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Review of Current Knowledge and Data on Marine Litter in Asia

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FOREWORD

Plastic pollution is a burgeoning planetary crisis. It threatens marine and fresh water species and ecosystems. And it presents dangers to human health through multiple pathways, including contributions to climate change.

The Asia-Pacific Region is the largest generator of plastic waste globally and the site of numerous hotspots of plastic emissions into the ocean, as revealed in this report. Over the years, Member States in the region have adopted multilevel mitigation strategies and action plans. Their implementation and effectiveness in reducing plastic emissions into the ocean, however, have not been quantitively and rigorously assessed. Constraints to this end have been insufficient data-collection, inadequate solid waste management and the absence of systematic reporting of plastic production and consumption.

The COVID-19 pandemic has further intensified the reliance on single-use plastic, increasing the quantity of waste especially from delivery services and medical personal protective equipment, affecting overall waste composition and complicating treatment and disposal capacities. While fighting the pandemic, governments have seen the pollution challenge deepening on both land and in the seas. Even with the ambitious commitments currently set by governments and industry, plastic emissions into the region's marine and freshwater ecosystems are set to grow rapidly in the years ahead.

Ultimately, these insidious and emerging challenges to our environment threaten the progress and delivery of several interlinked Sustainable Development Goals, including Goal 9 – Industry, Innovation and Infrastructure; Goal 12 - Responsible Consumption and Production; Goal 13 - Climate Action; and above all, Goal 14 - Life Below Water.

We appreciate the inspirational collaboration from our regional partners, authors and reviewers as well as our colleagues at the UNEP Regional Office for Asia and the Pacific in making this report available. It has served as an essential resource in guiding discussions of the Inaugural Session of Asia-Pacific Science-Policy-Business Forum on the Environment, held virtually on 5 October 2021. This report has also informed the fourth session of the Forum of Ministers and Environment Authorities of the Asia-Pacific, co-hosted by UNEP and the government of the Republic of Korea.

We strongly hope the data and knowledge presented in this report and shared at these sessions would spearhead transformative re-evaluation of technological and policy solutions by policymakers, industry and the public.

To this end, we also call for a multi-stakeholder, pan-regional commitment to closing the most critical scientific data and research gaps. Agreed upon standards and near-real-time measurement and reporting of material flows and impacts across the plastics supply chain will guide the interventions—required at all levels—to eliminate plastic pollution for generations to come.

Dechen Tsering
UNEP Regional Director and Representative
for Asia and the Pacific

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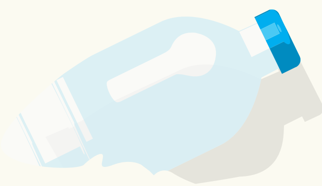

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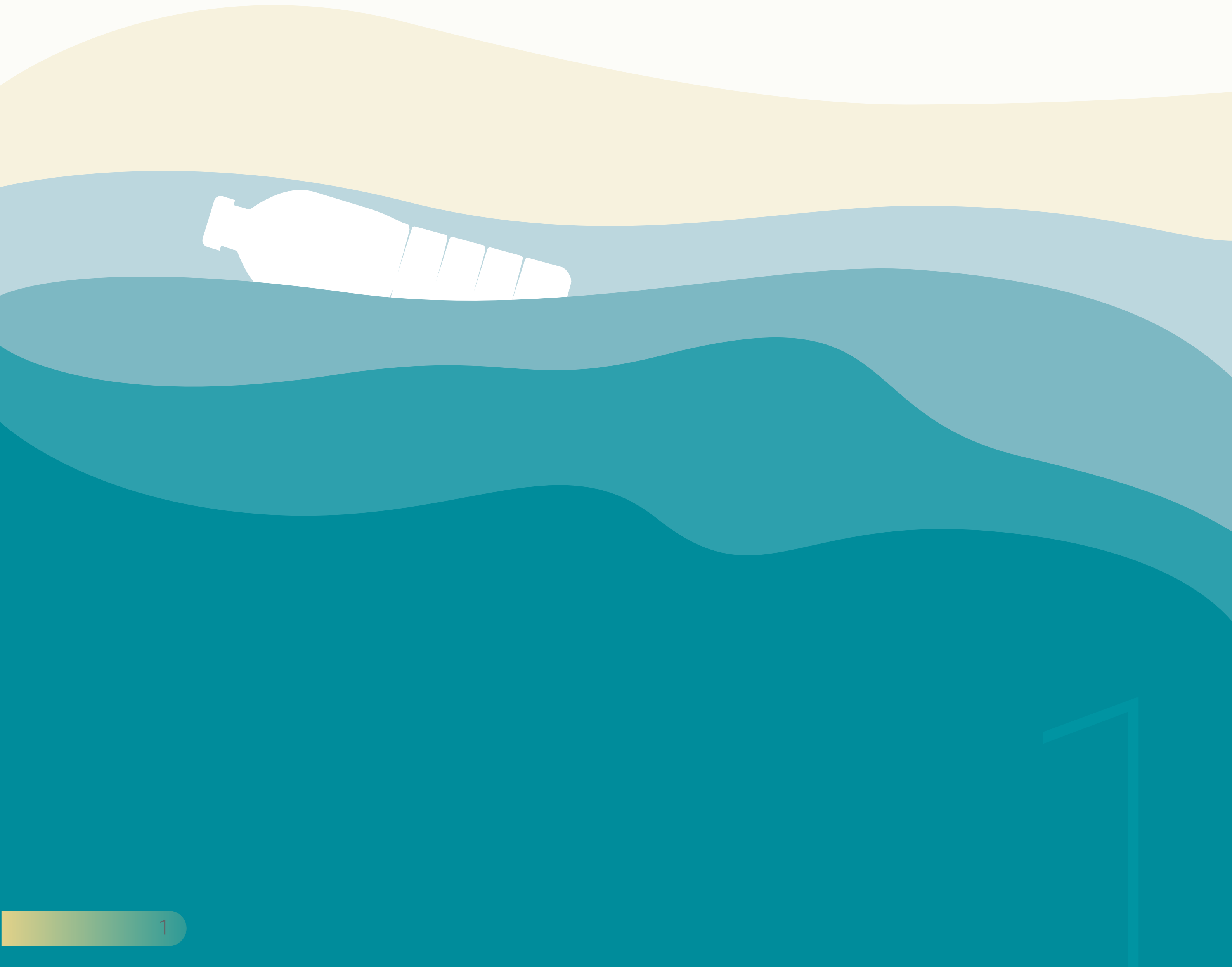
ACRONYMS AND ABBREVIATIONS

APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
COBSEA	Coordinating Body on the Seas of East Asia
FAO	Food and Agriculture Organization of the United Nations
FTIR	Fourier-transform infrared spectroscopy
GPML	Global Partnership on Marine Litter
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
HDPE	High-density polyethylene
IMO	International Maritime Organization (of the UN)
IOC-UNESCO	Intergovernmental Oceanographic Commission of UNESCO
LDPE	Low-density polyethylene
LLDPE	Linear low-density polyethylene
MSW	Municipal solid waste
NGO	Non-governmental organization
NOWPAP	North West Pacific Action Plan
NSWMC	National Solid Waste Management Commission (of the Philippines)
PET	Polyethylene terephthalate
PP	Polypropylene
RAP MALI	Regional Action Plan on Marine Litter
ROV	Remotely operated vehicle
SACEP	South Asia Co-operative Environment Programme
SDG	Sustainable Development Goal
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCRD	United Nations Centre for Regional Development
UNDP	United Nations Development Programme
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNGA	United Nations General Assembly
UNSD	United Nations Statistics Division
WtE	Waste-to-energy

Introduction



Marine litter has become a global concern in recent decades owing to the high concentration of human activities and ineffective waste management practices in coastal regions. Of all marine litter, plastics are the most common type, making up between 60 to 80 per cent of the entire share (Rios, Moore and Jones 2007); it accumulates along shorelines, including on those of the most remote islands (Lavers and Bond 2017), as well as in the open ocean and deep seas (Barnes 2004).

In this report, the term "marine litter" is defined as "any persistent, manufactured or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment" (UNEP[OCA]/LBA/IG.2/7).

While marine litter, especially plastic marine litter, has quickly gained attention globally, the understanding of its sources, transportation and fate is still scant, thereby hindering the implementation of effective solutions to this global issue. It is commonly agreed that marine litter generation is closely associated with inadequate waste management practices on land.

Since Asian nations have been regarded as one of the top sources of marine litter (Jambeck *et al*. 2015; Lebreton *et al*. 2017), their priority action must include an improved understanding of the status of marine litter and waste management in Asia. More importantly, plastic pollution disproportionately affects marginalized communities and communities living in proximity to plastic production and waste sites, constituting an environmental injustice (UNEP 2021).

Moreover, it is crucial to understand the impact of this issue on gender diversity. Although both men and women suffer from the negative health impact of marine litter, women and children are especially sensitive to toxins contained in fish and microplastics in the environment (Campanale *et al*. 2020; Street and Bernasconi 2021). Thus, coordinating an effective mitigation strategy in this region is an imperative.

The need to better understand marine litter in Asia has been made even more urgent by the COVID-19 crisis. While it is too soon to have a full picture of the pandemic's impacts on marine litter in Asia, available data has shown a significant increase in single-use plastic in the region (UNESCAP 2021). The measures adopted as a response to the crisis have often made it difficult for the informal waste sector to continue to operate, and coupled with low oil prices, these factors have negatively affected the profitability of plastic recycling, resulting in decreased recycling rates compared with pre-pandemic levels (United Nations Environment Programme [UNEP] 2021).

As recognized in the 2006 United Nations (UN) General Assembly Resolution "Oceans and the law of the sea" (A/RES/60/30), a substantial barrier in addressing marine litter pollution is the absence of adequate research, assessment and monitoring, activities upon which the status and impacts of marine litter on a global, regional, national and local scale can be thoroughly determined (UNEP 2009).

With the adoption in 2019 of "Marine plastic litter and microplastics" (UNEP/EA.4/Res. 6) at the Fourth Session of the UN Environment Assembly, UNEP acknowledged the need to foster effective science-based policy action via the collection of high-quality data and the effective monitoring of land- and sea-based sources, focusing on the quantities and the fate of marine litter, including its distribution and impact, on the ecosystem. This 2019 resolution also requests that UNEP strengthen scientific and technological knowledge on marine litter through various measures. These include compiling available scientific and other relevant data and information needed to prepare an assessment on the sources, pathways and hazards of marine plastic litter, including plastic litter and microplastics, in rivers and oceans.

Thus, this study aims to provide a science-based review of the current knowledge and data available on marine litter in the coastal countries of South Asia, North East Asia and South-East Asia. Aqualitative summary of and quantitative data from the latest peer-reviewed scientific publications on marine litter distribution and impacts, its land-based sources, waste management and end-of-life fate pathways are presented, along with a brief analysis of data credibility and data gaps.

In doing so, this report also includes the latest research led by the Minderoo Foundation to establish a baseline measurement, at the country level, of single-use plastic waste—the single largest source of plastic losses to the environment (UNEP 2018). This assessment is achieved via a global analysis of relevant material flows from polymer production to waste generation (Minderoo 2021).

