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Addressing the challenge of Marine Plastic Litter using Circular Economy methods

Relevant considerations

INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

Disclaimer

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Pictures

Executive summary

Plastics are versatile materials, being inexpensive, light, easily shaped and durable and have brought immeasurable benefits to many areas of life. They are used in numerous industrial sectors, including packaging, health care, construction, automotive, aviation, agriculture, logistics and storage, consumer goods, clothing and many more. Primarily made from fossil-fuels, plastic materials are valuable and embody our world's limited natural material resources (in addition to oil, a lot of energy, mostly of the non-renewable kind, and water) and come with sunk investment costs that may be reused to create fresh economic value.

Plastics production and waste generation

In 2015, global production of primary, or virgin, plastics was 407 million metric tons (Mt) and expected to double by 2030 and to double again by 2050, excluding bio-based plastics production that was approximately 1% of total annual production of fossil fuel-based plastics.

In 2015, 302 Mt of plastic waste was generated, amounting to 74% of the total primary plastics production in the same year, including secondary (recycled) plastics. In the same year, plastic waste generated as a proportion of plastics produced for use in sectors such as plastic packaging, plastic consumer and institutional goods, and synthetic textiles were 97%, 88%, and 71%, respectively.

As of 2015, approximately 6,300 Mt stock of plastic waste had been generated, around 9% of which had been recycled, 12% was incinerated, and 79% was accumulated in landfills or the natural environment; a huge loss in economic terms and alarming with respect to potential harm that this could mean to humans, animals and plants and our ecosystems.

State of marine plastic litter in oceans

The global community, particularly G20 members have mobilized to put a stop to the global marine plastic litter challenge. This challenge comprises of an estimated stock of 83 Mt of plastic waste that has already accumulated in oceans and an estimated 8 Mt of additional, mismanaged plastic waste entering oceans annually, at least 80% of which originates directly from land-based sources. In 2017, the G20 Leaders' Summit in Hamburg agreed on a G20 Action Plan on Marine Litter and discussions continued at the G20 2018 in Argentina. The Japan Presidency for G20 2019 has prioritized the global marine litter challenge and aims for an implementation framework for concerted action.

There is hardly any global, regional, national report and research study on marine plastic litter that does not point out the role of plastic packaging, single-use or short-lived and fast-moving consumer products, personal care products containing microbeads, synthetic clothing and microfibers, and fishing gear lost at sea.

Circular economy practices for addressing the marine plastic litter challenge

The problem of marine plastic litter can be addressed inter alia through implementing circular economy practices. This, in conjunction with optimizing landfill management, will help to substantially reduce the amount of those plastics most likely to end up as marine plastic litter. Together with measures to tighten the management of marine based sources of marine litter, and with clean-up operations where feasible, increased plastic pollution of oceans may be stemmed and eventually prevented.

In the ***product design stage***, the following might be considered: a) scrutinizing the necessity of packaging altogether, including of plastics, b) selection of renewable, bio-degradable and compostable materials and additives that are not or less toxic for essential plastic packaging or single-use plastic products; c) designing for less material use to decrease waste; d) designing packaging and products that use a single or small number of polymers that are easy to separate during recycling.

Policy measures to incentivize circular economy practices in design could consist of supporting implementation of innovations in design of existing and new products, and support to innovations and start-ups in particular related to new, biodegradable and compostable plastics. A number of initiatives could trigger both supply side motivation for circular product designs and preference for such products on the demand side, such as; measures for creating markets for recycled plastics and improving markets for bio-based plastics; differentiated taxes on virgin and recycled plastics; introduction of standards for recycled content; improving information on recycled content in products in combination with educational campaigns for consumers. Furthermore, support for development of effective infrastructure for collection and separation of waste streams and empowering local authorities with sufficient financial and technical resources could induce product designs for ease of recyclability.

In the ***production stage***, strengthening management of plastic raw materials to eliminate material losses into wastewater streams, and improving resource productivity of manufacturing by implementing resource efficient cleaner production methods could prevent leakages of plastic raw materials and industrial plastic waste into the environment. In the ***service sectors***, tourism and retail businesses and industrial laundries may be encouraged to implement circular economy practices to: replace single use packaging with durable and reusable packaging; substitute materials for packaging with renewable ones; implement new business models that eliminate the need for packaging and single-use plastic products; and reduce and eliminate shedding of microfibers and microbeads into waste and waste water management systems. Policy responses supporting the above measures could go a long way by extending their adoption by enterprises from micro to large; these could include the development of information and knowledge platforms on good practices and emerging regulatory requirements and support programmes for their implementation.

In the ***use stage***, suppliers as well as customers should be led towards choices supporting circular economy practices, in particular opting out of single-use plastic products, and supporting waste management systems that can collect, sort, separate and effectively recycle plastics. This can be achieved through means such as the enforcement of bans for some and levies for other plastic products, enforcement and fees in cases of non-compliance, and deposit return schemes for reducing single-use or short-lived plastic product use.

Furthermore, consumers could be encouraged to shift to business models based on product-as-service or sharing to extend lifetime of plastic products consumed; and to reject products containing microbeads or that shed microfibers; also, retrofits to e.g. household washer/driers could filter out microbeads/microfibers. Bulk consumers could deploy their purchasing power along circular use patterns. Policies facilitating the proposed changes should be complemented by consumer education that starts at early ages for a future without plastic litter.

At the ***end of the first life***, products should have various directions to follow before becoming waste: reuse with or without repairs or refurbishment, recycling for secondary materials either for the same type of use; up-cycled to higher value uses or down-cycled to an alternative use. In a circular economy, options are or should be the same for plastic packaging and short-lived, fast moving plastic product.

Consequently, plastic waste of short-lived products, including packaging should find their way into effective waste management and recycling systems. It should be an aim to make recycling of plastics competitive to the tipping fees for landfilling; these fees are frequently considered to currently not reflect all externalities. It also appears meaningful to provide support for innovation towards technology improvements in mechanical and, in particular, chemical recycling to help production of recyclates of high quality for new products.

Extending and further developing producer responsibility schemes supports both greener product designs for recyclability, as well as collection and consolidation of waste streams for recycling operations. Easily understandable labelling schemes can help consumers to participate effectively in waste management. Regulating use of certain, in particular the hazardous materials in products have also brought about many effective outcomes.

Support for international cooperation within the G20 and, beyond, with relevant developing countries will allow to share best practices on successes recorded by G20 members. This might include but should not be limited to: transfer of recycling technologies and knowledge sharing; technical assistance for integration of informal sector waste operators into waste management systems; and capacity building in developing countries on circular economy practices. Finally, seeking and supporting innovations for measures to clean-up plastics from shores and water columns and open oceans would need to continue, in particular where economically feasible (ocean surface, coasts, ports, …).

With today's technologies, it is almost impossible not to have a waste fraction that requires ***final disposal***, including for short-lived, fast moving plastic products and packaging. Options would be safe landfilling or elimination, particularly of hazardous material containing plastic fractions under controlled incineration conditions. An additional option might be to encapsulate residual plastics in other materials, such as in paving mixes in road construction, as long as it could be ascertained that leakage of plastic particulate matter and some of the hazardous additives they contain into the environment is assured.

In ***summary***, designing out waste to retain plastics within the economy; regaining the value embodied in plastics that leaked out of the economy as waste; and continuing efforts for recovering plastics already in oceans, in particular in services, on beaches, ports and coastal waters emerge as strategies worthwhile to consider on the way to a circular plastics economy and an end to the global marine plastic litter challenge.

In this working paper

This Executive Summary (Chapter 1) precedes a short background on the interest of G20 in the marine plastic litter given in the Introduction (Chapter 2), which is followed by a discussion on the application of Circular Economy practices to the short-lived, fast moving plastic products and packaging (Chapter 3). In Chapter 4, the state of plastics today is reviewed. Chapter 5 scopes the scale of the marine plastic litter challenge and briefly describes how plastics move from the economy to the environment. Chapter 6, the by far largest chapter, discusses how circular economy practices could be applied through the product design, production, use, end-of-first-life and disposal stages to short-lived and fast-moving plastic products and packaging and offers some policy responses based on experiences of G20 members. Chapter 7 contains a summary of strategies proposed and some final thoughts on how loops could be closed in a circular plastics economy.

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2 Introduction

Annually, 8 million tons of plastic waste enter the oceans. As of 2015, it is estimated that of the huge stocks of plastic waste already generated, about 9% had been recycled, 12% was incinerated, and 79% was accumulated in landfills or the natural environment.

Marine plastic litter is recognized as a challenge that has to be tackled holistically along the plastics value chain at the global, regional and national levels. In 2017, António Guterres, the UN Secretary General called for concerted and concrete action:

"Now we need concrete steps, from expanding marine protected areas, to the management of fisheries; from reducing pollution, to cleaning up plastic waste. I call for a step change, from local and national initiatives to an urgent, coordinated international effort." Guterres said.[1]

The 'Our Ocean, Our Future: Call for Action'[2] declaration of the 2017 UN Ocean Conference stated commitments of all member states of the United Nations to address marine plastic pollution through individual and collective measures ranging from investments in infrastructure to protection regimes for the coastal areas, from education to support of research and development. The member states, foundations, research organizations, NGOs, international organizations made 300 commitments in addition to their commitments along a number of international and regional conventions that support actions against marine plastic pollution (Annex C).

In 2017, at the G20 Meeting in Hamburg, the G20 representatives recognized "the urgent need for action to prevent and reduce marine litter in order to preserve human health and marine and coastal ecosystems and mitigate marine litter's economic costs and impacts" (G20 Action Plan on Marine Litter 2017). The action is a significant move as it aims at collective initiatives to prevent and reduce marine litter. G20 discussions in Argentina in 2018 emphasized critical importance of stakeholder engagement and effective exchange of information and good practices among G20 member states.

1 Opening address at the UN Ocean Conference, New York 2017

2 https://oceanconference.un.org/callforaction

Another environmental topic with a recent strong history in particular in the G20 has been resource efficiency. All G7 economies and some other G20 members, notably China, Republic of Korea and South Africa, have been improving resource efficiency; implementing 3R (reduce, reuse, recycle) and Circular Economy (CE) policies and programmes. On the other hand, there are other G20 members who are in the initial stages of considering and/or deploying similar measures.

Resource efficiency and Circular Economy policies and practices aim at "doing more and better with less", encouraging higher resource (materials, water and energy) productivity. These systematic shifts generate new and expanded business and economic opportunities and provide environmental and social benefits, such as social equity, resource security, pollution prevention and job creation. Marine plastic litter is a substantial resource inefficiency, and for reducing it at source, Circular Economy has been suggested to provide a suitable approach.

The G20 Summit in Osaka, to be held from June 28 to 29, has identified stemming the marine plastic litter challenge as one of its priorities with an ambition to move towards a coherent implementation framework. The implementation framework is expected to focus on periodic reporting, information sharing and promotion of good practices, innovation, scientific research and international cooperation through the involvement and awareness raising of a multitude of stakeholders at all levels and in coordination with relevant G20 initiatives.

The objective of this paper is to contribute to G20 experts' discussions on marine plastic litter, allowing to use circular economy concepts as well as work undertaken by the G20 on resource efficiency to provide useful pathways forward.

"Now we need concrete steps, from expanding marine protected areas, to the management of fisheries; from reducing pollution, to cleaning up plastic waste. I call for a step change, from local and national initiatives to an urgent, coordinated international effort."

UN Secretary-General António Guterres

3 Circular Economy

Circular economy is an economy that is restorative and regenerative by intention. It is a new way of creating value, through extending product lifetime and relocating waste from the end of the value chain to the beginning - in effect, using products and their resources more efficiently by using them more than once. Systemic innovation is at the core of circular economy practices.

Circular economy practices ensure products and resources (materials, water, energy, labor) in products are put to productive uses within the economy over and over again; the retained value in products and resources thereby continuing to create new business opportunities, income and jobs; many times and not only once as in a linear industrial system where products usually end up in landfills at the end of their first life.

Circular economy starts at product design by thinking in a forward looking way to understand how the product and its components and parts could be easily maintained, repaired, reused, remanufactured and recycled so that both the product and its materials have a longer and productive lifetime. Examples abound for large investment goods, such as a heavy mining excavator, which may weigh over 90,000 kg and have an engine of 525 HP. These excavators are designed so that its engine, cabin, electronics, hydraulics and its various other parts could be repaired and replaced easily during use. Once a part of the same excavator cannot be reused, for instance, its bucket, it can be shredded and melted down to recycle the steel to be reused in making parts for a new excavator or another steel product, saving inefficiencies and environmental externalities from mining and virgin steel. At the end of its first life, careful design of the excavator's engine - one of the most valuable of its components – allows for remanufacturing to a quality level of a new excavator's engine, and to start its second life in another excavator.

From design, production, and use to recycling and final disposal stages, new value is extracted from a product, its parts, components and its materials to repeatedly create new economic benefits, including through business models based on performance or functionality, e.g. by renting, leasing, and sharing. This is typical circular economy practice for products that last long; from durable consumer goods such as washing machines, furniture to high quality shoes that do not fall out of fashion very quickly or tear apart after a few uses, to industrial, agricultural, road, marine and air transport, electrical, electronic and healthcare equipment to buildings that we live and work in.

Plastics, on the other hand, are versatile materials, being inexpensive, light, easily shaped and durable which have brought immeasurable benefits to many areas of life. They are used in numerous industrial sectors, including packaging, health care, construction, automotive, aviation, agriculture, logistics and storage, consumer goods, clothing and many more. Primarily made from fossil-fuels, plastic materials are valuable and embody our world's limited natural resources (in addition to oil, a lot of energy, mostly of the non-renewable kind, and water) and come with sunk investment costs that may be reused to create fresh economic value.

Some plastic products such as those used in construction (e.g. PVC windows, doors and water pipes, outside paneling), automotive (e.g. many parts under the hood, bumpers outside and in the passenger cabin, including seat textiles), healthcare (plastic parts of magnetic resonance imaging devices-MRIs), consumer goods (e.g. plastic garden chairs and tables, plastic shelves in refrigerators, seats in office furniture) and many other plastic products are made to last.

With respect to circular economy practices, behavior of these long-lasting, durable plastic products and their parts and components are similar to the heavy excavator: they can be repaired, reused, repurposed and recycled depending on the type of plastic polymers in them.
Other plastics have a very short or shorter lifetimes and become plastic waste almost immediately in a linear economy. Examples of these are single use plastic packaging (e.g. plastic

Figure 1. Cycle of a Circular Economy
Source: UNIDO

beverage bottles, cling wrap, candy wrappers, fast-food, cleaning and personal care product containers); single use plastic products (e.g. cutlery, plates, shopping bags); or short-lived plastic consumer goods such as inexpensive clothing or trainers that go out of fashion and favor rapidly or fall apart quickly through normal wear and tear; or those plastic products that cannot stand up to the forces of nature long enough (e.g. fishing gear that gets lost in open seas such as plastic fishing nets, ropes, floats, oyster spacers, baskets, crates, traps).

Plastic waste of single use and short-lived products tends to leak into our freshwater bodies, riverine systems and find their way into our oceans as plastic pollution that is either visible on the surface, dispersed in the water column or ultimately settled on the seabed. They impact on marine life and ecosystems, causing harm to animals, marine plants and humans, and result in huge economic losses.

By adopting circular economy practices, we can start from product design and make systemic innovations so that short-lived plastic products and their materials are renewable, easily recyclable, non-toxic and more durable. Plastic waste and its leakage to the environment can be prevented in production, service delivery and during product use. By motivating consumers of plastics to understand the benefits of circular economy practices and incentivizing appropriate collection and sorting systems and technologies in recycling, we can extract most of the value in plastics, including the short-lived plastics that are the topic of the ensuing discussion in chapters that follow.

