3 600-7 200	1 440-2 880

(*) Including Norway. Excluding Norway, the estimates would approach the Nova Institute figures.

In the EU, the overall amount of PVOH leakage issued from protective films for laundry and dish detergents is estimated to be around 18 000 – 20 000 tonnes annually using different approaches

202 Kaur et al. Wastewater production, treatment and use in India, 2012

203 Schonberger, H., Baumann, A. and Keller, W., ‘Study of microbial degradation of polyvinyl alcohol (PVA) in wastewater treatment plants’, *American Dyestuff Reporter*, Vol. 86, 1997, pp. 9-18.

204 Chand, R., Rasmussen, L.A., Tumlin, S. and Vollertsen, J., ‘The occurrence and fate of microplastics in a mesophilic anaerobic digester receiving sewage sludge, grease and fatty slurries’, *Science of the Total Environment*, Vol. 798, 2021, Elsevier BV.

(bottom-up & top-down) obtained from technical literature and stakeholder information. As the PVOH issued from protective films for laundry and dish detergents is directly discharged into urban wastewater, the overall amount related to PVOH leakage is exclusively through waste water followed by sludge. In the wastewater treatment plants, around 60-80% of the overall amount of PVOH is totally biodegraded, and the remaining fraction, i.e., around 20-40%, is mainly released to the sludge from which the ultimate release of PVOH in the environment is not properly assessed from the current scientific literature. This means that from the microplastics released into wastewater treatment plants, around 3 600-8 000 tonnes reach the sludge. In the EU, about 40% of sludge is applied on agricultural land. Assuming that about 40% (EU average) of this sludge is applied to agricultural land, i.e. 1 440-3 280 tonnes. Of this, about 60% will reach natural waters and the rest remain in the soil. Recent evidence shows that microplastics in soil could also be taken by the crops.[205]

There is only one study estimating the PVOH release in the environment directly through wastewater at 15.7%[206], which would represent around 2 700 tons a year for the EU. The PVOH in water could biodegrade over a period of time, but the extent of biodegradation in natural conditions has not been studied. The possible non-biodegraded part of PVOH could still remain in the water.

Adding the share of PVOH through aqueous and sludge routes, we can assume that **4 140 – 5 980 tonnes (thus on average around 5000 tonnes) of microplastics coming from PVOH of detergent capsules would be directly released into the environment**.

5.4.2 Uncertainties and data gaps

The estimated amount of microplastic losses through capsules to the environment bears several uncertainties. The principal uncertainty comes from a lack of information on the composition of PVOH and related mixtures used for detergent capsules due to trade secrets and uncertainties about the fate of PVOH in WWTP and later in the marine environment and soils upon the existing testing protocols as:

- Initial discussions with the International Association for Soaps, Detergents and Maintenance products/AISE (March 12th, 2022) highlighted that the current PVOH and related mixtures used for detergent capsules are trade secrets due to their long history of implementation as water-soluble plastics not only in detergent applications but other applications. The report made by AISE (April 27th, 2022) has reduced the uncertainties on the PVOH release even though the AISE members report that these figures may be slightly underestimated based on their PVOH consumption (which may also include internal wastage). However, no better basis is currently available to calculate quantities of film placed on the market/released by dissolution during use.
- The testing protocols used for assessing the biodegradation extent of PVOH and related mixtures are related to OECD norms in which a 28-day duration is applied during testing. However, it could be affected because these PVOH and related mixtures are associated with mixtures and/or contaminated with detergents.
- Depending on the characteristic features of wastewater systems, a PVOH biodegradation in acclimated wastewater systems could reach a degradation rate close to 80%, as referenced by

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[205] Sciencealert.com, 'Study shows how microplastics can easily clim the food chain. Should we be worried?', 2022 (https://www.sciencealert.com/study-shows-how-microplastics-can-easily-climb-the-food-chain-should-we-be-worried).

[206] Rolsky, C.; Kelkar, V. Degradation of Polyvinyl Alcohol in US Wastewater Treatment Plants and Subsequent Nationwide Emission Estimate. Int. J. Environ. Res. Public Health 2021, 18, 6027.

Schonberger et al. (1997)[207], but this need to be confirmed. There exist some more appropriate protocols (e.g., EU ECOLABEL)[208].

5.5 Baseline for geotextiles

According to the supporting study for this IA, a total of 530 712 tonnes of geotextiles were used in the EU in 2019 and since 2002, 5 048 962 tonnes of geotextiles have been installed.[209] Geotextiles are used for various construction applications, from building roads to protecting coasts from erosion and enabling vegetation to root. Because of climate change, sea levels are rising, and the intensity of storms is increasing, which in turn will increase the demand for geotextiles. Various market projections suggest a threefold growth in the geotextiles market in Europe during 2019-2029[210] , and one can expect similar growth in emissions.

5.5.1 Calculation of the baseline

Different market data were compiled to estimate the quantities of geotextiles used worldwide yearly.

Table 12: Existing sources on geotextile use and microplastics emissions

Source	Year of estimate	Geotextile quantity	Geotextile type	Emissions
Bai, Xue et al.[211]	2021	14 billion m2	All types, 2% natural fibre, 17% PET-based materials	0.24 – 0.79 million tonnes emitted by PET geotextiles. *However the findings of this study have been strongly criticised for their unreliability.*
Prambauer et al. [212]	2019	1.4 billion m2	All types, 2% natural fibre	
Methacanon [213]	2010	700 million m2	All types, 2% natural fibre	
US Department of Agriculture [214]	1991	700 million m2	All types, 2% natural fibre	

[207] Schonberger, H., Baumann, A. and Keller, W., 'Study of microbial degradation of polyvinyl alcohol (PVA) in wastewater treatment plants', *American Dyestuff Reporter*, Vol. 86, 1997, pp. 9-18.

[208] European Commission, 'EU Ecolabel', EU Ecolabel - Home (europa.eu).

[209] Grand View Research Inc, 'Geotextiles Market Size & Share, |Industry Report, 2020-2027', 2022 (https://www.grandviewresearch.com/industry-analysis/geotextiles-industry).

[210] Ibid.

[211] Bai, X., Li, F., Ma, L. and Chang, L., 'Weathering of geotextiles under ultraviolet exposure: A neglected source of microfibers from coastal reclamation', *Science of the Total Environment*, Vol. 804, 2022, Elsevier BV.

[212] Prambauer, M., Wendeler, C., Weitzenböck, J., & Burgstaller, C., 'Biodegradable geotextiles – An overview of existing and potential materials', *Geotextiles And Geomembranes*, Vol. 47, No. 1, 2019, pp. 48-59, Elsevier BV.

[213] Methacanon, P., Weerawatsophon, U., Sumransin, N., Prahsarn, C., & Bergado, D., 'Properties and potential application of the selected natural fibers as limited life geotextiles', *Carbohydrate Polymers*, Vol. 82, No. 4, 2010, pp. 1090-1096.

[214] English, B.W., 'Geotextiles, A special Application of biofibers', United States Department of Agriculture, 1995 (https://srs.fs.usda.gov/pubs/5718).

Source	Year of estimate	Geotextile quantity	Geotextile type	Emissions
Own calculations	2021	530 712 tonnes (EU) 2 653 560 tonnes (worldwide)	All types, 62.5% non-woven textiles, 27.5% woven, 10% other	
Miszkowska et al. [215]	2017	NA	Non- woven grammage: 200, 280, 450 g/m^2	
Grand View Research [216]	2020	4.323 billion m^2	All types, non-woven 1 561million m^2, knitted, 279.8 million m^2	

Notably, the table's first source (Bai, Xue et al.)[217] is the only one to estimate geotextile emission but also includes many errors in the methodology and calculations. As a result, it is impossible to rely on the results provided by this study. The quantification of the total quantity of geotextiles used in civil engineering applications is presented here. This will serve as a basis for applying the precautionary principle because although geotextiles are built to last, they will eventually break down into microplastics. The exact emission estimates are being made.

The data used to calculate the figures given below are from Edana, the nonwoven and related industries association. Using this data, the total non-woven production in the EU in 2019 was 1.775 million tonnes[218] (calculated from their country data).

Non-woven materials are used for a wide variety of applications; Edana lists the applications for which their members' products are used, and these percentages are assumed to be the same for non-members. Thus, it is assumed that out of all non-wovens:

- building and roofing industry applications represent 9.8% of the market,
- filtration (air & gas and liquid) applications represent 3.7% of the market, and
- civil engineering / underground applications represent 5.4 % of the market.

Thus, 18.9% of the non-woven production can be considered geotextiles.

Since not all geotextiles produced in the EU are used in the same geographical area perimeter, the export and import of non-woven must be taken into account when estimating the total EU consumption. The EU imports close to 370 000 tonnes of non-woven materials and exports close to 390 000 tonnes, so the total quantity of nonwoven used in the EU is roughly as follows:

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[215] Miszkowska A., Lenart, A. and Koda, E., 'Changes of Permeability of Nonwoven Geotextiles due to Clogging and Cyclic Water Flow in Laboratory Conditions', *Water*, Vol. 9, No. 9, 2017, pp. 660.

[216] Grand View Research Inc., 'Grand View Research Forecasts Global Geotextiles Market', 2014 (https://www.estormwater.com/grand-view-research-forecasts-global-geotextiles-market).

[217] Bai, X., Li, F., Ma, L. and Chang, L., 'Weathering of geotextiles under ultraviolet exposure: A neglected source of microfibers from coastal reclamation', *Science of the Total Environment*, Vol. 804, 2022, Elsevier BV.

[218] Edana, 'Nonwovens markets, facts and figures', Consulted March 21st 2022 (https://www.edana.org/nw-related-industry/nonwovens-markets).

1 775 000 + 370 000 – 390 000 = 1 755 000 tonnes

The share of nonwoven used in geotextile applications is 18.9%, so the total quantity of non-woven geotextiles used in the EU is:

1 755 000 * 0.189 = 331 695 tonnes.

Assuming that the EU geotextile market is similar to the US one, nonwovens represent 62.5% of the market, woven represent 27.5%, and the other types represent 10%. [219]

Thus, the total tonnage of geotextiles used in the EU in 2019 was estimated to be:

331 695/0.625 = **530 712 tonnes**

As discussed earlier, since geotextiles, once installed, are for the large majority not removed, and despite being stable for an extended period, are going to eventually break down, the total amount of geotextiles installed over the last 20 years was calculated. To do so, a constant CAGR of 10% was used, [220] and so the total geotextile tonnage installed in the EU in the period 2002 – 2022 is:

$$\sum_{n=0}^{n=20} \frac{530712}{1.1^n} = \mathbf{5\ 048\ 962}\ \boldsymbol{tonnes}$$

The figures calculated before are estimations of installed quantities and not microplastic emissions. However, they represent the total quantity of material susceptible to emitting microplastics into the environment. In order to provide an estimate of microplastic emissions from geotextiles, a worst-case scenario is developed. It is based on the microplastic emissions figures presented in the article from Bai Xue et al[221], which, although clearly flawed, is the only source quantifying emissions which we could find.[222] Their estimate global microplastic emissions from non-woven PET geotextiles used in erosion control applications are between 240 thousand tonnes and 790 thousand tonnes. However, as stated previously, they misquoted their source for market data and used multiplied it by a factor of 10. Therefore, their figure for microplastic emissions will be divided by a factor of 10, bringing it down to between 24 thousand tonnes and 79 thousand tonnes. The EU represents 25% of the global geotextile market[223], the worst-case estimate for microplastic emissions from geotextiles (assuming all geotextiles sold in the EU will be used in applications where microplastic emissions could occur) would be:

between 6 000 and 19 750 tonnes per year in the EU.

There are several caveats to these figures, which bear a lot of uncertainties:

- PET geotextiles are not the only materials used for erosion control applications, in fact, the

[219] Geotextiles Market Analysis Report By Material, By Application, By Product, By Region And Segment Forecasts From 2020 To 2027. (2020). Retrieved from https://www.millioninsights.com/industry-reports/geotextile-market

[220] Markets and Markets, 'Geotextile Market by Material Type (Synthetic, Natural), Product Type (Nonwove, Woven, Knitted), Application (Road Construction and Pavement Repair, Erosion, Drainage, Railway Work, Agriculture), and Region – Global Forecast to 2022', 2017 (https://www.marketsandmarkets.com/Market-Reports/geotextiles-market-492.html).

[221] Bai, X., Li, F., Ma, L. and Chang, L., 'Weathering of geotextiles under ultraviolet exposure: A neglected source of microfibers from coastal reclamation', *Science of the Total Environment*, Vol. 804, 2022, Elsevier BV.

[222] Stakeholders were consulted on that matter but did not send us articles or scientific data quantifying microplastic emissions.

[223] Fact.MR, 'Geotextile Market – Forecast to 2019 to 2029', 2022 (https://www.factmr.com/report/4655/geotextile-market).

polymers used are more generally polypropylene and polyethylene-containing additives to increase their UV resistance. However, we don't have market figures for other polymer types and thus cannot be extrapolated.

- Not all geotextile materials are exposed to the harsh conditions necessary to degrade the polymers and cause microplastic emissions.
- The emissions figures are coming from a study of questionable quality and so are difficult to trust.

5.5.2 Uncertainties and data gaps

There are several uncertainties and data gaps when discussing geotextiles in the EU. The quantities installed and for which application they are used, and the related microplastics emissions are the most important ones. Indeed, depending on their applications, geotextiles do not represent the same microplastic emission potential, e.g., geotextiles used to stabilise the soil during road construction are not exposed to UV, air, or abrasion in the same way as geotextiles used for coastal protection. From these differences will stem variations in microplastic emissions.

6 POTENTIAL MEASURES

6.1 Measures for tyres

6.1.1 Long list of measures

Tyre wear emissions can be reduced by measures that impact one or more of the parameters. Furthermore, there are measures to increase the treatment of road run-off after the emissions have been released. Hence, potential measures have been grouped in the following way:

Tyre characteristics: The most direct type of measure would be to improve tyre characteristics by introducing regulatory limits for tyre wear. Such a measure would aim at banning tyres with high emissions from the market. More broadly, it could require developing tyres with lower tyre wear emissions. There are potential trade-offs with other functionalities of the tyres, notably safety, which need to be taken into account. This would impact the overall tyre design and composition. In terms of specific policy instruments, the Commission should prepare a report on tyre abrasion by the end of 2024 to review the measurement methods and state-of-the-art in order to propose tyre abrasion limits. A placeholder for such limits was introduced in the recently adopted Euro 7 Regulation. The existing legislation on tyre labelling224 could be amended to include tyre abrasion as a criterion for the labelling in addition to energy use, safety and noise. Another measure could be to oblige manufactures to clean the tyres from the fine rubber pins (remaining from the production process) when placing tyres on the market.

Vehicle characteristics: Vehicle characteristics can affect tyre wear emissions. The trends towards the higher weight of passenger cars and consumers buying bigger vehicles potentially increase the wear. Whether it is possible to introduce measures that would limit the weight of the vehicles is difficult to assess, and it depends partly on innovation and development in battery technology. The engine power and acceleration potential also impact tyre wear, so it could be limited in some way to

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224 European Parliament and Council of the European Union, Regulation (EU) 2020/740 on the labelling of tyres with respect to fuel efficiency and other parameters, OJ L 177, 5.6.2020, pp. 1–31.

reduce tyre wear emissions. Changing the vehicle characteristics in order to indirectly affect tyre abrasion is not considered an effective method to limit microplastics release.

Road infrastructure characteristics: The use of alternative road surface materials could decrease tyre wear. More generally, the whole layout of the infrastructure plays a role. Given that the design of roads is subject to many requirements, a possible measure would be to also include tyre wear as a criterion in the overall design i.e. to try and reduce overall tyre wear. This could include road layout and/or the materials used for road surfaces. However, there are also important safety aspects (i.e. level of grip) to take into consideration.

Sustainable mobility: Vehicle operation, including the total volume of road transport, is subject to various policy instruments and strategies at local, national and EU levels. Currently, there is a significant focus on the need to decarbonise transport and reduce impacts of air pollution. Most instruments are not directed against the transport volume, but rather reducing transport externalities. The trade-off between the benefits of mobility and the external costs of road traffic demonstrates that it is not likely that transport volumes can be affected as an instrument to reduce the amount of tyre wear. However, adding microplastic pollution to the list of external effects of transport could give a prominence to incentives aiming at reducing the amount of road transport.

Emissions treatment: On the emissions side, measures can be taken by treating the stormwater. A set of rules for treating stormwater runoff for discharge into surface waters, "Requirements for stormwater treatment-DWA A102" (DWA-A 102)225 has been published in Germany. The DWA 102 requires that the stormwater must be treated from a traffic volume of 2000 motorised vehicles / 24 h. As already mentioned above, decentralised filter systems or sustainable drainage systems can be used here. Furthermore, optimised street cleaning is also a potential measure for reducing the input, e.g., cleaning the roads at hot spots before rain events. This requires intelligent networking of street cleaning and weather forecasting. Finally, measures could be taken to remove microplastics from the sewage sludge generated at urban wastewater treatment plants. Microplastics are generally well captured by existing techniques applied at such plants. However, they can then be released into the environment when the sludge is used as a fertiliser and spread on agricultural land.

Overall, 205 measures (including duplicates and measures that could be grouped together) were identified during desk research and by participants of the 2nd stakeholder workshop (24 November 2021). Using this feedback and literature review, a long list of 29 unique measures was established. A number of the measures identified by stakeholders at the workshop were duplicates and/or could be grouped together hence the much smaller number of measures taken forward for the screening process (discussed below).

6.1.2 Measures discarded prior to assessment

The table below summarises the measures that have been screened out from the evaluation as well as the reasons for their exclusion. It should be noted that, in some instances, the measures that have been screened out could be effective for reducing microplastic releases from tyre wear but are not considered appropriate for EU intervention and/or interact/overlap with existing EU initiatives.

[225] DWA-A [German Association for Water, Wastewater and Waste], DWA-A Arbeitsblatt 102-2/BWK-A 3-2 – 'Grundsätze zur Bewirtschaftung und Behandlung von Regenwetterabflüssen zur Einleitung in Oberflächengewässer – Teil 2: Emissionsbezogene Bewertungen und Regelungen' [DWA-A worksheet 102-2/BWK-A 3-2 – 'Principles for the management and treatment of stormwater runoff for discharge into surface waters - Part 2: Emission-related assessments and regulations'], 2020 (https://webshop.dwa.de/de/dwa-a-102-2-regenwetterabflusse-12-2020.html), De.

Table 13: Screening of measures for tyres

Problem area	Measure description	Reason for screening out
Market failure / Information failure	Disclose tyre composition: transparency of all tyre components and additives to reduce toxic leakage into the environment. As tyres are recycled as materials for playgrounds and sports pitches, this would be important to understand.	This measure has been excluded on the grounds of **technical feasibility** and **political acceptability** due to concerns over the confidentiality of information on the exact composition of different tyre models. Tyre composition for generic families of tyres is already made available with more details in data sheets provided by the manufacturers when supplying tyres to the vehicle manufacturers. The use of hazardous substances could be regulated through REACH. The measure is also not considered specific enough on microplastics.
Market failure / Information failure	Monitoring tyre emissions in the environment by adding a tracing material to the tyres.	Whilst this measure would be valuable from a research perspective, it has been excluded from the evaluation on the grounds of **proportionality** and **effectiveness and efficiency**. There is already a significant body of research on tyre particle emissions with lots of ongoing attention. Further research should be continued under the Commission's Horizon programme.
Market/Regulatory failure	Alternative materials (e.g., biodegradable materials): Prioritise sustainable and regenerative materials that do not have externalities (e.g. cutting down forests for more rubber plantations).	The measures is excluded on the grounds of **technical feasibility** as there are no commercially available alternative materials that could replace current materials without compromises for lifetime, safety etc. Additional research and development is required before this can be considered further.
Market/Regulatory failure	Extending tyre lifetime to reduce wear.	A measure focused on extending tyre lifetime could incentivise manufacturers to innovate to reduce abrasion, but it could also lead to manufacturers simply producing tyres with a thicker tread. This would lead to heavier tyres with implications for fuel efficiency and not necessarily any reductions in TWP emissions. The measure to establish an abrasion limit value is considered a more appropriate measure to avoid such outcomes. Therefore, this measure has been excluded on **effectiveness and efficiency** grounds.
Market/Regulatory failure	Reducing vehicle weight: Incentives for reducing vehicle weight	While reducing vehicle weight can reduce TWP emissions, it is not so simple to do so, not least with the increasing development and uptake of electric vehicles. At present these are generally heavier than their internal combustion counterparts due to the weight of the batteries (however higher energy density in future batteries might compensate the difference). There is also a shift towards greater uptake of larger vehicles, e.g., SUVs, with larger wheels and tyres. Therefore, this measure has been excluded for **technical feasibility** reasons as well as **coherence/overlaps with wider EU policies** such as those focused on, e.g. decarbonisation.
Market/Regulatory failure	Install particle catchment systems to collect tyre particles from cars, light-duty vehicles and/or heavy-duty vehicles	This measure has been excluded on **technical feasibility** grounds. The techniques themselves are not fully commercially available, and there are some technical constraints with their implementation, e.g. space constraints.
Market/Regulatory failure	Acceleration limitation in urban areas: Acceleration reduction could be installed in new	Whilst these measures tackle driver behaviour and could help reduce TWP emissions, they have been excluded on the

Problem area	Measure description	Reason for screening out
	vehicles. Buses already use it to prevent people from falling during acceleration. / Kick-downs for emergency situations can be limited to a certain number per time / Slip: traction control system (TCS)	grounds of **political feasibility** as they are expected to face significant opposition from the industry and consumers.
Market failure / Information failure	Advanced driver information systems in vehicles to reduce abrasion	Whilst measures to change driver behaviours can help to reduce TWP emissions, this measure would only be voluntary, so it has been excluded as **effectiveness** is unlikely to be significant.
Regulatory Failure	Speed limits for motorway and/or urban areas	All of the sustainable mobility measures identified act to either reduce overall vehicle kilometres and/or change driver behaviour, all of which can impact TWP emissions. However, these measures have been excluded on **proportionality** and **coherence** grounds and **subsidiarity**. Traffic management and other related measures fall within the remit of local, regional and national authorities and are not appropriate for EU intervention. Furthermore, there is already significant action on sustainable mobility driven by other agendas, including decarbonisation and local air quality. However, whilst these measures have been excluded from further consideration for a specific microplastics intervention, the impacts of such measures on TWP releases (as co-benefits) should be taken into account for their development and review. This may help to make an even stronger case for their adoption.
Market failure / Regulatory failure	Improve traffic management to support smoother traffic flows	
Market failure / Information failure	Awareness campaigns: consumer awareness campaigns on driving impact	
Market failure / Information failure	Reduction in individual automotive traffic promoting shared rides and communal transport as well as public transport.	
Market failure / Regulatory failure	Distance/ Road transport reduction: Reduce road transport (passenger and freight) to limit microplastic released from abrasion of car and truck tyres	
Market failure / Regulatory failure	Bicycle traffic: improved cycle safety and connectivity, e.g. bike lanes	
Market failure / Information Failure	Field research: Research to determine pathways of TWP to the environment, including through drainage infrastructure and storm water pipes, combined sewer overflows (CSOs), wastewater treatment plants (WWTP) / hotspot identification/marker substance	A number of stakeholders indicated that further research was required in order to understand the pathways of TWP to the environment better. There is already a considerable body of research focused on this topic, with more ongoing, including through EU programmes, and **further EU intervention is not considered necessary**.

Problem area	Measure description	Reason for screening out
Market failure / Regulatory failure	Sludge treatment: Reducing/preventing the spreading of sewage sludge on agricultural land	The recent revision of the Urban Wastewater Treatment Directive (UWWTD)[226] identified that existing practices remove up to 80-94% of microplastics from the wastewater and then transfer them to the sludge. According to the ongoing evaluation of the Sewage Sludge Directive (SSD), 40% of sewage sludge is spread on agricultural land and used as a fertiliser. Some MS have introduced a ban on the use of sewage sludge in agriculture. As for the EU level, around half of sewage sludge is applied on agricultural land. The Sewage Sludge Directive (SSD) may be revised in the coming years (depending on the findings of the evaluation) and could consider this issue further.
Market failure / Regulatory failure	Sludge treatment: Enhancement of capabilities of water treatment facilities to eliminate microplastics from sludge	Whilst current treatment techniques at UWWTPs have a relatively high removal rate for capturing microplastics from the wastewater, and this is mostly transferred to the sewage sludge. There are yet commercially available techniques to remove the microplastics (at least to any significant extent) from the sewage sludge prior to its application on agricultural land (in those Member States where it is spread and not incinerated). The supporting study to the evaluation of the Sewage Sludge Directive[227] concluded that further research is needed to understand the potential impacts of sewage sludge treatments on microplastics. Therefore, the measure has been excluded due to a lack of **technical feasibility**.
Market failure / Information Failure	Artificial intelligence / promoting autonomous driving and advanced driver assistance systems vehicles to reduce abrasion (TYR#4)*	This measure is already being taken up by the car industry
Regulatory failure	Improve capture and treat road run-off water (e.g. filter systems for gullies)	A voluntary approach through guidelines would be the best approach in this phase. This is taken up in another measure
Regulatory failure	Improve road cleaning in high emission hotspots (intelligent network)	A voluntary approach through guidelines would be the best approach in this phase. This is taken up in another measure
Regulatory failure	Mandatory shaving off of vent spews	IDIADA information given to the JRC (unpublished) indicates that for a specific tyre brand the total amount of the rubber pins (also called vent spews) could reach approximately 10 g per tyre. Considering an average abrasion of approximately 1.0-1.5 kg during the tyre's lifespan, the overall effect is calculated to be at the level or lower than 1%. Taking into account that most tyres in the fleet do not feature these rubber pins, the overall impact is expected to be much less than 0.5% and probably closer to 0.1%. Further implications: Based on the available information, there are tyres with almost no or very few rubber nibs, while some

[226] European Commission, Commission staff working document - Evaluation of the Urban Waste Water Treatment Directive; SWD(2019)701 final, 2019.

[227] Wood et al., Study report in support to the evaluation of the Sewage Sludge Directive, Exploratory study - final report, 2021.

Problem area	Measure description	Reason for screening out
		other tires feature long and numerous rubber nibs. One can safely assume that this amount of extra rubber will be much different from one tyre to another depending on each tyre manufacturer. Furthermore, there is no information regarding the additional cost of removing the rubber pins at the manufacturing procedure.

(*) To note that this measure was discarded later in the process, which is the reason why it has a number (TYR#4) that cannot be found later in this study.

6.1.3 Measures to be assessed for tyres

Measure TYR#7: Road design and cleaning guidelines

Type of measure: Non-binding approach

Description of the measure

This measure is about the support the EC could give to the development of guidelines at a European level for use by the Member States for road design (design, materials and capture and treatment of run-off water) and cleaning. These guidelines would encompass the following:

- The development of criteria to define the contribution of the road design and material to tyre abrasion and specifications for road design, including considering road materials that can absorb TWP (e.g. porous asphalt) and/or TWP rates (e.g. rubber asphalt).
- Approaches for increasing uptake of capture and treatment systems for road run-off water (focused on urban areas) to prevent or minimise direct runoff into surface waters.
- Options for changing current road cleaning practices to optimise the removal of TWP. This would cover the timing of the cleaning where it should take place before any major rainfall as well as more cleaning of road/street sections with a high level of tyre wear.

How would the measure work?

There are still a number of uncertainties on the effectiveness and technical feasibility of such measures, so a regulatory intervention is not considered feasible. Therefore, the measure would entail the development of guidance and specifications for road design requirements (including options for capture and treatment of road run-off) and material characteristics, which the Member States could then apply when maintaining and building roads. The measure could include criteria for when to collect and treat road run-offs as well as when and how to undertake road cleaning. The guidance could identify best practices to demonstrate examples where such approaches have been delivered in practice and the benefits that have been realised.

For road cleaning, the guidelines would support more informed cleaning of roads in high-release hotspots ahead of major rain and storm events to reduce run-off to UWWTPs and the environment. It could encourage the cleaning of roads with the largest traffic volumes and, therefore, the most significant amounts of TWP and would encourage timings based on weather forecasts. It should be noted that treatment of the run-off water would lead to the generation of sludge and that no commercially available technology is currently available for removing the microplastics from the sludge (to any significant extent). It means that the sludge would need to be incinerated to be removed entirely.

How could the measure be implemented?

The measure could be implemented by developing guidance and technical materials informed by a technical working group to be established. There could also be potential for amendment of the Green Public Procurement (GPP) criteria for road transport in the future to accommodate microplastic considerations[228].

Measure TYR#3: Modulated fees in EPR for tyres

Type of measure: Market-Based Instrument

Description of the measure

Introducing or modifying an EPR scheme so that it covers the use phase of tyres would require that all companies placing a tyre on the EU market would incur fees related to the emissions of the tyre, and the revenue from the fees could then finance the treatment of run-off from roads in order to capture and remove the microplastics and/or consumer awareness raising activities.

How does the measure work?

There are already EPR schemes for tyres in 20 Member States[229], and they have been introduced for managing end-of-life tyres (ELTs). In such a scheme, a producer would be responsible for the disposal and management of tyres after their use. Other systems which exist for managing ELTs in the EU are free market systems and tax systems.[230] Under a tax system, the government is responsible for ELT management, as seen in Denmark and Croatia. A tax on tyre producers is used to finance the government's management of ELTs and will be passed on to the consumer. [231] EPR schemes and tax systems are similar in that producers face a cost to manage ELTs; however, under an EPR, the responsibility of the management falls upon the producer.

A free market system is operated in Germany and Austria. Under a free market system, laws are usually set regarding the transportation, use, disposal and storage of ELTs.[232] Unlike other systems, there is no party which is designated as responsible for the management of ELTs. Any operations to recover ELTs are contracted under free market conditions to comply with the relevant legislation. This is often accompanied by voluntary action within the industry to promote best practices. Unlike EPR and tax systems, there is no direct payment from producers which can go towards ELT management.

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[228] JRC, JRC Technical report and criteria proposal – Revision of the EU Green Public Procurement Criteria for Road Transport, 2021 (https://ec.europa.eu/environment/gpp/pdf/criteria/EUGPP_roadtransport_technicalreport.pdf).

[229] Includes Belgium, Bulgaria, Czech Republic, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden. Based on: European Tyre & Rubber Manufacturers' Association (ETRMA), 'Circular Economy' (https://www.etrma.org/key-topics/circular-economy/#:~:text=In%20the%20EU%2C%20three%20different,of%20a%20product's%20life%20cycle).

[230] European Tyre & Rubber Manufacturers' Association (ETRMA), 'Circular Economy, 2019 (https://www.etrma.org/key-topics/circular-economy/).

[231] World Business Council for Sustainable Development (WBCSD), 'Global ELT Management – A global state of knowledge on regulation, management systems, impacts of recovery and technologies, 2019 (https://docs.wbcsd.org/2019/12/Global_ELT_Management%E2%80%93A_global_state_of_knowledge_on_regulation_management_systems_impacts_of_recovery_and_technologies.pdf).

[232] World Business Council for Sustainable Development (WBCSD), 'Managing End-of-Life Tires', 2018 (https://docs.wbcsd.org/2018/02/TIP/End_of_Life_Tires-Full-Report.pdf).

It is unclear how Cyprus, Luxembourg and Malta conduct ELT management or whether any formal system is in place. In 2018, high percentages of ELT were treated in Cyprus (145%) and Malta (100%), suggesting that measures are in place.[233] No data is available for Luxembourg.

The measure considered here would be about the use phase of tyres. The scheme could be designed in alternative ways with regard to how the fees would be calculated and what the revenue would finance. Current EPR schemes and tax systems, as seen across 22 countries in the EU, could be adapted with modulated fees (EPR) or taxes to cover microplastic releases. For Austria and Germany and a free market system, it is unclear if they could be adapted to also account for microplastic releases or if an EPR scheme or similar system would need to be introduced. For those Member States without any such scheme in place, then there would be a need to introduce something new. Any EPR scheme for abrasion (new or modulated fees for an existing scheme) would have to comply with Article 8a(4) of the Waste Framework Directive (Directive 2008/98/EC). It requires that

Member States shall take the necessary measures to ensure that the financial contributions paid by the producer of the product to comply with its extended producer obligations: ..

(b) ***in the case of collective fulfilment of extended producer responsibility obligations, are modulated, where possible, for individual products, or groups of products, notably by taking into account their durability, reparability, reusability and recyclability and the presence of hazardous substances, thereby taking a life-cycle approach and aligned with the requirements set by relevant Union law,*** *and where available, based on harmonised criteria in order to ensure smooth functioning of the internal market*[234]

This requirement could potentially be challenging as the cost of removing the microplastic from road run-off might be difficult to estimate and also challenging to agree on the criteria for what the EPR should cover. See the discussion below under *Implementation.*

The proposed revision of the Urban Wastewater Treatment Directive (UWWTD) establishes an EPR scheme. It would cover releases of micropollutants by introducing a fee for products that lead to their release (e.g. pharmaceuticals), based on the quantities and the toxicity of the products placed on the market. An EPR scheme could be implemented in a similar way.

How could the measure be implemented?

As mentioned above, there are already EPR schemes in many Member States, although it seems that they differ in the way they are implemented. In several Member States, there is more than one scheme[235]. EPR schemes that deal with end-of-life management are more straightforward in many ways. They are focused on ensuring that used tyres are managed safely and ensuring a high level of reuse or recovery of materials/energy. The introduction of EPRs in all Member States would therefore require EU legislation, and it would be necessary to specify some minimum requirements for an EPR. Though there are existing EPRs, changes to their working might be needed, or it might be necessary to define new and specific EPRs to cover tyre wear.

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[233] European Tyre & Rubber Manufacturers' Association (ETRMA), 'End of Life Tyres Management – Europe 2018 Status', 2020 (https://www.etrma.org/wp-content/uploads/2020/09/Copy-of-ELT-Data-2018-002.pdf).

[234] European Parliament and Council of the European Union, Directive 2008/98/EC on waste and repealing certain directives, OJ L 312, 22.11.2008, pp. 3-30.

[235] Winternitz, K., Heggie, M. & Baird, J., 'Extended producer responsibility for waste tyres in the EU: Lessons learnt from three case studies – Belgium, Italy and the Netherlands', *Waste Management*, Vol. 89, 2019, pp. 386-396.

The practical implementation would require the definition of:

- Who should pay the fee, and what should be the level and differentiations?
- What should the collected fee cover?
- Definition of the governance and the practical organisation set-up for the EPR

While the specific governance set-up might be left to the discretion of each Member State, issues of minimum fees etc. might be required at an EU level.

There is a recent OECD study on modulated fees in EPR schemes[236]. The study lists key considerations for an EPR with a more advanced fee structure. Generally, there are few actual examples, but there could be an issue if the EPR is not perceived as fair and transparent. For an EPR to work, the test standard needs to be defined as required for the previous measures (TYR#1 and TYR#2). Then the fee would be correlated to the emission level of each tyre in order to provide an incentive for innovation in tyres with lower emission rates. The next question is what the revenue should cover. Currently, experience suggests that much of the microplastics are actually captured by the wastewater treatment processes but then released into the environment in some Member States via the spreading of sewage sludge. The share of road run-off is not covered; which are collected by separate storm-water systems or just discharged into the ditches along the roads. An EPR system could be used to fund the treatment of stormwater that is not being treated and improve the collection and treatment of road run-off currently not collected. It could also cover consumer awareness-raising activities.

The challenge in setting up the system would be:

- The emissions are not constant along the road network, but the hotspots might not be known or registered.
- An EPR would probably not be able to fund improvement for all roads, and it would be necessary to define priority criteria.
- Collection and treatment of road run-off would also potentially remove other types of pollution.

Given the described issues and challenges, there is a need for further clarifications of the legal aspects on what can and should be defined at an EU level and what will be for Member States to define. For those Member States that currently do not have an EPR scheme in place for the end-of-life tyres, there are two main options:

- Require the establishment of an EPR scheme but potentially only covering microplastic releases.
- Adapt existing approaches (e.g. taxation) to provide a financial mechanism for charging manufacturers depending on the abrasion rates of their tyres, e.g. taxes could be modulated to account for microplastic releases.

<u>Measure TYR#1: Emission limit value for particles from tyre wear/abrasion</u>

Type of measure: Regulatory action

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[236] OECD, OECD Environment Working Paper No. 184 - Modulated fees for Extended Producer Responsibility schemes (EPR); ENV/WKP(2021)16, 2021.

Description of the measure

The aim of this measure would be to phase out the worst-performing tyres from an abrasion point of view through the implementation of an emission limit value. This would require an appropriate test method and standard, which is already under development, as discussed previously. Only then could the absolute limit values be defined for different tyre types (sizes and models). In principle, lower abrasion tyres should also have a longer lifetime, thus increasing the time before they need to be replaced, although tyre design means that no direct comparison can be made between different tyres in terms of durability. As discussed previously, data from recent studies show quite a high variation across different tyre brands and tyres with respect to their abrasion rates. Hence, by restricting the use of the worst-performing tyres, TWP emissions would be decreased. The measure could have an impact fairly quickly, considering that the average lifetime of a tyre before being replaced is around 5-10 years (dependent on usage and driver behaviour).

How does the measure work?

There is no internationally agreed standard for measuring the emission rate of a particular tyre. However, as discussed earlier, such methods are now under development. Then an emission limit for tyre wear can be set (broken down for different tyre types), and only tyres that pass that emission limit value using the agreed test method will be approved. A ban on the worst-performing tyres will lead to lower average emission rates and lower total emissions of TWP from tyres. Limits would need to be defined separately for different types (i.e. summer, winter, all-year tyres, sizes and performance classes) and light-duty and heavy-duty vehicles. Options for setting limits could be based on the lower, e.g. 10% of performers in each category or a certain percentile. Limit values could be phased over time, with limits being tightened (within technical feasibility bounds) as manufacturers innovate to produce tyres with lower abrasion rates.

How could the measure be implemented?

Abrasion limits will be introduced in recently adopted Euro 7 Regulation once the methodology is available.

Measure TYR#2: Emission labelling of particles released from tyre wear.

Type of measure: Regulatory action

Description of the measure

There is already a labelling scheme for tyres focused on safety, energy efficiency and noise. This measure would add tyre abrasion as a fourth element to the label.

How would the measure work?

All tyres placed on the EU market would have to be tested to determine their abrasion rate. As with measure TYR#1, this measure would require that a technical standard and method for measuring the emission rates be established. Once this has been adopted, different emission levels would be defined by label values (like A, B, C etc.) and a symbol to be placed on the label. The label would give the consumer a possibility of taking the microplastic emissions into account when purchasing new tyres. It may be most effective to consider including the abrasion rate alongside impacts on tyre lifetime as lower abrasion rates may equate to an increase in tyre lifetime, thus saving consumers money. This is considered to be a greater driver for consumer purchasing than microplastic emissions[237]. In the future, such a label could also be utilised by city and other local/regional authorities where emissions are greatest, e.g. to apply restrictions on the sale of certain tyres with higher abrasion rates.

How could the measure be implemented?

Regulation (EU) 2020/740 includes a provision for the Commission to introduce tyre abrasion and mileage criteria as soon as reliable test methods are in place (Article 13).

Measure TYR#6: Regular wheel alignment to minimise tyre wear

Type of measure: Regulatory action

Description of the measure

This measure is about ensuring the axis (wheel) alignment is maintained so that the abrasion rate is kept at the level that follows the vehicle design. Misalignment can appear through the use and wear of the vehicle and lead to increased abrasion. Therefore, this measure would be a requirement to test the alignment regularly and correct and adjust the wheels in case of any misalignment.

How would the measure work?

By a requirement to regularly test the alignment, the negative effects of misaligned wheels could be reduced or eliminated. This could be done as part of the mandatory roadworthiness tests. As the roadworthiness tests only take place every fourth year (as a minimum, in many Member States they are more frequent), there would still be an effect from misalignment, assuming the misalignment happens gradually.