The geographic scope of this review covers the following countries: Bangladesh, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, Democratic People's Republic of Korea, the Republic of Korea, Malaysia, Maldives, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Timor-Leste and Viet Nam.

The goals of this review are to:

- Support regional cooperation mechanisms and equip policymakers with scientific evidence and information needed to advance the prevention, management and control of marine litter.
- Communicate the latest knowledge and information of marine litter to the broader stakeholder community—to raise public awareness and empower stakeholder actions.
- Contribute to the implementation of relevant Sustainable Development Goals—that is, SDG 6, SDG 9, SDG 11, SDG 12 and SDG 14 (Table 1).

Sustainable Development Goals and Targets aimed at marine litter and waste management

Table 1 /

6 CLEAN WATER AND SANITATION

Ensure availability and sustainable management of water and sanitation for all.

Target 6.3

By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Target 9.4

By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

11 SUSTAINABLE CITIES AND COMMUNITIES

Make cities and human settlements inclusive, safe, resilient and sustainable.

Target 11.6

By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Ensure sustainable consumption and production patterns.

Target 12.4

By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed upon international frameworks, and significantly reduce their release to air, water and soil to minimize their adverse impacts on human health and the environment.

14 LIFE BELOW WATER

Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Target 14.1

Reduce marine pollution

By 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution.

Target 14.2

Protect marine and coastal ecosystems

By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and taking action for their restoration to achieve healthy and productive oceans.

Target 14.a

Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular Small Island Developing States and least developed countries.

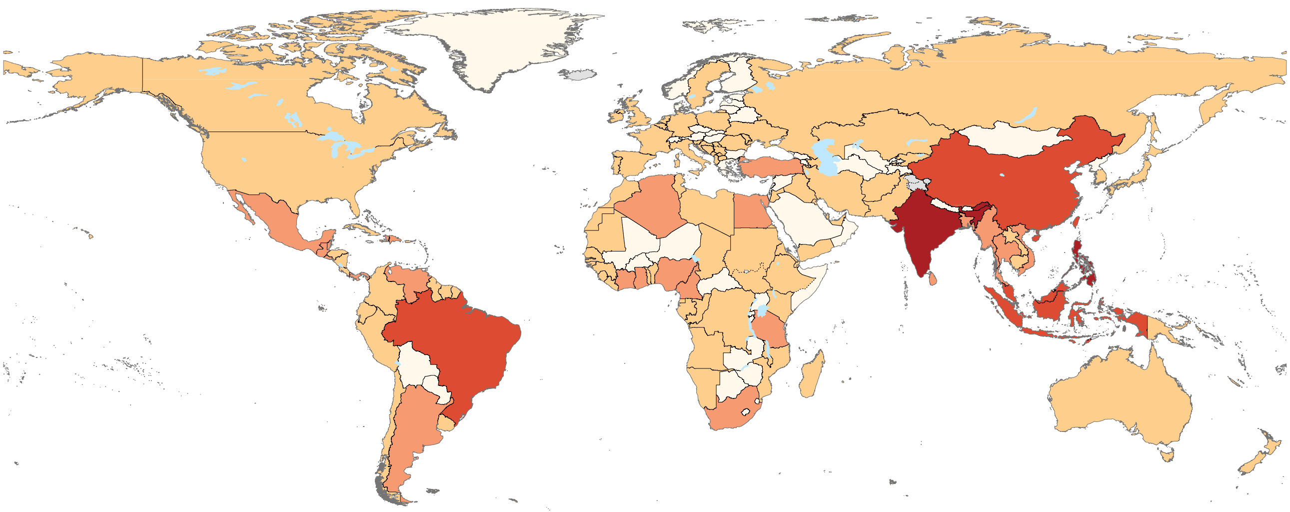
Institutional Capacity for Marine Litter Management in Asia

Regional context

Reviewing the state of the current knowledge and available data on marine litter in Asia is an issue of great urgency and global importance. Measures of the total accumulation and negative impacts of marine plastic litter *at any level* (national, subregional, regional or global) are elusive and challenging. Previous independent research in 2010 has estimated, however, the annual flows of plastic entering the ocean at between 4.8 and 12.7 million metric tons globally, with Asian countries combined contributing more than 70 per cent of the global total (Jambeck *et al*. 2015).

As knowledge of the entire plastics value chain and lifecycle increases—including waste generation rates, waste management rates and fate pathways for losses to the environment—measures of both the sources and flows of plastic litter into the ocean are being refined (UNEP 2018; Lebreton and Andrady 2019). But coastal areas of Asian countries are still being recognized as marine litter hotspots—with one recent study finding that 10 of the top 20 rivers with the highest annual plastic emissions are in Asia (Meijer *et al*. 2021), as shown in Figure 1.

As marine litter becomes a more pressing global concern, rapid industrialization, economic growth, booming population and social development as well as natural factors (wind, current, waves and precipitation) and disasters have all been contributing factors that have made Asia a significant source of marine litter leakage into the seas and ocean (Gall and Thompson 2015). These factors will continue to exacerbate the marine litter challenge over the coming decade. In fact, in a previous global-scale study, Borrelle *et al*. (2020) found that among the 19 countries included in this review—Bangladesh, Brunei Darussalam, Cambodia, China, India, Indonesia, DPR Korea, Republic of Korea, Japan, Malaysia, Maldives, Myanmar, Pakistan, the Philippines, Singapore, Sri Lanka, Thailand, Timor-Leste and Viet Nam—8 countries have been listed among the world's top-20 contributors to increased marine plastic litter emissions by 2030.



