Nordic Council
of Ministers

Addressing microplastics in a global agreement on plastic pollution

Contents

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Abbreviations

AMAP	Arctic Monitoring and Assessment Programme
ASEAN	Association of Southeast Asian Nations
BAT	Best Available Technique
BEP	Best Environmental Practice
CEN	European Committee for Standardization
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
EPS/XPS	Expanded and extruded polystyrene
ESM	Environmentally Sound Management
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
HELCOM	The Baltic Marine Environment Protection Commission
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organization
INC	Intergovernmental Negotiating Committee
ISO	International Organization for Standardization
MARPOL	The International Convention for the Prevention of Pollution from Ships
MSFD	EU Marine Strategy Framework Directive
NOWPAP	Northwest Pacific Action Plan
NOAA	National Oceanic and Atmospheric Administration
OCS	Operation Clean Sweep
OECD	Organisation for Economic Co-operation and Development
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PAME	Protection of the Arctic Marine Environment Working Group
PIC	Prior Informed Consent
POP	Persistent Organic Pollutant

RAC	EU Committee for Risk Assessment
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SAPEA	Science Advice for Policy by European Academies
SDG	Sustainable Development Goals
SEAC	EU Committee for Socio-economic Analysis
UN	United Nations
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
WHO	World Health Organization
WWTP	Wastewater treatment plant
ZPAP	Zero Pollution Action Plan

Executive summary

In March 2022, the second session of the 5th United Nations Environment Assembly unanimously adopted *Resolution 14. End Plastic Pollution: towards an international legally binding instrument*[1]. The resolution marked the start of a process to negotiate a legally binding international agreement to end plastic pollution. The preamble to the resolution highlights that "*plastic pollution includes microplastics*", hence the Intergovernmental Negotiating Committee will need to consider how to address both macroplastic and microplastic pollution in a global agreement.

Objectives of the report

The Nordic Report on Addressing Microplastics in a Global Agreement provides a reference for how microplastics may be addressed under a global agreement on plastic pollution, and what considerations should be taken to that end. The report elaborates on how microplastics are currently regulated and managed, as well as the most appropriate measures and modalities to address microplastics. It is intended to inform and inspire stakeholders and policymakers, including negotiators and delegates in the Intergovernmental Negotiating Committee (INC), to consider microplastics holistically.

To do so, the report first introduces key concepts, principles and terminology to establish a framework for addressing microplastics in a global agreement, before summarising the current knowledge base and the challenges that remain for the science-policy interface on microplastic pollution. It provides an analysis of existing measures on microplastics, focusing on effectiveness, and elaborates on how different sources and pathways may require different measures. A separate chapter is dedicated to examining lessons learnt from existing multilateral environmental agreements under the chemicals and waste cluster (e.g. the Stockholm, Rotterdam, Basel and Minamata Conventions), before proposing constellations of measures and supporting mechanisms to address microplastic pollution in the global agreement.

1. UNEP/EA.5/Res.14

The current knowledge basis for addressing microplastics

Microplastics (see Box 1) are widely present in different environmental compartments, including biota, air, water, and sediments, including the most remote regions of the world. Once released into the environment, microplastics are very difficult to fully remove due to their small size. Their accumulation in the environment poses a growing though still not quantified risk to biota, human and environmental health as concentrations will continue to increase without action. Recent studies have reported on microplastics in human lungs and bloodstreams, driving concerns over the long-term health effects of exposure. The transboundary nature of microplastic pollution, both with regards to environmental transport across national borders (by air, through sediments and in water), as well as human transport through globalized production and trade systems, including waste shipments, necessitate international measures under a global agreement to end plastic pollution.

Whether intentionally produced and used, or arising from the degradation of plastic materials, microplastic pollution is a symptom of current unsustainable production and consumption patterns. All plastic products shed microplastics, at rates determined by chemical composition and integrity, and exposure to degradative forces. While releases can be reduced with appropriate measures, it is impossible to prevent all microplastic releases from plastic products. Yet, different control measures may significantly reduce the rates of release by phasing out non-essential uses of microplastics, reducing and phasing out the production and use of non-essential plastic products, and targeting the production, safe design, use and waste management of essential and non-substitutable plastic products, microplastics and plastic materials.

Box 1. Categorising microplastics

Microplastics can be defined as*:

Plastic particles smaller than 5 millimetres, including nanoplastics**.

Microplastics are commonly sub-categorized into four broad categories:

- **Plastic pellets, flakes and powders:** Microplastics produced for the use in manufacturing of plastic products.
- **Intentionally added primary microplastics:** Microplastics purposefully designed to be small in size for their application and use, such as in cosmetics or abrasive scrubbers.
- **Use-phase secondary microplastics:** Microplastics originating from the degradation and weathering of plastics during use.
- **Degradation-based secondary microplastics*:*** Microplastics originating from the degradation and weathering of larger pieces of plastics after deposition in landfills or when lost in the environment. This category also includes microplastics generated unintentionally in the recycling sector.

* An extensive elaboration on the various definitions of microplastics and their implications is provided in Chapter 2 of the report.

**Nanoplastics are microplastics smaller than 1/10 000 millimetre.

An ambitious global agreement should therefore address the dominant sources of microplastic pollution, including microplastics released from the degradation of plastic products, to minimize emissions. Microplastics cannot be regulated in a vacuum, and as all plastic products and materials can degrade into microplastics unless immobilised, measures to reduce plastic production and subsequent pollution is an important starting point.

There has been substantial research addressing the fate and effects of microplastics. Enough evidence is available to establish key sources and pathways for release of microplastics to the environment and thus the development of targeted measures. Though, there may be important sources of microplastics pollution that are not recognised due to limitations in methods, protocols, and scales of monitoring. The human and environmental risks associated with microplastics are still being investigated. Some impacts, including both physical and chemical effects, have been observed in scientific studies, but vary depending on the characteristics of the microplastics, organisms (including humans) and environments in question. Further, microplastics represent a diverse suite of contaminants and there is insufficient research addressing the various particle typologies (sizes, shapes, chemical compositions, e.g. polymer types and additives) that can be included under the umbrella term of microplastics.

In identifying measures to limit microplastic pollution under a global agreement, central tenets of international environmental law such as prevention, the precautionary principle, and the polluter pays principle should lie at the foundation. It has been argued that the accumulation of microplastic in the environment, and the complexities in assessing data on risk, makes microplastics *non-threshold contaminant*s for risk assessment purposes. These are contaminants for which no safe threshold for emissions can be identified. The approach is based on the rationale that even if a safe threshold exists, it will inevitably be surpassed because of the continued accumulation and persistence of microplastics in the environment. This underlines the necessity of a precautionary approach to reduce the emissions of microplastics.

Current measures to address microplastics

Presently, there are no legally binding measures on the global level addressing microplastics. On the national and regional level there are few regulatory measures addressing microplastics beyond microbeads in rinse-off cosmetics. Yet, in recent years there has been a step-change in the number and breadth of measures being proposed or introduced. The EU has adopted a quantitative reduction target for microplastic pollution, aiming to cut emissions by 30% by 2030 compared to 2016 levels, and is developing an intricate web of measures to address microplastics across the plastic product lifecycle. Furthermore, research efforts and commitments to formulate policies are increasingly moving from overall efforts to monitor microplastics in the environment, to quantifying key sources and pathways, and identify appropriate control measures.

Existing policies also reflect different capabilities between countries in assessing and addressing microplastics pollution. Overall, the present review shows that lower- and middle-income countries have introduced fewer policies specifically targeting microplastics, while some higher income countries are developing upstream measures addressing intentionally added microplastics and microplastics pollution stemming from pellet losses, textiles, road wear and agricultural plastics. It is important to note that there are differences in the primary sources of microplastics to the environment according to climate, geography, key industries and consumer behaviours, which will necessitate different measures according to context. National action plans have been suggested as a format under the treaty to capture such local variability.

Addressing microplastics under a global agreement

Drawing on the four categories of microplastics (Box 1), and experience from other environmental treaties, there is a strong incentive for differentiating between intentional and unintentional sources of release, which trigger different control measures. Measures to control '*plastic pellets, flakes and powders*' should focus on setting standards and requirements for transport, storage, trade and stockpile management. Common best available techniques and best environmental practices (BAT/BEP) standards and guidance, alongside emission limit values from industrial facilities, may be established to prevent emissions from the production of these materials.

The second category of intentional use, '*intentionally added primary microplastics*', is a category that can be controlled and potentially eliminated. Provided that less harmful alternatives are accessible and economically feasible, the production, consumption, and trade of these microplastics should be banned or restricted.

When it comes to unintentional sources of microplastics, '*use-phase secondary microplastics*', are generated during use due to wear and tear of products containing plastic materials. Establishing bans or restrictions on products with the greatest risk of generating microplastics; improving product design through design criteria and requirements; restrictions on use and application of certain materials; labelling requirements; voluntary codes of conduct; BAT/BEP on industrial applications and improved wastewater treatment systems are relevant measures to control this category of microplastics.

The last category, '*degradation-based secondary microplastics*' is also an unintentional source category, that would require somewhat different control measures. Prevention, reduction, safe circularity and improved management of plastic waste are by far the most important measures to control this source. Improved product design and BAT/BEP for mechanical recycling activities could also contribute to reduce emissions of this category of microplastics.

In line with other comparable environmental treaties, the new plastic treaty should be a dynamic and flexible instrument, opening for the addition of new polymers, products, and/or processes to be regulated, should emerging science disclose the need for further regulation due to the scales of releases or impacts of microplastics pollution. Considering the scale of the plastic market and the high degree of product innovation, a scientific review committee, evaluating the listing of new polymers, additives, products or processes could be warranted. Establishing such a committee would increase credibility and would require provide fair representation from all regions.

Recommendations

In conclusion, we make the following recommendations based on the findings of the Nordic Report *Addressing Microplastics under a Global Agreement on Plastic Pollution.*

- A global agreement to end plastic pollution will need to specifically address microplastics as a distinct category of plastic pollution, warranting specific control measures.

Objectives and preamble

- The objective of the treaty should include language on achieving reductions in the generation and release of microplastics to the environment, and to prevent harm to human and environmental health.
- The overarching objective could be supplemented by sub-objectives and targets. These could be quantitative or qualitative and should in all cases be possible to follow up.

Definitions

- Microplastics should be defined under the treaty in a manner which enables the diversity of microplastics to be captured.
- A definition should ensure that key sources of microplastics such as plastic pellets, flakes and powders; polymeric coatings; microbeads; synthetic microfibres; paints; degradation of macroplastics; rubber infill materials, tyre and road wear particles, etc. are included under a treaty and addressed by its relevant measures.
- A definition should therefore have inclusion criteria to ensure all categories of microplastics are covered.
- While plastic pellets, flakes and powders are commonly considered microplastics, these materials may exceed commonly used size boundaries. To avoid microplastic regulations inadvertently leading to a shift towards larger sizes to avoid regulation, measures on plastic pellets, powders and flakes may be considered as microplastics even if exceeding the common size boundary of 5 mm.

- A definition should not have a lower size bound in order to allow the instrument to adapt to future development of methods for sampling and analysis. Today particles below 0,1 μm are difficult to identify and quantify using available analytical methods. Such small particles may be subject to measures, when technically feasible, as the instrument strengthens over time.
- **A potential definition could be formulated as:**
  Particles with synthetic polymers (including biodegradable and water-soluble polymers) that are either contained within or building a continuous surface coating on the particles, where:
  i) all dimensions of the particles are equal to or less than 5 mm; or
  ii) the particles have a length of 0.3 μm ≤ x ≤ 15 mm and length to diameter ratio of >3; or
  iii) the particles are plastic pellets, flakes and powders used for the production of plastic products.
  Excluding polymers that occur naturally and are not chemically modified substances.

The design of operational provisions

- Measures under the provisions addressing microplastics should differentiate between categories of microplastics as these differ with regards to routes of leakage and control measures. The categorisations should include:
  i) Plastic pellets, flakes and powders
  ii) Intentionally added microplastics
  iii) Use-phase secondary microplastics
  iv) Degradation-based microplastics
- Operational provisions to address microplastic pollution should strive to adhere to the waste hierarchy, prioritising upstream reduction, alongside the principles of prevention, precaution and polluter pays.
- Data gaps around dominant sources of microplastics in many parts of the world necessitate a start-then-strengthen approach. Sources for which measures are readily available to eliminate, mitigate or remediate, should be included in the first iteration of the treaty. Provisions should be formulated sufficiently adaptive to allow the addition of new control measures as new sources and pathways are identified.
- The dominant sources of microplastic pollution differ according to the economies, climates, biodiversity, and social structures. In countries with poor or non-existent waste management systems, degradation-based secondary microplastics are likely to constitute the largest proportion of microplastic pollution. Measures to address microplastics should reflect this but must be coupled with international obligations to phase out problematic uses and processes contributing to point sources of microplastic pollution.
- In cases of substitution, alternatives should be assessed through holistic life cycle approaches that balances benefits and trade-offs between the three dimensions of sustainability: economic, social and environmental.

Operational provisions

Plastic pellets, flakes and powders can be regulated through global measures across the value chain to prevent losses.

- The agreement should include requirements for the reporting on production, composition and trade of plastic pellets, flakes and powders.
- A global agreement should set requirements for the safe production, transport, handling and storage of plastic pellets, flakes and powders, including measures addressing the chemical content of these materials.
- The delegates of the INC could consider restrictions on trade of pellets, flakes and powders, which could be supported by Harmonized System (HS) codes.
- A global agreement could include commitments to prevent and cooperate in response to acute plastic pollution events such as accidental spills of plastic pellets, and hold polluters responsible for mitigation, remediation and compensation for any pollution events.
- Best practices could be operationalised through global certification schemes building on, but not limited to, the industry initiative Operation Clean Sweep across the supply chain.
- Enforcement of effective product stewardship could be ensured through requiring producers and brand owners of plastic products to prove chain of custody through certified supply chains to gain access to markets.

Intentionally added primary microplastics can be addressed through an essential use approach.

- A dedicated ad-hoc expert group should be established to identify key global sources of intentionally added primary microplastics; develop criteria for restrictions; and create a shortlist of essential and non-essential uses of these microplastics to be provided to the INC. The expert group could also identify where alternative materials, designs and models need to be developed.
- All non-essential intentionally added primary microplastics should be phased-out with timebound targets, compliance and enforcement measures, and subjected to trade restrictions on exports and imports.
- Essential intentionally added primary microplastics should managed through restrictions on use, emissions regulations, guidelines, the development of BAT/BEP, and reporting requirements.

Use-phase secondary microplastics could be addressed through measures addressing reduction, product design, use and maintenance.

- An agreement should include commitments to develop global product standards or design criteria for dominant sources, hotspots and pathways of use-phase secondary microplastics with minimum requirements which must be met to prevent releases from abrasion and other forms of fragmentation.
- An ad-hoc expert group should be formed to assess key sources, pathways and fates of use-phase secondary microplastics, availability of alternatives, and needs for BAT/BEP guidelines to be reported to the INC.

- An agreement should include measures to establish BAT/BEP to further mitigate emissions from key sources of use-phase secondary microplastics.
- Measures should allow for sufficient flexibility for Parties to design incentives, economic tools and regulatory requirements to reduce dominant sources in their jurisdictions.

Degradation-based secondary microplastics

- An agreement must include measures to reduce secondary microplastic emissions from macroplastics, including measures to prevent and reduce production of unnecessary and problematic plastic products; improve durability for safe reuse, recycling, repair, and remanufacture and improved plastics waste management for all sectors, including the informal sector.
- An agreement should include dedicated measures to prevent microplastics pollution from the repurposing, reuse and recycling of plastics.

Other components

Microplastic pollution differs from macroplastic pollution in many ways. Throughout the INC process, specific considerations related to microplastics pollution will need to be incorporated. This includes the design of national action plans, establishing source inventories, efforts under scientific and technical cooperation and coordination, capacity building, and technical and financial support for monitoring and reporting, especially for less developed countries.

Chapter 1. Introduction: Microplastics in a global agreement on plastic pollution

1.1 The UN Resolution to End Plastic Pollution emphasized microplastic pollution

In March 2022, the second session of the 5th United Nations Environment Assembly unanimously adopted *Resolution 14. End Plastic Pollution: towards an international legally binding instrument*[2] (hereafter referred to as the resolution). The resolution marked the start of a process to negotiate a legally binding international agreement to end plastic pollution. The preamble to the resolution highlights that "*plastic pollution includes microplastics*". Hence, the intergovernmental negotiating committee (INC) will also have to consider how best to address microplastics alongside macroplastics and their chemical constituents in the design of a global agreement.

2. UNEP/EA.5/Res.14.

Box 2. Categorising microplastics

Microplastics can be defined as*:

Plastic particles smaller than 5 millimetres, including nanoplastics**.

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- **Plastic pellets, flakes and powders:** Microplastics produced for the use in manufacturing of plastic products.
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* See Chapter 2 of the report for an elaboration of the various definitions of microplastics and their implications.

**Nanoplastics are microplastics smaller than 1/10 000 millimetre.

1.2 Why address microplastic pollution in a global agreement on plastic pollution?

Microplastic pollution is an urgent issue due to the increasing releases and persistence of microplastics in the natural environment, and associated risks to human and environmental health[3].

Microplastics are either intentionally produced or result from the degradation and weathering of larger plastic pieces. Once in the environment, microplastics are highly persistent, practically impossible to fully clean up and can degrade into increasingly small fractions[4]. Annual emissions of microplastics are estimated to exceed 3 million tonnes globally[5]. Microplastics are found on all continents and in the most remote regions of the world[6]. Microplastics are transported by natural processes such as winds, rivers and ocean currents, making microplastic pollution a transboundary issue requiring global coordination[7].

The accumulation and persistence of microplastics in the environment warrants concern around the potential environmental and human health impacts associated

3. Andrady 2017; Barrett et al. 2020; Boucher & Friot 2017a
4. GESAMP 2015
5. UNEP 2018a
6. Aves et al. 2022; Napper et al. 2020; Peng et al. 2018
7. Evangeliou et al. 2020

with such pollution[8]. Most early research on impacts focused on marine animals or ecotoxicology studies on model organisms. Although, recently, microplastics have been reported in human lungs, bloodstreams, breastmilk and embryos[9]. The risks associated with microplastics are not solely due to their physical presence (physical toxicity) but are linked to the uncertain impacts of the chemicals associated with plastics (chemical toxicity). This includes chemicals incorporated into plastics during production as well as environmental contaminants, including organic chemicals and heavy metals which sorb to plastics surfaces once in the natural environment[10]. Such chemicals, e.g. brominated flame retardants, bisphenol A and polychlorinated biphenyls, are known to have impacts on microbial communities and human health, including endocrine disruption, genotoxicity, carcinogenicity and reproductive toxicity[11].

While the mechanisms for releasing contaminants from microplastics and their impacts on human health are less well understood[12], recent evidence suggests that ingestion and digestion of microplastics may pose a risk to human health due to the release and exposure to plastic associated chemicals[13]. The diversity of microplastics in terms of their chemical makeup (polymers and additives), shapes, and sizes makes comprehensive risk- and impact assessments challenging[14]. Still, there is increasing evidence for the potential harmful impacts of microplastics on biota and human health[15]. A comprehensive review from 2019 found that while present levels of micro- and nanoplastics in the environment do not yet comprise a widespread risk to humans or the environment, 'pockets' of risk exist where there are high exposure levels to microplastics[16]. As microplastics accumulate and persist in the environment, the number and scales of such pockets can be assumed to increase indefinitely if appropriate measures to prevent microplastic pollution throughout the plastic lifecycle are lacking.

The persistence, risk and transboundary nature of microplastic pollution thus warrants action to prevent and reduce microplastic pollution. The globalised and transboundary nature of plastic production, supply chains and waste trade makes it challenging for individual nations to effectively implement measures to address microplastic pollution. Furthermore, piecemeal legislation is a significant barrier for equitable competition and competitiveness between and within markets. Preventive and mitigating measures for microplastic pollution require global coordination for the benefit of individual states as well as for industry actors currently facing a rapidly expanding regulatory environment. A global approach is necessary to ensure harmonised and effective legislation and a level playing field for businesses and industry as the ultimate sources and producers of the products that result in microplastic pollution.

8. Andrady 2017
9. Jenner, Rotchell, et al. 2022; Leslie et al. 2022; Ragusa et al. 2021; 2022
10. Rochman 2015; Rodrigues et al. 2019
11. SAPEA 2019
12. Alidoust et al. 2021; Koelmans et al. 2022; Rodrigues et al. 2019
13. López-Vázquez et al. 2022
14. Amy L. Lusher et al. 2020; Mitrano & Wohlleben 2020; Rochman et al. 2019; Thornton Hampton et al. 2022
15. Gomes et al. 2022; Persson et al. 2022; Wardman et al. 2021
16. SAPEA 2019

1.3 Aims of report

This report provides a reference for how microplastics may be addressed under a global agreement on plastic pollution, and what considerations should be taken to that end. In the coming chapters, we elaborate on how microplastics are currently regulated and managed, as well as the most appropriate measures and modalities to address microplastics. We intend to inform and inspire stakeholders and policymakers, including negotiators and delegates in the INC, to consider microplastics holistically in accordance with the guidance provided by the United Nations Environment Assembly (UNEA) in Resolution 5/14.

To do so, we first introduce key concepts, principles and terminology to establish a framework for addressing microplastics in a global agreement in **Chapter 2,** before we summarise the current knowledge base and the challenges that remain for the science-policy interface on microplastic pollution in **Chapter 3**. In **Chapter 4**, we analyse existing measures on microplastics, focusing on effectiveness, and elaborate on how different sources and pathways may require different measures. **Chapter 5** takes a step back to examine lessons learnt from existing multilateral environmental agreements under the chemicals and waste cluster, before proposing measures and supporting mechanisms to address microplastic pollution in the global agreement in **Chapter 6.**

1.4 Approach and methodology

In developing this report, we prioritised engaging with diverse stakeholders from all continents and representing policymakers, industry actors and civil society to ensure a holistic consideration of microplastic pollution, including relevant sources and control measures. As emphasised in the resolution, the agreement will require recognition of the various experiences with plastic pollution.

More specifically, this report is based on a review of the current policies and measures to address microplastics at the global, regional and national level. As the regulatory landscape is rapidly expanding, we have prioritised policies specifically targeting microplastics, though there are policies primarily related to waste and wastewater management, product design, etc. which may indirectly be relevant for microplastics. Due to resource constraints, we have primarily examined national-level policies available in English, though we have endeavoured to try to capture a representative overview.

Drawing on the review, we identified questions which were put up for consideration to stakeholders engaged in the advisory committee of the report. Through three rounds of consultations, the measures proposed are thought to combine the necessary specificity to enable global coordination, while ensuring flexibility to be appropriate for implementation at the national and local level.

1.5 Glossary of terms

Acute plastic pollution: Pollution events where a large amount of plastics (either macro- or microplastics) are released into the environment from a single source.

Degradation-based secondary microplastic: Microplastics generated from the degradation and weathering of plastic wastes and litter.

Diffuse pollution: Pollution which is challenging to attribute to a specific source as the pollution is caused by multiple emissions of pollutants over time and space.

Harmonisation: Translation and comparability of data collected in different contexts.

Hazardous chemicals: Hazardous chemicals are substances with hazardous properties that may cause significant adverse impacts on human health and the environment; such as, but not limited to, carcinogens, mutagens and chemicals hazardous to reproduction, persistent bio-accumulative and toxic substances, endocrine-disrupting chemicals and chemicals with neurodevelopmental effects.

Intergovernmental negotiating committee (INC): An ad hoc forum for the purpose of negotiating an international legal instrument, such as a framework convention.

Microbead: Microplastics used in products as an abrasive, i.e., to exfoliate, polish or clean.

Microfiber: Microfibers are solid, polymeric, fibrous materials: to which chemical additives or other substances may have been added, and which have at least two dimensions that are less than or equal to 5 mm, length to width and length to height aspect ratios of greater than 3, and a length of less than or equal to 15 mm. Fibers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded[17].

Microplastics: Plastic particles typically smaller than 5 millimetres, including nanoplastics (see chapter 2).

Nanoplastics: Plastics within the nanometre size range. The size threshold associated with nanoplastics is not yet set and both 100 and 1000 nm are used.

Persistent organic pollutants (POPs): Organic chemical substances that once released into the environment remain intact for exceptionally long periods of time (many years); become widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air; accumulate in the living organisms including humans, and are found at higher concentrations at higher levels in the food chain; and are toxic to both humans and wildlife[18].

Polymer: Refers to a molecule of high molecular weight consisting of a repetitive sequence of a large number of simple molecules called monomers, which may or may not be the same[19].

Plastic: Defined as synthetic organic polymers with thermo-plastics or thermo-set properties (synthesized from hydrocarbon or biomass raw materials), elastomers (e.g. butyl rubber), material fibres, monofilament lines, coatings and ropes[20].

Plastic dust: Fine particulate matter with irregular form and size, produced when plastics are manufactured, handled, conveyed, machined or processed[21].

17. US EPA 2022
18. UNEP n.d.
19. UNEP 2021a
20. GESAMP 2019
21. OSPAR Commission 2021

Plastic flakes: Small flat shaped matter with regular or irregular form that serves as feedstock in plastic product manufacturing operations or plastic that has been shredded. Plastic flakes can be manufactured or generated though the agglomeration of plastic dust or powder when plastics are processed[22].

Plastic pellets: Mass of pre-formed moulding material, having relatively uniform dimensions used as feedstock in plastic product manufacturing operations[23].

Plastic powders: Fine particulate matter that serves as a feedstock in plastic product manufacturing operations[24].

Point-source pollution: A single identifiable source of pollution.

Primary microplastic: Microplastics purposefully designed to be small in size for their application and use, such as in cosmetics or abrasive scrubbers.

Use-phase secondary microplastic: Microplastics generated during intended product use. Examples include microfibres from synthetic textiles, polymers from tyre, road and brake wear and the degradation of paints.

22. OSPAR Commission 2021
23. OSPAR Commission 2021
24. OSPAR Commission 2021

Chapter 2. Foundations: Key terms and concepts

2.1 A common definition of microplastics

A definition impacts both what is regulated, and what is measured and monitored in the environment.

Presently, there is no single, universally agreed definition of microplastics. 'Microplastics' is an umbrella term commonly used to refer to all plastic particles smaller than 5 mm in size. This seemingly simple definition leaves much up for interpretation. Different definitions have been established for use in different contexts (see **Table 1**). Some of the questions that may arise relate to the proportion of plastic polymers in a given fragment or particle; the size and shape; whether biodegradable plastics undergoing degradation are included (see **Box 3**); and the state of the polymer; as outlined in **Figure 1.** There is increasing consolidation and agreement around some of these questions, and ongoing research is looking into harmonising definitions and monitoring protocols[25]. Establishing coherence in defining microplastics and the implications of different definitions will be important input to the INC process.