How could the measure be implemented?

There are already some requirements on wheel alignment captured by existing EU legislation, namely Directive 2014/45/EU on periodic roadworthiness tests[238]. This sets minimum requirements (and frequencies) for periodic testing of road vehicles, including specific technical elements to be covered. These include wheels and their alignment (namely, to check that the alignment of the wheels is in accordance with the vehicle manufacturer's requirements). However, this specific requirement is marked with an "X" which the footnote specifies: *"(X) identifies items which relate to the condition of the vehicle and its suitability for use on the road but which are not considered essential in a roadworthiness test,"* i.e. it does not appear to be a mandatory requirement for roadworthiness testing. The test is also focused on the steered wheel requirement on driving safety. The alignment of the axis is an additional requirement, but it could be implemented as amendments to the existing legislation.

Measure TYR#5: Enhance monitoring of tyre pressure

Type of measure: Regulatory action

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[237] European Commission, 'Study assessing consumer understanding of tyre labels, 2019 (https://ec.europa.eu/info/sites/default/files/energy_climate_change_environment/overall_targets/documents/tyre-label_final-report_0.pdf).

[238] European Parliament and Council of the European Union, Directive 2014/45/EU on periodic roadworthiness tests for motor vehicles and their trailers and repealing Directive 2009/40/EC, OJ L 127, 29.4.2014, pp. 51.

Description of the measure

The measure would entail enhancing the on-board monitoring of tyre pressure in new vehicles to reduce TWP emissions.

How would the measure work?

According to the ETRMA[239], under-inflated tyres can increase fuel consumption (up to 4%) and have implications for the tyre's lifespan (reduction up to 45%). Tyre pressure monitoring systems (TPMS) are currently required for new cars and vans and will be for trucks but are primarily calibrated for driver safety, i.e. TPMS currently shows if tyres are at dangerously low pressure, typically 20% below optimal. The measure would entail a more sensitive calibration of the TPMS to flag when the pressure is not optimal from a tyre wear perspective (i.e. it would alert the driver sooner when the pressure has dropped). The feasibility of tightening current thresholds (in the context of the uncertainties of the systems) and the exact threshold at which alerts would need to be determined based on a more in-depth technical assessment of the optimal level for reducing tyre wear, the sensitivity of the systems and likely driver behaviour (including the risk of driver annoyance if set too low). This could be combined with a communication campaign to make consumers aware of the importance of proper tyre pressure.

It should be noted that if the system is very sensitive, then it might face opposition from industry and car users. It might also lead to car users having the system switched off or ignoring it if it is very sensitive.

How could the measure be implemented?

The change of the TPMS to give warnings when lower pressure increases the abrasion rate could be implemented as amendments to the existing type approval regulations.

6.2 Measures for textiles

6.2.1 Long list of measures

Following a workshop with stakeholders and a review of relevant literature, a long list of measures to reduce microplastics releases from synthetic textiles was developed. About 155 measures were identified during the workshop. After removing duplicates and regrouping some measures, the list was refined to 29 measures. The long list of measures is described in the table below. They can be classified by the type of measure:

Standardisation: There is a need to quantify microplastic release from synthetic textiles on the whole life-cycle with a standardised method.
Regulating releases: Microplastic releases can be limited by setting thresholds for specific life-cycle steps. For example, it could be at the production plant or in washing machines by households.
Technological: Technologies can help reduce microplastic releases from textiles at different life-cycle steps.
Communication and behaviour change: To raise awareness and promote behaviour by reducing microplastic releases (purchase decision, washing practice, etc.) could also be relevant to reducing releases and supporting other measures.

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[239] European Tyre & Rubber Manufacturers' Association (ETRMA), 'The tyre industry's role in advancing Connected & Automated Driving' (https://www.etrma.org/key-topics/mobility/).

Incentives and disincentives: Taxes and subsidies could provide incentives/disincentives to companies/consumers to change their production process (material input, plant equipment, etc.) and purchase behaviour favouring less microplastic releases.
Research needs: There are still a lot of uncertainties regarding microplastic releases from textiles (quantification, health impact, production techniques to limit releases). Research would help reduce these uncertainties and help companies implement the changes in their production process.

6.2.2 Measures discarded prior to assessment

The table below summarises the measures that have been screened out from the evaluation and the reasons for their exclusion. It should be noted that, in some instances, the measures that have been screened out could be effective for reducing microplastic releases from textiles but are not considered appropriate for EU intervention and/or interact/overlap with existing EU initiatives.

Table 14: Screening of measures for synthetic textiles

Problem area	Name of the measure	Description	Reason for screening out
Market failure / Regulatory failure	Professional laundries' emissions regulation	Making microplastics filters compulsory for professional large-scale laundries. There would be a need to define a minimum efficiency threshold for the filter and define a set of criteria to identify the laundries subject to the regulation.	This measure has been excluded on the grounds of **relevance** because this measure was very close to another measure that was kept (the one making filters compulsory on all washing machines) but with a smaller scope.
Information failure	Textiles production facilities reporting requirement	The reporting of releases of the production facility would be compulsory for all textiles sold on the EU market.	This measure has been excluded on the grounds of **effectiveness** because this measure does not entail reductions in microplastic releases directly. It is only a means to compare production plants on their microplastics releases more easily. In addition, textiles production installations which are regulated by the Industrial Emissions Directive and the European Pollutant Release and Transfer Register (E-PRTR), are already subject to reporting.
Market failure / Regulatory failure	Technological solutions to reduce microplastic releases	Improving the efficiency of the microplastics filters.	This measure has been excluded on the grounds of **effectiveness** because it is not prone to create short-term results, as it is an R&D measure. It would need to support another measure, like the measure to make washing machine filters compulsory.
Market failure / Regulatory failure	Emission limit for textiles placed on the EU market	An emission limit that targets the whole life-cycle will lead to technology changes that enable the textile manufacturer to respect the emission limit.	A custodial sequence that occurs as ownership or control of the material supply is transferred from one custodian to another in the supply chain295 has to be organised to ensure the traceability of the textile's characteristics regarding microplastic emissions. It could be organised via certificate

Problem area	Name of the measure	Description	Reason for screening out
			trading, stating a microplastic emission category, for example296. This measure has been discarded as most of the production is outside the EU, often in SMEs in developing countries, making the implementation very difficult for products place on the EU market. This measure would not be feasible, proportionate nor political feasible. Other measures also seem much more suited, like TEX#3: Restriction of synthetic fibres and fabrics with high releases of microplastics.
Market failure / Regulatory failure	Emission limit during production	During production, an emission limit will lead to technology changes that enable the production plants to respect the emission limit.	Discarded for the same reasons as the measure before (emission limit for textiles placed on the EU market)
Regulatory failure/ Information failure	Develop guidance on Best Available Techniques	Developing Best Available Techniques (BAT) on textiles and their associated levels of releases for these parts of the value chain for which there are no BATs. This measure would make information more easily accessible to a greater number of professionals.	This measure has been excluded on the grounds of **effectiveness** because this measure would only make information more easily accessible. However, it would not create any constraint or incentive to reduce microplastic releases in the short/medium term.
Market failure / Regulatory failure	Mitigate and control WWTP	Equipping WWTP above a size threshold (e.g., > 50 000 PE) with compulsory filters.	This measure has been excluded. It would rather belong to the evaluation of the Urban Wastewater Treatment Directive, which is dealt with in a distinct policy process. Further, the measures is also excluded on the grounds of **effectiveness** because an extra filter in WWTP would not be cost-effective as most of the microplastics are already captured (between 80 and 95 %, according to EurEau).
Market failure / Regulatory failure	WWTP sludge incineration	Compulsory incineration of WWTP sludge.	This measure was screened out on several grounds, including **technical feasibility, coherence with other EU objectives, proportionality, and political feasibility**. Mandating incineration of sewage sludge instead of spreading is not considered realistic. In some Member States, it is an important fertiliser. There is not the capacity to incinerate it, and/or it would conflict with other objectives, including, e.g. decarbonisation, circular economy and agriculture.

Problem area	Name of the measure	Description	Reason for screening out
Information failure	School intervention	Funding programs/associations that intervene in schools to raise awareness on the issue of microplastics and communicate best practices surrounding the issue.	This measure has been excluded on **legal feasibility** because education is not one of the EU areas of action. Moreover, this measure was close to another that consisted of funding communication campaigns to raise awareness on microplastics and communicate best practices.
Regulatory failure	Taxing microplastic release	Taxing textiles sold in the EU based on their estimated microplastic releases over their life-cycle.	The measure was screened out on the grounds of **proportionality** and **political feasibility** of common taxation between all MS.
Regulatory failure	Taxing textile plastic content	Taxing textiles sold in the EU based on the quantity of plastic in their production.	The measure was screened out on **proportionality** and the **political feasibility** of common taxation between all MS.
Market failure / Regulatory failure	Subsidising sustainable clothing	Subsidising clothes producers who make clothes following the product environmental footprint category rules on textile and apparel. This is a long-term measure, and the implementation could take place through the textile EPR scheme (by using eco-modulation).	The measure was screened out on the grounds of **proportionality** and the **political feasibility** of subsidies.
Market failure / Regulatory failure	Subsidising innovative textiles	Subsidising the producers of textiles who apply techniques prone to reducing microplastic releases to their textiles.	This measure was screened out on the grounds of (1) political feasibility, as to subsidise a part of the textile sector, and (2) **technical feasibility** as there are not yet innovative textiles with much lower microplastic releases made with synthetic fibres. It is too soon to think about subsidizing producers of innovative textiles, as the industry is still at the R&D stage on this question.
Information failure	Research yarn/fabric characteristics	Funding research on the link between microfibers release and yarn/fabric characteristics.	These measures are screened out on the grounds of **effectiveness** because R&D measures cannot create short-term results and have highly uncertain outcomes. R&D is nevertheless already happening under EU programmes and will continue to be pursued.
Information failure	Textiles microplastics release sources database	Developing a database of the risk of microplastic release depending on several characteristics (yarn type, fabric, age, washing condition, etc.).	
Information failure	Research textile's use phase	Funding research on microfibers releases during textiles' use phase.	
Information failure	Research dying techniques	Funding research on less emitting dyeing techniques.	

Problem area	Name of the measure	Description	Reason for screening out
Information failure	Research biodegradable	Research on biodegradable microplastics.	
Information failure	Research mixing organic/synthetic fabric	Funding research on the link between microfibers release and the mixing of organic/synthetic fabric.	
Information failure	Research on health effects	Funding research on the health effects of microplastics (airborne included).	
Information failure	Research on pre-wash releases	Funding research on the amount of microplastic released during pre-wash.	
Information failure	Research Microfibre Consortium's roadmap	Funding research on the need for the Microfibre Consortium's roadmap.	

6.2.3 Measures to be assessed for textiles

Measure TEX#8: Raising awareness on best practices for consumers of textiles

Type of measure: Supply chain/consumer information to enable selection of less polluting products or change in behaviour

Description of the measure

The measure would involve a communication campaign aiming to raise awareness on microplastics and communicate best practices surrounding the issue.

How does the measure work?

The Member States could coordinate the communication campaign.

The list below gives a few communication examples:

- Which fibres emit microplastics
- Washing practices to reduce microplastic releases
- Washing machine filter maintenance
- Impact of fast fashion on microplastic releases

Consumers and households will be affected by this measure as the communication campaign will target them.

How could the measure be implemented?

The measure would be implemented through dedicated actions or legislation changes (ecodesign for textiles and electrical and electronic equipment).

<u>Measure TEX#9: Mandatory label showing textiles' emissions of microplastics</u>

Type of measure: Supply chain/consumer information to enable selection of less polluting products or change in behaviour

Description of the measure

The measure implies that each textile item must have a label informing the consumer of the estimated microplastic releases during the product's life-cycle.

How does the measure work?

It is important to note that there is currently no methodology to quantify the microplastic releases of textiles over the life-cycle. Therefore, the mandatory label measure needs to be combined with the measure TEX#1 "Create a standardized measure to quantify microplastic releases on the life-cycle".

How could the measure be implemented?

The measure would be implemented through legislation changes (ESPR or Textiles Labelling Regulation).

<u>Measure TEX#7: Modulated fees in EPR for textiles</u>

Type of measure: Market-Based Instrument

Description of the measure

By 2025[240], there will be targets at the EU level to increase the separate collection of textile waste. Whether it will be applied via an EPR by the Member States is unclear. The European Commission also adopted an EU strategy for sustainable and circular textiles[241], which states that "the Commission will propose harmonised EU extended producer responsibility rules for textiles with eco-modulation of fees". This measure aims to include a "microplastic release" component in existing and future textile EPR schemes[242].

How does the measure work?

Including a "microplastic release" component to existing and future textile EPR schemes can be done via eco-modulated fees, the microplastic release externality into account or financing measures reducing microplastic releases. The EPR is a tool to combine with other measures. The administrative cost of a waste management EPR for textiles with a microplastic component should not be completely allocated to microplastics as the EPR serve many purposes. The cost of the microplastic part in the eco-modulated fee might be very low. An EPR scheme could also be dedicated to microplastics for textiles or combined with other sources of microplastics if reduction measures are similar.

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[240] European Parliament and Council of the European Union, Directive (EU) 2018/851 on waste, OJ L 150, 14.16.2018, pp. 109-140, article 12b.

[241] European Commission, Commission communication - EU Strategy for Sustainable and Circular Textiles; COM(2022)141 final, 2022.

[242] Extended Producer Responsibility.

How could the measure be implemented?

The measure would be implemented through legislation changes (Waste Framework Directive).

Measure TEX#2: Restrict synthetic fibres for certain applications

Type of measure: Regulatory action

Description of the measure

For some types of clothes, synthetic fibres could be replaced by natural or artificial ones. The use of synthetic textiles could be restricted by law to technical applications (see table further).

How does the measure work?

The measure consists of replacing synthetic fibres in all non-technical clothes243 with natural fibres or non-oil based man-made fibres (such as cellulose-based fibres), except for those categories of clothes for which it is impossible to do without synthetic polymers because of their technical specificities (waterproofing, flexibility, etc.). The table below summarises the proportion of such clothing that is not considered feasible to be replaced by natural fibres or non-oil based man-made fibres.

Table 15: Technical products

Products	Proportion of technical clothing (assumption)
T-shirts (sportswear)	50%
Trousers and shorts (sportswear)	50%
Technical jackets	-
Anoraks, ski jackets, etc.	*100%*
Anoraks, ski jackets, etc. (knitted or crocheted)	*100%*
Raincoats	*100%*
Overcoats, car coats, capes (other)	*50%*
Overcoats, car coats, capes (knitted or crocheted)	*50%*
Swimwear	100%
Tracksuits	100%
Ski suits	100%
Hosiery	100%

For all other products, oil-based synthetic materials (polyester, polypropylene/elastane, acrylic and polyamide) are replaced by natural or other artificial materials (cotton, viscose, flax, wool). The current fibre mix was assumed to replace the oil-based synthetic fibres[244]:

243 The focus is on clothes because the majority of microplastics emissions arise from clothes and not from households textiles.

244 Beton, A. et al, 'Environmental Improvement Potential of textiles (IMPRO Textiles)', *Publications Office of the European Union*, EUR 26316, JRC85895, 2014.

- Cotton: 66%
- Viscose: 15%
- Wool: 15%
- Flax: 3%

Weight, numbers of units and composition data from the JRC Impro textiles study[245] have been used. The Impro Textiles study is still relevant because the technological changes have been limited since then. Moreover, this study compares the fibres with a consistent methodology relevant to this impact assessment. With this measure, the proportion of oil-based synthetic materials used falls from 38% (baseline scenario) to 12%. Other important assumptions and limitations include the following:

- Natural materials also emit microfibres. There is little evidence about the fate and persistence of natural fibres such as wool and cotton. In addition, natural fibres could be the source of the leaching of chemicals present on the fibres following the dyeing or finishing stages. (ETC, Microplastic pollution from textile consumption in Europe, February 2022). This is, therefore, a limit of this measure.
- The measure was defined by considering an increase in the proportion of cotton in clothing from 41% to 58%. In practice, the proportion of cotton is subject to the constraints of the production (notably land use) and the demand for this material.
- The proportions of natural and man-made materials following the implementation of measure 1a have been calculated based on the current proportions of these materials in clothing. In practice, each fibre has particular characteristics, and its use depends on the properties expected for the product. The replacement of oil-based synthetic materials will therefore require identifying the most suitable natural or artificial material(s) for each use.

How could the measure be implemented?

The measure would be implemented through legislation changes (ESPR).

Measure TEX#3: Restrict synthetic fibres & fabrics with high releases of microplastics

Type of measure: Regulatory action

Description of the measure

For the type of clothes with high releases of microplastics, oil-based synthetic fibres could be replaced by natural or artificial ones. The use of synthetic textiles could be restricted by law in these clothes with high releases of microplastics.

How does the measure work?

Replacing oil-based synthetic fibres in clothes with natural or other man-made fibres where it is feasible from a technical and production capacity points of view and only where the highest emitting types of fibres and categories of clothes are targeted. Synthetic fibres are kept for the specific categories of clothes for which synthetic fibres are necessary for their technical characteristics

[245] Ibid.

According to the literature[246], knitted polyester, acrylic and polyamide lead to the highest microplastic releases.

In addition, the following figure shows that the main categories of clothing, in terms of tonnes, are tops, underwear, nightwear and hosiery and bottoms. These categories also correspond to products with high wash frequencies, which are therefore likely to emit more during washing (variation between 1 and 5 for the number of uses before washing: 1 for T-shirts and underwear, 2 for the shirts, 5 for pullovers, 3 for trousers) (PEFCR Apparel and footwear, draft version, 2021).

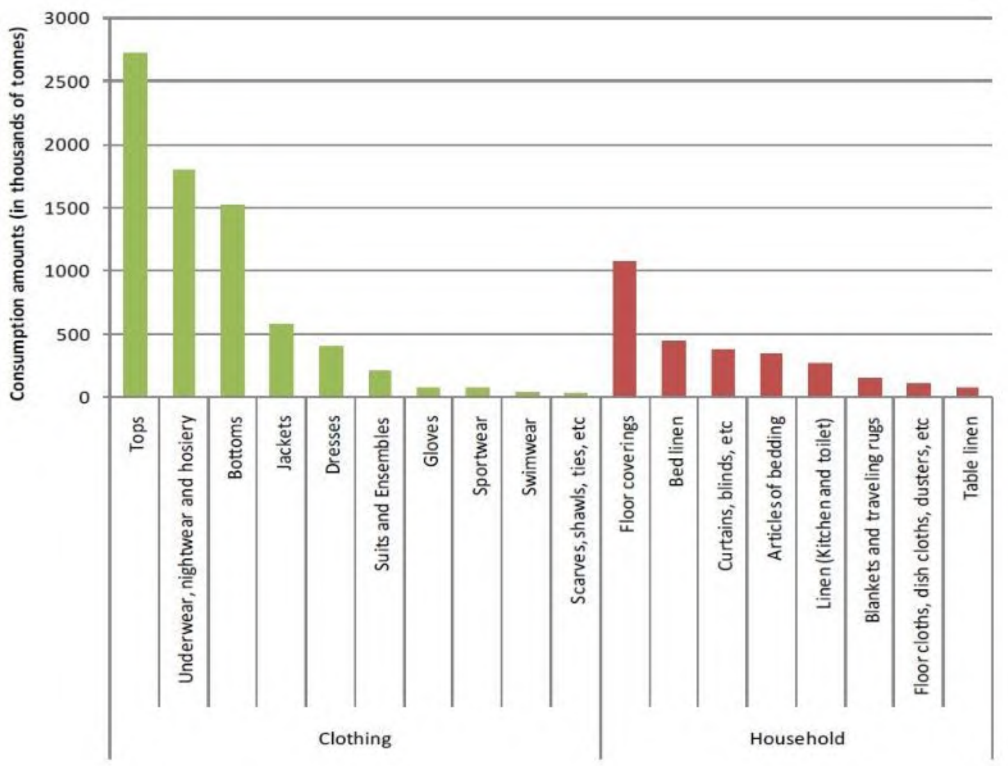

Figure 35: Consumption of different categories of clothing and household textile products in the EU-27 (source: IMPRO textile, 2014)

For non-technical applications with the highest releases of microplastics, oil-based synthetic materials are replaced by natural or other artificial materials (cotton, viscose, flax, wool).

The current natural fibre mix was taken to replace the synthetic fibres[247]:

- Cotton: 66%

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[246] Cai Y., Mitrano, D.M., Heuberger, M., Hufenus, R. and Nowack, B., 'The origin of microplastic fiber in polyester textiles: The textile production process matters', Journal of Cleaner Production, Vol. 267, 2020, Elsevier BV.
Folkö, A., 'Quantification and characterization of fibres emitted from common synthetic materials during washing', *Environmental Science*, 2015.
Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.
[247] Beton, A. et al, 'Environmental Improvement Potential of textiles (IMPRO Textiles)', *Publications Office of the European Union*, EUR 26316, JRC85895, 2014.

- Viscose: 15%
- Wool: 15%
- Flax: 3%

Weight, numbers of units and composition data of the JRC Impro textiles study[248] are used. Only few synthetic fibres have been replaced by natural ones. The proportion of synthetic materials falls from 38% (baseline scenario) to 21%

How could the measure be implemented?

The measure would be implemented through legislation changes (ESPR)

Measure TEX#4: Mandatory prewashing of textiles before placing on the market

Type of measure: Regulatory action

Description of the measure

Prewashing would be mandatory for all the textiles put on the EU market. Therefore, the plants in and outside the EU putting textiles on the EU market would need to equip themselves (washing and drying machines).

How does the measure work?

In practice, a certification mechanism with a chain of custody model could attest to the prewashing of the textiles. The amount of microfibre released from synthetic fabrics is bigger in the first few washes than at other stages. Therefore, at the end of the production phase and/or before the textiles/garments are put on the EU market, mandatory prewashing could reduce the microplastic released during the washing phase. To be efficient, especially outside the EU, where wastewater treatment is limited, this measure should be combined with measure TEX#5: Specific wastewater treatment in production plants.

How could the measure be implemented?

The measure would be implemented through legislation changes (review of the IED Directive, BREF for the companies in the EU and potentially the non-quantitative performance requirements of the ESRP).

Measure TEX#5: Specific wastewater treatment in textile production plants

Type of measure: Regulatory action

Description of the measure

A specific wastewater treatment would be mandatory for all the textiles put on the EU market. Therefore, the plants in and outside the EU putting textiles on the EU market would need to equip themselves. This measure implies a microplastic filtering system for the wastewater of textile

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[248] Ibid.

production plants. Some of the production plants in the EU are covered by the IED and by the BAT Conclusions for the Textiles Industry[249], in which cases the corresponding permits must contain emission limit values based on the BAT Conclusions. The BAT Conclusions contain, inter alia, levels for direct emissions of suspended solids into water bodies.

This measure is associated with measure TEX#4: Mandatory prewashing before placing on the market. There are microplastic emissions at several steps of textile production (pre-treatment of the fibres, dyeing, etc.). Therefore, wastewaster treatment is more relevant than only filters for prewashing.

How does the measure work?

In practice, a certification mechanism with a chain of custody model could attest to a specific wastewater treatment to capture microplastics during the production phase, especially during wet processing as dyeing, printing, and chemical finishing.

How could the measure be implemented?

The measure would be implemented through legislation changes (possibly through the Urban Wastewater Directive for the companies in the EU).

Measure TEX#6: Compulsory filters for washing machines

Type of measure: Regulatory action

Description of the measure

This measure aims to reduce microplastic releases from the washing process during the use phase by making filters compulsory for household washing machines.

How does the measure work?

A filtration device can be added to the drum of the washing machine or positioned at the end of the drainpipe (external filters), or it can be a built-in filter (internal filter). Performance criteria and handling criteria have to be defined. There is a risk of mishandling the retained microplastics. For example, if the consumer rinses the filter in the sink, the microplastics will still be transferred to the urban wastewater system. Therefore, clear communication is needed to advise on and promote best practices of filter cleaning.

A filter could be mandatory for new machines sold as those filters are more cost-efficient than the filters added to existing machines. External filters would be advised to consumers with high awareness who would like to reduce their microplastic emissions because they are likely to apply best practices and avoid rinsing the filtering system in the sink. It would take between 7 and 12 years to cover all washing machines with internal filters based on the uptake in new and existing stock and the average lifetime of washing machines.

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[249] COMMISSION IMPLEMENTING DECISION (EU) 2022/2508 of 9 December 2022 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the textiles industry, OJ L 325, 20.12.2022, p. 112–161

How could the measure be implemented?

The measure would be implemented through legislation changes (implementing measure under the Ecodesign Directive for electrical and electronic equipment or possibly under the proposal for Ecodesign for Sustainable Products Regulation).

<u>Measure TEX#1: Standardised methodology to quantify microplastics releases from textiles</u>

Type of measure: Standardised measurement methodology

Description of the measure

This measure entails creating a standard for the measurement of microplastics releases over the life-cycle of synthetic textiles.

How does the measure work?

This measure requires defining a reference method to quantify (via weight, for example) microplastic release at each step of the life-cycle and a standard testing method (filter to use, washing temperature, etc.) for synthetic textiles. The result could be a CEN standard that covers the microplastic releases of textiles on the whole life-cycle.

How could the measure be implemented?

It could be implemented through voluntary or regulatory channels (e.g. a new EU legislation).

6.3 Measures for paints

6.3.1 Long list of measures

Microplastic releases from paints can be reduced by measures that impact one or more of the life cycle stages of the paint and the painted object. Hence, potential measures have been grouped in the following manner:

Knowledge and capacity building: Paint with respect to other sources of microplastic pollution has only recently caught the attention of policymakers. Thus, several actions could be taken to deepen the understanding of the paint microplastics problem and address it at both a scientific and legal/policy level. Awareness-raising and education on the issue is also a key point to tackle.
Product Design; Measures could be taken at the very first stage of the paint life, meaning improving the paint formulations and improving the quality of the products on the market in the light of environmental compatibility.
Application & Maintenance Actions can also be taken at a later stage, at the moment of application or once the paint is already on the intended object (e.g. maintenance and removal).

During the stakeholder workshop organised on 17 March 2022, 53 proposals in total were identified, out of which 7 were excluded as they were only comments and not measures. 5 were screened out. The remaining 41 selected measures were grouped and merged to form 12 more comprehensive measures.

6.3.2 Measures discarded prior to assessment

The table below summarises the measures that have been screened out from the evaluation as well as the reasons for their exclusion. The reasons for exclusion are mainly technical feasibility or their lack of coherence with other EU objectives.

Table 16: Screening of measures for paints

Category	Measure description	Reason for screening out
Market failure / Regulatory failure	Use more biocide anti-fouling agents to prevent organisms from sticking to the hull and thereby prolong the lifetime of antifouling paint	The measure has been discarded for **lack of coherence with other EU objectives**. This is because it is in contrast to other efforts at the European level to reduce the detrimental effects of biocide in nature Biocidal Products Regulation (BPR), Regulation (EU) 528/2012.
	Promote the use of self-healing paints	The idea of self-healing paints is based on the reparability of applied paint layers. Repair of the paint layer is currently only possible once for each crack, and this technique is still under development. The expected full-scale application could still take 10 years […].[250]In light of this information, we discarded the measure for reasons of **technical feasibility** as we want to focus on more promptly available solutions.
	Promote the use of paints with higher content of solids (less solvent/water) in order to consume less of the paint itself	This measure was discarded as it doesn't address the problem. The share of the paint that solidifies is the one constituted by the polymers; what renders the mixture liquid is a solvent. Therefore, having thicker paint (i.e. with less solvent) would not affect its microplastic release.
	Replace antifouling paint with silicone paint	Antifouling paint is used to prevent biofouling, which causes increased ship fuel consumption, reduces the ship's top speed, and can spread invasive species. Most antifouling paints release biocide to prevent biofouling, and silicone paint is a biocide-free alternative that prevents fouling by creating a sleek surface. The measure has been discarded because it does not necessarily reduce microplastic releases.
Market failure / Regulatory failure	Since winter maintenance of roads can influence road marking wear (e.g. street sweeping), one could provide a monitor and reporting scheme on when street sweeping should be carried out in relation to precipitation events, etc.	This measure has been discarded for **low efficiency** and **lack of coherence with other EU objectives**; road maintenance is designed to prioritise safety and not avoidance of wear and tear of road markings.

[250] Faber, M., Marinković, M., de Valk, E., & Waaijers-van der Loop, S. L., 'Paints and microplastics. Exploring the possibilities to reduce the use and release of microplastics from paints. Feedback from the paint sector', *RIVM (Dutch National Institute for Public Health and the Environment) report*, 2021.

Category	Measure description	Reason for screening out
	Introduce microplastic releases during paint maintenance as a criterion in the Taxonomy Regulation.	The measure would require economic activities that wish to be labelled as sustainable to not emit microplastics during paint maintenance. The measure would, therefore, target only selected sectors such as wind energy. Consequently, the measure has been discarded due to a potential **lack of effectiveness and efficiency**.
	EPR to finance proper disposal of paint removed during surface maintenance	The measure was discarded because it is not possible to clearly attribute the responsibility (from an EPR perspective) to paint producers as they are not alone responsible for the poor application and maintenance of paints.
Information failure	Assess and try to better understand which paint substitutes can be used for specific applications.	The measure has been discarded for **technical feasibility reasons.** Differentiating the use of paint and pairing it with possible substitutes would require a comprehensive assessment of the economic, environmental, and social impact of all those substitutes. Also, a substitute for application A may not work for application B. Different aspects such as climatic conditions also needs to be considered.
	Investigate the degradation process of paints	"Degradation" in this context refers to the change in polymer-based product (paint particles in the environment) properties such as tensile strength, shape, colour, molecular weight etc., under the influence of one or more external (environmental) factors such as heat, light, chemicals, or other applied forces. Investigating degradation mechanisms alone will not be efficient in reducing microplastic releases, and consequently, this measure has been discarded due to a **lack of effectiveness and efficiency**.
	Innovation challenges	The measure has been discarded due to a lack of **effectiveness** in controlling microplastic release in the short term.
	Monitoring of paint microplastic pollution in the aquatic environment	This measure has been discarded because it is not specific to paints. This can be dealt with by including microplastic monitoring in environmental monitoring through existing policies.
Market failure / Regulatory failure	Preventing boats from undergoing ship-breaking beaching practices	The measure has been discarded because of **proportionality**.

6.3.3 *Measures to be assessed for paints*

<u>Measure PNT#2a: Mandatory label on paint lifetime and plastic content</u>

Type of measure: Supply chain/consumer information to enable selection of less polluting products or change in behaviour. The label requirement should be mandatory. Possibly, the measure could be set up as a voluntary label (not assessed). Further on, the requirement could be transformed as a threshold value needed for product authorisation and to enter the EU market. This is assessed in Measure PNT#2b.

Description of the measure

This measure aims to inform consumers on key properties of paint, i.e., the plastic content of paint (expressed, for example, as a percentage of the total weight) and the paint lifetime, so that they can make an informed choice based on their needs and avoid polluting behaviour. Paint is a mixture; therefore, its performances and properties are correlated to the nature and the relative quantities of its components, a major one being the binder, which is the one commonly made of synthetic organic polymers. Plastic content is, therefore, to some extent, correlated to the paint system properties, for example, the lifetime, but that largely depends on the nature of the polymers themselves and the conditions to which they are exposed. A higher plastic content could, in fact, increase the paint lifetime and therefore decrease the need for repaint). However, examples of completely different systems also exist, such as mineral-based architectural paint, which contains less than 5% of plastic and requires repainting every 20-25 years on exterior surfaces, while most plastic-based paint used for exterior surfaces requires repainting every 8-12 years. Not all applications require long-lasting paint systems. Interior walls, for example, tend to be repainted every 3-4 years, not because the paint system breaks and the substrate risks being damaged, but for aesthetic purposes. Interior decorative paint is estimated to cover 70% of the architectural paint demand[251], which itself covers more than 50% of the market share. The DIY sector is another sector where probably weather-enduring paint systems are unnecessary (e.g., for paintings, woodworks, etc.), although this sector covers a much smaller portion of the market.

How does the measure work?

The measure requires paint producers that sell on the EU market to add on the paint label the plastic content and the lifetime of the paint. To reach this goal, several steps are required. Having a clear definition of plastic content in paint is key: whereas the REACH[252] only refers to polymers (chapter 2), and the Single use plastics directive [253] – point 11 – clearly excludes paint from the scope, a definition of the plastic content in the paint is missing. This creates disagreement among stakeholders regarding the issue.

As a first step, a scientific task force can be created to investigate the use of synthetic polymers in paint and come up with a definition of plastic content in paint that is sufficiently inclusive to cover the development of a new formulation of synthetic polymers. In that regard, after scientific discussions conducted with polymer experts in academia, the following point of discussion (non-exhaustive list) need to be considered:

- *Should the plastic in the paint definition include all synthetic polymer-based materials?* The definition of plastic material should comprise the terms polymer and resin as well, as resins are actually polymers. Also, the definition should be inclusive enough to account for the current paint formulation and synthesis/usage of new polymers.
- *In which physical state is a substance considered plastic: solid/liquid/gas?* Typically, with the term plastics, only solid polymers are considered, but one has to pay attention to the fact

[251] Hall et al., Constructing sustainable tourism development: The 2030 agenda and the managerial ecology of sustainable tourism, J. of Sustainable Tourism, 27:7, 2018.

[252] European Parliament and Council of the European Union, Regulation (EC) 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, OJ L 396, 30.12.2006, pp. 1.

[253] European Parliament and Council of the European Union, Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment, OJ L 155, 12.6.2019, pp. 1-19.

that an amorphous solid polymer is considered liquid by thermodynamics because it is not crystalline. In this context, though, a liquid should be considered as a material showing the container's shape. Polymer dispersions instead could also be solid (e.g. pigmented plastics) but also liquid as those in paint. The inclusion of liquid polymers and PLF (Polymer in Liquid Formulations), which can solidify in various circumstances (type of polymer, temperature, evaporation of solvent etc.), should also be discussed.

- *What should be biodegradability?* For this point is particularly important to discuss whether to include biodegradable polymers (if so, which are the characteristics of the material to be considered biodegradable)? A valuable starting point is represented by the analysis done in the RIVM report 2016 (Verschoor et al., 2016). To be noted that in this case, the definition of what should matter is the final product and not the synthetic route nor the source (e.g., bio-sourced polymer) as they do not affect potential risk assessments.

The measure would require that agreements are made on the definition of paint lifetime and that the use of a standardised test is being ensured (see PNT#1).

Thresholds to limit plastic content below a certain amount and/or lifetime above a certain number of years could be set to access the European market (PNT#2b).

Antifouling paints should be excluded from this legislation. Antifouling paints are applied on ship hulls to prevent marine biofouling (e.g., algae, barnacles, and mussels). Biofouling reduces the speed and increases fuel consumption, which is crucial in preventing non-indigenous species contamination from one water basin to another. The principle through which the paint works is based on the presence of the release of active substances, i.e., toxic biocides, from the coating that acts to repel and/or poison fouling organisms. These types of paint are either hard paints, which are more durable (but still wear off over time) or ablative paints, also known as self-polishing paint, which slowly slough off in the water. This kind of paint contaminates the environment by design with both toxic substances and microplastic particles. We suggest excluding antifouling paint from the scope as plastic releases being one of the concerns, as antifouling paint is also related to biocides emissions, CO_2 emissions and the spread of non-indigenous species. Therefore, for antifouling paint, a more inclusive approach needs to be taken into account to avoid trade-offs between a reduction in microplastic releases and an increase in biocides or CO_2 emissions, for example.

<u>Benefit</u>:

The expected/desired impact is:

- Consumers choose less plastic-intense paints, especially when a long paint lifetime is not a key requirement for the application (e.g., interior architectural paint, DIY decorative works)
- Promote the use of mineral-based paints (as opposed to plastic-based paints), especially for exterior architectural paint
- Inspire formulations of new products or improvement of existing ones or other technological alternatives to paint to reduce the environmental impact of paint coatings

Negative environmental impacts in terms of CO_2 emissions or toxicity cannot be excluded, for example, a more toxic compound could be introduced by extending the lifetime of the paint. There is insufficient evidence on the effects of reduced plastic content, and whether it could impact the functional properties of the paint and its cost. Once a definition of plastic paint is agreed upon at the EU level, it should be easy for paint producers to determine the amount of plastic in paints based on the paint formulation. The plastic content could be expressed as a "wet" share, i.e., plastic weight/paint weight, as a "dry" share, i.e., plastic weight / (paint weight when cured), or in grams. Probably, the "dry" share, in %, is the one that would have the most significant impact in driving consumer behaviour, as it is easier to understand than values in grams, and it is higher than the "wet" share. Having the plastic content in grams instead would simplify reporting of plastic content for paint importers (see the measure on a deposit-return scheme for paint containers).

The crucial step is the development and adoption at the EU level of a standardised methodology to determine the paint-system lifetime (linked to the wear & tear rate)[254]. While in light of new legislation, testing the lifetime of the paint products should not be a burden for big paint producers, small businesses might encounter difficulties. Open access or creating conventions with testing facilities at the European level for companies might be a valuable means of implementation. Alternatively, a threshold on the amount of paint put on the market could be set to exclude smaller companies from the labelling requirements. Attention should be put on how the consumer understands the concept of paint "lifetime". The lifetime should be understood as "time needed before repaint" and not as "time before the paint degrades in the environment". The label's design must be agreed upon so that it is easily understandable and highly visible since the main target group of the measure is the general public. A monitoring framework should verify compliance with the legislation. In order to facilitate monitoring of compliance with the label requirements, standardised tests to assess plastic content could be put in place.

We believe imposing thresholds to enter the EU market should take place at a later stage (see measure PNT#2b). Following this reasoning, if the thresholds on maximum plastic content would be imposed, the compositions of the paints will need to change to provide the same (or improved) performances. There is no way to predict what new formulations would look like in terms of environmental impact (one possibility out of many: lower plastic content, same lifetime but more toxic degradation products once released into the environment).

How could the measure be implemented?

At the EU level, some directives on paint composition exist already, for example, to define eligibility requirements that minimize environmental impact (e.g. Ecolabel[255]), or GPP that requires the inclusion of clear and verifiable environmental criteria for products and services in the public procurement process and also directives on the VOCs (Volatile Organic Compounds[256]) aimed to prevent the negative environmental effects of emissions of chemicals included in paint. Other relevant legislation which could take up this measure include the Construction Products Regulation and the Ecodesign for Sustainable Products Regulation.

Measure PNT#3a: Promote mineral paint in the architectural sector

Type of measure: Non-binding approach

Description of the measure

Measure 'PNT#3b: Restrict polymer-based paints in the architectural sector' has a similar set-up, but with a regulatory, binding approach. Currently, the paint market is dominated by formulations based on polymeric organic binders. This doesn't leave much space for alternatives, which might be valuable for some sectors that might not necessarily require high plastic content paints or might even benefit from different formulations. Mineral paint (formulations based on inorganic binders like silicate or lime) is a valuable alternative in the Architectural sector. Mineral paint should contain less

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254 KTA-Tator, 'Expected service life and cost considerations for maintenance and new construction protective coating work', 2016 (https://kta.com/kta-university/expected-service-life-coatings/).

255 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014D0312

256 Directive 2004/42/EC

than 5% organic compounds (including binder, solvent, and additives) (according to German regulation DiN 18363 2.4.1), while the rest is mineral raw materials (e.g., alkali potassium silicate). The very nature of the chemical bonds within the ingredients renders these products robust and resistant, especially to UV radiation (in contrast to paint based on organic binders). When applied to a mineral substrate, these products present a lifetime which can go up to two folds the one of usual dispersion paint (the one based on organic binders), i.e., a lifetime of 20-25 years compared to a standard 8-12 years, for exterior coatings[257]. This measure aims to increase the market for mineral paint and render it the primary product used in architecture. The desired impact is to decrease the use of paints with high plastic content in the Architectural paint sector, which represents the highest market share. This will significantly decrease the amount of microplastic pollution due to paint particles from buildings.