National riverine plastic emissions (MT year^{-1})

0 - 10 | 10 - 5,000 | 5,000 - 30,000 | 30,000 - 100,000 | 100,000 - 500,000

Source: Adapted from Meijer *et al*. (2021).

Geospatial distribution of plastic entering the ocean through rivers

Figure 1 /

However, although by viewing global maps, it may seem that Asia is the primary contributor of marine litter, it is important to note that Western countries contribute a significant share of leaked debris into the seas (Lyons, Su and Neo 2019; Law *et al*. 2020). The magnitude of this phenomenon appears clear when we consider that between 1992 and 2017, the year in which China announced the permanent ban on the import of non-industrial plastic waste, an estimated 111 million metric tons of plastic waste was exported to that country (Brooks, Wang and Jambeck 2018).

Government and intergovernmental action

The severity of the issue of marine litter and its consequences for the region have pushed Asian states towards action not only at the national level but also at the regional and international levels. In particular, actions on the issue of marine litter in the region have been taken through active regional seas programmes (for example, the Coordinating Body on the Seas of East Asia, the Northwest Pacific Action Plan and the South Asian Seas Programme) as well as

Country participation in specific regional marine litter action plans Table 2 /

Country	COBSEA RAP MALI	NOWPAP RAP MALI	G20 Osaka Blue Ocean Vision	ASEAN Bangkok Declaration on Combating Marine Plastic Debris in ASEAN Region
Bangladesh				
Brunei Darussalam				●
Cambodia	●			●
China	●	●	●	
India				
Indonesia	●		●	●
Japan		●	●	
Democratic People's Republic of Korea				
Republic of Korea	●	●	●	
Malaysia	●			●
Maldives				
Myanmar				●
Pakistan				
Philippines				●
Singapore	●			●
Sri Lanka				
Thailand	●			●
Timor-Leste				
Viet Nam	●			●

Abbreviation note: COBSEA RAP MALI = COBSEA Regional Action Plan on Marine Litter 2019; NOWPAP RAP MALI = Regional Action Plan on Marine Litter (second phase of NOWPAP marine litter activities).
Source: COBSEA Regional Action Plan on Marine Litter; NOWPAP Regional Action Plan on Marine Litter; Towards Osaka Blue Ocean Vision - G20 Implementation Framework for Actions on Marine Plastic Litter; Bangkok Declaration on Combating Marine Debris in ASEAN Region.

under the framework of the Group of 20 and the Association of Southeast Asian Nations (ASEAN). These participations are listed in Table 2.

The Coordinating Body on the Seas of East Asia (COBSEA) was set up in 1981 as the coordination and decision-making body for the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Seas Region. Part of the Regional Seas Programme of UNEP, COBSEA has nine Member States, namely Cambodia, China, Indonesia, Malaysia, the Philippines, the Republic of Korea, Singapore, Thailand and Viet Nam. Administered by UNEP, COBSEA has been active on the issue of marine litter, with the Regional Action Plan on Marine Litter (RAP MALI) approved in 2008. Despite high awareness on the issue of marine litter in the region, financial constraints have so far limited the implementation of relevant activities. The updated and revised plan was adopted in June 2019.

The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) was adopted in 1994 by China, Japan, the Republic of Korea and Russia as a part of the Regional Seas Programme of UNEP. NOWPAP has been active on the issue of marine litter since 2005, with the adoption of a Regional Action Plan on Marine Litter (RAP MALI) approved in 2008. Since the adoption of this Plan, NOWPAP has been engaging on the issue through the development of sectoral guidelines and public awareness-raising activities as well as through activities focused on the strengthening of data-collection and assessments and on the development of best practices.