4 Plastics today

4.1 Plastics production and waste generation

Inexpensive, light, easily shaped and durable, plastic products brought immeasurable benefits to many areas of life and are used in numerous industrial sectors, including packaging, health care, construction, automotive, aviation, agriculture, logistics and storage, consumer goods, clothing and many more.

In 2015, global production of primary, or virgin, plastics (most commonly used resins and fibers) was 407[3] million metric tons (Mt) and expected to double by 2030 and to double again by 2050. This figure does not include bio-based plastics, for which total production was about 4 Mt in 2015, approximately 1% of total annual production of fossil fuel-based plastics.

In 2015, 302 Mt of plastic waste was generated[4], amounting to 74% of the total primary plastics production in the same year, including secondary (recycled) plastics, Figure 2.

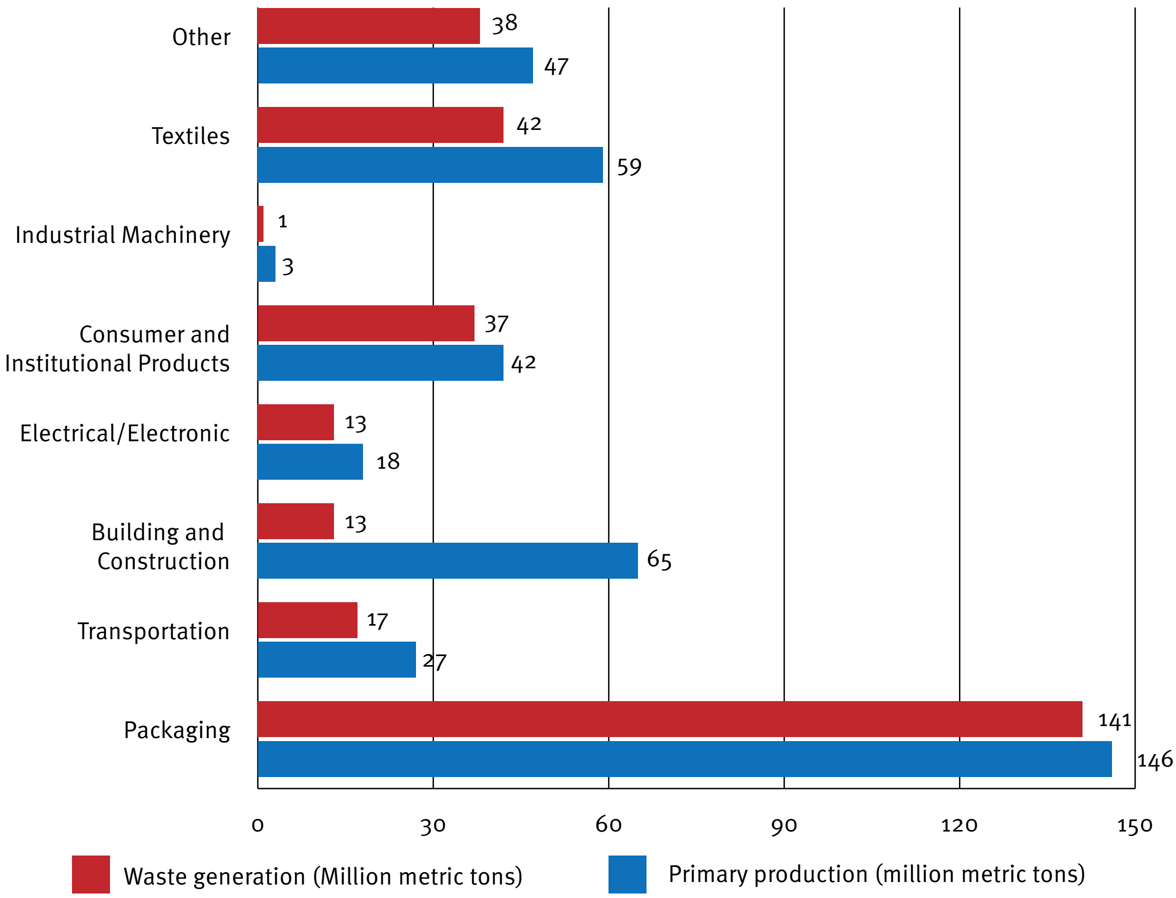

Figure 2. Primary plastics production and waste generated by use sector in million metric tons in 2015
Source: Geyer, et al, 2017.

Plastics production was globally dominated by four use sectors in 2015: packaging (146 Mt, 36%), building and construction (65 Mt, 16%), textiles (47 Mt, 14%) and consumer and institutional products (42 Mt, 10%). In waste generated as the proportion of annual production, packaging led use sectors with 97%, followed by 88% for consumer and institutional products. In total annual waste generated, packaging (47%), textiles (14%) and consumer and institutional products (12%) emerged as top contenders, Table 1.

3 Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), e1700782, 19 July. – http://advances.sciencemag.org/content/3/7/e1700782

4 Ibid.

Plastic use sector	Primary production (% of total)	Waste generation (% of production)	Waste generation (% of total waste)
Packaging	36%	97%	47%
Transportation	7%	63%	6%
Building and construction	16%	20%	4%
Electrical/Electronic products	4%	72%	4%
Consumer & institutional products	10%	88%	12%
Industrial machinery	1%	33%	0%
Textiles	14%	71%	14%
Other	12%	81%	13%

Table 1. Importance of plastics use sectors in production and waste generation, 2015
Source: Based on Geyer, et al, 2017.

As of 2015, approximately 6,300 Mt stock of plastic waste had been generated, around 9% of which had been recycled, 12% was incinerated, and 79% was accumulated in landfills or the natural environment.[5]

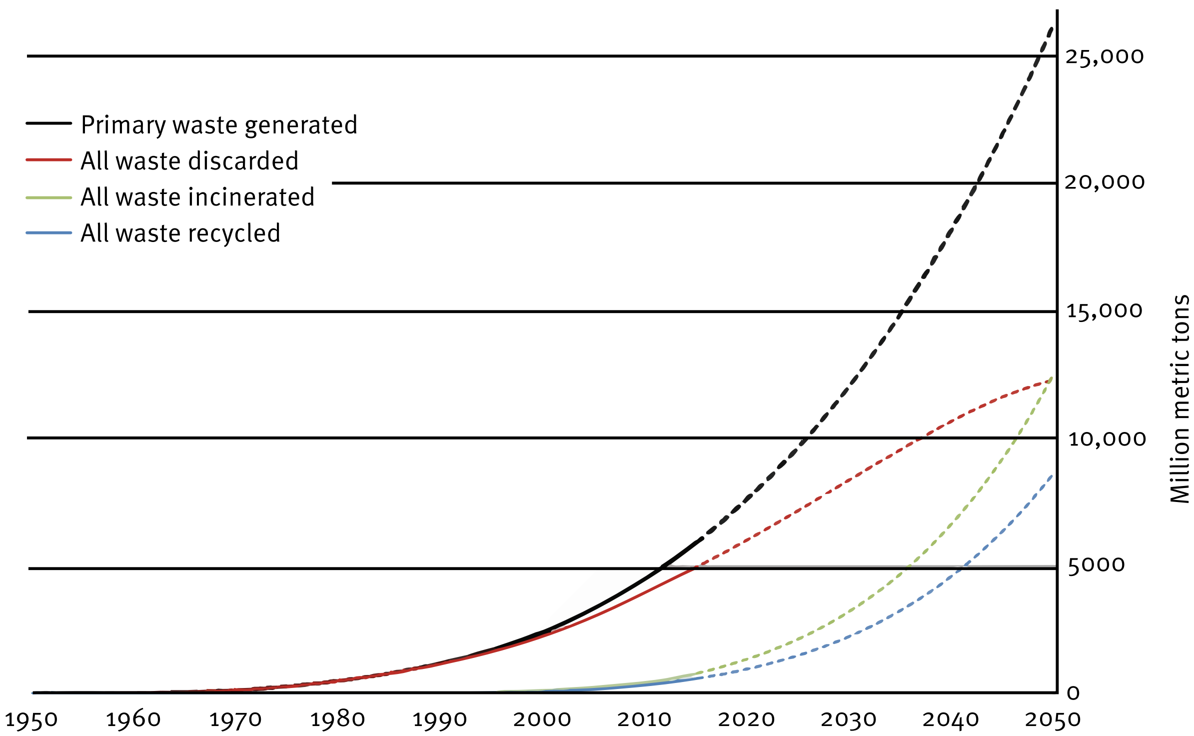

Figure 3. Cumulative plastic waste generation and disposal (in million metric tons, Mt)
Source: Geyer, et al, 2017

If current production and waste management trends continue, roughly 12,000 Mt of plastic waste will have been in landfills or in the natural environment by 2050[6] , Figure 3. Contrary to public perceptions, use of crude oil for petrochemicals and plastics is forecasted to overtake their use as fuel (IEA 2018)[7].

5 Ibid.
6 Ibid.
7 International Energy Agency (2018). The Future of Petrochemicals: Towards more sustainable plastics and fertilizers

4.2 Most commonly used polymers and additives in plastics

To meet the demands of various industrial sectors, a range of plastic polymers are produced. They can be classified according to application (commodity, engineering and specialty), chemical composition, and physical structure and manufacturing processes.

Most commonly used fossil-based plastics exist in two types—thermoplastics and thermosets. Thermoplastics may be mechanically recycled and remolded after heating, while thermosets must be chemically recycled, a more complex process.

Polyethylene (PE)[8] , a thermoplastic with approximately 110 Mt annual production is traditionally used for packaging such as plastic bags, films, containers, including bottles and in geomembranes.

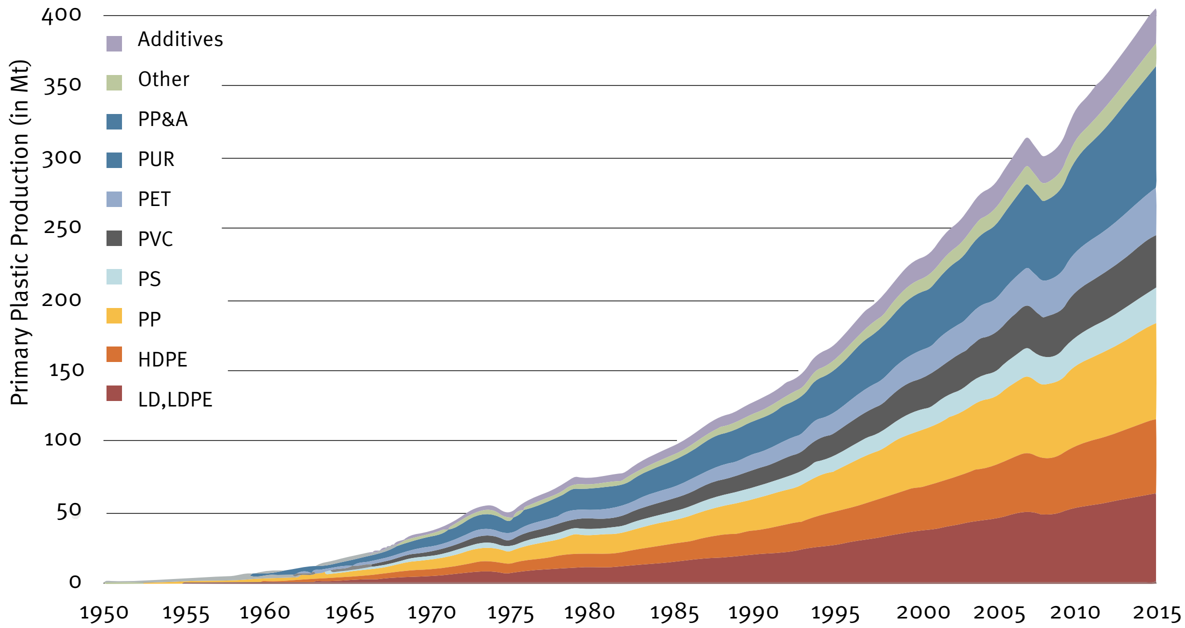

Figure 4. Global primary plastic production (in million metric tons) by polymer type, 2015
Source: Geyer, et all, 2017

Polypropylene (PP) has a broad spectrum of applications due to its resistance to high temperatures, corrosion and bacteria, and its tensile strength. PP is used in packaging, automotive, health care, fibers and fabrics (including ropes for marine applications), and in industrial products (e.g. chemical tanks, pipes, sheets, etc.)[9].

Polyethylene Terephthalate (PET) – commonly known as polyester – accounts for 18 percent of global polymer production (fourth most produced after PE, PP and PVC) and is used for production of bottles (about 30 percent) and synthetic fibers (over 60 percent) (Ji 2013).[10]

Polyvinylchloride (PVC), is applied predominantly in the building and construction sector (69% of all PVC), for instance in windows and doors, as well as in water pipes. However, PVC is also used in food packaging, in particular to ensure easy, gas tight packaging for fresh fruits, vegetables and meat and as industrial stretch film.

Polystyrene (PS) is commonly used for CD "jewel" boxes, disposable cutlery, in food packaging such as yogurt containers, lids, trays, bottles, and in foam form for disposable coffee cups, filling for packaging in blocks or beads, and as building insulation. It is not recycled, and usually not accepted in curbside recycling programs.

8 PE is further differentiated into Low-density Polyethylene (LDPE), High-density Polyethylene (HDPE) and Linear Low-density Polyethylene (LLDPE)

9 https://omnexus.specialchem.com/selection-guide/polypropylene-pp-plastic

10 L. N. Ji, "Study on Preparation Process and Properties of Polyethylene Terephthalate (PET)", Applied Mechanics and Materials, Vol. 312, pp. 406-410, 2013 - https://doi.org/10.4028/www.scientific.net/AMM.312.406

Plastic polymers may also be made from renewable materials that are usually plant based. Being made from renewable materials, replacing fossil fuel-based input, may bring environmental benefits, although they may or may not be suitable for home composting and may require industrial composting conditions (at higher temperatures). Conditions for bio-degradability and compostability are defined by many variables such as heat, moisture, duration as well as type of bio-polymer, thickness of finished product, etc.

Two common bio-polymers are polylactic acid (PLA) and polyhydroxyalkanoates or PHA. PLA is a bio-degradable and bioactive thermoplastic aliphatic polyester derived from renewable biomass, typically from fermented plant starch such as from corn, cassava, sugarcane or sugar beet pulp. PHAs are polyesters produced in nature by numerous microorganisms, including through bacterial fermentation of sugar or lipids. In the industrial production of PHA, the polyester is extracted and purified from the bacteria by optimizing the conditions of microbial fermentation of sugar or glucose.

Properties of plastic products are usually enhanced by a variety of additives to an average amount of 7% by weight. Additives come in about 18 functional groups. In each group are numerous substances, to be combined within and between different functional groups, which creates an immense variety of permutations. A number of the additives can have hazardous characteristics (Gallo et al., 2018)[11]. While the additives are typically selected in a way that their undesired characteristics are not relevant for the intended use phase, they can pose serious issues at the end of life. A number of additive groups, e.g. flame retardants, are already under severe regulatory pressure. The large variety of permutations and the difficulties of separation in mechanical processes pose a serious impediment to mechanical recycling (see below Section 6.4), which is, together with thermal recycling (use as fuel) the currently most prevalent form of plastic recycling.