25. The EU Horizon 2020 project EUROqCHARM (Grant Number: 101003805) aims to develop optimised, validated and harmonised methods for monitoring and assessment of plastics, including microplastics, in the environment, as well as blueprints for standards and recommendations for policy and legislation. See euroqcharm.eu for more.

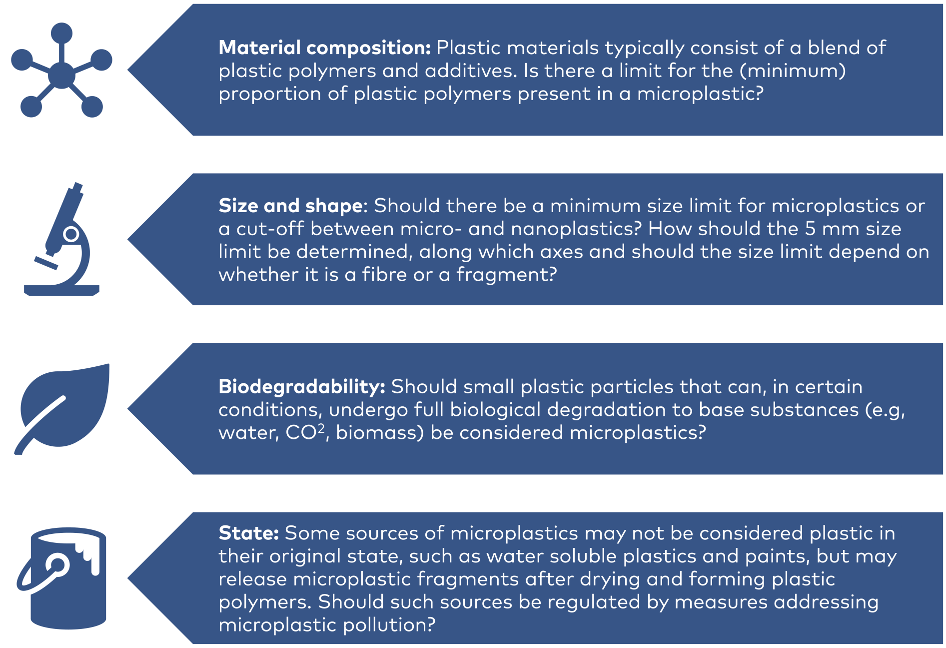

Figure 1. Examples of factors that could be considered in defining microplastics.

The definition of microplastics and its level of detail has implications on a legal, policy and scientific level (see **Box 4**). Natural scientists often require a highly specific definition of microplastics, which outlines specific shapes, sizes, states, etc. to allow for effective analyses and harmonisation of data. A policymaker, on the other hand, requires a definition that can be applied in a legal context for establishing implementable governance and policy frameworks to guide measures. This typically necessitates different levels of specificity, and a scientifically accurate definition may not be applicable in a legal context. It should therefore be noted that while the specific definitions used for the term ‘microplastics’ may vary between fields, this does not necessarily represent an obstacle to progress both within and across these fields.

Box 3. Defining biodegradability

Definitions and standards

Biodegradable plastics are plastic materials that are capable of being biodegraded. Biodegradation refers to the process whereby the plastic is completely or partially converted to water, carbon dioxide or methane, energy, and/or new biomass by microorganisms such as bacteria or fungi[26]. Biodegradable plastic materials may be partially or completely composed of plastic polymer: some materials contain a blend of a biodegradable plastic and other biodegradable materials such as natural polymers (e.g. starch). Examples of biodegradable plastics include poly-3-hydroxyalkanoates (PHAs), polycaprolactone (PCL), and polybutylene adipate terephthalate (PBAT). Biodegradable plastics are certified for biodegradability in different environments or conditions based on a series of standards or test methods; for example, ISO 14851:2019 for aqueous media and ISO 17556:2019 for soils. These set requirements for the extent of biodegradation, such as 90% biodegradation within 24 months.

Compostable plastics are plastic materials that are capable of being biodegraded under specific conditions. These refer to elevated temperatures and a controlled environment that is typically achieved during industrial composting[27]. These conditions may not necessarily include those available in home composting settings[28]. An example of a compostable plastic is polylactic acid (PLA). Standards for compostability set requirements for biodegradation (e.g. 90% of the organic material is converted to carbon dioxide within 6 months) and disintegration (e.g. ≤10% of the original mass is left as residue on 2 mm sieve after 3 months of composting); for example, ISO 17088:2021 or ASTM D6400-21.

In addition to these, the terms **bio-based plastics** and **bioplastics** are increasingly used. This has the potential to cause some confusion or misinterpretation of the material properties of a plastic[29]. Bio-based plastics are plastic materials that are produced from a feedstock that is partially or completed composed of biomass, as opposed to fossil. Some bio-based plastics may be biodegradable, such as polyhydroxybutyrate (PHB), whilst others are not, even if their original starting material was biodegradable[30]. Non-biodegradable bio-based plastics are sometimes labelled as "bio", such as bioPE referring to bio-based polyethylene[31]. Bioplastic is a term that can be used to describe all of the materials addressed above: biodegradable plastics produced from a feedstock of either biomass or fossil or bio-based plastics which may or may not be biodegradable. Bioplastic, therefore, does not infer biodegradability.

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26. UNEP 2015
27. UNEP 2015
28. SAPEA 2020
29. SAPEA 2020
30. Albertsson & Hakkarainen 2017
31. SAPEA 2020

Box 4. Size boundaries and their implications

The ISO definition (**Table 1**) limits microplastics to more limited size boundaries (1 mm – 1 μm) than what is common in the policy literature (e.g. RAC/SEAC, NOAA). From the policy perspective, an upper bound of 1 mm may drive a shift to make intentionally added primary microplastics (which are commonly subject to restrictions) to be larger than 1 mm to avoid regulations, rather than the desired phase-out of such materials. Similarly, setting a lower size bound of 1 μm may push producers to shrink materials below the size boundary to avoid regulation. While an argument for a lower size limit has been that it is difficult to adequately detect such small particles, setting a lower limit assumes that future innovation and improvement in detection technologies will not solve this problem, while simultaneously creating a loophole from regulation[32]. A definition could therefore be framed without a lower size boundary, and rather include exemptions to relevant measures and regulations for materials below a size bound. The exemptions may then be amended with scientific and technological progress.

A global agreement will need to agree on a common definition of microplastics. However, the definition needs to both reflect scientific needs for adequate monitoring and reporting on microplastics in the environment, as well as policy needs with regards to the feasibility of regulation and ensuring compliance. A key point then is to consider whether the inclusion and exclusion of materials (e.g. water-soluble polymers), sizes or sources under the definition of microplastics is conducive to effective regulation or if some materials should be considered singular categories subject to targeted measures.

A way to tackle the issue of heterogeneity of microplastics could be to use several inclusion criteria under the definition of microplastics, allowing for the term to cover particles with different characteristics.

A potential definition *may* then be formulated as:

Particles containing synthetic polymers (including biodegradable and water-soluble polymers) that are either contained within or building a continuous surface coating on the particles, where:

i. all dimensions of the particles are equal to or less than 5 mm; or
ii. the particles have a length of 0.3 μm ≤ x ≤ 15 mm and length to diameter ratio of >3; or
iii. the particles are plastic pellets, flakes and powders used to produce plastic products.

32. Gigault et al. 2018

Excluding polymers that occur naturally and are not chemically modified substances.

Table 1. Overview of commonly used definitions of microplastics, and relevant inclusions/exclusions.

Body (year)	Definition of microplastics	Exclusions / Inclusions
GESAMP (2015)	Particles in the size range 1 nm to <5 mm.	The follow-up report* includes resin beads, microbeads from personal care products, textile fibres and tyre dust under the definition.
EU Committee for Risk Assessment (RAC) and EU Committee for Socio-economic Analysis (SEAC)**	'Microplastic' means particles containing solid polymer, to which additives or other substances may have been added, and where ≥ 1% w/w of particles have (i) all dimensions 0.1 μm ≤ x ≤ 5 mm, or (ii), a length of 0.3 μm ≤ x ≤ 15 mm and length to diameter ratio of >3.	The proposed regulation under the EU (discussed in chapter 4), includes several exemptions from the regulation, rather than including these in the definition.
NOAA (2021)***	Microplastics are small plastic pieces or fibers that are smaller than 5 mm in size	
ISO (2020)****	Any solid plastic particle insoluble in water with any dimension between 1 μm and 1000 μm (=1 mm)	i – This term relates to plastic materials within the scope of ISO/TC 61. Rubber, fibres, cosmetic means, etc. are not within the scope. ii – Typically, a microplastic object represents a particle intentionally added to end-user products, such as cosmetic means, coatings, paints, etc. A microplastic object can also result as a fragment of the respective article. iii – Microplastics may show various shapes. iv – The defined dimension is related to the longest distance of the particle.
California Water Boards*****	'Microplastics in Drinking Water' are defined as solid (i) polymeric materials (ii) to which chemical additives or other substances may have been added, which are particles (iii) which have at least three dimensions that are greater than 1 nm and less than 5,000 μm. Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded.	i – 'Solid' means a substance or mixture which does not meet the definitions of liquid or gas. ii – 'Polymeric material' means either (i) a particle of any composition with a continuous polymer surface coating of any thickness, or (ii) a particle of any composition with a polymer content of greater than or equal to 1% by mass. iii – 'Particle' means a minute piece of matter with defined physical boundaries; a defined physical boundary is an interface

*GESAMP 2015
**GESAMP 2016
***European Commission 2022
****McCoy 2021
***** ISO 2020

2.2 The structure and components of a global agreement and the negotiations

The primary outcome of resolution 5/14 from UNEA 5.2 was the establishment of an INC and a mandate for negotiations to establish an international legally binding agreement to end plastic pollution. The agreement will address all plastic pollution, both in the terrestrial and marine environment. Thus, microplastics are only one of several categories of plastic pollution that will need to be addressed. By the end of 2024, the INC will meet at least five times to negotiate the structure and content of a legally binding agreement. The INC will negotiate on all aspects of the treaty, from its format and structure, to the objectives and goals and the provisions on control measures, monitoring and financing mechanisms (see **Annex 1** for a comprehensive list).

While the content is yet to be determined, the resolution highlighted the following issues to be addressed in the negotiations which are particularly relevant for microplastics:

- Inclusion of both legally binding and voluntary approaches;
- Sustainable consumption and production of plastics, including product design, environmentally sound waste management, circular economy and resource efficiency;
- Cooperative measures to reduce plastic pollution in the marine environment;
- National action plans to work towards the prevention, reduction and elimination of plastic pollution;
- National reporting on progress of implementation and effectiveness of measures.

Even though the INC is requested to consider all aspects listed in **Annex 1**, and many are likely to be reflected in the provisions of the agreement, the negotiating countries may also agree to not integrate all measures and provisions. While the structure of the final agreement is not determined, drawing from the past fifty years of multilateral environmental negotiations and collaboration, some common features may be expected[33]:

- **General provisions:** Defining the objective, principles and strategic goals of the treaty, alongside scope, definitions and use of terms.
- **Operational provisions:** Commitments and measures to prevent or control plastic pollution to meet the agreement objective. These may include provisions on phase-out or phasedown of certain materials, manufacturing of product types, controls on certain uses of plastics, national action plans, trade, waste management and more.
- **Support to Parties:** Articles relating to financial mechanism, provision of capacity building, technical assistance and technology transfer, access to data and implementation and compliance support.
- **Information and awareness raising articles:** Addressing information exchange,

33. Based on the Stockholm and Minamata Conventions, and Raubenheimer and Urho (2020)2020

research, development and monitoring, implementation plans, public information, awareness, education, as well as including a multi-stakeholder platform and science-policy interface.
- **Administrative matters:** Including assessment, reporting and effectiveness evaluation, and other administrative procedures such as dispute settlement and amendments.

In this report, we base the proposals and recommendations on the assumption that the agreement will contain provisions addressing these aspects. The priority of the report is to provide input to the design of the general and operational provisions, as other reports have elaborated on other elements[34].

Table 2. Overview of lifecycle phases, pathways and microplastic categories impacted by measures targeting each lifecycle stage.

Lifecycle stage	Pathways and considerations	Microplastic categories
	Upstream	
Polymer production	• Leakage from production facilities	• Plastic pellets, flakes and powders
Design	• Design considerations to reduce microplastic emissions	• Intentionally added primary microplastics • Use-phase secondary microplastics • Degradation-based secondary microplastics
Conversion	• Industrial emissions to air and wastewater from manufacturing facilities	• Plastic pellets, flakes and powders • Intentionally added primary microplastics • Use-phase secondary microplastics
	Midstream	
Transportation and distribution	• Spills and leakages during loading, unloading, storage and terrestrial and marine transport	• Plastic pellets, flakes and powders • Intentionally added primary microplastics
Use	• Direct emissions from use to environment and wastewater systems • Direct releases from product wear	• Intentionally added primary microplastics • Use-phase secondary microplastics
	Downstream	
Recovery	• Emissions to air, soils and wastewater from reprocessing	• Plastic pellets, flakes and powders • Degradation-based secondary microplastics
Disposal	• Emissions to soils, waterways and air from the degradation of mismanaged macroplastics and plastics deposited in landfills	• Degradation-based secondary microplastics

34. e.g. Raubenheimer & Urho 2020; Rognerud et al. 2022

2.3 Microplastics in the global agreement: Key concepts

Operational provisions addressing microplastics under an agreement will have to reflect that different measures and provisions may be required for different sources of microplastics and pathways across the product lifecycle (**Table 2**). In practical terms, microplastics can be categorised into the following four categories[35] (**Box 2**):

- **Plastic pellets, flakes and powders:** Microplastics produced for the use in manufacturing of plastic products. These may be made from virgin fossil- or bio-based plastic materials or recycled polymers.
- **Intentionally added primary microplastics**: Microplastics purposefully designed to be small in size for their application and use. This includes as microbeads in cosmetic products, glitter, industrial abrasives, rubber infill materials or polymer encapsulated agricultural products. Such microplastics could also be considered plastic products.
- **Use-phase secondary microplastics**: Microplastics generated during intended product use. Examples include microfibres from synthetic textiles, polymers from tyre, road and brake wear, and the degeneration of paints.
- **Degradation-based secondary microplastics**: Microplastics originating from the degradation and weathering of larger pieces of plastics after deposition in landfills or when lost in the environment. This category also includes microplastics generated unintentionally in the recycling sector.

Specific examples of the different categories of and their uses and release pathways are provided in **Table 3.**

35. OECD 2021

Table 3. Examples of microplastic types within the four identified categories in Box 2, their relevance in the context of a microplastic definition, and typical uses or sources. This list is not exhaustive but includes some common microplastic types. A more elaborated list of potential microplastic sources or types is provided in Annex 6.

Type		Relevance for microplastic definition	Typical uses/sources and release pathways
Plastic pellets, flakes and powders		• Composed of plastic • Small in size	• Used in the production of other plastic products • May be released through spills or other unintentional losses or as residues in industrial effluents
Intentionally added primary microplastics	Microbeads	• Composed of plastic • Small in size	• Used in personal care products • Released during or after use, typically in wastewater
	Glitter	• Coating composed of plastic • Small in size	• Used in arts and crafts or cosmetics • May be released during or after use through wastewater or solid waste streams
	Industrial abrasives	• Either completely or partially composed of plastic • Small in size	• Used as an exfoliant in cleaning processes • Released during or after use, in wastewater or direct release to the environment
	Rubber infill material	• Rubber materials contain a proportion of synthetic rubber (elastomer) • Small in size	• Applied to artificial turf used for sport fields, particularly in Northern countries where it can extend the period of use through winter • Transported from fields by wind or water or in removal of snow during winter
	Polymer encapsulated agricultural products	• Exterior coating or shell is composed of plastic • Small in size	• Seeds encapsulated in a polymer coating which contain nutrients or plant protection products • Fertilisers and plant protection products encapsulated in a plastic shell which allows for slow or controlled release and therefore reduced (better targeted) use of chemical products • Added directly to soils. Non-degradable synthetic polymer components remain after the product use (e.g. germination of seed or release of fertiliser)

Use-phase secondary microplastics	Microfibres	• Either completely or partially composed of plastic • Small in size	• Fibres released from synthetic textiles or semi-synthetic cellulose-based fibers during laundering and use • Typically released in wastewater or direct releases or the environment
	Tyre, brake and road wear particles	• Tyre tread contains a proportion of synthetic rubber (elastomer); Brake pads contain synthetic polymers in their binder; Polymer-modified bitumen in road asphalt and road marking contains a proportion of synthetic polymer (various polymers) • Small in size	• Particles of tyre, brakes, road marking and polymer modified bitumen from the road surface are created by abrasion and typically released in road and tunnel drainage systems, municipal sewer systems or direct releases to the environment through atmospheric deposition or runoff • May be directly released to the environment or entered into urban drainage systems
	Agricultural film fragments	• Either completely or partially composed of plastic, including biodegradable plastic in some cases • Small in size	• Particles can be created during the degradation of films during use, recovery, or waste handling due to weathering or mechanical stress • May be directly released to the environment, specifically the soils they are in contact with, or be transferred to the wider environment through water or wind transport
	Fisheries and aquaculture residues	• Either completely or partially composed of plastic, including biodegradable plastic in some cases • Small in size	• Particles can be created during the degradation of in-use fisheries and aquaculture infrastructure, including vessels, moorings, nets, ropes, aquaculture structures, buoys, etc. • May be directly released to the environment
	Paint fragments	• Contain a proportion of synthetic polymer • Small in size	• Particles of dried paint or coatings can fragment (e.g. from building surfaces or ships) over time • May be directly released to the environment or entered into wastewater streams
Degradation-based secondary microplastics		• Composed of plastic • Small in size	• Degradation and weathering of plastic wastes, including from mechanical recycling processes. • • Direct release to the environment through generation in-situ

Chapter 3. Science: The unique case of microplastics

There are several persistent knowledge gaps but based on the available research, microplastics warrant a specific focus within the context of a global agreement.

3.1 Similarities and differences between microplastics and other pollutants

Similarities between microplastics and other pollutants

Microplastics can be defined as an environmental pollutant. In this regard, when designing measures to address microplastic pollution, understanding the similarities and differences between microplastics and other environmental pollutants may prove beneficial. **Table 4** lists the key similarities. These common traits are typically broad concepts that are used to classify pollutants, such as their potential to cause harm and occurrence in the environment that represents contamination. Microplastics are anthropogenic in origin. This corresponds with several other environmental pollutants, and thus introduces additional broad similarities. From these, it is possible to draw insights from a longer track record of monitoring and research for different pollutant types.

Table 4. Similarities between microplastics and other pollutants

Environmental occurrence	• Microplastics contaminate the environment. • Microplastics do not occur naturally so this occurrence is, by definition, elevated above natural conditions.
Potential to cause harm	• Microplastics have the potential to cause harmful effects on ecosystems (Section 3.3). • Microplastics are present in some environments at concentrations where some effects can be observed (Section 3.3).
Persistence	• Microplastics from conventional non-readily degradable polymers are persistent in the environment and can accumulate over time, similar to other stock pollutants such as persistent organic pollutants (POPs) or heavy metals. • Microplastics have the potential to be taken up by organisms and may be transferred along the food chain.
Sources	• Microplastics are anthropogenic in origin. As such, they share several common sources as other anthropogenic pollutants, such as urban environments or wastewater discharges.
Fate	• Microplastics follow similar broad transport pathways as other pollutants, for example they can be transported in water and air and have been observed to accumulate in soil and sediments.

Differences between microplastics and other pollutants

Yet, several important distinctions exist between microplastics and other types of environmental pollutants. Many characteristics of microplastic pollution differ from other pollution types and this necessitates different approaches for addressing it within the context of both research and regulation. **Table 5** summarises these differences.

In particular, the lack of a standardised framework for classifying microplastic is important. The concept of 'microplastics' representing an umbrella term encompassing a diverse suite of contaminants has already been introduced (**Chapter 3.1**). Several groupings of chemical pollutants exist – such as POPs, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) – but these represent groups of distinct and well classified chemical compounds. In contrast, different typologies present under the microplastic term are poorly defined. For example, microplastics occur across several orders of magnitude with regard to size and differ in terms of morphology, where defining size boundaries and classification or nomenclature related to shape have not yet been agreed.

Table 5. Differences between microplastics and other pollutants

Form	• Microplastics are usually present in the environment as particles, which differs from other dissolved pollutants. • The form (size, shape, surface, etc.) of microplastic particles can differ significantly within what is generally accepted to be a microplastic
Heterogeneous distribution	• Due to the particulate nature, microplastics tend to be heterogeneously distributed in environmental matrices (e.g. water or sediments).
Behaviour and fate	• Due to the particulate nature, microplastics behave differently in the environment and follow some different transport pathways to other pollutants, such as dissolved pollutants. • Microplastics can be taken into organisms (plants and biota) through different exposure/uptake pathways.
Potential to cause harm	• Organisms interact with microplastics differently because microplastics are particulate and can cause harm through particle toxicity in addition to chemical toxicity. • Effects on organisms can be indirect. For example, the presence of microplastics may alter the habitat in which organisms operates, resulting in indirect effects on their viability. This type of effect would not be typically observable in conventional toxicological tests.
Lack of systematic framework for classification	• The term microplastic encompasses a range of particles with varying physical and chemical properties (e.g. size, shape, polymer type, chemical additive composition). • There is a lack of a standardised or systematic framework for classifying a particle as microplastic or classifying a microplastic based on its physical or chemical properties.
Analytical detection	• There are many different methods used for detecting microplastics in environmental samples. • Different types of microplastics may require different analytical techniques for detection.

The particulate nature of microplastic pollution is a critical aspect. This represents an important distinction from dissolved pollutants which behave differently in the environment, follow different transport pathways and present different modalities of harmful effects (**Table 5**). Parallels can be drawn with other forms of particulate pollution, such as particulate matter. In fact, microplastics of a certain size form a component of particulate matter pollution[36]. However, microplastics exhibit a wider range in particle characteristics that can also be more morphologically complex, which limits the extent of the similarities.

The particulate nature of microplastic and the lack of a standard classification

36. Sridharan et al. 2021

system also introduces analytical challenges related to detection and quantification in different sample types. There is no analytical instrument that can process an untreated sample and yield a single number corresponding to a microplastic concentration based upon a standardised method. Instead, there is typically a need to extract and isolate microplastics from a matrix through a series of treatment steps before utilising one or more analytical techniques that can be adapted to report in either numbers of plastic particles or concentrations of individual polymers. This is approached differently depending on the aims of individual studies and can vary between investigating organisation, country, and region. Not all microplastic types (e.g. sizes, shapes, polymer types) can be recovered from matrices and quantified analytically in a uniform way. Microplastic data may therefore only represent a proportion of the total microplastic pollution. This issue has been further accentuated by the development of a wide variety of different analytical protocols with a lack of harmonisation thus far. Similarly, it has also limited the development of standard toxicity tests to investigate the risks posed by different microplastic types.

Differences between microplastics and larger plastic items

Finally, microplastics differ from other forms of plastic pollution. Whilst there are similarities related to the material properties of microplastics and macroplastics (larger plastic items from which a proportion of microplastic pollution is in fact derived), there are several important distinctions that warrant different approaches to handling microplastics in the context of the global agreement. The small size of microplastics introduces unique challenges for detection and characterisation and can impart different effects. **Table 6** presents these differences, many of which pertain to size.

Table 6. Differences between microplastic and macroplastic pollution

Size	• Microplastics and macroplastics are distinguished, by definition, based upon size (although no defining boundary has been unanimously agreed). • Microplastics are smaller and, as such, behave differently in the environment with different potential fate and effects.
Detection and analysis	• Different methods are required to monitor microplastics and macroplastics in the environment. • Macroplastics are visible to the naked eye and can be monitored through visual observation or physically intercepted from the environment and characterised by hand or eye. • Macroplastics can potentially be assigned to a product group and/or polymer types without chemical analysis based upon visual inspection and labelling with international resin codes. • Microplastics typically require different infrastructure for sampling due to their small size. • Most microplastics are not visible to the naked eye and instead require sample treatment to isolate and analyse particles.
Potential to cause harm	• Microplastics and macroplastics present different modalities of harmful effects and target different species. • Organisms interact with microplastics mostly through ingestion, so typically most studies on the consequences of this interaction focus on internal harm. • For macroplastic, effects are more often due to entanglement or smothering. Ingestion of macroplastics is less likely than for microplastics due to their size.
Source identification	• It may be possible to identify the source of a macroplastic item based on the shape, appearance or presence of labelling. Due to their larger size, it may be possible to characterise a wider range of physical and chemical properties which may offer insights regarding provenance. • • Due to the smaller size and often high level of weathering, source identification is more difficult for microplastics. This is related to a lack of visible, identifiable information and analytical challenges related to thorough characterisation.

3.2 Current state of knowledge

3.2.1 Sources of microplastics to the environment

Sources can be defined as the initial point at which microplastics are formed and/or released into the environment. The term 'environment' in this sense can refer to a perceived natural environment, like a river, a technical system, such as a wastewater network, or even the built environment, such as the home environment.

In theory, any plastic item specifically engineered to be small in size (e.g. microplastic encapsulation of slow-release fertilisers), any product that contains microplastics (e.g. personal care products containing microbeads) or any plastic item represents a potential source of microplastic. Some polymer types or final material compositions have a greater potential to shed microplastic particles when exposed to degradative forces. Conceptualising microplastic from a source perspective represents a potential mechanism through which to address microplastic in a global agreement. In this case, estimates of source emissions and assessments of the potential to generate microplastic are useful tools for evaluating different plastic uses and practices.

In addition to these direct sources, there are numerous potential release pathways. These are often referred to as sources in different contexts, as they may represent the main input to a studied location – for example, wastewater effluent discharging into a water body. However, microplastics have passed through different systems before entering effluent and the wastewater treatment plant (WWTP) is not the primary source for these microplastics. *Source* is therefore used to describe the origins of microplastic and *pathway* to describe the route of environmental release. **Figure 2** gives examples of sources and pathways of environmental release for microplastic particles.

3.2.2 Scales of microplastic emissions

Box 5 summarises published estimates of microplastic emissions performed at different geographical resolutions and for different microplastic types. From these assessments, several sources have been identified as likely contributing a substantial proportion of total microplastic emissions. These include tyre, brake and road wear particles, primary microplastics such as those used in personal care products or agriculture, fibres from synthetic textiles, plastic pellets, flakes and powders and rubber infill materials. These represent sources where plastics or polymer-containing products are known to be used and have the potential to release microplastics into the environment; these estimates focus on known potential sources only. In addition, whilst studies provide valuable insights to investigate the relative importance of different sources, they are hindered by disparities in the methodology and reported units which limits the extent to which they can be directly compared. Access to data to accurately estimate emissions from different sources in harmonised reporting units represents a persistent hindrance to establish national, regional or global source inventories for microplastic.