How does the measure work?

This measure will use voluntary approaches to increase the penetration of mineral paints through market demand and supply.

How could the measure be implemented?

The measure could be implemented as an inclusion of the mineral paint in the GPP or the ECOLABEL in a way that will be a soft push towards this kind of no-plastic-containing coatings.

Measure PNT#5: Good practices for paint applications in all sectors

Type of measure: Non-binding approach

Description of the measure

This measure is about the EC support to draft guidelines by the paint sector on good practice guidelines for all sectors using paints to prevent microplastic releases to the environment during the paint application and maintenance of the painted layer of an asset. This measure could indirectly incentivise the technological development of clean maintenance techniques. The measure requires compiling a set of good practices for various assets (buildings, road markings, industrial facilities, auto, industrial wood items) for paint application, removal, surface preparation and waste management. In terms of enforcement, environmental permits granted to asset owners could include the requirement of compliance with good practices. The expected impact of the measure is the reduction of microplastic release from paint maintenance in Europe and incentivising the technological development of clean paint removal methods.

How does the measure work?

The first step is to define a set of good practices to limit paint releases to the environment. These practices should cover (non-exhaustive list):

1) Paint application in a closed environment
2) Paint application in an open environment
3) Paint removal in a closed environment
4) Paint removal in an open environment

[257] Personal communication by a stakeholder

Furthermore, they should include best practices for surface preparation, as good surface preparation is key to guaranteeing good paint adherence to the substrate and maximising the paint lifetime (reducing paint input on the market and microplastic releases during the use phase).

Overall, we estimate that around 139 kt of microplastic is leaked into the environment due to improper paint removal (note that of this, 48 kt are lost during ship maintenance outside of Europe). Losses at applications are also to be considered, especially in sectors where spray is used (automotive and industrial wood) and in situations where the application cannot be made indoors (e.g. general industrial settings). The architectural sector, in this respect, contributes less than others because brushes and rollers are used.

Specifically for the sectors of Marine, Road Markings, Architectural, General Industrial, and Automotive, good practices are already available, as presented below.

Marine:

Various activities occur at shipyards that can lead to paint microplastic releases into the environment. Overall, we estimate that around 50 kt of microplastic is lost to the ocean during commercial ship maintenance at dry-dock, and another 10 kt is lost due to the maintenance of leisure vessels. For commercial vessels, the activities performed in shipyards are: paint application during boat building, paint removal and re-paint during boat maintenance (for example, at dry-dock or floating dock), and in-water removal of biofouling of the boat hull. For leisure vessels, instead is generally paint removal and re-paint (mostly done onshore, in the open air).

The good practices for ship maintenance should cover (non-exhaustive list):

1) Paint application in a closed environment (for leisure boat maintenance or ship-building)
2) Paint application in an open environment (for leisure boat maintenance onshore and commercial boat maintenance in dry-dock or floating dock)
3) Paint removal in a closed environment (for leisure boat maintenance)
4) Paint removal in an open environment (for leisure boat maintenance onshore and commercial boat maintenance in dry-dock or floating dock)
5) In water hull cleaning

Furthermore, they should include best practices for surface preparation, as good surface preparation is key to guaranteeing good paint adherence to the substrate and maximising the paint lifetime (reducing paint input on the market and releases during the use phase). For points 1 and 3, it is straightforward to identify good practices, as the paint losses are confined to a closed space. On the other hand, avoiding releases requires technological development or capturing mechanisms when it comes to maintenance in the open environment or in water.

Some of the technologies known to prevent releases during maintenance of metallic surfaces are vacuum blasting and ultra-high pressure water jetting with vacuum systems and filter technology. For the maintenance of wood surfaces (mostly for leisure vessels), infrared paint removal prevents dust formation and facilitates the collection of removed paint. For paint application, air-less spray guns have a higher transfer efficiency, 90%, than air guns, 70% (*International Labour Office (2012). Encyclopaedia of Occupational Health and Safety 5th edition*). For in-water hull cleaning, which is done to remove biofouling but can also lead to antifouling paint losses, technologies exist that provide in-water vacuum cleaning of the hull. In general, open-sand blasting of painted surfaces should be avoided in open environments, as it has been shown that the dust formed can travel hundreds of meters from the blasting site (*EPA, 2016. Evaluation distances for effective air quality and noise management.*), directly polluting ocean and seas. Dust formation during maintenance has been a concern mainly for the workers' health. During a personal communication, a stakeholder mentioned that China is now banning the use of open sandblasting in shipyards and promoting hydro-blasting instead. Hydro-blasting without a pump/vacuum system prevents dust formation, requiring the water to be collected and filtered to remove microplastic. Currently, some shipyards are using gravitational settling tanks to "treat" the water collected from drydocks (email exchange with InfoMil Netherlands). This could be insufficient to guarantee to capture microplastics, which have specific gravity similar to that of water (0.9 – 1.4g/cm3, *Andrady AL, 2011.)*

The Best Available Techniques Conclusions document for surface treatment using organic solvents including preservation of wood and wood products with chemicals define Best Available Techniques for painting of ships, including removal of old paint, for those shipyards using a large quantities of organic solvents. Shipyards in the scope of this document are required to implement the BAT in order to operate. The techniques allowed during drydocking involve the use of protection systems like nets when sandblasting or the use of wet blasting methods. Both these techniques redirect the removed paint residues to the water that is collected at the bottom of the drydock. The document indicates that the water should be collected, separated, and sent to wastewater treatment plants. In addition, a document of the Infomil Knowledge centre in the Netherlands[258]also states that the water collected from the dock is to be sent to wastewater treatment or treated aside with settling tanks and then released to surface water or water treatment plants.

In conclusion, in application of the current set of BAT, the paint lost during surface preparation and paint re-application would be redirected to wastewater. Unfortunately, as a study made by the Tumlin and Bertholds for the Swedish Svenskt Vatten shows, 40-60% of the microplastic in the incoming wastewater is then found then in the sludge, which in Europe is often used as a soil fertilizer. Another aspect on which the guidelines could be clear and strict is the spraying techniques. In fact, some of the spray techniques listed in the BAT have a transfer efficiency of 50% or 60%, which is much lower than the transfer efficiency of 90% that one can obtain with airless spray guns. Transfer efficiency of 50% would imply that half of the paint is lost at application, and if the paint application is made outdoors, this is a significant direct leakage to the environment.

The conclusions that can be drawn from the analysis of the BAT document show that the good practices for ship maintenance should then involve techniques that maximise transfer efficiency at application and minimize dust formation at removal. The latter can include both vacuum blasting techniques and water blasting, but in the second case (as for any technique involving water usage), the wastewater should be appropriately treated; otherwise, the microplastics that end up in the sludge would just be used in agricultural soil.

Road Markings: The document *"Effective Removal of Pavement Markings"* by the *National Academies of Sciences, Engineering, and Medicine 2013. Washington, DC: The National Academies Press*[259] reports various techniques for removing road markings, and for our purposes, we may focus on those with low to no dust formation. These will be grinding, shot blasting, excess oxygen, laser and chemical removal. Another potential solution is the creation of inlaid road markings; although this is a quite demanding technique which might compromise the integrity of the road, therefore it is valuable only in countries with heavy snowfalls where snow can ruin the markings[260].

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[258] Rijkswaterstaat Environment [The Directorate-General for Public Works and Water Management], 'Kenniscentrum InfoMil [Knowledge Centre InfoMil] (https://www.infomil.nl/), Nl.

[259] Pike, A.M. and Miles, J.D., 'Effective Removal of Pavement Markings', *National Cooperative Highway Research Program*, Report 759, 2013.

[260] Johannesson, M., & Lithner, D., 'Potential policy instruments and measures against microplastics from tyre and road wear: mapping and prioritisation', *Swedish National Road and Transport Research Institute (VTI)*, No. 1092, 2021.

Architectural: For the application of paint products on buildings, mineral paint can be used when mineral substrates are as concerned (see PNT#3a & PNT#3b). For interior surfaces, using paint products with low polymer content should be considered, as performance against harsh weather is not an issue.

In the removal phase, especially on wood substrates, the best practices to minimise paint release from wood surfaces are vacuum sanding or infrared removal. For metal surfaces, instead, the best option is to optimise the applications using technologies with a high transfer rate.

General Industrial: This sector is characterised almost exclusively by metal surfaces on which the paint is applied. The best option to reduce microplastic leakage is to optimise the applications, reducing overspray losses using higher transfer rates. Technologies with transfer rates from 50% to 75% could be found in the Best Available Techniques Conclusions by Chronopoulos et al.[261]. According to the ILO, air-less spray guns have a transfer efficiency of 90% (*International Labour Office (2012). Encyclopaedia of Occupational Health and Safety 5th edition*).

During the removal phase, it is imperative to use technologies that capture the paint particles during operation. This will guarantee the elimination of releases into the environment. Lastly, during removal, a critical step is to perform proper surface preparation prior to reapplication. Indications on the process are provided by the paint product warranty, and this will maximise the paint lifetime.

Automotive: The only recommendation we can provide is to increase the transfer efficiency of paint guns for repair jobs. Several studies exist where they relate spray systems and application conditions to transfer efficiency. *Heitbrink et al., 1996; Poozesh, S., et al., 2018.* The recommendation is always to use the best system and condition possible to minimize the losses of paint ad application.

Once good practices have been developed, they could be implemented by granting a certification to paint professionals who comply with good practices to promote their work and incentivize the use of clean methods for asset maintenance.

How could the measure be implemented?

A set of guidelines should be developed per sector and adopted by the relevant industrial sectors voluntarily.

Measure PNT#4: Deposit-return scheme for paint containers

Type of measure: Market-Based Instrument

This measure should be mandatory.

Description of the measure

The aim of this measure is to put in place an EPR scheme to drive knowledge creation and gather valuable insight on the volume of unused paint, its contribution to environmental pollution and its fate (points 1-3 above). Subsequently, once a better understanding exists, the EPR scheme will be valuable in driving change, reducing unused paint, microplastic pollution and increasing circularity.

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[261] Chronopoulos G. et al., 'Best Available Techniques (BAT) Reference Document on Surface Treatment Using Organic Solvents including Preservation of Wood and Wood Products with Chemicals', *Publications Office of the European Union*, EUR 30475 EN, JRC122816, 2020.

It will address the problem of market failure and regulatory failure. I will also address the information failure problem because:

1. The amount of unused paint is potentially currently underestimated
2. It is unknown how much unused paint is improperly disposed of in EU-27 (e.g., disposal to unauthorised dumpsites, disposal through household drainage system), leading to environmental pollution
3. Of the unused paint that is collected, only a small fraction is recycled

Point 1

It is believed that, on average, 3% (OECD, 2009) of professional paint and 15% of DIY paint are unused.[262] (Release of microplastics and potential mitigation measures: Abrasive cleaning agents, paints and tyre wear)., OECD, 2009.). But, according to a personal communication with ADEME (the French agency for ecological transition), paint cans recovered through an EPR scheme targeting household chemicals are, on average, 40% full. Additionally, an internal paint company document indicates that 30-40% of paint prepared for an offshore maintenance job can end up being unused and subsequently disposed of.

Point 2

In terms of fate, in our baseline assessment, we assumed that the 85 kt of plastic within unused paint in Europe is always disposed of as waste. A personal conversation with an architectural paint industry expert revealed that professionals and DIYers might use the domestic drainage system to dispose of unused paint. Since sludges recovered from wastewater treatment in Europe (except for the Netherlands) are spread on agricultural land as fertilizer, the disposal of unused paint in the domestic drainage system leads to microplastic pollution to the environment. Moreover, some paint is also disposed of in unauthorised dumpsites (personal conversation with ADEME), although an assessment of the volumes of improperly disposed paint is not yet available.

Point 3

Unused paints are a valuable resource, and their recycling is technically feasible[263]. Paint is 37% plastic as the binder. Added microbeads are a specific case used only in some technical coatings (e.g. road markings). So unused paint has also plastic and though emission from unused paint into the environment is not necessarily in the form of microplastic, but as plastic, that in turn will be fragmented in microplastics. It is unknown how much of the unused paint is recycled in EU-27. According to a personal communication with ADEME, in France, where there is an EPR system in place to target the disposal and management of household chemicals (including paint), it is estimated that less than 1% of the recovered paint is recycled. The lack of recycling is due to a conflict between the PRO and the only paint recycler on French territory. "The vast majority of the waste is still incinerated (mostly with energetic valorisation – R1 treatment)". But in the process, metallic containers are also incinerated.

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262 Verschoor, A. et al., 'Emission of microplastics and potential mitigation measures: Abrasive cleaning agents, paints and tyre wear', Dutch National Institue for Public Health and the Environment, 2016 (https://rivm.openrepository.com/bitstream/handle/10029/617930/2016-0026.pdf?sequence=3).

263 AkzoNobel, 'AkzoNobel launches recycled paint to help close loop on waste', 2019 (https://www.akzonobel.com/en/media/latest-news---media-releases-/akzonobel-launches-recycled-paint-to-help-close-loop-on-waste).

Benefit: The ultimate desired impact is to increase the disposal of unused paint through proper channels and finance its recycling. An efficient way to target DIYers could be by actively involving the distribution chains through deposit-return schemes (i.e., easily accessible collection points and communication/promotion campaigns to encourage the general public) or by promoting the door-to-door collection.

How does the measure work?

This measure requires setting up an EPR scheme where paint producers pay based on how much plastic they put on the market. The money collected will be used in the first phase to drive knowledge creation and in the second phase to drive change.

The EPR scheme requires paint producers, as well as paint importers within the EU market, to declare to the EPR operator how much (wet) paint they put on the market and how much of that paint is plastic. In order to harmonise the reporting, a standard definition for plastic in the paint should be agreed upon. A threshold could be set to only target the main producers, therefore avoiding excessive administrative burdens for the authority as well as for small paint producers. A small number of large producers dominate the paint industry. Both European and non-European paint companies sell paint on the EU market. We could not find figures for the paint sold to the European market from non-European producers, but there are figures for paint sold by European producers[264]. These indicate that the top 3 European producers cover more than 50% of the paint sales (from EU producers to the EU market), and the top 10 cover 80%. At the global level, the trend is similar, with the top 20 producers covering 80% of the global paint sales[265]. Input from ADEME confirms the trend; according to their data, the top 5 paint producers represent 81% of the market.

For each paint sector, after it has been determined how much paint is sold in the EU market, one could decide that all producers and importers of more than a tenth of it should be included in the EPR scheme. This would probably limit the number of paint producers/importers to 3-5 per sector. There is currently no single definition of the different paint sectors. In this assessment, we used a split based on the asset on which the paint is applied, but a different split could be more suitable for the paint industry. In the first phase, the objective of the EPR scheme and the role of the PRO would be to:

1. Assess the amount of unused paint as well as the amount of paint put on the market
2. Finance research and assessment studies of improper disposal of unused paint
3. Assess the current recycling rate of unused paint and the potential recycling capacity

In the second phase, the objective of the EPR scheme will be to increase the collection rate of unused paint through the proper channels (e.g. by setting up deposit-return schemes, door-to-door collection, etc.) and reduce microplastic pollution through preventive measures (such as communication campaigns) or curative measures (e.g., by financing wastewater treatment). Ultimately, the EPR should incentivise the recycling of unused paint. A successful example of a take-back scheme seems to be PaintCare, a program of the American Coatings Association, active in 10 US states, that encourages households and businesses to bring unused paint to the collection site.[266]In Denmark, the city of Odense put in place a door-to-door collection system for hazardous household waste (see *GOOD PRACTICE ODENSE: Hazardous Waste Collection October 2014, for reference).).* In

[264] European Coatings, 'Ranking: The 25 largest coatings producers in Europe', 2018 (https://www.european-coatings.com/articles/archiv/ranking-the-25-largest-coatings-producers-in-europe).

[265] Coatings World, 'Top Companies Report', 2021 (https://www.coatingsworld.com/issues/2021-07-01/view_top-companies-report/top-companies-report-163001/).

[266] PaintCare, 'Home page'(www.paintcare.org).

Odense, paint accounts for 75% of the volume of the recovered hazardous waste. On the other hand, a distribution chain in France, Tollens, currently allows for the take-back of paint cans. However, a conversation with a local distribution centre revealed that they accept only clean cans or small quantities of paint residue. The recovered cans are sent to recycle the can itself and not the paint. Therefore, if a take-back scheme is put in place, the scheme's basic principles and organization should be clearly stated and communicated to actually target the paint and avoid the return of the can alone.

The information gathered through the EPR scheme and the PRO should be made publicly available. Such a report could also implicitly allow keeping track of the amount of paint that has not been recovered and improperly disposed of by comparing the performance in the different Member States. To facilitate the comparison, it would be better to require the paint producers or the importers to declare the amount of "wet" paint put on the market, i.e., including the solvent or water that evaporates upon application.

How could the measure be implemented?

This measure would require setting up a Producer Responsibility Organisation (PRO).

Measure PNT#2b: Threshold on lifetime and plastic content for paints

Type of measure: Regulatory action

This measure is dependent on measure PNT#1 and PNT#2a.

Description of the measure

This measure aims to regulate access to the European market only to paints that have plastic content below a chosen threshold (expressed, for example, as a percentage of the total weight) and a lifetime above a certain threshold, in order to reduce microplastic pollution. A better insight on how plastic content and paint lifetime are defined and their relation to plastic pollution is available in measures PNT#1 and PNT#2a.

How does the measure work?

The measure aims on building on the knowledge created through the introduction of labels on paint lifetime and plastic content (PNT#2a), in order to exclude from the market the worst performing paints in terms of microplastic pollution potential. The thresholds could become increasingly stringent over the years. The measure should be applied on all paints sold on the European market (with the exception of antifouling paints – see measure PNT#2a). The thresholds could be different for the different paint sectors. The direct benefits of setting an upper threshold for plastic content and a lower threshold for paint lifetime would be:

- Reduction of wear & tear losses (due to longer lifetime of paint system), which should be visible as a reduction of paint demand (less repaint needed);
- Reduction in microplastic releases due to lower plastic content in paint formulation.

It is necessary for measure PNT#2a to be introduced first in order to have a clear idea of what is the current configuration of the market in terms of plastic content and its correlation with paint lifetime. As this becomes clear, thresholds can be imposed. After the introduction of thresholds, the compositions of the paints will need to change to provide the same (or improved) performances. There is no way to predict what new formulations would look like in terms of environmental impact (one possibility out of many: lower plastic content, same lifetime but more toxic degradation products once released into the environment).

How could the measure be implemented?

Imposing thresholds on plastic content and lifetime is a type of product regulation.

Measure PNT#3b: Restrict polymer-based paints in the architectural sector

Type of measure: Regulatory action

Description of the measure

This measure builds on the analysis of 'Measure PNT#3a: Promote mineral paint in the architectural sector', but going from a non-binding to a binding, regulatory approach. Currently, the paint market is dominated by formulations based on polymeric organic binders. This doesn't leave much space for alternatives, which might be valuable for some sectors that might not necessarily require high plastic content paints or might even benefit from different formulations. Mineral paint (formulations based on inorganic binders like silicate or lime) is a valuable alternative in the Architectural sector. Mineral paint should contain less than 5% organic compounds (including binder, solvent, and additives) (according to German regulation DiN 18363 2.4.1), while the rest is mineral raw materials (e.g., alkali potassium silicate). The very nature of the chemical bonds within the ingredients renders these products robust and resistant, especially to UV radiation (in contrast to paint based on organic binders). When applied to a mineral substrate, these products present a lifetime which can go up to two folds the one of usual dispersion paint (the one based on organic binders), i.e., a lifetime of 20-25 years compared to a standard 8-12 years[267], for exterior coatings. This measure aims to increase the market for mineral paint and render it the primary product used in architecture.

How could the measure be implemented?

The measure requires a new regulation which imposes limits on the use of dispersion paint (based on organic polymeric binders) for the architectural sector. The desired impact is to decrease the use of paints with high plastic content in the Architectural paint sector, which represents the highest market share. This will significantly decrease the amount of microplastic released due to the paints used in buildings.

How does the measure work?

It could be in the form of imposing limits on the use of dispersion paint (based on organic polymeric binders) in the architectural sector. It can be intended as a full ban on this kind of product or a limitation on the allowed share. We advise this measure not to be imposed on architectural coatings intended for wood and metal, as mineral-based paint is brittle and weak when tensile forces are applied. At the moment, to the best of our knowledge, only one independent study was done (Trischler & Partner GmbH, Ökobilanzierung von Silikatfarben- und Kunstharzdispersionsfarben – ein systematischer Produktvergleich, Darmstadt u. Freiburg, 1996) and points in favour of the mineral paint. But it is an outdated report with respect to new LCA standards and to new technologies in paint production. Therefore, an updated life cycle assessment would be needed first.

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[267] Personal communication with a stakeholder

How could the measure be implemented?

The measure could be implemented through the CPR or a new legislation.

Measure PNT#1: Standardised methodology of paint lifetime

Type of measure: Standardised measurement methodology

Description of the measure

When a plastic-based coating (for this measure, we consider any organic polymer-based coating) starts losing its intended properties, it is at risk of detaching from the support and being released into the environment contributing to microplastic release. Evaluating how well and how long a paint coating will last on the support is one of the big challenges the paint industry has to face. There is no unique way to do it as it depends on numerous factors: paint formulation (type and quantities of ingredients) and substrate properties, environmental conditions, coating thickness, etc. Currently, the "expected lifetime" is reported for certain paints to establish a warranty for the product. The definition of the expected lifetime, though, is currently open to interpretation and it can be different for decorative paints and performance coatings. In the case of decorative coating, it indicates the time after which the coating loses its decorative purpose; in the case of performance coatings, it indicates the time after which the coating loses its functional purpose. The lifetime is usually estimated by the paint producers using different techniques. For example, for coatings designed to protect assets in exterior environments, accelerated testing is one means by which formulators assess the specific performance properties relevant to different end-use applications. Long-term performance under harsh conditions is, as a matter of fact, required for coatings used in the oil and gas, petrochemical, and wastewater industries.

There are several internationally applied standardised test methods — ISO (e.g., ISO 12944 on corrosion), ASTM (e.g., B117 salt fog test for evaluation of corrosion performance, D4587 weathering assessment based on UV exposure coupled with condensation, D5894 cyclic salt fog/UV testing, etc.) — but not all are required nor applicable for every coating and, to the best of our knowledge, are not mandatory. Furthermore, these standardised tests assess only one phenomenon at time, be it abrasion, corrosion, exposure to UV light, resistance to water, etc, but the lifetime is determined by the combination of all. These testing methods are also not free from limitations, evolving coating technologies, lack of real-time monitoring for test conditions, new expectations of coating performances, regulations and a certain level of subjectivity involved in reporting the results, only to mention a few. In addition, there is a need to identify the appropriate tests to perform for a given coating formulation and application.[268]

A word of caution is needed at this stage: a direct, clear, positive correlation between one parameter, plastic content, and lifetime or other properties of paint cannot exist, or at least cannot be the same for all paint types. It is, in fact, the combination of all the components of the paint mixture (which includes the polymers) and how they interact with each other that determines the product's performance. Polymer properties (strength, elongation at break, elasticity, environmental resistance etc.) are determined by the chemical composition, the molecular weight and molecular weight distribution, the morphology of the polymer particles and of the polymer film itself. The first step should be to agree on a definition of paint lifetime, valid for all sectors, and this should be intended as "time needed before repaint" and not as "time before the paint degrades in the environment". For

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[268] Element, 'Materials testing: Abrasion & wear testing' (https://www.element.com/materials-testing-services/abrasion-and-wear-testing).

example, it could be defined as the time until 5%-10% of coating breakdown occurs (KTA, 2017), which implies a release of 5-10% of the paint (and plastic) to the surrounding environment. This measure is applicable for all paint types independently from the solvent they are based on (water-born – dispersion paints and water-soluble paints - or solvent-born) because they can all release microplastics. A special case could be constituted by those paints which are both water-soluble and water-sensitive. These, in fact, might release polymers as molecular dispersions in water. Nevertheless, they should be assessed and accompanied with a lifetime because they do release polymeric content into the environment, just on occasion, not in solid form[269].

How could the measure be implemented?

It could be implemented through voluntary or regulatory channels. A scientific panel with coating experts should develop a definition for paint lifetime and identify the best testing methods available – which should be regularly updated by the agency which develops them – for each type of paint application.

6.4 Measures for detergent capsules

6.4.1 Long list of measures

During the stakeholder meeting (17 March 2022), a preliminary list of policy measures was first presented to the stakeholders, such as the eventual environmental persistence and the complete biodegradability of these PVOH in different natural compartments; the most suitable standard to assess the biodegradation of these PVOH and related mixtures; the use of alternatives to PVOH and related mixtures such as casein- and starch-based products in which their water-solubility and biodegradability in water have been demonstrated; and the redesign of the capsules in such as a way that the use of PVOH is not necessary. After discussing these different measures, six main ideas were identified in the stakeholder workshop, divided into different themes. After eliminating the duplicates, the list of selected measures is shown below:

- Commitment to propose a fully biodegradable water-soluble plastics and related additives;
- Redesign the capsules in such a way to avoid the use of PVOH;
- Ensure the implementation of a suitable standard to demonstrate the biodegradation of PVOH films with respect to microorganisms/references used for testing in real-life conditions (e.g., wastewater treatment plants);
- Implement the OECD test guidelines selectively to PVOH and related mixtures;
- Use instructions on how to load the capsules in an appropriate way to avoid any overloading;
- Strengthening enforcement and sanctioning for breaches of relevant obligations deriving from applicable EU legislation.

[269] Kopeliovich, D., 'Classification of paints', *Substances & Technologies*, 2014 (https://www.substech.com/dokuwiki/doku.php?id=classification_of_paints).

6.4.2 Measures discarded prior to assessment

Table 17: Screening of measures for detergent capsules

Problem area	Measure title	Reasons for screening out
Market/Regulatory failure	Implementing alternatives to PVOH	The detergent industry is willing to deliver more sustainable products, mainly based on bio based and biodegradable alternatives. However, the current biodegradable alternatives derived from biomass cannot meet the minimum technical requirements of PVOH and related mixtures, i.e., an appropriate water-solubility on use, a good compatibility with detergent products and good film-performances.
Market/Regulatory failure	Make biodegradation standards compulsory for marine and freshwater	The biodegradation assessment is conducted on the basis of six tests in OECD 301, and each method results in an assessment of aquatic effluent biodegradability in fully aerated conditions. Briefly, OECD 301A measures the disappearance of organic carbon, OECD 301B quantifies the generation of carbon dioxide, OECD 301C, 301D, and 301F monitor oxygen uptake, and OECD 301E monitors the disappearance of dissolved organic carbon. These tests are stringent tests that provide clear figures about biodegradation. A compound giving a positive result in such a test may be assumed to biodegrade quickly in municipal wastewater treatment plants and the environment. A separate measure is not needed at this moment.
Market/Regulatory failure	Banning PVOH and related mixtures	Even if the measure could solve the microplastic releases from PVOH, it could result in excess use of detergents, leading to increased environmental impact. Another reason is related to the health issue because using PVOH and related mixtures avoids any skin contact with detergents and any allergic issues during handling and using the capsules.
Market failure	Load the capsules in an appropriate way	This is already part of existing policy and market practices.
Regulatory failure	Strengthening enforcement	Biodegradation standards are not taken up yet so enforcement of this cannot happen.

6.4.3 Measures to be assessed for capsules

Measure CAP#1: Standardised methodology to quantify microplastics releases from detergent capsules

Type of measure: Standardised measurement methodology

Description of the measure

As there is a critical knowledge gap, this measure will enable an understanding of the volume and scale of capsule losses occurring at different life cycle stages and addresses the problem driver, "information/knowledge failure". There remain some uncertainties on the release of PVOH into the environment, particularly the exact usage of PVOH and related mixtures as detergent capsules and after wastewater treatment in which the biodegradation of PVOH depends on acclimatised microorganisms. These uncertainties are related to the fact that the current standards to assess the biodegradation of commercial PVOH and related mixtures, particularly OECD 301, gives a quick figure about the biodegradation of tested compounds in municipal wastewater treatment plants. However, a positive result is obtained when a certain value of biodegradation (beyond 60%) is achieved after 28 days, and it is assumed that the compounds will continue to get biodegraded after water waste treatments. The complete biodegradation of the tested compounds is not required for validating the test, giving some uncertainties on the fate of PVOH, particularly whether the non-degraded fractions will completely biodegrade after or not.

How could the measure be implemented?

It could be implemented through voluntary or regulatory channels (REACH, Detergents Regulation, ESPR, new EU Framework on microplastics), including the use of appropriate characterization techniques to assess the biodegradation of PVOH and related mixtures after wastewater treatments in an appropriate manner.

Measure CAP#2: Apply current biodegradability standards to detergent capsules

Type of measure: Regulatory action

Description of the measure

This measure will enable complete biodegradation of PVOH and related mixtures after wastewater treatments. Currently, no tests are applied to evaluate the biodegradability of PVOH. The measure would mean that PVOH is required to comply with an already available biodegradability test method potentially the OECD 301B[270] (with or without the relevant 10-day window) which would ensure a higher level of biodegradation. According to the OECD guidelines for the testing of chemicals, the 10-day window begins when the degree of biodegradation has reached 10% Dissolved Organic Carbon (DOC) removal, theoretical oxygen demand (ThOD) or theoretical carbon dioxide (ThCO2) and must end before or at day 28 of the test. Pass levels after 28 days (with 10–day window):

• 60% ThCO2 - Theoretical carbon dioxide production

• 60% ThOD - Theoretical oxygen demand

• 70% DOC - Dissolved organic carbon removal

Chemicals which reach the pass levels after the 28-day period are not deemed to be readily biodegradable.

How could the measure be implemented?

The Detergents Regulation could be adapted to use an existing biodegradation standard.

Measure CAP#3: Redesign biodegradability standards for detergent capsules

Type of measure: Updated standardised measurement methodology and its application

[270] Test No. 301: Ready Biodegradability | OECD Guidelines for the Testing of Chemicals, Section 3 : Environmental fate and behaviour | OECD iLibrary (oecd-ilibrary.org)

Description of the measure

This measure will enable assessing the biodegradability of any water-soluble plastics in normal environmental conditions.

How does the measure work?

Once the films are dissolved in water after use, the dissolved polymer chains are disposed of and degraded during the wastewater treatment. In principle, they must be biodegraded afterwards, but some PVOH could remain intact and could be released into the environment. However, the natural conditions are different in terms of temperature and the likely absence of acclimatized microorganisms. The adaptation of biodegradability standards to more relevant natural conditions could be envisioned in such a way that even if PVOH traces are released, their full biodegradation is ensured.

How could the measure be implemented?

This could be taken up potentially in the detergents regulation or a new legislative framework.

6.5 Measures for geotextiles

6.5.1 Long list of measures

After desk research, through the stakeholder workshop held on 17 March 2022, and bilateral discussions with industrial stakeholders, 58 measures were identified. After refining this list, 6 measures were retained; a large reduction in the number of measures came from the removal of duplicates and the combination of measures that different stakeholders identified. Following is the longlist of measures:

- Guidelines for correct installation, use and maintenance of geotextiles in different applications
- Work with relevant industry groups/associations to gather data
- Define an appropriate testing protocol to measure the potential release of microplastics
- Design product to ensure adequate durability and end-of-life handling, and optimum Life Cycle assessment (including global warming)
- Ban of geotextiles
- Plastic-free alternatives should replace geosynthetics used for coastal or riverbank protection
- Publication of product passports to give the exact list of contained chemicals for each product
- Work on developing erosion-control applications in which the geotextile is covered and unlikely to be able to release microplastics
- Procedure to request and receive approval by authorities to use the geotextile must be established, not just free for all
- Inform municipalities and other public administrations on the environmental impacts of geosynthetics in the open environment
- Make producers/users responsible for regular reporting on the condition and maintenance of geotextiles in use

6.5.2 Measures discarded prior to assessment

The table below presents the measures which were discarded after the preliminary screening of measures, along with the justification for discarding.

Table 18: Screening of measures for Geotextiles

Problem Area	Measure Title	Reason for screening out
Information/knowledge failure	Work with relevant industry groups/associations to gather data	This measure was discarded because it is included in other retained measures. It is not a standalone measure but an element that can be used in other measures to achieve a goal.
Product design	Design product to ensure adequate durability and end-of-life handling, and optimum Life Cycle assessment (including global warming)	This measure is part of other retained measures.
Regulatory failure	Blanket ban of geotextiles	It doesn't seem politically acceptable nor proportionate nor efficient to ban geotextiles in general; they serve a purpose and should be kept among the possible solutions for civil engineering solutions available in the EU.
Market failure/ Regulatory failure/ Information failure	Product passport gives the exact list of contained chemicals for each product	This measure would not reduce microplastic releases nor increase our understanding of microplastic releases from geotextiles; it would only give information regarding the potential release and toxicity of microplastics from geotextiles as well as some information on their material properties.
Information failure	Inform municipalities and other public administrations on the environmental impacts of geosynthetics in the open environment	The gains from this measure are expected to be minimal if enforced on its own because geotextiles are cheaper to install than traditional materials and so will still be used in construction works. It is also covered by a retained measure.

6.5.3 Measures to be assessed for geotextiles

Measure GEO#2: Guidelines for geotextile use

Type of measure: Non-binding approach

Description of the measure

This measure requires the industry to develop guidelines for: the selection of geotextiles for specific applications, the proper installation methods for geotextiles to limit microplastic releases, the correct maintenance of geotextiles (how to repair damaged materials, when to replace damaged geotextiles, their end-of-life management, etc.). The industry has extensive knowledge regarding the applications that their products can be used for as well as the optimal conditions to use their materials in, e.g., during an exchange with members of the International Geotextiles Society (IGS), we were informed that the society does not recommend using geotextiles to reduce glaciers melting and that geotextiles exposed to UV light should have high stabilizer content to reduce their weathering.

How does the measure work?

Whenever a project is designed to contain geotextiles, the industry would follow the guidelines provided with the material. Moreover, the clients would be able to verify that the selected material and its installation are up to the industry's standard set by the guidelines.

How could the measure be implemented?

A set of guidelines for the proper usage of geotextiles (which material, what manufacturing process and how to install them) will be published by the industry and used when appropriate when geotextiles are installed.

Measure GEO#3: Use biodegradable geotextiles for specific applications

Type of measure: Regulatory action

Description of the measure

There are applications of geotextiles for which geotextiles are needed for a limited time, such as holding vegetation still while they root. For these applications, a plastic mesh (Figure 36) is used, which will then biodegrade and released into the environment.

Figure 36: Geotextile mesh used for vegetation support

These materials might not be fully biodegradable; the measure GEO#3 would require that only geotextiles biodegradable, following certain standards, are used in the EU for vegetation support applications.

How does the measure work?

The measure works by restricting the use of non-biodegradable geotextiles for vegetation support applications.

How could the measure be implemented?

This measure could be implemented through the CPR or the Waste Framework Directive. However, in the current version of the CPR, it would be non-binding for the Member States.

Measure GEO#4: Establish geotextile classes according to emissions of microplastics

Type of measure: Regulatory action

Description of the measure

This measure aims to develop an emission control framework. Similar to existing classifications in the CE marking for construction materials, a classification system for geotextiles would be developed. It would be based on the microplastic release potential of the geotextile (depending on its material and manufacturing process). This classification would then be used to define applications where, depending on the class, only certain geotextiles could be used, requiring the highest class of materials to be used for the harshest applications.

How does the measure work?

First, using a testing method for microplastic releases (currently non-existing) from geotextiles (see GEO#1), the materials would be classified according to the quantity of microplastics they emit. Then, the applications for which a certain class of material are required (because their environment is harsher than others) will be defined. The result would be a list of applications for which each class of geotextile could be used. As a result, the geotextiles with higher microplastic release potential would be only used in certain conditions (e.g. not exposed to UV, sea water etc.). Consequently, only geotextiles with low microplastic release potential would be used in exposed conditions, which will limit releases

How could the measure be implemented?

It could be implemented through the existing CPR[271], which already has the class concept implemented for other materials. This measure can be implemented under the current version of CPR, provided that GEO#1 has been implemented.

Measure GEO#1: Standardised methodology to quantify microplastics released from geotextiles

Type of measure: Standardised measurement methodology

Description of the measure

Develop measurement standards and testing protocols for microplastic release from geotextiles to assess the impact of UV, temperature variations, water and salt-water and abrasion on release rates for all types of geotextiles. These measurement protocols will need to be designed so that they consider the interactions between the different weathering agents. Indeed, a recently published study shows that the interactions have a non-negligible impact on the weathering of geotextiles. Moreover, the measurement protocols will need to be designed to monitor microplastic releases since current standards used to monitor the impact of different weathering agents on geotextiles focus on their

[271] European Parliament and Council of the European Union, Regulation (EU) No 305/2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC, OJ L 88, 4.4.2011, pp. 5-43.

influence on the mechanical properties (e.g. tensile strength) of the materials, not on the microplastic releases. Some work is already done, or first steps are taken; for instance, the method to assess the effects of internal hydrolysis/oxidation is regulated and included in CE marking; the method for abrasion is an ISO standard and needs further development to include microplastic release potential. The impact of UV and temperature variation needs to be assessed further because the internal hydrolysis test is done at 100ºC. The assessment of microplastic release makes sense for the leaching obtained from the abrasion test, but further ageing approaches because the test is not aggressive enough to produce microplastic release. This point needs to be verified.

How does the measure work?

This measure requires defining a reference method to simulate the influence of different weathering agents (such as UV light, temperature variation, exposure to fresh and seawater, abrasion, etc.) on microplastic releases from geotextiles and then quantify the microplastic releases.

How could the measure be implemented?

It could be implemented through voluntary or regulatory channels (new EU Framework).

6.6 Summary of policy measures

The following table summarises the policy measures initially retailed for assessment.

Table 19: Summary of policy measures

Sources	Policy measures
Paints	PNT#1: Standardised methodology of paint lifetime
	PNT#2a: Mandatory label on paint lifetime and plastic content
	PNT#2b: Threshold on lifetime and plastic content for paints
	PNT#3a: Promote mineral paint in the architectural sector
	PNT#3b: Restrict polymer-based paints in the architectural sector
	PNT#4: Deposit-return scheme for paint containers
	PNT#5: Good practices for paint application in all sectors
Tyres	TYR#1: Emission limit value for particles from tyre wear/abrasion
	TYR#2: Emission labelling of particles released from tyre wear/mileage
	TYR#3: Modulated fees in EPR for tyres
	TYR#5: Enhance monitoring of tyre pressure
	TYR#6: Regular wheel alignment to minimise tyre wear
	TYR#7: Road design and cleaning guidelines
Textiles	TEX#1: Standardised methodology to quantify microplastic releases from textiles
	TEX#2: Restrict synthetic fibres for certain applications
	TEX#3: Restrict synthetic fibres & fabrics with high releases of microplastics
	TEX#4: Mandatory prewashing of textiles before placing on the market
	TEX#5: Specific wastewater treatment in textile production plants
	TEX#6: Compulsory filters for washing machines
	TEX#7: Modulated fees in EPR for textiles
	TEX#8: Raising awareness on best practices for consumers of textiles
	TEX#9: Mandatory label showing textiles' emissions of microplastics
Detergent capsules	CAP#1: Standardised methodology to quantify microplastics releases from detergent capsules
	CAP#2: Apply current biodegradability standards to detergent capsules
	CAP#3: Redesign biodegradability standards for detergent capsules
Geotextiles	GEO#1: Standardised methodology to quantify microplastics released from Geotextiles.
	GEO#2: Guidelines for geotextile use
	GEO#3: Use biodegradable geotextiles for specific applications
	GEO#4: Establish geotextile classes according to emissions of microplastics

7. Initial identification and screening of impacts

The first step in assessing the impacts is a screening to identify the most important ones. The identification of impacts covers both direct and indirect impacts. The following section sets out how we have screened the impacts to be considered in the impact assessment.

