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Introduction: Plastic Pollution in the Global Ocean

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Plastic pollution is a growing environmental problem that is attracting increasing interest across society, from academics to the general public. A significant factor in the wide public interest in plastics is its visibility: present throughout urban and rural environments, washing up on beaches and even visible from space (Biermann *et al*., 2020; Topouzelis *et al*., 2019). With growing plastic production and usage, plastic waste within the environment will continue to increase. This increased input, along with its persistence, leads to accumulation and increasing ecosystem exposure, with as-yet-unknown consequences.

Public awareness of plastic pollution lies primarily in the portrayal that is presented by the media. This usually entails charismatic megafauna such as whales, dolphins and turtles entangled in plastic fishing lines or carrier bags, or washed up dead on beaches with stomachs found to be full of plastic. Indeed, this is part of the plastic pollution story, but certainly not the entirety. Recently, news stories have more frequently been presenting broader aspects of plastic pollution, including the abundance of microplastics (plastic particles 1 μm–5 mm in size) and possible ecological hazards posed by these, both to ecosystems and to human health. While useful for people to be aware of the wide aspects of environmental issues and ongoing areas of research, dramatic stories are often prioritised to garner attention, often despite incomplete evidence or only preliminary data. This presentation of provisional or uncertain information as hard facts can lead to scaremongering, leading people to feel overwhelmed, scared or powerless given the scale of the issue, thus leading to inaction, apathy or "environmental fatigue". While many media outlets will in fact endeavour to present an unbiased and accessible picture, the best way to present accessible and factually correct scientific information to the public is directly via communications from scientists themselves.

With respect to scientific research on plastics, this is a highly nuanced and complex field. In addition to the aforementioned topics of megafauna ingestion and plastic hazard, research is targeting a huge variety of aspects of the issue, including material sources, chemistry and degradation, plastic transport and fate, trophic transfer and ecosystem-scale effects, human health, and novel polymer alternatives, to name only a few. The field of plastic pollution research is moving incredibly quickly, with multiple new publications and data published every week. However, while the scientific literature is rapidly growing, these publications are often targeted at those with very specific expertise, and it can be difficult even for researchers themselves to determine which are the most pertinent, and of the highest quality, without sifting through large volumes of information. There is, therefore, a need for an accessible, up to date volume which draws together the key state-of-the-art knowledge and research in a comprehensive yet concise way.

This book brings together a collection of chapters written by world-leading experts in environmental plastic pollution inputs, fate, effects and solutions. This book provides a clear overview of the current scientific understanding, future implications and key considerations for the management and mitigation of plastic waste within the world's oceans. This is delivered through synthesis and presentation of current and relevant information in a logical and manageable structure. This book will, therefore, act as a key reference text which can be used by undergraduates to experienced academics wishing to learn more or update themselves on the subject, in addition to policymakers, regulators and industrial professionals who have a stake in better understanding, addressing and tackling the issue of plastic waste within the environment.

1. Current Understanding of Plastic Pollution

The amount of plastics being produced annually is exponentially increasing, from 1.7 million tonnes (Mt) in 1950 to 368 Mt in 2019

(Figure 1). However, waste management systems have not kept pace with this rapid development and production of plastic materials, and consequently, large amounts of plastics now enter the environment annually, as a result of both intentional and unintentional disposal. It is estimated that of the 6.3 billion metric tonnes of plastics produced globally up until 2015, 79% of this remains as waste within landfills or in the natural environment (with the remainder having been recycled or incinerated). By 2050, this could account for 12 Bt of waste plastics in the environment (Geyer *et al*., 2017). Estimates of the volumes of plastic input to the environment vary depending on the factors used to predict losses (including population size, waste generation, waste mismanagement, regional income and more), but estimates currently range between 5 and 23 Mt of plastics entering aquatic systems (including rivers and lakes) per year (Borrelle *et al*., 2020; Jambeck *et al*., 2015).