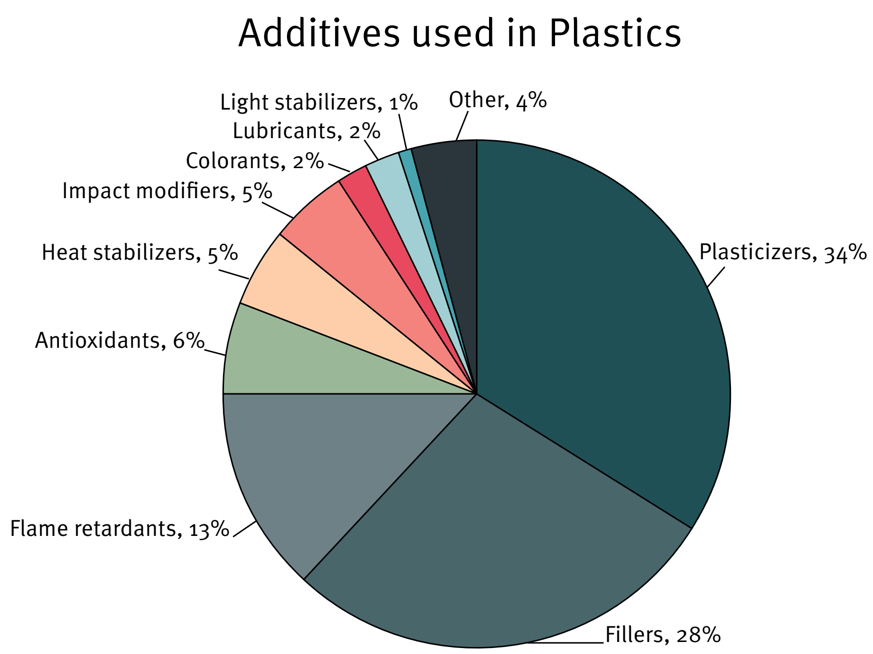

Figure 5. Commonly used additives in plastics, by function
Source: Geyer, et al. 2017

Hazardous additives in plastic packaging may range from heavy metals, to bisphenols, phthalates and two per-and polyfluoroalkyl substances (PFAS).

11 Gallo F, Fossi C, Weber R, Santillo D, Sousa J, Ingram I, Nadal A, Romano D. (2018) Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. Environ Sci Eur. 2018;30(1):13

4.3 Some considerations on plastics applications

A very large application sector for plastics is packaging, with a share of almost 45%. At the same time, as will be shown in chapter 6 below, packaging is considered a very substantial contributor to the problem of marine plastic litter. It's clear from Table 2 that packaging products[12] may use PE in its various forms, PET, PP, PS, PVC, PUR and other polymers, which pose challenges in collection, separation and recycling of packaging waste.

Market Sector	*LDPE, LLDPE*	*HDPE*	*PP*	*PS*	*PVC*	*PET*	*PUR*	*Other*	***Total***
Transportation	0.1%	0.8%	2.6%	0.0%	0.3%	0.0%	1.6%	1.4%	**6.7%**
Packaging	13.5%	9.3%	8.2%	2.3%	0.9%	10.1%	0.2%	0.1%	**44.8%**
Building & Construction	1.1%	3.3%	1.2%	2.2%	8.1%	0.0%	2.4%	0.5%	**18.8%**
Electrical/Electronic	0.5%	0.2%	0.9%	0.6%	0.4%	0.0%	0.4%	1.0%	**3.8%**
Consumer & Inst Products	2.9%	1.7%	3.8%	1.8%	0.6%	0.0%	1.0%	0.2%	**11.9%**
Industrial Machinery	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.3%	0.0%	**0.8%**
Other	1.7%	0.9%	4.2%	0.7%	1.4%	0.0%	2.5%	1.7%	**13.2%**
Total	**20.0%**	**16.3%**	**21.0%**	**7.6%**	**11.8%**	**10.2%**	**8.2%**	**4.9%**	**100.0%**

Table 2. Polymers used by application sectors
Source: Based on Geyer, et al, 2017.

Packaging products – the largest consumer of plastics - are effective due to their low weight, high strength and durability and flexible nature. Yet, with their short lifespan, commonly ending after only a single use, they put pressure on collection, recovery and disposal systems. According to the Ellen MacArthur Foundation (2017)[13], at the global level, only about 14 percent of plastic packaging is recycled, resulting not only in considerable stress on the environment but also a US $80-100 billion loss to the economy.

Other products having longer lifespans, such as in particular textile products, cause significant microfiber pollution in their use stage due to friction as a result of normal wear and tear, and washing. A 5 kg load of woven polyester (PET) was shown to have shed 6,000,000 microfibers depending on the type of detergent (De Falco et al. 2017)[14]. In general, woven polyester (PET) textiles shed more microfibers compared knitted polyester products and woven polypropylene (PP) products when washed with powder detergents and at higher temperatures, higher water hardness and with mechanical washing, particularly in industrial washing. De Falco et al. 2017 further indicate that the size and number of microfibers generated from textile laundry could not be totally retained by wastewater treatment plants and may enter aquatic ecosystems.

To the degree this working paper focusses on marine plastic litter, it will avoid comparing or weighing different environmental objectives. However, it should be pointed out that the environmental objective of avoiding plastics might not necessarily support other environmental objectives, like the reduction of release of greenhouse gases. A case in point is the debate about the environmental benefits of the substitution of glass bottles by PET bottles. Independently of the merits of different calculations of greenhouse gas emissions related to either alternative, in case PET bottles would lead to lower greenhouse gas emissions, how would this impact on the discussion of PET bottles in the context of plastic litter? The obvious conflict between different environmental objectives, which is true for multiple issues raised in this working paper can neither be sufficiently investigated nor resolved within the scope of it.

12 Packaging is a business to business product.

13 Ellen MacArthur Foundation, 2017 at https://www.ellenmacarthurfoundation.org/assets/downloads/New-Plastics-Economy_Catalysing-Action_13-1-17.pdf (2017)

14 https://doi.org/10.1016/j.envpol.2017.10.057


Photo: Tony Webster

5 Marine plastic litter

5.1 Scale of the problem

Marine plastic pollution, commonly referred to as marine plastic litter, is a major global environmental problem of today, as recognized by the global community in recent years. Plastics that enter the marine environment are already harmful as debris; they further degrade under the influence of sunlight, mechanical stress, oxidation and biodegradation under the influence of micro-organisms (Gewert et al. 2015)[15]. This results in formation of smaller fragments. Such micro- and nanoplastics[16], which might also stem from land-based attrition of plastics during the use phase or from intentionally produced micro plastics, contaminate food chains and through release of harmful chemicals, are expected to negatively impact individual species and ecosystems for decades to come. Further, global production of plastics is expected to grow at rapid rates, and, pending successful mitigating activities, so will marine plastic litter.

Marine plastic litter harms marine species through ingestion and entanglement, violates the integrity of ecosystems, inhibits growth of marine plants, accumulates and transports pathogens that may cause disease and injuries to marine animals, plants and humans, and partly ends up in the food chain. Moreover, it causes economic losses due to reduced fishery yields, declining amenity for tourism, and damage to shipping and related infrastructure (particularly its moving parts).

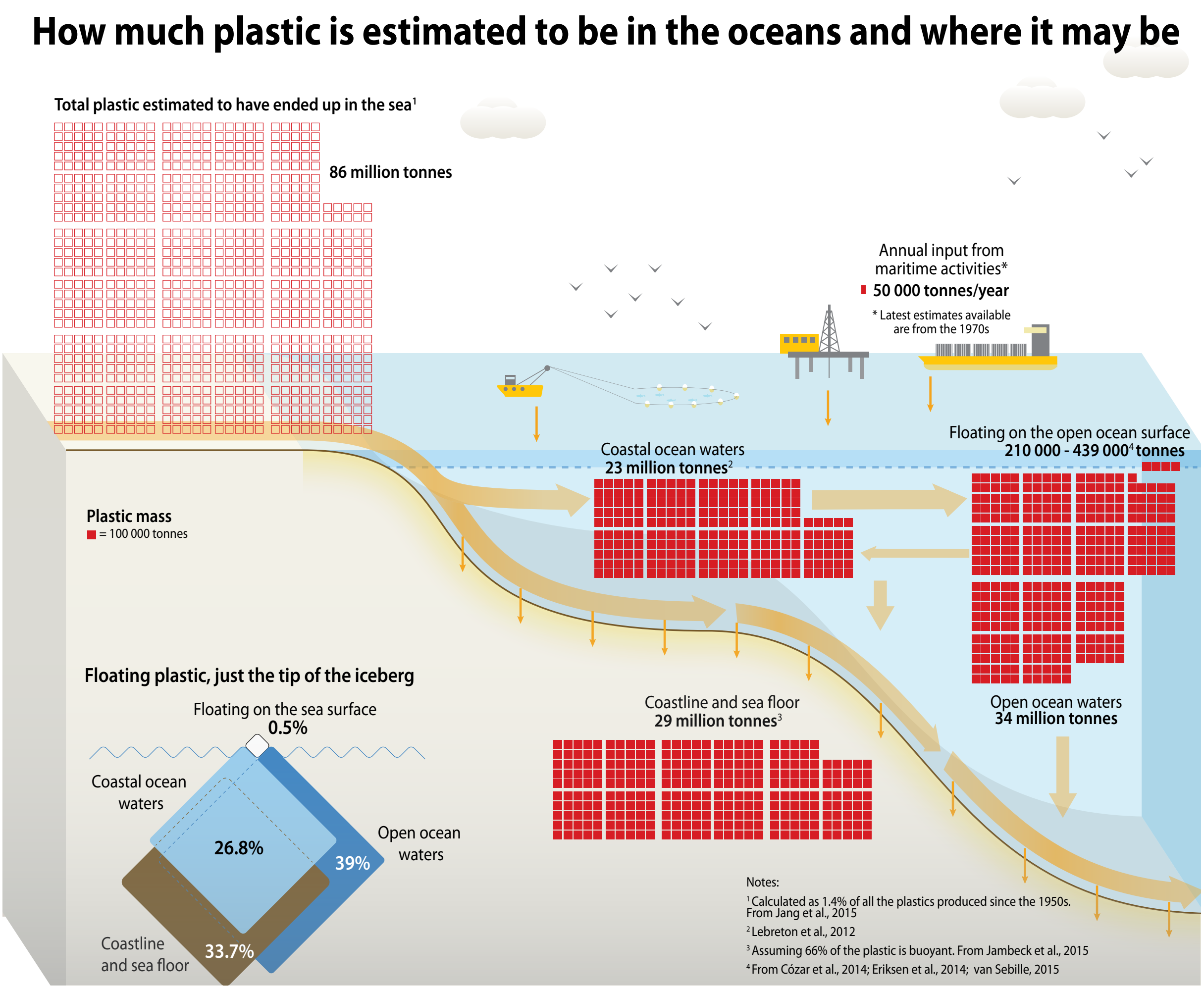

Figure 6. How much plastic is estimated to be in oceans and where it may be
Source: Marine litter vital graphics; downloaded on 24 March 2019 from http://www.grida.no/resources/6933

15 Environ Sci Process Impacts. 2015 Sep;17 (9):1513-21. doi: 10.1039/c5em00207a. Epub 2015 Jul 28. Pathways for degradation of plastic polymers floating in the marine environment. Gewert B1, Plassmann MM, MacLeod M.

16 Microplastics are particles with sizes between 1 nanometer and 5 millimeter according to GESAMP Joint Group of Experts.

Data shared by the Plastic and Ocean Platform[17] estimate that plastics represent 45 to 95 percent of the total marine litter. The estimates of the World Economic Forum (2016) indicate that more than 8 million metric tons of plastic waste annually enters oceans – this figure is expected to double by 2030 to 16 million tons and then again by 2050[18].

Jang, et al (2015) estimated that there are already 86 million metric tons of plastics in the sea[19]. Of this total, only 0.5% or 210,000 to 439,000 tons are estimated to float on the ocean surface and 23 million tons (26.8%) are in coastal ocean waters. Open oceans and coastal and sea floor are host to estimated 34 million tons and 29 million tons, respectively, see Figure 6.

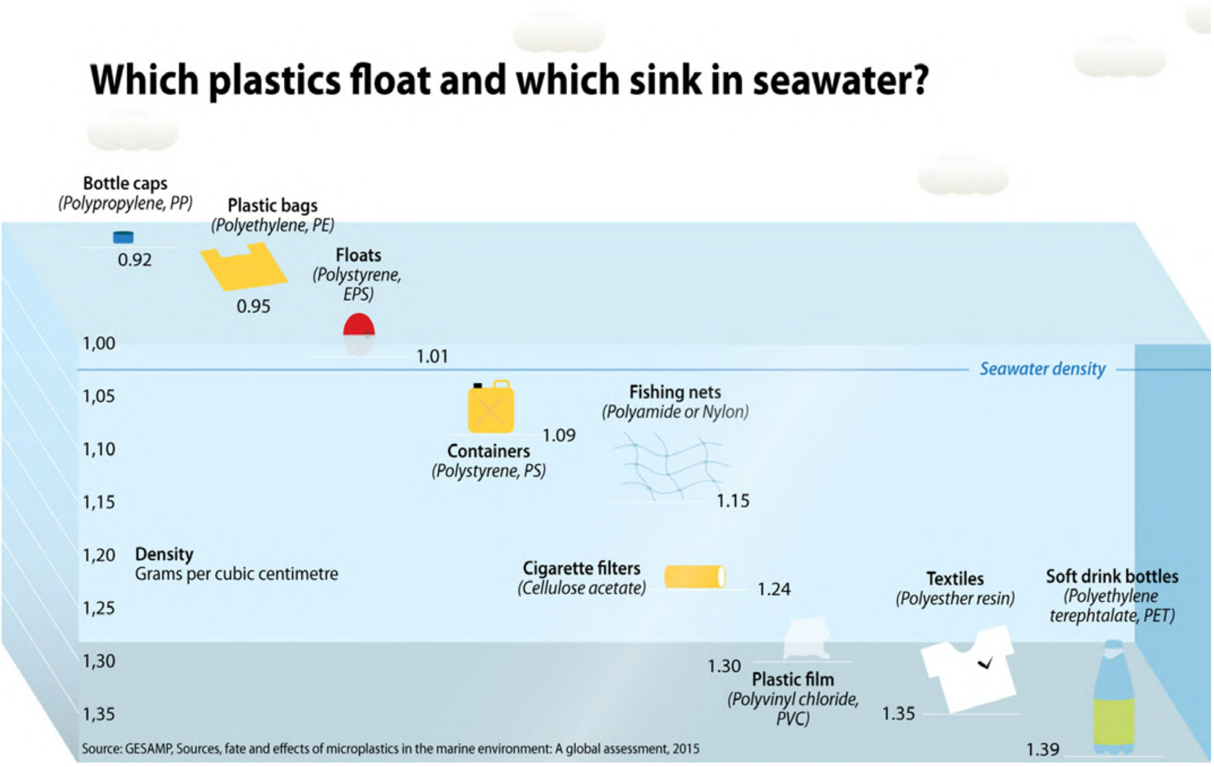

Figure 7. Plastics afloat in seawaters
Source: Marine litter vital graphics; downloaded on 24 March 2019 from http://www.grida.no/resources/6933

The distribution of plastic debris in oceans depends on their density in comparison to the density of sea water. Experts of the German Federal Environment Office (UBA)[20] estimate that 70 percent of the plastic sinks to the seabed, 15 percent of marine debris is washed on the beaches, and 15 percent is suspended in the water column. What is visible on the surface or in so-called garbage patches[21] in the North Atlantic, the South Atlantic, the North Pacific, the South Pacific, and the Indian Ocean mostly consist of plastics with a lower density than seawater, Figure 7, for instance, bottle caps, plastic bags and floats made of expanded polystyrene and possibly some containers kept afloat due to entanglement with lower density debris. However, below the surface and hence less visible the presence of substantial amounts of higher density plastics is assumed, such as plastic film, textiles, soft drink bottles and primary and secondary micro and nanoplastics. These are expected to form the vast majority of marine plastic litter.