7.1 Identifying and selecting of impacts

The list of impacts that need to be considered is based on the Better Regulation Toolbox Tool #18. The table below presents the impact by the three categories: environmental, economic, and social.

Table 20: Potential economic, social and environmental impacts

	Economic	Social	Environmental
Climate			√
Quality of natural resources			√
Biodiversity			√
Animal welfare			√
Working conditions etc		√	
Public health & safety and health systems		√	
Culture		√	
Governance, participation and good administration		√	
Education and training	√	√	
Conduct of business	√		
Position of SMEs	√		
Administrative burden on business	√		
Sectoral competitiveness, trade and investment flows	√		
Functioning of the internal market	√		
Public authorities (and budgets)	√		
Sustainable consumption and production	√		√
Efficient use of resources	√		√
Land use	√		√
The likelihood or scale of environmental risks	√		√
Employment	√	√	
Income distribution, social protection and inclusion	√	√	
Technological development/digital economy	√	√	
Consumers and households	√	√	
Capital movements, financial markets and stability of the euro	√	√	
Property rights, intellectual property rights	√	√	
Territorial impacts (specific (types of) regions and sectors)	√	√	√
Innovation and research	√	√	√
Fraud, crime, terrorism and security	√	√	√
Resilience, technology sovereignty, open strategic autonomy, security of supply	√	√	√
Transport and the use of energy	√	√	√
Food safety, food security and nutrition	√	√	√
Waste production, generation and recycling	√	√	√
Third countries, developing countries, and international relations	√	√	√
Sustainable development	√	√	√
Fundamental rights	√	√	√

For the issues to be covered in the impact assessment, we have screened the following as potentially relevant impacts (but not necessarily significant).

Table 21: Potentially relevant impacts

Environmental impacts
Quality of natural resources / reducing pollution of microplastics for the biodiversity
Efficient use of resources
Waste production, generation and recycling and its impact on land use
Climate change
Economic impacts
Conduct of business (operating costs)
Administrative burdens on businesses
Position of SMEs
Public authorities including local communities (and budgets) Change in costs to MS authorities for administrative, compliance and enforcement activities; Change in costs to EU institutions
Innovation and research
Technological development / digital economy
Functioning of the internal market and competition
Macroeconomic environment
Third countries and international relations
Consumers and households
Social impacts
Public health & safety
Employment
Governance, participation and good administration

When selecting the most relevant and significant impacts, the following criteria have been taken into consideration:

- The **relevance** of the impact within the intervention logic: this considered whether the impact is relevant to assessing the policy options' direct contribution to the objectives.
- The expected absolute **magnitude** of the expected impacts.
- The relative size of expected **impacts for specific stakeholders**: this considered whether any of the impacts would be particularly relevant and significant for a specific stakeholder group, even if the impact overall may be small. This includes whether impacts will be concentrated on specific Member States or industries and whether they will add to the existing regulatory burden for any specific stakeholder group. Impacts on SMEs are also considered.
- The **importance for Commission's horizontal objectives and policies**: this considered whether the impact is relevant to determine any trade-offs between the objectives for amending the Regulation and other EU objectives and policies.

The outcome of this step is the final list of impacts that have been examined, indicating whether they are likely to be positive or negative (using the following signs: ++, +, o, -, --) and which stakeholder groups they are most likely to impact. Colour coding is used to summarise the impacts referring to the direction (positive or negative) and size (small or large) of any expected impacts.

Table 22: Coding used to present expected impacts

--	-	0	+	++	U
Strongly negative	Weakly negative	No or limited impact	Weakly positive	Strongly positive	Unclear

Table 23: Screening of significant impacts

Impact	Significance	Impact on key stakeholder groups	Justification for inclusion / exclusion
Impacts included			
Environmental impacts			
Quality of natural resources	++	Reduced microplastic pollution or better quality of natural resources means improved eco-systems, improved biodiversity and improved services for the economy and society (e.g. fishery), but the general public is the affected group	The objective is to reduce microplastic pollution, so this is a key impact category.
Efficient use of resources	+/-	No specific group is impacted	Reducing waste is about more efficient use of resources. In particular, the objective is to reduce the waste, and therefore this category should be included. Some mitigation strategies could in turn, lead to increased resource use (e.g. reduction of product lifespan leading to increased renewal rate), e.g. reducing paint spillage. It is, therefore, an important category that should be included.
International environmental impacts	++	Reduced eco-system services could impact fisheries, but it is the general public being the affected group	Pollution with microplastic affects both cross-border river basins and the seas and is, therefore, an important international impact that should be included.
Waste production, generation and recycling and its impact on land use	+	Wastewater treatment companies Sectors potentially affected by microplatics waste such as tourism and agricultural sectors	The amount of microplastics is impacting the infrastructure needed for waste water treatment. If not properly managed, microplastics can pile up in certain areas (such as coastal areas) and negatively impact other activities (tourism, agriculture) As with efficient resources, reducing and managing waste is part of the objectives, and the impact category should be included.
Climate change	+ / -	No specific group is impacted	Reducing waste will lead to less GHG emissions, for example, during the

Impact	Significance	Impact on key stakeholder groups	Justification for inclusion / exclusion
			production of plastics. Some mitigation strategies could, in turn, lead to increasing or decreasing GHG emissions. It is, therefore, an important category that should be included.
Economic impacts			
Operating costs and conduct of business	--	Industrial operators	Most measures will affect the operating costs of industries.
Administrative burdens on businesses	--	Industrial operators	Some of the considered measures will have administrative costs that should be quantified and included.
Operation / conduct of SMEs	- / 0	SMEs are part of the affected sectors.	The affected industries include SMEs. There are high shares of SMEs in the textile industry.
Functioning of the internal market and competition	++	Industrial operators	Several Member States are starting to take action, it is therefore important to tackle this at EU level, preserving the internal market. The proposed measures are not expected to significantly affect the internal market's functioning. As the options will place the same obligations on industries and businesses in all Member States, the functioning of the market should not be affected. However, if EU policies replace national policies affecting only a few Member States, the impact will be more equal competition across the EU and therefore have a positive impact on the internal market.
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	Member State competent authorities (at local, regional and/or national levels depending on PRTR responsibilities).	The considered measures will impact Member State authorities in terms of data collection, verification, correction and enforcement activities.
Public authorities: Change in costs to the Commission	-	European Commission	The considered policy options could have impacts on the Commission and its services.
Innovation and research	+	Industrial operators.	Some of the options could provide incentives for innovation and research.
Third countries and international relations	+/-	Third countries	There could be effects on countries outside of the EU with both direct and indirect impacts, and this category should be included.
Consumers and household	-	Households	Some measures directly target consumer behaviour or affect consumers through prices or availability of products. The impacts are likely to be negative (price increase)

Impact	Significance	Impact on key stakeholder groups	Justification for inclusion / exclusion
Social impacts			
Reduced health impacts due to lower pollutant emissions	++	Public	It is an objective of the considered measures to reduce risks to human health.
Governance, participation and good administration: Improved public access to information	+/0	Public	The options are not expected to change governance and public administration significantly. Though the options might not directly target access to information, there might be improved data on microplastic pollution.
Impacts not included			
Macroeconomic environment	0	Manufacturers primarily	Though there could be significant costs associated with some of the considered measures, it is not likely to have macroeconomic impacts.
Technological development / digital economy	0	Industrial operators, Member State authorities, manufacturers	The innovation and research impact category covers the impacts on technological development related to the sectors concerned.

The economic impacts primarily include the costs of implementing the measures. The benefits of the measures are reductions in emissions of microplastics. Whilst it is not feasible to quantify or value changes in environmental impacts, reductions in emissions of microplastics will reduce the negative environmental impacts from the baseline. In most cases, the emission reductions will affect emissions to all environmental compartments. Hence, the environmental impacts will be more or less proportional to the reduced emissions. There may also be impacts on fuel efficiency for some measures and associated changes in GHG emissions. Similarly, the social impacts, which include the possible negative human health effects, are also likely to be affected proportionally by reductions in emissions. It means that all measures have more or less the same types of environmental and social impacts, and only the magnitude differs. Where there are differences, they are described under the respective measure.

The approach to the assessment of cost impacts draws on evidence identified as part of the literature review and stakeholder consultations. In many cases, the costs are affected by multiple factors, so the cost estimates presented are generally an order of magnitude estimates. Similarly, for the assessment of the reduction potential and the likely realisation of it. Many factors influence the assessment of the reduction potential, and the assessment provides order of magnitude estimates.

7.2 Impact of measures for tyres

Table 24 shows the comparison between all measures evaluated to reduce microplastic emissions from tyres.

Table 24: Comparison of measures for tyres

Measure	Estimated reduction potential		Estimated Cost-effectiveness (EUR/tons reduced/year)	Other environmental impacts	Other economic impacts	Social impacts
	%	Ktons/ year				
TYR#7: Road design and cleaning guidelines			Not quantified – guidance only		Additional costs for road authorities for new road costs and road maintenance	
TYR#3: Modulated fees in EPR for tyres				Not quantified		Costs are likely to be passed on to consumers in higher prices although they can choose to purchase lower abrasion tyres where cost increases will be much more limited.
TYR#1: Emission limit values for particles from tyre wear/abrasion	5-25%	85 500	136	Reduction of microplastic pollution in marine environment, air and soil	Costs are likely to be passed on to consumers in higher prices	Health and environmental benefits from microplastic release reductions
TYR#2: Emission/mileage labelling of particles released from tyre wear	less than 1%	4 275	1 604	Reduction of microplastic pollution in marine environment, air and soil	Costs are likely to be passed on to consumers in higher prices	
TYR#6: Regular wheel alignment to minimise tyre wear	1% - 2%	9 108	145 245 (without fuel savings)	CO_2 emission reductions due to fuel savings Reduction of microplastic	Positive impact for motorists and customers (increased	

			-43 287 (with fuel savings)	pollution in marine environment, air and soil	tyre lifetime and lower fuel consumption)	
TYR#5: Enhance monitoring of tyre pressure	1% - 3%	10 403	996 (without fuel savings) -23 298 (with fuel savings)	CO_2 emission reductions due to fuel savings Reduction of microplastic pollution in marine environment, air and soil	Positive impact on motorists and customers (increased tyre lifetime and lower fuel consumption) Additional costs for motorists for testing and alignment (where necessary)	Marginal positive impact on road safety and noise reduction

Table 25 shows the comparison of the impacts of the measures assessed to reduce microplastic emissions from tyres.

Table 25: Summary of impacts for measures for tyres

Policy Option	Environmental impact	Economic Impact	Social impact
TYR#7: Road design and cleaning guidelines		Additional costs for road authorities for new road costs and road maintenance	
TYR#3: Modulated fees in EPR for tyres	Provide incentive for manufactures to innovate and produce tyres with lower abrasion rate Provide incentive for the consumers to purchase low abrasion rate tyres Provide financing for road infrastructure measures	Medium costs to set-up and manage the scheme (where required) / minimal costs to amend existing schemes. Costs for industry depends on fee level and structure Fee might be passed on to consumers – higher costs of tyres	There are already EPR schemes for tyres covering end-of-life management in 20 Member States so limited social impact.

TYR#1: Emission limit values for particles from tyre wear/abrasion	Benefit in the order of 5-25% reduction of emissions Benefits can be realised fairly quickly	Precondition to have test method in place Costs of testing is assessed as low No or low additional costs for tyres with low abrasion rate	Important to make sure that safety is not compromised. Testing seems to indicate that there are lower abrasion tyres on the market which do not compromise on safety.
TYR#2: Emission/mileage labelling of particles released from tyre wear	Benefit depends on consumer reaction, supporting consumer awareness raising will be needed Benefits in the order of less than 1% reduction of emissions.	Precondition to have test method in place Costs of inclusion of abrasion levels on label minimal	To maximise the impacts of inclusion of tyre abrasion levels on labels, there should also be consideration of impacts for tyre lifetimes so consumers can see the potential financial benefits of buying lower abrasion tyres.
TYR#6: Regular wheel alignment to minimise tyre wear	Benefit potential depends on current situation which is not known. Maximum potential is in the order of 2%.	High total costs for checking wheel alignment at regular inspections and realigning where necessary.	Significant co-benefit is lower energy use and longer tyre life. This should increase the incentive for vehicle users. In some Member States these checks may already be mandatory.
TYR#5: Enhance monitoring of tyre pressure	It is estimated that this measure could give up to 10-20% emission reduction for an individual vehicle, but it depends on vehicle user's behaviour i.e. whether they actively follow the warning signals to inflate tyres.	System is already in place. Potentially only minor costs of calibrating the systems. Technical assessment to determine feasibility and appropriate threshold and consumer awareness raising activities.	Significant co-benefit is lower energy use and longer tyre life. This should increase the incentive vehicle users.

The impact of each measure is outlined below.

TYR#7: Road design and cleaning guidelines

What would be the costs of the measure?

The direct costs of developing guidelines for road design and road cleaning will be relatively small. The guidance could be incentivised by the EC and developed by a technical working group comprised of relevant Member States experts in road design, road cleaning and tyre abrasion.

In order for the guidance to achieve results, road authorities in the Member States would have to invest in specific technical measures. They are discussed below.

- For road design:
    - The road design elements where abrasion rate criteria could be added include, for example:
        - Choice of road surface materials (porous asphalt / rubber asphalt)
        - Road designs (use of roundabouts and traffic lights, road curvature etc.)
    - Using road surface materials which generate less abrasion is one that can be applied on most roads. It is likely that such pavements are more costly than the standards used today. Overall, it is difficult to estimate the costs as it will depend on how much of the road network where such surfaces would be applied. Applying careful identification of sections with high traffic loads and high levels of TWP emissions, the cost-effectiveness of this measure can be increased. There are examples of road surfaces that lead to more energy-efficient driving and less noise generation, where the additional investment costs are in the order of 10%[272]. The Danish example illustrates that although the surface is more expensive, the savings on energy consumption and the lower noise levels lead to a positive economic cost-benefit assessment.
    - Having abrasion rate criteria for road design is mostly relevant for new roads. Existing roads are not changed very frequently in terms of the use of different types of crossings, curvatures, etc. It is, therefore, a more long-term measure. There are no data to allow an assessment of the cost implications of including a criterion on abrasion rate in the construction or reconstruction of roads.
- Collection of road run-off
    - The costs of improving the collection and treatment of road run-off vary according to local conditions. There are many factors that make it very difficult to generalise the costs.
    - In urban areas with combined sewer systems, run-off is already collected and treated at UWWTP, albeit microplastics captured at the plant end up in the sewage sludge, which, in some Member States, is then spread on agricultural land. At heavy rain events, there may be storm-water overflows meaning the run-off is not treated and is released directly into the environment. In urban areas where run-offs are collected in a separate system, there are no additional costs of collection, but additional treatment needs to be put in place. Additional treatment can be costly to install.
    - Outside of the main urban areas, there might be varying degrees of collection and treatment. In many Member States, a collection of road run-off is installed for the most utilised roads[273] Upgrading existing collection and treatment could lead to

[272] See M. Pettinari, Bjarne Bo Lund-Jensen, B. Schmidt (2016) Low rolling resistance pavements in Denmark
[273] CEDR, 2016, Management of contaminated runoff water: current practice and future research needs

increased treatment, but the costs would vary depending on the specific local conditions.
    - In all cases, increased treatment would result in the generation of volumes of sludge with high concentrations of microplastics. There is currently no commercially available technology for removing microplastic (at least to any significant extent). It means that only the incineration of the sludge will remove the microplastics in the sludge.
- Intelligent road cleaning
    - The costs of this technical measure depend on current practices across the EU. If there is already regular road/street cleaning, then by focusing on cleaning of hotspots and aligning the timing with weather forecasts might not lead to any significant additional costs. If more frequent cleanings are required, the measure will increase the operating costs of the responsible authorities.
    - There are no data that provide an overview of the current practices in EU27, and therefore, it is difficult to estimate the costs. It would be necessary to have an estimate of the length of roads that could be considered as hotspots and costs per km of road cleaning.
    - The RIVM (2018) study has assessed the technical measure, and through a small survey of 8 municipalities in the Netherlands the study indicates that road cleaning takes place from 2 to 12 times annually. This indicates a large possible variation in current practices.

As this measure provides guidance, the actual level of implementation of the specific measures and the associated costs will depend on the uptake of the guidance by relevant Member State competent authorities.

What would be the benefits of the measure?

Given that the measure is guidance, the impacts will, as mentioned above, depend on the uptake by Member States.

Below, we discuss the possible benefits for each type of technical measure: road design, road run-off management and road cleaning.

- Road design:
    - Quantification of the benefits is challenging as there are no data on the distribution of emissions by the length of the network. The RAU study has estimated that emissions are higher at crossings and curves[274], but without more specific data, it is not possible to estimate the reduction potential. It can be noted that:
        - By considering hotspots, it might be possible to achieve cost-effective reduction
        - A full realisation of the measure will only happen in the long term. The road designs are not changed very frequently. Also, road surfaces have long lifetimes.
- Collection of road run-off
    - This technical measure will reduce the amounts of microplastic that are being washed into the freshwater environment. The total reduction potential is difficult to estimate. In principle, all the run-off in urban areas is collected. With the installation of filter systems on gullies in urban areas, at least 50% of the emissions collected by not treated

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    road-run off could be removed. Currently, about half the urban emissions are not treated. Installation of filters on all urban roads which are currently not subject to treatment of the run could amount to reductions in the order of 10%.

- Intelligent road cleaning
    - The RIVM 2018 study concludes that the effect is relatively low. The study estimates an effect of road cleaning in the order of 2% of the emissions being captured. The result was based on simulating a large number of cleaning events with varying efficiency. Such impacts are very localised in nature.

Economic impacts

The economic impacts depend on the use of the guidance and the level of implementation of the technical measures covered by the guidance.

- Road design:

The choice of using road surfaces that create less abrasion might initially lead to higher investment costs for road authorities. The benefits in terms of less energy consumption are gained by the road users.

The economic impacts depend on how road authorities will apply abrasion criteria and whether including such criteria will impact the costs of road construction and/or road maintenance. It might lead to higher costs, but data do not allow for the estimation of the magnitude of potential costs.

- Collection and treatment of road run-off

Increased collection and treatment of road run-off will require investment costs in collection and treatment systems. It is important to note that there are considerations on the management of stormwater in relation to the ongoing revision of the UWWT Directive. Storm-water overflows and non-treated stormwater causes pollution with a number of pollutants. Considering all the pollutants from road run-off might increase the cost-effectiveness of increased collection and treatment. However, the level of costs that would be attributable to the problem of tyre wear cannot be further assessed with significant in-depth analysis.

- Intelligent road cleaning

The economic impacts will be increased costs for road maintenance authorities. The costs will depend on current practices. In case street cleaning already takes place on a regular basis, optimisation with regards to hotspots and before major rainfall might not lead to any additional costs.

Environmental impacts

The environmental impacts depend on the use of the guidance and the level of implementation of the technical measures covered by the guidance.

- For road design

The environmental impacts will be proportional to the reduction in emissions, although they cannot be quantified.

- Collection and treatment of road run-off

Collection and treatment of road run-off will reduce the emissions reaching soils and being discharged into water bodies. The magnitude of the impacts depends on how much road run-off will be additionally collected and treated. As discussed above, the ongoing revision of the UWWT Directive might lead to changes in the management of stormwater, including road run-offs. If there are changes to the management of stormwater, it might have impacts on pollution with nutrients and micropollutants as well as microplastics.

It is important to note that currently, there is no commercially available technology to remove microplastics from the wastewater sludge to any significant extent (based on current knowledge). It means that the only method to manage the sludge so that the microplastics are permanently removed is incineration. Incineration could lead to negative air quality impacts as well as CO_2 emissions, and it is not in line with EU objectives on the circular economy.

- Intelligent road cleaning

The environmental impacts will be proportional to the reduction in emissions which are highly uncertain. Furthermore, it should be noted that if the overall level of street cleaning is increased, then it will lead to higher energy and water consumption.

Social impacts

The social impacts depend on the use of the guidance and the level of implementation of the technical measures covered by the guidance.

- For road design

The impact on human health from lower microplastic emissions will be proportional to the reductions achieved. If the use of more porous asphalt surfaces leads to less noise, it will have a positive impact on the human health of residents living nearby the roads.

- Collection and treatment of road run-off

The potential impacts on human health will be affected to the degree that the microplastic emissions are no longer released into soil or end up in water bodies.

- Intelligent road cleaning

The potential impacts on human health from less microplastic emissions will be proportional to the achieved reductions.

Illustrative example of the impacts and cost-effectiveness of collection of road runoff

An illustrative example comprises the installation of a filter at road gullies that collects the road runoff. The possible cost-effectiveness of this measure can be illustrated by estimating the costs of measures under different circumstances. It should be noted that local specific conditions can vary and the following calculations are illustrative.

Based on data from a project on improved collection and treatment of road runoff in Berlin[275], the following assumptions can be applied. The area that one gully drains is assumed to be 400 m2. The investment cost of a filter system that can retain 50% of microplastic emission is EUR 2000[276] and the lifetime of the filter system is assumed to be 20 years. The annual maintenance costs are EUR 120[277]. Based on these assumptions, the annualised investment costs can be estimated at EUR 130[278], so the total annual costs are EUR 250 per gully. The resulting costs for different road examples are illustrated below.

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[275] Barjenbruch, Matthias „DSWT - Dezentrale Reinigung von Straßenabflüssen - Projekt im Berliner Umweltentlastungsprogramm UEPII/2" / final report Berlin 2016

[276] Ibid

[277] Ibid

[278] The BR suggested discount rate is 3% and here a lifetime of 20 year is applied.

Table 26: Illustrative examples of potential costs of installation of filter systems in road gullies

Road section of 1 km	Road width (*)	Area	Number of gullies	Total annual costs in EUR
500 AADT	10 meter	10000	25	6,361
5,000 AADT	10 meter	10000	25	6,361
50,000 AADT	20 meter	20000	50	12,722
100,000 AADT	20 meter	30000	75	19,082

Source: Own calculations.
(*) The assumptions are that each lane including shoulder etc. is about 5 meter in width.

The annual amount of TWP is estimated using the standard emission rates. The filter is assumed to provide 50% efficiency, meaning the 50% of the microplastic will be retained in the filter.

To complete the illustrative example, the benefits of the gully filters installed at roads with different traffic loads has been assessed and is presented in the following table.

Table 27: Illustrative examples of potential benefits of treatment for different scenarios and overall cost-effectiveness

Road section of 1 km	TWP emission reduction in kg per year	Total costs of treatment	Cost-effectiveness
500 AADT	6,400	15	435
5,000 AADT	6,400	150	44
50,000 AADT	12,700	1,460	9
100,000 AADT	19,100	2,920	7

Source: Own calculations.

The illustrative example shows that for the busiest roads, the measure might be cost-effective. As noted, the filter system for road run-off will prevent the emission to soil and water if the sludge from the filters is managed in a safe way, for example, incinerated. The costs of filter sludge incineration are not included in the above calculation.

The above calculation indicates that it will only be cost-effective to install such a filter on the busiest urban road. There are no data on how much of the urban emissions are from such roads.

It should be noted that such filter systems are not likely to be cost-effective for rural roads. Not only are traffic volumes often low, but additional investment in collection systems will be needed.

TYR#3: Modulated fees in EPR for tyres.

What would be the costs of the measure?

The administrative costs would comprise:

- Setting up the organisation that should manage the EPR
- Running costs of the organisation managing the EPR

Currently, the majority of Member States (20 MSs) have set up an EPR for the end-of-life management of used tyres. These existing EPRs could be expanded to include tyre wear. Then, there would be a modulated fee where each manufacturer pays a fee differentiated by the level of abrasion. For the Member States with currently no EPR, there would be an initial cost of setting up and operating the system (noting that some of these appear to have some form of taxation in place covering end-of-life management of used tyres). For existing systems, the additional operating costs would be very limited. For new systems, the operating costs would have to be financed by the collected fee.

For all the companies placing tyres on the market, the costs would be:

- Testing of tyres in order to determine the fee (testing costs would be as defined under measure TYR#1)
- Payment of the fee

The cost burden of the importers and manufacturers will therefore primarily depend on the fee level. The fees are likely to be passed on to the consumers, so the costs will lead to price increases for the tyres, where the tyres with the highest abrasion rates will be more expensive.

The current EPR systems seem to vary with respect to organisational setup. In several Member States, there are more than one Producer Responsibility Organisation (PRO)[279]. It would therefore require further actions at the level of Member State authorities and industry to define and agree on set-up that could include tyre wear.

What would be the benefits of the measure?

The measure would provide benefits in several ways:

- Give manufacturers/importers an incentive to innovate to sell tyres with less emissions (to reduce their fee and thereby costs of the tyres)
- Give consumers an incentive to change to tyres with less tyre wear (assuming the fee would be passed on to the price of the tyre)
- Provide funding for road design and maintenance, collection and treatment of road run-off, intelligent road cleaning (see measure TYR#7) and/or other measures to capture and treat microplastic emissions from tyres.

It is not possible to quantify the total potential. Assuming the fee would be passed on the consumers and that it would be differentiated by emission rates, the measure might achieve reductions comparable with the effects of measure TYR#1 on type-approval although likely towards the lower end of the range unless fees were set very high. The likely impacts are highly uncertain and depend on the levels at which any fees are set.

The collected fees would then provide funding for the collection and treatment of road run-off, awareness-raising and/or other measures to capture and treat microplastic emissions from tyres. It is difficult to estimate how much this funding would be able to increase the collection and treatment of road run-off.

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[279] See for example: Winternitz, K, Heggie, M & Baird, J 2019, 'Extended producer responsibility for waste tyres in the EU: Lessons learnt from three case studies – Belgium, Italy and the Netherlands', Waste Management, vol. 89, pp. 386-396. https://doi.org/10.1016/j.wasman.2019.04.023

Economic impacts

The economic impacts will include the costs of expanding existing EPR schemes or setting up a new EPR scheme to cover the issue of tyre wear. The collected fees will be paid by the manufacturers but will be passed on to the consumers of the tyres. How much the consumers will be impacted will depend on the level of the fee.

Environmental impacts

The environmental damages are estimated to be reduced by the same order of magnitude as the reduction of the tyre wear. Potentially, this measure might lead to reductions of around 5% (lower end of the range for TYR#1) depending on the level of the fee and how much it would be differentiated by abrasion rate of the individual tyre.

The detailed environmental impacts cannot be assessed. The tyre wear comprises different particle sizes and has different content of hazardous substances. There are no data on the detailed composition of particle size and substances in the current emissions. Therefore, the impacts of the reduction of emissions cannot be estimated (see also the discussion on the health effects).

The reduction in emissions will be proportional for all the environmental compartments. No significant impacts are expected on waste, efficient use of resources or climate change.

Social impacts

The social impacts include potential human health impacts associated with microplastic emissions. If the measure would achieve emission reductions in the order of 5-25%. As discussed in the problem definition, the emissions of tyre wear contain a large number of chemical substances with varying levels of toxicity. A study has estimated the difference in a weighted toxicity index of a factor of 4 between the most and the least toxic tyre[280]. The health impacts will therefore depend on how the limit values are defined. If they include particle size and toxicity, the health impacts could be significantly reduced. If the criteria only focus on total tear wear mass, then there is a potential risk of an increase in the negative health impacts.

<u>TYR#1: Emission limit value for particles from tyre wear/abrasion</u>

It should be noted that there are significant uncertainties attached to the assessment. The following factors are most important for understanding the nature of the assessment and the inherent uncertainties.

- Test methods: Currently, the test methods for tyres are under development. Before a standardised test has been developed and agreed upon, the estimated reduction potentials are based on currently applied test approaches which vary between different studies. They might therefore give different results than what will be the case when a standard test method has been implemented.
- Volumes of different tyres sold (type, model, size) and their usage (i.e. vehicle kilometres driven).
- Costs of tyres and regulatory costs: As the test is not yet agreed upon, the costs for compliance with the test requirements and type approval are not yet known. Whether compliance with the

[280] Emission Analytics / PEW report (2022) - Research report - Tire chemical composition and wear emissions

future test requirements might lead to significant additional costs cannot be estimated using current evidence and will be evaluated in detail in Euro 7. The thorough analysis that will be required for setting limits in Euro 7 will also take into account potential R&D costs in order to change the tyre formulation and design in order to comply with the new limits and expected cost increases in the tyre price by the different materials/composition.

Therefore, the estimated values are uncertain, but the assessment provides the order of magnitude estimates based on current evidence for most of the measures.

Key assumptions:

- The emissions calculation, as presented in section 5 underpins the assessment of impacts on emissions as well as costs. The estimation is based on emission factors disaggregated by type of vehicle and the total km by urban roads, rural roads and motorways.
- The distribution of the emissions by environmental compartment, as described in section 4 underpins the assessment of any changes to where the emissions are released to.
- Where costs are annualised, the relevant lifetime is included, and the discount rate is 3%[281].
- The average lifetime of a tyre is assumed to be between 5-10 years (and depends on driving styles and mileage).

The measures will affect either the emission factors by vehicle types or the distribution of emissions by environment compartment.

What would be the costs of the measure?

The implementation of the measure would include the following potential cost elements:

- Compliance costs for type approval and market surveillance
- R&D Costs for tyre manufacturers of changing their design in case their tyres fail to comply with emission limits
- Cost premium of producing compliant tyres (if applicable)

Each of these cost elements is discussed below.

The cost of the type-approval procedure is one of the cost elements to be considered for this measure. Introducing an emission limit will require a type-approval procedure for all tyres placed on the EU markets. Data from the assessment of testing of tyres on safety, noise, and energy efficiency suggest costs in the order of EUR 5 000 - 10 000 per type of tyre[282]. The Eunomia (2018) study assessed and estimated the costs of introducing a type-approval requirement. The study estimated testing costs in the order of EUR 5 000 – 10 000, but it could be up to EUR 40 000[283]. Information from the industry indicates that type approval costs would be in the order of EUR 15 000[284]. The higher value is because the test is likely to be on-the-road tests. To reflect the uncertainties in what exactly the final testing

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281 BR Tool#64 Discount factors

282 SWD(2018) 189 final

283 Hann, S., Sherrington, C., Jamieson, O. et al., *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Eunomia report for the Directorate-General for Environment, 2018.

284 Personal communication from ETRMA, April 2022

method(s) will entail, this assessment assumes a range of EUR 5 000 - 15 000 with a mid-point of EUR 10 000.

The next step is to estimate the total costs associated with type approval and the cost impact for each tyre placed on the market. This impact depends on how many tyres are supplied for each specific type and tyre brand. Therefore, more popular tyres will be less cost impacted.

The Eunomia 2018 study found, through using different databases containing the individual tyre brands and types, that there are between 2 500 and 30 000 individual types of tyres (types and brands). Feedback provided by ETRMA[285] suggested that, on average, manufacturers renew their ranges every four years (or longer for some tyre types). ETRMA also provided a "worst case" estimate of tyres requiring type approval of around 1,700 each year. Taking this as an upper estimate and using the Eunomia lower estimate (but divided by four to derive an annual figure), the total costs of type approvals can be estimated and are presented in the table below.

Table 28: Total costs of tyre type approval costs (per year)

	Costs per type approval in EUR		
Number of tyre models (brand and type)	**5,000**	**10,000**	**15,000**
625	3 125 000	6 250 000	9 375 000
1,700	8 500 000	17 000 000	25 500 000

Source: Own calculation

According to the ETRMA database, the annual sales of tyres amounts to 325 million. Based on that the approximate cost impact per tyre sold on the market can be estimated assuming that all additional costs for type approval would be passed on to the consumer. This is done by dividing the total type approval costs by the total number of tyres sold.

Table 29: Average additional cost per individual tyre of type approval costs

	Type approval costs EUR per type of tyre		
Number of tyre models (brand and type)	5,000	10,000	15,000
625	0.01	0.02	0.03
1 700	0.03	0.05	0.08

Source: Own estimation

It means that the additional costs will vary between EUR 0.01 to EUR 0.08 per tyre. It is, in any case, a relatively low additional cost. This would amount to less than 0.1% of the price of an average tyre[286].

The introduction of type approval for tyre abrasion would require some market surveillance by the Member State authorities in order to ensure that only tyres meeting the requirements are being placed

285 Personal communication from ETRMA, June 2022

286 Assuming a price around EUR 100 per tyre.

on the market. Such surveillance will already be done by the Member States to check for other requirements; therefore any additional time and cost burdens are expected to be minimal.

The next cost elements to consider include:

- Costs for tyre manufacturers of changing their design in case their tyres fail to comply with emission limits
- Cost premium of producing compliant tyres (if applicable)

Manufacturers will have to ensure that all the tyres they produce comply, and that may require a redesign of certain tyres. It should be noted that the tyre industry is constantly developing tyre designs aimed at improving tyre performance based on R&D activities. The design of tyres includes balancing and optimising a large number of performance criteria. The additional costs for adjusting the tyre design to comply with the type approval specifically for abrasion are highly uncertain and cannot be quantified.

There are also no detailed statistics that can allow for an assessment of the cost difference between tyres with low or high abrasion rates, and discussions with the industry have not revealed any obvious price differentials linked to abrasion rates. The ADAC study indicates that both low and high rates of TWP are found in different price segments of the tyre market. It is, therefore, not necessarily the case that tyres with lower abrasion rates are more expensive to produce and, therefore, more expensive for the consumers. Consultation with the industry has also not identified any evidence of lower abrasion tyres costing more. Therefore, for this assessment, no additional costs are assumed for producing compliant tyres.

The last cost-related element to consider is that of a potential longer lifetime of the tyres with lower abrasion rates. There is no strict correlation between abrasion rate and lifetime (mileage of a tyre). A longer lifetime of tyres can be achieved by improving the quality of the material and adding to the thread depths and mass. It means that there could be examples of tyres where poorer material is causing the high abrasion rate but also a higher lifetime due to design characteristics. There are no data to undertake a detailed assessment of this aspect.

It is assumed the additional costs for producers to comply with a type approval regulation will be passed on to the tyre price. Savings from a longer lifetime might partially offset the additional costs of tyres, although this is highly uncertain, as discussed above.

Therefore, the costs expected for this measure are those associated with type approval which gives costs between EUR 3 and 26 million per year depending on the final costs of the test method and number of tyre models to be tested each year.

What would be the benefits of the measure?

A few studies have assessed the reduction potential of setting emissions standards that prevent the worst-performing tyres from being placed on the market. For example, a study by ADAC that tests passenger car tyres regularly has compared abrasion rates with safety performance across several different tyre models, sizes and types. They conclude that it is possible to find tyres with low emission rates and sufficient safety performance. The emission reductions from the best performing tyres to the average are about 15-30% in all the tested tyre categories (summer/winter and tyre sizes).

Table 30: ADAC tyre testing abrasion rates

Type of tyres	Average in g/1000 km	Lowest abrasion rate	% Difference
Summer tyres			
185/65/R15	95	60	37
205/55/R16	115	80	30
225/40/R118	130	110	15
Winter tyres			
185/65/R15	110	85	23
195/65/R15	140	100	28
205/55/R16	120	85	29

Source: ADAC

Another study is by Emissions Analytics 2022[287]. They have measured a sample of 13 tyres, whether the wear rate varies between 38 mg/vkm and 89 mg/vkm[288]. The average of the 13 tyres was 65 mg/vkm. The absolute values cannot be compared as the testing methods might vary. However, the study indicates that the tyres with the lowest abrasion rate are around 37% lower than the average, and the tyres with the highest abrasion rates are 33% above the average. The distribution of the total tyre sales (and their subsequent usage) by abrasion rate for both studies (ADAC and Emissions Analytics) is not known.

The estimated reduction potential will depend on the testing method. As an official testing method is still only under development, it might be that the reduction potential will turn out differently when a standard test method is finally agreed upon. Another factor is that increased focus on the abrasion rate and the potential definition of the limit values for abrasion might lead to innovation given even lower abrasion rates. There could be merit in considering phased limits which tighten over time as the manufacturers produce new, lower abrasion models.

A study by RIVM[289] has assessed the likely impacts of this measure (amongst others) on reducing emissions from tyres based on a review of available literature and traffic and vehicle statistic for the Netherlands. The study estimates a reduction potential in the order of 5-15% out of the total emissions from tyre wear.

Based on the above discussion, a range in the order of 5-25% is estimated as the reduction potential. The low end of the range is based on the above considerations on what removing the worst-performing tyres would mean on the total emissions combined with the RIVM study results. The high end of the range is based on a higher degree of ambition and would require the replacement of at least 50% of current tyre types with lower-emitting ones.

The estimated emission reductions for TYR#1 is shown in the table below. The range is estimated to be between 29,000 and 143,000 tonnes per year.

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287 Emissions Analytics 2022 Tire chemical composition and wear emissions

288 There is one value of 161 which for this assessment is excluded as it very much different from rest of the tyres.

289 A.J. Verschoor and E. de Valk, RIVM 2017, *Potential measures against microplastic emissions to water,* RIVM Report 2017-0193

Table 31: Estimated emission reductions for TYR#1 – annual emissions in tonnes

	2020	2030		
Effect of measure	Total emissions	Total emissions	Emissions with measure	Effect of measure
Low (5%)	450 000	570 000	541 500	28 500
High (25%)	450 000	570 000	427 500	142 500

Based on the estimated costs and the estimated reduction potential, the cost-effectiveness of the measure can be estimated. This is estimated to be between EUR 41 and 612 per tonne of microplastic emission reduction (depending on assumptions). There are also likely to be additional benefits in terms of a longer lifetime of lower abrasion tyres, although there is limited evidence to quantify this, and the industry has noted[290] that tyre lifetime is not just a function of tread but also overall tyre structure and integrity.

Economic impacts

The economic impacts are summarised in the table below based on the above analysis. Economic impacts are expected to be weakly negative overall, with some additional costs for manufacturers. These costs are likely to be passed on to the consumers of tyres.

290 ETRMA, personal communication, April 2022.

Table 32: Economic impacts of TYR#1

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	-	Importers and manufacturers of tyres	It might cost more to produce compliant tyres (although the evidence does not seem to indicate this), but the cost increase will affect all manufacturers and importers. Hence it can be passed on to the consumer prices.
Administrative burdens on businesses	-	Importers and manufacturers of tyres	The estimated cost of type-approval per tyre is in the order of EUR 5 000 to 15 000 based on the costs of different options for the testing method.
Operation / conduct of SMEs	- /0	Few SMEs would be affected	Tyre manufacturers are generally larger companies and hence, limited impacts on SMEs.
Functioning of the internal market and competition	0	Importers and manufacturers of tyres	The cost impacts are moderate and affect all importers and manufacturers of tyres. Hence the internal market and the level of competition should not be affected.
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	Member State competent authorities	This measure will only require resources in the phase of introducing the measure.
Public authorities: Change in costs to the Commission	-	European Commission and EU institutions	This measure will only require resources in the phase of introducing the measure.
Innovation and research	-/+	Manufacturers of tyres	There will be an incentive to innovate to comply with emission limits, and this might take R&D resources away from R&D in other aspects of tyre performance. Unclear whether there are trade-offs or synergies.
Third countries and international relations	+/-	Third countries	The measure will require third-country manufacturers to comply.
Consumers and household	0	Households	The potential impacts on tyre prices are uncertain but are expected to be limited.

Environmental impacts

Overall, the emission reduction is estimated in the order of 5-25% (between 28,500 to 142,500 tonnes per year) and the environmental damages are estimated to be reduced by the same order of magnitude. The detailed impacts cannot be assessed. The tyre wear comprises different particle sizes and has different content of hazardous substances. There are no data on the detailed composition of particle size and substances in the current emissions. Therefore, the impacts of emissions reduction cannot be estimated (see also the discussion on the health effects).

The reduction in emissions will be proportional to all of the environmental compartments. No significant impacts are expected on waste, efficient use of resources or climate change.

