



Solutions for global marine litter pollution

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Since the 1950s the amount of plastics in the marine environment has increased dramatically. Worldwide there is a growing concern about the risks and possible adverse effects of (micro)plastics. This paper reflects on the sources and effects of marine litter and the effects of policies and other actions taken worldwide. Current knowledge offers a solid basis for effective action. Yet, so far the effects of policies and other initiatives are still largely insufficient. The search for appropriate responses could be based on possible interventions and profound understanding of the context specific factors for success. Moreover, the scope, timeframe and dynamics of all initiatives are distinctly different and orchestration at all levels, in close cooperation with one another is currently lacking.

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Introduction

Since the 1950s the amount of plastics in the environment has increased dramatically [1^{**}]. Jambeck *et al.* [2^{**}] estimated that between 4.8 and 12.7 million tons of land-based plastic waste ends up in the ocean every year. Plastics not only negatively affect aquatic ecosystems [3], but also societies and their economies [4]. Economic

activities such as shipping, fishing, aquaculture, tourism and recreation are directly affected by plastic pollution and the total negative impact on oceans has been estimated at least \$8 bn per year [4]. Moreover, there is an increasing concern about the risks and possible adverse effects of (micro)plastics to organisms [5,6] and human health [1^{**},7].

Current knowledge on the main causes of marine litter and about possible solutions offers a solid basis for effective actions [8]. Yet, it has become clear that so far the effects of policies and other initiatives are still largely insufficient [1^{**},2^{**}]. Moreover, global plastic production increases each year, it already exceeded 300 million tons in 2014 [9]. Considering the drivers for plastic use and the vital importance of plastics for modern life, for example due to its properties and the possibility of mass production, it is not expected that plastics production and use will be restricted anytime soon. If the current trend of a 5% production increase per year continues, an additional 33 billion tons of plastic will have piled up around the globe by 2050 [10]. High densities of litter are already found in very remote and uninhabited places like Henderson Island, where the density of litter was the highest reported anywhere in the world [11]. These figures stress the importance of preventing flows of plastics to the (marine) environment.

The solution to marine litter is likely to be found in a transition towards more sustainable ways of production and consumption that are also promoted via the Sustainable Development Goals (SDGs). The UN sustainable development agenda represents a plan of action involving 17 SDGs and includes targets to prevent and significantly reduce marine pollution of all kinds, including marine litter. Such a sustainability transition is a context-dependent, non-linear, evolutionary process that will include successes as well as failures [12,13]. It requires collective actions amongst a large diversity of actors across sectors and scales, and dealing with divergent perspectives and interests [14].

In this paper we set out to explore the particular governance and management challenges of marine litter. We reflect on the extensive literature on the sources and effects of marine litter, current knowledge on the effects of policies and other actions that are taken worldwide to mitigate and prevent pollution and the context-specific requirements for initiatives, policies and strategies. The aim of this paper is to identify the main challenges and to propose ideas that can help to orchestrate and accelerate the implementation of different solutions.

Marine litter

Marine litter (also called marine debris) is waste created by humans that has been discharged into coastal or marine environments, resulting from activities on land or at sea [15]. The majority of marine litter consists of plastics [1]. Plastics are generally divided into macroplastics and the smaller microplastics; the plastic particles <5 mm in diameter including nanoplastics [1]. Common smaller macroplastic parts (<2.5 cm) can originate from direct and indirect sources such as lost bottle caps or plastic fragments; common macroplastics, smaller than 1 m, originating from rivers or maritime sources such as plastic bags, food and other packaging, fishing floats, buoys, balloons and macroplastics larger than 1 m from fishing activities or catastrophic events such as abandoned fishing nets and traps, rope, boat hulls and plastic films from agriculture [16**]. There are two types of microplastics; primary microplastics that have been made intentionally (such as pellets or microbeads) and secondary microplastics that are fragmented parts of larger objects [16**].