The geographies of microplastic sources are likely to be important. Many sources, including those which represent dominant releases to the environment, may exhibit substantial regional variability. This may be based upon the predominant industries, different practices the leading microplastic release, and the level of economic development, amongst others. For example, many primary microplastics related to agricultural production represent expensive products so this microplastic source may be concentrated in specific regions with sufficient economic development to justify this cost. On the other hand, countries with less well-established solid waste and wastewater systems may see larger environmental releases of microplastics associated with these pathways. This aspect represents an important factor to consider in the context of a global agreement on microplastic.

Box 5. Global, national and type-specific estimates of microplastic emissions

Several studies have attempted to quantify the scales of different microplastic sources. These are often performed at the **country or regional level**; for example, for Norway[37], Sweden[38], Denmark[39], the Netherlands[40], Germany[41], Switzerland[42], China[43] and the EU[44]. These correspond with several tens of thousands of tonnes of microplastics released per country per year, although different studies focus on different microplastic sources. For the EU, approximately 14 million tonnes of microplastics are estimated to be released from selected important sources in the period 2013-2017 (of which 4.05 million tonnes are released to surface waters)[45].

Boucher and Friot[46] estimated releases of **primary microplastics and some sources of secondary microplastics,** but scaled this up to a global level, outlining a central figure of 2.9 million tonnes that is lost to the environment each year. Microplastic fibres from synthetic textiles and particles derived from tyre wear were the two largest sources (together, 63%). These sources are often presented as secondary microplastics elsewhere. Land-based activities were responsible for the almost all (98%) of the losses of primary microplastics, globally. Eunomia estimated the annual environmental release of intentionally added microplastics from different sectors and product groups in Europe[47]. In total, 11,200 to 95,000 tonnes are released each year, where **rubber infill materials** represent the largest source. These materials are used in artificial sports turf and can be spread during heavy rainfall events, player dispersion, and during winter in countries that receive higher snowfall there can be losses of infill materials through snow removal, representing a regionally specific microplastic source. An estimated 2,000 to 72,000 tonnes of rubber infill materials are released to the environment per year across the EU, with a concentration in northern European countries[48]. Other important sources include microplastics contained in detergents, microplastics used in agriculture and horticulture and cosmetic products.

Vehicle tyres have been identified as one of the largest sources of microplastics by several studies[49]. Annually, 5.9 million tonnes are estimated to be released across the world, equivalent to 0.81 kg per capita per year[50]. This source can be expanded to include other microplastic releases related to vehicle use and road environments, including brake and road wear particles.

Microplastic fibres are also widely observed in environmental samples and estimated to represent an important source[51]. Small fibres are produced during the use and laundering of synthetic textiles, and different fabric types and laundry processes can

37. A. Lusher & Pettersen 2021; P. Sundt et al. 2016; Peter Sundt et al. 2014
38. Magnusson et al. 2016
39. Lassen et al. 2015
40. Verschoor et al. 2016
41. Essel et al. 2015
42. Kawecki & Nowack 2019
43. Cheung & Fok 2017; T. Wang, Li, et al. 2019
44. Gouin et al. 2015; Hann et al. 2018a; Sherrington et al. 2016
45. Hann et al. 2018a
46. Boucher & Friot 2017bv
47. ECHA 2020
48. ECHA 2020; Hann et al. 2018a
49. Galafassi et al. 2019; Knight et al. 2020; Kole et al. 2017; Sommer et al. 2018
50. Kole et al. 2017
51. oucher & Friot 2017b; Napper & Thompson 2016; Y.-Q. Zhang et al. 2021

alter emissions[52]. However, the particle volume of a fibre is comprehensively lower than many other microplastic types, so estimated emissions calculated by mass (instead of particle count) suggest a lower proportion of total release – for example, in the order of 0.5 and 11.8 g per capita per year from domestic washing machine use[53].

Additional specific sources have also received much attention and, in some cases, subsequent legislation limiting or banning their use. The most well-known example is the case of **microbeads**. Emissions of microbeads derived from personal care products use have been estimated for several countries, regions or cities[54]; however, these are typically also presented in units corresponding to particle counts. **Plastic pellets, flakes and powders** have also been estimated as a source of microplastics to the environment, typically through unintentional losses during shipping and manufacture. Estimates of this source vary, but the potential upper range of this sources places it second in the list of microplastics releases to surface waters in the EU: 16,888 to 167,431 tonnes per year[55].

It is important to note that this list is not exhaustive and only addresses a number of sources that have been identified as being important or dominant. Several additional sources of microplastic exist and have been highlighted in national and regional assessments of the scales of emissions.

52. Napper & Thompson 2016
53. Y.-Q. Zhang et al. 2021
54. Cheung & Fok 2016; 2017; Kalčíková et al. 2017; Praveena et al. 2018
55. Hann et al. 2018a

Estimates for all these sources are dwarfed by mass-based estimates for the annual release of plastic litter, which range between 0.8 and 12.7 million tonnes from various sources[56]. Plastic litter represents a source of microplastic particles through degradation and fragmentation. Yet, the scales upon which these processes occur are still poorly defined for a range of different plastic items and environmental conditions[57]. Thus, the actual release of microplastic from this total is not known. This information can be a critical factor in establishing the most effective approach to address microplastic in a global agreement on plastic: if most plastic litter ultimately degrades into microplastic particles, then targeting plastic litter will make the most significant reduction in microplastic pollution over relevant timescales. If common plastic litter types do not degrade into microplastics over such relevant timescales, then addressing other sources of microplastic will be more important.

In addition to these efforts to quantify contributions from various known sources, it is possible that numerous other sources have not yet been identified. These could include:

1. **Sources that generate microplastic in a form that is difficult to detect analytically**

Detection of microplastic in environmental samples is not a straightforward task[58]. Some microplastic types are difficult to identify with confidence using the most common analytical approaches, such as tyre wear particles[59] and paint fragments[60]. Additionally, protocols for sample processing may destroy some polymers[61] or offer a low recovery for particle types based on the selected method[62] or microplastic density or morphology[63]. Finally, many methods used to analyse microplastic concentrations have a lower size limit of detection which may miss a substantial proportion of the total microplastic load, as well as some sources in their entirety[64]. These challenges hinder efforts to estimate sources related to the examples given here, and other unknown sources may still be entirely undetected for these reasons.

2. **Sources that have not thus far been captured by monitoring activities**

Many microplastic sources are expected to vary significantly across both time and space [65]. Monitoring of microplastic sources and environmental pollution has increased in recent years, but the global coverage of monitoring data is still fragmentary across spatiotemporal scales[66]. Sources that are episodic in nature may be missed by the temporal frame of monitoring activities or as a result of challenges in monitoring during important release events (e.g. during flood events)[67]. Some countries or regions may exhibit several important and unique microplastic sources but have not yet been subject to substantial monitoring efforts.

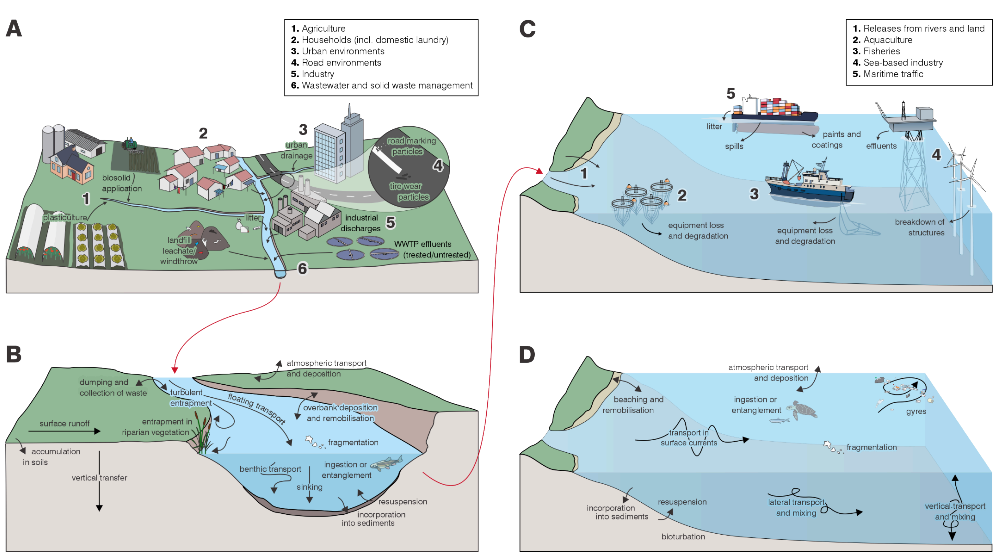
56. Jambeck et al. 2015; Lebreton et al. 2017; Meijer et al. 2021
57. Lin et al. 2022; K. Zhang et al. 2021
58. Silva et al. 2018
59. Rauert et al. 2021
60. Käppler et al. 2016
61. Enders et al. 2017; R. R. Hurley et al. 2018
62. Dimante-Deimantovica et al. 2022
63. Way et al. 2022
64. Conkle et al. 2018; Pérez-Guevara et al. 2022
65. Kallenbach et al. 2021
66. Amy L. Lusher et al. 2021
67. Hitchcock 2020

3. **Sources that account for a proportion of microplastic already observed in the environment but where provenance is challenging to demonstrate**

The ubiquity of many common polymer types, combined with a lack of distinguishing features that can be detected through physical and chemical characterisation techniques, represents a major challenge hindering the possibility to track or apportion microplastic sources. Some particle types, such as microbeads or microplastic fibres, exhibit a characteristic morphology and polymeric composition that can indicate the likely origin[68]. However, particles that have fragmented from a larger plastic item generally do not offer sufficient information to identify specific sources with confidence. A single particle is often too small to identify specific chemical compounds or other discriminatory features through current analytical approaches[69]. Ageing of particles due to environmental exposure introduces additional challenges in this regard.

The latter point (**3.**) is the primary mechanism confounding efforts to back-calculate microplastic sources from environmental monitoring data. This has been highlighted in several studies that attempt to identify potential sources responsible for environmental pollution, which are often qualitative or are unable to achieve full source apportionment[70]. Only some selected particle typologies can be related to probable inputs (e.g., fibrous microplastics likely derive from synthetic textiles) or some known local sources (e.g., plastics used in aquaculture with a corresponding colour, texture and polymer type).

Figure 2. Major sources and release pathways of microplastics in freshwater and terrestrial (A) and marine environments (C) and associated fate and transport processes (B, D).



68. Helm 2017
69. Fahrenfeld et al. 2019
70. Ashwini & Varghese 2020; Campanale, Stock, et al. 2020; T. Wang, Zou, et al. 2019

Finally, whilst it has been established that microplastics present several challenges that sets them apart from other contaminants (e.g., macroplastics, chemicals), some emerging microplastic sources may generate particle typologies that introduce further complexity. This includes potential future increases in 'transient' microplastic derived from increasing uptake of biodegradable or compostable plastics for a range of products, as an alternative material to conventional polymers (**Box 6**). Microplastic particles may be generated as these products biodegrade[71]. There is a lack of research regarding the potential toxicity of these particles during degradation or the timescales over which they occur for a range of polymer types in a range of environments[72].

Box 6. Biodegradable or compostable polymers as sources of microplastics

Biodegradable and compostable plastics as a potential source of microplastics to the environment

In the context of this report, biodegradable and compostable plastics are important in terms of their potential to act as a source of microplastics to the environment either due to incomplete degradation or on a transient basis during degradation. **Standards for compostable plastics include disintegration as a requirement**, necessitating that plastic materials physically fragment into microplastic-size particles within a relatively short timeframe. **Biodegradable plastics may also produce microplastics during their degradation**, especially for products which are purposefully fragmented after use, such as in the case of some agricultural mulching films. Microplastic may form for both these material types in the case of incomplete degradation[73]. More knowledge is required on the potential impacts of these microplastics, including associated additive chemicals, on timescales relevant to their degradation. In addition, the potential for microplastic particles derived from these materials to either **form or migrate into an environment in which they are not biodegradable** (either due to mishandling of waste or transport of particles by water or wind) should be considered[74]. Knowledge on the occurrence of microplastic composed of biodegradable or compostable polymer types may be hindered by analytical methods that destroy these polymers during sample treatment[e.g.75].

71. Kubowicz & Booth 2017; Wei et al. 2021
72. Kubowicz & Booth 2017
73. Filiciotto & Rothenberg 2021
74. SAPEA 2020
75. e.g., Möller et al. 2022

Debates around the use of biodegradable and compostable plastics

Interest in the use of compostable or biodegradable polymers is growing. The concept that plastics may degrade in the environment into biologically useful components represents a potential solution for some plastic applications, particularly those which are difficult to manage after use[76]. However, the extent to which these materials represent a 'golden solution' to plastic waste pollution is being discussed[77]. This centres on the fact that **no biodegradable or compostable plastics are biodegradable in all natural environments**[78]. In reality, the solutions to tackle global plastic pollution are elsewhere, such in the reduction of plastic consumption and appropriate disposal of items. **Certified biodegradable or compostable plastics are designed for specific applications or end-of-life scenarios** and current standards or test methods focus on assessing biodegradability under the specific conditions dictated by these scenarios. As a result, it has been recommended that the use of biodegradable or compostable plastics are limited to particular applications where handling of plastic waste is difficult or losses are expected to occur, for example agricultural mulching films or fishing gear[79].

Within this, there is also a **need to improve the labelling and communication** about these materials, such as connecting the biodegradability to the specific relevant environment, to enhance the level of understanding about what these materials represent. These recommendations aim to limit the extent to which biodegradable or compostable plastics are used where their labelling as such may lead to the disposal of a wide range of plastic products directly in the open environment with the expectation that they will break down into biological useful components. The extent to which these recommendations limit the use of these polymer types *versus* the current trend towards their use – as well as the ways in which these products are used and disposed of – will determine the extent to which these plastics represent important microplastic sources in the future. **More, and open, knowledge** on degradation rates and the potential risks associated with degrading materials, including non-plastic components such as dyes or plasticisers, and the potential for interactions with other pollutants is needed before biodegradable and compostable polymer types can be considered a viable non-polluting alternative to conventional non-degradable plastics[80].

76. SAPEA 2020
77. Narancic et al. 2018
78. Albertsson & Hakkarainen 2017
79. SAPEA 2020
80. Ding et al. 2022

3.2.3 Pathways

In addition to microplastic sources, measures under a global agreement could also target pathways as a means of assessing or minimising environmental pollution. Pathways can include both releases to the environment and the passage of particles within and between environments. **Figure 2** depicts several well-established pathways of microplastic input and transport in terrestrial and aquatic environments, many of which are also relevant for other environments such as arctic, alpine and desert environments.

In some cases, sources of microplastics do not directly release particles into the natural environment. Instead, the microplastics pass through one or more systems before eventual release. A commonly used example of this is a WWTP. These facilities receive microplastics from a diverse set of sources including, but not limited to, fibres from laundering of synthetic textiles, microplastics from personal care products and – depending on their connectivity – microplastic particles from road environments or industrial effluents[81]. A proportion of these particles may be captured by different wastewater treatment processes[82]. Wastewater effluents discharging into water bodies or the spreading of sewage sludge onto land represents two pathways for environmental release of microplastics from WWTPs. In many cases, pathways such as these represent an opportunity to intercept microplastics or to identify important sources of microplastics that are released to the environment[83].

Environmental pathways relate to the fate and transport of microplastics released into the environment. This includes processes that govern the sedimentation or deposition of particles, their (re)mobilisation and entrainment in air or water (**Figure 2**). These processes can establish hotspots[84] and, in some cases, hot moments[85] of microplastic accumulation. Monitoring data that measure microplastic concentrations in the environment represent a combination of source dynamics and the net result of fate and transport processes that encourage accumulation *versus* mobilisation. For example, a hotspot observed at a monitoring site may reflect: i) proximity to an important source or release pathway; ii) the result of physical processes that encourage particles to be deposited and concentrated at the location; or iii) a combination of these factors[86]. Due to point ii), it is possible for high microplastic concentrations to occur in a location without major sources or release pathways in the immediate vicinity. An example of this is the development of oceanic gyres caused by currents concentrating particles[87]. This introduces additional complexity to efforts to track sources of microplastics in the environment: particles can't necessarily be related to nearby sources. Currently, research into the fate and transport of microplastic of different typologies (e.g. different particle characteristics) and in a range of environments (e.g. cities, soils, rivers, oceans) is fragmentary[88]. Several knowledge gaps remain, hindering a thorough and effective interpretation of monitoring data[89].

81. A. L. Lusher et al. 2018
82. A. L. Lusher et al. 2020
83. Freeman et al. 2020
84. R. Hurley et al. 2018; Kane et al. 2020
85. Hitchcock 2020
86. Kallenbach et al. 2021
87. Law & Thompson 2014
88. Alimi et al. 2018; Allen et al. 2022; R. R. Hurley & Nizzetto 2018
89. Amy L. Lusher et al. 2021

A global agreement could potentially use microplastic monitoring data to establish important sources or pathways and target effective strategies for minimising environmental pollution. This would help to focus onto relevant microplastic types and release pathways by matching effort with scales of contamination. However, the knowledge gaps described here challenge this approach. As discussed in Section 3.2.1, we may not have a complete perspective over the full range of microplastic sources contaminating the global environment. Microplastic monitoring has not yet been performed in many regions and monitoring across relevant spatiotemporal scales is still lacking across most parts of the globe. Even in the case of widespread and well-designed monitoring activities, the current lack of understanding about the fate and transport of microplastic in the environment will limit how effectively data can be interpreted in the context of a global agreement. Monitoring represents a useful tool – especially due to the current ongoing advances in analytical methods and harmonisation – but it should be used as part of a larger toolkit until critical knowledge gaps can be addressed.

3.3 Risks and impacts

With the knowledge of microplastic presence in the global environment, this has raised concerns for the impact they may have on ecosystems, biota and ultimately humans. As mentioned in the previous sections, everywhere that microplastics have been investigated: they have been found, although the concentrations and particle characteristics can vary between studies and environmental compartments, as well as spatially and temporally. Despite the substantial information on microplastic occurrence in the environment gathered in the last decade, understanding of the consequences, impacts and risks associated with microplastic pollution remains in its infancy[90]. The complexity of gathering comparable data has been highlighted as one of the challenges to understand the risk and consequences of microplastics to the environment and humans. One reason for this is the diversity of approaches applied to investigating microplastics[91]. This diversity, coupled with access to methods, infrastructure and funding, has resulted in widespread debate on the reliability and comparability of reported results[92]. Fully validated, harmonised and, at best, standardised, methods are necessary for traditional environmental risk assessment approaches to microplastics pollution[93]. That said, substantial effort has been made by the research community to achieve this[94]. Information gathered from environmental assessments, as well as laboratory exposure experiments, can provide an overview of potential impacts and risks at given exposure concentrations. In the following sub-sections, we present the current state of knowledge on impacts and risks to the environment, for organisms and for human health.

90. Amy L. Lusher et al. 2021
91. Rist et al. 2021
92. Cowger et al. 2020; Provencher et al. 2020; Underwood et al. 2017
93. Gouin et al. 2019
94. e.g. Koelmans et al. 2022; Rubin et al. 2021

3.3.1 Risks to the environment

Microplastics move through the earth's system through a combination of natural processes, driven by wind and water movement or transported by biota. They have now been found in all five earth systems: the hydrosphere, atmosphere, geosphere, biosphere and cryosphere. The impacts of microplastics to a given ecosystem will depend on their ability to move within a specific ecosystem, their concentration, their chemical makeup and the receiving ecosystem. The heterogeneous occurrence of microplastics, their persistence in the environment and their impacts could be linked to a combination of morphology, size and the composition of chemicals or other associated additives.

Plastics are found on land and in freshwater and marine systems. Within each of these systems they can be divided into different environmental compartments, each with different properties which can accommodate a variety of microplastic particles. For example, low density and buoyant particles might be retained floating in the water column and be moved by currents, whilst heavier, dense and less buoyant particles could more readily sink and reach the sediment zone without moving far from their sources.

To assess the risk of plastic pollution to the environment, one must evaluate how likely it is that the environment may be impacted as a result of exposure to plastics. In risk assessment evaluation, exposure can be assessed by measuring environmental concentrations and a prediction and evaluation of the likelihood and magnitude of the potential adverse effects can be derived via laboratory experiments for the estimation of the threshold dose/concentration. The combination of both exposure and effect of plastics leads to a risk assessment. Risk assessments are needed to focus investigations and solutions towards the issues with the highest risk. They are also useful for interregional comparisons, harmonisation and to guide policy making and measures as needed by international requirements such as the Sustainable Development Goals (SDGs). One approach taken by ECHA in the proposed REACH restriction on intentionally added microplastics was to treat microplastics as "non-threshold substances", in a similar way to how persistent, bioaccumulative and toxic substances are assessed under the REACH regulation (see **Chapter 4** for more information). In this regard, any release to the environment can be assumed to result in a risk due to the accumulation over time.

3.3.2 Exposure risk to the organisms (plants and biota)

Organisms interact with microplastics through (1) ingestion, (2) inhalation, (3) absorption, (4) physical contact/entanglement or (5) trophic transfer, depending on the size of the particle.

1. **Ingestion**

The small-size and ubiquitous presence of microplastics in the environment means that microplastics are available for ingestion by an array of species, including species which feed through filtration, suspension and deposit feeding, as well as predators and scavengers. Many reviews are available summarising the ingestion of microplastics in the environment, including marine[95], freshwater[96] and terrestrial[97] ecosystems. Notably, terrestrial systems are still far less studied than aquatic systems. In many cases, observations in the wild focus on gills, stomach or gut contents or in faecal matter, representing ingestion but also egestion of microplastic particles. The presence of biofilms on microplastics may play a role in the likelihood of microplastics being targeted as a food source, either because it impacts visual, olfactory or gustatory cues[98].

In a recent assessment of factors determining microplastic ingestion by fish, there did not appear to be any link between trophic level and microplastic concentration, suggesting that there is limited biomagnification[99] of microplastics in fish[100]. Although, larger fish were likely to contain more microplastics, and planktivorous fish tended to have more particles. If lower trophic organisms are prey to larger predators, this may have subsequent ramifications throughout the food web, including trophic transfer and bioaccumulation[101,102].

Laboratory studies have allowed a greater understanding of the residence time of particles in the gastrointestinal tract and provided opportunities to study the movement of particles outside of the digestive tract. Once ingested, microplastics could cause harm through several pathways. In the case of fish, some of the effects observed include behaviour, sensory and neuromuscular functions, metabolism, alimentary and excretory systems, microbiome diversity and the immune system[103]. Regarding benthic species, toxicity, biochemical and physical effects of microplastics are seldom reported[104]. The effects of microplastic ingestion across taxa are highly variable, with research suggesting that smaller organisms are more susceptible for negative impacts[105], and that small particles (<20 μm) cause more effects[106].

2. **Inhalation**

Respiratory uptake has been identified as a route of exposure for organisms, whether that is through inhalation or ventilation in aquatic environments. Ventilation can concentrate microplastics from the surrounding environment on gills of fish and invertebrates[107], whilst microplastics have been reported in human lung tissues[108].

95. Covernton et al. 2021; Pinheiro et al. 2020
96. Ta & Babel 2022; Talbot & Chang 2022
97. Azeem et al. 2021; Dissanayake et al. 2022
98. Kooi et al. 2017
99. Biomagnification: A term usually associated with an increase in a compound's concentration (such as pollutant or pesticide) as it travels up the food chain, from prey to predators.
100. Covernton et al. 2021
101. Bioaccumulation: The accumulation over time of a substance or contaminant (such as a pesticide or heavy metal) in a living organism. No transfer to other organisms.
102. Au et al. 2017
103. Jacob et al. 2020
104. Pinheiro et al. 2020
105. Foley et al. 2018
106. Jacob et al. 2020
107. Gray & Weinstein 2017; Watts et al. 2016; F. Zhang et al. 2021
108. Jenner, Rotchell, et al. 2022

3. **Absorption**

Smaller sized microplastics are likely capable of being absorbed across plant cell boundaries, such as being taken up through root hairs and translocating from roots to leaves[109]. However, impacts on terrestrial plants are not well understood[110]. The resulting responses from plants likely depend on species, soil and microplastic properties. Interactions could induce changes in plant physiology, including moisture, density, structure and nutrient content, which in turn could alter plant root characteristics, growth and nutrient uptake[111]. One particular study identified that germination was delayed[112]. This may have consequences for crop growth.

4. **Adherence/Entanglement**

Adherence and entanglement are commonly observed impacts of large plastics and litter on biota. Similar impacts have been observed for microplastics to smaller organisms. Adherence of fibres to surfaces of algae has been observed in the Great Lakes[113]. Entanglement in fibrous microplastics has been observed for many species, including entanglement on swimming and feeding appendages of invertebrates and value gaps of bivalves[114]. Observations of entanglement include sea pens and hermit crabs affected in the deep sea[115]. A likely implication of entanglement is restriction in movement and feeding, or trophic transfer if the adhered particles are presented when organisms are consumed by a predator.

5. **Trophic Transfer**

Once microplastics have been ingested by an organism, if they are retained, or simply still present when the organism becomes prey itself, the consumer will be indirectly consuming microplastics, in a process referred to as trophic transfer. This process has been documented in invertebrates[116], fish[117] and even mammals[118]. Trophic transfer occurs when microplastics are consumed alongside prey, this can include microplastics adhered to the surfaces of algae[119] or appendages of zooplankton[120]. Trophic transfer has been posited as a likely exposure route to humans, if they consume food which itself contains microplastics. This has been suggested to be more likely with seafood where gut contents are not removed[121]. Even though this route for microplastic ingestion may be significant, there may be low levels of bioaccumulation when microplastics are egested along with other waste particles.