As these estimates show, in line with human activities, it is recognised that majority of marine plastics come from land, and indeed studying land and rivers is imperative to understanding the bigger picture of plastic pollution. Nonetheless, the ocean is recognised as the final sink for a large proportion of land- and marine-derived plastics (such as fishing gear and shipping debris), whereby once plastics enter the oceans, they are unlikely

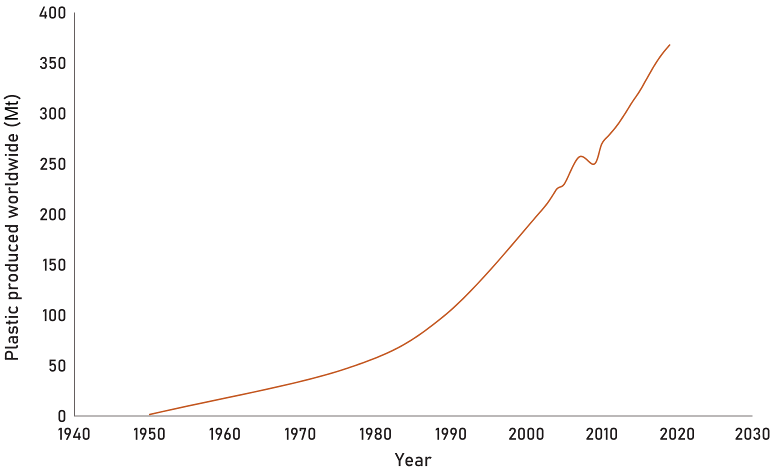

Figure 1. Global plastic production by year since commercial plastic production began in 1950.

Source: Adapted from PlasticsEurope (2012, 2015, 2016, 2018, 2020, 2021).

to be returned to land, except for the small proportion that washes up on beaches (note that the predicted amount of plastics beaching is variable depending on different models used, and whether beaches are actually included in the models — exclusion from models does not necessarily mean that no beaching occurs (Lebreton *et al*., 2019)).

Plastics on land will be subject to environmental processes that accelerate their degradation, such as exposure to UV radiation, proportionally higher temperatures achieved on land, biodegradation via microorganisms and mechanical degradation (for example, on road surfaces or via agricultural activities). However, plastics in the oceans, especially sub-surface, will not be subject to such dramatic variations in conditions and are thus likely to degrade at a far slower rate (Andrady, 2015; Barnes *et al*., 2009) (Table 1). While microorganisms may be more likely to colonise plastics within an aquatic environment than on land and can secrete enzymes which facilitate biodegradation, the actual decomposition resulting from microorganism associations is negligible in the marine environment, due to limited oxygen and low temperatures (Andrady, 2015). Especially where plastics reach the ocean floor, they will also be exposed to little or no sunlight plus low temperatures, and thus degradation will be considerably restricted. This can lead the deep sea floor to become a sink for microplastics (Woodall *et al*., 2014), leading to accumulation hotspots (Courtene-Jones *et al*., 2020; Kane *et al*., 2020).

In 2015, a publication by van Sebille *et al*. (2015) stated that due to the scarcity of ocean plastic data, 99% of the plastics believed to have been input to the ocean were unaccounted for, i.e., only 1% had been detected and quantified. Since then, research has developed significantly, however we still do not have a full understanding of the fate and final sinks of the majority of marine plastics. Recent research has shown that there are in fact greater volumes of plastic by mass in the oceans (in a study focussed on the Atlantic Ocean) than was previously believed to have been input. Of only three common polymers (polyethylene, polypropylene and polystyrene) and even if only considering microplastic-sized items, it was calculated that over five times as much plastic was present within the Atlantic than predictions would suggest (Pabortsava & Lampitt, 2020). This may be due to the combined factors of analysing far smaller particles than the majority of studies to date (>25 μm compared to >100 or >300 μm) and also analysing sub-surface waters. In many previous studies, only surface plastics were considered within ocean plastic budgets,

Table 1. Processes affecting plastic degradation in different environments.

	Environment			
Driver of degradation	**Land**	**Beach**	**Surface water**	**Deep water or sediment**
UV exposure (sunlight)	Yes	Yes	Yes	No
High temperatures	High	High	Moderate	Low
Oxygen levels	High	High	High/Moderate	Low
Biofouling[a]	No	No	Yes	Yes

Note: [a]May contribute to biodegradation through presence of microorganisms or may shield particle from UV light.
Source: Modified from Andrady (2015).

based on an assumption that the majority of plastics will float. We now know this not to be the case: in addition to large amounts of non-buoyant plastics within the ocean (i.e., plastics with a greater density than seawater, for example, PET and PVC; Table 2), many supposedly buoyant polymers can be found within the water column and deep sea (Bergmann *et al*., 2017; Pabortsava & Lampitt, 2020; Zhang *et al*., 2020), as a result of biofouling, aggregation or incorporation into organic matter, such as faecal pellets and marine snow, all of which can enhance an item's density (Cole *et al*., 2016; Porter *et al*., 2018). Publications such as these highlight the rapid development of our understanding in this area over the last few years but also highlight the crucial need to continue to develop our understanding and research in this field, given how significantly our understanding can change with new data and synthesis.