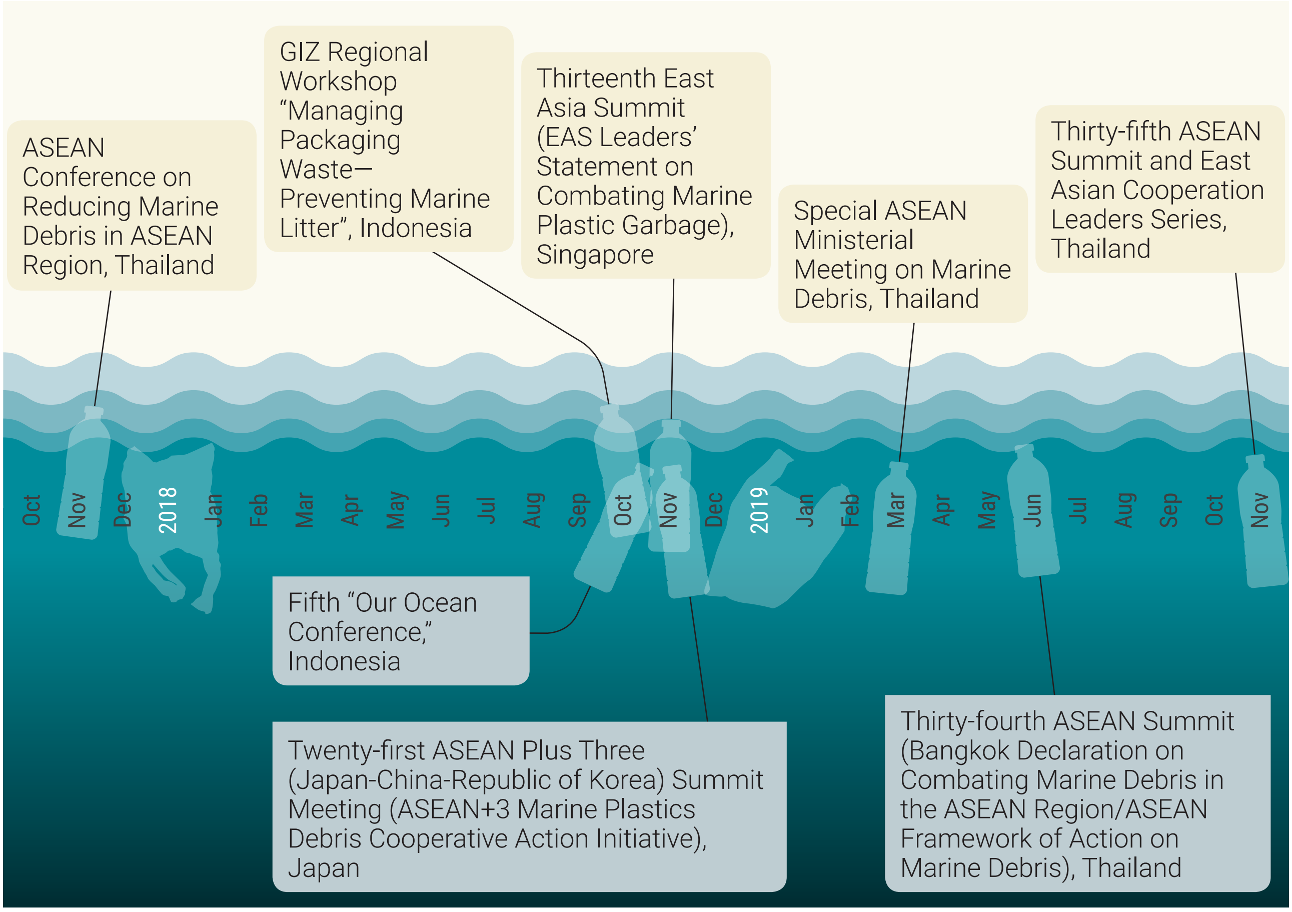
The Action Plan for the Protection and Management of the South Asian Seas Programme (also known as "SASP") was adopted in 1995—by Bangladesh, India, the Maldives, Pakistan and Sri Lanka—with the aim of assisting its Member countries in the sustainable management of the marine environment and coastal ecosystems. The Action Plan identifies four priority areas for its activities, namely integrated coastal zone management, protection of the marine regional centres of excellence and development of national and regional oil and chemical spill contingency plans. The South Asia Seas Programme has been engaging on the issue of marine litter mostly through a review of the status of marine litter in the region, which included a framework for and a report on marine litter management in 2007 and the development of the Regional Marine Litter Action Plan in 2017. The Plan, prepared by the South Asia Co-operative Environment Programme (referred to as "SACEP") with the support of UNEP-GPA, was envisaged as an implementation guide and reference tool.

After the first COBSEA workshop on marine litter in East Asian waters, held in Jakarta in 2007, outputs were consolidated into the draft COBSEA Regional Action Plan on Marine Litter (COBSEA RAP MALI), which were circulated among Member countries during 2007. The COBSEA RAP MALI was adopted by the Nineteenth Intergovernmental Meeting of COBSEA, in Siem Reap, Cambodia, on 22-23 January 2008. The Regional Review on Marine Litter in the East Asian Seas Region 2008 identified a major lack of data on the sources, types, extent, distribution, impacts and trends over time of marine litter in the East Asian Seas Region. The review also highlighted that this lack of understanding is a barrier to effective marine litter prevention and management in the region.

At this COBSEA intergovernmental meeting, the New Strategic Direction for COBSEA (2008–2012) was adopted. This strategic plan identified marine litter as an emerging issue and noted the lack of funds has limited activities towards implementation of the COBSEA RAP MALI, including tracking of progress.

Moreover, with most of ASEANs maritime Member countries serving as COBSEA

South-East Asia meetings on marine litter, 2017–2019 **Table 3 /**



participants, its working group focusing on improving ASEAN coastal members' marine environment has been instrumental in controlling litter in ASEAN marine environments. In January 2012, the Third Intergovernmental Review Meeting of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities was held in Manila, the Philippines. This meeting featured the adoption of the Manila Declaration, which directly contributed to the Global Partnership on Marine Litter launched at the United Nations Conference on Sustainable Development (Rio + 20) in June 2012.

In recent years, pollution, especially marine litter and plastic marine litter has attracted growing attention from Asian Governments, and ASEAN countries have gradually shifted towards including marine litter prevention as one of the focus issues of their bilateral and multilateral cooperation. Under international cooperation frameworks such as ASEAN and APEC, several international conferences on marine litter (Table 3) were held to discuss strategies and cooperation methods for dealing with marine litter pollution. Indonesia, Malaysia, the Philippines, Thailand and Vietnam have also developed national action plans that focus on non-biodegradable disposable plastic products.

In 2016, the United Nations and ASEAN adopted a five-year cooperation plan (2016–2020), which included the protection of the marine environment. In November 2017, the Thai Government and the ASEAN Secretariat presented "ASEAN Conference on Reducing Marine Debris in ASEAN Region" in Phuket, Thailand. In October 2018, ASEAN held a seminar in Bali, Indonesia, hosted by GIZ ASEAN on managing packaging waste and preventing marine litter, while the

Fifth "Our Ocean Conference" also centred on the issue of marine litter pollution. In November of the same year, the Statement on Combating Marine Plastic Debris was issued at the Thirteenth East Asia Summit in Singapore, and the Marine Plastics Debris Cooperative Action Initiative was announced at the Twenty-first ASEAN-China-Japan-Korea Leadership Summit in Japan.