17 https://thecamp.fr/sites/contenthub/files/documents/plastic_pollution_in_ocean_POP_scientific_summary.pdf
18 New Plastics Economy: Rethinking the future of plastics, World Economic Forum, 2016
19 http://dx.doi.org/10.7846/JKOSMEE.2015.18.4.263
20 https://www.helmholtz.de/en/earth_and_environment/the-plastic-plague
21 5 Gyres Institute - https://www.5gyres.org

5.2 How do plastics move from the economy to the environment?

Ocean plastic pollution results from both marine and land-based sources, with an estimated 80 percent or more of it coming from land.

Marine-based plastic pollution comes from fisheries, aquaculture, nautical activities and, at times, illegal dumping. Fishing gear - nets, lines, ropes, floats, oyster spacers, baskets, crates, traps – estimated to represent about half of marine sources of plastics and thus responsible for up to 10% of total marine plastic litter[22].

Land-based plastic pollution is caused primarily by inappropriate management of waste of plastic packaging and short-lived products originating from various consumer products in numerous sectors. These consist for example of plastic bags; single and multilayer food and beverage containers; cleaning and personal care product containers; food wraps and trays; plastic foils; single use cutlery; cups; synthetic textiles and clothing; plastic footwear; and so on. In addition to such consumer products, a number of industries such as tourism, construction, agriculture and other sectors are using plastic packaging and plastic products and thus also contribute to the problem, in cases where their plastic waste has been mismanaged.

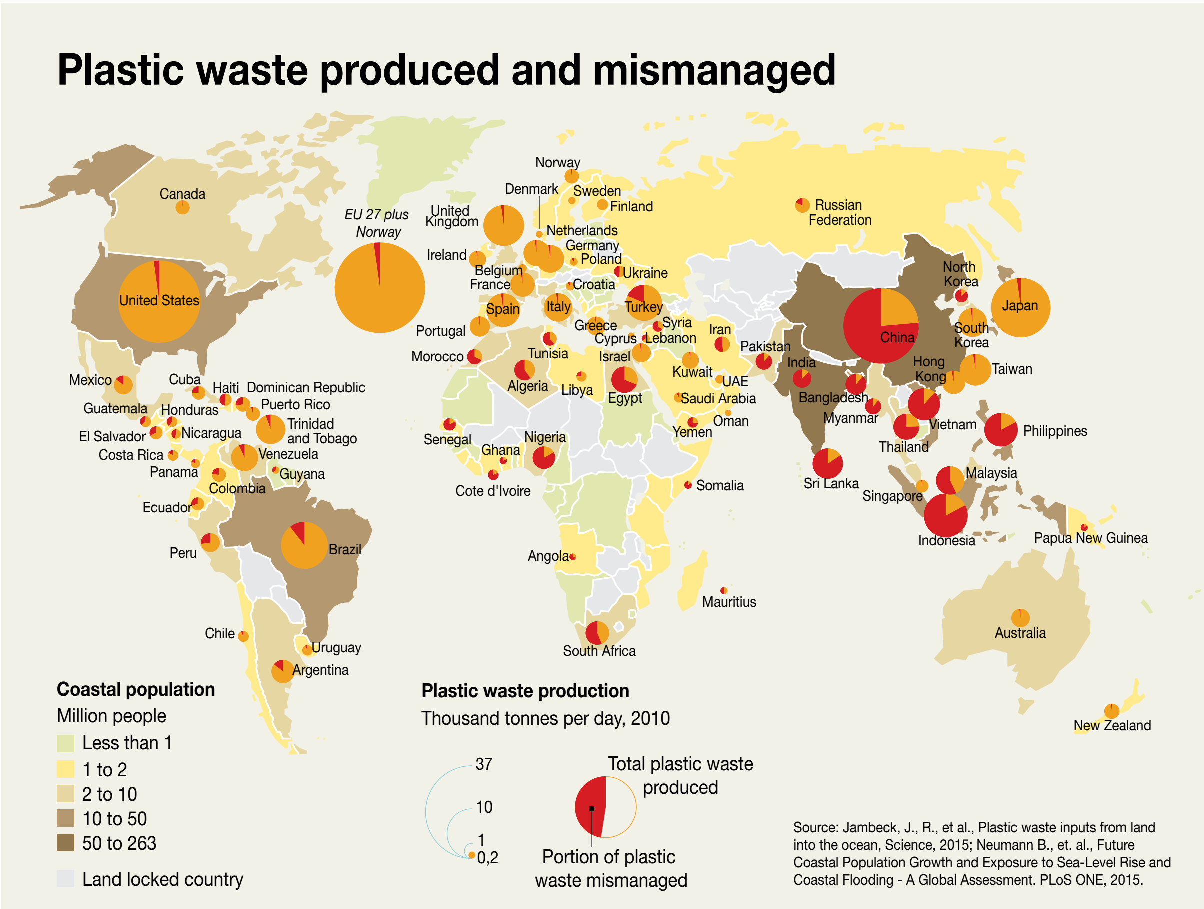

Figure 8. Plastic waste produced and mismanaged
Source: Marine litter vital graphics; downloaded on 24 March 2019 from http://www.grida.no/resources/6933

According to Jambeck, et al. (2015) 4 to 12 million tons of plastic waste ends up in oceans from land as a result of mismanagement of plastic waste every year[23], Figure 8.

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22 UNEP & FAO (2009). Abandoned, lost or otherwise discarded fishing gear. FAO Fisheries and Aquaculture Technical Paper No. 523; UNEP Regional Seas Reports and Studies No. 185. http://www.fao.org/docrep/011/i0620e/i0620e00.htm.

23 J.R. Jambeck, R. Geyer, C. Wilcox, T. R. Siegler, M. Perryman, A. Andrady, R. Narayan, K. L. Law (2015), Plastic waste inputs from land into the ocean, Science, Vol 347, Issue 6223, p.768-771, 13 February; this study is the basis for the estimated 8 million tons of plastic waste entering oceans from land.

Mismanagement usually occurs in one of the following ways:

a. Waste, including plastic products and packaging is deposited at non-sanitary landfills or dumps or not collected at all, particularly in rural areas where waste collection and management systems are missing;
b. Accidental and/or voluntary releases of plastic pellets into the environment from industrial sites, plastic blasting, and tire wear in terrestrial transport.
c. Plastics are blown into the marine environment by wind from waste dumps or improperly managed landfills; washed away by rainwater, waves and tides; carried in by rivers;
d. Plastics are released by sewage plants (e.g. microbeads in cosmetics and personal care and cleaning products, micro- and nanoplastics from laundry), (VanSebille et al, 2016)[24], or are simply carried in wastewater in cases where there are no sewage plants.

A graphic representation can be found in Figure 9.

Consequently, rivers remain one of the main pathways that transport plastic waste into the oceans. It was estimated that 1.15 and 2.41 million tons of plastic flows from the global riverine system into the oceans every year[25]. The top 20 polluting rivers were mostly located in Asia and accounted for about two thirds (67%) of the global annual input (Lebreton et al., 2017)[26].

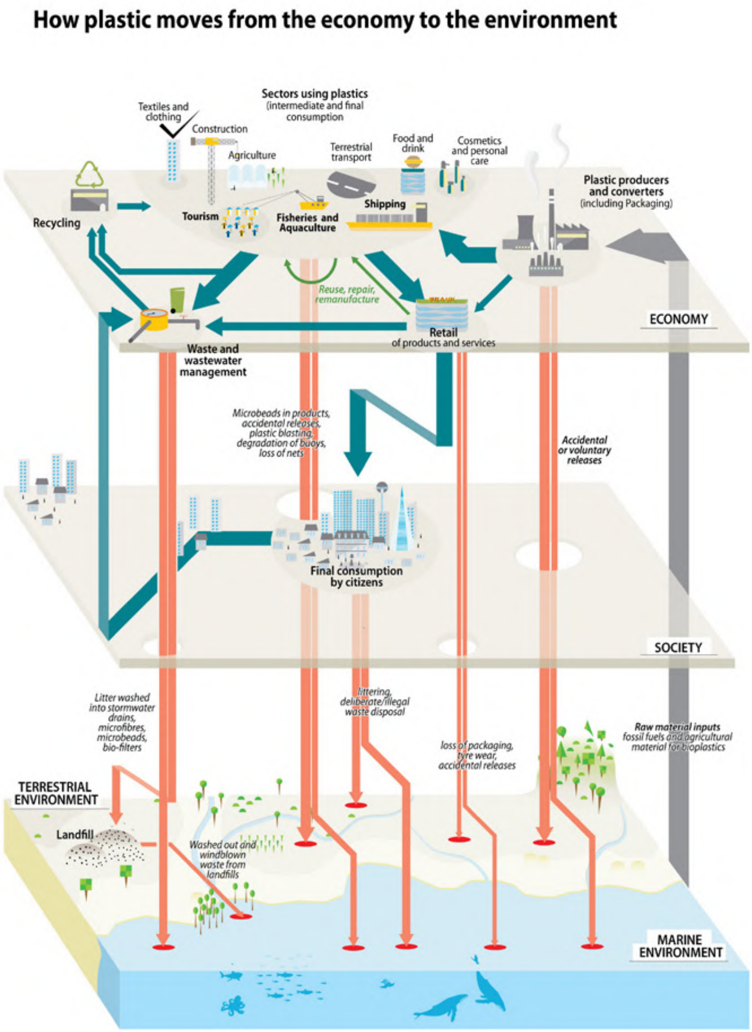

Figure 9. Movement of plastics from the economy to the environment

Source: Source: Marine litter vital graphics; downloaded on 24 March 2019 from http://www.grida.no/resources/6933

24 Erik Van Sebille, Chariklea Spathi and Alissa Gilbert (2016). The ocean plastic pollution challenge: towards solutions in the UK. Imperial College London, Grantham Institute Briefing paper No 19 July 2016

25 This is a conservative estimate; it is based on plastics particles and pieces larger than 3 mm and smaller than 0.5 m, as per Lebreton, L. C., Van der Zwet, J., Damsteeg, J. W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. Nature Communications, 8, 15611, https://www.nature.com/articles/ncomms15611

26 Ibid.

Photo: @_javardh_001

6 Circular economy practices for addressing the marine plastic litter challenge

The understanding that sustainability efforts will have to go beyond end-of-life recycling and adopt circular economy practices is growing within industry as well as the global society. Plastic packaging, synthetic textiles and clothing, and short-lived, fast-moving consumer and institutional products made of plastics contribute significantly to generation of marine plastic litter. There is hardly any global, regional, national report and research study on marine plastic litter that does not point out the role of packaging, single-use or short-lived consumer products, personal care products containing microbeads, synthetic clothing and microfibers, and fishing gear lost at sea.

Circular economy practices, as shown in chapter 3, propose policy frameworks to create incentives for economic actors, such as industry, to increase the utilization of resources. This is realized by maintaining the value of the product and its materials at any point of its life cycle and avoiding premature discarding of products and/or their materials.

This working paper will follow plastics through different stages their life cycle. It will for each stage examine which circular economy practices are possible and meaningful to apply; provide examples where such practices are already employed; and identify the possible and already existing regulatory frameworks aiming at facilitating such practice.

In the context of industrial examples given, it should be noted that these examples are not meant as an endorsement of any particular manufacturer or practice, but only as an illustration of the current technical possibilities and trends. Moreover, the authors were not in the position to inspect and verify the different claims made by manufacturers or others about performance characteristic of products and processes.

6.1 Circular economy practices in product design

Rationale

Plastic packaging is a special product with its very short life span. It protects the product it encloses from external influences during transport and distribution, including from theft at the retailer's display; it may carry information about the product it contains; and it promotes the brand and instills trust in the consumer about the product. In some societies the aesthetic quality of packaging is a value in itself.

The packaging's primary consumer is a business entity: it is the producer of food, beverages, clothes, shoes, shampoo, toothpaste, detergent and similar products, mostly for the consumer market. When the end user consumes the meat, the vegetables, the candy bar, the toothpaste, the shampoo or starts using the shoes or the clothes, the value of the packaging is diminished for all practical purposes. In fact, most plastic packaging is used only once, thereby immediately losing almost all of its value[27]; while there are certain exceptions, such as for example the use of a plastic bottle to water plants, these have currently no significant impact on the problem of marine plastic litter.

Similar to plastic packaging are ***short-lived plastic consumer products*** such as single-use plastic bags and utensils (forks, knives, spoons, cups, etc.); plastic toys for children and pets (balloons, balls, etc.); giftware; and sanitary and personal care products. Synthetic clothing or trainers usually have very short lives as well in those cases where fashion is a significant determinant of consumption. All these products are consumed and become waste to be discarded very rapidly. Many find their way into fresh water bodies, riverine system and to oceans if their waste is not properly managed.

27 Haffmans, van Gelder, van Hilte, Zijlstra, "Products that Flow", BIS Publishers, 2018.

Practices to address challenges of plastic litter by product design

This rapid flowing nature of plastic packaging and short-lived plastic consumer products becoming waste would need to be addressed by the consumers of plastic packaging, namely industries such as manufacturers of food and beverage producers, shoe, textile and garments, etc., as well as the manufacturers of short-lived consumer products. This is best done at the design phase within the value chain, through the collaboration of plastic producers and converters[28].

In both plastic packaging and short-lived plastic consumer products, a principle consideration in the design stage is material selection. Recycling of thin films, multilayer plastic packaging each made of a different polymer, some very durable plastics for instance polyvinylchloride and sorting of certain color plastics during recycling are all challenging in mechanical recycling and are likely to lead to low value retention at the end of life, i.e. typically during recycling. Furthermore, some plastics containing hazardous chemicals[29] as additives would either require chemical recycling to extract the useful polymers or thermal recycling, and hence would not be suitable for mechanical recycling.

Design questions for ***plastic packaging*** such as the following need to be answered:

- Is it possible to replace plastic packaging with alternative (e.g. renewable or more easily recyclable) packaging and offers similar functionality? This alternative packaging should both likely reduce the amount of plastic waste in oceans and, ideally, have no other (significant) environmental disadvantages;
- Can the manufacturer reduce the amount of plastic packaging used (light-weighting)?
- Can the packaging be replaced with reusable and more durable plastic packaging to render it suitable for multiple uses and a longer lifetime? Could this also result in a new business model?
- Can this packaging be made from one polymer rather than different polymers in the same product, e.g., caps and lids made from different polymers when beverage containers and bottles are made of PET?
- Is it possible to eliminate multilayer packaging or use an easier to recycle multilayer packaging?
- Is there a mechanism to manage the plastic packaging after its use to maintain some economic value?
- Is it possible to totally eliminate packaging for a product?

28 Plastics converters manufacture plastic products ranging from toothbrushes to building pipes, from fruit boxes to car interiors

29 OECD (2018), Meeting Report of the Global Forum on Environment: Plastics in a Circular Economy - Design of Sustainable Plastics from a Chemicals Perspective ENV/EPOC/WPRPW/JM (2018)1/FINAL, Environment Directorate.