2. Key Themes for Understanding Plastics in the Oceans

2.1. *Sources of plastics to the environment*

Plastics are a diverse and heterogeneous material group. They are synthetically produced using a carbon-hydrogen (C–H) backbone, with different functional groups. Each permutation of chemical structure, formed as a result of the composition and position of atoms, thus forms a different polymer type. To the polymers are added colourants and additive chemicals to give each plastic its desired characteristics for the intended application, from packing to textiles, construction materials to paints, and many more in between.

As a result of the growing global demand for plastics due to their cheap, convenient and resilient nature, sources of plastics to the environment are also widespread, as a result of careless discard, mismanagement of waste streams, or intentional dumping. The key sources vary regionally, however the largest contributors also tend to correlate with the polymers and items most commonly produced (Andrady, 2011; PlasticsEurope, 2020) and those products designed for a short lifetime and rapid replacement (regardless of how long the material is capable of continuing to do its intended job). The most common polymer types produced in 2019 were polypropylene (PP), low-density polyethylene (LDPE) and high-density polyethylene (HDPE) (Table 2) (PlasticsEurope, 2020), which correlates strongly with polymer types found in environmental studies (Jones *et al*., 2020; Naidu *et al*., 2021; Zhang *et al*., 2017). Examples of the most common items found within the environment, or fragments thereof, include pre-production pellets, single-use packaging, vehicle tyres, paints and coatings, fishing gear and textile fibres (Boucher & Friot, 2017; Hann *et al*., 2018).

Confounding our understanding of the abundance, fate and effects of plastics in the environment is the fact that plastics are commonly

Table 2. Common polymer types produced in Europe in 2020.

Polymer name	Abbreviation	Polymer density (g/cm^3)	Proportional demand (%)
Polypropylene	PP	0.89–0.91	19.7
Low-density polyethylene	LDPE	0.89–0.94	17.4
High-density polyethylene	HDPE	0.94–0.97	12.9
Polyvinyl chloride	PVC	1.3–1.58	9.6
Polyethylene terephthalate	PET	1.29–1.4	8.4
Polyurethane	PUR	1.17–1.28	7.8
Polystyrene	PS	1.04–1.08 (expanded PS = 0.015–0.03)	6.1
Other	—	—	18.1

Note: Density of seawater ranges from 1.02–1.03 g/cm^3.
Source: Demand data from PlasticsEurope (2021); Density data from Nuelle *et al*. (2014).

considered as a single pollutant type ("plastic"), regardless of variations in polymer type, size or shape. In early plastics research, this very broad characterisation was sufficient — studies were simply interested to report, for example, plastic particles ("microplastics") within the environment where these had not been previously observed (Carpenter & Smith, 1972; Thompson *et al*., 2004). However, it is now clearly known that these varied characteristics can significantly influence the behaviour, fate and ecological effects of plastics and are, therefore, crucial to take into account when trying to understand plastic abundance and distribution within the oceans (Bansal *et al*., 2021; Skalska *et al*., 2020; Walsh *et al*., 2021). With our greatly improved knowledge, these days, this generalisation is, therefore, no longer appropriate. Much more constructive is distinguishing by polymer type and shape (e.g., "polystyrene microplastic beads"). This is becoming widely recognised by researchers in this field, who are more frequently measuring and reporting the specific and varied characteristics of particles both found in the field and those used in experimental laboratory studies.

2.2. *Regional differences*

It is fundamental to our understanding of plastics in the environment to acknowledge that plastics, while globally ubiquitous in their presence, are extremely heterogeneously distributed, both in terms of abundance and type. This depends on a combination of factors including local sources and environmental processes affecting the transport of plastic (wind, rainfall, water currents, natural or artificial structures and anthropogenic activities). For example, in the River Ganges, a very large proportion of large (macro)plastic debris has been identified to be derived from fishing gear (Nelms *et al*., 2021), translating, along with laundered clothing, to an abundance of microplastic fibres also observed in this river (Napper *et al*., 2021). In the Great Pacific Garbage Patch, 46% of debris is derived from fishing nets, likely transported from Asia (Lebreton *et al*., 2018). These observations are likely due to the importance of artisanal fishing in countries whose income depends on abundant natural resources derived from rivers and coastal areas, and thus the high level of fishing activity compared to countries who do not have such abundant resources or rely on them less. For example, the River Mekong supports the largest inland fishery in the world, while the Ganges–Brahmaputra–Meghna Delta fisheries (India and Bangladesh) contribute 4–5% GDP (Lauria *et al.*, 2018). In other regions, other sources of plastic dominate. For example, in the River Thames, UK, wet wipes and sanitary products (made from synthetic textiles) derived from untreated sewage are the dominant form of macroplastic litter, in addition to single-use items (Bernardini *et al.*, 2020; McCoy *et al.*, 2020; Morritt *et al.*, 2014). Also in Europe, the dominant sources of plastic (if only considering microplastics) are tyre wear particles, road marking paints, and pre-production pellets (Hann *et al.*, 2018). This regional variability is very important to be aware of, especially when developing models of plastic abundance and sources using field data, as data from one study may not be directly representative of the wider area or areas being modelled.