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109. Azeem et al. 2021
110. Dissanayake et al. 2022
111. Azeem et al. 2021
112. Bosker et al. 2019
113. Peller et al. 2021
114. Rebelein et al. 2021
115. Taylor et al. 2016
116. Farrell & Nelson 2013
117. Santana et al. 2017
118. Nelms et al. 2018
119. Bhattacharya et al. 2010
120. Cole et al. 2013
121. A. Lusher et al. 2017

3.3.3 Exposure risk to humans

Humans encounter microplastics in different ways: we wear clothing made of synthetic textiles or use personal care products (e.g., toothpaste, facial scrubs, cleansers, cosmetics) containing microplastics[122], we consume food and beverages which might contain microplastics and plastics are also used in the production of some medical devices and in pharmacological applications[123]. Given this information, microplastics, in a similar way to other substances of concern, pose an exposure risk to humans through three pathways:

1. **Ingestion through food and beverage products**

Microplastics have been identified in food and beverage products. Given this information it is not unlikely that humans ingest microplastics from a variety of sources. Possibly the most discussed source is seafood, which is not surprising given the marine focus of microplastics research in the past decade[124]. Other food commodities found to contain microplastics include salts[125], honey[126], sugar[127], fruit and vegetables[128], poultry[129], packaged meat, fish and food containers[130], drinking water[131], alcoholic beverages[132] and tea bags[133]. Food packaging[134] and preparation might also act as a source (e.g., plastic cutting boards)[135], as well as the settling of dust during meal-time[136]. In most cases, the sources of the microplastics are expected to come from the packaging material, rather than the environment. Nevertheless, drinking water has been suggested as one of the biggest sources of exposure[137].

Humans have been estimated to possibly ingest 0.1-5 g of microplastics a week through various pathways[138]. The annual exposure microplastic of humans, by way of ingested food products, have been estimated to be as high as 52,000 particles year^{-1}[139], with oral exposure expected to be higher in places where fish and shellfish consumption is higher. When considering dust settling during a meal, estimated exposure increased to 68,415 particles year^{-1}[140]. See **Box 7** for an elaboration on consequences of intake.

122. Guerranti et al. 2019
123. Kapoor et al. 2015; Maitz 2015
124. A. Lusher et al. 2017
125. Kim & Song 2021
126. Mühlschlegel et al. 2017
127. Afrin, Rahman, Hossain, et al. 2022
128. Oliveri Conti et al. 2020
129. Kedzierski et al. 2020
130. Du et al. 2020; Karami et al. 2018; Kedzierski et al. 2020
131. Danopoulos et al. 2020; World Health Organization 2022
132. Joana C. Prata et al. 2020
133. Afrin, Rahman, Akbor, et al. 2022; Mei et al. 2022
134. Fadare et al. 2020
135. Habib et al. 2022
136. Catarino et al. 2018
137. Senathirajah et al. 2021
138. Senathirajah et al. 2021
139. Cox et al. 2019
140. Catarino et al. 2018

2. **Dermal / skin contact**

Dermal contact with microplastics may occur when humans come into contact with materials generating microplastics, although the likelihood of dermal uptake is limited to the barrier of the upper-most skin layer (stratum corneum). The skin forms a barrier and microplastics need to be <1 μm to penetrate this barrier. Three potential scenarios have recently been highlighted: (i) human skin provided a formidable barrier to microplastics and nanoplastics, (ii) hair follicles act as collection sites for nanoplastics, and (iii) physiochemical properties of particles will influence the possibility for permeation[141]. Another dermal exposure route comes from micro-and nanoplastics generated from plastic medical devices introduced to the body, such as prosthetic replacements and implants[142].

3. **Inhalation**

Particulate matter is present in the atmosphere. It contains a mixture of particles from various natural and anthropogenic sources[143]. Human health risk assessments suggest that the inhalable faction of particulate matter (usually defined as the fraction between 2.5 and 10 μm[144]), represents the smaller sizes of microplastics. Compared to other environmental matrixes, the atmosphere has been studied to a lesser extent. Nevertheless, microplastics have been detected in outdoor and indoor air in urban and remote environments[145].

Studies highlight that people are exposed to higher concentration of microplastics within their homes[146] or areas with high human activity[147]. The main sources of microplastics in indoor and outdoor air are likely a combination of degraded and fragmented textiles and other plastic items, as well as tyre and road wear, respectively. Studies of indoor and outdoor air have simulated the presence of inhalation by humans, suggesting that microplastics are in concentrations ranging from 1.7-17.3 particles m^{-3} [148]. The annual exposure of microplastics to humans, by way of inhalation, has been estimated to be as high as 110,000 microplastics $year^{-1}$ [149]. Considering the many emerging approaches to calculate exposure and inhalation from air, it can be challenging to come to conclusions on estimated exposure. In view of the current detection limit for microplastics particles ~10 μm, it is unlikely that particles detected in the aforementioned studies reach the alveolar areas of the lungs[150].

141. Revel et al. 2018; World Health Organization 2022
142. Sternschuss et al. 2012
143. Morakinyo et al. 2016
144. World Health Organization 2022
145. Gasperi et al. 2018; Habibi et al. 2022; Luo et al. 2022
146. Jenner et al. 2021
147. Jenner, Sadofsky, et al. 2022
148. Torres-Agullo et al. 2022; Vianello et al. 2019
149. Cox et al. 2019
150. World Health Organization 2022

3.3.4 Impact of exposure for organisms

Potential impacts associated with microplastic interactions can be split into two broad categories (1) physical impacts of the particles themselves, or (2) the chemical constituents either included during plastic manufacture or sorbed from the surrounding environment[151].

1. ***Physical impacts related to properties of microplastics***

The size of microplastics is probably the most important factor which will determine how organisms interact with, and the impacts of microplastic particles. Following ingestion or inhalation, microplastic absorption, translocation and distribution in circulatory system, uptake from the gut and entry into different tissues and cells may occur. The extent of adverse effects will be linked to the physical and chemical characteristics of the microplastics, as well as the organisms it enters. Microplastics have a high surface area which may lead to toxic impacts on organisms (and humans) which ingest them. Some pathways of toxicity include oxidative stress, cytotoxicity, disruption of energy homeostasis and metabolism, disruption of immune function and neurotoxicity, carcinogenicity and reproductive toxicity[152]. In additional, microplastics may act as vectors for microorganisms, including bacteria, such as *Vibrio ssp.*[153]. If pathogens reach tissues, they may cause tissue damage or alter the gut microbiome[154].

Consequences of microplastic intake by humans may be localised disease, oxidative stress, inflammation, cytotoxicity, enhanced immune response and translocation[155]. In terms of biota, microplastic exposure studies find effects as well as no-effects, as recently reviewed in Gomes *et al.*[156] where little consistency regarding the biological impacts on biota were seen across 220 studies.

2. ***Chemical impacts related to microplastics***

In addition to potential adverse effects from interacting with microplastics themselves, impacts could also result from (a) inherent contaminants leaching from the microplastics, and (b) disassociating contaminants sorbed or adhered to the microplastics from the environment. Additives are not bound to the polymer structure, and along with a small proportion of unreacted monomers present in the plastic, and those sorbed from the environment, they can be (re)released to the environment or receiving organism. These chemicals can be toxic, carcinogenic or have endocrine-disrupting properties[157]. However, it is not yet clear how significant a role microplastics play in contributing to exposure to these chemicals. Examples of sorbed contaminates include polychlorinated biphenyls and polycyclic aromatic hydrocarbons, these substances can be carcinogenic. Furthermore, phthalates and bisphenols are considered to be endocrine disrupting compounds, which have been linked to reproductive and developmental disorders (cancer, blood infection, early puberty and genital defects)[158].

151. Gamarro & Costanzo n.d.
152. Joana Correia Prata et al. 2020; Rahman et al. 2021
153. Kirstein et al. 2016
154. Zhu et al. 2018
155. Joana Correia Prata 2018; Revel et al. 2018; Wright & Kelly 2017
156. Gomes et al. 2022
157. Campanale, Massarelli, et al. 2020
158. Gamarro & Costanzo n.d.

Box 7. Consequences of microplastics exposure for humans

Human exposure likely occurs by inhalation, ingestion and dermal contact. Data is mostly concentrated for dietary exposure, whilst inhalation and dermal contact refers to smaller sized particles.

Oral exposure for humans has been investigated by both the European Food Safety Authority (EFSA) and the Food and Agriculture Organisation of the United Nations (FAO). They conducted two case studies on dietary exposure to chemical substances from microplastics contained in seafood[159]. Mussel (225g) consumption was used for a worst-case scenario case study, considering that they are eaten whole. Both studies came to the overall conclusion that if shellfish are a source of microplastics to humans, the risk of exposure to microplastics and humans could be considered negligible. **It is important to highlight that there were a number of assumptions in these calculations, and only limited data was used.**

Both the nature and extent of adverse health effects of microplastics on the human body following exposure are still under investigation[160]. As of 2022, microplastics[161] have been reported in human blood[162], breast milk[163], placentas[164] and lungs[165]. Historical lung biopsies reporting fibrosis and lesions containing acrylic, polyester and nylon dust have long been seen in lung biopsies from textile workers[166]. Prolonged exposure might lead to persistent lung diseases, cancer and death[167]. There is evidence that microplastics also leave the human body, with particles being identified in the human stool[168]. Additionally, phthalate plasticisers have been identified in blood, sweat and urine[169]. The illnesses and disease linked to associated chemicals (phthalates, organochlorines, PCBs, PBDEs and toxic metals) suggest that microplastic uptake may pose a significant risk. Although due to the methodological limitations, there is **large uncertainty about human exposure to biologically relevant particles < 10 μm.** Even with the method limitations and need for further research and development to target the smallest microplastics, there is sufficient evidence to necessitate a precautionary approach[170].

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159. Chain (CONTAM) 2016; A. Lusher et al. 2017
160. Gamarro & Costanzo n.d.
161. Methods used for the identification of smaller microplastics (<20 μm) are not necessarily robust or use the most technologically advanced approaches. So, whilst these studies present an indicator of microplastic presence in tissues outside of the digestive system, further studies to validate these observations are required.
162. Leslie et al. 2022
163. Ragusa et al. 2022
164. Ragusa et al. 2021
165. Amato-Lourenço et al. 2021; Jenner, Rotchell, et al. 2022; Pauly et al. 1998
166. Pimentel et al. 1975
167. Joana Correia Prata 2018
168. Ibrahim et al. 2021; Schwabl et al. 2019
169. Genuis et al. 2012; Lee et al. 2021
170. Gamarro & Costanzo n.d.

3.3.5 Indirect impacts

In addition to these potential direct effects on organisms, indirect impacts to ecosystems may also occur. This refers to changes in one or more properties of an environment, including both biotic and abiotic factors, as a result of the occurrence of microplastic which may alter habitat conditions and introduce knock-on effects. Indirect impacts are likely to occur in many environments[171], where soil environments are discussed here as an example. The occurrence of microplastics in soils may alter a range of soil physicochemical and biological properties, including the soil structure[172], hydrology[173], pH[174], microbial community structure and diversity[175] and enzyme activity[176]. These factors can affect the way in which soils support healthy plant growth, for example by changing the availability of moisture or nutrients[177] or affecting root and plant development[178], therefore imparting indirect impacts on plants[179]. It is expected that microplastic occurrence will influence several of these individual properties simultaneously and in different ways. More knowledge is needed to better unravel the complexities of soil-microplastic interaction[180], as well as the cascade of effects across different fundamental levels in soil ecosystems, such as how micro-scale effects can propagate indirect impacts across wider spatial or temporal scales[181]. Indirect impacts may, in many environments, create an interplay of effects and a series of feedback loops which may complicate our understanding or assessment of risk.

171. Khalid et al. 2020; Ockenden et al. 2021; F. Zhang et al. 2020
172. de Souza Machado et al. 2018; Lozano et al. 2021
173. Wan et al. 2019
174. Zhao et al. 2021
175. Hou et al. 2021; Rong et al. 2021; Jie Wang et al. 2020
176. Huang et al. 2019; Zhao et al. 2021
177. Rong et al. 2021; Wan et al. 2019
178. de Souza Machado et al. 2019; Yao et al. 2022
179. Khalid et al. 2020
180. F. Wang et al. 2022
181. de Souza Machado et al. 2019

Chapter 4. Policy: A fragmented governance landscape

There are currently no global, legally binding regulations specifically addressing microplastics pollution[182].

Over the past decade, awareness and understanding of microplastic pollution has steadily increased, partially driven by UNEA resolutions 1/6, 2/11, 3/7 and 4/6 (see Annex 5) calling for increased research into the sources and pathways of microplastics into the environment, as well as relevant control measures, best practices and harmonised monitoring methods.

In 2019, **UNEA resolution 4/6** marked a step change as member states were specifically invited to work with the private sector to:

- Phase out products containing microplastics;
- Innovate product design to reduce secondary microplastic releases;
- Improve waste management; and
- Prevent losses of plastic pellets, flakes and powders across the manufacturing and supply chain.

Despite the apparent agreement on the need to eliminate microplastic pollution, reviews have elaborated on the limited extent of microplastic regulations[183]. National action plans against plastic pollution have tended to neglect specific measures to address microplastics[184]. Up until now, the most common regulatory measure has been microbead bans, despite this category of microplastics making up a small fraction of emissions compared to tyre wear, agricultural plastics, plastic pellets, microfibers and paints[185]. In recent reviews, Diana *et al.*[186] and Karasik *et al.*[187] found that policies from higher-income countries were more likely to address microplastics compared to middle- and lower-income countries, suggesting varying capacities to map, monitor and address this problem. Research from the Pacific Islands indicate

182. Diana et al. 2022; FanpLESStic-sea 2019
183. Diana et al. 2022; FanpLESStic-sea 2019; NOWPAP CEARAC 2020; OECD 2021; UNEP 2017; 2018b; 2019
184. Diana et al. 2022
185. Boucher & Friot 2017a; Lau et al. 2020; Paruta et al. 2022; Xanthos & Walker 2017
186. Diana et al. 2022
187. Karasik et al. 2020

that lack of access to information and data may be a contributing factor[188]. Yet, as this chapter will show, the picture of microplastics policy is changing, as there has been a marked increase in the breadth of measures and policies being developed in the past five years.

The reviewed policies and measures can be clustered into three categories[189]:

- ***Research and monitoring*** to identify impacts, sources, pathways and sinks of microplastic pollution; harmonise monitoring and testing methods for different sectors; measure effectiveness of measures; and create new solutions and innovations to prevent, reduce and capture microplastics pollution.
- ***Policies on products likely to result in microplastic pollution***: Voluntary guidelines, binding standards and reporting requirements for plastic pellets, flakes and powders; Bans and phaseouts of intentionally added primary microplastics; Bans and phaseouts, voluntary guidelines, standards, best practices, innovation and mitigation action for use-phase secondary microplastics.
- ***Policies to prevent aquatic and terrestrial litter*:** Single-use plastic bans, reuse, recycling and waste management policies to reduce degradation-based secondary microplastics.

This chapter examines current policies and frameworks on microplastics in a rapidly moving policy landscape, as well as different measures that have been taken (see **Box 8**) to address microplastics pollution. We elaborate on priorities, focus and categories of measures and their relevance for a global agreement.

The review is primarily concerned with *existing* policies directly addressing microplastics and does not provide a full overview of all *possible* measures that could be taken to address different sources and pathways of microplastic pollution. We have also excluded policies only related to litter and plastic pollution in general, though such policies have relevance due to the generation of microplastics from plastics in the environment. A range of such overviews already exist, see for instance UNEP's *From Pollution to Solution*[190], the FanpLESStic-sea *policy review*[191]; The Duke University *Plastic Policy Inventory*[192], the Portsmouth University *Plastic Policy Centre*[193], and the review by Singapore National University and Cobsea on *ASEAN plastic research and regional measures*[194] and more[195].

188. Farrelly et al. 2021
189. OECD 2021
190. UNEP 2021a
191. FanpLESStic-sea 2019
192. Diana et al. 2022
193. Global Plastics Policy Centre n.d.
194. Lyons et al. 2020
195. OWPAP CEARAC 2020

Box 8. Categorisation of typical policy measures

Measures to address microplastics may cover different dimensions. They may be regulatory, fiscal, educational, voluntary or a combination:

- **Regulatory measures:** Command-and-control measures including bans, listings, requirements and standards for production, handling, use and disposal of plastic products and microplastics.
- **Fiscal measures:** Market-based approaches creating financial incentives and disincentives for businesses and consumers to change practices, including permits, taxes and subsidies.
- **Information and educational measures:** Measures aiming to shift behaviours through provision of information, such as through labelling schemes, disclosure and transparency requirements or awareness-raising campaigns.
- **Voluntary measures:** Self-regulatory measures such as company commitments, or industry associations agreeing on sector standards and best practices.

4.1 Research and monitoring on microplastic pollution

Monitoring of microplastics in the environment is intended to provide data and information on the types of materials found, the major sources of microplastics, changes in fluxes over time, the movement of microplastics in different environments and settings and exposure of ecosystems to microplastic pollution. Coordinated monitoring of microplastics is still in the early stages internationally; yet, whilst limited, these activities are intended to identify sources and set baselines for microplastic in the environment to allow for tracking of changes over time. Monitoring activities across the world utilise varying protocols and methodologies and take place across diverse temporal and spatial scales. This variability makes it challenging to compare data from different datasets. As an effort to enable data comparison, encouraged by agreements from G7 and G20 summits, Japan has been working on harmonisation of monitoring methods and data compilation for ocean surface microplastics and published the Guidelines for Harmonising Ocean Surface Microplastic Monitoring Methods in 2019, updated in 2020[196]. In addition, EUROqCHARM, an ongoing research project funded by the European Union, is looking into how monitoring activities can be harmonised (or standardised) to allow for improved comparability across different methods and protocols[197].

Marine, and some freshwater, monitoring activities are typically coordinated through Regional Sea Programmes (e.g. the Northwest Pacific Action Plan[198]) and Regional Seas Conventions[199]. Thus, national monitoring activities have been informed by

196. Yutaka et al. 2020
197. *Macro- & microplastics monitoring - EUROqCHARM project* n.d.
198. NOWPAP CEARAC 2020
199. Through recommendations coming from work under The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), The Baltic Marine Environment Protection Commission

these efforts to develop guidelines and protocols for monitoring and reporting. For instance, **The Republic of Korea** started its monitoring program in 2012, while **China** established a monitoring program of microplastics in 2016 with 30 sampling points outside the Chinese coasts[200]. **Norway** initiated its monitoring program on microplastics in 2021, with nationwide sampling in oceans, lakes and rivers[201]. The state of **California** recently started a four-year monitoring program of microplastics in drinking water[202]. **Malaysia** has committed to establish a monitoring program by 2022, under their National Plastic Action Plan[203]. Monitoring activities can also be conducted by other actors such as research institutions, intergovernmental organisations, non-governmental organisations and private companies. To the best of our knowledge, there are at present no examples of countries routinely monitoring the presence of microplastics in terrestrial environments.

Accompanying these monitoring activities is the **proliferation of research** examining the presence, prevalence, impacts, sources and sinks of microplastic pollution, coupled with an emerging body of literature on microplastic policies and measures. This includes numerous large research consortia funded by global, regional and national research councils that include a microplastic component in their research agendas. As well as national research programmes, such as the Swedish research agenda on microplastics[204].

These **research efforts are *predominantly* conducted in and by high-income countries**, resulting in an imbalance in the understanding of the dominant sources, sinks and drivers of microplastic pollution. For instance, a recent study found that researchers based in Latin America and the Caribbean only accounted for five percent of the global scientific production on microplastics[205]. As elaborated in **Chapter 3**, the rates of release and sources of microplastics vary according to local environmental, economic or social factors; for example, the influence of climate on degradation and fragmentation, the dominant industries present or the behaviours and practices that lead to microplastic releases. Impacts of microplastics on ecosystems may also vary with climate and/or relate to the occurrence of different species. If global policy measures are developed based only on the evidence gathered from countries in the global North, there is a risk that other important sources, pathways and impacts in other climates, ecosystems and socioeconomic contexts will be missed.

(HELCOM) and Arctic Monitoring and Assessment Programme (AMAP)
200. Juying Wang et al. 2017
201. *Mikroplast i kystområder, elver og innsjøer (Mikronor) - Miljødirektoratet* n.d.
202. California Ocean Protection Council 2022
203. Government of Malaysia n.d.
204. SEPA 2021
205. Orona-Návar et al. 2022

Box 9. Microplastic policies in the US

The United States of America is making steps towards a greater level of control of microplastics pollution. Measures are in development or being implemented on both the federal and state level.

On the federal level, the US was the first country to implement a ban on microbeads. **The Microbead-Free Waters Act** of 2015, banned the manufacturing, packaging, and distribution of rinse-off cosmetics containing plastic microbeads, with a stepwise phase-out starting in 2017[206]. The US Environmental Protection Agency is currently conducting a public consultation on a report for the US Congress on Microfiber Pollution. The report contains a **draft Federal Plan for 2023-2028 to reduce microfiber pollution**[207].

On the state level, several states have independently introduced additional **bans or restrictions** on microbeads in personal care products (e.g. Illinois and Indiana)[208]. Whereas California has adopted a **state-wide microplastics strategy**[209]**.** The California microplastics strategy takes a two-pronged approach: 1) Solutions, and 2) Science to inform policy. The *Solutions* refer to measures that can be implemented immediately. These include measures to eliminate plastic wastes at source, pathways interventions (i.e. filters, interception of road runoff, wastewater treatment), and education and engagement with the public, industries and other bodies. The measures under *Science to inform policy* address investment in research on monitoring, risks, sources and pathways prioritisation and evaluation of new solutions.

While the global North has a larger research community on microplastics, there are many initiatives and studies being conducted across the world. These are partially driven by commitments under **National and Regional Action Plans on plastic pollution** to improve the knowledge base on the presence, impact and risks of microplastics in the environment to people and ecosystems[210]. On the global level, intergovernmental organisations lead research and review efforts to establish consensus on the risks of microplastics to humans and the environment. Of note is the Science Advice for Policy by European Academies (**SAPEA**) Evidence Review Report on micro- and nanoplastic pollution[211], which provides a comprehensive review of the current state of knowledge. The **FAO** has conducted several studies and broad reviews of the scientific evidence related to food and health risks of microplastics highlighting the need to take a balanced approach towards addressing microplastic pollution. While the **WHO** has looked into drinking water as a pathway for

206. FDA 2022
207. US EPA 2022
208. *Plastics Policy Inventory Search The Nicholas Institute for Energy, Environment & Sustainability* n.d.
209. California Ocean Protection Council 2022
210. See for instance, Chile's National Action PlanMinisterio del Medio Ambiente 2021, the ASEAN Regional Action Plan on Combating Marine DebrisASEAN Secretariat 2021, the Southeast Asian Fisheries Development Center's Action Plan for 2020 to 2030.
211. SAPEA 2019

exposure[212]. The **OECD** published an extensive overview of policies to target microplastic emissions from tyre wear and textiles[213]. **UNEP** has developed several reports and factsheets on microplastic pollution in different environments[214]. Additionally, international non-governmental organisations such as the **International Union for the Conservation of Nature,** the **Centre for International Environmental Law** and the **Minderoo Foundation** have funded and produced relevant research and reports[215].

Another emerging field of research on microplastics regard **the design, implementation and compliance with policies**. Despite 7 years having passed since the introduction of the first national microbead ban, few studies examine the effect of and compliance with the bans. Research on the drivers and barriers to implementation of such bans also remains limited[216]. Though some countries have reported data on effectiveness under the G20 Implementation Framework[217]. This gap is also increasingly being addressed by the establishment of recent centres and policy inventories tracking plastic related policies. Notable examples are The Duke University Plastic Policy Inventory[218] and the Portsmouth University Plastic Policy Centre[219].

4.2 Regional policies, measures and collaborations on microplastic pollution

The European Union (EU)

As of 2022, the European Union is the only regional body to set a quantitative target for reduction of microplastic pollution.

In 2021, the EU Commission adopted the Zero Pollution Action Plan (ZPAP)[220]. Target 5 under ZPAP states that "*By 2030, the EU should reduce by 50% plastic litter at sea and by 30% microplastics released into the environment*" compared to the 2016 baseline[221]. The target is founded on calculations by the European Chemicals Agency (ECHA) which indicated that measures targeting textiles, tyres and plastic pellets, flakes and powders, alongside measures on intentionally added primary microplastics could achieve a 60% reduction by 2038. The ZPAP highlights the 'zero pollution hierarchy' as a core approach to address pollution, stating that "EU environmental policies should be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should, as a priority, be rectified at source and that the polluter should pay"[222].

Similarly, the EU Soil Health Strategy sets out a framework and concrete measures to protect and restore soils and ensure their sustainable use[223]. The document sets objectives to achieve healthy soils by 2050, including the objective of reducing by 30% microplastics released into the soil by 2030. A new Soil Health Law is foreseen

212. amarro & Costanzo n.d.; A. Lusher et al. 2017; World Health Organization 2022
213. OECD 2021
214. United Nations Environment Programme 2021; United Nations Environment Programme (2022)
215. Boucher & Friot 2017a; CIEL 2022; Minderoo Foundation n.d.
216. Nøklebye et al. In press; Xanthos & Walker 2017
217. IGES 2022
218. Karasik et al. 2020
219. Global Plastics Policy Centre n.d.
220. Towards Zero Pollution for Air, Water and Soil.
221. See **Annex 2** for an excerpt of the target and monitoring approach
222. *Zero Pollution Action Plan* 2021
223. *Zero Pollution Action Plan* 2021

by 2023 as an implementation instrument for this strategy. While it is not yet clear how microplastic pollution will be included in the law, it will build on the ongoing work to restrict intentionally used microplastics. It may also set provisions on measures on the unintentional release of microplastics and adopt biodegradability criteria for certain polymers, such as coating agents and agricultural mulching films.

Furthermore, the EU Marine Strategy Framework Directive (MSFD)[224] and the four Regional Sea Conventions[225] are providing frameworks for large-scale actions against marine litter, including micro-litter. It is a policy framework for 23 coastal Member States of EU with sea borders in the four European seas: Mediterranean Sea, Black Sea, Baltic Sea and North-East Atlantic region. Monitoring is implemented in all EU member states, yet microlitter (including microplastics) has recently been put forward as a suggested indicator[226]. Indicators are being developed to monitor microlitter on coastlines, in surface water layers, on the seabed and ingested by biota. As Member States must develop action plans to achieve targets by 2027, a number of states have started to address microplastics in their MSFD action plans.

Concurrently, the EU has taken several actions to develop interlinked policies to reduce microplastic emissions under the EU Green Deal, ZPAP, the Plastics Strategy and the Circular Economy Action Plan. The EU will also present measures to address microplastic pollution from textiles, tyres and pellet losses by the end of 2022.

Plastic pellets, flakes and powders

- **The EU Plastics Strategy** *proposed* three measures to prevent losses of pellets, flakes and powders that are yet to be implemented[227]:
    - A certification scheme along the plastic supply chain.
    - Best Available Techniques reference document under the Industrial Emissions Directive.
    - Encourage industry to put in place measures to avoid spillage of plastic pellets.