In March 2019, the Special ASEAN Ministerial Meeting on Marine Debris in Bangkok, Thailand, issued a joint media statement on marine litter management, calling on all Member States to cooperate and take effective measures to improve waste management, prevent land-based pollution from entering the seas and formulate action plans. Through this statement, ASEAN also announced the founding of Regional Knowledge Centre for Marine Plastic Debris, established on 1 October 2019 in Indonesia and Thailand; this information clearing house was charged with gathering information on the state of marine plastic debris in the ASEAN region, monitoring the pollution of plastic waste in rivers, promoting research and development of new technologies for waste management and formulating measures to reduce the emission of plastic waste into the sea.

In addition, ASEAN will establish a sub-centre of its centre in Thailand to monitor debris pollution in the Mekong River and reduce its discharge into the sea. Furthermore, Thailand plans to reduce marine debris by 50 per cent by 2027.

In April 2019, the IOC-Subcommission for the Western Pacific (IOC-WESTPAC) established the UNESCO/IOC Regional Network of Training and Research Centers on Marine Science in the Western Pacific and its adjacent regions. Hosted by East China Normal University, the Network's objective is to (i) improve research capacity, including sampling, measuring, modelling and assessing abilities, of countries in the Asia Pacific region, including ASEAN countries; (ii) cultivate talented young researchers from IOC Member states, particularly those from developing countries; and iii) promote the ability of marine environmental governance by developing countries in the region.

In May 2019, Japan announced that it will rely on the Economic Research Institute for ASEAN and East Asia to set up an international research centre for plastic debris to strengthen cooperation with ASEAN Member States. In October 2019, the Institute established the Regional Knowledge Center for Marine Plastic Debris (RKC-MPD), which was expected to serve as an information clearinghouse on marine plastic debris in ASEAN+3 countries.

On 22 June 2019, leaders of 10 ASEAN Member States—namely, Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam—jointly signed the Bangkok Declaration on Combating Marine Debris in ASEAN Region, a milestone on marine litter management in Asia and the Pacific. The Declaration aimed at promoting cooperation for the protection, restoration and sustainable use of the coastal and marine environment and at responding and dealing with the risk of pollution and threats to marine ecosystem and coastal environment, in particular with respect of ecologically sensitive areas. The Declaration, along with its relevant ASEAN Framework of Action on Marine Debris, is the first agreement reached on the management of marine litter under the ASEAN Framework.

Furthermore, in November 2019, at the Thirty-fifth ASEAN Summit, which included a series of leaders' meetings on East Asian cooperation, participants re-emphasized the urgency and necessity of countries to work together to combat marine litter.

Apart from establishing partnerships between ASEAN Member States, ASEAN is also working closely on marine litter and plastic pollution with the Governments of Japan and Norway, the European Union and

multilateral agencies such as UNEP and the World Bank Group. In December 2019, the Government of Norway announced a US$3 million[1] contribution to launch and support the ASEAN-Norway Cooperation Project on Local Capacity Building for Reducing Plastic Pollution in the ASEAN Region. In addition, many environmental protection organizations from Europe and the United States have carried out source control and prevention of marine litter-related activities in Asia, including those regarding the circular economy, plastic waste recycling, river litter interception and treatment as well as beach clean-up activities.

Ever since the Chinese ban on foreign waste imports came into effect in 2018, Malaysia, Thailand and other ASEAN countries have become emerging destinations for waste exports from Western countries. From January to July 2018 alone, Malaysia imported 456,000 tons of plastic waste, a rapid increase in imports from 168,000 tons in 2016 and 316,000 tons in 2017. The high volume of foreign waste comprises a large share of its original recycling treatment system, making it impossible to recycle the bulk of domestic rubbish and increasing the possibility of it entering the ocean.

Therefore, the issue of marine debris management, particularly the import of foreign waste, has attracted ASEAN's attention: ASEAN countries have started to take corresponding measures to ban or reduce the import of plastic waste. For instance, the Malaysian Government intends to ban the import of plastic waste, the Vietnamese Government announced a halt on issuing licences for importing plastic waste, and the Thai Government discussed their goal to stop importing plastic waste in 2021.

1 All dollars are in U.S. currency unless otherwise noted.

Relevant provisions of the international legal framework

Even though the general public's widespread awareness of marine litter pollution is a relatively recent phenomenon, many provisions of international legal frameworks are of direct relevance to this issue. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Convention) came into force in 1975 with the objective of providing effective control of all sources of marine pollution, including preventing pollution by dumping at sea.

Currently, 87 countries are Parties to the London Convention, while only 46 countries are Parties to the London Protocol, negotiated with the aim of modernizing the Convention and entered into force in 2006. Of the countries considered under this review, only China, Japan, the Republic of Korea and the Philippines are Parties to both the London Convention and the London Protocol.

The United Nations Convention on the Law of the Sea (commonly known as "UNCLOS"), which was entered into force in 1994 and in many aspects codifies customary law, includes Part VII, Protection and Preservation of the Marine Environment, which specifically requires States to take, individually or jointly as appropriate, all measures consistent with UNCLOS that are necessary to prevent, reduce and control pollution of the marine environment from any source. Of the 19 countries considered in this review, 17 ratified UNCLOS, with Cambodia and the DPR Korea being the only countries that did not (Table 4).