2.3. *Factors influencing plastic fate*

The diverse nature of plastics detailed earlier has a significant influence on their degradation, fate and interactions within the environment. The principal consideration is the density of the polymer, which will determine whether an item sinks or floats in seawater or freshwater. If pristine, a polymer that is denser than 1 g/cm^3 will sink in freshwater, while a polymer denser than 1.02–1.03 g/cm^3 will sink in seawater. However, environmental studies have shown that polymers which would be expected to be buoyant are commonly found within the water column and sediment, far below the water surface (Kanhai *et al.*, 2019; Pabortsava & Lampitt, 2020). This is because their density, and thus their fate, is also significantly influenced by biological interactions, for example, the development of biological communities (biofilms) on the surface of plastics, ingestion by organisms, or aggregation with organic matter, such as marine snow or faecal pellets (Cole *et al.*, 2016; Porter *et al.*, 2018). The behaviour of plastics will also be influenced by their initial shape and size, which will influence physical interactions of plastics with the surrounding environment, for example, whether they are transported easily by currents and winds. Furthermore, their size will influence their surface to volume ratio, and thus their surface area, determining the area available for biological and chemical interactions (Chen *et al.*, 2021; Deng *et al.*, 2021; Endo & Koelmans, 2019).

While plastic is persistent, degradation does occur, leading plastics to age, crack and break down into smaller pieces. In this way, large items will eventually form microplastics and nanoplastics, which have different toxicological effects compared to larger, pristine items (Lambert *et al*., 2017). For example, smaller particles are often observed to be more toxic than larger particles due to their enhanced bioavailability and ability to translocate within tissues and cells (especially in the case of nanoplastics) (An *et al*., 2021; Yang *et al*., 2020), although this size effect is not consistent across studies (Wu *et al*., 2021). Ageing also leads to the association of microplastics with pathogens, organic chemicals or metals not present on pristine particles, and thus toxicity may increase by association (Castro-Castellon *et al*., 2021; Wang *et al*., 2020). Nonetheless, ageing can reduce the inherent toxicity of plastics, as incorporated chemicals are leached out and thus plastics become more inert over time (Pflugmacher *et al*., 2021). Exposure to leached chemicals can also cause toxicity in itself, even where the physical plastic item is no longer in the vicinity (Luo *et al*., 2020; Zimmermann *et al*., 2020). This highlights that the characteristics of the particles, in addition to the amount of time they have been in the environment, can significantly influence the hazard that plastics pose to organisms and ecosystems.

2.4. *Ecological and toxicological effects*

Complicating our understanding of the hazard posed by plastics is the fact that under some experimental conditions and with some species, plastics (especially small-scale particles such as microplastics and nanoplastics) cause rapid and extreme health effects or mortality, while under other conditions and to other species, no effect is observed. Experimental ecotoxicological studies are commonly carried out using microplastics and nanoplastics (as opposed to macroplastics) due to the practical and ethical limitations of working with large items and organisms. However, it is not often observed that microplastics and nanoplastics cause outright mortality to organisms, unless at very high (unrealistic) concentrations. Instead, chronic exposure can lead to the manifestation of sub-lethal effects, such as hormonal changes, oxidative stress, and reduced growth and reproduction (Piccardo *et al*., 2021; Wang *et al*., 2019; Yu *et al*., 2020). This means that the acute ecotoxicological studies that are commonly carried out are unlikely to provide a good representation of the chronic effects of extended low-level exposure that will be characteristic of the real environment. Nonetheless, they can give an indication of toxicity thresholds, above which harm will occur for different species.