In the case of ***short-lived plastic consumer products***, in addition to the above design considerations such as maintaining the value of plastic materials at the product's end of first life, additional questions on how the product behaves in the use phase would be justified:

- Is it possible to reduce impacts during use by reducing or eliminating microplastics emitted when clothing is laundered?
- Is it possible to eliminate microbeads in cleaning and personal care products and maintain a similar functionality?
- Can single-use plastic products be replaced with durable, recyclable or renewable alternatives?
- Is it possible to use no/fewer and less harmful additives in this product?
- Is it possible to use recycled plastics in this product?
- Can it be avoided to mix bio-based plastics with fossil-fuel-based plastics in the same product which renders them not easily recyclable to high quality secondary materials?
- Is it possible to have synthetic fibers in textiles and clothing that reduce microfiber formation during use[30]?
- Can fossil-fuel-based plastics in this product be replaced with bio-based plastics, subject to the latter having more favorable life cycle impacts compared to the former?

G20 members' experience

Design without packaging

Terracyle has launched Loop[31], an ecommerce platform, in partnership with Procter & Gamble, Nestlé, PepsiCo, Unilever, Mars, Clorox, Coca-Cola, Mondelēz, Danone and about a dozen smaller brands in January 2019. The European retailer Carrefour, logistics company UPS and resource management company Suez also joined. Loop brings the old "Milkman" model by delivering cleaning, personal care and food products bought online in reusable packaging. Packaging is returned in tote bags provided by Loop.

Design with bio-degradable packaging and single-use products

Kaneka of Japan has launched PHBH[32], a 100% bio-based, bio-degradable material which is a polyester made with microbial fermentation with similar properties of polyethylene (PE) and polypropylene (PP) and an alternative to these fossil-based polymers. It has been certified for food packaging as well as bio-degradability and compostability both on land (home composting) and in the marine environment. Nihon-Cornstarch[33] has a bio-degradable polymer, PLA, (Corn pole) on the market that is suitable for making ball point pens, agricultural mulch films and paints. Mitsubishi Chemicals bio-based polybutylene succinate has been certified for food contact, compostability and bio-degradability.

Evoware in Indonesia uses seaweed for making single-use food sachets and wrappings[34] that, at the end, can be dissolved or eaten. The raw material – seaweed, is used without additives. The same company has also come up with a material from the South Asia fig tree that holds liquid and can be used for personal care products and applications in medical supplies such as hygienic encasements for medical instruments. F***ull Cycle Bioplastics, Elk Packaging,*** and ***Associated Labels and Packaging*** have created bio-based compostable plastics made from organic waste combined with cellulose-based materials made from plant matter to replace multilayer packaging for food and other consumer products[35].

30 In the case of synthetic fiber production, multiple modifications in design exist that could lead to lesser microplastics formation, e.g., design of yarns with continuous fibers, plied yarns (instead of single yarn), yarns with high twist (instead of yarns with low twist), a low linear density of the yarn (instead of high yarn count).

31 https://loopstore.com and https://www.greenbiz.com/article/loops-launch-brings-reusable-packaging-worlds-biggest-brands

32 http://www.kaneka.co.jp/en/business/material/nbd_001.html

33 https://www.nihon-cornstarch.com/product/bio_plastic/tabid/160/Default.aspx#1

34 https://newplasticseconomy.org/assets/doc/NPEC-winners-brochure-2018-23.01.18.pdf

35 https://newplasticseconomy.org/innovation-prize/winners/full-cycle-bioplastics

Saathi is India's first biodegradable sanitary pad made from banana fibers with zero chemicals[36] that are also affordable for low-income women; in addition, the materials are sourced locally, reducing also environmental impacts from transportation. The German company ***Tecnaro GmbH*** produces a material called Liquid Wood, a biodegradable material, combining natural wood fibers with lignin, a bi-product of the pulp industry. Liquid wood has properties of plastic in terms of design and manufacturing, is highly durable and withstands combined tensile and compressive loads and, in addition to other uses, may be used in some household items.

Design for less material use

Without doubt, plastic products are becoming less material intensive. According to a report by BVK[37], the weight of a yogurt cap has halved in comparison to the 1970s, and the average weight of a plastic bag in Germany has dropped by nearly one third from ten years ago. The use of light-weight plastics in place of other heavier materials means less plastic is introduced into the environment. Achievements in these areas are indisputable but their full potential is only realized when other components of the circular economy are in place, particularly awareness leading to responsible consumer behavior, widespread collection and recycling systems and infrastructure for collection of light-weight plastics.

Design for easier recycling

Multi-layer plastics are more challenging, yet innovations are showing a possible way forward. ***Aronax Technologies Spain***[38], Circular Materials Challenge[39] winner, provides an alternative concept to the multilayer packaging by using a magnetic additive, making it easier to identify and separate layers of packaging during recycling. The particles, that play a role similar to the aluminum coating used in multilayer materials today, can be recovered and reused. The alternative technology can be used to replace materials for toothpaste tubes, food and drink containers. The ***University of Pittsburgh*** has used nanotechnology to create a multilayer food packaging from a single polymer, namely, polyethylene[40], combining it in layers with different properties. The material replaces a multi-layer packaging containing PET, polyethylene and aluminum. The new technology enables easy re-processing of the materials without separation steps.

Policy responses

Design innovations that will maintain the value of plastic packaging and short-lived, fast moving plastic products in the economy are the domain of key global decision makers at the start of the plastics value chain—those who determine the designs. Widespread awareness that has been created by better understanding of the problem, changing consumer preferences and increasing public pressure has started motivating these key global decision makers to take action. However, more, such as leadership by G20, is needed to create a global coalition of value chain leaders to systematically identify and implement actions.

Support for innovations and start-ups is critical for development of alternative materials, products, and new business models, as well as the markets for secondary and biodegradable and compostable plastics. One successful, but small-scale example is UNIDO's Global Cleantech Innovation Programme (GCIP), supported by the Global Environment Facility (GEF), for SMEs. It is a global multi-stakeholder partnership that leverages the power of innovation and entrepreneurship to address resource and energy efficiency challenges. However, to create sufficient impact on this particular issue, such innovation support programs would need to be on a larger scale and receive support for a longer timeframe.

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36 http://low-carbon-innovation.org/frontend/pdf/gcip-iInnovator-profiles-2017.pdf

37 The BKV – Platform for Plastics and Recovery - https://www.bkv-gmbh.de/fileadmin/user_upload/broschueren/bkv_web_englisch.pdf

38 https://newplasticseconomy.org/projects/innovation-prize

39 The Circular Design Challenge winners were announced at the Our Ocean Conference in Malta on October 5, 2017.

40 https://newplasticseconomy.org/innovation-prize/winners/university-of-pittsburgh


Photo: UNIDO

Furthermore, by developing plastics collection, sorting and recycling infrastructure and markets for secondary materials, public policies can secure availability and quality of secondary plastic materials.

To *support markets for recycled materials*, policies need to address supply and demand side of recycled materials and products. These policies need to address the dual goal of facilitating consumer acceptance and providing incentives for producers and their suppliers (OECD 2018[41]).

The *supply side* of recycled plastic materials and products could be stimulated through a policy mix that removes or cancels out subsidies for the hydrocarbon that serves as an input for the relevant (fossil-based) virgin plastic production, imposes differentiated taxes on virgin and recycled plastic, and introduces standards for recycled content. Facilitation of information on recycled content and environmental product declarations can create the transparency necessary for decisions on utilization of secondary plastic materials in products, including plastic packaging.

The *demand side* can be facilitated through policies that open larger markets by introducing requirements for labeling on recycled content and support educational campaigns for consumers.

Policies for *development of effective infrastructure for collection and separation* of waste streams are required to secure necessary volumes of plastic waste (economies of scale and security of supply) for recycling and for better quality of secondary materials. Here, it would be critically important to empower local authorities and ensure sufficient financial and technical resources are available for them for setting up the necessary systems and infrastructures.

41 http://www.oecd.org/environment/waste/policy-highlights-improving-plastics-management.pdf

6.2 Circular economy practices in manufacturing and service delivery

Rationale

Marine litter can be caused;

By the manufacturing sector through;

- Inappropriate handling of packaging waste related to delivery of raw material and components;
- Poor handling of raw material for plastics, in particular lost or wasted plastic inputs (pellets); Plastic pellets are the precursors of most thermoplastics produced in polymer production or recycling facilities. Due to their small size (2-5 mm), pellets are being lost at all stages of the supply chain and are found on beaches (also on those away from petrochemical or polymer industries)[42].
- Not reusing (where possible) and poor disposal of waste product caused by start-up of continuous operations, process disruptions, trimmings, etc.;

By the service sector through, e.g.

- Laundries, especially industrial ones, which can release significant volumes of microplastics;
- Retail establishments and tourism businesses, which can leak large quantities of single use plastic products (cutlery, plastic bags, bottles and caps), frequently, in case of tourism, even in direct proximity to large water bodies and waterways;
- Escape of plastics also originates from (mis-)handling of materials during transportation, loading and unloading and other forms of handling, as well as through tire wear for plastic products.

Manufacturing practices

Means to reduce losses in manufacturing are summarized under Resource Efficient and Cleaner Production (RECP) methods that entail the continuous application of preventive environmental strategies to processes, products and services in order to increase efficiency and reduce risks to humans and the environment (UNIDO)[43].

Strategic goals of RECP can be operationalized through a variety of managerial, technical and operational measures at the level of each enterprise (See Figure 10) as well as actions along the value chain; alternatively, at the regional level, through industrial clusters or exchanges with municipal services.

The application of resource efficient and cleaner production methods and demonstration of practices show convincing results in multiple sectors such as food processing, building materials, tourism, textiles and chemicals across the developed and developing world. These methods have a high degree of relevance for actors along the plastics value chain.

Processes of particular relevance are extrusion (used for manufacturing films and sheets), blow molding (used for production of bottles, containers, toys and houseware), and injection molding (of packaging, bottle caps, toys, combs). Companies could and often are taking numerous measures, subject to the type of their operations, to eliminate loss of raw materials, while also preventing defects in products. Often these measures relate to procedures including additional quality monitoring system installations. For certain processes such as injection molding, production waste can be reintroduced into the production process (See table in Appendix A for some additional examples).

42 https://www.sciencedirect.com/science/article/pii/S0025326X18300523

43 RECP aims at reaching three interconnected goals of achieving higher economic performance through, 1) resource productivity, 2) minimizing impact on the environment through waste minimization, and 3) positively contributing to human wellbeing through improving health, safety and employment opportunities. The three goals are synergistically related – resource productivity results in reduced losses of materials (minimization of waste) and cleaner and more efficient work spaces (reducing of materials, water and energy used in production) and communities facilitate stronger motivation for efficiency.

Figure 10. RECP methods

In several countries the plastic industry broadly employs principles of smart manufacturing and better operational control under the banner of Industry 4.0 to achieve productivity and minimize material and energy losses.

Regarding synthetic fibers and their contribution to microfiber pollution in oceans, it has been demonstrated that changing the characteristics of their production – *notably by operational control, equipment modification, product modification, and technology change* – may result in fiber characteristics leading to lower release of microfibers during normal wear and tear and washing. For instance, dyeing yarns instead of fabrics has been shown to reduce microfiber releases, and so does adjusting operation velocity in knotting processes[44].

Service delivery practices

Service providers, such as industrial laundries, can also significantly reduce the release of microplastics by observing a number of good practices in the *selection of materials* (selection of liquid light duty detergents) and operations (using *operational conditions* that create minimum mechanical damage to the fibers). The use of filters to capture microfibers from effluent of commercial and industrial laundries as well as household washing machines is also an option that could be deployed[45].

Tourism and retail operations considerably impact the generation of plastic litter through waste of plastic packaging (e.g. food and beverage packaging, wraps for various products) and as part of their direct service to the customers (single use bags, cutlery, etc.), whether they are located in coastal areas or far away. Numerous cases demonstrate good practices in the area of *good housekeeping* (prevention of plastic materials escaping the operators own operations and creation of conditions for the customers to follow good practices rules), and total *elimination or substitution of plastics* with other materials.

In larger scale retail operations, offering customers to bring their own containers to take away suitable food products, e.g. dry goods, cleaning supplies and personal care products such as shampoo have been proposed and implemented in some cases, albeit with mixed results due to consumer awareness issues and low uptake of these options by large scale retailers.

44 Ocean Clean Wash. Handbook for zero microplastics from textiles and laundry - http://oceancleanwash.org/wp-content/uploads/2018/10/Handbook-for-zero-microplastics-from-textiles-and-laundry-developed-2.pdf

45 McIlwraith, et. al, 2019, Capturing microfibers – marketed technologies reduce microfiber emissions from washing machines, https://doi.org/10.1016/j.marpolbul.2018.12.012

G20 members' experience

Industry associations are making strides towards cleaner operational practices. For example, following the launch of the Plastic Strategy by the European Commission, the industry NGO PlasticsEurope has published "Plastics 2030 - Voluntary Commitment" with a focus on increasing reuse and recycling, preventing plastic leakages into the environment and striving towards resource efficiency[46,47].

The Plastics Industry Association (PLASTICS) has launched the Zero Net Waste program that supports Association members in identifying waste reduction opportunities. The Minco Group (Ohio, USA) a provider of thermoplastic solutions is the first Zero Net Waste recognized company[48]. Actions of the All Service Plastic Molding (ASPM)[49], a company owned by The Minco Group, helped to divert 88 percent of total manufacturing waste from landfill and decrease landfill-directed waste weight by 46 percent, which also corresponded to a 28 percent cost decrease for disposal.

Within the international program Operation Clean Sweep[50], companies from the plastics industry have committed to practices that prevent the loss of pellets. The program involves all the actors along the supply chain – manufacturers of plastics, processors, distributors, logistic and recycling companies. They focus on a range of good housekeeping practices such as identification of potential sources of pellet leaks (loading and unloading), installation of retainers (including for waste), training, monitoring, and engagement with partners along the supply chain.

Importance of operational control in the plastic industry is widely recognized. In the context of Industry 4.0, by use of intelligent sensors, improved plans and designs to eliminate human error, and to increase flexibility of production, the industry also aims to customize products and services.

Policy responses

In several countries, RECP practices are widely well known and are followed not only by individual enterprises but also at a larger scale such as in whole industrial parks or along supply chains. Related experiences are also available in several developing countries, often supported by national RECP centers, by implementing organizations such as UNIDO demonstrating benefits and piloting large scale approaches, and by further developing methodologies and guidelines, including for eco-industrial parks.

However, upscaling is challenging since the necessary investments, albeit typically profitable, are competing with other more profitable and tangible ones such as capacity enlargements. Adjustments to the policy framework with the objective to facilitate uptake of RECP practices would therefore be helpful, through interventions like:

- *Development of information and knowledge platforms on good practices and emerging regulatory requirements* for various industrial activities;

- *Establishing and supporting industry 'clubs',* especially for the MSMEs, that would help adjust concepts and strategies of RECP into actual practices and would provide ongoing support during implementation.

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46 https://www.plasticseurope.org/en/newsroom/press-releases/archive-press-releases-2018/plastics-2030-voluntary-commitment

47 https://www.plasticseurope.org/application/files/7215/1715/2556/20180116121358-PlasticsEurope_Voluntary_Commitment_16012018_1.pdf

48 www.plasticsindustry.org

49 https://www.plasticsindustry.org/sites/default/files/Zero%20Net%20Waste%20-%20Case%20Studies%20-%20The%20Minco%20Group.pdf

50 https://www.opcleansweep.org

6.3 Circular economy practices for product and service use

Rationale

The critically important stakeholder is an individual consumer who ‘votes’ with her wallet in favor of a particular product or service or selects to reject it. Choice of the product or its rejection is thought to be influenced by retailers who not only occupy an important position between producers and consumers but can serve as ‘translators’ of ideas behind particular product choices as well as manners for their disposal. As such they have a significant role in influencing sustainable choices, especially as retailers become increasingly large.