Social impacts

The social impacts primarily include human health impacts. There are two components to consider:

- Potential health impacts from reduced emissions of microplastics
- Possible impacts on road safety leading to more casualties

Overall, the emission reduction is estimated in the order of 5-25%. As discussed in the problem definition, the emissions of tyre wear contain a large number of chemical substances with varying levels of toxicity. A study has estimated the difference in a weighted toxicity index of a factor of 4 between the most and the least toxic tyre[291]. The health impacts will therefore depend on how the limit values are defined. If they include particle size and toxicity, the health impacts could be significantly reduced. If the criteria only focus on total tear wear mass, then there is a potential risk of an increase in the negative health impacts.

The safety of the tyres could potentially be compromised, but it depends on how the measure is implemented (and the level at which a limit value is set) and the choice of the consumers. However, there is a minimum standard for safety, so the introduction of a limit value for abrasion cannot lead to tyres with safety characteristics below the type-approval requirement[292]. Furthermore, the ADAC study has shown that there are already tyres on the market with low abrasion with no compromises for safety. Therefore, no reduction in safety is expected.

No impacts on employment are expected considering the relatively low-cost impacts and the fact that any additional costs would likely be passed on to the consumer.

<u>TYR#2: Emission labelling of particles released from tyre wear</u>

What would be the costs of the measure?

The introduction of TWP emission labelling requires – just as the measure on type-approval above – that standardised test methods have been developed. As described above under TYR#1, such a test method is being developed, and it is considered to be available (and needed) before introducing TWP labelling of tyres. Hence, the implementation of the measures would include the following costs:

- Costs for tyre manufacturers of having their tyres tested
- Cost of changing the label
- Consumer information campaigns

There will be a cost of having each type of tyre labelled. The cost of testing is assumed to be similar to the costs of type-approval described above the TYR#1(but if both measures are combined, then testing costs here would be zero as already accounted for in 4f). The cost of the testing has been estimated to be in the order of EUR 5 000 to 15 000 per type of tyre. It has been estimated to mean additional costs per tyre at a level between EUR 0.01 and 0.08 depending on how many individual tyres are produced and sold for a given type as well as the final choice of test method; see Table 128.

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[291] Emission Analytics / PEW report (2022) - Research report - Tire chemical composition and wear emissions

[292] See Type Approval Regulation (EC/661/2009) Annex B

Tyre manufacturers would not have to redesign their tyres, but the label will give an incentive to improve the design in order to achieve a better scoring on the criteria.

The final cost element is related to the modification of the label to include the abrasion rate. Eunomia (2018) concludes that the costs of modifying the label will be marginal when compared to the price of each tyre sold on the market. The Commission's Staff Working Document accompanying the proposed revision of the Tyre Labelling Directive provides some estimates of the costs to manufacturers of revising the existing labels[293]. This assumes a one-off cost of EUR 40 million for the readjustment of label classes and reprinting labels. The costs for incorporating abrasion classes / levels in the label have been assumed to be similar to this.

In addition, it is assumed that some level of consumer information campaigns would be delivered to maximise the benefits of the measure and ensure that consumers understand what the labels are showing. Based again on the estimates developed for the revision of the Tyre Labelling Directive, this is assumed to be a one-off cost of around EUR 12 million.

Therefore, the total costs associated with the measure (excluding type approval which is included within 4f) are around EUR 52 million (one-off) equating to around EUR 6 million per year when annualised over 10 years.

For the motorist, the measure will not lead to additional costs as it will still be possible to purchase any tyres (although it is likely that manufacturers would pass on the above costs in tyre prices). If the label includes the mileage of the tyre, the consumer will be able to see whether a low abrasion tyre would also be the better choice from a financial perspective.

What would be the benefits of the measure?

The effect of a label depends on how the consumers will react, which is difficult to assess. The level of information that is provided will affect the impacts of the label e.g. whether consumer awareness information campaigns are launched.

Eunomia (2018) has assessed the uptake and effect of introducing a TWP label. The study refers to the observed effects of the labels on energy efficiency and wet grip, where the annual changes have been in the order of 1% improvement for energy efficiency (in total across all tyres due to changes in consumer purchase behaviour). While energy efficiency improvements have a financial implication for vehicle users and wet grip has a safety aspect, tyre abrasion is much more abstract for the consumer (unless a clear link to tyre lifetime / durability could be established and communicated). Therefore, the reduction potential of the label is estimated to be much lower, between 0.1-0.2% annual improvement on overall tyre microplastic emissions, which, if introduced in 2025, could give a total reduction of 0.5-1% in 2030.

Table 128: Estimated emission reductions for TYR#2

	2022	2030		
Effect of measure	Total emissions	Total emissions	Emissions with measure	Effect of measure
Low (0.5%)	450 000	570 000	567 150	2 850
High (1%)	450 000	570 000	564 300	5 700

[293] Available from : https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/1460-Evaluation-and-potential-revision-of-the-EU-tyre-labelling-scheme_en

The costs-effectiveness of the measure is estimated in the order of EUR 1 100-2 100 per tonne reduced emissions of TWP.

Economic impacts

The main economic impact is the costs of having all type of tyres tested to determine the label rating. While the testing costs might turn out differently from what is the current estimate when the final testing method has been developed and agreed, it is unlikely to be of a different order of magnitude. These costs are described and included under TYR#1. Costs for changing the label and information campaigns are expected to be around EUR 6 million per year.

The testing and label cost will firstly be borne by the manufacturers/retailers but is then expected to be passed on to the consumer in the price of the tyre. For the consumers, it means a marginal increase in the price of the tyre. Therefore, it is not expected to have any significant impacts on consumers. Costs for information campaigns are expected to fall to the Member States and Commission.

It may be most effective to consider including the abrasion rate alongside impacts on tyre lifetime as lower abrasion rates may equate to an increase in tyre lifetime, thus saving consumers money. This is considered to be a much greater driver for consumer purchasing than microplastic emissions[294]. The effect of a label depends on how the consumers will react, which is difficult to assess. The level of information that is provided will affect the impacts of the label e.g. whether consumer awareness information campaigns are launched.

Eunomia (2018) has assessed the uptake and effect of introducing a TWP label. The study refers to the observed effects of the labels on energy efficiency and wet grip, where the annual changes have been in the order of 1% improvement for energy efficiency (in total across all tyres due to changes in consumer purchase behaviour). While energy efficiency improvements have a financial implication for the vehicle users and wet grip has a safety aspect, tyre abrasion is much more abstract for the consumer (unless a clear link to tyre lifetime / durability could be established and communicated). Therefore, the reduction potential of the label is estimated to be much lower, between 0.1-0.2% annual improvement on overall tyre microplastic emissions, which, if introduced in 2025, could give a total reduction of 0.5-1% in 2030.

Impacts on other economic impact categories are expected to be similar as for TYR#1.

Environmental impacts

Overall, the emission reduction is estimated to be in the order of less than 1% and the environmental damages are estimated to be reduced by the same order of magnitude. The detailed environmental impacts cannot be assessed. The tyre wear comprises different particle sizes and has different content of hazardous substances. There are no data on the detailed composition of particle size and substances in the current emissions. Therefore, the impacts of the reduction of emissions cannot be estimated (see also the discussion on the health effects).

The reduction in emissions will be proportional for all of the environmental compartments. No significant impacts are expected on waste, efficient use of resources or climate change.

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[294] https://ec.europa.eu/info/sites/default/files/energy_climate_change_environment/overall_targets/documents/tyre-label_final-report_0.pdf

Social impacts

The social impacts primarily include potential human health impacts. There are two components to consider:

- Potential health impacts from reduced emissions of microplastics
- Possible impacts on road safety leading to more casualties

Overall, the emission reduction is estimated to be in the order of less than 1%. As discussed in the problem definition, the emissions of tyre wear contain a large number of chemical substances with varying levels of toxicity. A study has estimated the difference in a weighted toxicity index of a factor of 4 between the most and the least toxic tyre[295]. The health impacts will therefore depend on how the limit values are defined. If they include particle size and toxicity, the health impacts could be significantly reduced. If the criteria only focus on total tear wear mass, then there is a potential risk of an increase in the negative health impacts.

The safety of the tyres could potentially be compromised, but it is not likely. There are minimum standards for safety, so the introduction of a label for abrasion rate cannot lead to tyres the safety characteristics below the type-approval requirement[296]. It is not likely that consumers will be more inclined to buy tyres where the safety performance is low if a tyre abrasion rate label would be introduced. Therefore, no reduction in safety is expected.

No impacts on employment are expected considering the relatively low-cost impacts and the fact that any additional costs would likely be passed on to the consumer.

<u>TYR#6: Regular wheel alignment to minimise tyre wear</u>

What would be the costs of the measure?

The costs of this measure relate to ensuring the wheels are aligned as part of the regular vehicle roadworthiness inspection. Some Member States seem to have this included as a mandatory requirement as part of regular vehicle inspections (at least France, Ireland and Spain[297]) although there is very limited data on the national practices across all of the EU27 for this particular check and therefore, it is difficult to estimate the costs (so costs and benefits presented below may be overestimates if more Member States already require such checks). Furthermore, the share of cars which may have wheels / axis that are not aligned is not known. RIVM (2017) refers to studies that suggest that potentially a large share of cars needs this adjustment. The estimate for the Netherlands is that it could affect between 20% to 40% of the total car stock. They estimate that the level of abrasion could be around 10% higher for vehicles with poor alignment. It means that if these estimates would apply to the EU27, the total reduction potential would be between 2% - 4% (in practice it is lower as some Member States already require such checks).

To assess the cost-effectiveness of this measure, the following assumptions have been used. The cost of testing for the alignment would be in the order of EUR 20 and in case the axis would need adjustment that would cost around EUR 40[298]. It is assumed that 30% of the inspected cars and vans needs the adjustment every 4 years. This gives a total cost of around EUR 1.2 billion per year

[295] Emission Analytics / PEW report (2022) - Research report - Tire chemical composition and wear emissions
[296] See Type Approval Regulation (EC/661/2009) Annex B
[297] Personal communication from the International Motor Vehicle Inspection Committee (CITA), July 2022.
[298] Expert estimates based on information from car repair shops

assuming all Member States apply the measure (except for France, Ireland and Spain who already require such checks).

The alignment of wheels would also have an impact on the energy use of the car or van. The RIVM (2017) study suggests that it is in the same order as for abrasion rates i.e. 10%. Assuming that 30% of existing cars and vans would need adjustment, this would give a potential fuel saving for the fleet of around 1.6% (as new cars and vans are excluded). This equates to a financial saving of around EUR 1.5 billion per year[299]. The potential saving for tyre costs is highly uncertain so has not been quantified but would increase the cost savings further.

Total estimated costs and cost savings are presented in the table below.

Table 33: Estimated total costs and cost savings for TYR#6 in 2030 (million Euros)

Cost element	One-off costs	Recurring costs	Total annualised costs
Testing and alignment costs	0	1,176	1,176
Fuel savings	0	-1 526	-1 526
Total costs	**0**	**-350**	**-350**

Overall there is expected to be a net cost saving associated with this measure due to the potential fuel savings that may be realised. These equate to a cost-effectiveness of EUR -28 900 to -57 700 per tonne of microplastics reduced i.e. a saving overall. If fuel savings are excluded, then the cost-effectiveness is EUR 96 400 to 193 700 per tonne of microplastics reduced.

What would be the benefits of the measure?

Based on RIVM (2017) the emission reductions per car or van which is subject to an adjustment of misaligned wheel would be around 10%. Assuming that the vehicle drives 12 000 km per year, the savings can be estimated to be around 0.12 kg per car.

As discussed above, the RIVM also estimated the share of vehicles with misalignment to be between 20 and 40%. This leads to annual emission reduction of 2% to 4% for cars and vans and 1.1% to 2.1% for the fleet overall (taking into account that some Member States already require such checks).

Table 34: Estimated emission reductions for TYR#6

	2022	2030		
Effect of measure	Total emissions	Total emissions	Emissions with measure	Effect of measure
1.1% reduction	450,000	570,000	563,928	6,072
2.1% reduction	450 000	570 000	557 856	12,144

[299] Based on vehicle kilometre data from Eurostat, average fuel economy figures from the IEA Fuel Economy in the European Union analysis and average fuel costs from the EEA (available from https://www.eea.europa.eu/data-and-maps/daviz/nominal-and-real-fuel-prices-6#tab-chart_1).

In addition to the reductions in microplastic emissions, improvements in fuel efficiency, discussed above, could also lead to a reduction in CO_2 emissions of around 6,610 kt in 2030. The CO_2 savings can also be valued and equate to around EUR 661 million per year[300]. There would also be benefits for the reduction of exhaust emissions of air pollutants (for ICEVs).

Economic impacts

The main direct economic impacts would be the costs for motorists to have the wheel alignment checked at the roadworthiness inspection and the alignment adjusted where needed. The inspection is mandatory when the car is four years old and then at least every four years[301]. The additional costs at the inspection could be around EUR 20 every four years. For those where adjustment would be needed, there would be another EUR 40 to be paid. Total costs would be in the order of EUR 1.2 billion in annual costs.

A side-effect of wheel alignment is reduced energy consumption and lower tyres costs due to longer lifetimes. These will lead to cost savings for the motorists. As described above, these have been estimated to be in the order of EUR 1.5 billion per year due to fuel savings, although these are highly uncertain due to limited evidence on the proportion of vehicles that operate with misaligned tyres.

Environmental impacts

Based on the RIVM (2017) study, the reduction potential could be estimated in the order of 1.1% to 2.1% for the fleet overall (taking into account that some Member States already require such checks). If testing of alignment is already mandatory in more Member States than those identified, the potential would be less. The environmental damages would be reduced by the same order of magnitude (as would costs).

The reduction in emissions will be proportional for all the environmental compartments. The measure would also reduce energy consumption. It means a positive impact on climate change as in 2030 a significant share of passenger cars would still be with internal combustion engines. Reductions in CO_2 emissions of around 6,610 kt may be realised in 2030.

No significant impacts are expected on waste.

Social impacts

The social impacts include potential human health impacts. Overall, the emission reduction is estimated in the order of 1.1% to 2.1% for the fleet overall (taking into account that some Member States already require such checks). Any potential health impacts are estimated to be reduced by the same order of magnitude.

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300 Based on average fleet emission factors from EEA analysis and expectations for the future (https://www.eea.europa.eu/ims/co2-performance-of-new-passenger). The avoided CO2 cost is based on the Update of the External Costs of Transport, with a central value for the short-and-medium-run costs (up to 2030) of EUR 100/tCO2 equivalent for external costs of climate change (https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1)

301 There are Member States with more frequent inspections.

TYR#5: Enhanced monitoring of tyre pressure

What would be the costs of the measure?

Tyre Pressure Monitoring Systems (TPMS) are already required on new cars and vans (and have been since 2014), and will be in the future for trucks. This measure includes two elements:

- Change the calibration of the systems for new vehicles being placed on the market so that it gives a warning with smaller deviations from the optimal pressure levels (exact threshold to be determined based on a more in-depth technical assessment).
- Information campaigns to make all motorists aware of the importance of having the right pressure (as it has several benefits).

Changing the systems to provide a warning at a lower threshold is not expected to entail any significant costs for new cars and vans. However, an in-depth technical assessment would need to be undertaken at an EU level to determine the feasibility of changing the threshold considering the uncertainties associated with the existing systems. Both indirect and direct systems are currently applied across the EU and the uncertainties associated with the systems differ. Engagement with relevant stakeholders has not identified any clear evidence on whether or not it is feasible to tighten the current threshold so further investigations are necessary. Furthermore, if deemed feasible to tighten the thresholds, then such an assessment would need to consider the optimal level at which the thresholds should be set taking into account levels of tyre abrasion, the sensitivity and accuracy of the systems and likely driver behavioural response. This has been assumed as a one-off cost of EUR 1 million.

The main effect will only be achieved if motorists are aware of the importance of having the correct pressure. Therefore, information campaigns would be useful to actually achieve the desired effects. Such campaigns can differ in scope and scale of effort, and with more effort, more impacts are expected to be achieved. Assuming the campaign would cost in the order of EUR 0.8 million per Member State[302], the total costs would be around EUR 22 million one-off costs for a campaign across the EU. If such campaigns could be done at EU level or based on material produced for all Member States, it might be possible to reduce the costs.

By having the right pressure, energy consumption will also decrease and the lifetime of the tyres would increase. It means that motorists that frequently drive with tyres at low pressure will save on fuel and tyre costs if they make sure to regularly fill tyres with air. Fuel consumption is estimated to increase by 1% every 2,9 psi / 0.2 bar the tyre is under-inflated[303]. Current TPMS systems should alert the driver when the pressure drops by 20%[304]. If we assume that the system would be changed to alert the driver when tyre pressure drops by 10% instead (actual figure to be determined via an in-depth technical assessment) and the average car tyre has a recommended pressure between 2 and 2.2 bars (when cold)[305] then the impact (benefit) on fuel consumption could be around 1%.

However, this is based on the assumption that all drivers would refill their tyres when the warning shows. Recent surveys have shown that with the current systems (which are much less sensitive than

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302 Data from Danish Road Safety organisation that runs multiple campaigns indicating that the average costs of a campaign is 6 million DKK. (https://www.ft.dk/samling/20191/almdel/TRU/bilag/418/2218983/index.htm)

303 https://unece.org/DAM/trans/doc/2007/wp29grrf/ECE-TRANS-WP29-GRRF-62-inf17e.pdf

304 https://op.europa.eu/en/publication-detail/-/publication/e96ed45b-d8a8-11e8-afb3-01aa75ed71a1

305 Review of selected tyres available on the market.

they would be under this measure) some drivers still ignore such warnings[306]. TNO (2013)[307] considered a low and high response scenario, with the latter assuming the user always responds to TPMS warnings and the former around half respond. The high response scenario is not considered realistic here; therefore, a range of 50-75% of users responding to TPMS alerts has been assumed.

Considering the introduction of the measure in 2025 and around 25% of cars and vans in 2030 having such a system, this would give a potential fuel saving for the fleet of around 0.1-0.2%. This equates to a financial saving of around EUR 124 to 210 million per year[308]. The potential saving for tyre costs is highly uncertain, so it has not been quantified but would increase the cost savings further.

Total estimated costs and cost savings are presented in the table below.

Table 35: Estimated total costs and cost savings for TYR#5 in 2030 (million Euros)

Cost element	One-off costs	Recurring costs	Total annualised costs
Technical assessment	1.0	0.0	0.1
Information campaigns	21.6	0.0	7.6
Fuel savings (low)	0.0	-124.4	-124.4
Fuel savings (high)	0.0	-210.7	-210.7
Total costs (low)	**22.6**	**-124.4**	**-116.7**
Total costs (high)	**22.6**	**-210.7**	**-203.0**

Overall there is expected to be a net cost saving associated with this measure due to the potential fuel savings that may be realised. These equate to a cost-effectiveness of EUR -7,470 to -39,130per tonne of microplastics reduced, i.e. a saving overall. If fuel savings are excluded, then the cost-effectiveness is EUR 500 to 1500 per tonne of microplastics reduced.

What would be the benefits of the measure?

The effect of the measures is difficult to estimate as the share of cars and vans driving with tyres with sub-optimal tyre pressure is not known. RIVM (2017) refers to older data on the share of both heavy-duty vehicles and cars, indicating that a large share of vehicles is operated with tyres with sub-optimal pressure. The RAU project (see Figure 4) suggests that the effect of the tyre pressure on microplastic emissions is 30-40%, but it is unclear how low the pressure should be before such an effect materialises. RIVM (2017) estimates that the reduction potential could be 10-20%, but the uptake by the motorist is key for achieving the full potential.

Here is assumed that, in combination with information campaigns, the measure can achieve around a 10-20% reduction in microplastic emissions, which, when combined with the share of cars and vans expected to have the new threshold applied by 2030 (25%) and an assumption that 50-75% of users respond to TPMS alerts, gives a total microplastic reduction of around 0.9-2.7%.

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306 https://www.transportenvironment.org/wp-content/uploads/2021/07/Report%20-%20EU%20drivers%20at%20risk%20of%20under-inflated%20tyres.pdf

307 https://ec.europa.eu/clima/system/files/2017-03/tno_2013_final_report_en.pdf

308 Based on vehicle kilometre data from Eurostat, average fuel economy figures from the IEA Fuel Economy in the European Union analysis and average fuel costs from the EEA (available from https://www.eea.europa.eu/data-and-maps/daviz/nominal-and-real-fuel-prices-6#tab-chart_1).

Table 36: Estimated emission reductions for TYR#5

	2022	2030		
Effect of measure	Total emissions	Total emissions	Emissions with measure	Effect of measure
0.9% reduction	450 000	570 000	564 813	5 187
2.7% reduction	450 000	570 000	554 382	15 618

In addition to the reductions in microplastic emissions, improvements in fuel efficiency, discussed above, could also lead to a reduction in CO_2 emissions of around 540 to 910 kt in 2030. The CO_2 savings can also be valued and equate to around EUR 54 to 91 million per year[309]. There would also be benefits for the reduction of exhaust emissions of air pollutants (for ICEVs).

Economic impacts

The main direct economic impacts will be the costs of undertaking an in-depth technical assessment to determine the optimal level at which the systems should be set (assumed as a one-off cost of EUR 1 million) and the costs for undertaking information campaigns to raise awareness amongst consumers (assumed to be around EUR 22 million one-off costs for a campaign across the EU). Changing the systems to provide warning at a lower threshold is not expected to entail any significant costs for new cars and vans.

Having the optimal level of tyre pressure will reduce energy consumption and lead to a longer lifetime of the tyres. These will lead to cost savings for motorists. As described above, these have been estimated to be in the order of EUR 124 to 210 million per year due to fuel savings, although these are highly uncertain and depend on the reaction of the consumer to a more sensitive TPMS.

Environmental impacts

Overall, the emission reduction is estimated in the order of 0.9-2.7% in 2030 (increasing in future years as more vehicles have the new threshold applied) and the environmental damages are estimated to be reduced by the same order of magnitude.

The reduction in emissions will be proportional for all the environmental compartments. The measure would also reduce energy consumption. It means a positive impact on climate change as in 2030 a significant share of passenger cars would still be with internal combustion engines. Reductions in CO_2 emissions of around 540 to 910 kt may be realised in 2030 depending on consumer behaviour.

No significant impacts are expected on waste.

[309] Based on average fleet emission factors from EEA analysis and expectations for the future (https://www.eea.europa.eu/ims/co2-performance-of-new-passenger). The avoided CO2 cost is based on the Update of the External Costs of Transport, with a central value for the short-and-medium-run costs (up to 2030) of EUR100/tCO2 equivalent for external costs of climate change (https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1)

Social impacts

The social impacts include potential human health impacts from reduced emissions of microplastics. Overall, the emission reduction is estimated in the order of 0.9-2.7% in 2030, and any potential health impacts are estimated to be reduced by the same order of magnitude.

Having the correct tyre pressure may also have marginal impacts (benefits) on safety and noise, but they cannot be further quantified.

7.3 Impact of measures for textiles

Table 37 shows the comparison between all measures evaluated to reduce microplastic emissions from textiles.

Table 37: Comparison of measures for textiles

Measure	Estimated reduction potential		Estimated Cost-effectiveness (EUR/tons reduced/year)	Other environmental impacts	Other economic impacts	Social impacts
	%	Ktons/ year				
TEX#8: Raising awareness on best practices for consumers of textiles		Not quantified small				
TEX#9: Mandatory label showing textiles' emissions of microplastics		Not quantified small	> 411 000		Costs are likely to be passed on to consumers	
TEX#7: Modulated fees in EPR for textiles				Not quantified		Costs are likely to be passed on to consumers in higher prices.
TEX#2): Restrict oil-based synthetic fibres for certain applications		26 353 (1 420 – 51 285)	202 000 €/t (103 000 – 3 747 000 €/t)	Negative impact on water consumption & biodiversity Reduction of microplastic pollution in marine environment, air and soil	Costs are likely to be passed on to consumers in higher prices	

Measure	Estimated reduction potential		Estimated Cost-effectiveness (EUR/tons reduced/year)	Other environmental impacts	Other economic impacts	Social impacts
	%	Ktons/ year				
TEX#3: Restrict synthetic fibres & fabrics with high releases of microplastics	28 %	17 168 (923 – 33 412)	176 000 (90 000 – 3 265 000)	Negative impact on water consumption and biodiversity Reduction of microplastic pollution in marine environment, air & soil	Costs are likely to be passed on to consumers in higher prices	
TEX#4: Mandatory prewashing of textiles before placing on the market		854 (96 – 1 613)	1 802 000 (955 000 – 16 102 085)			
TEX#5: Specific wastewater treatment in textile production plants	8%	4 024 (287 – 7 760)	143 000 (74 000 – 2 000 000)	Negative impact on water consumption and CO2 emissions Reduction of microplastic pollution in marine environment, air and soil	Costs are likely to be passed on to consumers in higher prices	
TEX#6: Compulsory filters for washing machines	5%	3 087 (635 – 5539)	2 627 000 (1 464 000 – 12 764 000)	Negative impact on water consumption and CO2 emissions Reduction of microplastic pollution in marine environment	Costs are likely to be passed on to consumers in higher prices	
TEX#1: Standardised methodology to quantify microplastics releases from textiles						

Table 38Table 38 shows the comparison of the impacts of the measures assessed to reduce microplastic emissions from textiles.

Table 38: Summary of impacts for measures for textiles

Policy measure	Environmental impact	Economic impact	Social impact
TEX#8: Raising awareness on best practices for consumers of textiles	The communication campaign will raise awareness about microplastic releases, but it is uncertain how and if it will influence the consumer decision about purchases and washing/drying practices.	Cost estimated to be EUR 449 million per year; it will depend on the level of ambition of the communication campaign.	Job creation in the communication sector
TEX#9: Mandatory label showing textiles' emissions of microplastics	Reduction of microplastic releases if the label would influence the consumer purchase decision in favour of textiles releasing less microplastics.	Between 1.41 and 1.72 billion euros per year, depending mainly on the testing costs. Increase in costs for consumers (EUR 0.06) per clothing put on the market) as the producers might pass it on.	Job creation in labelling and certification companies
TEX#7: Modulated fees in EPR for textiles	Tool to combine with other measures	EPR cost (PRO, MS, companies): The additional cost of this measure might be relatively low since will it only add the inclusion microplastics in the criteria for modulation of textile fees. SMEs Public authorities	Consumers and households
TEX#2: Restrict synthetic fibres for certain applications	Microplastic release reduction (26 353 t/year) Environment (climate change)	Total cost (5.3 billion EUR/year)	Consumers and households
TEX#3: Restrict synthetic fibres & fabrics with high releases of microplastics	Microplastic release reduction (17 168 t/year) Environment (water, biodiversity)	Material cost (3 billion EUR/year) SMEs Public authorities (only short-term) Third countries	Consumers and households

Policy measure	Environmental impact	Economic impact	Social impact
TEX#4: Mandatory prewashing of textiles before placing on the market	Microplastic release reduction (854 t/year) Environment (water, climate change)	CAPEX (washing and drying machines) OPEX (water, energy, detergent, labour) Total cost (1.54 billion EUR/year) SMEs Public authorities Third countries	Consumers and households
TEX#5: Specific wastewater treatment in textile production plants	Microplastic release reduction (4 024 t/year) Environment (water quality, climate change)	CAPEX OPEX (energy) Total cost (594 million EUR/year) SMEs Public authorities Third countries	Consumers and households
TEX#6: Compulsory filters for washing machines	Microplastic release reduction (3 087 t/year) Environment (water, climate change)	CAPEX (filters) OPEX (water and energy) Total cost (8.1 billion EUR/year) Public authorities (only short-term) Already in place France (applicable from 2025)	Consumers and households
TEX#1: Standardised methodology to quantify microplastics releases from textiles	No emission reduction per se but helpful in other measures and knowledge improvement	Administrative cost (expert group and companies): 0.85 million EUR/year Cost of testing the materials between EUR 10 000 and 20 000	There could be new jobs in the R&D sector (private company or research organisations) unless developed by the existing research staff

The impact of each measure is outlined below.

<u>TEX#8: Raising awareness on best practices for consumers of textiles</u>

What would be the costs of the measure?

The cost will be the labour cost to run the communication campaign in the EU.

What would be the benefits of the measure?

The benefit would mainly be raising consumer awareness and may lead to a small reduction of microplastic releases.

Economic impacts

The table below details the data about the administrative cost of the communication campaign.

Table 39: Data to estimate the communication campaign administrative cost

Description	Data	Unit	Source
Days of work to communicate in the EU	1 350	days	Assumption based on expert judgement
Overheads	11	%	Assumption based on expert judgement
Average hourly labour cost in the "Information and communication" sector (EU 27)	39.40	EUR/hour	Eurostat (2020)
Average EU number of working hours per day	8.12	hours/day	

Considering an average of 50 days of work for each Member State in the EU27, the total cost of a communication campaign would be around EUR 449 000 per year. These campaigns could also take place at the Member-State level and be financed by the EPR schemes.

The cost will depend on the level of ambition of the communication campaign. In comparison with other measures, the cost would always be low.

Environmental impacts

The communication campaign will raise awareness about microplastic releases, but it is uncertain how and if it will influence the consumer decision about purchases and washing/drying practices. Research[310] shows that price is the most influencing factor in consumer purchasing decisions. However, according to the Eurobarometer survey[311], more than half of respondents think that educating people on how to reduce their plastic waste is very important (58%). It is expected that the emission reduction potential of this measures is rather low.

Social impacts

No significant social impacts are expected.

<u>TEX#9: Mandatory label showing textiles' emissions of microplastics</u>

What would be the costs of the measure?

The cost of a mandatory label is composed *measure* of three parts:

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310 For example: Sanad, R. A. (2016). Consumer attitude and purchase decision towards textiles and apparel products. World, 2(2016), 16-30.

311 Attitudes of European citizens towards the Environment (Eurobarometer 2019).

- Tests
- Audits
- Label

The tests and audits cost to apply to each textile collection while the label to each piece of textile.

This measure will only require the resources of public authorities in the phase of introducing the measure. SMEs will be affected as textile production is not limited to larger companies. The measure will require third-country companies to comply with placing textiles on the EU market. Consumers and households will be affected by this measure as they will likely support the cost of the label.

What would be the benefits of the measure?

The benefits would be a reduction of microplastic releases if the label would influence the consumer purchase decision in favour of textiles releasing less microplastics. Brands would also feel the need to reduce releases in order to improve their rating in terms of microplastic releases and this would have impacts along the textiles value chain.

Economic impacts

Table 40: Assumptions to estimate the costs of a mandatory label

Description	Data	Unit	Source
Total cost of the tests	660	EUR per collection	Assumption based on Bureau Veritas prices in ADEME (2020), Définition de critères d'éco-modulation applicables à la filière REP TLC[312].
	1 440	EUR per collection	
Audit cost for a label	1 700	EUR per collection	EU Ecolabel
	2 000	EUR per collection	EU Ecolabel
Labelling cost (just the label)	0.03	EUR/ pieces	Bilateral discussion with industry.
Administrative cost	11%	%	Assumption based on expert judgement
Number of collections put on the market in the EU	25 157 780 000	pieces	JRC, Environmental Improvement Potential of textiles (IMPRO Textiles), January 2014.
Average number of pieces per collection	100 000	pieces per collection	ADEME (2020), Définition de critères d'éco-modulation applicables à la filière REP TLC[313]

The total average cost of the label is around EUR 1.56 billion per year. The cost range varies between EUR 1.41 and 1.72 billion per year, depending mainly on the uncertainty of the test costs.

312 https://librairie.ademe.fr/dechets-economie-circulaire/4561-definition-de-criteres-d-eco-modulation-applicables-a-la-filiere-rep-tlc.html

313 https://librairie.ademe.fr/dechets-economie-circulaire/4561-definition-de-criteres-d-eco-modulation-applicables-a-la-filiere-rep-tlc.html

By assuming that the higher bound consumption change would be that 10 % of the population would change their purchase behaviour and therefore reduce the total microplastic releases from textiles by 10 %, even without taking the additional material cost into account, it would correspond to an average cost of 411 000 EUR/t of avoided microplastics.

If the measure TEX#9 "Mandatory microplastic label for textile" is combined with the variation of measure "TEX#1 Create a standardized measure to quantify microplastics emissions on the life-cycle", the cost would be reduced from EUR 1.56 billion per year to EUR 795 million per year. This is due to the fact that the variation of TEX#1 already implies the existence of a standard and respective testing costs.

Environmental impacts

The label will raise awareness about microplastic releases but is it uncertain if the label will influence the consumer decision. Research[314] shows that price is the most influencing factor in consumer purchase decisions. Also, brands would be incentivised to reduce releases to improve their rating and promote their image as sustainable producers.

Assuming that the higher bound consumption change would be that 10 % of the population would change their purchase behaviour and therefore reduce the total microplastic releases from textiles by 10 %, the average microplastic releases reduction would be 3 808 t per year. However, if the switch happens to natural fibres, other impacts (see other measure TEX#2) would increase, in particular, related to land use and biodiversity.

Social impacts

The consumer would bear the label cost in the end. The average label cost per piece of textile put on the EU market is EUR 0.06.

<u>TEX#7: Modulated fees in EPR for textiles</u>

What would be the costs of the measure?

An EPR leads to an administrative cost for several actors:

- Producer responsibility organisations (PROs)
- Companies
- Member States

The EPR would lead to the use of resources for public authorities and to an administrative burden for companies (including SMEs). The consumer will likely support the cost of the EPR system.

What would be the benefits of the measure?

The benefits depend heavily on how the microplastic component of the EPR is implemented.

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[314] For example: Sanad, R. A. (2016). Consumer attitude and purchase decision towards textiles and apparel products. World, 2(2016), 16-30.

The EPR could reduce microplastic releases if the modulated fees provided incentives for companies to reduce microplastic releases and if the EPR fees financed microplastic releases reduction measures.

Economic impacts

The table below details the data for the EPR administrative cost.

Table 41: Data to estimate the EPR administrative cost

Description	Data	Unit	Year	Source
Entities placing on the market				
Number of marketers in the EU – textiles	160 000		2020	Euratex
Number of marketers in the EU - washing machines	27			Gifam
One time shot to organise EPR - companies	0.001	FTE	-	Feasibility of an EPR system for micro-pollutants (070201/2020/837586/SFRA/ENV.C.2)
Annual FTE for EPR - companies	0.001	FTE	2000	Fost plus study2
Overheads for the companies, EPR	11%		2021	Feasibility of an EPR system for micro-pollutants (070201/2020/837586/SFRA/ENV.C.2)
PROs				
Number of FTE for the EPR	183	FTE	2021	Feasibility of an EPR system for micro-pollutants (070201/2020/837586/SFRA/ENV.C.2)
One shot consultancy cost to organise the EPR	1 235 000	EUR		Feasibility of an EPR system for micro-pollutants (070201/2020/837586/SFRA/ENV.C.2)
Number of days for financial audit per PROs and of the quality of the declaration and statistics of the PRO members	50	days/ year	-	Feasibility of an EPR system for micro-pollutants (070201/2020/837586/SFRA/ENV.C.2)
Member State				
Number of days per Member State to control for EPR	20	days/ year	-	Feasibility of an EPR system for micro-pollutants (070201/2020/837586/SFRA/ENV.C.2)
General				
Average annual EU FTE admin cost	52 309	EUR/ FTE	2021	Eurostat
Average annual EU FTE financial and insurance activities	82 430	EUR/ FTE	2021	Eurostat

Description	Data	Unit	Year	Source
Average EU number of working hours per day	7.98	h/day	2021	Eurostat
Average EU number of working days per year	230	Days /year	2000	Fost plus study[315]
Amortisation of the one-shot cost	20	years	-	Feasibility of an EPR system for micro-pollutants (070201/2020/837586/SFRA/ENV.C.2)

The total administrative cost of an EPR for textiles would be around EUR 21.1 million per year. PROs and companies would bear most of the cost; respectively EUR 11.2 and 9.8 million per year. The share of the costs of the Members States would be EUR 0.14 million per year. However, this measure is not about setting up a new EPR, but including microplastics in an existing one. To include a cost component, we have estimated that taken into account microplastics would cost 5% of the total cost for the EPR, thus a set up cost of around EUR 1 million. Currently, there is already an EPR for textiles in France. An EPR for textiles is expected in the following years in the Netherlands and Sweden. The cost of the measure could therefore be a bit lower, but it would not change the impact calculations, and the cost of this measure is negligible compared to most of the other measures.

The EU Strategy for Sustainable and Circular Textiles includes proposing of an EU wide EPR with modulated fees. This will be established in the revision of the Waste Framework Directive and evaluated in the respective IA. Therefore the additional cost of this measure might be relatively low since it will only add the inclusion microplastics in the criteria for modulation of textile fees.

Environmental impacts

The environmental impact depends heavily on the way the microplastic release component is included in the EPR. The eco-modulated fee could provide incentives for microplastics reduction and/or the impact of another measure that the EPR would finance.

The environmental impacts are difficult to be estimated, as they will depend on the level of the modulated fees. If textiles with high emissions have higher fees, microplastics emission of those would decrease. In measure TEX#2, we analyse a restriction of synthetic fibers. A modulated fee will always have a much lesser effect than such a total ban (restriction). Supposing a perfect price elasticity, we can assume that cost efficiency would be similar, but the order of magnitude of the reduction much lower and the measure more proportionate.

Fees could be used to improve technology and wastewater treatment. While technology improvement can have a significant effect over the medium to long term, it is to be expected that the level of the fees will be too low to have an important improvement in microplastic capture in wastewater.

Social impacts

No significant social impacts are expected for the administrative costs.

[315] RDC Environment, Emploi et investissements liés aux activités de collecte sélective, tri et recyclage des projets FOST PLUS, 2000

The cost of the EPR system will likely be supported by the consumer, but the administrative cost is very limited (on average less than EUR 0.001 per piece of textile).

<u>TEX#2: Restrict synthetic fibres for certain applications</u>

What would be the costs of the measure?

The economic cost is the cost difference of the switch of fibres (cotton, wool, flax, viscose, polyester, acrylic, polyamide, polypropylene).

When comparing the production costs of textiles made from the different fibres, the significant difference comes from the prices of these fibres. The change in production process is not considered significant for the total cost[316] but investments may be required in some cases.

This measure will only require resources of public authorities in the phase of introducing the measure. SMEs will be affected as textile production is not limited to larger companies. The measure will require third country manufacturers to comply when placing textiles on the EU market.

What would be the benefits of the measure?

This measure acts on the emission of microplastics during production, wearing, washing and drying according to the proportion of synthetic materials in clothing.

Economic impacts

The costs associated with the foregone synthetic fibres were compared to those associated with the additional natural fibres, and the total cost of the measure was computed.

Table 42: Prices of fibres

Fibre	Data	Unit[317]	Source
cotton	2.59	EUR/kg	IndexMundi
wool	10.75	EUR/kg	IndexMundi
flax	3.11	EUR/kg	Indexbox
viscose	3.68	EUR/kg	Fiber2Fashion
polyester	1.23	EUR/kg	Fiber2Fashion
acrylic	2.32	EUR/kg	Fiber2Fashion
polyamide	2.78	EUR/kg	Plasticker
polypropylene	1.40	EUR/kg	Plasticker

[316] The yarn represents more than 50 % of the total fabric cost (Handfield, R., Sun, H., & Rothenberg, L. (2020). Assessing supply chain risk for apparel production in low cost countries using newsfeed analysis. Supply Chain Management: An International Journal.).

[317] The used exchange rates were taken from the European Central Bank.

The total cost of the measure is EUR 5.3 billion per year. It corresponds to 202 000 EUR/t of avoided microplastics on average (lower bound: 103 000 EUR/t; higher bound: 3 747 000 EUR/t).

In addition, further assessment is still needed on the possible scalability of production and competitiveness.