One way to assess the effects of microplastics across a range of species is to use a species sensitivity distribution (SSD) curve. This uses toxicity data for a given endpoint (for example, mortality or growth) to give an indication of likely community-level effects across multiple species (Posthuma *et al.*, 2001). By starting with multiple data points of microplastic toxicity for one species, a species-specific probability function can be used to assess the likelihood of microplastics being toxic (or harmful) to this species (Adam *et al.*, 2019). While it is possible to use a single toxicity measurement for one species, it is not useful to use only data from one study, as many factors other than simply the microplastics concentration (such as temperature and food availability) can also influence the toxicity. Calculating these species-specific probabilities across a range of different species then enables an SSD curve to be plotted, to compare species sensitivities and predict the cumulative proportion of species that will be affected at a given concentration of microplastics (Adam *et al.*, 2019; Burns & Boxall, 2018). This also enables the calculation of a predicted no effect concentration (PNEC), i.e., a "safe" environmental concentration at which, theoretically, no ecological harm occurs. It should be noted that the more data available, the more likely it is that this value can be predicted accurately, although some uncertainty is unavoidable (Posthuma *et al.*, 2001). These data can (and should) be further separated by polymer type, particle size and particle shape where possible, however this relies on sufficient available data across multiple species for these descriptors. SSDs can only work effectively where multiple data points are available across multiple species (Besseling *et al.*, 2019). For certain species, for example, model organisms such as *Daphnia magna* which are commonly tested upon, data are often available across a range of stressors including different types of microplastics, but such calculations become difficult or impossible where limited data exist.

Where data are available, further calculations can be undertaken to compare the PNEC resulting from the SSD to measured environmental concentrations (MECs) within different locations, to predict location-specific risks to ecosystems. Current predictions suggest that global risks resulting from microplastics are low (overall in the global surface ocean 0.17% of organisms inhabiting the surface layer are at risk), but thresholds may exceed in particularly contaminated regions, such as the Mediterranean Sea and the Yellow Sea. This risk is likely to increase, given predicted increases in contamination over coming decades (Everaert *et al.*, 2020).

However, it is worth bearing in mind that due to limited data, this particular analysis did not take into account particle characteristics in influencing their toxicity. It is for this reason that continued ecotoxicity testing, especially across varied species (not simply model organisms), is crucial for a broader understanding of long-term ecosystem-level effects of microplastics.

3. Structure of the Book

This book provides a wide overview and greater depth of some of these key issues and considerations related to plastics within the oceans. The structure is intended to logically flow through the fundamental topics, starting from an overview of the history and usage of plastics and the likely future of these materials moving through the state of the knowledge in different specific research areas and key oceanographic regions, with considerations on waste management, novel materials and potential solutions to the problem of plastic pollution. This format will give the reader a sound overview of the current state of the science in this highly topical and fast-moving field.

A brief overview of each chapter is given as follows.

Chapter 1 gives the backstory of plastics, how and why they were developed, and how they became viewed as a "wonder material" leading to huge consumer demand and the rapid growth in plastic production in recent decades. The chapter also outlines some of the challenges related to the handling of these materials as waste, potential future options for reducing our huge reliance on plastics, and thus angles for solutions to the huge volumes of plastic currently entering the ocean and wider environment.

Chapter 2 considers the amounts, sources and pathways of plastic waste into the ocean (including air, land and freshwater), especially considering the importance of rivers as part of the "plastic cycle". It is essential to be aware that not all plastics that enter rivers will reach the ocean, given that rivers can act as significant sinks for plastics. This is crucial to account for in global plastic transport models, many of which currently assume that all plastics derived from land and entering rivers will ultimately reach the ocean. This chapter thus better helps the reader to understand how location, environment and annual/seasonal conditions can influence plastic transport and retention in the environment, and what ultimately reaches the sea.

Chapter 3 elucidates some of the key factors that influence the distribution and fate of plastics once they reach the oceans. There are a multitude of factors influencing plastics' transport, from physical, biological and chemical interactions of the particles with other materials and biota to environmental conditions, such as waves, wind and currents. All of these will influence where plastics end up, how they will degrade and ultimately their accumulation and longevity in the oceans.

Multiple reports have now highlighted the perils of large plastics within the marine environment, posing a hazard to marine megafauna, such as mammals and reptiles. These plastics may be in the form of large litter lost from land or discarded from ships, or abandoned or discarded fishing gear (also known as ghost gear). These plastics have the potential to last for hundreds of years, capturing, entangling and injuring countless organisms during their time at sea. **Chapter 4** details some of the current knowledge and considerations for megafauna interactions with plastics, and future research recommendations.