Intentionally added microplastics:

- **EU Ecolabel**[228]: The EU Ecolabel is a *voluntary* measure to encourage producers to adopt more sustainable practices. In 2014, the Ecolabel requirements were amended to require rinse-off cosmetics to be microbead-free to qualify for the label.
- **EU Plastics Strategy (2018)**[229]: The strategy lays out the ambition, vision and measures to achieve a circular plastics economy by 2030, in line with the EU Action Plan for a circular economy. The strategy includes measures on intentionally added microplastics, and a proposal to consider these materials under the Registration, Evaluation, Authorisation and Restriction of Chemicals

224. European Commission 2008
225. The four regional seas and dedicated RSCs: Mediterranean Sea (UNEP/MAP), Black Sea (BSC), Baltic Sea (HELCOM) and North-East Atlantic region (OSPAR).
226. González-Fernández & Hanke 2020
227. European Commission 2018a; 2018c
228. European Commission 2017
229. European Commission 2018a

(REACH) regulation.

- **Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) *(under development)***: In 2019, ECHA proposed a wide-ranging restriction on intentionally added primary microplastics under REACH[230] (see **Box 10**). The restriction is based on a differentiated risk management approach, banning the placing on the market of sectors and applications of intentionally added microplastics where releases were considered unavoidable. The proposed restrictions on several categories of products, including artificial grass granulates, containing microplastics. It excludes microplastics that can be contained within industrial facilities (see Annex 6 for an exhaustive list of uses of intentionally added primary microplastics, including in industrial facilities), as well as biodegradable polymers, water-soluble polymers, and polymers that are not chemically modified. In addition to the restrictions of access to the market of set product categories, the restriction lays out information requirements to producers of some categories of products, as well as suppliers and industrial users of plastic pellets, flakes and powders. At the point of writing (November 2022) this restriction is still under debate, and the final policy may differ from what was proposed.
- **Fertilizer regulation (2019)[231]:** The 2019 amendment restricted access to the market of any EU fertilising product containing non-biodegradable plastic polymers after July 2026. Biodegradable polymers may only be added to control nutrient release, and products containing biodegradable polymers will need to adhere with criteria which are to be set by July 2024[232]. The polymers must pass several toxicity tests to prove that the polymers and their degradation by-products do not have any adverse effects on animal or plant health.

Use-phase and degradation-based secondary microplastics

- **EU Textile Strategy (2022)**[233]: Proposes measures to address synthetic microfibres from all lifecycle stages of textiles. The strategy prioritises proposals for upstream prevention and reduction measures, including binding design requirements under the *Ecodesign for Sustainable Products Regulation*[234]; measures targeting manufacturing processes, such as requiring pre-washing at industrial manufacturing plants, labelling and the promotion of 'innovative' materials; reduction of emissions from laundering through measures on washing machine filters, development of mild detergents, caretaking and washing guidelines; measures on end-of-life textile waste treatment, and regulations for improved wastewater and sewage sludge treatment.

230. ECHA 2019b
231. Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003 (Text with EEA relevance)Text with EEA relevance 2022
232. In the absence of such criteria, fertilising products containing plastic polymers cannot enter the market after 2024.
233. European Commission n.d.
234. In the 2022 proposal for the updated ecodesign regulation, microplastics releases are listed as one of the parameters in Annex I to be considered as a basis for setting ecodesign requirements for productsEuropean Commission 2022.

Box 10. Elaboration on the proposed REACH restriction of intentionally added primary microplastics

Proposal for EU REACH restriction of microplastics

Definition - Synthetic polymer microparticles:

polymers that are solid and which either are contained in particles and constitute at least 1 % by weight of those particles, or build a continuous surface coating on particles; where at least 1 % by weight of those particles fulfil either of the following conditions:

a. all dimensions of the particles are equal to or less than 5 mm;
b. the length of the particles is equal to or less than 15 mm and their length to diameter ratio is greater than 3.

The proposed restriction includes four categories of polymers excluded from the regulation:

1. Polymers that are the result of a polymerisation process that has taken place in nature, which are not chemically modified substances;
2. Polymers that are degradable as proved in accordance with degradation tests set out in an appendix to the regulation;
3. Polymers that have a solubility greater than 2 g L^{-1} as proved in accordance with criteria set out in an appendix to the regulation.
4. Polymers that do not contain carbon atoms in their chemical structure.

The proposed restriction also excludes:

1. Synthetic polymer microparticles for use at industrial sites; medicinal and veterinary products; fertilising products covered by Regulation (EU) 2019/1009 (Fertilizer Directive); food additives regulated by Regulation (EC) No 1333/2008; and in vitro diagnostic devices.
2. Synthetic polymer microparticles that are: a) contained by technical means so that releases to the environment are prevented when used in accordance with instructions; b) modified during intended use in a way that the polymer no longer falls under the scope of the regulation; c) permanently incorporated into a solid matrix during intended end use.

Suppliers of polymers for these uses must report on the end uses, generic information of polymers and estimates of the quantities released to the environment for the previous year.

The proposed regulation sets out deadlines for when the following products containing intentionally added microplastics cannot be placed on the market:

1. Encapsulation of fragrances.
2. Rinse-off products.
3. Lip products, nail products and makeup.
4. 'Leave-on' products.

5. Waxes, polishes and air care products
6. 'Devices' under EU Regulation (EU) 2017/745 on medical devices.
7. Fertilizing products that do not fall under the EU Fertilizer Regulation.
8. Plant protection products and biocidal products.
9. Agricultural and horticultural uses not addressed under points 7 and 8.
10. Granular infill for use on synthetic sports surfaces.

The proposed regulation further sets out information, reporting and labelling requirements for products containing intentionally added microplastics. This includes requirements to manufacturers and industrial downstream users of plastic pellets, flakes and powders to submit information on the uses of these materials each year, information on the identify of polymers used and estimates of quantities released to the environment.

- **EU Plastics Strategy (2018):** The Plastics Strategy includes several actions to reduce microplastics pollution:
    - Examination of policy options for reducing unintentional release of microplastics from tyres, textiles and paint (e.g. including minimum requirements for tyre design (tyre abrasion and durability if appropriate);
    - Information requirements (including labelling if appropriate);
    - Methods to assess microplastic losses from textiles and tyres;
    - Information (including possibly labelling)/minimum requirements;
    - Targeted research and development funding.
    - Evaluation of the Urban Waste Water Treatment Directive[235] to assess effectiveness as regards microplastics capture and removal

- **Initiative to reduce the presence in the environment of unintentionally released microplastics from tyres, textiles and plastic pellets (under consultation)**[236]: The initiative proposes measures to prevent releases of non-intentionally added microplastics from the three largest sources in the EU. The initiative prioritises upstream reduction at source, through measures targeting tyre abrasion such as ecodesign requirements, knowledge generations and capture through infrastructure. For textiles, proposed measures include ecodesign requirements, improved manufacturing processes (pre-washing of clothes), minimum sustainability or information requirements, and labelling according to levels of microplastics emissions, alongside voluntary measures by industry.

- **Drinking Water Directive (2020)**[237]: The 2020 recast Drinking Water Directive includes measures to establish guidelines for monitoring microplastics in drinking water by 2024. The Directive also encourages member states to consider microplastics pollution under the risk assessments for surface water drinking water sources. The Commission must also establish and update a watch list addressing substances or compounds of concern to the public or the scientific community on health grounds ('the watch list'), such as pharmaceuticals, endocrine-disrupting compounds and microplastics.

- **Urban Wastewater Treatment Directive**[238] **(under revision):** The EU Commission is proposing expanding the scope of the Urban Wastewater Treatment Directive to require treatment of stormwater in densely populated areas, in order to capture microplastics, litter and other pollutants[239]. The revised directive could also include requirements of monitoring of microplastics.

- Other relevant regulations under revision are the Environmental Quality Standards Directive and the Groundwater Directive which may include microplastics under lists for substances to monitor.

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235. Council Directive of 21 May 1991 concerning urban waste water treatment (91/271/EEC) 2014
236. European Commission 2021
237. European Commission 2020
238. Council Directive of 21 May 1991 concerning urban waste water treatment (91/271/EEC) 2014
239. *New EU rules on treating urban wastewater* n.d.

Association of Southeast Asian Nations (ASEAN)

In the ASEAN region, the Bangkok Declaration on Combating Marine Debris and the ASEAN Regional Action Plan on Combating Marine Debris outline initiatives to improve regional cooperation on marine debris issues and improve capacity to address marine plastic pollution through upstream and downstream measures[240]. The ASEAN action plan highlights the limited understanding of microplastics leakages and lack of measures amongst ASEAN Member States to address microplastic pollution. The action plan further emphasises the need to improve knowledge in ASEAN on quantifying and monitoring plastic marine debris; and to contribute to global research efforts to better understand the sources and impact of microplastic. The plan includes a regional study on microplastics scheduled for 2024, which includes four components: 1) baseline regional study on microplastics; 2) stocktaking of existing studies and methods on microplastics and research institutes; 3) analysis of samples from different microplastic-releasing products to identify the rate of release; and 4) identification of main sources of release of microplastic in the environment.

Arctic Council

The Arctic Council has noted a growing concern related to increasing levels of microplastics in the Arctic[241]. Both the Arctic Monitoring and Assessment Program (AMAP) and Protection of the Arctic Marine Environment (PAME) address litter and plastics in the Arctic region[242]. Specifically, AMAP has now put forward recommendations to prioritize monitoring primary indicators for beaches/shorelines, sediments (freshwater and marine), water (freshwater and marine) and seabirds, while secondary recommendations include indicators for air, fish and invertebrates[243]. Moving forward, PAME will continue working towards developing an implementation plan for the Regional Action Plan on marine Litter in the Arctic (2021-2023). Main activities will include a roadmap for implementation of the Arctic Council's strategic actions[244].

4.3 Source-oriented measures to address microplastics pollution

The most common approach at the national level to limit microplastic pollution is through downstream measures to reduce mismanagement of wastes[245]. Some examples of upstream sectorial approaches exist. This sub-chapter reviews current policies and measures, in addition to those discussed in the previous section, taken to prevent and address microplastic pollution through specific measures on the four categories of microplastics.

240. SEAN Secretariat 2021
241. Arctic Council 2017
242. PAME n.d.-b; n.d.-a
243. AMAP 2021
244. PAME n.d.-b
245. Deme et al. 2022; Nielsen et al. 2020

4.3.1 Plastic Pellets, Flakes and Powders

Losses of plastic pellets, flakes and powders take place across the plastic value chain. The emissions may be both acute and diffuse. **Diffuse** pellet pollution occurs during production, storage, loading and unloading, transportation, conversion, packaging and recycling as smaller quantities of pellets, flakes or powders are lost at various stages. **Acute** pellet pollution events may be much more visible than the diffuse losses, due to the high volumes of pellets lost over a short period of time. Two notable examples are the TransCarrier accident in the North Sea in 2020[246] and the X-press Pearl spill in 2021[247]. The X-press Pearl accident alone released 1,680 tonnes of plastic pellets to the waters outside Sri Lanka in 2021[248]. Following these two accidents, there is reason to think that diffuse and acute pellet pollution may require differentiated measures.

Regulatory measures

Acute pollution events

Pollution by plastic pellets, flakes and powders is largely regulated by policies targeting environmental pollution more broadly. Spills from international shipping (such as the TransCarrier and X-Press Pearl accidents), are regulated by international treaties such as the MARPOL Convention (Annex V) and the London Convention/London Protocol which prohibit pollution from maritime activities. Clean-ups of maritime spills are typically covered by pooled insurance agents (P&I insurers) which may contribute to cover the costs of clean-ups. However, the extent to which the shipping companies are held responsible for clean-up costs and damages varies according to national practices and the willingness of the companies to cooperate[249]. Following the two accidents, Sri Lanka, with the support of several countries, have proposed to the IMO Sub-Committee on Pollution Prevention and Response to reclassify plastic pellets as *hazardous substances* according to the IMDG Code[250]. This change to the code would make it possible to identify containers carrying pellets, flakes or powders, so that they may be stored below deck, thus reducing the risks of spills. In April 2022, the IMO Correspondence Group on Marine Litter from Ships has been assigned the task to evaluate all options, including classification, that could reduce the risk associated with the maritime transport of plastic pellets, flakes and powders. This group is planned to deliver its recommendations to IMO PPR-10 early 2023. Another proposal is to classify plastic pellets as dangerous goods under Annex III of MARPOL, which could improve the labelling, cargo handling, storage and handling on-board ships and reduce accidents resulting in plastic pellets entering the marine environment[251].

Beyond preventive measures, measures to address acute plastic may also relate to cooperation and emergency preparedness to mitigate the negative impacts of spills and facilitate clean-up efforts. For instance, Sweden has taken the initiative to examine how to better increase emergency preparedness and response to spills in the Nordic countries following the TransCarrier accident under existing Regional Seas Conventions and Action Plans.

246. Hilde Dolva et al. 2020
247. "X-Press Pearl" 2021
248. UNEP 2021b
249. Jefferies & Maes 2022; *Sri Lanka eyes major compensation case over X-Press Pearl sinking* 2022
250. Sub-committee on Pollution Prevention and Response 2022a
251. Sub-committee on Pollution Prevention and Response 2022b

Diffuse pollution

On the national level, diffuse pellet pollution is typically governed by national level legislation on industrial pollution. Some countries have taken additional measures:

- **France** introduced a decree in 2021[252], demanding the presence of equipment and procedures across producers, handlers and transporters of plastic pellets to prevent losses. The decree requires regular, independent inspections within one year, which are then repeated every three years.
- In **Spain**, the Spanish Association of plastics industries, has developed a *c*ertification scheme to verify the implementation of voluntary industry measures to reduce pellet losses[253].
- The **UK National Standards Body** published specification PAS 510:2021 which defines best practices for managing and handling plastic pellets across the value chain[254].
- **Sweden** has developed voluntary guidelines to prevent emissions of microplastics from manufacture and management of plastics[255].

The French policy and Spanish efforts reflect increasing momentum for the establishment of binding standards and guidelines to reduce pellet losses in Europe. While in the EU, the Plastics Strategy and a subsequent report proposed a regulation **requiring supply-chain accreditation of best practices** to prevent pellet losses as a potential measure to address such leakage[256]. OSPAR Recommendation 2021/06[257] calls for the development and implementation of pellet loss prevention standards and minimum requirements, alongside certification schemes for the entire supply chain and the promotion of best practices[258]. The accompanying OSPAR guidelines emphasize that policy measures should prioritize prevention of spills at source with a clear hierarchy of measures in standard and certification frameworks: 1) prevention, 2) containment and mitigation, and 3) clean-ups[259].

Voluntary actions on plastic pellets, flakes and powders: Operation Clean Sweep

Operation Clean Sweep (OCS) is a *voluntary* programme initiated by the American Chemical Council and the US plastic industry association PLASTICS to reduce the losses of plastic pellets, flakes and powders to the environment. It targets all stakeholders along the value chain, including the resin producers, transporters, bulk terminal operators and plastics processors. The programme was initially launched in the US and has been exported several other countries and regions. The design of the programmes varies between countries. The programme is structured around **pledges** by companies and employees committing to prevent pellet loss. The host organisations of the OCS programmes also conduct **awareness raising, trainings and provide guidance materials** to support companies and employees in implementing measures.

252. Decree No. 2021-461 of 16 April 2021 on the prevention of losses of industrial plastic pellets into the environment
253. OSPAR Commission 2021
254. *PAS 510:2021 31 Jul 2021 BSI Knowledge* n.d.
255. OSPAR Commission 2021
256. European Commission 2018a; 2018c; Hann et al. 2018a
257. See OSPAR Guidelines in support of Recommendation 2021/06 on the reduction of plastic pellet loss into the marine environment (OSPAR Agreement: 2021-06) for more information.
258. OSPAR Commission 2021
259. OSPAR Commission 2021

OCS in Europe has been criticised for primarily involving the producers of plastic pellets and not including the agents involved in handling and transporting these materials, and for lacking compliance and verification mechanism[260]. In response, the European producer organisations for plastic producers (Plastics Europe) and plastic converters (European Plastics Converters) are developing a **European certification scheme**. The certification scheme aims at controlling and documenting compliance with commitments to prevent pellet losses and should be ready by the end of 2022[261].

The content of the pledges, requirements for reporting, validation and implementation of measures varies between OCS programmes. Whereas the US and European schemes do not require documentation from signatories, the Brazilian iteration of OCS, the *Zero Pellet Program – OCS* was co-designed by the plastics industry and the Oceanographic Institute of the University of São Paulo[262]. In this iteration, signatories must comply with a two-year programme:

1. Conduct an assessment of the company and risks of losses within six months,
2. Design a workplan within a year,
3. After two years supply an implementation report.

The Brazilian OCS initiative is thus an intermediary between the more stringent requirements under a certification scheme, and the softer approaches under the present iterations of OCS in the US and Europe.

4.3.2 Intentionally added primary microplastics

The reviewed policies that on intentionally added primary microplastics predominantly address microbeads (see 4 for policies reviewed), with some examples of measures addressing rubber infill materials. With regards to other common sources of intentionally added primary microplastics such as polymer-coated fertilisers and plant protection agents and glitter, no specific policies and measures were found beyond the activities being undertaken under the EU[263].

- **Microbeads**

Microbeads were the first microplastic category to achieve widespread attention[264]. Driven by civil society campaigns[265], the first policy aiming to remove microbeads in rinse-off cosmetics was introduced in the Netherlands in 2014. The Dutch government opted for a **voluntary approach**, engaging with industry to phase out microbeads by 2016[266]. Other countries, such as Australia and Austria, have also opted for voluntary measures to phase out the use of microbeads[267].

Indeed, the groundwork laid down through work with industry may have reduced the resistance faced by other governments that chose to implement bans later on. For instance, in 2015, the industry association **Cosmetics Europe** called for the **voluntary elimination of microbeads** in rinse-off cosmetics by 2020 amongst its members. By 2018, the members reported having phased out more than 97% of use[268].

260. European Commission 2021
261. Plastics Europe 2022
262. Turra 2022
263. See Section 4.2.1 for an extensive discussion of the measures taken under the EU including the proposed EU restriction on synthetic polymer microparticles
264. Xanthos & Walker 2017
265. *Our Impact on the Cosmetics Industry* n.d.
266. *Beat the Microbead: The Netherlands speak out Plastic Soup Foundation* n.d.
267. Arroyo Schnell et al. 2017; Department of Agriculture, Water and the Environment 2021
268. Cosmetics Europe 2018

Since 2015, **bans on certain uses of microbeads** have been implemented in countries in Asia-Pacific, Europe and North America (see **4**). The initial bans were typically limited to the import, manufacture and sale of microbeads in rinse-off cosmetics. Over time, more expansive regulations have been put in place, such as restricting microbeads in detergents (China; South Korea) and industrial cleaning products (Sweden). Furthermore, in 2022, China has introduced additional legislation to define responsibilities for ensuring **compliance**. Under the proposed EU REACH Restriction for synthetic polymer microparticles, other uses of microbeads would also be included.

- **Artificial turf granulates**

Artificial turf (rubber) granulates are estimated to be amongst the largest sources of microplastics in some Northern countries where artificial turf sport pitches are common[269]. In Europe alone, an estimated 50,000 artificial turf pitches are installed[270]. With an estimated 3% loss rate annually, the EU Commission has proposed **a phase-out of the placing on the market** on rubber infill materials for artificial pitches under the EU REACH restriction[271]. In the meanwhile, Norway has amended the national pollution regulation to include **requirements** to the design, operations and maintenance of artificial turf sport pitches, as well as the management of snow from sport pitches (which acts as a vector for transmitting granulate to waterways)[272]. The regulation also includes requirements on informing users of best practices, and that any new pitches must consider using alternative infill materials. Other measures include an **EU CEN technical report** (UNE CEN/TR 17519:2021 IN) on reducing losses[273], OSPAR Action 5.2 to develop best practices and guidelines, and planned HELCOM **guidelines** on establishment and operation of artificial turfs to prevent plastic losses[274]. Finland has established **guidelines** and **best practices** for the management and design of artificial turf pitches[275], while the Swedish Environmental Protection Agency has produced guidelines for regulatory authorities giving information on what requirements they can place on the operators of artificial turf pitches[276].

4.3.3 Use-phase secondary microplastics

Measures and policies addressing use-phase secondary microplastics primarily target tyre and road wear and microfibres from textiles. Measures to reduce the microplastic generation from agricultural plastics during use are limited, beyond an FAO initiative to develop a Voluntary International Code of Conduct for Agricultural Plastics by 2024 and actions taken in China to control mulching films[277]. Measures and policies targeting other prominent sources such as paints and paint fragments were not identified in this review.

269. MEPEX 2021
270. Hann et al. 2018b
271. ECHA 2019a; Hann et al. 2018b
272. *Gummigranulat fra kunstgressbaner - Miljødirektoratet* n.d.
273. European Standards n.d.
274. HELCOM 2021; OSPAR 2022
275. Finnish Ministry of Environment 2021
276. *Vägledning om konstgräsplaner* n.d.
277. FAO 2021; MEE 2020

- **Tyre and road wear**

Tyre and road wear is estimated to be one of the largest discrete sources of microplastics to the environment globally[278]. Several potential reduction and mitigation measures have been identified[279]. These address tyre design (standards and labelling requirements, voluntary commitments, best available techniques, bans on tyre pins); traffic rules and road design (stricter speed limits and reduced road traffic); awareness-raising and education (eco-driving); car design (weight, acceleration rate); behaviour change (incentivising public transport, driving bans, autonomous driving); and treatment of emissions (filter systems and sustainable drainage systems, street cleaning, capture infrastructure)[280].

Measures addressing tyre and road wear are still in the early stages of development, prioritising research and development to lay the foundations for regulation. The EU has proposed the development of a standard to measure tyre abrasion as a first step to introduce legal limits for tyre abrasion and labelling of tyre wear propensity[281]. Finland is planning to conduct studies on how microplastic emissions can be reduced through measures addressing tyres, cars and awareness-raising and public engagement[282]. In Norway, the current focus is to establish knowledge on the national levels of tyre and road wear emissions and evaluate the efficiency of already established measures for road pollution[283].

Alongside these measures, the industry has taken **voluntary** actions. The European Tyre and Technical Organisation facilitated the *Tyre and Road Wear Particles Platform*, a multi-stakeholder platform. The Platform's *Way Forward Report* outlines possible mitigation measures identified during meetings of the initiative and recommendations for continued collaboration[284]. Through the Tyre Industry Project, several members are contributing to projects to further understand the potential environmental and human impacts of tyre and road wear particles.

- **Textiles**

Synthetic textiles are the second largest known significant source of use-phase secondary microplastics. Beyond measures by the EU addressed in the previous sub-chapter, countries have opted for different strategies. France and Canada are implementing **regulations** requiring the installation of filters in new washing machines, whilst Australia is implementing a **voluntary** scheme to phase-in such filters by 2030[285]. These strategies prioritise the reduction and capture of losses, and no measures were identified aiming to prevent or reduce the use of materials that contribute to microplastic pollution from textiles. Other suggested measures address pre-washing of textiles, emission limits during production, limits to microfibre shedding and EPR-schemes for textiles[286].

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278. PEW Charitable Trusts & SystemIQ 2020
279. European Commission 2019b; European TRWP Platform 2019; OECD 2021
280. OECD 2021; Trudsø et al. 2022
281. Regulation (EU) 2020/740 of the European Parliament and of the Council of 25 May 2020 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 (Text with EEA relevance) 2020
282. Finnish Ministry of Environment 2021
283. Government of Norway 2022: 75
284. European TRWP Platform 2019
285. Department of Agriculture, Water and the Environment 2021; LOI n° 2021-1104 du 22 août 2021 portant lutte contre le dérèglement climatique et renforcement de la résilience face à ses effets (1) 2021; Legislative Assembly of Ontario n.d.
286. OECD 2021

The US EPA has drafted a **Federal Plan to Reduce Microfiber Pollution**[287]. The proposed plan targets five goals: (1) Conduct, fund, and support research to address the most critical research needs related to microfiber pollution, (2) Prevent and reduce microfiber pollution from textiles and other sources from entering the natural environment, (3) Capture microfibers in major microfiber pollution pathways, (4) Minimize toxicological hazards associated with microfiber pollution, and (5) Coordinate and share microfiber pollution accomplishments, best practices and science. The plan takes a broad approach to microfibres, addressing textiles, fabrics, personal care products (face masks, tissues), cigarettes and fishing gear.

Private sector initiatives have proliferated, including innovations in product design to create new materials[288] and voluntary commitments and activities[289]. The EU Cross Industry Agreement (CIA) is an effort to coordinate industry action. The five industry associations organised under CIA committed to support finding effective and economically feasible solutions by[290]:

- Contributing to the development of international standardised test methods to identify and quantify microplastic present in water and the environment
- Sharing information on progress of research, knowledge gaps, options and priorities
- Support and participate in industrial research for feasible and effective solutions.
  Coordination of efforts is meant to top up, without replacing individual efforts and to accelerate identifying and deploying effective global solutions.

Simultaneously, the Microfibre 2030 Commitment and Roadmap, another industry initiative, aims to have established a **rating system** for rating microfibre losses from textiles by 2025. The rating system will be based on test data of microfibre releases from signatories in a central data portal, with tests following a standardised protocol[291].

4.3.4 Degradation-based secondary microplastics

Measures to address degradation-based secondary microplastics typically aim to:

1. Reduce the generation of plastic wastes;
2. Prevent littering and mismanagement of wastes;
3. Improve capture in wastewater treatment and prevent leakages
4. Clean-up and remove legacy wastes in the environment.

These kind of measures are by far the most common form of policies relevant for microplastics[292]. While this report has dedicated most of the space to policies addressing other forms of microplastics, the importance of addressing degradation-based secondary microplastics should not be underestimated, as this is likely to be the largest source of microplastics in the environment in large parts of the world due to insufficient waste management and wastewater treatment systems[293]. The following section provides a broad overview of the types of measures and some key

287. US EPA 2022
288. NOWPAP CEARAC 2020
289. *Ocean Wise Microfibre Partnership* n.d.; *The Microfibre Consortium* n.d.
290. "Cross Industry Agreement" n.d.
291. The Microfiber Consortium 2021
292. NOWPAP CEARAC 2020
293. Mitrano & Wohlleben 2020

sources and pathways of degradation-based secondary microplastics.

- **Upstream elimination**

Plastic products at high risk of littering: Several countries have implemented policies targeting commonly littered items[294]. The EU single-use plastics directive targets plastic products most commonly found on European beaches. It includes bans on certain products, as well as labelling requirements for single-use products containing plastics (such as cups, cigarettes and sanitary products), and extended producer responsibility schemes to hold the producers responsible for pollution generated. In many countries across the world, commonly littered plastic products such as plastic bags, takeout containers, straws, cutlery and cups have been banned[295]. Additionally, some countries have implemented policies regulating the thickness of plastic bags, banning thinner materials which are more likely to tear and degrade to microplastic particles than thicker materials (e.g. Philippines[296], India[297]).