Environmental impacts

The measure allows an average reduction of 26 353 tonnes per year (lower bound reduction: 1 420 tonnes per year, higher bound reduction: 51 285 tonnes per year).

The environmental analysis carried out on the production of raw materials (fibre production) shows an increase in the impact of water consumption between the baseline scenario and measure 1a (+37%). This increase is linked to the increase in the proportion of cotton. Indeed, cotton production involves intensive use of water (Luján-Ornelas C. et al., A Life Cycle Thinking Approach to Analyse Sustainability in the Textile Industry:A Literature Review, Sustainability 2020, 12, 10193).

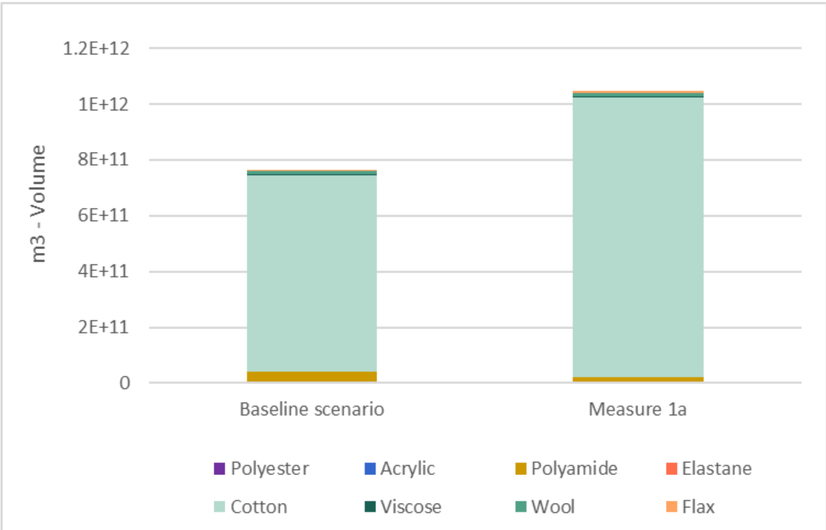

Figure 37: Water use for the production of textile raw materials (quantities of textiles: 9 million tonnes)

The figure only shows the production of fibres. The other stages of the life cycle (production, use, distribution, end of life) are also impacted by the change of raw materials (e.g. different dyeing, different care conditions) but the main impact is the raw material production. (ETC, Microplastic pollution from textile consumption in Europe, February 2022).

The following figure shows the global warming impact of clothing production (including the production of raw materials).

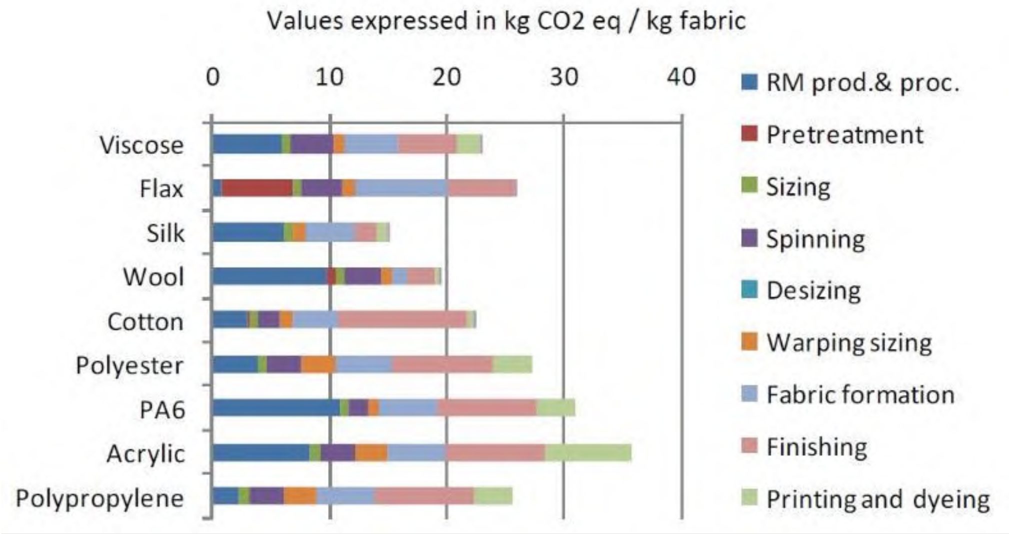

Figure 38: Impact on climate change due to the production of fabric from different fibres types

For the production of raw materials, cotton and polyester have a similar impact on climate change. Cotton has a lower impact than polyester in the production of the fabric (pretreatment to printing and dyeing). Thus, cotton fabric has a lower impact than polyester fabric.

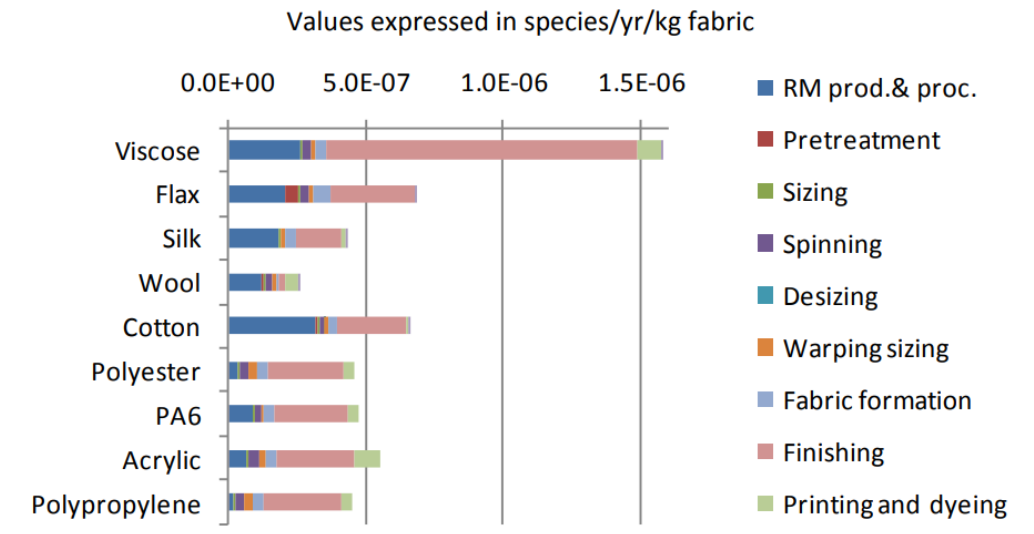

Figure 39: Impact on ecosystem diversity due to the production of fabric from different fibre types

The impact on ecosystem diversity is bigger for most natural fibres (viscose, flax and cotton) than for synthetic fibres.

Biodiversity was assessed qualitatively in the T-shirts PEFCR pilot[318] as there is currently no adequate indicator to express impacts on biodiversity[319].

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318 Sandrine Pesnel, Jérôme Payet (Cycleco) on behalf of the Technical Secretariat of the T-shirts PEFCR pilot, Product Environmental Footprint Category Rules (PEFCR) T-shirts, February 2019.

319 Technical Helpdesk, Mark Goedkoop, Issue Paper - Addressing biodiversity in the Environmental Footprint pilots, May 2015.

Activities related to clothing production contribute to the impact on biodiversity. Mainly, it focuses on raw material extraction and production of natural and synthetic fibres. Five potential pressures constitute an important effect on biodiversity: loss and degradation of natural habitats, overexploitation of biological resources, pollution and excessive nutrient loads, climate change and invasive alien species on the ecosystem[320].

The relations between raw material and their consequences on biodiversity are described in the following list:

Raw material for natural fibres (from crops) as cotton, hemp, flax, etc.:

- extensive area cropland could cause degradation and fragmentation of habitats;
- use of large amount of water with a significant impact on the ecosystem, for instance cotton production uses more water consumption than flax or hemp;
- chemical product as fertilizers or pesticides and other agricultural chemicals contributing to excessive nutrient lead in soil and water.

Raw material for natural fibres (from animals) as wool, silk, etc:

- impact from multiple land uses affect to degradation and fragmentation of natural habitats, however, for the production of silk the area extension impact is limited by way of cultivation;
- the livestock production pollution impact could come from pesticides used to protect animals from parasites (for wool);
- climate change impact has as its source the fossil fuel used in the agrochemicals production, the farming and distribution of feed crops, as well as the own livestock.

Raw material for artificial or regenerated fibres as viscose:

- lack of management of natural forests and plantations could occasion degradation and fragmentation of habitats;
- utilisation of agrochemical in forest plantations and the pulp mill could discharge pollutants into soil and water;
- loss of forest and use of energy contribute to the climate change impact.

Raw material for synthetic fibres as polyester: only the areas exploitation for non-renewable sources and energy use contribute to impact the pressures mentioned before.

There are different production processes to obtain viscose. The impact on global warming and human toxicity varies greatly depending on the production method (production of the wood pulp and chemical process to obtain the viscose) (Li Shen et al., Environmental impact assessment of man-made cellulose fibres; Changing Markets Foundation, Dirty Fashion – How pollution in the global textiles supply chain is making viscose toxic, June 2017).

Social impacts

The economic cost of the measure per piece of clothing is approximately EUR 0.21 which is likely to be passed on to consumers in price rises.

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[320] IUCN (International Union for Conservation of Nature), Biodiversity Risk and Opportunities in the Apparel Sector, 2016

There are also potential health impacts from reduced emissions of microplastics.

TEX#3: Restrict synthetic fibres & fabrics with high releases of microplastics

What would be the costs of the measure?

The economic cost is the cost difference of the switch of fibres (cotton, wool, flax, viscose, polyester, acrylic, polyamide, polypropylene) like for measure TEX#2: Restriction of all synthetic fibres for certain applications. The price of the fibres is detailed in Table 42.

When comparing the production costs of textiles made from the different fibres, the significant difference comes from the prices of the fibres. The change in the production process is not significant.

This measure will only require the resources of public authorities in the phase of introducing the measure. SMEs will be affected as textile production is not limited to larger companies. The measure will require third-country manufacturers to comply when placing textiles on the EU market.

What would be the benefits of the measure?

This measure acts on the emission of microplastics during production, wearing, washing and drying according to the proportion of synthetic materials in clothing.

Economic impacts

The costs associated with the foregone synthetic fibres were compared to those associated with the additional natural fibres, and the total cost of the measure was computed. The assumption taken is thus a complete switch from these "high release synthetic fibres" by natural fibres. Hereunder is a variation with a switch from these fibres to "low release synthetic fibres".

The total cost of the measure is around EUR 3 billion per year. It corresponds to 176 000 EUR/t of avoided microplastics on average (lower bound: 90 000 EUR/t; higher bound: 3 265 000 EUR/t).

Environmental impacts

The measure allows an average reduction of 17 168 tonnes per year (lower bound reduction: 923 tonnes per year, higher bound reduction: 33 412 tonnes per year).

The environmental analysis carried out on the production of raw materials (fibre production) shows an increase in the impact of water consumption between the baseline scenario and measure 1b (+23%). The explanation is the same as for measure TEX#2: Restrict synthetic fibres for certain applications.

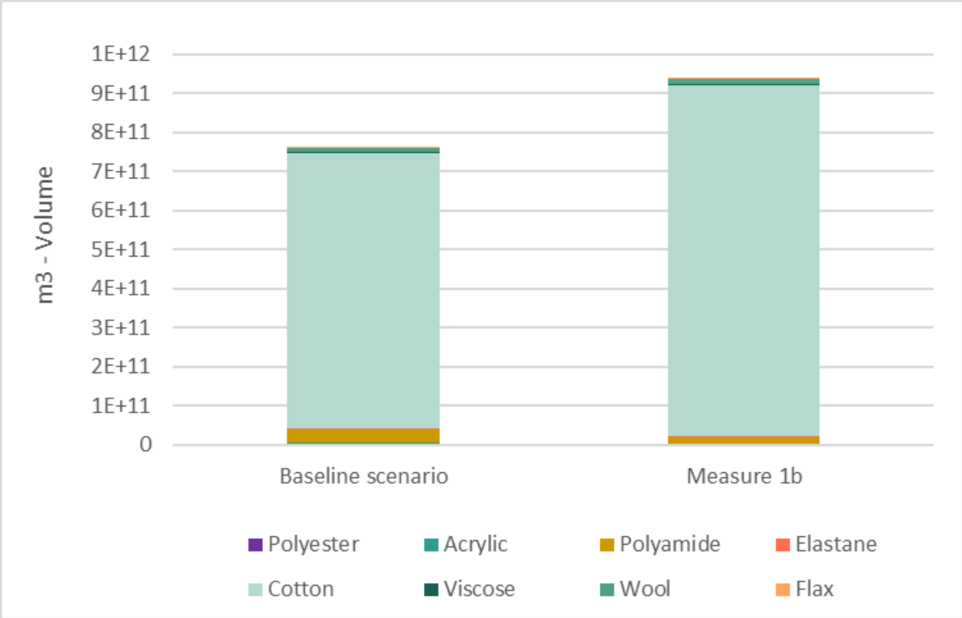

Figure 40: Water use for the production of textile raw materials (quantities of textiles: 9.0 million tonnes)

As for measure TEX#2: Restrict synthetic fibres for specific applications, the other stages of the life cycle are also impacted by the change of raw materials, but the main impact is the raw material production.

Social impacts

The economic cost of the measure per piece of clothing is approximately EUR 0.12 which is likely to be passed on to consumers in price rises.

There are also potential health impacts from reduced emissions of microplastics.

Variation of the measure

For the type of clothes with high releases of microplastics, synthetic fibres could be replaced by synthetic fibres with lower microplastic releases (instead of natural or artificial ones). The total economic cost to replace knitted polyester with acrylic for those clothes would be EUR 670 million per year. The measure variation allows an average reduction of 1 249 tonnes of microplastics per year (lower bound reduction: 134 tonnes per year, higher bound reduction: 2 365 tonnes per year). The microplastic release reduction is low because there is no reduction for production and wearing as there is no specific emission data per synthetic fibre despite the fact that these life-cycle steps are significant in terms of microplastic releases. This variation measure is not cost-effective as it leads to EUR 536 000 per of avoided microplastics on average (lower bound: 283 000 EUR/t; higher bound: 4 998 000 EUR/t).

If we assume that the microplastic release reduction for production and wearing would be the same as for washing (around 15 %) by replacing knitted polyester with acrylic, the measure variation will allow an average reduction of 5 877 tonnes of microplastics per year (lower bound reduction: 318 tonnes per year, higher bound reduction: 11 436 tonnes per year). It corresponds to an average cost of 114 016 EUR/t of avoided microplastics (lower bound: 58 592 EUR/t and higher bound: 2 109 597 EUR/t). This estimation is not based on scientific evidence but on an approximate extrapolation.

If we assume that the microplastic release reduction for production and wearing would be the same as for washing (around 15 %) by replacing knitted polyester with acrylic, the measure variation would allow an average reduction of 5 877 tonnes of microplastics per year (lower bound reduction: 318 tonnes per year, higher bound reduction: 11 436 tonnes per year). It corresponds to an average cost of 114 000 EUR/t of avoided microplastics (lower bound: 59 000 EUR/t and higher bound: 2 110 000 EUR/t). This estimation is not based on scientific evidence but on an approximate extrapolation.

TEX#4: Mandatory prewashing of textiles before placing on the market

What would be the costs of the measure?

The main costs would be the operating cost and conduct of business (CAPEX and OPEX) to prewash the textiles before placing them on the market.

This measure will require the resources of public authorities in the phase of introducing the measure and to organise the audits to control the certification schemes. SMEs will be affected as textile production is not limited to larger companies. The measure will require third-country manufacturers to comply when placing textiles on the EU market.

What would be the benefits of the measure?

This measure acts on the emission of microplastics during washing and drying with an assumed reduction of microplastic releases of 11% (assumption based on Textile Mission (2021) Textiles Mikroplastik reduzieren - Erkenntnisse aus einem Interdsziplinären Forschungsprojekt).

Economic impacts

The main cost impacts are:

- Capital expenditures:
  - industrial washing machines
  - dryer machines
- Operational expenditures:
  - energy consumption (gas, electricity)
  - water consumption
  - labour

Table 43: Data to estimate the costs of prewashing

Description	Data	Unit	Source
Number of production plants in the EU	160 000	plants	Euratex (2019)
Number of production plants outside the EU for the EU market	201 739	plants	Assumption based on European Environment Agency and Statista data
EU textile production	6 900 000	tonnes/year	European Environment Agency (2020)
Worldwide textile fibres production	109 000 000	tonnes/year	Statista (2020)

Description	Data	Unit	Source
Textiles imported into the EU in 2020	8 700 000	tonnes/year	European Environment Agency (2020)
Industrial washing machine price (capacity of 50kg)	7 200	EUR	Taizhou Haifeng Machinery Manufacturing Co,. Assumption based on expert judgement - Running time of 30 minutes
Water consumption - washing machine	15	l/kg of textiles	
Gas consumption - washing machine	1.925	MJ/kg of textiles	
Electricity consumption - washing machine	0.08	kWh/kg of textiles	
Dryer machine price (capacity of 50kg)	54 000	EUR	Taizhou Haifeng Machinery Manufacturing Co,. Assumption - running time of 30 minutes
Gas consumption - washing machine	4	MJ/kg of textiles	
Electricity consumption - washing machine	0.42	kWh/kg of textiles	
Average lifetime - Industrial dryer and washing machine	12	years	Assumption based on literature
Water price (EU)	4.01	EUR/m³	Economic Information and Forecasting Office(BIPE), French Federation of Water Enterprises (FP2E), 7th edition of the study on public water and sanitation services in France and abroad (2020)
Water price (Asia)	0.68	EUR/m³	CEIC, Price monitoring center
Electricity price (EU)	0.14	EUR/kWh	Eurostat (2020) for EU27, IA electricity consumption without taxes
Electricity price (Asia)	0.11	EUR/kWh	Global petrol prices
Gas price	0.00695	EUR/MJ	Eurostat (2019)
FTE	0.000050	per washing/drying cycle	Assumption based on expert judgement - 5 minutes per washing/drying cycle
Average yearly labour cost for manufacturing sector (EU)[230]	51 091	EUR/year	Eurostat (2020
Average yearly labour cost for manufacturing sector (non-EU)	11 590	EUR/year	Trading economics
Detergent consumption	10	g/kg	European Commission - Best Environmental Management Practice (2017)
Detergent price	0.15	EUR/kg	

The energy cost (including gas and electricity) represents the biggest part of the cost, 40% for EU plants and 56% for plants outside the EU.

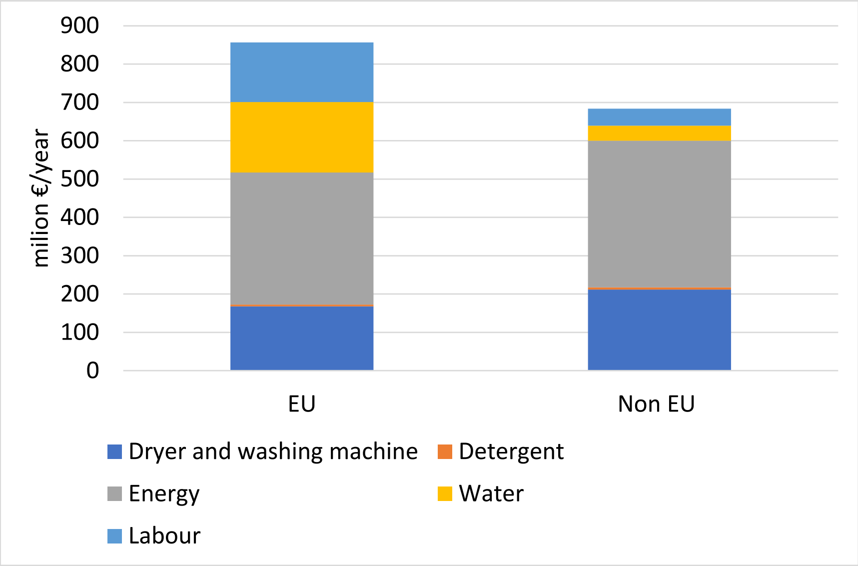

Figure 41: Prewashing step costs

The total cost of a prewashing step would be around EUR 1.54 billion per year. It would cost around EUR 856 million per year for plants in the EU and EUR 684 million per year for plants exporting to the EU from outside of the EU.

This cost is a higher bound cost because we supposed that textiles are not prewashed in the baseline as we do not have data about the numbers of plants and the amount of textiles that is already prewashed before placing on the market.

It corresponds to an average cost of 1 802 000 EUR/t of avoided microplastics (lower bound: 955 000 EUR/t and higher bound: 16 102 085 EUR/t).

Environmental impacts

The measure equates to an average reduction of 854 tonnes per year (lower bound reduction: 96 tonnes per year, higher bound reduction 1 613 tonnes per year).

The main impacts on global warming are related to energy consumption (electricity and heat) for washing and drying[321]. Considering a European consumption of 9 million tonnes of textiles, the impact on GHG emissions for prewashing is 8 364 kt CO_2 eq. It corresponds to around 0.93 kg CO_2 eq/kg of clothing. For the whole life cycle, this represents an increase of about 2% of the climate change impact of textiles.

[321] Electricity mix of Asia is used to model prewashing outside Europe. Heat is produced from natural gas.

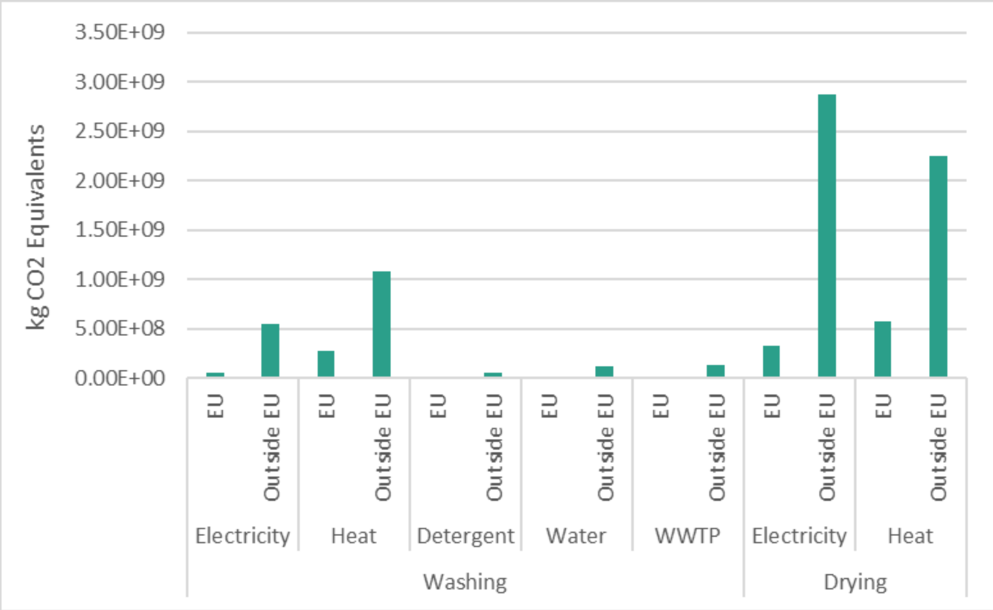

Figure 42: Impact of prewashing on climate change

The main impact on water use is related to water consumption during the washing. Considering a European consumption of 9 million tonnes of textiles, the impact on water use for prewashing is 1.44 billion m³. It corresponds to around 160 l/kg of clothing.

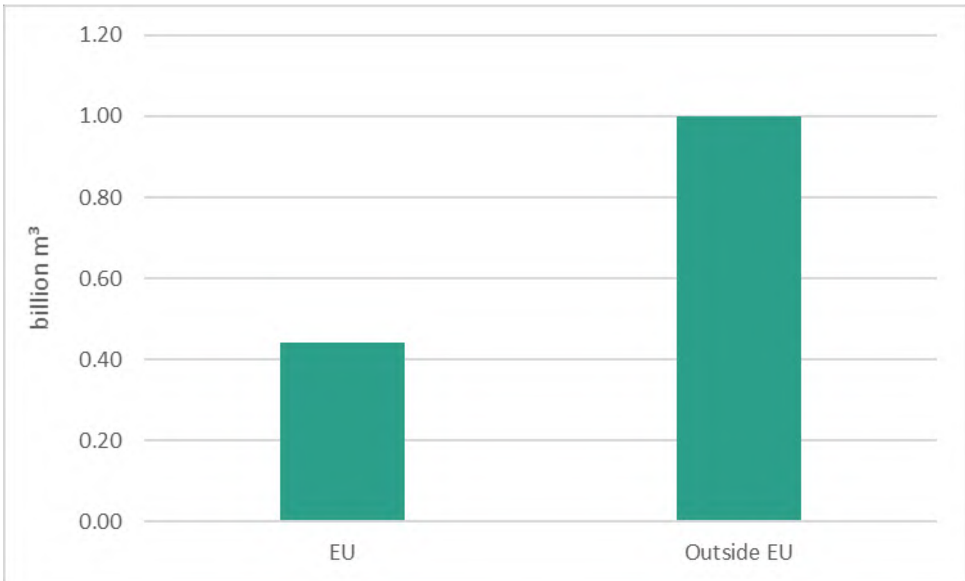

Figure 43: Impact of prewashing on water use (measure 3)

Social impacts

The average economic cost of the measure per piece of clothing is EUR 0.06 which is likely to be passed on to consumers as a price increase.

There are also potential health impacts from reduced emissions of microplastics.

TEX#5: Specific wastewater treatment in textile production plants

What would be the costs of the measure?

The main costs would be the operating cost and conduct of business (CAPEX and OPEX) to have a wastewater treatment tackling microplastics in textile production plants.

We do not have data about the number of plants that already have a wastewater treatment system that is effective in limiting microplastic releases. The costs and benefits of this measure are higher bound estimations because we assumed that none of the plants is equipped with wastewater treatment to limit microplastic releases.

This measure will require the resources of public authorities in the phase of introducing the measure and to organise the audits to control the certification schemes. SMEs will be affected as textile production is not limited to larger companies. The measure will require third-country manufacturers to comply when placing textiles on the EU market.

What would be the benefits of the measure?

This measure acts on the emission of microplastics during production and is assumed to reduce emissions of microplastics by 25% during production (assumption based on expert judgement).

Economic impacts

The table below details the data to compute the costs of this measure.

Table 44: Data to estimate the costs of wastewater treatment in production plants

Description	Data	Unit	Source
Number of production plants in the EU	160 000	plants	Euratex (2019)
Number of production plants outside the EU for the EU market	201 739	plants	Assumption based on European Environment Agency and Statista data
EU textile production	6 900 000	tonnes/year	European Environment Agency (2020)
Worldwide textile fibres production	109 00 000	tonnes/year	Statista (2020)
Textiles imported into the EU in 2020	8 700 000	tonnes/year	European Environment Agency (2020)
CAPEX - Textile wastewater machine price	21 420	EUR	Gongyuan Environmental Equipment
Average lifetime of the machine	15	years	Assumption based on review of literature
Electricity	29 000 000	MJ/year	WP08, E. N. E. A. Life Cycle Assessment of silk-and charged silk yarn in I09 company.
Electricity price (EU)	0.14	EUR/kWh	Eurostat (2020) for EU27, IA electricity consumption without taxes
Electricity price (Asia)	0.11	EUR/kWh	Global Petrol prices

The total cost of introducing specific wastewater treatment in textiles production plants would be EUR 594 million per year. It would cost EUR 267 million per year for plants in the EU and EUR 327 million per year for plants exporting to the EU from outside the EU.

The cost for the plants in the EU is a higher bound as some plants may already have a wastewater treatment plant that is effective in limiting microplastic releases.

It corresponds to an average cost of 143 000 EUR/t of avoided microplastics (lower bound: 74 000 EUR/t and higher bound: 2 000 000 EUR/t).

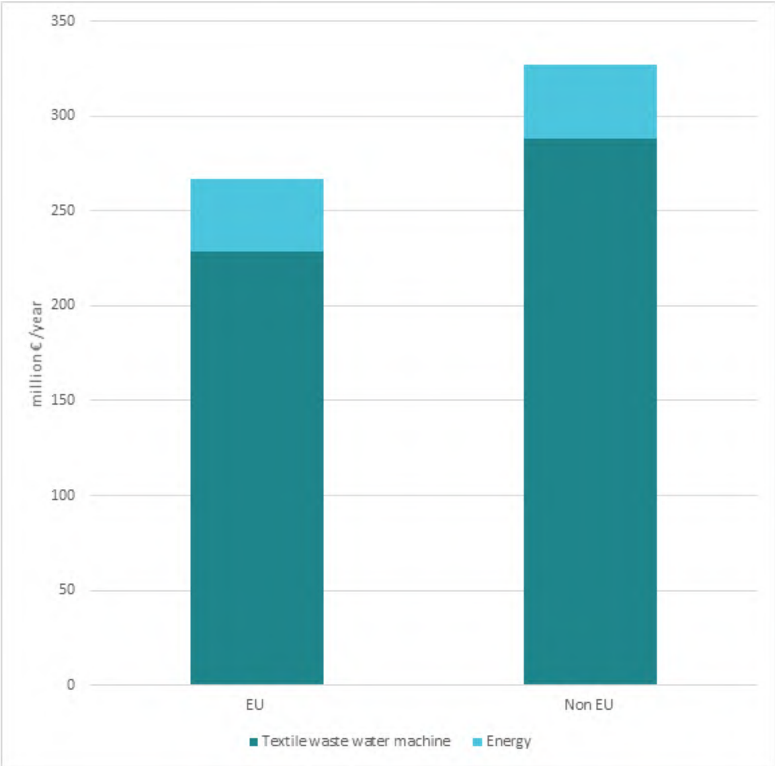

Figure 44: Specific wastewater treatment in production plants cost

The CAPEX of a wastewater treatment represents more than 85% of the total annual cost.

Environmental impacts

The measure equates to an average reduction of 4 024 tonnes per year (lower bound reduction: 287 tonnes per year, higher bound reduction: 7 760 tonnes per year).

In addition to reducing the microplastic releases from the textile industry, adding a new filter system in textile plants could also improve water quality by removing other pollutants from, for example, the textile dyeing process.

Introducing additional wastewater treatment will incur additional energy usage. Considering a European consumption of 9 million tonnes of textiles, the impact on global warming for wastewater treatment is 1 044 kt CO_2 eq. It corresponds to 0.12 kg CO_2 eq/kg of clothing.

For the whole life cycle, this represents an increase of about 0.2% of the climate change impact of textiles.

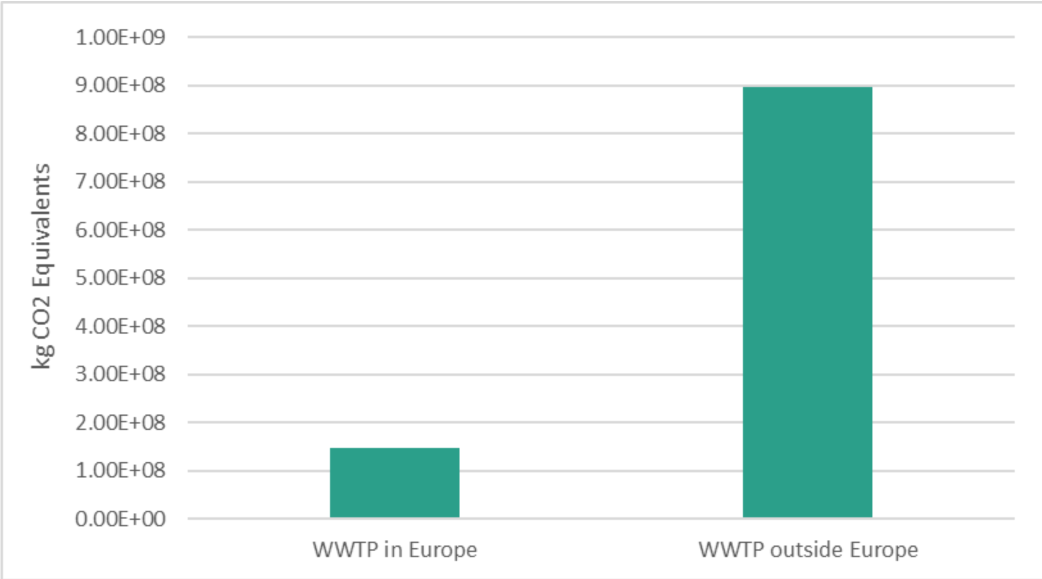

Figure 45: Impact of wastewater treatment in production plants on GHG emissions

Social impacts

The economic cost of the measure per piece of clothing is estimated to be EUR 0.02 which is likely to be passed on to consumers as a price increase.

There are also potential health impacts from reduced emissions of microplastics.

<u>TEX#6: Compulsory filters for washing machines</u>

What would be the costs of the measure?

The main cost would be the cost to equip the washing machines with microplastic filters.

Filters will be mandatory on new washing machines in France from 2025, but this was not considered in the baseline. Therefore, the benefits and costs would be around 15 % smaller by taking the French policy measure into account.

This measure will only require the resources of public authorities in the phase of introducing the measure. SMEs will not be affected as washing machine producers are larger companies. The measure will require third-country washing machine producers to comply when placing washing machines on the EU market. This measure will also require communication to consumers in order to avoid inadequate filter maintenance. This is complementary with measure TEX#8: Raising awareness on best practices for consumers of textiles.

What would be the benefits of the measure?

This measure acts on the emission of microplastics during washing with an assumed efficiency of an external filter of 89%.

Economic impacts

Table 45: Data to estimate the cost of washing machine filters

Description	Data	Unit	Source
Number of washing machines sold in the EU per year (2018/2019)	27 700 000	pcs	Applia (2019)
Number of washing machines in the EU	195 000 000	pcs	Eurostat (2019)
Cost of an internal filter - Xfiltra	100	EUR	Industry assumption during a bilateral interview
Efficiency - Xfiltra	78%	%	Napper, I. E., Barrett, A. C., & Thompson, R. C. (2020). The efficiency of devices intended to reduce microfibre release during clothes washing. Science of The Total Environment, 738, 140412.
Lifetime - Xfiltra	12.5	years	Assumption - the lifetime is equal to the washing machine one
Cost of an external filter - Guppyfriend washing bag	30	EUR	OECD (2021), Policies to Reduce Microplastics Pollution in Water: Focus on Textiles and Tyres, OECD Publishing, Paris.
Efficiency - Guppyfriend washing bag	54%	%	Napper, I. E., Barrett, A. C., & Thompson, R. C. (2020). The efficiency of devices intended to reduce microfibre release during clothes washing. Science of The Total Environment, 738, 140412.
Lifetime-washing bag	0.25	year	The washing bag can last for a minimum of 50 cycles, and there are on average of 20 cycles per month per household
Cost of an external filter - Filtrol 160	141	EUR	Filtrol
Replacement Filter Bag	13.4	EUR	Filtrol
Efficiency - Filtrol 160	89%	%	Microfiber Policy Brief 2019 - Rochman Lab
Lifetime - Filtrol	1	year	For 253 cycles
Yearly electricity consumption for laundry washing	160	per household in kWh	Pakula, C., & Stamminger, R. (2010). Electricity and water consumption for laundry washing by washing machine worldwide. *Energy efficiency*, *3*(4), 365-382.
Yearly water consumption for laundry washing	10	per household in m3	
Water consumption for one cycle	60	Litres	Assumption based on literature
Energy consumption for one cycle	1	kWh/cycle	Assumption based on literature
Additional water use	39	%	Association of Home Appliance Manufacturers (AHAM)
Additional run time	15	%	

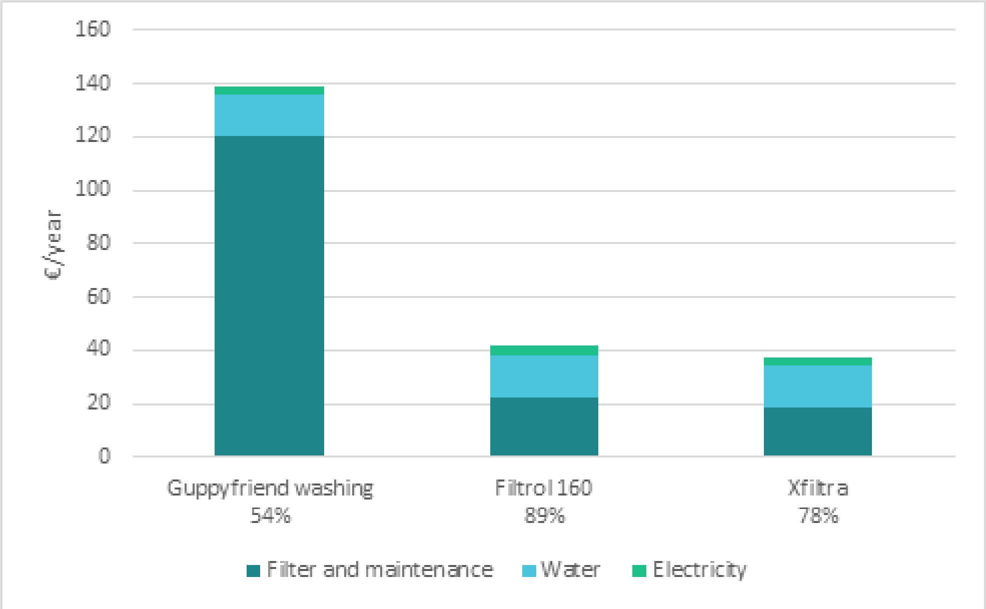

Figure 46: Cost of microplastic filters for washing machines

It would cost around EUR 8.1 billion to equip all washing machines with an internal microplastics filter based on current costs. It corresponds to an average cost of 2 627 000 EUR/t of avoided microplastics (lower bound: 1 464 000 EUR/t and higher bound: 12 764 000 EUR/t).

The costs are likely to decline as the technology is relatively new. There is probably improvement potential to reduce the filter production cost and also to reduce the increased consumption during its use (water and electricity).

Environmental impacts

The measure equates to an average reduction of 3 087 tonnes per year (lower bound reduction: 635 tonnes per year, higher bound reduction 5 539 tonnes per year)) based on a filter efficiency of 89 %.

The microplastic release reduction is relatively low because the microplastic releases of washing are small compared to those at the other life-cycle steps (mainly production and wearing).

The following figure shows the impact on GHG emissions associated with 1 wash[322]. The increase in the impact on GHG emissions is mainly related to the increase in electricity consumption (linked to the additional run time)—the impact increases by 18%.

According to the IMPRO Textile study, the use phase accounts for 45% of the life cycle impact of the product on global warming. The washing accounts for 56% of climate change impact for the use phase. Washing, therefore, accounts for 25% of the product's life cycle impact on global warming. For the whole life cycle, the use of a filter represents an increase of about 1 to 2% of the climate change impact of textiles (increase depending on the number of wash cycles).

[322] Depending on the product, there can be up to 104 washes (Impro Textiles)

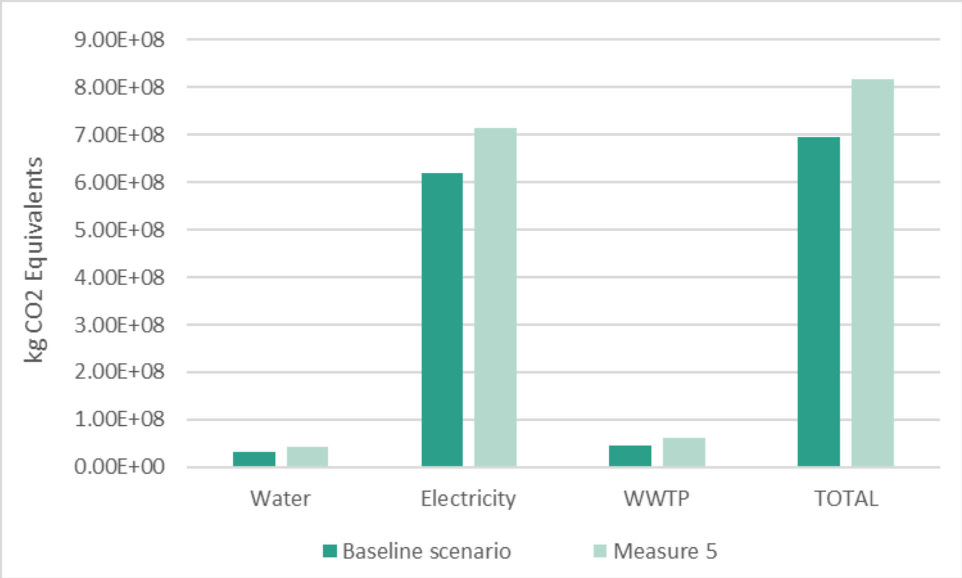

Figure 47: Impact of microplastic filters for washing machines on GHG emissions

The following figure shows the impact on water use associated with 1 wash. The increase in the impact is mainly related to the increase in water consumption. The impact increases by 27%.