A call for circularity brings into focus new business models that minimize material intensity and environmental impact at various stages of material flow. In the circular economy the concept of consumer is being transformed into that of user with redefinition of relations between the producer, user and partners ‘down’ the value chain. Several such models modify relations between products and consumers, leading to changes in consumption patterns. Three types of such models are particularly interesting from the perspective of the use stage (OECD 2018)[51]. *Product life extension models* slow resource flow by extending the use periods of products. *Sharing models* minimize demand for more material by maximizing the utilization of products through leasing, sharing, renting and pooling strategies. *Product service system* models minimize demand for resources and promote greener products by focusing on provision of services rather than sale of products that are to deliver such services.

Sustainability of the use stage, like other stages of material flow in the circular economy, can be assessed at the system level where various contributing factors are simultaneously considered. Factors that are significant include transportation, packaging, performance of products from the perspective of water and energy consumption, emission generation, opportunities to be safely recycled, reused, refurbished, remanufactured, and be disposed of.

Practices to address challenges of plastic litter in product and service use

To realize the benefits of better product design requires avoidance of ‘leaks’ along the whole life cycle of products. This particularly applies to the users of plastic products, both businesses and individuals, with significant examples paving the way.

An example of retailers’ role in the area of plastic is the role different stores play in response to introduction of bans on plastic bags in various countries. Such responses include provision of alternatives, installation of plastics sorting facilities and consumer information.

Important efforts have also been undertaken by the business sector which, traditionally, uses plastic products in offering their services. For example, ***Starbucks*** has announced that by 2020 it will stop providing plastic straws. Other food and drink companies that have joined the move towards elimination of single-use plastic are ***KFC, Danone*** and ***Nestle***. Large retailers such as ***Carrefour***, ***IKEA*** and ***Adidas*** will also reduce the use of single-use plastics, including some packaging, and will use more recyclable alternatives. ***Shoprite*** and ***Woolworths***, retailers In South Africa, as well as ***Spar*** in Eastern Cape focus on phasing out-single use plastic shopping bags, straws and cutlery. ***Pick n Pay*** has been running a “Make Plastic Bags Extinct” campaign since 2008 and features recyclable packaging in its PnP Green range. Initiatives of retailers are supported by legislative moves that ban or partially ban the use of single-use plastic bags (and other single-use plastics) or subject them to levies (see Appendix B). In addition, deposit-return schemes for single-use plastic drink bottles, where a small deposit is added to the price of the product and returned to the customer upon its return are being implemented in 40 countries and 21 US States in some form. These schemes have tended to increase recycling of bottles to 80-95%[52].

51 http://www.oecd.org/environment/waste/policy-highlights-business-models-for-the-circular-economy.pdf

52 https://www.bbc.com/news/science-environment-43571269

Some of the global producers of personal care products have already committed to remove plastic microbeads from some or all of their brands or products. Among them are ***Procter and Gamble, Shiseido, Amway, Household and Healthcare,*** and ***Estee Lauder***.

Similar to commercial laundries discussed above, at the household level, use of washing machines that limit mechanical damage to textiles, including with low temperature washing, and use of microfiber filters on washing machines[53] have been shown to be effective in reducing microfiber releases.

Bulk consumers, private and public, are some of the influential partners that can use their purchasing power in shifting preferences towards particular products or models of use. Depending on regions, green public procurement may have a significant influence on various markets; for example, in countries with feeding support programmes (e.g. milk, other nutritious foods) for children in school, options to reduce or eliminate single-use plastic packaging may be implemented, followed by collection and sorting of remaining waste at schools even by students, as part of their education.

G20 members' experience

Consumer concern about single-use plastics and choices are impacted by a variety of factors, including price and availability of alternatives or measures that prevent access to single use items[54]. A review of practices with respect to single use plastic bags in G20 countries demonstrated that all of them implemented bans or levies on the products at the national or local levels (see Table at the Appendix B for more details). Assessment of the results is often difficult. However, in cases where success has been recorded, a well-chosen level of levies, availability of alternatives and functioning waste management systems seem to contribute, as are stakeholder consultations, sustained awareness campaigns, and efforts to communicate progress and take feedback.

A number of countries have also moved towards bans on microbeads, Table 3.

France, 2018	Ban on the sale, manufacture and import of rinse-off products
Canada, 2018	Ban on products with microbeads less than 5 mm in size
UK, 2018	Ban on plastic microbeads in cosmetics and personal care products
Italy	Draft legislation to ban microbeads in rinse-off cosmetics from 2020
India	Ban on microbeads to enter force in 2020
South Africa	Microbeads ban has been proposed
United States of America	Federal ban on manufacture and sale of rinse-off cosmetics containing intentionally-added plastic microbeads, 2015 As of October 2015, all states, except California, banned plastic microbeads but allow biodegradable ones. The state of California ban does not allow even biodegradable microbeads.

Table 3. National restrictions on use of microbeads

Assistance with choices leading to minimization of plastic litter has been successfully facilitated through innovative business models, with some of them rooted in already established business practices. While multiple examples demonstrate use-oriented product-service system (PSS), practices related to need satisfaction -- or result-oriented PSS – can be particularly useful for addressing marine litter generation. For example, purified drinking water in some public places in Brazil is provided as a PSS. This is a business model under which consumers pays for purified (through reverse osmosis) water which they collect with own containers instead of paying for bottled water.

53 McIlwraith, et al, 2019, Capturing microfibers – marketed technologies reduce microfiber emissions from washing machines, https://doi.org/10.1016/j.marpolbul.2018.12.012

54 The survey by Ipsos MORI and King's College Polling Club finds that many consumers are ready to make environmentally sound choices, but without paying extra or avoiding suppliers with unsustainable practices. They preferred actions directed at other actors along the supply chain, e.g., taxing retailers for unrecyclable products, municipal spending on recycling, naming and shaming those lacking in recycling efforts.

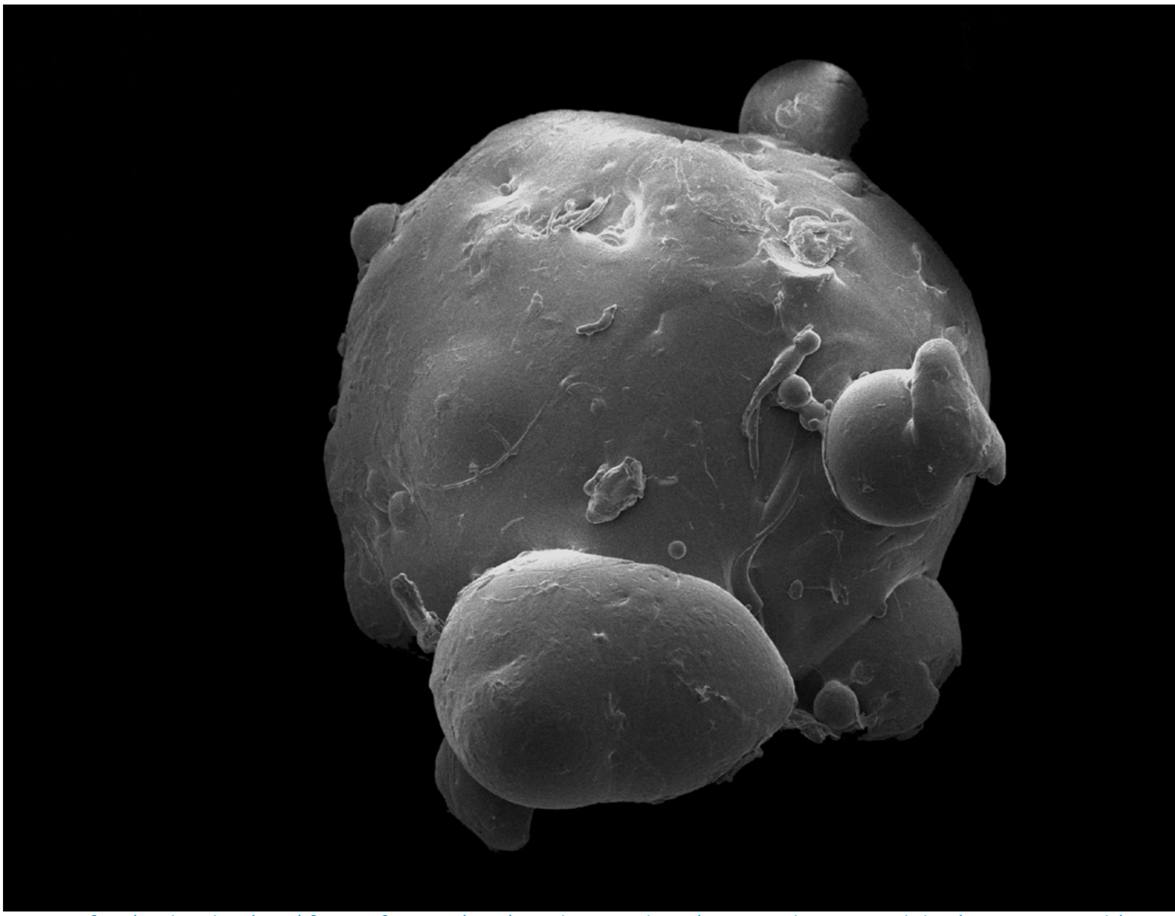
Photo: University of Exeter

Image of a plastic microbead from a facewash, taken via scanning electron microscopy; it is about 0.5mm wide.

Policy responses

Consumer education is seen as an important factor in selection of products and services that could reduce marine plastic litter. Multiple campaigns accompanying introduction of desirable products were considered successes. However, in the absence of continuous effort, consumers might accept the action only temporarily. For example, the levies on single use plastic bags may be accepted as part of their purchasing budget (reported case of South Africa after initial success) without also resulting in choices towards more environmentally sound alternatives, although deposit-return schemes have tended to improve returns and recycling of plastic bottles. Generally, as in case of any required behavioral change, *consultations prior to actions* as well as *ongoing feedback on results from introduced actions* and *leadership by high-level decision makers* have proven to be important for success. Information can go a long way in modifying user practices; for example, communal laundries can be equipped with information leading to washing with minimal release of microplastics. The washing machines can also be set on regimes that lead to similar outcomes.

While well-designed campaigns are necessary for facilitating consumer choices, attention also has to be given to education. The UN Decade of Education for Sustainable Development (2005-2014)[55] with its Global Action Programme on Education for Sustainable Development (ESD) focused on developing competencies that enable critical choices, including those in the area of consumption/use. Governments can empower users of products and services by *mainstreaming ESD and consumer education through formal and informal educational curricula. Assessment of policies and practices, consultations* with key stakeholders, national/regional and sectoral *guidelines for implementation* of education for sustainable consumption could lead to mainstreaming sustainable consumption practices. Experience of such action exists in Indonesia[56].

55 https://unesdoc.unesco.org/ark:/48223/pf0000154093

56 https://en.unesco.org/countries/indonesia

In relation to bulk consumers, green (or sustainable) public or private procurement has the potential to become a powerful instrument, albeit with so far mixed results due to difficulties in clearly defining objectives and actions in a forward-looking approach—a complex undertaking in itself. On the other hand, a case study example from a Swedish public entity has shown potential also to shift focus from consumption of products to services provided with the help of this instrument[57].

Partners along distribution networks play a significant role in facilitating circularity. Some of them, such as large retailers and department stores have already proven impactful in minimizing plastic pollution. Policies applied to them range between regulations, e.g., total or partial ban of single use plastic bags, and information on potential good practices, and deposit-return schemes for plastic bottles, e.g., for collection and separation of wastes.

With respect to the development of new circular business models, while public policies that facilitate introduction of new circular business models depend on the particular area of service/application, the general principle would be to identify and remove main barriers and risks and introduce incentives for producers and consumers. In general, information about new business models would need to be disseminated and partners across the value chain would need to be encouraged to actively seek information and act on it. Public policy might extend support – financial, technical and scientific - to the partners who aspire to pilot new circular models of production and consumption.

6.4 Circular economy practices at end-of-first-life

Rationale

The end-of-life stage in the linear model of economy assumes limited choices in 'post-use' product management, except for disposal in modern landfills or worse, in dump sites. In a circular economy, end-of-life is defined as the end of the 'first life' of products so that restoration and regeneration of the product, its components and its embedded resources (materials, water, energy and labor) are properly managed.

In the case of durable, longer-living plastic packaging and longer-lived plastic products, end-of-first-life may, in fact, be extended by strategies for reuse, repurposing and by extraction of materials through recycling. However, for single-use plastic packaging and short-lived plastic products this is usually not the case due to lack of required policy frameworks, systems and infrastructure for their collection, sorting, recycling and/or repurposing.

At the end of the product's first life, some plastics can be recycled mechanically, i.e. separated from other materials and sorted into fractions of similar polymers for reuse, particularly the thermoplastics. While this operation is not very costly, it cannot currently separate out different additives, and it has difficulties with products containing multiple polymers in their components or multiple-layer plastics made of different polymers. Currently a second severe limitation of mechanical recycling is that with each product cycle of a particular batch of material, more and more additives and other impurities will accumulate in the material, increasingly reducing the value of the plastic.

Alternatively, chemical recycling can be used, where processes convert plastic waste to virgin feedstock for the production of plastics, as an alternative to virgin fossil based raw materials. This process allows removal of additives and other impurities, but requires considerably more effort, and most chemical recycling operations are just now emerging out of the experimental phase. Depending on the process used, the resulting recyclates might also be used to produce fuels. Data on costs, efficiency, environmental impacts, scalability and intellectual property rights in respect of chemical recycling could not be assessed as part of this work.

57 C. Bratt, S. Hallstedt, K.-H. Robèrt, G. Broman and J. Oldmark, "Assessment of criteria development for public procurement from a strategic sustainability perspective," J. of Cleaner Production, vol. 52, pp. 309 – 316, Aug. 2013

A third alternative is thermal recycling, or, put simpler, using plastic waste as fuel or recovering energy, which in effect is a final disposal practice. While typically plastics produce significant energy during combustion, breakdown processes and subsequent formation of other, potential hazardous chemicals are an issue; commonly known are for example the formation of dioxins and furans, with the related halogens stemming from additives[58]. This requires large scale incineration facilities with the possibility to control process temperatures during and after combustion, and possibly treatment of flue gases. Purpose made waste incineration facilities exist in many countries to treat substantial amounts of municipal and other waste; however, their substantial investment requirements and the need to supply downstream users with heat necessitate a constant and substantial waste stream, which might be in conflict with waste prevention efforts. Alternatively, large industrial users of heat, such as cement kilns, may substitute their current fuel with waste within certain limits, partially avoiding the conflicts mentioned above.

Practices to address challenges of plastic litter at end-of-first-life

Challenges with the end-of-first-life of plastics emerge when plastic has already been released into the environment and become pollution, or when plastic materials are contained but present a challenge for recycling. From the perspective of marine plastic litter, the first challenge is of a primary importance. Single use or short-lived plastic products and packaging do become plastic litter when there are insufficient stimuli, normative or financial, to keep these, potentially useful resources, circulating in the economy. In other words, marine litter is often the result of a market failure. For this reason, we highlight a range of factors that can keep the loop of plastic materials closed.

Economic considerations are possibly the most serious impediment for returning low value, fast moving plastics into the material loop, some of which are listed below:

- Currently, in most cases low waste tipping fees for landfills discourage the more expensive collection, sorting and recycling operations;
- A level playing field exists where recycled (secondary) raw materials are not disadvantaged vis-à-vis virgin material; the latter for example benefitting fromfossil-fuel subsidies[59];
- There is an economy of scale, which, in turn, is influenced by cooperation of users and existence of collection and separation systems and infrastructure for mechanical, chemical or thermal recycling.