Oxo-degradable plastics are plastic products containing additives which speed up the fragmentation of the products. However, contrary to some biodegradable plastics (see **Box 6, page 29**), there is no evidence of the full degradation of oxo-degradable plastics[298]. These materials are thus producing microplastics by design. The additives also make these materials unsuitable for recycling. Therefore, the EU and several other countries have **banned** all oxo-degradable products[299].

Expanded and extruded polystyrene (EPS/XPS) are porous and lightweight foamed plastic materials commonly used for packaging, insulation and for flotation devices in fisheries and aquaculture[300]. Unfortunately, the qualities of EPS/XPS qualities make these materials highly susceptible to degradation in the environment, resulting in microplastics pollution when exposed to the elements[301]. At present, regulatory measures targeting EPS/XPS primarily address takeout containers due to the high risk of littering[302]. The HELCOM Revised Action Plan on Marine Litter includes an action to encourage the development and use of buoys, floats and docks that do not release EPS, with the aim to phase out the use of those containing unprotected expanded polystyrene and other problematic materials[303]. Meanwhile, OSPAR has committed to reduce the impact of EPS in the marine environment drawing on the concluded research project, *OceanWise*[304]. Other research activities are ongoing to identify alternatives and best practices[305].

294. Diana et al. 2022
295. Xanthos & Walker 2017
296. Galarpe et al. 2021
297. Government of India 2021
298. European Commission 2018b
299. Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment.
300. Cheng n.d.; Huntington 2019; Lassen et al. n.d.
301. Lassen et al. n.d.
302. E.g. the ASEAN Action PlanASEAN Secretariat 2021, EU Single Use Plastics DirectiveEuropean Union 2019, India Waste Management RulesGovernment of India 2021.
303. HELCOM 2021
304. OceanWise n.d.; OSPAR 2022
305. "Hong Kong looks for alternative to polystyrene fish boxes" 2017

- **Midstream prevention**

Product design standards and use guidelines can be applied for products that contribute to the generation of microplastics during and after use. Agricultural mulching films are likely one of the largest sources of microplastics to soils globally[306], while the use and degradation of fishing ropes and nets used in fisheries and aquaculture contribute to marine microplastic pollution. Proposed measures to address these sources include strengthening design standards and guidelines to make products more resistant to shedding and tearing or switching to substitutes. Finland has in the Plastic Action Plan included a commitment to identify measures to reduce microplastics from agricultural plastics by 2023[307]. The EU has introduced measures on fishing gear under the Single-Use Plastics Directive, including encouraging the European standardisation organisations to develop harmonised standards relating to the circular design of fishing gear to encourage re-use and facilitate recyclability[308].

- **Downstream reduction and interception**

Improved waste management and collection systems can contribute to reduce the generation of degradation-based secondary microplastics. Measures may address investment in waste management systems and efforts to divert waste from landfills for recycling or reuse. Efforts may target both household level source segregation and recycling, but also sector specific measures such as collection and return schemes targeting known sources such as agricultural plastics or fisheries related waste[309]. Specific measures have also been planned or implemented targeting more specific waste streams such as fiberglass boats and waste tyres[310].

Incineration ash is a by-product of the incineration of plastics and other wastes. This ash may contain microplastic residues, alongside other hazardous substances[311]. Some countries have therefore prohibited the disposal or release of incinerated plastic ash into the marine environment[312].

Wastewater treatment and sewage sludge constitute other pathways for microplastics to the environment. WWTPs have been found to remove progressively higher ratios of microplastics according to increasing levels of treatment (up to 99% with tertiary treatment[313]). However, the high costs of wastewater treatment infrastructure mean that this is not a short-term solution in many parts of the world. Additionally, the removed microplastics are transferred to sludge generated in WWTPs. In several countries, such as Australia, the EU, the UK and North America, 40–75 per cent of biosolids generated from wastewater sludge are used as fertiliser or soil conditioner[314]. This thus makes up a significant source of microplastics to agricultural soils in these regions[315].

Environment authorities can set limits to permissible discharges of pollutants from

306. UNEP 2022
307. Finnish Ministry of Environment 2022
308. European Union 2019: 094
309. PAME n.d.-b
310. Karasik et al. 2020; MDir 2020
311. Yang et al. 2021
312. Karasik et al. 2020
313. Sun et al. 2019
314. Okoffo et al. 2021
315. A. L. Lusher et al. 2020

WWTPs. Some have therefore started to develop such limits to the allowed discharge of microplastics from WWTP. Finland has a target to filter out 98% of microplastics from wastewaters according to the MSFD implementation plan for 2022–2027[316]. While the EU is considering including such limits under the EU Urban Waste Water Directive. Norway has proposed limits under the EU Fertiliser Directive to the amount of impurities (including plastics) allowed in sludge that is to be used as fertiliser[317]. However, a key limitation is the lack of standardised monitoring methods for measuring the concentrations of microplastics in wastewaters and biosolids[318].

Mechanical recycling facilities can contribute to the release of microplastics to the environment from the entire process, from collection and sorting, to washing, dedusting, grinding and shredding processes. The shredded material is fed into the extruder, where it is transformed into pellets. Losses are common also in this part of the process. In formal facilities this could be addressed through imposing and enforcing regulations on preventive measures, waste management and releases to wastewater from such facilities, alongside regulations on labour health stipulating the right to a clean and safe working environment. However, informal recycling facilities are unlikely to have facilities necessary to prevent the release of microplastics (including plastic dust) to soils, water and air. These informal businesses do not always respond well to regulatory pressure, hence there are large challenges with implementation, corruption and enforcement.

Clean-up activities targeting plastic waste in the environment is a final form of activities to contribute to reduce emissions of microplastics. As waste is exposed to sun, wind and water it can continue to degrade. Clean ups are organised by governments, non-governmental organisations, and enterprises to remove wastes, and is in some cases financed through extended producer responsibility schemes[319]. Clean up activities can also contribute to monitoring and mapping of microplastic pollution through citizen science initiatives[320].

4.4 Summary and take-aways from the policy review

Policies addressing microplastics have evolved over the past five years, moving from the knowledge-generation phase in some countries, to the formulation and implementation of specific policies and measures addressing key sources of microplastics pollution. These developments reflect the importance of the *Zero Pollution Hierarchy*, **prioritizing upstream prevention** and mitigation at source and the polluter pays principle, due to the complexities of addressing and cleaning up microplastic pollution after the event.

As the review shows, in addition to increasing public pressure and political will, research on microplastics appears to have reached a **critical mass**, spurring the development of measures to address sources of microplastic pollution **across the**

316. Finnish Ministry of Environment 2022
317. Government of Norway 2021
318. European Commission 2019a
319. *Handelens Miljøfond - Norges største private miljøfond!* n.d.
320. *Pellets overboard – experiences from a plastics discharge* n.d.

plastics product lifecycle (from reduction measures, to pellet management, product design, wastewater management and waste treatment). Though many countries still primarily resort to promoting research, these research efforts are increasingly targeted towards *specific sources* and accompanying *source-specific measures.*

Indeed, a key issue for policy formulation is lack of data on important sources and emissions. **Establishing these baselines** is crucial for policymakers to identify the key discrete sources in order to target and justify measures. For instance, while rubber infill materials were found to be an important source in Northern Europe, this is less likely to be an issue in tropical climates where artificial sports pitches are uncommon. A key lesson from the review is thus the value of **source inventories** or mapping to guide policy. Such a source inventory need not spring from extensive and elaborate monitoring programmes, but may be guided by existing monitoring efforts, knowledge and data from international monitoring regimes, coupled with information on socioeconomic determinants and key industries in the countries in question. Several countries are planning to develop inventories or map key sources, such as Chile, Malaysia and on the region level in the ASEAN, as well as the state of California[321].

The development of policies is still in its infancy: several **prominent sources**, such as microfibres, tyres, paints and agricultural plastics, are **largely unregulated** with regards to microplastic emissions. Additionally, many of the measures aiming to address key sources such as microfibres and tyre and road wear discussed in this chapter are still at the *proposal* stage and have not been implemented. Most measures are also voluntary recommendations and not binding. We do therefore not have information on the effect and efficacy of potential measures, nor how to ensure compliance. Still, recent developments are promising, as they display a clear momentum and willingness to act.

The **lack of binding measures** on many of these sources can be attributed to the issue of substitutability and technological complexity. Microbeads in rinse-off cosmetics can be substituted with natural materials, making it simpler to phase-out use. It is harder to find acceptable substitutes with the same properties for other uses and sources of microplastics, such as agricultural coatings, synthetic fabrics and tyres, as well as prominent sources of secondary degradation-based microplastics such as fishing gear and agricultural plastics. Additionally, issues of technological feasibility are prominent, particularly with regards to developing protocols and standards for measuring rates of microplastic generation, tyre abrasion, microfiber losses and other measures to prevent unintentional losses.

Working with and nudging industry in establishing best practices, guidelines and standards is key to reduce microplastic emissions. As seen in the case of microbeads, the willingness of industry to adapt and change formulations, has contributed to show how it is feasible to phase-out microbeads. Similarly, the industry-led initiative OCS has been highly important in increasing awareness of pellet pollution across and within the plastic supply chain, and the value of the initiative is reflected in how subsequent standards and guidelines are building on OCS guidelines and measures. Cooperating with industry to develop new solutions and measures to other key sources of microplastics is thus crucial to ensure the acceptability and uptake of

321. ASEAN Secretariat 2021; California Ocean Protection Council 2022; Government of Malaysia n.d.; Ministerio del Medio Ambiente 2021

measures, as well as to reduce the negative consequences and trade-offs that may result from efforts to reduce microplastic pollution.

There are **significant geographical disparities** in the extent to which microplastic policies are developed and implemented. The EU is a driving force, developing an extensive web of interlinked measures addressing various products and industrial sectors under a suite of regulations, directives and strategies. Meanwhile, this review has found no policies and measures on the African continent specifically addressing microplastics, and only a few from the Asia-Pacific, Latin America and the Caribbean. This could possibly be explained by the focus on English literature and information sources. Furthermore, it is important to note that the lack of information does *not* translate to inaction in these regions. As emphasised throughout the report, microplastic pollution will need to be managed through complimentary measures to reduce plastic use and consumption and improve waste management as well as measures addressing discrete sources of microplastics.

Finally, policies on microplastics must be seen in relation to macrotrends around climate mitigation, biodiversity loss, and chemical pollution. As this chapter has shown, addressing microplastics without **systemic changes** to reduce consumption and production of plastic products, eliminating non-essential uses and establishing more sustainable transportation patterns will prove expensive and technically challenging. In accordance with the waste hierarchy, reducing microplastic emissions is far more targeted, cost-effective, and feasible than filters and clean-up efforts.

Chapter 5. Cooperation: Learning from current chemicals regulations

5.1 Introduction to the 'chemicals and waste cluster'

Regulatory lessons may be drawn from existing multilateral environmental agreements (MEAs) when considering how to address microplastics under a global agreement to end plastic pollution. As described in **Chapter 3.1**, microplastics share several features with hazardous substances. Hence, the global treaties commonly referred to as 'the chemical and waste cluster' may be particularly relevant for the design of a plastic treaty. The cluster includes the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, the Minamata Convention on Mercury, Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade and the Stockholm Convention on Persistent Organic Pollutants[322]. Alongside the Montreal Protocol, the four treaties form an international control framework that embeds the management and restriction of select chemicals and wastes throughout their life cycles[323]. For the present report, we focus on the relevant operational provisions, i.e., the control measures set up to meet the overall objectives of the respective conventions.

The Basel Convention

The Basel Convention entered into force in 1992 and aims to protect human health and the environment against the adverse effects resulting from the generation, transboundary movement and management of hazardous wastes and other wastes.[324] The convention was set up to prevent or minimize the generation of waste at source and enhance the environmentally sound management (ESM) and disposal of such waste. The convention specifically regulates which types of waste are allowed or not allowed to be transported; from and to which States; and under which circumstances, applying Prior Informed Consent (PIC) approach. Shipments without

322. More information about these treaties can be found on their respective webpages: www.mercuryconvention.org/ and www.brsmeas.org/
323. UNEP 2019
324. The convention does specifically not regulate radioactive waste and ship breaking that are controlled by other international frameworks.

PIC are illegal under the convention. A distinct feature of the Basel Convention is that it expects Parties to minimise the quantities that are moved across borders and to treat and dispose of wastes as close as possible to where they are generated.

In 2019, the Basel Convention was amended with the so-called 'plastic waste amendments'. The amendments ensure that specific categories of plastic waste are subject to the Convention's provisions on PIC. With this addition, the convention regulates the transboundary movement of 'dirty' plastic waste and mixtures, i.e., plastic waste that contains hazardous substances or additives or that are otherwise contaminated. The amendment also clarifies the scope for transboundary shipments of several types of plastic waste that are not subject to PIC procedures, such as wastes destined for recycling and ESM.

The Minamata Convention

The Minamata Convention entered into force in 2017 and was set up to manage and control mercury throughout its entire lifecycle, from cradle (extraction) to grave (waste). Its operational provisions embed control of supply (extraction and recycling), trade, use in products and industrial processes, use in artisanal and small-scale gold mining (considerable social implications), emissions to air, releases to land and water, storage of mercury stocks, waste and contaminated sites. The treaty consists of a suite of different measures, including soft and voluntary measures, as well as more firm control measures such as bans on products and defined emission control targets.

The Rotterdam Convention

The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade entered into force in 2004 and regulates the international trade and environmentally sound use of specific hazardous chemicals. The treaty evaluates and lists pesticides and industrial chemicals that has been banned or restricted by Parties and notified for inclusion in a legally binding PIC procedure. The Convention may subsequently decide to allow or not allow import, or to allow under specific conditions. Different requirements are placed on different actors, e.g., requiring the exporting party to ensure up-to-date safety data sheets are submitted to the importer and compliance with labelling requirements.

The Stockholm Convention

The Stockholm Convention entered into force in 2004, and currently regulates 31 POPs. The treaty is dynamic in the sense that new candidate POPs are nominated by parties, evaluated by a scientific review committee and regularly added. The POPs are listed in three different annexes, of which A and B concerns intentionally added compounds and C unintentional sources. The chemicals listed in Annex A are prohibited and Parties are obliged to take measures to eliminate the production and use of these chemicals. The POPs listed in Annex B are subject to restrictions. Substances listed in both Annexes come with import restrictions. The unintentional sources listed in Annex C include POPs when formed and released unintentionally from anthropogenic sources and are most commonly controlled through BAT/BEP and corresponding guidance documents developed under the convention.

In the next section we provide an overview of the key operational measures derived from the four treaties of relevance to addressing microplastics under a plastic treaty.

5.2 Overview of relevant operational provisions from the chemical cluster

The four MEAs in the chemicals and waste cluster contain a range of different measures and modalities that have been developed to reach the respective objectives of the treaties, drawing a delicate balance between the needs and capacities of its Parties. Many of these elements may have relevance when also addressing microplastics under the new treaty on plastic pollution.

Intentional versus unintentional

Both the Stockholm and the Minamata Convention makes a distinction between **intentional** and **unintentional sources** of release. Intentional sources of release refer to when substances are actively added to a product or applied in a process, and subsequently leak into the environment, e.g., as waste or losses along the product lifecycle. In contrast, an unintentional source of release is however an expected, yet secondary effect of a process or activity that leads to leakage to air, land and water. As we have discussed earlier in the report it makes sense to differentiate between the two, as different control measures would be required to prevent and mitigate the different sources of release.

Intentionally added microplastics, e.g., in toothpaste or soap, could be restricted or banned, providing cost-efficient alternatives are readily available on the market. When the Minamata Convention was negotiated, it was originally suggested to include a 'negative list' approach, meaning that all mercury-containing products would be banned, unless specifically exempted under the convention[325]. However, the outcome of the negotiations was instead a 'positive list' approach, banning a handful of the most important products, leaving those not listed legal. The selection of mercury-containing products to be banned was based on a thorough assessment of issues, such as its importance as a pollution source and the availability and feasibility of alternatives.

Indirect and unintentional releases, such as the breakdown of macroplastics, would require different measures, as elaborated in Section 5.3. Filters to capture microfibres from in washing machines, and development and promotion of best practices to avoid losses in recycling processes, are examples of measures applied for unintentional releases.

Restrictions and bans

Restrictions and bans are commonly used to control intentional use of various substances. However, they are rarely used in isolation. Under the Minamata Convention – applying the positive list approach - specific **phase out** dates were agreed for a set of mercury-containing products, from which the products would be banned internationally.[326] The dates were set a few years in the future, allowed Parties three years to comply. For dental amalgam containing mercury, the

325. Eriksen & Perrez 2014
326. The treaty opened for some flexibility allowing time-limited exemptions.

negotiating parties could not agree on a concrete date, hence a **phase down** approach was opted for. The approach includes a list of potential measures that each could contribute to raise awareness, enhance policies, build capacity and contribute to reduce the use of mercury in dental practices. Under the Stockholm Convention, the bans were not directed towards products, as compounds (POPs) and groups of compounds were banned or restricted. A similar distinction could be relevant for microplastics. A plastic *product* regulation, banning problematic products such as wash-off cosmetics containing intentionally added microplastics could be implemented using a phase out or phase down approach. Or, like the Stockholm Convention, phase outs and phase downs could be directed towards specific, problematic types of plastic *materials* such as oxo-degradable plastics or uses of EPS/XPS.

Bans and restrictions have also been directed towards certain *practices*. For instance, under the Minamata Convention, a specific date was set for phasing out some practices using mercury, whereas other were subject to a phase down approach, obliging the parties to implement measures to restrict the use of the problematic substances over time. A similar approach could also be relevant for a plastic treaty regulating specific *purposes*, such as the use of unprotected EPS in the fishery sector, combining different measures to reduce losses from specific sectors with a high risk of leakage.

BAT/BEP

BAP/BEP are measures typically used to control unintentional emissions and releases. Under the Stockholm Convention, BAT is defined as "*the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for release limitations designed to prevent and, where that is not practicable, generally to reduce releases of chemicals [...] and their impact on the environment as a whole*" (Article 5.f.(i)). Under the same convention, BEP is defined as "*the application of the most appropriate combination of environmental control measures and strategies*" (Article 5.f.(v)).

When introducing such measures, it is not uncommon to distinguish between new and existing sources, prescribing more stringent measures on new sources compared to existing sources. Particularly when the management of old sources requires costly investments in abatement technologies and infrastructure. Under the Minamata Convention, new emission sources (e.g., a new industrial plant) are obligated to implement BAT/BEP within five years, whereas for existing sources BAT/BEP was one option of several measures, with a ten-year deadline.

Concerning industrial processes involving microplastics, examples of BAT/BEP could be closed loop production systems carefully controlling all outlets (e.g., wastewater, air emissions, waste fractions, etc.) from plants; specific requirements and practices on interim storage and shipment; and listings of worst practices. BAT/BEP guidance documents, based on state-of-the-art knowledge, can be developed during the INC process and adopted at the first Conference of the Parties (COP).

Creating a dynamic treaty

Acknowledging the presence of scientific gaps and the expectation of scientific development, treaties are commonly designed as dynamic instruments, that may be developed and amended over time. Both the Rotterdam and Stockholm Convention opens for adding new substances, whereas the Minamata Convention opens for adding new products and processes involving mercury. Several of the conventions have review mechanisms that direct Parties to evaluate the chosen measures and strategies. Both the Rotterdam and the Stockholm Convention has scientific review committees to evaluate the nomination of new substances, whereas under the Minamata Convention, new products and processes are proposed by any Party and evaluated by the COP itself. It should be noted that the scientific review committees under the Stockholm and Rotterdam convention consist of government nominated experts, adopted by the COP.

As outlined in **Chapter 3**, there are scientific unknowns and uncertainties related to microplastic pollution and impacts. The uncertainties indicate the need for a start-then-strengthen approach to address microplastics on the global level. This could entail starting with microplastic sources that are well documented and for which mitigation technologies and substitutes exist, and follow-up with further research and monitoring to add new sources and pathways in the future. This discussion also relates to the application of the precautionary principle. Negotiators will have to decide upon the degree of precaution, e.g., what degree of uncertainty is acceptable and what degree of risk warrant action.

A **scientific review committee** could be warranted also under the new global plastic treaty, as future scientific progress may prove new products, processes or practices problematic, hazardous to human health or environment or of emerging concern[327]. For those plastic products or microplastics where no sound alternatives exist, the committee may regularly reassess the availability and feasibility of alternatives and phase-outs of products or practices. A benefit of scientific review committees is that they may increase the credibility and legitimacy of measures. Such a committee should not be exchanged with the parallel development of a science panel on chemicals, waste and pollution, that is expected to be set up as an independent scientific panel with the mandate to compile, assess and synthesise scientific knowledge for the purpose of international management and regulation.

Stockpiles, storage and waste management

Plastic pellets, flakes and powders form the feedstock for new plastic products. There is a risk for spills and pollution when these materials are stored in insecure or inappropriate locations. Drawing on the experiences under the Stockholm Convention, a first step to manage stockpiles and storage (interim or long-term) would be to identify such sites. Secondly, specific requirements could be set to manage such sites, potentially including environmentally sound management, BAT/BEP, storage and disposal requirements, time limitations for storage, registration and more.

Similarly for waste which can result in the generation of degradation-based

327. The distinction between a scientific panel on chemical, waste and pollution, as agreed to be developed at UNEA 5.2, and a scientific review committee, is that the former normally consists of scientists and is a body existing independent of the convention it supports with scientific knowledge. Whereas the latter is an expert body, normally consisting of government nominated experts, mandated to assess the existing scientific knowledge to consider the need for amending the treaty.

secondary microplastics, several of the treaties in the chemicals and waste cluster specify requirements for environmentally sound management of waste, definitions for hazardous waste and for what purposes wastes may be recycled, re-claimed or reused (e.g., refused-derived fuel used as fuel in furnaces for brick making). Common guidelines for management of these potential release sources (stockpiles and storage and waste) have been developed under the treaties in the chemical and waste cluster, with strong references to the Basel Convention. These documents have relevance also for the management of microplastic stockpiles, storage and waste; however, they must be adapted to fit the waste fractions associated with plastics and microplastics.

Regulating supply

Under the chemical treaties it has been critical to limit the supply of hazardous chemicals, thereby disincentivising further use and strangling illegal trade. Regarding plastic pollution in general, it is also sensible to reduce general consumption levels. Particularly if one considers the tremendous growth in consumption expected within the next decades and that plastics are derived from a non-renewable resource with significant climate impacts[328]. As previously described, plastic material fulfil multiple essential needs in our modern societies and a complete ban on production of virgin plastic is not warranted as there are applications for which no alternatives exist (e.g., medicinal uses). An important element in this regard is the high variability in plastic consumption patterns, in particular between developed and developing countries. To capture such variability a relative reduction target for production of virgin plastic could be anticipated. If implemented, such a measure and associated volume reductions would also impact the presence and drivers of microplastic pollution.

Trade and transboundary movement

As described in the first part of this chapter, the Basel Convention regulates the transboundary movement of hazardous waste, and since 2019 certain types of plastic waste. This has direct implications for microplastics in two ways: the reduction of plastic waste import significantly reduces the share of dirty plastic waste that earlier tended to be mismanaged or illegally dumped in the recipient country[329]. Although, illegal shipments of plastic waste still take place, the Basel Amendment is expected to reduce the amount of mismanaged waste that would otherwise have contributed to degradation-based secondary microplastics[330]. However, plastics intended for recycling in an environmentally sound manner, can still be legally traded without a PIC procedure.

However, the Basel Convention does not regulate plastic raw materials, such as pellets, flakes and powders, or products containing intentionally added microplastics. Nor does it regulate important types of plastic wastes made of polyethylene (PE), polypropylene (PP) or polyethylene terephthalate (PET), that are still allowed to be shipped across international borders in ways considered acceptable under the treaty[331]. As has been emphasised throughout this report, there is a significant risk

328. Borrelle et al. 2020; CIEL 2019; Ford et al. 2022; Lau et al. 2020
329. W. Wang et al. 2019
330. Cook & Velis 2022; Interpol 2020
331. Cook & Velis 2022

for spills and leakage during transport and storage.[332] If a plastic treaty is to enforce bans or restrictions on certain products, constituents, polymers or processes, regulating and controlling international trade may become an essential tool.

In addition to having specific control measures on waste, the Stockholm and Minamata Convention are closely aligned with the Basel Convention. A future plastic treaty will also have to align with the Basel Convention, making sure that existing regulatory gaps are shut and that trade between both Parties and non-Parties are regulated adequately.

5.3 Relevant measures to manage microplastics under a new global treaty

Drawing from the overview of measures within the chemicals and waste cluster, we here discuss potential measures to reduce microplastics pollution under a global agreement to end plastic pollution (**Table 7**).

332. As previously mentioned, the IMO is considering redefining plastic pellets as a hazardous substance and regulating the transport of pellets at seaSub-committee on Pollution Prevention and Response 2022a.

Table 7. Relevant measures for different categories of microplastics (see Box 2 for a description of the categories).

Microplastic category	Typical sources	Relevant measures
Plastic pellets, flakes and powders (pre-production microplastics)	• Loss during storage and transport • Leakage during manufacturing and production processes • Leakage during recycling (pellets)	• Trade restrictions • Transport requirements • Adequate labelling of shipments • Storage restrictions/requirements • Stockpile mapping and management • BAT/BEP for raw material as before production, manufacturing and recycling • Guidance, trade forms and procedures
Intentionally added primary microplastics	• Microbeads and microplastics in rinse-off cosmetics • Fertiliser, seed and pesticide coatings • Industrial abrasives • Glitters and sequins • Rubber granulates for artificial turfs	• Product design • Bans and restrictions, phase out/down • Essential use • Trade restrictions • BAT/BEP for large scale application, incl. mitigative measures • Advancement of wastewater systems • Guidance, trade forms and procedures
Use-phase secondary microplastics	• Microfibers from textiles • Plastic roads • Tire and brake wear • Fishing and aquaculture gear • Agricultural films, twines, nets • Paints • Brushes, strimmers	• Product design • Bans and restrictions on products prone to leakage • Restrictions on use and application • Industry and product standards • Labelling systems • BAT/BEP • Wastewater systems • Clean-up campaigns
Degradation-based secondary microplastics	• Environmental degradation of macroplastics • Mechanical plastic recycling • Incineration of plastics	• Prevent generation of waste • Improve design, increase circularity • Improve waste collection systems, ESM • ESM disposal, capture landfill leachate • Targeted litter clean-ups • BAT/BEP for mechanical recycling

Plastic pellets, flakes and powders

Most production processes of plastics involve plastic pellets, flakes and powders. This includes recycling processes where plastics are shredded, extruded and made into pellets, before moulding into new products. Hence, any policies to reduce the production of plastic, e.g., through agreed reduction targets, would also imply a reduction in the production and use of pellets, flakes and powders, and subsequently the volumes at risk of being released into the environment.