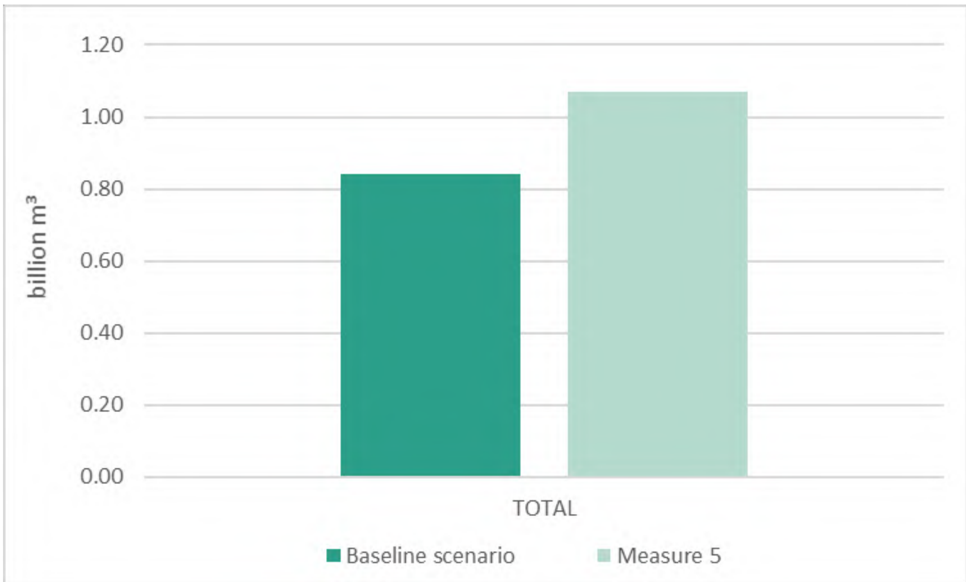

Figure 48: Impact of microplastic filters for washing machines on water use

Social impacts

The economic cost would lead to an additional cost of EUR 0.24 per washing cycle supported by consumers.[323]

[323] Based on 174 washing cycles per year (AISE).

The cost of the filter would represent between 28 and 40 % of the average price of a 7 kg washing machine[324]. As mentioned previously, the cost of the filters is likely to decline as the technology is relatively new.

There are also potential health impacts from reduced emissions of microplastics.

TEX#1: Standardised methodology to quantify microplastic releases from textiles

This measure was developed in response to the knowledge gaps we identified around the precise measurement of microplastic emissions. Developing a standardised measurement methodology will enable the development of reduction-specific measures at a later stage.

What would be the costs of the measure?

The one-shot costs of creating a standard are divided into two parts:

- The administrative costs of elaborating the standard (EUR 850 000)
- The costs of conducting tests for companies (EUR 10 000-20 000)

This measure will only require the resources of public authorities in the phase of introducing the measure.

What would be the benefits of the measure?

This measure will benefit all other measures on textiles as the release of microplastics during the life cycle of synthetic textile is a critical knowledge gap. The indirect benefits will also include the awareness-raising of the textile value chain actors and consumers. If an EPR system is implemented, the eco-fee can also be modulated according to the volume of microplastic release and respective actors' contributions. It is already a necessary step to measure any reduction measure's success rate. This measure would be necessary to support other measures (TEX#9 Mandatory label showing textiles' emissions of microplastics).

Economic impacts

The table below details the data to compute the cost of developing the standard.

Table 46: Assumption and data to estimate the costs of developing and implementing a standard

Description	Data	Unit	Source
Number of people working full time necessary to elaborate the standard between 8 and 36 months[325]	7.25	People	ISO website
Mean cost of labour in EU of one engineer working full-time	39.5	EUR/hour	Eurostat
Number of hours per week in a full-time job	40.6	hours/week	Eurostat
Number of marketers in the EU - textiles	160 000	Number	Euratex
Number of marketers in the EU - washing machines	27	Number	Gifam

[324] Based on an average 7 kg wahsing machine price of EUR 360. ADEME. F. Michel, T. Huppertz, J. R. Dulbecco et J. Lhotellier, RDC Environment. décembre 2019. Evaluation économique de l'allongement de la durée d'usage de produits de consommation et biens d'équipements– Rapport. 148 pages.

[325] The ISO technical committee on the environmental aspects of plastics is comprised of 29 members (the national standardization organisation). We assume that each member contributes 0.25 FTE to work on the committee.

Description	Data	Unit	Source
Fraction of companies conducting tests for elaborating the standard	5	%	Assumption
Number of engineers necessary per company to conduct the tests	1	person	Assumption
Mean worked hours per day in the EU by a full-time employee	8.12	hours/day	Eurostat
Number of hours necessary per company to conduct the tests	24	Hours	Assumption based on expert judgement

The total cost of the measure on average, is one-shot cost of EUR 8.5 million. The methodology would be relevant for at least 10 years. This would lead to an annualised cost of EUR 0.85 million.

Once the standard is developed, there will be the additional cost of testing the materials (only once per material). This cost was evaluated to range between **EUR 10 000 and 20 000** by expert judgement.

Environmental impacts

No significant environmental impacts are foreseen.

It will raise awareness on microplastic release for the companies that participate to the elaboration of the standard.

Social impacts

No significant social impacts are foreseen[326].

Variation

In addition to the development of a methodology to quantify microplastic emissions on the life-cycle, a variation of the measure would be to make the application of the standardized methodology mandatory for the companies putting a lot of pieces of textiles on the EU market. This would imply tests, audits and reporting on the microplastic emissions on the whole life-cycle.

Focussing on the companies putting a lot of pieces of textiles on the market is more cost effective as those companies usually have a large number of pieces per collection. This implies that the cost is spread on more textile pieces compared to smaller companies with have usually a lower number of pieces per collection. This would also spare SMEs.

In France, based on producer responsibility organisation for textile (Refashion/Eco TLC) data, the 14% of the biggest companies based on the number pieces of textiles put on the market put 95% of the textile's pieces[327]. If we apply this proportion to pieces put on the market in the EU with an average number of pieces by collection of 100 000, the average cost of the test to quantify microplastic emissions of the life-cycle stage and the audits would be EUR 769 million per year.

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326 The total cost of the measure per piece of clothing is EUR 0.0003.

327 ADEME (2020), Définition de critères d'éco-modulation applicables à la filière REP TLC (https://librairie.ademe.fr/dechets-economie-circulaire/4561-definition-de-criteres-d-eco-modulation-applicables-a-la-filiere-rep-tlc.html)

Seen the huge number of piece, a sampling approach seems to be warranted. A sample of 10% of the market (biggest companies) could be tested every year, leading to a cost of EUR 77 million per year.

If the tests would be realised on all the textiles put on the market, the cost would be like the labelling measure as the cost of the label itself is insignificant (EUR 1.56 billion). It seems however disproportioned to apply this measures to all.

Table 47: Assumption and data to estimate the costs of tests, audits and reporting of microplastic emissions

Description	Data	Unit	Source
Total cost of the tests	660	EUR per collection	Assumption based on Bureau Veritas prices in ADEME (2020), Définition de critères d'éco-modulation applicables à la filière REP TLC[328].
	1 440	EUR per collection	
Audit cost for a label	1 700	EUR per collection	EU Ecolabel
	2 000	EUR per collection	EU Ecolabel
Administrative cost	11%	%	Assumption based on expert judgement
Number of pieces put on the market in the EU	25 157 780 000	pieces	JRC, Environmental Improvement Potential of textiles (IMPRO Textiles), January 2014.
Average number of pieces per collection	100 000	pieces per collection	ADEME (2020), Définition de critères d'éco-modulation applicables à la filière REP TLC[329].

7.4 Impact of measures for paints

Table below shows the comparison between all measures evaluated to reduce microplastic emissions from paints.

[328] https://librairie.ademe.fr/dechets-economie-circulaire/4561-definition-de-criteres-d-eco-modulation-applicables-a-la-filiere-rep-tlc.html

[329] https://librairie.ademe.fr/dechets-economie-circulaire/4561-definition-de-criteres-d-eco-modulation-applicables-a-la-filiere-rep-tlc.html

Table 48: Comparison of measures for paints

Measure	Estimated reduction potential		Estimated Cost-effectiveness (EUR/tons reduced/year)	Other environmental impacts	Other economic impacts	Social impacts
	%	Ktons/ year				
PNT#2a: Mandatory label on paint lifetime and plastic content	1-2.5%	3.5 – 6.5	190–354 EUR/kg (1 240 million EUR/ 3.5-6.5 kt)	Potential other negative impacts, e.g. CO_2 emissions	Cost for paint producers that may be borne by customers	
PNT#3a: Promote mineral paint in the architectural sector	Not relevant	0kt	-	Reduction of microplastics released into environment	Negative impact on paint costs for paint producers that may be borne by customers. Minimal impact expected is because most polymer-based producers will not switch to mineral-based products through a voluntary scheme	
PNT#5: Good practices for paint application in all sectors	Low	Low	Low	Reduction of microplastics released into environment		
PNT#4: Deposit-return scheme for paint containers	0%	0 kt (increase in circularity)	- 54 -1 000 million EUR/year / 0 kt	Positive impacts in terms of circularity of paints (increased reuse and recycling)	Negative impact on paint cost for paint producers that may be borne by customers	
PNT#2b: Threshold on lifetime and plastic content for paints		Not quantified		Reduction of microplastic release into environment	Cost for paint producers that may be borne by customers	
PNT#3b: Restrict polymer-based paints in the architectural sector		Not quantified				
PNT#1: Standardised methodology of paint lifetime		-				

The table below shows the comparison of the impacts of the measures assessed to reduce microplastic emissions from paints.

Table 49: Summary of impacts for measures for paints

Policy measures	Environmental impact	Economic impact	Social impact
PNT#2a: Mandatory label on paint lifetime and plastic content	Reduction of microplastic releases as the label would raise the knowledge of paint-related microplastics pollution and it would encourage the consumers to take a better decision.	Negative impact on paint cost for paint producers that may be borne by customers	Job creation in labelling and certification companies
PNT#3a: Promote mineral paint in the architectural sector	Microplastic release reduction (71 kt, non-incremental) Risk of increased CO_2 emissions	Material costs limited if applied through ecolabel/GPP. If implemented through a ban, very high material costs due to complete change of production line, for >95% of architectural paint sector. SMEs	Consumers and households
PNT#5: Good practices for paint application in all sectors	Reduction of microplastics release from paints into environment		
PNT#4: Deposit-return scheme for paint containers	1.5 kt reduction of microplastics release	Limited economic impact	No social impact
PNT#2b: Threshold on lifetime and plastic content for paints	Reduction in microplastic emissions Potential increase in paint toxicity, negative CO2 impacts and increase in waste generation	Negative impact on paint cost for paint producers that may be borne by customers	No social impact
PNT#3b: Restrict polymer-based paints in the architectural sector	Reduction in microplastic emissions Proper LCA needed to assess environmental footprint	Negative impact on paint cost for paint producers that may be borne by customers	Job creation, albeit limited

PNT#1: Standardised methodology of paint lifetime	No emission reduction per se but helpful in other measures and knowledge improvement	Material cost 100-500 k EUR	There could be new jobs in the R&D sector (private company or research organisations) unless developed by the existing research staff

The impact of each measure is outlined below.

PNT#2a: Mandatory label on paint lifetime and plastic content

The measure can be associated with a product authorization to enter the EU market, or it can be just left as a labelling requirement (see measure PNT#2b).

The overall economic impact is related to the standardization of the assessment methodology of paint lifetime and plastic content. The R&D departments of the paint producers should already be aware of the lifetime of their product in various conditions. This is the kind of information generally used for issuing a warranty of the paint product when requested by the client, which guarantees, for example, that the paint will not blister or peel from properly prepared and primed surfaces and will not wear down or weather to expose the previously painted surface. See, for example https://www.dunnedwards.com/products/lifetime-warranty/. Seemly, as the paint producers know the composition of their paint formulations, they should be able to report the plastic content once the definition of plastic in paint is released.

The real difficulty and potential cost are associated with the necessity of having standard protocols for the lifetime assessment and a unique/unambiguous definition of plastic content in paint so that different products can be compared to each other. This could entail some scientific research costs but mostly should be administrative.

The labels though, should be changed to comply with the new regulation. The labelling could be managed as part of the continuous ongoing redesign from product innovation so the costs could be reduced.

To provide some indications, we refer to *Assessment and Review of Directive 2004/42/EC, Annex 26*, an estimate of re-labelling cost for decorative paint done by CEPE, which estimates a total re-labelling cost for decorative paints to be **740 million euros**, considering 4000 companies in the EU with 1,000-2,000 sku’s (Stock keeping units) each.

This estimate could be lowered if the compliance deadline to the measure would be set within a couple of years (and not immediate), because the relabelling would be facilitated by the normal life cycle of the products.

The amending of the proper legislation and the cost for monitoring compliance and reporting should be minor.

What would be the costs of the measure?

- Cost of developing the standard methodology for assessment of paint plastic content
- Cost for paint producers to change the design of their label

What would be the benefits of the measure?

The emission pathways and sources that are indirectly targeted by this measure are:

1) paint used on the architectural exterior (by substitution with mineral-based paint),
2) paint used on the architectural interior (by substitution with less plastic-intense paint).
3) improper disposal of unused paint (for non-industrial applications, i.e., marine leisure DIY and architectural),

<u>Point 1)</u>

Currently, mineral paint covers 10% of the architectural paint market in Germany and Austria. In comparison, in all other European countries, the share is likely to be between 0.5 and 2% (from communication with a producer of silicate-based paints).

Mineral paint is used on the mineral substrate but not on wood and metal since it breaks under tensile forces.

We currently estimate that there is 171 kt of plastic used in architecture paint applied on the exterior concrete or mineral substrate; of these, 49 kt are leaked to the environment.

According to a mineral-based paint producer, the main hurdles to further market penetration are reputation (silicate-based paint used to be a two-component system that was difficult to apply), and price, as they are on average 10-20% more expensive than organic polymer-based paints.

In order to understand how plastic content labelling will impact consumer behaviour, we can look at the packaging and textiles sectors.

70% of European consumers are actively taking steps to reduce their use of plastic packaging[330][331]

Plastic packaging consumption in EU-28 + NO/CH was 20.3 Mt in 2017 (*PlasticsEurope, 2018),* 20.4 Mt in 2018 (*PlasticsEurope, 2019*), and 20.1 Mt in 2019 (*PlasticsEurope, 2020*). Therefore, there has been a decrease in plastic packaging consumption of 1% in 2018-2019. Packaging paper & board consumption in Europe also decreased by 0.4% in 2018-2019, from 41.51 Mt in 2018 to 41.35 Mt in 2019 (*CEPI, 2020)*

In the textile sector, the use of fossil-based fibres has increased in recent years, while the use of cotton has remained constant[332]. In the textile sector, the use of fossil-based fibres has increased in recent years, while the use of cotton has remained constant.

Based on these figures from the packaging and textiles industry, it is unlikely that more than 2% of consumers will switch to mineral-based paint within a year, based solely on the plastic content information. Mineral-based paints have almost twice the lifetime of regular paint, which should also affect consumer behaviour, but we cannot assess the impact on sales. Overall, given the fact that the current market share of mineral-based paint is 0.5-10% in Europe, we could estimate that 0% to 3% of consumers would switch from plastic-based to mineral-based paint based on labelling information only in a year.

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[330] https://www.twosides.info/documents/research/2020/packaging/European-Packaging-Preferences-2020_EN.pdf
[331] https://www.twosides.info/documents/research/2020/packaging/European-Packaging-Preferences-2020_EN.pdf
[332] https://textileexchange.org/wp-content/uploads/2021/08/Textile-Exchange_Preferred-Fiber-and-Materials-Market-Report_2021.pdf

In conclusion, the plastic reduction demand for exterior paint on the mineral substrate could be a maximum of 5.1 kt in a year (3% of 171 kt), and the related plastic pollution would decrease by **1.5 kt** (3% of 49 kt). Over the years, given the longer lifetime, one should also see a reduction in paint demand as a whole, and it would be more or less of the same order of magnitude.

Point 2)

Currently, we assume 719 kt of plastic is used every year for architectural interior paint. Of these, 42 kt are released to the environment in the form of microplastic

For interior paint, we have not investigated specific alternatives to standard polymer-containing paints, but it should be possible to decrease the paint lifetime by decreasing the plastic content, and this should not affect the paint demand since interior paint in currently repainted instead for aesthetic reasons.

If we assume that products are available that have half of the plastic content and that 0-3% of the consumer would prefer them to the current formulations (based on assessment at point 1), we obtain a maximum leakage reduction of **0.6 kt**.

The benefits assessed above are minimal, as they lead, at most, to a 3% of the Architectural paint microplastic leakage (yearly).

Point 3)

The amount of plastic contained in unused paint from the architectural sector is 58.1 kt, while from marine leisure DIY, it is around 3 kt. In the baseline assessment, we assumed that unused paint is never improperly disposed of in Europe. However, a stakeholder from the architectural paint industry considered that disposal of unused architectural paint in the drainage system has a high probability for DIYers and a medium probability for professionals.

We make the following assumptions:

- If the plastic content label is sufficiently visible, 50% to 90% of the consumers will become aware of the fact that there is plastic in paint
- 90%-100% of the consumers that are aware that paint contains plastic will not improperly dispose of it. In fact, at the European level, the littering rate of disposable plastic items is around 7%[333], while the littering rate of multi-use items is much lower <0.01%.

As a result, between 45% and 90% of the unused plastic in the paint targeted by the measure, i.e., 61kt, would not be improperly disposed of, for a range of 27 – 55 kt. At the moment, though, we consider in our baseline assessment that this paint is already properly disposed of.

[333] Timothy Elliott, R. B., Chiarina, D., Laurence, E., Chris, S., Ayesha, B., Mathilde, B., & Hilton, M. (2018). Assessment of measures to reduce marine litter from single-use plastics. ICF Consulting Services Limited and Eunomia, M. European Commission, Brussels

Economic Impact

Table 50: Economic impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	-	Paint producer	Cost of testing the products with the standard methodology. Cost relative to the design and implementation of new label
Administrative burdens on businesses	-	Paint producers/importer	Some costs might be due to changes in the internal policy of the companies due to the necessity to be compliant with the labelling regulations.
Operation / conduct of SMEs	-	Small paint producers	Performing the assessment with the standardized methodology might be an economic burden for small producers who might not have adequate equipment. Providing open access or special agreements with testing facilities at the EU (or member state) level might be a valuable strategy to ensure compliance with the rules.
Functioning of the internal market and competition	+	Paint producers/ importers	The measure will probably favour the paint producers and importers who provide more environmentally friendly products.
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	Member State competent authorities or European Commission	Cost of amending the existing regulation or creating a new one Monitoring and reporting: at this stage is unclear whether the monitoring will be run at the EU or Member State level.
Innovation and research	+	Paint maintenance professionals	The measure will be an incentive to develop more environmentally friendly paint products.
Third countries and international relations	-	Paint producers in third countries	Will be affected as only the paints which are compliant with the EU regulation on the labels can enter the market.
Consumers and household	+	Paint maintenance professionals and DIYers	The potential impacts on paint prices are uncertain, but it is possible that the economic burden of product testing at the producer's level might be reflected in the cost of the paint itself.

Environmental Impact

Without enforcement (thresholds and fee system) is challenging for the measure to have a substantial environmental benefit. But in the best-case scenario, the label would raise the knowledge of paint-related plastic pollution (mostly for the DYI sector), and it would encourage the consumers to use the best paint system for their needs maximising the lifetime minimizing plastic content when possible.

There could be an increase in CO_2 emissions if the reduction of plastic content happens through substitution with material with a higher CO_2 footprint. Similarly, we cannot exclude that the substituting materials will be more toxic.

Finally, there could be an increase in waste generation due to the testing needed to assess the paint properties.

Social impact

No social impact is expected.

PNT#3a: Promote mineral paint in the architectural sector

This measure can be applied with a voluntary scheme such as ECOLABEL or GPP.

What would be the costs of the measure?

- The costs related to the amendment of the ECOLABEL regulation or the GPP
- The costs for the producers of mineral paint to apply for the label and include it on their product

What would be the benefits of the measure?

In measure PNT#2a an estimate is proposed to assess the impact of label showing plastic content of paint on the sales of mineral based paint, which has polymeric content below 5%. This estimate is based on consumer purchasing trends in the past years of plastic products in favour of an alternative material. We cannot use the same estimate here as the ECOLABEL would not display information regarding plastic content, furthermore the ECOLABEL is a voluntary label.

Overall, we envision minimal impact as most polymer-based producers will not switch to mineral-based products through a voluntary scheme.

Economic Impact

Table 51: Economic impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	-	Mineral paint producer	Cost of inserting the new label on the paint can
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	European Commission	Cost of changing the ecolabel Regulation

Environmental Impact

No impact expected.

Social impact

No impact foreseen.

PNT#5: Good practices for paint application in all sectors

This measure is not dependent upon any measure. This measure is voluntary.

What would be the costs of the measure?

The costs of the measure are:

1. The cost of researching good practices for the various paint sectors is estimated to be around EUR 100k - 500k, based on the level of ambition.
2. The cost for the paint professionals and relevant stakeholders of implementing those good practices (e.g., by purchasing a different type of paint removal machinery, etc.)

The latter depends on changes made, but as it is a voluntary measure, we assume that a professional will undertake it only if it leads to an economic advantage (e.g., an increase in business volume due to stronger appeal for costumer of less polluting techniques). So the actual economic impact is expected to be minimal.

For the marine sector, in particular, good practices for ship maintenance could be more expensive in terms of technology (e.g., water treatment to capture microplastic, robotic vacuum technology for paint removal), the time required to adopt them (e.g., vacuum cleaning of the drydock before re-floating is more time consuming than just re-floating without cleaning), and training of the paint maintenance professionals. The costs would ultimately be bear by the ship owners and by the paint maintenance professionals.

In the last 10 years, only 1-3% of the commercial world fleet was built in Europe, but 36% of the world fleet belongs to Europe (UNCSTAD). If ship-building capacity is taken as a proxy for ship-maintenance capacity, the implication is that European commercial ships undergo maintenance overwhelmingly outside of Europe. Conversation with stakeholders from the shipping sector concurs with this assessment.

Estimating the monetary cost of this measure is very difficult as it depends entirely on the actual list of good practices – and relative technologies – that will be set up, but to make an estimation one can say that the main cost that overshadows all other costs will be that of upgrading the current technologies in shipyards in order to capture microplastic releases during paint removal (the last two voice costs). There are two options:

1. Blasting is done with vacuuming technologies that prevent paint emissions

2. Blasting is done with wet technologies, without dust formation, and then membranes are used to filter the paint residues from the water

Option 1.

There are already technologies that do vacuum blasting, and the cost of the technology itself is competitive. The main challenge vacuum technologies are facing, especially for dry-docking, is productivity, i.e. how many square meters per hour they clean from paint residues. According to exchanges with stakeholders that develop vacuuming technology, the best way to have high productivity is using a robotic solution, which currently is able to clean 10 m^2/h (but could go up to 30-40 m^2/h).

On the other hand, hydro blasting technologies (no capturing) can clean up to 300 m^2/h [334]

In the table below, we summarise the key figures impacting the costs of drydocking.

Table 52: Factors impacting the costs of drydocking.

	min	max	units
Dry-docking cost	30'000	60'000	€/day
Productivity of standard technology	-	300	m2/h
Productivity of capturing technology	-	10	m2/h
Rental of standard technology	-	60	€/day
Rental of capturing technology	-	100	€/day
Ship surface area to treat	10'000	60'000	m2/day

The part of the boat that needs more intense cleaning and repainting is the one below the waterline. The below-water surface area can vary from 10,000 m^2 for a Panamax, to 60,000 m^2, for an Ultra Large Crude Carrier.

This means that with one hydro-blasting machine, the ship can be cleaned in 33-200 h, or 3.3-20 days, assuming a 10h working schedule. Drydocking usually lasts 10-20 days[335], meaning that paint maintenance lasts all throughout the drydocking period. Since the current vacuuming technologies are 30 times slower, it would take them 1 000-6 000 h to clean a ship. If this was done by a single machine, on a 10h shift, the drydocking would last 100-600 days. Data collected from one of the biggest shipyards in the Persian Gulf show that dry-docking costs varied from 30 000-60 000 $/day in 2008-. Given the high daily drydocking cost, it is imperative in order for paint vacuum capturing technologies to be competitive, to use more machines in parallel. The main cost would be renting additional machines, at a cost of EUR 100/day each. Considering the scenario that 30 machines would be needed (to compensate for the 30x lower productivity), the cost increase would be EUR 3 000/day. Since maintenance would last 3.3-20 days[336], the overall cost increase per drydocking period would be EUR 10 000 – 60 000. This excludes the cost of having a person operating the machine; given that the technology is robotic, it is not clear what the impact would be. On the other hand, we are assuming a working schedule of 10 h a day, which with robotic technology could (is) probably higher, reducing the number of days needed for the rental.

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334 (http://www.gimsid.ro/aplicatii/Industria%20navala/Hammelmann/Shipcleaning.pdf).

335 Apostolidis, A., Kokarakis, J., & Merikas, A. (2012). Modeling the Dry-Docking Cost-The Case of Tankers. Journal of Ship Production & Design, 28(3)

336 2012 (Apostolidis, A., Kokarakis, J., & Merikas, A. (2012). Modeling the Dry-Docking Cost-The Case of Tankers. Journal of Ship Production & Design, 28(3).)

Considering that there are 1.8 million commercial ships (*UNCTAD, 2017*), that 36% belong to EU-27 countries and that 3% undergo maintenance in EU-27 every 4 years, there would be around 5000 ships undergoing maintenance in the EU every year.

The total costs would be at least **50-300 million EUR/year**, with the current productivity.

Option 2

If hydro-blasting is used instead, then the water should be filtered from the paint residuals before re-emitting it to surface water. Sending to a wastewater treatment plant should be discouraged since the paint would end up in oil.

Ultrafiltration units exist that filter particles in the range of 0.01-0.1 microns. Their operating costs is 0.235-0.338 $ per m^3 of water filtered[337].

Ultra-high water jetting technologies that can operate at around 300 m^2/h use 85 l/min of water [338]Therefore, filtering the water emitted in one hour would cost from 1,200-1,700 $/h. Since it takes 33-200 h to clean the bottom of a ship during dry-docking with this technology, the overall operating cost would be 40-340 k EUR/ship.

Using the same estimate of the number of ships maintained in EU-27, the total operating costs would be between **200-1 700 million EUR/year,** depending on the boat size and the number of boats.

A further cost would be the creation of a European certification for those paint professionals that follows the guidelines. This cost is expected to be a bit minimal with respect to the rest.

What would be the benefits of the measure?

The benefits in terms of microplastic pollution reduction are potentially high, as the good practices would cover losses at both applications, removal (maintenance) level, and surface preparation, which impacts wear & tear. Nevertheless, since this is a voluntary measure, the expected compliance is low.

For the marine sector, there are 40 kt/year of microplastic emissions to ocean and waterways due to maintenance of EU commercial vessels. Since only 1-3% of the maintenance takes place in EU-27, the measure could potentially tackle 0.4 – 1.2 kt of micro-plastic emissions. Nevertheless, we estimate that applying this measure only at EU-27 level (with either a voluntary or a mandatory approach) will not lead to any change in the status quo, as commercial ship will choose to dock outside of the EU where maintenance will be cheaper.

[337] Drouiche, M., Lounici, H., Belhocine, D., Grib, H., Piron, D., & Mameri, N. (2001). Economic study of the treatment of surface water by small ultrafiltration units. Water SA, 27(2), 199-204
Yoo, S. S. (2018). Operating cost reduction of in-line coagulation/ultrafiltration membrane process attributed to coagulation condition optimization for irreversible fouling control. Water, 10(8), 1076.).

[338] Shipcleaning.pdf (gimsid.ro)

Economic Impact

Table 53: Economic impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Public authorities: Change in costs to the Commission	-	European Commission / and EU institutions	Cost for the European Commission of defining the good practices.

Environmental Impact

The implementation of good practices would also reduce the emission of biocides contained in antifouling paint.

On the other hand, the use of more advanced technologies or better water management filters and systems could lead to an increase in CO_2 emissions.

Social impact

No social impact is foreseen by this measure.

PNT#4 Deposit-return scheme for paint containers

What would be the costs of the measure?

- Cost for paint producers and importers who should pay the development and maintenance of the system
- Cost of reporting paint quantities put on the market and collected
- Cost of funding research and study to assess improper disposal of paint and related microplastic pollution
- Cost of setting up improved collection schemes such as DRS scheme (e.g., cost of economic analysis to set up the financial scheme behind the EPR scheme - financial incentives, how much is the fee, how much is the reward, how much are the running costs) or door-to-door collection.
- Running cost of the organization managing the collection scheme: cost for establishing collection systems; collection and transport, administrative costs, public communication, and awareness-raising on waste prevention and collection, appropriate surveillance of the system
- Cost of promoting recycling of unused paint

Unused paint is often considered as special/hazardous waste and like waste oil, chemicals and spent batteries; for example, in several countries (e.g. Belgium and Denmark), it is successfully being collected with the goal of proper disposal or recycling [339]The overall cost of running EPR scheme for unused paint could be estimated, making a parallel with waste oil. The two products are similar at

[339] Formation Gestionnaires de déchets, module 2b, Déchets dangereux, Alain Vassart, Mike Van Acoeyen (Arcadis), Environment Brussel and GOOD PRACTICE ODENSE: Hazardous Waste Collection October 2014,

several levels: hazardous waste, and liquid, used both in professional and household settings, hold some intrinsic value but might need to be treated to be used again.

For waste oils, EPR schemes already exist for several European countries[340], from their review we can estimate that the cost of measure PNT#4 in EU will be between **54 million** and **1 billion** euros per year

To that, the administrative costs, the costs to perform for economic analysis and to develop the framework of the EPR itself have to be added. Drawing a parallel with the costs estimated for an EPR scheme for the Pharmaceutical and Cosmetic Industry in Europe, we can assume they will be in the order of 16 million euros at the EU level.

What would be the benefits of the measure?

It will be possible to compute the benefits of the measures solely in terms of microplastic pollution reduction once phase one is completed and a better understanding exists especially on the improper disposal of unused paint. Then depending on the effectiveness of the measures put in place (e.g. citizens awareness campaign, collection scheme), it will be possible to assess the reduction in microplastic pollution[341].

Based on the current estimates, the measure would target around **85 kt** of plastic from unused paint in EU-27.

Even if the fee is applied to the plastic content, it is expected that this will not drive change in the product design, as the fee would be too low to drive change.

Economic Impact

Table 54: Economic impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	-	Paint producer/importers	Pay the fee to the PRO (running economic impact) to finance knowledge creation, as well as the collection and management of unused paint and the reduction of improperly disposed paint
Administrative burdens on businesses	-/0	Paint producers/importers	Cost of reporting the plastic content input on the market.

340 Development of Guidance on Extended Producer Responsibility (EPR)", 2014 by BIO by Deloitte, in collaboration with Arcadis, Ecologic, Institute for European Environmental Policy (IEEP), Umweltbundesamt (UBA). https://www2.deloitte.com/content/dam/Deloitte/fr/Documents/sustainability-services/deloitte_sustainability-les-filieres-a-responsabilite-elargie-du-producteur-en-europe_dec-15.pdf

341 https://www.akzonobel.com/en/media/latest-news---media-releases-/akzonobel-launches-recycled-paint-to-help-close-loop-on-waste

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Functioning of the internal market and competition	-	Paint producers/ importers	The paint producers/importers that input more plastic on the market are penalized (pay more through the fee payment scheme).
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	Member State competent authorities or European Commission	Running cost of the EPR operator (including monitoring and reporting).
Public authorities: Change in costs to the Commission	-	European Commission / and EU institutions	This measure will only require resources in the phase of introducing the measure.
Third countries and international relations	-	Paint producers in third countries	Will be indirectly affected because importers have to pay based on how much plastic they import.
Consumers and household	0	Paint maintenance professionals and DIYers	The potential impacts on paint prices are uncertain but are expected to be limited.

Environmental Impact

If a deposit-return scheme is put in place, there could be a CO_2 impact related to the transport of the recovered paint, but it could be minimised by matching purchases of new paint with taking back of removed paint.

A potential positive environmental impact could be the development of recycling technologies for unused paint and an increase in circularity.

Social impact

There are no social impacts foreseen for this measure.

PNT#2b: Threshold on paint lifetime and plastic content for paints

This measure depends on measure PNT#2a to be implemented first.

Product authorisation in the European market depends on compliance with thresholds to regulate an upper bound for plastic content and a lower bound for paint lifetime.

Once it becomes clear, by paint sector (marine, architectural, road markings, etc.) and its sub-categories (e.g., architectural interior, exterior-concrete, exterior-wood), what are the ranges of plastic content (%) and lifetime for the different paint formulations available for the market, regulators can decide to ban from the market products that have a high plastic content and/or a lifetime much shorter than that of the painted object.

What would be the costs of the measure?

Additional cost with respect to measure PNT#2a:

- Cost of defining thresholds based on paint properties for entering EU markets and creating appropriate legislation
- Cost of defining and applying a fee system for non-compliant products

Besides the costs which are common to both the application framework of the measure, we can indicate the cost of defining thresholds as the one of a highly qualified consulting company: **100-500 k EUR, one time.**

Cost for paint producers of adapting the **paint formulation** to match the new requirements: **500 k EUR** per paint formulation[342] or 0.4% of sales value[343], i.e. EUR **500 million**.

What would be the benefits of the measure?

The benefits of the measures will depend on which types of paint formulations are currently available on the market.

<u>Road markings - case study</u>

For example, in the case of road markings, there are currently 4 main paints formulations: solvent-based (17.3% plastic, 1-2 years lifetime), water-based (16.6% plastic, 1-2 years lifetime), thermoplastics (16% plastics, 3-5 years lifetime) and cold plastics (35% plastic, 3-5 years lifetime). Here, the plastic contents are taken from the Eunomia report *Hann, et al. (2018)*, while the lifetime are taken from *Barbara, K. R., & Nicholas, D. O. D. D. (2018). Development of the EU Green Public Procurement (GPP) Criteria for Paints, Varnishes and Road Markings. Technical Report with final criteria.* If these values were to be confirmed, once the standardised methodology is established, the preferred road marking type would be thermoplastics, as it has the lowest plastic content and the longest lifetime.

Currently, given the market distribution of the different road markings formulations (*Hann et al. 2018)*, the polymer content in (dry) road markings paint is 16.6%, and the lifetime – weighted by the plastic content – is 3.3 years. If only thermoplastics were used, the polymer content would be 16% and the lifetime 4 years.

The microplastic leakage reduction can be approximated as: Leakage reduction = $leakage_{old}$ * reduction rate,

$$\text{Reduction rate} = (1 - \text{repaint\%}) * (1 - plastic_{new} / plastic_{old}) + \text{repaint\%} * (1 - plastic_{new} / plastic_{old} * lifetime_{old} / lifetime_{new})$$

In this case: $leakage_{old}$ = 20 kt, $plastic_{new}$ = 16%, $plastic\%_{old}$ = 16.6%, $lifetime_{old}$ = 3.3 years, $lifetime_{new}$ = 4 years. The "repaint %" indicates how much of the paint put on the market is used for

342 https://circabc.europa.eu/sd/a/2d163ccc-f496-44af-9b6a-8fd2006a4d5e/Final
343 https://ec.europa.eu/environment/archives/air/pdf/paint_solvents/decopaint.pdf),

re-paint jobs. We don't currently have this quantity, but we could estimate it to be at least 50% in Europe, given the road lifetime versus the paint lifetime.

The leakage reduction in this case would be 20 kt * 12% = 2.4 kt.

Architectural exterior – case study

If we apply the equation above to a scenario in which all exterior architectural paint is replaced with silicate-based paint, we will obtain:

$Leakage_{old}$ = 49 kt, $plastic_{new}$ = 5%, $plastic\%_{old}$ = 20%, $lifetime_{old}$ = 10 years, $lifetime_{new}$ = 20 years, (repaint % = 50%)

Leakage reduction = 49 kt * 81% = 39 kt

Total estimate

Let us assume that through legislation, it would be possible, every few years, to decrease the plastic content by 5%, and increase the lifetime by 5%, on all paint formulations besides antifouling paint, which has been excluded from the measure. In this case, the reduction rate could be:

Reduction rate = (1 - repaint %) * (1 – 0.95) + repaint % * (1 – 0.95 * 1/1.05)

Let us assume the repaint share varies between 0% and 100%, then the range in reduction rate would be between 5% and 10% every year.

Currently, the total microplastic leakage from paint is estimated at 482 kt, but 50kt comes from antifouling paints, and another 154 kt comes from other marine paint applied on European ships outside the EU. Therefore, this measure could target 278 kt of microplastic leakage by reducing it by 5% to 10%. The corresponding leakage reduction would be **14–26 kt**. Every year, the label requirements are made more stringent by 5%, and the leakage would be further reduced by 5-10%. According to CEPE, it took 4 years to develop a new paint formulation in 2009 [344] ; therefore, we could assume thresholds to become more stringent every 4 years.

Economic Impact

The specific costs for measure #2b are the ones of #2a with the addition of the following:

Table 55: Economic impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Technological development / digital economy	--	Paint producers	The threshold imposed for market authorisation will require paint companies to adapt their production lines.

[344] *European Commission Service Contract N°070307/2007/483710/Mar/C3 Implementation And Review Of Directive 2004/42/Ec (European Directive Limiting The Voc Content In Certain Products – Current Scope: Decorative Paints And Varnishes, Vehicle Refinishing Products) Final Report* http://ec.europa.eu/environment/air/pollutants/pdf/paints_report.pdf

Environmental Impact

It is possible that the measure will have adverse environmental impacts if, for example, a paint has a longer lifetime, a smaller plastic content, but higher toxicity or higher CO_2 impact.

The enforcement provided by the thresholds and fee system will most definitely have an environmental benefit in terms of microplastic pollution reduction.

But, if the thresholds on maximum plastic content were imposed, the compositions of the paints would need to change to provide the same (or improved) performances, by definition. Therefore, since we are talking about new formulations that may not exist at the moment, there is no way to predict how those would look like in terms of environmental impact (one possibility out of many: lower plastic content, same lifetime but more toxic degradation products once released in the environment).

We state here that a different (not quantifiable) environmental impact is a possibility, such as increased toxicity.

There could be negative CO_2 impacts and an increase in waste generation due to the testing needed for the assessment of the paint properties.

Social impact

No social impact is expected.

PNT#3b: Restrict polymer-based paints in the architectural sector

What would be the costs of the measure?

- Administrative and legal costs associated with the creation of the limitation regulation or ban
- Costs for the paint producers to produce more mineral paint (investments and shift in production volumes)
- Increased costs for asset owners or managers (the ones that buy the paint products) because the mineral paint is more expensive than the dispersive one (based on organic polymer binders)
- Cost of a monitoring and reporting protocol to verify compliance with the new regulations
- Costs for asset owners in the form of a fee if found non-compliant

From discussions with mineral paint producers, it appears that silicate-based paint (which is by far the kind most available on the market) is 10-20% more expensive than dispersion paints. Their cost definitely influences their usage, and it will represent a burden on the consumers. Nevertheless, the lifetime is significantly elongated with respect to dispersion paint (almost twice as much). The life-cycle cost seems thus to be lower for silicate-based than polymer-based paints.