Sources and pathways of marine litter are diverse and exact quantities and routes are not fully known. There is, however, a lot of research that aims to determine the exact quantities and types of plastic litter and pathways in the environment [2**,11,17–20]. Most of the plastic in our oceans originates from land-based sources [1**,21]. A study by Jambeck *et al.* [2**] revealed that developing economies are the most polluting. The study also showed that 83% of the 4.8–12.7 million tons of land-based plastic waste that ends up in the ocean from the 192 coastal countries originates from 20 countries (China, Indonesia, the Philippines, Vietnam, Sri Lanka, Thailand, Egypt, Malaysia, Nigeria, Bangladesh, South Africa, India, Algeria, Turkey, Pakistan, Brazil, Burma, Morocco, North Korea and the United States). Total annual waste generation was mainly determined by population size, hence the large populations of the ‘leading countries’ on the list. The amount of plastic waste eventually ending up in the ocean was mainly determined by the percentage of mismanaged waste. A study by Lebreton *et al.* [17] estimated that between 1.15 and 2.41 million tons of plastic waste flows from rivers into the ocean annually, likewise the main drivers were population density, mismanaged plastic waste and production per country. The top 20 of polluting rivers were mostly located in Asia, and accounted for 67% of the global total (Yangtze, Xi, Huangpu, Dong, Zhuijiang, Hanjiang in China; Brantas, Solo, Serayu and Progo in Indonesia; Pasig in the Philippines; Irrawaddy in Myanmar; Imo in Nigeria; Magdalena in Columbia; Tamsai in Taiwan; Kwa Ibio in Nigeria; the Ganges in India/Bangladesh; Cross in Nigeria/Cameroon; Amazon in Brazil/Peru/Columbia and Ecuador and the Mekong in Thailand/Cambodia/Laos/China/Myanmar and Vietnam).

Global efforts to support marine litter actions

Currently, there are several global efforts aiming at action for reducing and preventing marine litter and for mitigating its impacts. These include worldwide initiatives, for example, by the Global Partnership on Marine Litter (GPML), the Honolulu Strategy [15] and the G7 countries [22]. GPML is a voluntary multi-stakeholder coordination mechanism which brings together policymakers, civil society actors, the scientific community and the private sector to discuss solutions and catalyze actions. The Honolulu Strategy [23] is a planning framework for the prevention and management of marine litter and an effort to reduce the ecological, human health, and economic impacts of marine litter globally. It has a set of three specific goals to reduce marine litter and linked to each goal is a cohesive set of strategies: Goal A: reduced amount and impact of land-based litter and solid waste introduced into the marine environment; Goal B: reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, abandoned, lost or discarded fishing gears (ALDFG), and abandoned vessels introduced into the sea; and Goal C: reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters. At the 2015 G7 summit the protection of the Marine Environment was high on the agenda too and it was acknowledged that marine litter, in particular plastic litter, poses a global threat.

More and more countries are taking action against marine litter and during the 2016 United Nations Environment Assembly (UNEA-2) [24] countries unanimously adopted a stand-alone resolution on marine litter. The resolution acknowledged marine plastic and microplastic as a rapidly increasing, serious problem of global concern that urgently needs a global response. The resolution signals countries’ continued willingness to put marine plastic pollution high on the environmental policy agenda. In order to keep it also high on national agendas, pollution will be the focus of the 2017 UN Environment Assembly in December.

Four of the SDGs have targets relevant to marine plastic pollution (Table 1). These targets deal with untreated wastewater, waste management in sustainable cities, management of waste throughout their life cycle — with focus on prevention, reduction, recycling and reuse — and sustainable management of oceans.

At the June 2017 United Nations Conference to Support the Implementation of Sustainable Development Goal 14 of the 2030 Agenda affirmed a strong commitment to conserve and use our oceans, seas and marine resources for sustainable development. To increase global action leadership and commitment by government at all levels is needed.

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