Chapter 5 introduces microplastics: what they are, where they come from, how they are formed, and the factors that lead them to further fragment and degrade within the marine environment. Given that all plastics in the environment will eventually degrade into microplastics (and eventually, nanoplastics), microplastics form a fundamental part of the plastic issue and must be equally studied and understood if we are to understand the long-term implications, mitigation strategies and solutions for plastic pollution.

Following the introduction to microplastics, **Chapter 6** covers the various interactions of marine invertebrates, including zooplankton, with microplastics. Detail is provided on studies which have measured the abundance of microplastics in different invertebrate organisms globally, as well as some of the observed effects microplastics can have across different species. This chapter provides context for lower trophic organism exposure to plastics and also how these organisms might themselves influence the distribution of plastics within the environment.

Building on the previous chapter, **Chapter 7** provides a detailed overview of microplastic and nanoplastic toxicity across different organisms, and how toxicity is influenced by specific particle characteristics including polymer type, shape and size. Local environmental factors will affect concentration and thus ecosystem exposure, therefore microplastic effects on ecosystems are highly unlikely to be consistent worldwide, instead varying at a regional or local scale. Consideration is also given to the possible long-term ecological implications of the increasing volumes of plastic waste within the environment.

The Arctic has a low human population compared to most of the rest of the world but is nonetheless incredibly ecologically and economically important, including for fisheries, shipping and tourism. The Arctic is also one of the most rapidly changing global regions, as a result of a changing climate leading to air and sea surface warming, and melting sea ice. Despite comparatively few local sources, the nature of ocean currents, converging in the Arctic, means that once plastics reach the Arctic, they are unlikely to leave, leading the Arctic to become a sink for plastics of all sizes. **Chapter 8** details the implications that this contamination may have and the importance of studying the Arctic for plastic pollution.

Considered by many to be a pristine environment or "the last untouched ocean", Antarctica and the surrounding Southern Ocean are nonetheless subject to anthropogenic influence and contamination in the form of plastic (and other) waste. While the only continent without a permanent human population, and still comparatively clean compared to other regions, contamination results from tourism, research operations and long-range transport from far-afield regions. **Chapter 9** considers how the specific activities within, and characteristics of, this region influence the presence and abundance of plastics, and ways in which this might be managed in coming years, to ensure this important region remains as unpolluted as possible.

Plastics are known to act as substrates for a range of organisms which use these items as novel habitats. This extends not only from large organisms such as invertebrates and plants but also to microbes which build communities on the surface of macroplastics and microplastics. It has been observed that different communities form on plastics compared to on natural substrates, and that the colonisation and subsequent transport of lightweight plastics can lead to the transport of species to locations in which they are not native, known as "the vector effect". **Chapter 10** covers some of the issues surrounding this association of microbial communities with plastics.

Biodegradable plastics have recently been in the spotlight as a suggested solution to the plastic pollution problem, whereby these materials could replace conventional plastics. However, there are common public misconceptions that these materials are less hazardous than plastics and will naturally degrade if thrown anywhere within the environment. **Chapter 11** considers the pros and cons of these novel materials as plastic alternatives, from the perspective of the chemistry of the materials, their characteristics, and the ecological, social and economic and waste management considerations that must be taken into account when considering replacing plastics with these alternative materials.

No volume on plastic pollution would be justified or compete without expert thoughts and suggestions on how the plastic problem can be tackled from different angles. **Chapter 12** provides details and considerations of policies, industry action, novel technologies and innovative solutions required to reduce unnecessary plastic use and loss, all with the aim of preventing plastics from entering the environment.

The issue of plastics is complex and impossible to fully cover in detail in one book alone. Multiple different material types, production techniques and uses mean that plastics, while incredibly useful, pose long-term challenges for our use and disposal of them. No one solution alone will be capable of solving the problem of plastics in the ocean, and indeed many of the related issues will be far more costly to tackle (both economically and environmentally) than may be feasible or beneficial. Instead, a suite of interlinked approaches must be taken by various stakeholders to ensure plastics do not pose long-term risks to human and ecosystem health. This is especially crucial in the oceans given the fundamental importance of oceanic ecosystems for maintaining life on earth, through carbon sequestration, oxygen production and food supplies. Many marine ecosystems have yet to be fully explored or even discovered, and thus through anthropogenic activities, we risk damaging or totally changing these ecosystems before we are even aware of their existence. This book, therefore, aims to give the reader a broad overview of the topic of plastic pollution from the perspective of different experts, from which point the reader will be better informed to make decisions, pursue future research or simply discuss the topic with peers.

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