Another cost to consider is the market development for such paints. In Europe, the market share of mineral paint appears to be, on average, between 0.5 - 2% (both and value), with the highest value in Germany at 10%.

What would be the benefits of the measure?

The microplastic leakage reduction can be approximated as:

Leakage reduction = $leakage_{old}$ * reduction rate,

Reduction rate = (1 - repaint%) *(1 – $plastic_{new}$ / $plastic_{old}$)

+ repaint% * (1 - $plastic_{new}$ / $plastic_{old}$ * $lifetime_{old}$ / $lifetime_{new}$)

In this case: $leakage_{old}$ = 49 kt, $plastic_{new}$ = 5%, $plastic\%_{old}$ = 20%, $lifetime_{old}$ = 10 yrs, $lifetime_{new}$ = 20 years, (repaint % = 50%). The "repaint %" indicates how much of the paint put on the market is used for re-paint jobs. We don't currently have this quantity, but we could estimate it to be at least 50%.

Therefore, the leakage reduction of exterior architectural paint (excl. wood and metal substrates) would be:

Leakage reduction = 49 kt * 81% = **39 kt**

If the measure was to be extended to interior paint as well, we could compute the leakage reduction using the following parameters:

Leakage reduction = 49 kt * 81% = **39 kt**

$Leakage_{old}$ = 42 kt, $plastic_{new}$ = 5%, $plastic\%_{old}$ = 20%

We remove from the equation the part related to the increased lifetime because repaint practices on interior paint are not due to paint system failure.

Reduction rate = (1 – 5%/ 20%) = 75%

Leakage reduction = **32 kt**

Total leakage reduction = **71 kt**

Economic Impact

Table 56: Economic impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	-	Paint producer	Cost related to product design and investments for improving or adding production of mineral paint to their list of products.
Functioning of the internal market and competition	+	Paint producers/ importers	The paint producers/importers that already produce mineral paint will have an economic advantage.

Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	Member State competent authorities or European Commission	Cost of the creation of the regulation/ban.
Technological development / digital economy	--	Paint producers	The ban on mineral paint will require paint companies to adapt their production lines.
Innovation and research	+	Paint maintenance professionals	The measure will be an incentive to develop and use mineral paint in place of the more plastic intensive dispersion paint.
Consumers and household	0	Paint maintenance professionals and DIYers	There will be potential impacts on paint prices due to the higher cost of the mineral paint, but they are most likely balanced by the longer lifetime of the paint layer itself.

Environmental Impact

This measure will most definitely have an environmental benefit in terms of microplastic pollution reduction as it promotes the use of less plastic-intensive paint for one of the biggest sectors in terms of paint consumption, the architectural one. The environmental footprint of shifting the production from polymer-based paint should be assessed through a proper LCA (Life Cycle Assessment).

Social impact

Product design will also be incentivised. This might create new job positions in R&D, although this impact is estimated to be quite small.

PNT#1: Standardised methodology of paint lifetime

This measure was developed in response to the knowledge gaps we identified around the precise measurement of microplastic emissions. Developing a standardised measurement methodology will enable the development of reduction-specific measures at a later stage.

This measure does not depend upon any other measure but it is necessary for the application of the measures PNT#2a and PNT#2b.

What would be the costs of the measure?

Cost of a scientific task force to define paint lifetime and how to measure it in a consistent way for various types of applications

The cost then should be relative to the hiring of a scientific committee and/or consultancy firm to define the guidelines for the standard methodology of testing. Considering a highly qualified consultancy firm, this cost could be EUR **100k-500k.** Once the standard is developed, there will be the additional cost of testing the materials (only once per material). This cost was evaluated to range between **EUR 10 000 and 20 000** by expert judgement.

What would be the benefits of the measure?

This measure will benefit all other measures on paints as the release of microplastics during the life cycle of paints is a critical knowledge gap. The indirect benefits will also include the awareness-raising of the paints value chain actors. If an EPR system is implemented, the eco-fee can also be modulated according to the volume of microplastic release and respective actors' contributions. It is already a necessary step to measure any reduction measure's success rate. This measure is essential to the implementation of measure PNT#2.

Economic Impact

Table 57: Impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	0	Paint producer	No cost
Administrative burdens on businesses		Paint producers/importers	No cost
Operation / conduct of SMEs	0	Paint producers	No cost
Functioning of the internal market and competition	0	Paint producers/ importers	No cost
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	European Commission	Cost related to the creation of the scientific task force and remunerating their job.
Public authorities: Change in costs to the Commission	0	European Commission / and EU institutions	No cost
Innovation and research	+	Paint maintenance professionals	No cost
Technological development / digital economy	0		No cost
Macroeconomic environment	0		No cost
Third countries and international relations	+	Paint producers in third countries	No cost
Consumers and household	0	Paint maintenance professionals & DIYers	No cost

Environmental Impact

Mildly positive indirect environmental impact is foreseen due to the fact that the discussion around the plastic definition can help clarify important points for other scientific studies and policy creation on the microplastic pollution issue as well.

Social impact

No social impact is foreseen.

7.5 Impact of measures for detergent capsules

Table below shows the comparison between all measures initially evaluated to reduce microplastic emissions from capsules.

Table 58: Comparison of measures for capsules

Measure	Estimated reduction potential		Estimated Cost-effectiveness (EUR/tons reduced/year)	Other environmental impacts	Other economic impacts	Social impacts
	%	Ktons/ year				
CAP#2: Apply current biodegradability standards to detergent capsules	Uncertain, with possibly high potential	5 060 (4 140 – 5 980)	2 207 (1 739-2 676)	Full biodegradation is ensured and reduction of microplastic pollution	Negative impact on industry, depending on the applicable standard (Costs associated with the effort to redesign their products to comply with new standards)	
CAP#1: Standardised methodology to quantify microplastics released from detergent capsules						
CAP#3: Redesign biodegradability standards for detergent capsules						

Table below shows the comparison of the impacts of the measures assessed to reduce microplastic emissions from capsules.

Table 59: Summary of impacts for measures for capsules

Policy Option	Environmental impact	Economic Impact	Social impact
CAP#2: Apply current biodegradability standards to detergent capsules	Reduction of plastic emissions from water-soluble plastics are difficult to estimate, but possible high potential	Estimated increased production cost of EUR 7.2 - 16 million/year (initial assessment)	
CAP#1: Standardised methodology to quantify microplastics released from detergent capsules	No emission reduction per se but helpful in other measures and knowledge improvement	EUR 100k-500k	There could be new jobs in the R&D sector (private company or research organisations) unless developed by the existing research staff
CAP#3: Redesign biodegradability standards for detergent capsules	Reduction of plastic emissions from water-soluble plastics	Standard development costs of EUR 500 000 - 1 million, and increased production cost (likely higher than CAP#2). Other impacts not assessed	Possible jobs in the R&D sector. Other impacts not assessed

The impact of each measure is outlined below.

CAP#2: Apply current biodegradability standards to detergent capsules

This measure will enable ultimate biodegradation of PVOH and related mixtures during and after wastewater treatments.

What would be the costs of the measure?

Applying the measure may come at a certain cost as water-soluble plastic producers will have to adapt some of their products to the biodegradation standard. The exact costs are difficult to assess, because it depends on the exact application of the standard. The standard could for example be applied according to its adaptation for polymers (i.e. without the application of the 10-day window).

Some of the additional costs to redesign their products could be estimated to be around 20% of the actual prices of detergent capsules based on technical discussions with some stakeholders (AISE members).

Knowing that the actual price of water-soluble plastics derived from PVOH for detergent capsules is around 2-4 EUR/kg and the annual volume of PVOH put on the market is at the low end 18 000 tons, thus the total cost to redesign their products would be EUR 7.2 million, or at the high end, the volume being 20 000 tons, the total cost would be EUR 16 million in order to comply with this measure. It might be expected that this cost would decrease due to innovation.

Therefore: 2EUR/kg * 18 000 tons * 20% = 7 200 000 EUR

Emission reduction potential: 4 140 – 5 980 tons

Cost efficiency, low end: 7 200 000 EUR / 4 140 tons= 1739 EUR per tonne
Cost efficiency high end: 16 000 000 EUR / 5 980 tons = 2676 EUR per tonne

This is thus only an initial assessment. As mentioned above, economic costs are difficult to assess and depend on the exact application of the standard.

What would be the benefits of the measure?

As soon as this measure is enforced, PVOH pollution is expected to reduce. While the exact extend of the reduction of microplastic releases is unknown, the maximum potential is full biodegradation, this would then result in an emission reduction potential of 4140 – 5980 tons/year.

Economic impacts

Table 60: Economic impact of the measure CAP#2

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	-	Water-soluble plastic producers	EUR 7.2 – 16 million / year (initial assessment)
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	Member State competent authorities or European Commission	Costs associated with the effort to implement these standards at the national level

Further analysis is also needed to estimated possible other economic impacts.

Environmental impacts

This measure is expected to have a positive impact on the environment in terms of the reduction of microplastic releases from water-soluble plastics. Adopting good practices for water-soluble plastics can give a real chance to properly manage the water-soluble plastics during wastewater treatment.

Social impacts

There are no social impacts foreseen.

CAP#1: Standardised methodology to quantify microplastics releases from detergent capsules

This measure was developed in response to the knowledge gaps that were identified around the precise level of microplastic emissions. Developing a standardised measurement methodology will enable the development of reduction-specific measures at a later stage.

This measure aims to increase the knowledge about PVOH's pathway to the different environmental compartments it may reach after being released from households. Currently, there is a lack of understanding regarding the compartment (sludge or water bodies) in which PVOH finally ends up and the repartitioning between them. This is an issue specifically when it comes to testing for the biodegradability of PVOH because the complete biodegradation of PVOH in natural conditions and after WWTP has not been demonstrated yet. Its degradation depends on environmental conditions as well as on the microorganisms present, and it is important to identify in which environmental compartments PVOH end up.

What would be the costs of the measure?

Its cost would be that of developing a sampling procedure as well as performing the sampling and analysing it. This cost would be borne by the Commission and should be then relative to the hiring of a scientific committee and/or consultancy firm to define the guidelines for the standard methodology of testing. Considering a highly qualified consultancy firm, this cost could be **EUR 100 000-500 000.** Once the standard is developed, there will be the additional cost of testing the materials (only once per material). This cost was evaluated to range between **EUR 500 and 1000** per sample.

What would be the benefits of the measure?

This measure will provide information on the release of microplastics by using detergent capsules since this is a critical knowledge gap that has been identified. The indirect benefits will also include raising awareness of the detergent capsule value chain actors and consumers. It is already a necessary step to measure any reduction measure's success rate. It would further increase our knowledge and understanding of PVOH's degradation.

Economic impacts

Table 61: Economic impact of the measure

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	0	Detergent manufacturers	The use of optimized/enhanced compositions used for water-soluble films will probably come at a neutral cost as detergent manufacturers are innovating to improve their products because of the demand of sustainable products. However, they need to contribute for the development of the method which would entail minor costs.
Operating costs and conduct of business	0	Water-soluble plastic producers	Having a measurable harmonised method will enable them to design better water-soluble films.
Operating costs and conduct of business	0/-	Wastewater management companies	The method itself will not impact the wastewater treatment companies but would enable them to estimate better the proportion of soluble plastics in the waste water.
Public authorities: Change in costs to authorities for administrative, compliance and enforcement activities	-	Member State competent authorities or European Commission	Public authorities could finance or supervise the development of the method, e.g. through national standardisation bodies.
Public authorities: Change in costs to the Commission	-	European Commission & EU institutions	Cost for the European Commission to fund the research for the development of the method.

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Innovation and research	+	Scientific community	The measure will deepen the understanding of the release of PVOH through detergent capsules.

Environmental impacts

This measure is expected to offer a better understanding about the impact of water-soluble films in the real environment. It will enable to select the most appropriate water-soluble plastic compositions with no adverse impact.

Social impacts

There are no social impacts foreseen.

CAP#3: Redesign biodegradability standards for detergent capsules

Here, a biodegradability standard would be re-designed, which would reflect the different environmental compartments and the associated conditions that PVOH coming from detergent capsules may encounter after it is released from WWTP. It would reflect the varying temperature conditions, presence (or absence) of the required microorganisms, and selectivity of the microorganisms (will it still degrade PVOH when in the presence of other competing food sources?).

What would be the costs of the measure?

The cost of setting up this measure would be borne by industry. It would consist in developing other testing procedures reflecting the natural environmental conditions met by PVOH once it is released. The cost was evaluated to be comparable to that of other similar measures and range between EUR 500 000 and 1 million. (For geotextiles (GEO#1), the cost of developing a standard would be EUR 0.63 million and EUR 2.85 million. For, CAP#1, this cost would be EUR 100 000-500 000.)

The above described measure (CAP#2: Apply current biodegradability standards to detergent capsules) is expected to have an impact on producers. It is likely that the impact of this measure (CAP#3) would be larger, as biodegradability criteria would be more stringent. This measure (CAP#3) can for instance lead to a ban of products already on the market. As at this moment, it is not clear how much such a new biodegradability standard would affect which PVOH grades would be compliant, it is also difficult to estimate the cost and other impacts, such as on the SMEs that produce these capsules.

What would be the benefits of the measure?

After the protocol has been developed and declared the right standard to evaluate PVOH's biodegradability, the standard has a potential for a full emissions reduction. However, the development of the standard alone will have a limited impact.

Economic impacts

A summary of the impacts is given in the table below.

Table 62: Economic impact of the measure CAP#3

Impact category	Qualitative scoring of impact	Affected stakeholders	Description of impact
Operating costs and conduct of business	--	Water-soluble plastic producers	Water-soluble plastic producers will have to set up new standards and replace their PVOH grades were needed.
Public authorities: Change in costs to the Commission	-	European Commission and EU institutions	Cost for the European Commission to support the development of the new standards
Innovation and research	+	Scientific community	The measure will deepen the understanding of the fate of PVOH grades in the different natural compartments.

Environmental impacts

This measure is expected to have a positive impact on the environment in terms of the reduction of plastic emissions from water-soluble plastics. The adoption of this measure for water-soluble plastics can give a real chance to the collection and good management of water-soluble plastics.

Social impacts

There are no social impacts foreseen.

7.6 Impact of measures for geotextiles

Table below shows the comparison between all measures evaluated to reduce microplastic emissions from geotextiles.

Table 63: Comparison of measures for geotextiles

Measure	**Estimated reduction potential**		**Estimated Cost-effectiveness (EUR/tons reduced/year)**	**Other environmental impacts**	**Other economic impacts**	**Social impacts**
	%	**Ktons/ year**				
GEO#2: Guidelines for geotextile use	18 – 74%	2 880 – 11 840	15 – 272 EUR/t	No impact on already installed geotextiles	Negative impact on costs for geotextiles users (municipalities, construction companies)	
GEO#3: Use biodegradable geotextiles for specific applications	Not quantified					

GEO#4: Establish geotextile classes according to emissions of microplastics	25 – 85%	8 340 (3 360 – 13 320)	27.5 (20 – 351 EUR/t)	No impact on already installed geotextiles Reduction of microplastic pollution in marine environment, air and soil	Negative impact on costs for geotextiles users (municipalities, construction companies)	
GEO#1: Standardised methodology to quantify microplastics released from geotextiles						

Table 64Table 64Table below shows the comparison of the impacts of the measures assessed to reduce microplastic emissions from geotextiles.

Table 64: Summary of impacts for measures for geotextiles

Policy Option	Environmental impact	Economic Impact	Social impact
GEO#2: Guidelines for geotextile use	Microplastic release reduction by 2 880 tonnes and up to 11 840 tonnes	Between EUR 174 000 - 785 000 for developing the guidelines	No social impact
GEO#3: Use biodegradable geotextiles for specific applications	Reduction in microplastics released from the use of polymer-based geotextiles in short-term applications	Increased product prices for end-users	No social impact
GEO#4: Establish geotextile classes according to emissions of microplastics	Reduction in microplastics released, especially combined with 2c	Increased burden for geotextile manufacturers leading to higher prices	No social impact
GEO#1: Standardised methodology to quantify microplastics released from geotextiles	No emission reduction per se but helpful in other measures and knowledge improvement	One-shot cost of developing the standard 0.63- 2.85 million euros. Cost of testing the materials is between EUR 2 500 per test	There could be new jobs in the R&D sector (private company or research organisations) unless developed by the existing research staff

The impact of each measure is outlined below.

GEO#2: Guidelines for geotextile use

This measure would be for the EC to support the development of guidelines by the industry regarding how to properly install geotextiles to achieve a certain goal while minimising microplastic releases. These guidelines would cover three main areas:

- What should be the polymer used for certain applications?
- What should be the manufacturing process?
- How should the geotextile be installed?

This could take the form of a decision tree accompanied by a set of guidelines specific for each case

What would be the costs of the measure?

The cost of this measure is expected to be mostly borne by the entity that will develop the guidelines (European Commission or the industry). The cost of this measure is expected to be between **EUR 174 000 -785 000.**

Indirectly, the cost of geotextile solutions may be increased due to the additional requirements for installing them to reduce microplastic releases while still achieving the desired mechanical properties. So an indirect impact of this measure would be to increase the cost of coastal erosion protection systems for municipalities, for example.

What would be the benefits of the measure?

This measure would enable the use of geotextiles for coastal erosion protection applications (and others, although this is the application expected to release most microplastics) in optimal conditions, which would reduce the microplastic releases significantly from newly installed geotextiles.

When the guidelines are in place, the reduction in microplastic releases may not be significant as it depends on the will of users to follow or not the guidelines. The industry estimate it to range between 60 and 80% but we consider it will be much lower 20-30%. However, this reduction would only concern the newly installed geotextiles; the previously installed materials exposed to the environment would continue to release microplastics. Therefore, we estimate that it would reduce microplastic releases by **2 880 tonnes and up to 11 840 tonnes.**

Economic impacts

The economic impacts are expected to be twofold:

- Economic impact for the industry: they will be the ones developing the guidelines; this would require full-time equivalents from the industry association (the EAGM[345] in the EU or the IGS[346] if the guidelines are developed at a scale broader than the EU). Additional costs would be incurred by testing the materials and installing said materials together with the sampling of microplastics to ensure that the guidelines effectively reduce microplastic releases.
- Economic impacts for consumers / users: it is expected that these guidelines will require that higher quality materials are used and that they are adequately protected. This will most likely increase the cost of using geotextile solutions instead of their alternatives (rocks,

[345] European Association of Geotextile manufacturers
[346] International Geotextile Society

concrete structures, etc.). However, these economic impacts are expected to be reduced.

Environmental impacts

Environmental benefits are expected from this measure. Indeed, the guidelines will be designed with the goal of reducing microplastic releases. Thus, once they are in place, the emissions are expected to be significantly decreased. However, there are two caveats to this positive effect:

- It is possible that the guidelines may suffer from a significant delay from the industry during development, which would postpone the potential reduction of microplastic releases from this measure.
- All geotextiles which were installed before the publication of these guidelines will still release microplastics into the environment. Even more so, after they have been weathered by the environment, there is currently no scheme to remove geotextiles when they reach their end-of-life.

Social impacts

No social impact

GEO#5: Use biodegradable geotextiles for specific applications

Some geotextile materials are used to keep plants in place while they root. These materials are used for applications which are by definition short-lived and which will be impossible to recover once the plants have grown through them. Therefore, enforcing the mandatory use of biodegradable and bio-based materials made of jute, coco fibres, or others should significantly reduce microplastics from these materials.

What would be the costs of the measure?

This measure would increase the cost of the materials used for vegetation placement because biodegradable fibre geotextiles are more expensive than their non-biodegradable counterparts. In most cases, a biodegradable fibre has a natural origin, although not always. So, the cost for municipalities would increase. Moreover, members of the industry would suffer losses from the inability to sell their products, so an adaptation period will be necessary.

What would be the benefits of the measure?

There would be a reduction of microplastic releases from the use of polymer-based geotextile for short-term applications.

Economic impacts

The main economic impact will be on the end users as they will bear the additional costs of the biodegradable material, compared to the non-biodegradable ones.

Environmental impacts

This measure is expected to have a good positive impact on the environment in terms of the reduction of microplastic release as biodegradable in natural environment. Biodegradation will have to be supported by an appropriate standard.

Social impacts

There are no social impacts foreseen.

GEO#4 Establish geotextile classes according to emissions of microplastics

In the Construction Products Regulation (CPR), material classes can be defined through delegated acts depending on the quality/strength requirements for a given construction product. A similar system could be used for geotextiles: geotextile materials, depending on their manufacturing method, polymer type, and additive content (type of additive and concentration), could be classified according to quality standards based on the measurement protocols developed under 5f. Then, requirements regarding the minimum material class to use depending on the application would be made available, and only the accredited materials could be used for these applications.

What would be the costs of the measure?

The measure would need GEO#1 to be implemented before, in order to quantify the microplastic releases from geotextiles. The measure's cost would be due to developing the different material classes as well as testing the geotextiles to determine their class and defining for what application can a certain class of geotextile be used.

What would be the benefits of the measure?

This measure is expected to reduce microplastic releases from the installation of new geotextiles, and it is expected to reduce the emission faster than 2c (guidelines for geotextile applications) because it is expected to be implemented faster through a regulatory action than what the industry could do. The geotextiles may still be exposed to harsh environmental conditions, especially to weather events of unpredictable scale such as storms and could release some microplastics.

Economic impacts

It is expected to increase the impact on manufacturers to fulfil the class labelling obligations of the CPR. Increase costs of geotextile will also impact the cost for installing geotextiles for final users (e.g. municipalities, public works companies, landfill management companies etc. However, during the stakeholder consultation on levels and classes of performance (Article 27, Article 60) of the CPR, 64% of the respondents indicated no impact for establishing classes of performance and threshold levels in relation to the essential characteristics of construction products, some stakeholders believed that the process for establishing classes will be more time consuming and onerous.[347]

Environmental impacts

The reduction of microplastic releases is expected to be higher than 2c but in combination with 2c the reductions will be higher.

Social impacts

There are no social impacts foreseen for this measure.

GEO#1: Standardised methodology to quantify microplastics released from geotextiles

This measure was developed in response to the knowledge gaps that were identified around the precise measurement of microplastic emissions. Developing a standardised measurement methodology will enable the development of reduction-specific measures at a later stage.

This measure aims to develop a protocol to effectively measure microplastics released from geotextiles over the life cycle. There is evidence that microplastics are emitted from geotextiles; however, the quantification of such emissions still eludes researchers. Indeed, a systematic approach

[347] RPA (2015) Analysis of implementation of the Construction Products Regulation, DG GROW, European Commission

to microplastic sampling for geotextile particles in the environment currently does not exist. Moreover, since geotextiles are installed in various ways and for a wide range of applications, there would be some value in systematically taking samples to measure microplastic releases to the environment from different materials and installation methods.

The main goal of this measure would be to increase our understanding of the issue by developing a measurement methodology valid for measuring microplastic releases from different geotextile sources. E.g., different materials (PET, PP, etc.), different manufacturing processes (woven, non-woven, etc.). This should cover the complete life-cycle, i.e. producing geotextiles, their use in applications and end-of-life management.

Currently, there are tests used to evaluate the degradation of geotextiles from different weathering agents (UV light, temperature variation, water/saltwater,[348] oxygen exposure[349] or abrasion[350]).[351,352,353] The ISO 22182 test method simulates abrasion impacts on geotextiles and geotextile-related products such as that caused by the movement of rocks in an embankment or transport of sediment in rivers. This test can be used as a performance test by comparison of mechanical and/or additionally hydraulic properties before and after abrasion impact. Though not intended for assessing microplastic release, it could potentially simulate the development of abrasion-resistant geotextiles.[354] These methods do yield results which are currently used for the determination of geotextiles' lifetime expectancy. Still, they may not reflect the weathering power of the natural environment, especially when these affect the geotextiles conjointly. A recently published study highlighted the destructive effect that interacting weathering agents could have on geotextile aging:[355] "*The results, among other findings, showed the existence of relevant interactions between the degradation agents and showed that the reduction factors obtained by the traditional methodology were unable to represent accurately (by underestimating) the degradation occurred in the geotextile.*"

What would be the costs of the measure?

The costs would be split into two:

First, there would be the cost of developing the methodology (EUR 630 000-2 850 000).

Second, there would be the cost of testing the materials (EUR 2500/sample).

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[348] EN 12447, Geotextiles and Geotextile-Related Products-Screening Test Method for Determining the Resistance to Hydrolysis in Water, European Committee for Standardization, Brussels, Belgium, 2001.

[349] EN ISO 13438, Geotextiles and Geotextile-Related Products-Screening Test Method for Determining the Resistance to Oxidation, European Committee for Standardization, Brussels, Belgium, 2004.

[350] ISO 22182 :2020, Geotextiles and geotextile-related products — Determination of index abrasion resistance characteristics under wet conditions for hydraulic applications

[351] EN 14030, Geotextiles and Geotextile-Related Products-Screening Test Method for Determining the Resistance to Acid and Alkaline Liquids, European Committee for Standardization, Brussels, Belgium, 2001.

[352] EN 12224, Geotextiles and Geotextile-Related Products-Determination of the Resistance to Weathering, European Committee for Standardization, Brussels, Belgium, 2000.

[353] EN 12226, Geosynthetics—General Tests for Evaluation following Durability Testing, European Committee for Standardization, Brussels, Belgium, 2012.

[354] Maisner et al. (2019) Geosynthetics in traffic infrastructure construction in contact with groundwater and surface water – Environmental aspects. Georesources Journal (special issue)

[355] Carneiro, José Ricardo et al. "Laboratory Evaluation Of Interactions In The Degradation Of A Polypropylene Geotextile In Marine Environments". Advances In Materials Science And Engineering, vol 2018, 2018, pp. 1-10. Hindawi Limited, doi:10.1155/2018/9182658. Accessed 2 May 2022.

The estimated cost of developing the standard is shown in the below.

Table 65: Assumptions and data to estimate the costs of developing and implementing a standard

Description	Data	Unit	Source
Number of people working full time necessary to elaborate the standard between 12 and 36 months[356]	7.25	people	ISO website
Mean cost of labour in EU of one engineer working full-time	39.5	EUR/hour	Eurostat
Number of hours per week in a full-time job	40.6	hours/week	Eurostat
Number of Geotextile manufacturers in the EU	34	Number	Total EU members of the IGS and EAGM
Fraction of companies conducting tests for elaborating the standard	5	%	Assumption

Therefore, the **one-shot** cost of developing the standard would be in the range of **EUR 0.63 million and EUR 2.85 million** depending on the time it takes to develop the measurement standard.

In addition, once the standard is developed, there will be the additional cost of testing the materials (only once per material). This cost will be about 2,500 euros per test[357] according to ISO 22182.

What would be the benefits of the measure?

This measure will benefit all other measures as the release of microplastics during the life cycle of geotextiles is a critical knowledge gap. The indirect benefits will also include the awareness-raising of the geotextile value chain actors and users of geotextiles. If an EPR system is implemented, the eco-fee can also be modulated according to the volume of microplastic release and respective actors' contributions. It is already a necessary step to measure any reduction measure's success rate. Such information will also be useful in restricting the use of specific geotextiles in certain applications, such as coastal erosion, navigable waterways, etc.

This could be used to support further legislative development based on the evidence of microplastic releases from geotextiles. Another development could be to increase the industry's awareness about the emissions of microplastics from their materials. This would be exhibited by the industry focusing their efforts on developing new materials releasing fewer microplastics as well as considering microplastic releases whenever they develop geotextiles. Finally, this increased knowledge could be used to improve any type of recommendation regarding which material and manufacturing process to use for certain geotextile applications, as well as their installation requirements, as the results of this measure's test could point towards certain combinations releasing more than others.

Economic impacts

The economic impacts are expected to be limited because the cost of developing the sampling and testing protocols would be borne by the Commission.

[356] The ISO technical committee on the environmental aspects of plastics is comprised of 29 members (the national standardization organisation). We assume that each member contributes 0.25 FTE to work on the committee.

[357] https://materialtestinglab.org/

Environmental impacts

The direct environmental impacts are expected to be very limited, given that this measure is targeted at increasing our understanding of the issue. However, the secondary environmental impacts could be significant, especially if the industry takes up the practice of designing their products with the reduction of microplastic releases in mind.

Social impacts

There are no social impacts foreseen.

7.7 Overview of possible measures to improve source characterisation

The study of the six sources of unintentional microplastics has shown that many knowledge gaps still exist in the precise measurement of emissions. These knowledge gaps make the implementation of several measures impossible in the short term as it's not possible to define them (e.g. reduction targets) or evaluate their impact adequately.

Consequently, several measures that aim at increasing the knowledge of microplastic releases through the development of standards and methodologies in all sectors but tyres are recommended and presented in the table below.

These measures do not allow any reduction of microplastic releases per se; therefore, their cost-effectiveness cannot be assessed. Unlike other measures, the cost would be one-shot. They should be seen as enablers for other measures.

Table 66: Horizontal measures

Measure	Estimated cost
TEX#1: Standardised methodology to quantify microplastics releases from textiles	EUR 850 000 Testing cost EUR 10 000-20 000
PNT#1: Standardised methodology of paint lifetime	EUR 100 000 - 500 000 Testing cost EUR 10 000 -20 000
CAP#1: Standardised methodology to quantify microplastics released from detergent capsules	EUR 100 000 – 500 000 Testing cost: EUR 500-1000 per sample
GEO#1: Standardised methodology to quantify microplastics released from geotextiles	EUR 630 000 - 2 850 000 Testing cost about EUR 2 500 per sample

7.8 Abatement curve of assessed measures

The cost-effectiveness of individual measures was assessed as far as possible with the best available data. This has allowed for a ranking of the measures in terms of the cost to abate a tonne of microplastics. The abatement curve for all measures evaluated is shown in the figure below. The average or most plausible value is used for each measure, knowing that there is uncertainty about the data, depending on the source and measure, as explained in the annexes.

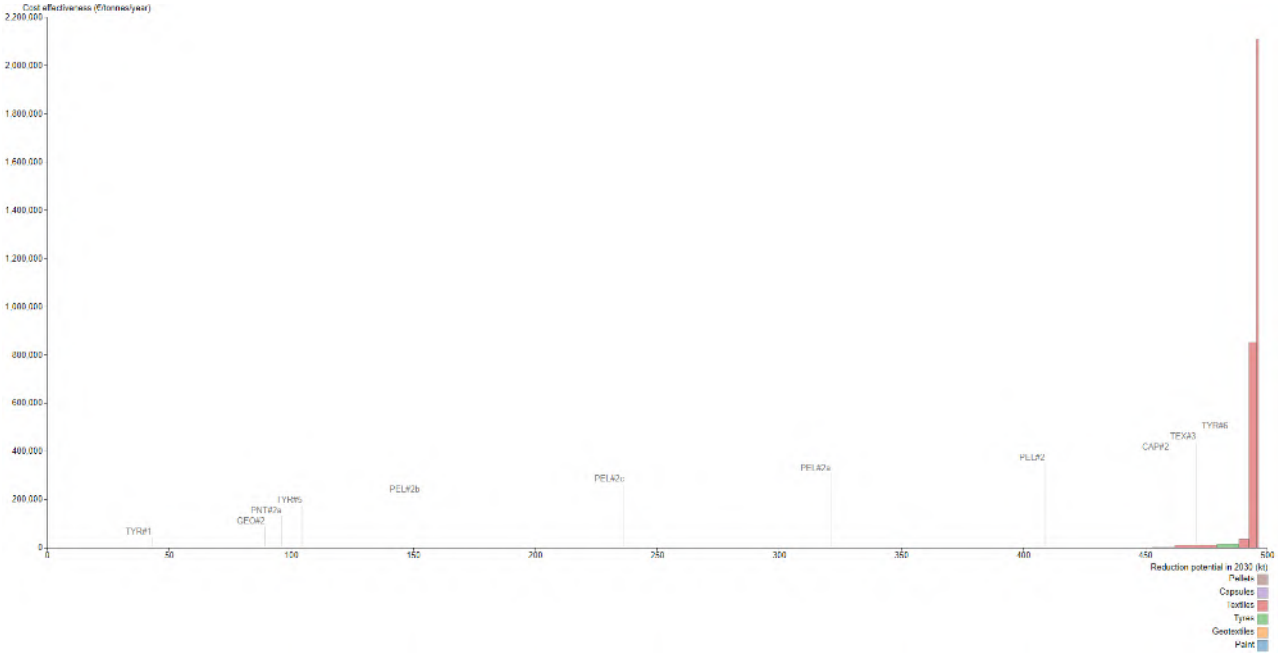

Figure 49: Abatement curve of all evaluated measures[358]

As the order of magnitude of the cost-effectiveness of the measure is different, a zoom of selected measures is displayed in the figure below.

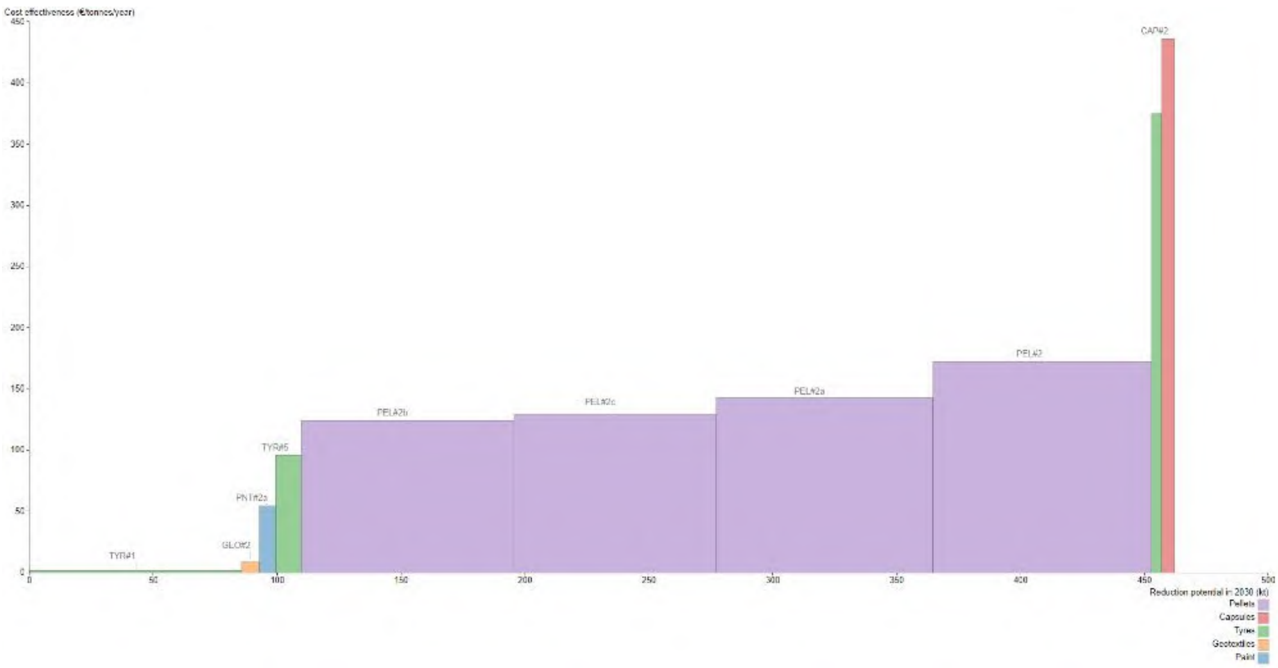

Figure 50: Abatement curve of evaluated options with cost effectiveness inferior to 6 k EUR/t microplastics/year

[358] TYR#5 and TYR#6 may have positive impacts in terms of fuel savings for customers.

8. Rationale for not yet pursuing the measures for sources: paints, tyres, textiles, detergent capsules, geotextiles

This section explains why the analysis of policy measures targeting five of the major sources of unintentional releases of microplastics were not pursued in this SWD. Indeed, the Commission's original mandate when this exercise begun was to assess all major sources of unintentional releases of microplastics. For this reason, these sources were examined and measures were identified. The preliminary analysis presented in Annex 15 shows that there is potential to reduce and prevent unintentional microplastics releases from sources such as paints, tyres, synthetic textiles, detergent capsules and geotextiles. However, the analysis also demonstrates that existing and upcoming policy instruments are better suited to tackle the unintentional microplastics releases from some of these sources, subject to additional information on cost-effectiveness, more sustainable alternatives, and the impacts and footprint of alternative actions. On a number of other sources, more information is needed in order to better understand their patterns and frame the most appropriate interventions.

Paints – Paints are widely used and on average 37% plastic polymer-based, making them a significant source of microplastic releases. While shifting towards mineral paints would help reduce microplastic releases, it is not clear yet if this would lead to an increase of other environmental impacts. The full environmental profile andlife-cycle assessments of polymer and mineral paints are not available yet. Once this information is obtained, requirements on microplastics in paints could be introduced via the Ecodesign for Sustainable Products Regulation (ESPR)[359], where paints is one of the twelve priority products.

Tyres – Tyre abrasion leads to the release of microplastics. It emerged during our analysis that these releases are already being targeted in the EURO 7 Regulation proposal[360] and may be addressed by a delegated act under the Tyre Labelling Regulation.[361]

Synthetic textiles – Most apparel is now made out of plastic fibres and releases microplastics. Some key challenges encountered in the course of the assessment are that microplastic releases from synthetic fibres occur throughout the value chain, that most of their production takes place outside of the EU, and that there is not sufficient data regarding the profiles of different synthetic fibres and fibre combinations in terms of microplastic releases. Subject to a better understanding of releases from synthetic textiles thanks to a standardised measurement methodology, along with more life-cycle data of alternatives' impacts, relevant measures could be introduced in the framework of the Ecodesign for Sustainable Products Regulation as announced in the EU Strategy for Sustainable and Circular Textiles. Such an approach will ensure the environmental sustainability challenges of textiles are addressed in a coherent and integrated way.

Detergent capsules – Laundry and dishwasher detergent capsules often rely on a dissolvable plastic film to dispense their product during the wash. However, this film could cause microplastic pollution if not completely biodegradable. More information on this possible lack of biodegradation is needed.

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[359] Proposal for a regulation of the European Parliament and of the Council COM/2022/142 final establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC.

[360] Proposal for a regulation of the European Parliament and of the Council COM/2022/586 final on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7) and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009.

[361] Regulation (EU) 2020/740 on the labelling of tyres with respect to fuel efficiency and other parameters, amending Regulation (EU) 2017/1369 and repealing Regulation (EC) No 1222/2009.

Subject to scientific evidence pointing towards a need for biodegradability criteria, future action could be taken under the proposed Detergents Regulation through the adoption of delegated acts.

Geotextiles – Geotextiles are a source of microplastic releases as they are mostly synthetic, used in harsh conditions and not removed at the end of their service life. However, data on their uses and profile in terms of degradation and microplastic releases is scarce. Once more data is available, future action could be taken in the framework of the Construction Products Regulation.[362]

Horizontal measures for all five sources – In order to bridge the data gaps on the unintentional release of microplastics from the above five sources, standardised measurement measures could be pursued through Research and Innovation Programmes by funding relevant research projects or under the Standards Regulation.[363] In particular for sources of microplastics that were already relatively known such as for tyres and textiles, this process is already ongoing.

[362] Regulation (EU) No 305/2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC.

[363] Regulation (EU) No 1025/2012 on European standardisation, amending Council Directives 89/686/EEC and 93/15/EEC and Directives 94/9/EC, 94/25/EC, 95/16/EC, 97/23/EC, 98/34/EC, 2004/22/EC, 2007/23/EC, 2009/23/EC and 2009/105/EC and repealing Council Decision 87/95/EEC and Decision No 1673/2006/EC.