Another convention of relevance, the International Convention for the Prevention of Pollution from Ships (known as "MARPOL") entered into force in 1983. MARPOL covers the prevention of marine pollution by ships from operational or accidental causes. Of its six technical annexes, of revelance is Annex V, Prevention of Pollution by

Waste from Ships, entered into force in 1988, because it bans the disposal of all forms of plastics into the sea. Annex V has been ratified by 16 out of the 19 countries analysed in this review (see Country Analysis sectiion), namely, Bangladesh, Cambodia, China, DPR Korea, India, Indonesia, Japan, Malaysia, the Maldives, Myanmar, Pakistan, the Philippines, the Republic of Korea, Singapore, Sri Lanka and Viet Nam.

The Basel Convention on the Transboundary Movements of Hazardous Wastes and their Disposal is another international legal instrument of relevance for the issue of marine litter. The Convention regulates transboundary movements of hazardous wastes, with hazardous marine litter from land-based sources falling under the scope of the Convention. Out of the 19 countries reviewed, 18 have ratified the Basel Convention, with Timor–Leste being the only exception.

The Global Programme of Action for the Protection of the Marine Environment from Land-based Sources (also known as "the GPA"), adopted in 1995, is a voluntary intergovernmental partnership hosted by UNEP. This action programme is the only global intergovernmental mechanism directly addressing the connectivity among terrestrial, fresh water, coastal and marine ecosystems—and the major threats to these systems from land-based activities. It recognizes the need for coordination at the global, regional, national and local levels. Action at the national level, supported by regional and global action, is considered as the guarantee for the programme's successful implementation. At the regional level, one of the programme's major objectives is to support and facilitate the implementation of the land-based sources—with marine litter being one of the priority source categories—and activities components of the various UNEP Regional Seas Conventions and Action Programmes (UNEP 1995).

The Global Partnership on Marine Litter was launched in 2012 at the Rio + 20 Conference as a voluntary multi-stakeholder partnership hosted by UNEP. The Global Partnership aims at protecting human health and the global environment by reducing and managing marine litter through specific objectives, such as as: (i) reducing the impacts of

Image from https://www.cleanseas.org

marine litter worldwide, (ii) enhancing international cooperation and coordination, (iii) promoting knowledge management and information-sharing and (iv) increasing awareness on sources of marine litter as well as their fate, distribution and impacts. The Partnership involves cooperation and coordination with intergovernmental organizations, governments, NGOs, the private sector and academia (Global Partnership on Marine Litter [GPML] 2017).

Under the Global Partnership on Marine Litter Framework, UNEP launched the Clean Seas Campaign in 2017 with the aim of catalysing the engagement of governments, the public and the private sector in the fight against marine plastic pollution. As of 2021, 63 governments have joined the Global Partnership, including India, Indonesia, the Maldives, the Philippines and Thailand. Moreover, the Marine Plastic Debris Research Center of East China Normal University has become a member of the Global Parternship in 2021.

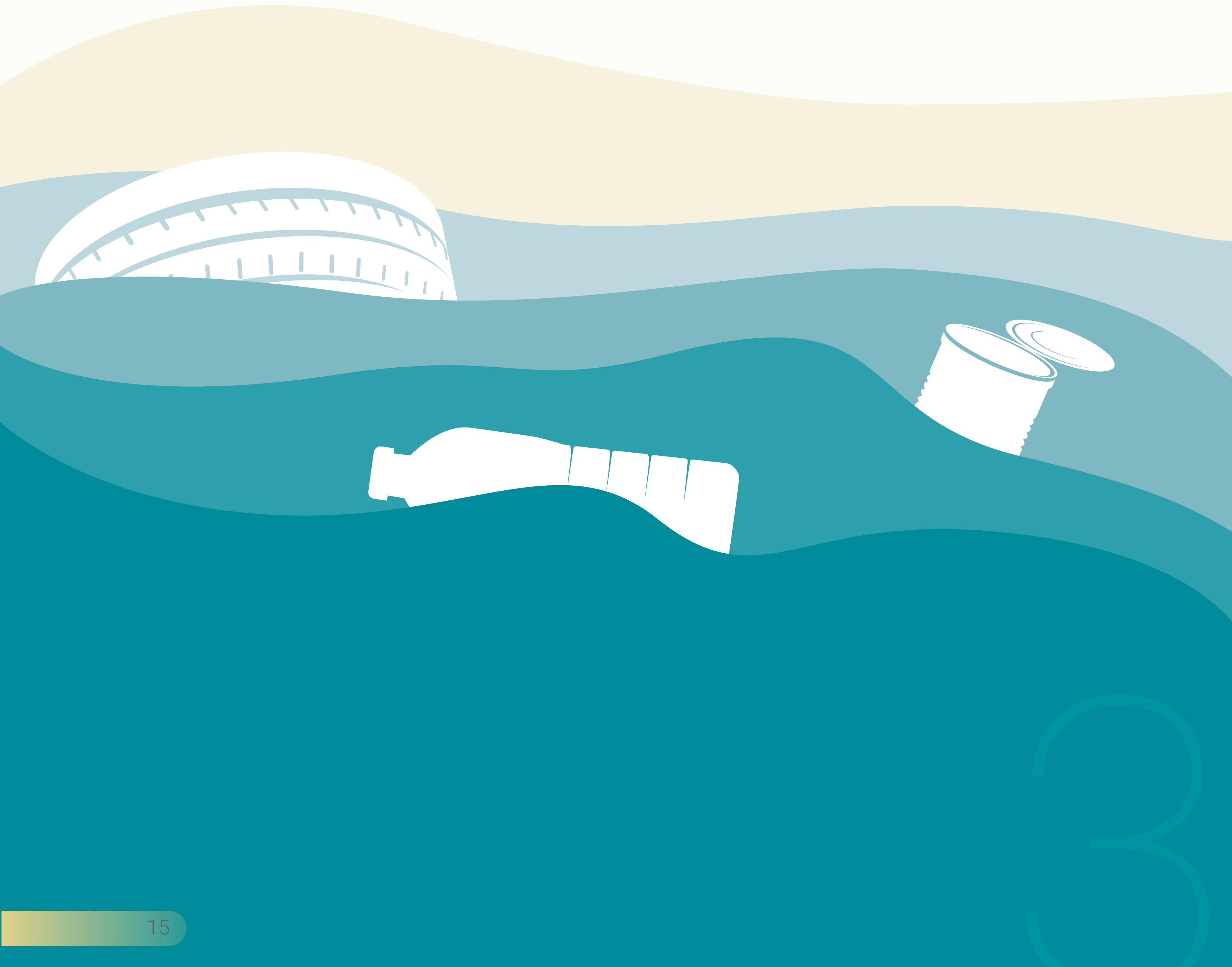
Countries that have ratified these global legal frameworks are listed in Table 4.