Consequently, a serious problem that stands in the way of closing the material cycle of plastics, especially single-use plastics, is inadequate at-the-source collection, separation and aggregation at the post-use stage. Here, among the most important actors is the end consumer, whose awareness and willingness to separate, at source, plastic packaging and single-use plastics; further, the existence or weaknesses of systems for collection and onward transfer of plastic waste to the next actor in a formal plastic waste management system.

In countries where formal collection infrastructure is weak, informal collectors and aggregators play a serious role in capturing value of discarded materials and contribute to high rates of recycling for some streams of materials, including plastics. Greatly flexible in their organization, informal recyclers show a high degree of adaptation to various circumstances accompanying emergence of new waste management systems. Some reports indicate that disappearance of informal collectors and aggregators of waste in fast-growing cities, where they increasingly come under regulatory pressure and are subject to falling profit margins, results in a strong pressure on the waste management infrastructure, resulting in its inadequate functioning[60].

58 M. E. Grigore (2017), Methods of Recycling, Properties and Applications of Recycled Thermoplastic Polymers, Recycling, doi:10.3390/recycling2040024

59 International Energy Agency estimated the fossil fuel consumption subsidies at $300 billion in 2017 at https://www.iea.org/weo/energysubsidies/

60 https://digital.detritusjournal.com/articles/in-press/is-there-a-future-for-the-informal-recycling-sector-in-urban-china/162

One of the often-neglected facts in the discussions of circularity is that in the process of recycling, a material gradually loses its quality[61]. It could remain in the material loop but not necessarily for the production of the same line of products, especially if quality requirements for the initial product are higher than those the recycled material can provide. Thus, the material is down-cycled to a less valuable use. Recycling of plastics clearly faces this challenge. Consequently, the recycled plastics might be used e.g. for road paving; however, this use in turn may be associated with leakages of material and additives into the environment during the lifetime of the road.

Upcycling of plastic waste through recycling is also possible, although this would depend whether the requirements of a higher value product are met by the secondary raw material. Safety of additives in the up-cycled plastic would define its suitability for food packaging, medical applications, children's products (toys or clothing) as well as other applications with particular requirements for materials.

One of the critical points to consider is that while recycling may be economically and environmentally beneficial, it does not necessarily come at low risk to the environment and the people. This is especially true in countries where the recycling infrastructure is not yet adequately developed, where standards are not yet fully formulated and enforced or where recycling operators are not fully compliant. It is also important to remember that recycling operators can themselves become a serious source for marine plastic litter by allowing plastic waste to escape from their operations. For the plastics economy to become circular, considerations of recyclability, and minimum harm at all stages of lifespan have to be considered at the design stage of the product and of the whole recycling system.

G20 members' experience

Transforming waste into other valuable products and services

Recent publications emphasize that there are a number of upcoming technologies and processes that have the potential to deal with the consequences of unsustainably designed plastics, particularly in the area of chemical plastic recycling that transforms waste plastic into feedstock while removing additives (OECD 2018)[62]. These systems would acquire financial feasibility by securing the needed volume of recyclates via adequately operating collection and recycling schemes. In this case, virgin fossil feedstock would be substituted with recycled materials derived from plastic waste.

For example, ***DEMETO***, a European consortium is working on chemical recycling of any waste plastic, including waste recovered from the oceans or from other production processes to make food grade plastic (PET)[63]. The technology used by the consortium is created by ***RG3N***, a Swiss-based startup. ***BASF's ChemCycling*** project[64] works with several types of plastics using thermos-cycling processes deriving feedstock comparable in quality with that from fossils. Californian ***Newlight Technologies*** produces AirCarbon™ combining air with methane-based carbon emissions and a biocatalyst to produce PHA (polyhydroxyalkanoates, a naturally occurring polymer that is biodegradable).

Another line of innovation relates to transforming non-recyclable waste into fuel. ***Rays Enserv*** in India has developed an 'Advanced Supercritical Thermal treatment technology' to convert Polyethylene, Polypropylene and Polystyrene plastic waste into usable low-sulphur synthetic fuel.

61 https://www.dw.com/en/plastic-waste-and-the-recycling-myth/a-45746469

62 http://www.oecd.org/chemicalsafety/risk-management/global-forum-on-environment-plastics-in-a-circular-economy-meeting-report-.pdf

63 https://www.coca-colacompany.com/stories/chemical-recycling-could-this-breakthrough-technology-curb-plastic-waste

64 https://www.basf.com/global/en/who-we-are/sustainability/management-and-instruments/circular-economy/chemcycling.html

Responsibilities of producers

Extended Producer Responsibility (EPR) schemes have been introduced in a majority of G20 countries and, in many cases, have assisted in setting up better plastic collection and recycling systems. It is, however, difficult to give justice to the performance of individual systems or to compare them to each other across G20 countries or even across EU region (26 of the 28 EU Member States have EPR schemes addressing packaging waste with different approaches). This is because the EPR systems vary in coverage (type and number of products covered), type of responsibilities (individual/collective, financial/operational/informational), design of the collection schemes, degree of monitoring (in some cases the schemes are not monitored and producer compliance is not enforced), targets (voluntary/obligatory), and ways of calculation[65]. While impact has been felt at the post-consumer stage, the schemes did not provide sufficient incentives for redesigning products towards greater recyclability (largely, it is weight that is privileged). Notable exceptions are CITEO scheme in France and CONAI in Italy that apply higher fees to non-sortable and non-recyclable packaging and no fees to reusable ones[66].

In the context of EU, an EPR system is also considered for addressing fishing gear plastic litter once it comes on shore[67]. The return to the shore will be done by the fishers who already have an obligation to collect or report lost fishing gear[68]. The new Port Facilities Directive of the European Commission (2018) has special provisions for addressing marine litter from marine-based sources. The EU member states are required to have adequate port facilities and to cover costs associated with delivery of marine waste ashore.

It also seems that deposit-return schemes have been working rather well in a number of countries helping to keep material streams clean(er) and, potentially, better suited for mechanical recycling of plastic waste to secondary plastic material.

Interestingly, the targets for recycling and reuse of plastic waste are seldom imposed by local authorities. Yet, there are regulations that encourage them to take necessary actions. For example, the Indian Plastic Waste Management Rules 2016 ask all Municipal Corporations and rural authorities to recycle, reuse and handle plastics without harming the environment.

Critical partners in facilitating recycling – informal sector

The informal waste operators are cause for a high rate of recycling in a number of G20 countries with large numbers of persons engaged. Two percent of Asian cities' population makes their living by scavenging recyclables (Sasaki & Araki, 2013). Estimates for India show that about 1% of the urban population is engaged in the informal recycling sector[69]. While the formal waste sector in South Africa employs 30,000 people, the informal sector employs two or three times this number. In Western Cape waste pickers have recovered 90% of polyethylene terephthalate (PET) (data from 2013)[70]. In urban China, informal waste collectors account for an estimated 17-35% of municipal recycling.[71] In Saudi Arabia, the informal sector is largely responsible for waste recycling[72].

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65 To reach the set targets for reuse and recycling, calculation of targets for each waste stream should be made with a view to collection, recovery, recycling/reuse. Today, in most of the EPR systems calculations of the targets is done only for the 'total' of a product or, in more advanced cases, the mass of materials in a product, without considerations of type and purity of recovered individual materials or type of required technologies for recovery.

66 https://ieep.eu/uploads/articles/attachments/95369718-a733-473b-aa6b-153c1341f581/EPR%20and%20plastics%20report%20IEEP%209%20Nov%202017%20final.pdf?v=63677462324

67 https://ec.europa.eu/maritimeaffairs/content/new-proposal-will-tackle-marine-litter-and-%E2%80%9Cghost-fishing%E2%80%9D_en

68 Council Regulation (EC) No 1224/2009

69 https://www.giz.de/en/downloads/gtz2010-waste-experts-conditions-is-integration.pdf

70 http://www.engineeringnews.co.za/article/informal-waste-pickers-should-be-integrated-into-formal-waste-management-sector-suggests-analyst-2018-10-17/rep_id:4136

71 https://www.coresponsibility.com/off-books-informal-recycling-china/

72 https://www.bioenergyconsult.com/recycling-waste-to-energy-saudi-arabia/

Estimates suggest that informal recyclers save up to 30% of landfill space by diverting materials from final disposals. In doing so, they reduce collection and transportation costs resulting in cost savings for municipalities[73]. The informal sector in India has a significant role in recycling of post-consumer plastic waste as well as in the running of the waste management system in general. The role of informal recyclers is particularly notable in the area of some plastics, e.g., PET, as well as for waste of electrical and electronic products (WEEE).

Clean-up – ocean waste collection solutions

With an estimated more than five trillion plastic pieces polluting ocean waters, technologies are being developed to clean up such debris. Different challenges are associated with different debris and location, in particular whether the debris is floating on the surface, is submerged or lies on the seabed. Due to the immensity of the oceans volume, something approaching an almost-complete clean-up or cleaning most of the water in the ocean appears not feasible. Cleaning along ports, beaches and of plastic floating on or near the surface will address only a fraction of marine plastic litter; according to the estimates presented in Chapter 5 about submerged litter, this fraction is likely to be less than 50% of the plastics reaching the oceans.

The technologies best known internationally, developed by Ocean CleanUp[74] creates a 600-meter-long floater intended to clean the Great Pacific Garbage Patch. In addition, there are a number of innovators and startups providing technologies and working on the commercialization of their concepts.

Sagar Defence's (India) vehicle "Trashfin"[75] is designed for round-the-clock autonomous, unmanned, solar powered waste collection, that extracts unwanted materials, gathers data about the marine environment and communicates with other vehicles in the water. The technology is smaller in scale than that of Ocean Cleanup's and suitable for different applications, e.g., in port areas and closer to shorelines.

Like with other practices discussed in previous chapters, the clean-up technologies are just one strategy that needs to be combined with measures that align plastic litter with the circular concept of development. The technologies are to be further tested and impact of their applications is to be investigated deeper – a work that is underway[76].

A lot of work focused on cleaning up plastic litter in the sea and on the shore is carried out by governments, NGOs and private citizens. Such activities are critical; it is unclear how their costs per ton of plastic removed relate to the costs of the practices outlined in previous chapters. For example, the United States spends around USD 10.8 billion on litter clean up, with spending on cleaning marine litter for West Cost communities exceeding USD 520 million (it includes beach and waterways cleanup). There are also practices that facilitate recovery of lost fishing gear from the sea as well as waste handling infrastructure in the ports. The European Maritime and Fisheries Fund allocated €53 million for such actions for the period 2014-2020.

73 file:///C:/Users/Zinaida/Downloads/Emerging-Issues-in-Solid-Waste-Management-in-Argentina.pdf

74 https://www.theoceancleanup.com/

75 http://low-carbon-innovation.org/cleantech-innovation

76 http://salt.nu/wp-content/uploads/2018/11/Komprimert-Report-1021-Feasibility-of-the-PGS-Plastic-Collection-Concept-compressed.pdf

Photo: Nyancho Nwanri / King Baudouin African Development Prize

Policy responses

With respect to economic incentives for recycling, policies could aim to disincentivize landfilling or totally banning it, as plastic waste management systems and infrastructure is strengthened. While this can be a successful approach for some G20 countries, e.g. members of the European Union, others will face substantial challenges and long transition times.

In the area of facilitating production based on the secondary materials, policy measures that create incentives for use of secondary raw materials might include (subject to individual national and regional conditions) measures that, simultaneously, address secondary material supply side and demand side of the products based on secondary materials.

Among other measures, public policies could consist of: improving waste collection and separation systems, regulating use of harmful chemicals in production of plastics, introduction of quality standards for products with recycled content, introduction of public procurement rules privileging products with recycled content, introducing easily understandable labeling systems and information/awareness programs.

What appear to be effective in supporting production based on recycled and recyclable materials are innovation programs. A number of technology incubators exist with mentorship programs for entrepreneurs providing ongoing support for innovative products and business models. As mentioned previously, UNIDO's Global Cleantech Innovation Programme (GCIP), supported by the Global Environmental Facility (GEF) is a successful example of such programs.
In the area of responsibilities of producers, exchange of practices and analysis of EPR systems is ongoing, yet it would be important to put more attention on the role of EPR in supporting circular economy. Analysis, limited by the scope of this study, has confirmed the relevance of recommendations given for the design of an effective EPR system (OECD 2001), especially with respect to incentives for producers towards improved product design for the benefit of the whole value chain. We find that attention to systems that provide stimuli for enhanced product design are particularly needed.

Given the significant role of informal recyclers in waste collection and aggregation in about half of the G20 countries, it is important that EPR systems have to secure their inclusion (practices of such kind are already well established).

In the area of informal recycling, with the experience of G20 countries in the area of integration of informal waste sector (in Brazil, for example, waste pickers are seen as part of the semi-formal system[77]) could focus on a variety of areas in developing countries such as:

- Models of legislation, directly and indirectly related to waste and material management, that have provisions for the informal waste sector;
- Strategies for formalization, including identification of barriers;
- Practices that improve living and working conditions of informal waste sector workers (issuing identity cards, assuring rights to collect in particular areas, provision of equipment and training, social security, providing spaces for recycling, etc.);
- Practices for integration of waste pickers into local, community based, decentralized waste management;
- Practices in creating new business models (contractual arrangements, strategies for official registration of enterprises);
- Support for associations and networking of and with informal waste sector workers;
- Awareness campaigns focused on their role in society as well as assessment of the economic and social contributions of the informal waste sector.

Policies for development of effective infrastructure for collection, separation and recycling to extract and return secondary materials to the economy are required to secure the necessary volume of collected plastic waste (economy of scale and security of supply) and its sufficient quality. Such policies would prevent loss of material and contamination of resources. These policies can be targeted at development of infrastructure internally, particularly at local levels through empowerment of municipalities with sufficient resources, including finances, and at encouragement of international investments.

77 https://www.giz.de/en/downloads/gtz2010-waste-experts-conditions-is-integration.pdf

6.5 Circular economy practices in final disposal

Rationale

Disposal, which in the context of a linear economy is a dominant practice at the end of product life, becomes the least desirable option within a circular economy. Ideally, only a small fraction of material that cannot be utilized in productive cycles would be safely disposed. While this remains the overarching ambition, landfilling still represents the main waste management solution for most of municipal solid waste management in many countries, and also for industrial waste in low- and middle-income countries. As explained in the previous section, thermal recycling to extract energy would be a superior option to landfilling.

Safe organization of landfills has to be made with consideration of many conditions, including cost for establishing, operations, and availability of technical expertise, geological and climatic conditions. Today, many guidelines for establishing landfills are available not only for developed but also for developing countries, e.g., the Guidelines for Design and Operation of Municipal Solid Waste Landfills in Tropical Climates (ISWA 2013).

Practices to address challenges of plastic litter at final disposal

Worldwide, an estimated 91% of plastic is not recycled. Majority of post-consumer plastic (79 percent) is landfilled or leaked into the natural environment (with much of it ending up in the oceans)[78]. In a landfill, depending on its composition, plastics can take hundreds of years to degrade, leaking contaminants into water and soil. Based on this reality, some suggestions focus on avoidance of plastic use, particularly single-use plastics, especially in the circumstances of suboptimal functioning of plastic recovery systems.