To reduce or eliminate microplastic pollution arising from this category, control measures should be oriented towards unintentional losses along the supply chain and in production processes. Pellets, flakes and powders are prone to leak into the environment during transport and storage through diffuse leakage, bad environmental practices or accidental spills. Agreeing on common rules to limit or prescribe safe transport and storage would be a sound way of reducing losses from this category. Such efforts to control (interim) storage and transport has precedence in other treaties.

Another point source of pollution from plastic pellets, flakes and powders is pollution directly from production facilities, e.g., through air, wastewater and spills, to the surrounding environment. Various policy measures are available to address these sources. A phase down or phase out approach could be set up to target worst practices associated with significant releases or where the risks and impacts warrant firm action. This could for instance be phase-outs of recycling activities in open facilities. Thus, distinguishing between manufacturing/production processes (products) and raw material production/recycling processes could be justified, considering the different leakage potential from the two.

Intentionally added primary microplastics

Intentionally added primary microplastics are added to products to achieve a feature or functionality, or are products in themselves (e.g., glitter, rubber granulate). Some microplastics in this category are intended to remain in the product (e.g., in paints), whilst others are designed for immediate release (e.g., rinse-off cosmetics, industrial abrasives, agricultural fertilizers). In the short or long term, these particles enter the environment, most commonly through wastewater, but also directly to air, soil and sediments.

Relevant control measures for this category could be applied both in the production phase and in the end-of-use phase. Both the Minamata and Stockholm Convention include bans and/or restrictions on the most problematic compounds and products. Since intentionally added primary microplastics are highly prone to end up in the environment, banning or restricting this category directly contribute to reduce environmental pollution. Product design standards and sustainability criteria have been promoted as tools to avoid primary microplastics being intentionally added to products, unless it is strictly needed (i.e., for medical or military purposes)[333].

Essential/non-essential use is another relevant approach in this regard. Non-essential uses or products could be more firmly regulated, e.g., with concrete phase out dates and stringent control measures. Essential use categories could on the

333. Raubenheimer & Urho 2020; Rognerud et al. 2022

other hand be targeted with more flexible reduction measures depending on the context of application, leakage and impact. Criteria for defining essential and non-essential uses could be based on the societal dependence of the type of microplastics/product, the availability and feasibility of alternatives (including cost, technical requirements and restrictions, market access, cultural context and more), and considerations around the human and environmental risk and impact of current use. It should be noted that MEAs commonly include a range of transitionary and flexibility mechanisms to facilitate the different needs of Parties in implementing restrictions and bans, such as time-limited extensions and exempted use. These are diplomatic greasing agents to ensure participation to the treaty, and advocate for the stringency of measures. When considering firm regulatory measures, the availability and feasibility of alternatives are essential information. The latter point also relates to the product design phase, as product developers for instance could be required to avoid developing products with primary microplastics. It should be noted that this may introduce important environmental trade-offs.

Measures to control end-of-life releases from this category could include BAT/BEP approaches to control the releases (e.g., closed-system application, capture and filtering technologies, etc.), advancement of wastewater treatment systems combined with environmentally sound management of sludge, and loss preventive practices.

Use-phase secondary microplastics

Plastic products can generate microplastics during use. Microfibres from textiles, tire and brake wear, microplastics from the degradation of aquaculture and fishing gear, agricultural films and paints are all examples of such releases. Reducing the overall consumption of plastic will also reduce the leakage from these sources. However, assuming that plastic will continue to be an important material for a range of purposes in the future, measures will have to be implemented at different stages of the product lifecycle to reduce releases from this category. It may be sensible to distinguish between industrial and consumer related sources, as they will trigger different control measures.

For mercury and POPs, the Minamata and Stockholm conventions prescribe some specific control measures to address unintentional leakages to the environment, while leaving the specific control measures to the discretion of the Parties. Restricting the use of dental mercury amalgam to its encapsulated form is one example, ESM of waste, and implementation of BAT/BEP are all examples of measures that have been promoted under the two conventions to manage releases of mercury and POPs from products and processes.

The design of plastic products may be improved to reduce susceptibility to abrasion and break-down into microplastics – keeping in mind the potential conflict with the demand of longevity and increasing recyclability. Similarly, careful consideration microplastic generation during use by managing factors that contribute to break-down of plastic products, has potential to reduce the release of this category of microplastics. Measures such as microplastic filters in washing machines, lower speed limit and tunnel washing, phase-in of plastic-free alternatives and materials with lower rates of shedding are all examples of measures that have been proposed to reduce emissions. Such measures could be addressed at various levels: consumers can be encouraged to choose more environmentally friendly products (e.g., through labelling systems); governments can establish product standards, minimum service life, and require the integration of filtration technology in washing machines; they can set emission limit on specific industry sources and establish guidelines or limitations for consumer behaviour. When considering alternative replacement materials, a life-cycle assessment would be justified to reduce the risk of problem shifting.

Degradation-based secondary microplastics

Degradation-based secondary microplastics are the result of larger plastic items breaking down into microplastic pieces, either passively through weathering or actively through mechanical treatment and recycling activities. Although strictly not a category of plastics, waste fractions arising from incomplete incineration[334], such as ash and waste arising from air pollution capturing devices are included in this discussion.

The chemicals embedded in the treaties discussed in this Chapter are all found in different waste fractions, and measures have been developed accordingly. Mine tailings, catalyst waste and residual pesticides are all examples of waste fractions potentially leaking to the environment. Guidelines for environmentally sound management of hazardous waste and other waste have been developed under the Basel Convention, and both the Stockholm and the Minamata Convention refer to this guideline. ESM of "hazardous wastes or other wastes [some types of plastic waste]" is defined as "means taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes". In line with the plastic waste amendment, this includes specific types of plastic waste, although exempting a range of plastic waste destined for recycling.

Key measures to reduce releases of this category of microplastics is reducing the overall generation of plastic waste through reducing consumption, increasing circularity and enhancing waste management systems. If not reused or recycled, the waste should be managed properly, in sanitary landfills, controlling potential fires and leakage. These measures will not prevent the break-down of plastics and generation of microplastics, however, it may prevent leakage to the surrounding environment.

The plastic waste that is captured for reuse or recycling may, as described in Chapter 4.3, also be a significant source of microplastic release throughout the entire processing phase, from sorting to pellet production, storage and transport. For inclusion in the treaty, we argue that it would be sensible to distinguish between the recycling process up to production of pellets, since they represent different routes of leakage. Hence, we have included the generation of microplastics during recycling, from collection of plastic to its transformation into pellets, as degradation-based secondary microplastics. Whereas the remaining fate of pellets are dealt with under the "plastic pellets, flakes and powders" category. It should be emphasised that the borders are blurry. Informal enterprises making pellets may

334. Yang et al. 2021

also make plastic products. For degradation-based microplastics generated during mechanical plastic recycling, various measures developed under other chemical MEAs would be relevant: BAT/BEP for recycling facilities, including identification of worst practices, requirements for wastewater treatment, physical requirements for plant operation and leakage prevention, air filter technologies, occupational health protective gear, safe reuse of surplus material, closed system operation modality, etc.

Chapter 6. Progress: Potential measures and supporting mechanisms

As all macroplastics could release microplastics, but not all microplastics stem from macroplastics, microplastics will have to be specifically addressed under a global agreement on plastic pollution. As the INC elaborates on the scope and content of an agreement, ensuring that microplastics are comprehensively addressed in the treaty will be crucial to achieve the ambition to *end* plastic pollution.

6.1 Considerations for incorporation of microplastics into the global treaty

In identifying measures to address microplastics under a global agreement there are several considerations that need to be taken:

- **Trade-offs of measures:** Eliminating all sources of microplastics would be neither desirable nor feasible in the short term, due to the value and benefits plastics provide to society and limitations to viable alternatives. As the treaty defines measures specifically addressing microplastics, it is critical to prioritise the measures that have proportional benefits and trade-offs across environmental, social and economic dimensions when considering the full lifecycle of products, technologies and non-plastic alternatives.
- **Varying national capacities:** In a proliferation of environmental policies, regulations and management practices, a treaty will need to fit varying national capacities to implement measures. Various flexibility measures in the treaty text, such as stepwise approaches, time-limited exemptions, options of measures, financial support etc. have in other treaties proven useful to that end, increasing participation and capability without jeopardising the overall objective.
- **Monitoring data:** There is a considerable lack of microplastic monitoring data and capacity in developing countries, and a majority of the existing knowledge is based on studies conducted in Europe and North America. There is a need to promote capacity, infrastructure, technological know-how and financial

incentives for strengthening monitoring and risk assessment efforts on microplastics in developing countries. Such efforts must be coordinated closely with the parallel process of establishing a science-policy panel on chemicals, waste and pollution.

- **Scales of sources:** The contribution of different sources of microplastics pollution vary between countries, and while some countries will predominantly produce degradation-based secondary microplastics from plastics waste in the environment, other countries release much higher rates of use-phase secondary microplastics from tyres and road wear and synthetic textiles. A global agreement will need to capture this diversity of and be adaptive to future changes in source profiles triggered by economic development, scientific advances and technological advances.
- **Substitutability:** Microplastics and their uses for which alternatives exist, or where the elimination of use would not cause undue burdens, should be prioritised for more stringent measures such as bans and phase-outs. Lifecycle analyses should be considered in comparing original use and alternatives.
- **Risk of harm and risk of leakage:** Measures should prioritise microplastics and sources that are at greater risk of leaking into the environment or where the particles may have a higher likelihood of causing negative effects to biota, humans or ecosystems.
- **The precautionary principle:** While the complexity of microplastics means that there are uncertainties and knowledge gaps with regards to their risks and impacts, there is sufficient scientific evidence on the ubiquitousness, persistence, accumulation and potential risk of harm (to environment and organisms) of microplastics to necessitate action.

6.2 Potential measures and supporting mechanisms

With the above considerations in mind, provisions addressing the following could be included under a treaty to address microplastics:

6.2.1 General provisions

Scope

- The instrument should have a broad scope covering microplastics and nanoplastics that are intentionally added to plastic materials and products, as well as unintentionally released microplastics, including plastic pellets, flakes and powders used as raw materials in plastic production.

Objectives and preamble

- The objective of the treaty should include language on achieving reductions in the generation and release of microplastics to the environment, and to prevent harm to human and environmental health.
- The overarching objective could be supplemented by sub-objectives and targets. These could be quantitative or qualitative and should in all cases be possible to follow up.

Definitions

- Microplastics should be defined under the treaty in a manner which enables the diversity of microplastics to be captured.
- A definition should ensure that key sources of microplastics such as plastic pellets, flakes and powders; polymeric coatings; microbeads; synthetic microfibres; paints; degradation of macroplastics; rubber infill materials, tyre and road wear particles, etc. are included under a treaty and addressed by its relevant measures.
- A definition should therefore have inclusion criteria to ensure all categories of microplastics are covered.
- While plastic pellets, flakes and powders are commonly considered microplastics, these materials may exceed commonly used size boundaries. To avoid microplastic regulations inadvertently leading to a shift towards larger sizes to avoid regulation, measures on plastic pellets, powders and flakes should be considered microplastics even if exceeding the common size boundary of 5 mm.
- A definition should not have a lower size bound in order to allow the instrument to adapt to future development of methods for sampling and analysis. Today particles below 0.1 μm are difficult to identify and quantify using available analytical methods. Such small particles may be subject to measures, when technically feasible, as the instrument strengthens over time.
- A potential definition could be formulated as:
  Particles with synthetic polymers (including biodegradable and water-soluble polymers) that are either contained within or building a continuous surface coating on the particles, where:
  i. all dimensions of the particles are equal to or less than 5 mm; *OR*
  ii. *the particles have a length of 0.3 μm ≤ x ≤ 15 mm and length to diameter ratio of >3; OR*
  iii. *the particles are plastic pellets, flakes and powders used to produce plastic products.*

Excluding polymers that occur naturally and are not chemically modified substances.

6.2.2 The design of operational provisions

- Measures under the provisions addressing microplastics should differentiate between categories of microplastics as these differ with regards to routes of leakage and control measures. The categorisations should include:
  i. Plastic pellets, flakes and powders,
  ii. Intentionally added microplastics,
  iii. Use-phase secondary microplastics
  iv. Degradation-based microplastics.
- Operational provisions to address microplastic pollution should strive to adhere to the waste hierarchy, prioritising upstream reduction, alongside the principles of prevention, precaution and polluter pays.
- Data gaps around dominant sources of microplastics in many parts of the world necessitate a start-then-strengthen approach. Sources for which measures are readily available to eliminate, mitigate or remediate, should be included in the first iteration of the treaty. Provisions should be formulated sufficiently

adaptive to allow the addition of new control measures as new sources and pathways are identified.

- The dominant sources of microplastic pollution differ according to the economies, climates, biodiversity, and social structures. In countries with poor or non-existent waste management systems, degradation-based secondary microplastics are likely to constitute the largest proportion of microplastic pollution. Measures to address microplastics should reflect this but must be coupled with international obligations to phase out problematic uses and processes contributing to point sources of microplastic pollution.
- In cases of substitution, alternatives should be assessed through holistic life cycle approaches that balances benefits and trade-offs between the three dimensions of sustainability: economic, social and environmental.

6.2.3 Operational provisions

Plastic pellets, flakes and powders can be regulated through global measures across the value chain to prevent losses.

- The agreement should include requirements for the reporting on production, composition and trade of plastic pellets, flakes and powders.
- A global agreement should set requirements for the safe production, transport, handling and storage of plastic pellets, flakes and powders, including measures addressing the chemical content of these materials.
- The delegates of the INC could consider restrictions on trade of pellets, flakes and powders, which could be supported by Harmonized System codes.
- A global agreement could include commitments to prevent and cooperate in response to acute plastic pollution events such as accidental spills of plastic pellets, and hold polluters responsible for mitigation, remediation and compensation for any pollution events.
- Best practices could be operationalised through global certification schemes building on, but not limited to, the industry initiative OCS and OSPAR Recommendation 2021/06 across the supply chain.
- Enforcement of effective product stewardship could be ensured through requiring producers and brand owners of plastic products to prove chain of custody through certified supply chains to gain access to markets.

Intentionally added primary microplastics can be addressed through an essential use approach.

- A dedicated ad-hoc expert group should be established to identify key global sources of intentionally added primary microplastics; develop criteria for restrictions; and create a list of essential and non-essential uses of these microplastics to be provided to the INC. The INC may subsequently decide on whether to opt for a positive or a negative list approach. The expert group could also identify where alternative materials, designs and models need to be developed.
- All non-essential intentionally added primary microplastics should be phased

out with timebound targets, compliance and enforcement measures, and subjected to trade restrictions on exports and imports.
- Essential intentionally added primary microplastics should be managed through restrictions on use, emissions regulations, guidelines, the development of BAT/BEP and reporting requirements.

Use-phase secondary microplastics could be addressed through measures addressing reduction, product design, use and maintenance.

- An agreement should include commitments to develop global product standards or design criteria for dominant sources, hotspots and pathways of use-phase secondary microplastics with minimum requirements which must be met to prevent releases from abrasion and other forms of fragmentation.
- An ad-hoc expert group should be formed to assess key sources, pathways and fates of use-phase secondary microplastics, availability of alternatives, and needs for BAT/BEP guidelines to be reported to the INC.
- An agreement should include measures to establish legal limits, labelling requirements, certification schemes, standardisation efforts alongside BAT/BEP and process standards to further mitigate emissions from key sources of use-phase secondary microplastics.
- Measures should allow for sufficient flexibility for Parties to design incentives, economic tools and regulatory requirements to reduce dominant sources in their jurisdictions.

Degradation-based secondary microplastics

- An agreement must include measures to reduce secondary microplastic emissions from macroplastics, including measures to prevent and reduce production of unnecessary and problematic plastic products; improve durability for safe reuse, recycling, repair and remanufacture and improved plastics waste management for all sectors, including the informal sector.
- An agreement should include dedicated measures to prevent microplastics pollution from the repurposing, reuse and recycling of plastics.

6.2.4 Other components

Microplastic pollution differs from macroplastic pollution in many ways. Throughout the INC process, specific considerations related to microplastics pollution will need to be incorporated. This includes the design of national action plans, establishing source inventories, efforts under scientific and technical cooperation and coordination, capacity building and technical and financial support for monitoring and reporting, especially for less developed countries.

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Annex 1. UNEA Resolution 5/14 paragraphs 3 and 4

The United Nations Environment Assembly [...]

3. *Decides* that the intergovernmental negotiating committee is to develop an international legally binding instrument on plastic pollution, including in the marine environment, henceforth referred to as "the instrument", which could include both binding and voluntary approaches, based on a comprehensive approach that addresses the full life cycle of plastic, taking into account, among other things, the principles of the Rio Declaration on Environment and Development, as well as national circumstances and capabilities, and including provisions:

a. To specify the objectives of the instrument;
b. To promote sustainable production and consumption of plastics through, among other things, product design and environmentally sound waste management, including through resource efficiency and circular economy approaches;
c. To promote national and international cooperative measures to reduce plastic pollution in the marine environment, including existing plastic pollution;
d. To develop, implement and update national action plans reflecting country-driven approaches to contribute to the objectives of the instrument;
e. To promote national action plans to work towards the prevention, reduction and elimination of plastic pollution, and to support regional and international cooperation;
f. To specify national reporting, as appropriate;
g. To periodically assess the progress of implementation of the instrument;
h. To periodically assess the effectiveness of the instrument in achieving its objectives;
i. To provide scientific and socioeconomic assessments related to plastic pollution;
j. To increase knowledge through awareness-raising, education and the exchange of information;
k. To promote cooperation and coordination with relevant regional and international conventions, instruments and organizations, while recognizing their respective mandates, avoiding duplication and promoting complementarity of action;
l. To encourage action by all stakeholders, including the private sector, and to promote cooperation at the local, national, regional and global levels;
m. To initiate a multi-stakeholder action agenda;
n. To specify arrangements for capacity-building and technical assistance, technology transfer on mutually agreed terms, and financial assistance, recognizing that the effective implementation of some legal obligations under the instrument will depend on the availability of capacity-building and adequate financial and technical assistance;
o. To promote research into and development of sustainable, affordable, innovative and cost-efficient approaches;
p. To address compliance;

4. *Also decides* that the intergovernmental negotiating committee, in its deliberations on the instrument, is to consider the following:

a. Obligations, measures and voluntary approaches in supporting the achievement of the objectives of the instrument;
b. The need for a financial mechanism to support the implementation of the instrument, including the option of a dedicated multilateral fund;
c. Flexibility that some provisions could allow countries discretion in the implementation of their commitments, taking into account their national circumstances;
d. The best available science, traditional knowledge, knowledge of indigenous peoples and local knowledge systems;
e. Lessons learned and best practices, including those from informal and cooperative settings;
f. The possibility of a mechanism to provide policy-relevant scientific and socioeconomic information and assessment related to plastic pollution;
g. Efficient organization and streamlined secretariat arrangements;
h. Any other aspects that the intergovernmental negotiating committee may consider relevant;

Annex 2. Guiding Questions

- Why should a new global agreement address microplastics?
- What possible commitments or measures on primary and secondary microplastics could be included in a new global agreement
- Are there any specific issues that need to be handled to pave the way for addressing microplastics in a global agreement?
- What effective measures on primary and secondary microplastics have been put in place by countries and regions that could be of relevance in a new agreement? This includes all sort of measures and incentives ranging from regulatory measures, voluntary measures, educational etc.
- What experiences and lessons learnt from other multilateral environmental agreements in the chemicals and waste cluster could be relevant for addressing microplastics? We suggest looking into bans, listings as used in other multilateral environmental agreements.
- What supporting mechanisms in a global agreement could be particularly relevant for addressing microplastics?
- How can business and industry engage in addressing microplastics in a new global agreement?
- Are there differences in measures needed to address different sources of microplastics?
- Are there monitoring and reporting obligations that could be particularly relevant for microplastics?

Annex 3. Excerpt from the EU Zero Pollution Action Plan

Target 5: By 2030 the EU should reduce by 50% plastic litter at sea and by 30% micro-plastics released into the environment

Basis: Directive on the reduction of the impact of certain plastic products on the environment (EU) 2019/904 ('Single Use Plastics Directive') and Marine Strategy Framework Directive 2008/56/EC, Chemicals' legislation (REACH)

Description:

Plastic litter at sea: Reaching the target of 50% reduction by 2030 would include consumption changes triggered by the sound implementation of existing (mainly the Waste Framework Directive) and new (mainly the Single Use Plastic Directive) EU law. Monitoring beach litter quantities, as required by the Marine Strategy Framework Directive, will be used as a proxy to track progress. Hence, this target will be achieved through the combination of the measures foreseen to reduce plastics use and waste and to foster a cleaner and more circular economy.

Microplastics: According to a 2018 Commission study, a 30% reduction by 2035 of micro-plastic emissions onto surface waters is feasible, provided that a combination of measures to tackle them from pellets, tyres and textiles is implemented. Moreover, the European Chemicals Agency (ECHA) analysed that, if appropriate prevention measures under the REACH Regulation are applied to the use of micro-plastics intentionally put in products (e.g. cosmetics, detergents), a 60% reduction in micro-plastic emissions over the next 20 years is feasible too. Thus, a 30% reduction by 2030 is proposed as a realistic ambition, mainly achievable through a sound implementation of the 2020 Circular Economy Action Plan.

Reference year: 2016

Evidence base: Impact Assessment for the Proposal of (now) Directive (EU) 2019/904 (plastic litter) and reports from the European Chemicals Agency (microplastics) as well as underpinning studies for the impact assessment for the Single Use Plastics Directive

Monitoring: The Marine Strategy Framework Directive (MSFD) requires regular monitoring of beach litter quantities by the Member States. On this basis the "EU Marine Beach Litter Baselines" was produced. MSFD monitoring (supported by EMODNET) will be included in the Zero Pollution Monitoring and Outlook Framework.

Annex 4. National and Subnational Microplastic Policies and Measures related to the control of microplastics

Country	Year	Policy name	Category	Target	Description	Reference
Argentina	2020	Law 27602	Regulation	Microbeads	Prohibiting of the production, import and marketing of cosmetic products and oral hygiene products for dental use that contain intentionally added plastic microbeads	https://www.argentina.gob.ar/normativa/nacional/ley-27602-345720
Australia	2021	National Plastic Plan 2021	Action Plan	Microbeads; Microfibres	Voluntary, industry-led phase-out of microbeads in rinse-off personal care, cosmetic and cleaning products sold in Australia. The Australian Government will work with industry to phase in microfibre filters on all washing machines sold in Australia by 2030	https://www.agriculture.gov.au/sites/default/files/documents/national-plastics-plan-2021.pdf
Bangladesh	2019	Standard specification for face wash	Standard	Microbeads	Bangladesh Standards and Testing Institution (BSTI) published a standard specification for face wash which includes specific requirements that plastic microbeads should be absent in any facewash in Bangladesh.	https://www.bstibds.com/bookre/book_rewrite/23978f72a5aabd893146152ea6b9039ff91a0fc36bb26c27f915b7dc33b362b19ded91fb699755ee1f98bf2efe464a12eb9395b5781b80f39dafbfe7ed8eeea2IBuaDpWp7DKAvR2J-WQUTyHhWfzFAOc5ae2oQoE7mUxo4e0NI-4XOoaeZumgV4c2lZEWFmSwkMAuaKitP0SHHg~~
Canada	2017	Microbeads in Toiletries Regulations (SOR/2017-111)	Regulation	Microbeads	The regulation prohibits the manufacture, import, and sale of toiletries used to exfoliate or cleanse that contain plastic microbeads, including non-prescription drugs and natural health products, starting January 1, 2018 with a complete ban as of July 2019.	https://nicholasinstitute.duke.edu/plastics-policies/microbeads-toiletries-regulations-sor2017-111
Canada	2022	Environmental Protection Amendment Act (Microfiber Filters for Washing Machines), 2022.	Regulation	Microfibres	The Bill amends the Environmental Protection Act to prohibit the sale or offering for sale of washing machines that are not equipped with a specified microfiber filter and to provide for corresponding penalties in case of non-compliance with the requirement.	https://www.ola.org/en/legislative-business/bills/parliament-42/session-2/bill-102
Canada (Ontario)	2015	Bill 75 Microbead Elimination and Monitoring Act (2015)	Regulation	Microbeads	Prohibits individuals to manufacture microbeads or add microbeads to cosmetics, soaps or similar products.	https://www.ola.org/en/legislative-business/bills/parliament-41/session-1/bill-75
China	2020	Opinions on Further Strengthening the Control of Plastic Pollution	Regulation	Microbeads	Prohibit the production of daily chemical products containing microbeads by the end of 2020 and in cleaning products by the end of 2022.	https://www.ndrc.gov.cn/xxgk/zcfb/tz/202001/t20200119_1219275.html?code=&state=123
China	2021	14th Five Year Plan Plastic Pollution Control Action Plan	Action plan	Microbeads; Research; Monitoring; Recycling; Waste management	Measures on source reduction of plastic pollution (including ban on microbeads), research on monitoring, prevention and control of microplastics in rivers, lakes and seas. General downstream measures on recycling and waste management.	https://www.mee.gov.cn/xxgk2018/xxgk/xxgk10/202109/t20210916_945621.html
China	2022	Notice on Solidly	Policy	Microbeads	Lays out responsibilities for ensuring	https://www.mee.gov.cn/xxgk2