78 https://news.nationalgeographic.com/2017/07/plastic-produced-recycling-waste-ocean-trash-debris-environment/

Final disposal in landfills comes with significant challenges in view of:

1. Unsafe organization of landfills (in many instances waste is just dumped in designated or random locations resulting in dispersion of plastic into the waterways and surrounding areas eventually finding its way to the ocean);
2. Landfills reaching or exceeding their capacity, leading to transportation of waste to other destinations with losses on the way, and;
3. Tremendous value lost in landfills not only of what is disposed of, but also in relation to inefficient land use.

G20 members' experience

The questions of plastics final disposal become particularly strong, also in economically wealthier countries, due to the move by China to ban the import of 24 types of plastics. Sending own plastic waste to other countries has become a common practice. Such transportation must come with an assurance that transportation and disposal (or other forms of utilization at the destination) is done in a safe manner. Regrettably, due diligence is not always exercised.
As mentioned before, another notable development is an emerging practice of 'immobilizing' plastic by using it as a component of construction materials, for instance in road paving, or any other products expected to have a long-life span. While such practice might be beneficial, the question of plastic safety is often neglected, and may allow potential leaks of microplastics and hazardous substances from the plastic components of the new products during use.

Policy responses

Although landfilling is the least preferred option in the context of circular economy, it will continue while search for and development of better alternatives continues. Under such circumstances, safety of landfill operations, publicly or privately operated, should be a priority of public policies, with a view to find and implement policies that will eventually divert plastics from landfills. Safe transportation of plastic waste to other regions and countries also must be a priority.

It will also be important for public policies to support research and comparative assessments, i.e., impact assessment, of recycling technologies and practices to avoid undesirable and unanticipated side effects.

7 Concluding Remarks

Reduction and, eventually, elimination of marine plastic litter requires a comprehensive, multi-pronged and aspirational plan of action that simultaneously addresses elements of circular economy practices, including changing of mindsets and behaviors of consumers, producers, policy makers. Practices in the G20 countries, as well as others, have already demonstrated technical and economic feasibility of minimizing leakage of plastic materials into the environment and their conveyance into the oceans along the life span of plastic packaging and plastic products, particularly of those that have short lives and move fast. They also demonstrate a range of policy measures that encourage actions by public and private actors.

Within the framework of circular economy, this paper highlights the potential contribution of policy measures and practices in design, production, use, end-of-first-life and disposal of plastic products that tend to litter waterways, freshwater bodies and oceans. It emphasizes that much of the challenge comes from land-based sources due to poor waste disposal and handling, insufficient waste infrastructure, in-efficient and polluting production practices and product designs, lack of awareness and indiscriminate littering behavior, and lack of alternatives to plastics products that do not compromise consumers' satisfaction and economics of industrial production.

Ultimately, plastic pollution is a sign of market failure. The cost of plastics does not include their economic and environmental impacts. By virtue of its material properties, particularly its resistance to degradation in the environment, the environmentally sound end of life plastics management in a resource-constrained world needs to be circular so as to ensure multiple, consecutive or rather endless and perpetual and complete recovery of plastics. The present costs for collection, sorting, separation, processing, use, recycling, reuse and disposal of plastics are much higher than cost of virgin plastics. Seemingly low cost of plastics leads to large volumes of consumption and lack of incentives for its recapture - in the form of material, product or product components - at the post-consumer stage.

Regulatory measures that close the leakage of plastics into the environment are required to create market incentives for investment and innovation for closing plastics loops. Product design, renewable and bio-degradable plastics, reverse logistics and innovative business models for product-life extension, sharing platforms, resource recovery, product as service and circular supplies could act as main drivers for unlocking economic value of plastic materials and prevent their escape to the oceans.

Based on the principles and practices of circular economy and review of key reasons for marine plastic pollution, three leverage points, each to be based on a comprehensive set of actions, can be proposed to start preventing marine plastic litter.

1. Design-out waste – retaining plastics within the economy

Prevention of plastic waste by closing the plastic materials loop through perpetual recovery and reuse focuses on extending, to the maximum, 'life' of the materials in the system including by utilizing discarded materials as secondary resources[79]. Closing the loop highlights the need for changing practices and encouraging innovations for adoption of plastic materials that are designed for circular use, products suitable for reuse, technologies needed for recycling and reprocessing plastics and business models that allow broad uptake of circular practices. Design based on the vision of the whole lifespan of plastic materials becomes paramount not only for materials and products (designed for recyclability/recoverability, without hazardous additives, with minimum material intensity) but also for production processes (based on principles of RECP), distribution, use (with choices leading to preferred products or services), recycling and disposal.

79 Closing the loop requires differentiation between biological and technical cycles where biological cycles feed materials back into the system and technical cycles recapture, recover and restore value of products, components and materials.

While policy portfolios aiming to prevent plastic leaks from the material loop will vary across countries, some common strategies for designing them could be guided by the following considerations:

a. “Closing the front door” by preventing some products entering the markets from domestic or foreign producers is one of the core principles. Examples of bans on production and/or sale of single-use plastics, e.g. plastic bags, products containing microbeads, single-use cutlery, cotton bud sticks, and bans on the use of hazardous substances in plastics and innovations towards these goals are examples of this strategy;

b. Providing incentives for perpetual use of plastic materials calls for a variety of actions ranging from support for research and development for new materials and product design to creation of conditions for technological solutions for enhanced recycling technologies and a level playing field for recycled (secondary) plastics, to development capacity for RECP within the private sector to facilitating investments in preferred technologies, support for technology transfer and citizen education;

c. “Closing the back door” by imposing measures that discourage leakage of plastic materials from the system. Among those are incentives (e.g., provision of the infrastructure to capture plastic materials and products before they leak, access to collection, sorting and separation systems and recycling facilities and measures for sharing the responsibility for the end-of-life stage between producers (EPR) and consumers (behavior changing measures such as levies, deposit-return schemes) as well as disincentives (e.g. fines).

These three points are closely interlinked – with closed “doors”, both front and back - stimuli for closing the material loop could start to drive the system towards the desired direction of circularity.

2. Prevent – containing leaked plastic

In instances where plastic did exit the continuous cycle of use and reuse, it is important to keep it from uncontrolled escape into the environment and, ultimately, from becoming marine litter. Capturing plastic waste at source is facilitated by a number of factors. For instance, effective waste and wastewater management systems to not only contain leaked plastics, but also to recapture and reintroduce some of it back to the loop; safe landfilling practices to keep deposited materials contained, possibly until such times that they can be recovered.

3. Recover – remove plastic material that is in the oceans

Complementary to multiple preventative measures that aim to stop further additions of plastics to oceans, actions are needed to recapture material that already found its way to the oceans – today's plastics litter being legacy of yesterday's poor choices, including in waste management. The amount of plastic litter – indicated by recent studies as significantly larger than estimated earlier – is a rapidly aggravating and immediate threat to ecosystems, human health and economic and social activities. While the cost of recovery operations is estimated at hefty billions, innovations are needed for new technologies for recovery in open seas, and to clean up beaches, river banks and drains.

The mechanisms that encourage waste collection from the seas, e.g., stimuli for fishers to retrieve fishing gear or other waste found in the water, are already successfully practiced. These normally require combined economic and legislative measures, e.g., legal responsibilities to take care of end of life products and financial schemes that assist in fulfilling such obligations. In addition to the technologies that are designed to physically collect marine litter, solutions that assist in tracking plastic pollution, using machine learning and data visualization, modeling of plastic litter movement providing leads to target cleanup operations and track perpetuators of littering and possibly illegal dumping are emerging and need further support. To bring the recovery actions to scale, realistic targets for recapturing of plastic litter might also be desirable at the national or regional levels.

The recommended framework of thinking and action for combating marine litter pollution is in line with the strategic direction of G20 members. The G20 Marine Action plan aims at both prevention and reduction strategies for elimination marine litter. Discussion of priorities, in the G20 meetings in Germany and Argentina, identified a number of actions, including effective waste management, remediation measures, awareness and education, research, engagement with stakeholders. It is hoped that this paper will contribute to further discussions of G20 stakeholder keeping plastic circulating within economy and out of oceans.

Annex A. RECP practices

The philosophy of RECP is built around minimization of resource consumption (including raw materials, water and energy) and wastes (including solid waste, waste water and air emissions) and is manifested within the production of plastic and plastic components. The table here demonstrates possible applications.

RECP Practice	Description	Examples for minimization of plastics waste in manufacturing
1. Good Housekeeping	Maintain a clean, organized and productive ('neat') workplace to eliminate avoidable 'wastage'	• Avoid mix-ups in material labeling, especially for additives • Make sure that no plastic waste is brought in during material delivery • Seal waste containers to avoid spill-overs during transport • Prevent mixing waste in the production process with other kinds of waste • Maintenance of equipment to prevent plastic material losses during breakdowns
2. Input Change	Choose inputs that are efficient, effective and/or pose minimum harm to the environment and human health	Change into more recyclable or biodegradable and compostable inputs
3. Better Process Control	Monitor and control processes and equipment so that they always run at highest efficiency and with lowest wastage	Establish and follow Standard Operating Procedures (SOPs)
4. Equipment Modification	Make existing equipment more efficient and less wasteful	Depends on the type of plastic production
5. Technology Change	Change over to new technology that is more efficient or produces less waste	Depends on the type of plastic production; 3D printing technology
6. On-Site Reuse and Recycling	Use previous 'waste' for similar or alternative purpose in company	Internal recycling depends on the type of plastic technology[80]. E.g., in injection molding, grinders are positioned close to injection presses that generate plastic waste in order to recover, crush and reintroduce the plastic waste into the production process. In rotary molding, plastic waste is ground, screened and re-introduced into the process. For the internal recycling of industrial plastics (machine purges, cores, manufacturing offcuts). In thermoforming, material for recycling is ground, extruded and re-introduced into the production chain as granules.
7. Production of Useful By-Product	Convert a previous 'waste' for a suitable use elsewhere	Plastic (and other waste) categorization and inventory as the first step for understanding potential use by company or other partners along the value chain
8. Product Modification	Redesign product to reduce its environmental impact during production, use and/or disposal	Dematerialization of the materials without compromising their quality (e.g., thickness of packaging, avoidance of additives), shift into biologically sourced raw material and material with easier recyclability

Source: R. V. Berkel, Z. Fadeeva (2018), Role of industries in resource efficiency and circular economy, conference paper, 8th International conference on sustainable waste management, India

80 https://www.paprec.com/en/understanding-recycling/recycling-plastic/using-plastics

Annex B. Regulations on plastic bags of G20 Members

Country and entry into force	Scale	Core focus
South Africa, 2003	National	Ban on bags less than 30 µm (microns, 10-6 meters) and levy on retailer for thicker ones. The first phase showed decrease in consumption, but lack of enforcement slowed the impact.
China, 2008	National	Ban on non-biodegradable plastic bags less that 25 µm and levy on consumer for thicker ones. Use of bags in supermarkets decreased by 60-80%. Not much impact among small retailers due to lack of enforcement.
India, 2016	National	Ban on non-compostable plastic bags less than 50 µm. The amendment of the Plastic Waste Management Rules (2018) put the country on the road to phasing out of Multilayered Plastic (MLP), which are "non-recyclable, or non-energy recoverable, or with no alternate use". Different states are now at various stages of planning and implementation.
Indonesia, 2016	Local level – for 27 cities, with Jakarta joining in January 2019	Levy on plastic bags on customers of selected retailers. In spite of some resistance from consumers, retailers and the plastic industry, reduction in use of bags was 40%.
South Korea	National	Proposal to ban single-use plastic bags in major supermarkets; stores are required to provide paper or cloth recyclable alternatives.
Japan	National	Proposal to impose a levy on consumers for the use of plastic bags (through shops and department stores). Ban, in principle, on the use of plastic straws and cutlery in government cafeterias and avoidance of the use of plastic bottles at conferences.
Germany, 2016	National	Shops and department stores to charge for the use of plastic bags.
Russia	Local	Ban by the Committee for Art and Culture on use of single-use plastic cutlery, caps and cutlery during events supported by the Committee and its entities.
Turkey, 2019	National	Levy on single-use plastic bags
Saudi Arabia, 2017	National	Regulation on the content of plastic bags and other plastic products that are locally made or imported. Plastic products must be made of an approved oxo-biodegradable material.
Argentina, 2017	Ban in the city of Buenos Aries	Ban on non-biodegradable plastic shopping bags less than 50 µm. Appears to have resulted in rising sale of private shopping trolleys
Brazil, 2009	Ban on polyethylene and polypropylene bags in Rio de Janeiro	Requirement to substitute polyethylene and polypropylene bags with more environmentally-sound alternatives, discount for bringing own bags, proper disposal of bags from any source if substitution did not happen.
Mexico	Mexico city local ban, 2010 and Queretaro local ban, 2018	Mexico requires use of biodegradable bags, with retailers to charge for them. Queretaro bans disposable bags
European Union, 2015	All Member States	According to the EU Directive 2015/720, Member-States must ensure that consumption of lightweight bags per person does not exceed 90 by 2019 and 40 by 2025. Selection of policies to reach these targets is left to the Member States.

France, 2016, 2015	National	Ban on single-use plastic, 2016, ban on lightweight single-use plastic extended to all plastic bags except compostable ones. Prohibition on production, distribution, sale, provision or use of oxo-degradable plastic bags. A ban, by 2020, on all disposable tableware that contains less than 50% of biologically sourced materials.
Italy, 2011	National	Ban on non-biodegradable plastic bags less than 100 µm with exception of reusable ones. Reduction of bag consumption by 55%
United Kingdom	Northern Ireland, 2013 Scotland, 2015 England, 2015	Levy on consumers of plastic bags in Northern Ireland, Scotland and England. Number of consumed bags decreased by 71% for the first year in Northern Ireland (followed by another 42.6% next year), 80% in Scotland within one year, 85% in England within six months.
Canada	Leaf Rapids, 2007 Wood Buffalo, 2010 Thompson, 2010 Montreal, 2015	Leaf Rapids – ban on plastic bags Wood Buffalo – ban on single-use plastic bags Thompson – ban on sale or free give away of plastic bags Montreal – ban on light-weight plastic bags
United States of America	Variety of bans and levies at the local level	Washington and Chicago – levy on consumers of plastic bags Seattle – ban of single-use plastic bags American Samoa – ban on use of petrol-based plastic bags Hawaii and Austin - ban on single-use plastic bags New York city - ban on single-use Styrofoam bags San Francisco and California – ban on single-use plastic bags and levy on consumers for use of recycled or reusable plastic bags.
Australia	Variety of bans and levies at the local level	Coles Bay - ban on non-biodegradable plastic check-out bags South Australia, Australian Capital Territory, Northern Territory, Tasmania and Queensland - ban on lightweight plastic bags

Source: compiled by the authors from various sources

Annex C: Global and regional conventions to control marine plastic pollution

Global scope	Regional scope
• *United Nations Convention on the Law of the Sea (UNCLOS)* • *London Convention* • *MARPOL Convention* • *The Basel Convention* • *Customary Law*	• *Bamako Convention (Africa)* • *OSPAR Convention (North Atlantic)* • *Cartagena Convention (Caribbean)* • *Tehran Convention (Caspian Sea)* • *Kuwait Protocol (Gulf Area)* • *Helsinki Convention (Baltic Sea)* • *Barcelona Convention (Mediterranean Sea)* • *Bucharest Convention (Black Sea)* • *Abidjan Convention (Atlantic coast of Africa)* • *EU Waste Framework Directive* • *EU Water Framework Directive* • *EU Marine Strategy Framework Directive*

Source: from Tickel 2019[81]

81 www.apeuk.org/OPLI

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