		Promoting Plastic Pollution Control			compliance to microbead bans.	018/xxgk/xxgk10/202007/t20200717_789638.html
China (Taiwan)	2017	Restrictions on the Manufacture, Import, and Sale of Personal Care and Cosmetics Products Containing Plastic Microbeads	Regulation	Microbeads	Ban on import, manufacture and sale of microbeads in rinse-off cosmetics	https://nicholasinstitute.duke.edu/plastics-policies/restrictions-manufacture-import-and-sale-personal-care-and-cosmetics-products
Finland	2019	A Plastics Roadmap for Finland	Action plan	General	Action plan laying out broad measures to address plastic pollution, including specific measures to address key sources of microplastics. Measures include: - The main sources of microplastics in agriculture and horticulture are identified and measures are sought to reduce these by over 50 per cent. - A set of research projects is launched and international research cooperation on the harmful impacts of plastic, in particular microplastics, is strengthened. In targeting research, the focus is on the sources of microplastics, exposure to microplastics, permanence and degradability of microplastics in nature, added and accumulated harmful substances, environmental and health impacts and, if necessary, socio-economic perspectives. - Solutions are developed for recovering microplastics in stormwater and wastewater as well as for utilising slurry that contains microplastics.	https://muovitiekartta.fi/userassets/uploads/2019/03/Reduce-and-refuse-recycle-and-replace.-A-Plastics-Roadmap-for-Finland.pdf
Finland	2022	A Plastics Roadmap for Finland 2.0	Action plan	General	Updated action plan. Measures include: - Identify and adopt measures for reducing microplastic emissions (for example, textiles) - Determine the worst sources of microplastics in agriculture and horticulture and find solutions for their mitigation by 2023. - Identify approaches to reducing the emissions and harmful impacts of microplastics and increase research on them	https://muovitiekartta.fi/userassets/uploads/2022/06/Muovitiekartta-2.0-EN.pdf
Finland	2022	Programme of Measures of the Finnish Marine Strategy 2022–2027	Action plan	General	The programme of measures to achieve the commitments under the MSFD includes measures to achieve the target of reduced microplastic loads, through targeting shipping, marinas, road transport, agriculture, wastewater and urban drainage, and artificial grass – as well as measures on abandoned glass fibre boats, and marine pollution.	https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/163705/YM_2021_31.pdf?sequence=1&isAllowed=y
France	2016	Reclaiming Biodiversity, Nature and Landscapes Act No 2016-1087 of 8, Article 124, August 2016	Regulation	Microbeads	Bans the placing on market of rinse-off cosmetic products for exfoliation or cleaning purposes containing solid plastic particles from 2018	https://nicholasinstitute.duke.edu/plastics-policies/article-124-law-8-august-2016-reconquest-biodiversity-nature-and-landscapes
France	2020	Law No. 2020-105 of February 10, 2020 relating to the fight against waste and the circular economy	Regulation	Microfibres	Art. 79. In order to reduce the dispersion of plastic microfibers in the environment resulting from laundry washing, from 1 January 2025, new domestic or professional washing machines are fitted with a plastic microfiber filter or any other solution internal or external to the machine. A decree specifies the methods of application of this article. "The Government shall submit to Parliament, before December 31, 2022, a report describing, from the production of the fabric to the	https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000043956924

					washing of the linen, the knowledge of the sources of emissions, the constraints of the sectors and the voluntary measures taken to reduce the emissions of plastic microfibers.	
France	2022	Decree No. 2021-461 of 16 April 2021 on the prevention of losses of industrial plastic pellets into the environment	Regulation	Plastic pellets, flakes and powders	Provides that production, handling (industrial sites using plastic pellets in their production processes) and transport sites (logistics platforms, sea and river ports) of industrial plastic pellets are equipped with equipment and procedures to prevent the loss and leakage of industrial plastic pellets that represent a portion of the microplastics that may end up in the environment. It also provides for the implementation of regular inspections by independent certified bodies. This decree lays down the modalities for the implementation of this provision.	https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000043388114
Germany	2012	Programme of Measures for the MSFD	Policy	Microbeads; Education;	Voluntary commitment to avoid the use of microbeads in cosmetics and cleaning products (incl. blasting media)	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/4494_N_2012_Programme_of_Measures.pdf
Germany	2018	Ban of microplastics in soaps, creams, toothpastes.	Regulation	Microbeads	On January 1, 2020, the ban on microplastics came into force. The law prohibits "placing on the market rinse off cosmetic products with an exfoliating or cleansing action containing microplastics". The penalties range from fines to the stop of production.	https://g20mpl.org/wp-content/uploads/2022/08/G20MPL-report-2022_2nd-edition_1108.pdf
Ireland	2019	Microbeads (Prohibition) Act 2019	Regulation	Microbeads	Ban on production and sale of rinse-off cosmetics and household and cleaning products with plastic microbeads	https://www.irishstatutebook.ie/eli/2019/act/52/enacted/en/print
Italy	2018	General Budget Law 2018: Law no. 205 of 27, Art.1, Sections 543 to 548, December 2017	Regulation	Microbeads	Ban on the production and marketing of rinse-off cosmetics products (including soaps, creams and toothpastes) containing microplastics	http://www.normattiva.it/eli/id/2017/12/29/17G00222/CONSOLIDATED/20221222
Italy	2021	Updated Programme of measures according to Article 13 of the MSFD:	Action Plan	Wastewater; Polystyrene	Study, design and creation of a supply chain for fish boxes to facilitate the transition from the use of disposable polystyrene boxes to washable and reusable ones; Design and testing of experimental prototypes for the removal of microplastics by wastewater treatment plants.	https://g20mpl.org/wp-content/uploads/2022/08/G20MPL-report-2022_2nd-edition_1108.pdf
Malaysia	2021	National Marine Litter Policy and Action Plan 2021–2030	Action plan	Research; Monitoring; Microbeads	Include measures on research of microplastic impacts, new solutions, standards and awareness raising. Measure include: -By 2026: explore safety mandatory standards for controlling adverse impacts of microplastics on the marine ecosystem and human health concerns - Enhance research/study on marine litter, including plastic and microplastics - Prevent use of microbeads-based products on plastic free islands - By 2028: Ban most common or damaging types of plastic marine litter for example microbeads, fish-egg-sized nurdles.	https://www.kasa.gov.my/resources/alam-sekitar/national-marine-litter-policy
Mexico City (Mexico)		Mexico City Solid Waste Law	Regulation	Microbeads	Mexico City prohibits the commercialization, distribution and delivery of products that contain intentionally added microplastics (Solid Waste Law), however its application and verification has not been defined.	https://g20mpl.org/wp-content/uploads/2022/08/G20MPL-report-2022_2nd-edition_1108.pdf
New	2017	Waste Minimisation	Regulation	Microbeads	Ban on import, manufacture and sale of wash-	https://nicholasinstitute.duke.e

Zealand		(Microbeads) Regulations 2017, under section 23(1)(b) of the Waste Minimisation Act 2008.			off products containing microbeads for the following purposes: (i) exfoliation of all or part of a person's body: (ii) cleaning of all or part of a person's body: (iii) abrasive cleaning of any area, surface, or thing: (iv) visual appearance of the product; but (b) does not include a medical device or medicine.	du/plastics-policies/waste-minimisation-microbeads-regulations-2017
Norway	2020	Norwegian Plastics Strategy	Strategy	General	Overarching strategy for Norway, including measures to: - implement the new requirements for artificial turf pitches in the pollution regulation - contribute to and regulate the use of intentionally added microplastics in various products in accordance with forthcoming EU/EEA regulations - take an active role in contributing to knowledge, in addition to being a driving force in the EU's work on new measures against secondary microplastics - further cooperation on measures to reduce the emissions of plastic pellets under the 2021–2024 initiative, "The Nordic Countries as a driving force in the work against marine litter and plastic pollution" - work to ensure that a global agreement on plastic litter and pollution also addresses the spreading of microplastics - assess the need for regulating maintenance operations which can result in microplastic pollution in marinas, slips and storage places for maintenance of recreational crafts - consider relevant measures nationally and internationally to adhere to OSPAR guidelines against plastic pellets discharge. - work to reduce gaps in knowledge by increasing and sharing knowledge regarding the sources, pathways and impacts of microplastics both nationally and globally - establish requirements, supervision, and guidance for enterprises causing microplastics emissions	https://www.regjeringen.no/contentassets/ccb7238072134e74a23c9eb3d2f4908a/en/pdf/norwegian-plastics-strategy.pdf
Norway	2021	Chapter 23A of the Regulations relating to pollution control	Regulation	Rubber infill	In March 2021, the Norwegian Government established requirements for the design and operation of sports pitches that use loose microplastic as infill materials. These regulations entered into force on 1 July 2021.	https://www.miljodirektoratet.no/ansvarsomrader/avfall/avfallstyper/gummigranulat-fra-kunstgressbaner/
Peru	2019	Law N°30884 "Law that Regulates Single-Use Plastic and Disposable Containers or Containers"	Regulation	Polystyrene; Oxo-degradable plastics	The Law, and all other legislation prohibit single-use plastic items including plastic bags, plastic straws, and plastic and expanded polystyrene food and drink containers, and those that contain additives that cause contamination by microplastics or hazardous substances and are not recyclable.	https://g20mpl.org/wp-content/uploads/2022/08/G20MPL-report-2022_2nd-edition_1108.pdf
South Korea	2017	Regulations on safety standards for cosmetics [Annex 1] {No. 2017-114, Notice, Article 3, Dec. 29, 2017	Regulation	Microbeads	Ban on sale all cosmetic products containing microplastics under 5mm.	https://g20mpl.org/partners/republicofkorea
South Korea	2021	Regulation on use of micro-bead	Regulation	Microbeads	Ban the use of microbeads in all cleansing agents, detergents and removers manufactured in and outside of South Korea.	https://g20mpl.org/partners/republicofkorea
Spain	2022	Law 7/2022, of April 8,	Regulation	Microbeads;	The introduction on the market of the following	https://www.boe.es/buscar/ac

		on waste and contaminated soil for a circular economy.		Oxo-degradable plastics	products is prohibited: a) Plastic products mentioned in section B of Annex IV. b) Any plastic product manufactured with oxodegradable plastic. c) Intentionally added plastic microspheres less than 5 millimeters. In relation to the restriction provided for in section c), the provisions of Annex XVII of Regulation (EC) No. 1907/2006 of the European Parliament and of the Council of December 18 (REACH Regulation) will apply.	t.php?id=BOE-A-2022-5809
Sweden	2018	Regulation (2018: 496) on state subsidies to reduce emissions of microplastics to the aquatic environment.	Regulation	General	Public support for 1. investments in technology or in other measures aimed at a) clean surface water from the micro plastics and other impurities, or b) otherwise reduce proliferation of micro plastics and other contaminants via surface water, and 2. feasibility studies and other preparatory measures for such investments.	http://www.fao.org/faolex/results/details/en/c/LEX-FAOC187073
Sweden	2018	Prohibition in Certain Cases in Connection with the Handling, Import and Export of Chemical Products Ordinance (1998:944),	Regulation	Microbeads; Oxo-degradable plastics	4 § Ban on import and manufacture of microbeads in rinse-off cosmetics in 2018 and sale of microbeads in rinse-off cosmetics in 2019, as well as ban on oxo-degradable plastics in 2021.	http://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-1998944-om-forbud-mm-i-vissa-fall_sfs-1998-944
Thailand	2020	Plastic Management Plan B.E. 2561-2573	Regulation	Microbeads	Ban on the use of plastic microbeads in the import, production and sale of cosmetics	https://g20mpl.org/partners/thailand
The Netherlands	2018	Dutch Policy Programme on Microplastics	Strategy	General	The programme focuses on: Banning deliberate additions of microplastics in products at the European level; Tackling the emissions of microplastics as a consequence of the breakdown of plastic litter; Cutting down on emissions of microplastics as the result of wear and tear on products such as car tyres, paint and clothing; Getting a better understanding of the effects of microplastics in the human body.	https://www.tweedekamer.nl/downloads/document?id=2021D25682
United Kingdom (England)	2017	The Environmental Protection (Microbeads) (England) Regulations 2017	Regulation	Microbeads	Ban on the manufacture and supply of rinse-off personal care products containing microbeads.	https://nicholasinstitute.duke.edu/plastics-policies/environmental-protection-microbeads-england-regulations-2017
United Kingdom (Scotland)	2018	The Environmental Protection (Microbeads) (Scotland) Regulations 2018	Regulation	Microbeads	Ban on the manufacture and supply of rinse-off personal care products containing microbeads.	https://nicholasinstitute.duke.edu/plastics-policies/environmental-protection-microbeads-scotland-regulations-2018
United Kingdom (Wales)	2018	Environmental Protection (Microbeads) (Wales) Regulations 2018 (S.I. No. 760 (W. 151) of 2018).	Regulation	Microbeads	Ban on the manufacture and supply of rinse-off personal care products containing microbeads.	https://nicholasinstitute.duke.edu/plastics-policies/environmental-protection-microbeads-wales-regulations-2018-si-no-760-w-151-2018
USA	2015	Microbead-Free Waters Act	Regulation	Microbeads	Prohibition against sale or distribution of rinse-off cosmetics containing plastic microbeads. Banned the manufacturing of such products from July 2017, and delivery across states by 2018, with a year delay for non-prescription drugs.	https://www.congress.gov/114/plaws/publ114/PLAW-114publ114.pdf
USA	2021	Save our Seas 2.0 Act	Regulation	Microfibres; Wastewater	Enables US Environment Protection Agency to provide grants for improvements to reduce	https://www.congress.gov/bill/116th-congress/senate-bill/198

					pollution from (amongst others) microfibres and microplastics in drinking water and from wastewater treatment.	2/text
USA (California)	2018	SB 1422: California Safe Drinking Water Act	Policy	General	Decision to define microplastics in drinking water, start a monitoring project, and provide information to constituents.	https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=116376.&lawCode=HSC
USA (California)	2018	SB 1263: Microplastic Materials	Policy	General	Decision and description of how to develop a statewide microplastics strategy.	https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1263
USA (California)	2018	California Ocean Litter Prevention Strategy	Strategy	General	OPC Goal 2 – Microplastics and Microfibers: Increase understanding of the scale and impact of microplastics and microfibers on the marine environment and develop solutions to address them. Priority objective: Advance research on the extent and impact of microplastics and microfibers in source waters and the ocean, assist in the development of technological solutions to reduce their prevalence in aquatic environments. Objective 4.1 Conduct a comprehensive characterization of microplastics and macro-debris Objective 4.2. Quantify microplastics pathways within watersheds and develop technological solutions	http://www.opc.ca.gov/webmaster/_media_library/2018/06/2018_CA_OceanLitterStrategy.pdf
USA (California)	2022	Statewide Microplastics Strategy	Strategy	General	Two-pronged approach: one track addressing "no-regrets" solutions that can be implemented and one track addressing research and monitoring.	https://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20220223/Item_6_Exhibit_A_Statewide_Microplastics_Strategy.pdf

Annex 5. Extracts of UNEA Resolutions relating to microplastics

UNEA 1/6. Marine plastic debris and microplastics

5. Also recognizes the need for more knowledge and research on the source and fate of microplastics and their impact on biodiversity, marine ecosystems and human health, noting recent knowledge that such particles can be ingested by biota and could be transferred to higher levels in the marine food chain, causing adverse effects;

6. Notes that microplastics may also contribute to the transfer in the marine ecosystems of persistent organic pollutants, other persistent, bioaccumulative and toxic substances and other contaminants which are in or adhere to the particles;

7. Recognizes that microplastics in the marine environment originate from a wide range of sources, including the breakdown of plastic debris in the oceans, industrial emissions and sewage and runoff from the use of products containing microplastics;

14. Requests the Executive Director, in consultation with other relevant institutions and stakeholders, to undertake a study on marine plastic debris and marine microplastics, building on existing work and taking into account the most up-to-date studies and data, focusing on:

a. Identification of the key sources of marine plastic debris and microplastics;
b. Identification of possible measures and best available techniques and environmental practices to prevent the accumulation and minimize the level of microplastics in the marine environment;
c. Recommendations for the most urgent actions;
d. Specification of areas especially in need of more research, including key impacts on the environment and on human health;
e. Any other relevant priority areas identified in the assessment of the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection;

17. Also encourages Governments to take comprehensive action to address the marine plastic debris and microplastic issue through, where appropriate, legislation, enforcement of international agreements, provision of adequate reception facilities for ship-generated wastes, improvement of waste management practices and support for beach clean-up activities, as well as information, education and public awareness programmes;

20. Requests the Executive Director to present the study on microplastics for the consideration of the United Nations Environment Assembly at its second session.

UNEA 2/11. Marine plastic litter and microplastics

17. Acknowledges the findings of the 2016 study of the United Nations Environment Programme on marine plastic debris and microplastics on the most important global sources of and possible measures for avoiding microplastics entering the marine environment, and recognizes that Governments need to further identify the most significant sources, as well as important and cost-effective preventive measures at the national and regional levels; invites Governments to undertake such prioritized measures nationally and through regional and international cooperation and in cooperation with industry, as appropriate, and to share their experiences; and urges the phasing out of the use of primary microplastic particles in products, including, wherever possible, products such as personal care products, industrial abrasives and printing products, and their replacement with organic or mineral non-hazardous compounds;

18. Encourages product manufacturers and others to consider the life cycle environmental impacts of products containing microbeads and compostable polymers, including possible downstream impacts that may compromise the recycling of plastic waste; to eliminate or reduce the use of primary microplastic particles in products, including, wherever possible, products such as personal care products, industrial abrasives and printing products; to ensure that any replacement products are environmentally sound; and to cooperate in the environmentally sound management of such plastic waste;

19. Also encourages the establishment of harmonized international definitions and terminology concerning the size of, and compatible standards and methods for the monitoring and assessment of, marine plastic debris and microplastics, as well as the establishment of and cooperation on cost-effective monitoring, building as far as possible on ongoing related monitoring programmes and considering alternative automated and remote sensing technology where possible and relevant;

20. Underlines that, while research already undertaken provides sufficient evidence of the need for immediate action, more research is needed on marine plastic debris and microplastics, including associated chemicals, and especially on environmental and social impacts – including on human health – and on pathways, fluxes and fate, including fragmentation and degradation rates, in all marine compartments and especially in water bodies and sediment deposits of the coastal and open ocean, as well as on impacts on fisheries, aquaculture and economy; and urges Governments at all levels and Member States in a position to do so to support such research;

UNEA 3/7. Marine litter and microplastics

1. Stresses the importance of long-term elimination of discharge of litter and microplastics to the oceans and of avoiding detriment to marine ecosystems and the human activities dependent on them from marine litter and microplastics;

3. Encourages all member States, based on best available knowledge of sources and levels of marine litter and microplastics in the environment, to prioritize policies and measures at the appropriate scale to avoid marine litter and microplastics from entering the marine environment;

4. Also encourages all member States and invites other actors, taking into account national conditions:

a. To fully implement the recommendations and actions set out in its resolutions 1/6 and 2/11, as relevant, and emphasizes that those resolutions have important elements and guidance that are not repeated in the present resolution;
b. To cooperate to establish common definitions and harmonized standards and methodologies for the measurement and monitoring of marine litter and microplastics;
c. To develop and implement action plans for preventing marine litter and the discharge of microplastics; encouraging resource efficiency, and increasing collection and recycling rates of plastic waste and re-design and re-use of products and materials; and avoiding the unnecessary use of plastic and plastic containing chemicals of particular concern where appropriate;
d. To include marine litter and microplastics in local, national and regional waste management plans and in wastewater treatment where appropriate;
e. To develop integrated and source-to-sea approaches to combat marine litter and microplastics from all sources, taking into account that plastic litter and microplastics are transported to the oceans from land-based sources by rivers and run-off or wind from land and that plastic litter is an important source of microplastics, and include the land/sea and freshwater/sea interface in action plans for preventing marine litter, including microplastics;
f. To step up measures to prevent marine litter and the discharge of microplastics from sea-based sources, such as fisheries, aquaculture, off-shore installations and shipping, including through the promotion of accessibility and use of port reception facilities;
g. To encourage the inclusion of measures to prevent marine litter and the discharge of microplastics, in particular from land-based sources, in plans to prevent and reduce damage from natural disasters and increasingly severe weather events;
h. To prioritize, where feasible, clean-up of the marine environment in areas where marine litter poses a significant threat to human health, biodiversity, wildlife and the coastal ecosystems, conducted in a cost-effective way;

UNEA 4/6. Marine plastic litter and microplastics

Noting that microplastics added to products or generated during their life cycle are found along the food chain and that there is therefore concern about their potential to negatively affect human health, including food safety, and that those aspects thus require further examination, [...]

1. Calls upon Member States and other actors at the local, national, regional and international levels, including in the private sector, civil society and academia, to address the problem of marine litter and microplastics, prioritizing a whole-life-cycle approach and resource efficiency, building on existing initiatives and instruments, and supported by and grounded in science, international cooperation and multi-stakeholder engagement;

4. Recalls its resolution 2/11 on marine plastic litter and microplastics and invites Member States, in close collaboration with the private sector, to:

a. Reduce the discharge of microplastics into the marine environment, including, where possible, through the phasing out of products that contain microplastics;
b. Foster innovation in product design to reduce secondary microplastics release from land- and sea-based sources and improve waste management where needed;
c. Prevent losses of primary microplastics, in particular pre-production pellets (flakes and powders), to prevent spillage into the environment across the whole manufacturing and supply chain;

Annex 6. ECHA Summary of uses and technical functions of microplastics in consumer and professional products

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Product group	Brief details of use and technical function(s)
Cosmetic products	Microplastics are used in cosmetic products to provide a variety of functions, e.g., exfoliating/cleansing functions, opacity control, smooth and silky feeling in products and an illuminating effect on the skin. They can be used in lipstick, loose or pressed powders and liquid or thick emulsions with powdery feel. Microplastics may also be used as a carrier for other ingredients.
Detergents and maintenance products	Microplastics are used in detergents and maintenance products (waxes, polishes and air care products27) to provide a range of functions, including as abrasives, fragrance encapsulations, opacifying agents and anti-foam agents. They can be used e.g. in surface cleaning products, fabric softeners, dishwashing liquids, waxes, polishes and air care products.
Agricultural and horticulture	Microplastics are used in controlled-release formulations (CRF) for fertilisers and plant protection products (typically as microencapsulation), as fertiliser additives (e.g. anti-caking agents) and as soil conditioners. Similar to microencapsulation, seed coating involves the deposition of polymeric material on seeds such that coated seeds may be considered microplastic particles as they fall below the upper size limit of 5 mm.
Granular infill material for synthetic sports surfaces	Microplastics are a key component of the latest generation of synthetic sports fields where they are used as infill material. They are polymeric granules usually produced from end-of-life (ELT) tyres or other synthetic elastomers.
in vitro diagnostic devices	In vitro diagnostic devices (IVDs) are non-invasive tests performed on biological samples (for example blood, urine or tissues). They can be used for human health applications (including medical devices IVDs covered by (EU) 2017/746 (aka IVDR)), but not only: IVDs are also used in research and development (various fields), and in veterinary and pest control applications. Microplastics, often with inorganic (e.g. iron oxide) cores and chemically functionalised surfaces, are ubiquitous as reagents, assays or calibration in IVDs and are essential in all automated IVD tests conducted worldwide. There is no overarching EU Regulation to regulate all types of IVDs. Therefore, in case a legal definition of IVDs would be needed, the Dossier Submitter proposes to define 'In vitro diagnostic devices' as 'reagent, reagent product, calibrator, control material, kit, instrument, apparatus, piece of equipment, whether used alone or in combination, intended by the manufacturer to be used in vitro for the examination of specimens, including blood and tissue donations, derived from living organisms', which is adapted from the IVD MD definition set in EU Regulation (EU) 2017/746 (aka IVDR).
Medical devices	Microplastics have various functions in medical devices (MD). Microplastics in medical devices are used as polymeric filters, adsorber and absorber granulates and in ultrasound devices. Microplastics are also frequently used in the manufacturing of IVD reagents and devices (e.g. chromatography columns used to purify antibodies). They are also present in (substance-based) medical devices used by healthcare professionals and consumers to prevent or treat oral, nasal, skin or eye conditions (e.g. toothpaste, denture adhesives, sun protection28 etc). In (substance-based) medical devices, microplastics have similar functions to those reported for cosmetic products: i.e. gel forming agent, emulsifiers, film-forming, thickening agent. Medical devices are regulated by EU Regulation (EU) 2017/745.
Medicinal products for human and veterinary use	In medicinal products, microplastics are the backbone of many 'controlled-release' medicines: in contrast to immediate release (to the stomach), these formulations can deliver drugs with a delay after administration (delayed release), or for a prolonged period of time (extended release), or to a specific target organ in the body (targeted release). Controlled-release mechanisms allow the active substance to be protected from the physiological environment (e.g. enzymes, pH), to control its release at a specific predetermined rate in specific location/organ. In addition, microplastics can be used for their taste masking, film coating, binding, filling and disintegrant function. In medicinal products, microplastics are often classified as excipients, but they can also be used as an active pharmaceutical ingredient (API).

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Food additives	Similarly to the medicinal products use, microplastics are used as authorised food additives in the formulation of food supplements (e.g. vitamins) and 'food for special medical purposes' as film-coating, 'controlled-release' agent, and to 'mask/disguise' unpleasant tastes. Microplastics can also have binding, filling or disintegrant functions.
Paints, inks and other coatings	Microplastics are an integral part of polymer dispersion binders in water-based paints and coatings, where they are present to coalescence into films (film-forming function). Microplastics are also used as speciality additives in architectural and industrial coatings (wood, plastic, metal). Microplastic additives enhance properties like matting, abrasion resistance, scratch resistance, mark resistance and side sheen control. In addition, they are used to add texture and structure to surfaces. Microplastics are also used in combination with metallic pigments to achieve a sparkle effect by controlling pigment orientation.
Oil and gas	Microplastics are used as additives in drilling and production chemicals (lubricants, friction reducing agents, antifoam agents, demulsifiers).
Plastics	Microplastics are used as speciality additives in thermoplastic masterbatches and engineered materials as light diffusion agents, anti 'blocking' agents and to introduce surface structure. Pre-production plastic (resin) pellets (also sometimes referred to as 'nurdles') that are used as raw materials in extrusion / moulding processes in article production, by nature of their size, are also microplastics.
Technical ceramics	Microplastics are used as a pore forming additive to achieve the correct size and number of pores in porous ceramics. According to industry stakeholders these materials are combusted as part of the production process.
Media for abrasive blasting	Plastic granules are used to remove difficult contaminants e.g. paint, plastics, rubber and adhesive from plastic tools and dies etc. The underlying surface is normally not affected by the blasting as the different plastic materials are somewhat softer than those made of minerals or metal. The material of the granules varies depending on the wanted features; they may consist of poly methyl metacrylic polymer, melamine, urea formaldehyde, urea amino polymers or poly amino nylon type. The granulate size typically ranges from 0.15–2.5 mm with a relative density of > 1 000 kg/m3, indicating that particles would not float.
Adhesives	Intentionally added microplastics can be used as spacers in adhesives and metallic plated microplastic particles can be used in conductive adhesives in electronics.
3D printing	Polymeric materials are used in Fused Deposition Modelling (FDM) printers for consumers. These printers are smaller than industrial ones and can be bought by private consumers to print smaller objects.
Toners and printing inks	The toner in laser printing is typically made of granulated plastic to make the powder electrostatic. Some printing inks contain microplastics.
Substance of mixture used as toys or for arts and crafts	Microplastics are reported to be used in toys or for arts and crafts. For example, glitters, certain sequins (that are not articles) and modelling clays.
Bulk IER for water purification	Professional and consumer uses reported where the IER (Ion Exchange Resins) would be placed on the market in bulk and would not be contained in a closed cartridge or envelop.
Substance or mixture used for glass sheet transportation	Used between panes of sheet glass for protection during transportation.

About this publication

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