Status of country ratification of relevant global legal agreements — **Table 4 /**

Country	UNCLOS	MARPOL Annex V	London Convention	London Protocol	Basel Convention
Bangladesh	●	●			●
Brunei Darussalam	●				●
Cambodia		●			●
China	●	●	●	●	●
India	●	●			●
Indonesia	●	●			●
Japan	●	●	●	●	●
Democratic People's Republic of Korea		●			●
Republic of Korea	●	●	●	●	●
Malaysia	●	●			●
Maldives	●	●			●
Myanmar	●	●			●
Pakistan	●	●	●		●
Philippines	●	●	●	●	●
Singapore	●	●			●
Sri Lanka	●	●			●
Thailand	●				●
Timor-Leste	●				
Viet Nam	●	●			●

Source: UNCLOS: United Nations Convention on the Law of the Sea; MARPOL Annex V: Annex V Prevention of Pollution by Garbage from Ships of the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL); London Convention and the London Agreement: The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention), and the protocol thereof (London Protocol), formulated in 1996 and entered into force in 2006; The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.

Country Analysis



3

This section of the study presents a succinct but thorough analysis of available data for selected countries in the region regarding the distribution of marine litter, its land-based sources and impacts on marine ecosystems, waste management practices and the fate pathways of plastic pollution. It is important to consider the various sampling methods adopted in different studies before examining the data under a regional context (Chae *et al*. 2015); therefore, this section also includes data on distribution and sampling methods as well as on other important findings from existing peer-reviewed scientific publications.

Regarding the distribution of marine litter and its impact on marine ecosystems, while in certain instances, this review showcases evident trends, what emerges from its entirety is a lack of recent, reliable and uniform data that could guide effective action on the issue at the regional, national and local levels. There is a large difference in the abundance of microplastics reported, mainly a result of the differences in the type and mesh size of the net used, collection media, sorting criteria and size categorizations (Hidalgo-Ruz *et al*. 2012; Chae *et al*. 2015; Song *et al*. 2015a; Song *et al*. 2015b). Thus, this lack of reliable scientific data on the sources, types, spatiotemporal distribution and impacts of marine litter can result in ineffective mitigation and recovery efforts (Hong *et al*. 2014).

Regarding the sources of plastic marine litter, losses into the environment occur across the lifecycle of plastics, that is, from manufacturing (e.g. pellet spills) through use (e.g. abrasion, weathering, littering, discarded fishing gear) and waste management (or the lack thereof) (Peano *et al*. 2020). Measurement of the volume of losses in both the manufacturing and use phases—across all geographies and cases—are understudied and limited to estimates that are often forced to extrapolate from single studies in single countries.

While additional research is clearly required, here, existing estimates indicate that the mismanagement of municipal solid waste (MSW) contributes the largest share (half or more) of plastic losses to the environment (UNEP 2019). MSW losses to the environment are in the form of larger macroplastics (>5mm), which will degrade over time through exposure to light, air, temperature, water and mechanical forces into microplastics. However, tyre abrasion and textile-fibre losses represent the largest sources of primary microplastic emissions to the environment.

MSW generation is not reported consistently across the Asia Pacific region, either in terms of frequency or standard methodologies. Independent studies of comparative waste generation rates across the Asia Pacific and of waste composition—specifically, the plastic proportion—have noted incomplete or inconsistent definitions; lack of dates, methodologies or original sources; inconsistent or omitted units; and estimates based on assumptions (Hoornweg and Bhada-Tata 2012; Kaza *et al*. 2018).

As a result, comparable country-level estimates of plastic waste have been mostly derived from formulas that establish a relationship between GDP per capita and MSW generation, upon which assumptions were made on the plastic proportion on a best-efforts basis. Thus, country-level estimates across studies show significant variance (Jambeck *et al*. 2015; Lebreton and Andrady 2019; UNEP 2019; Law *et al*. 2020).

While more frequent, consistent in situ measurement and reporting of MSW generation and composition are needed, recent studies have proposed an alternative approach to estimating plastic waste generation at the country level. This approach requires the tracking of plastic material flows through the lifecycle: from polymer production, through conversion into plastic applications—and finally, to consumption and waste generation (Antonopolous, Faraca and Tonini 2021; Hsu, Domenech and McDowell *et al*. 2021).

In 2021, the Minderoo Foundation published *The Plastic Waste Makers Index*, which provides the first global material-flow analysis of single-use plastics, which primarily consist of packaging as well as other applications such as plastic bags and personal protective equipment. This category of plastics is understood to represent the major share of the plastic component in MSW (Lau *et al*. 2020) and, by inference, of marine litter and plastic losses to the environment.

The Minderoo Foundation study provides for the first benchmark estimate of the primary source of marine litter that: (i) is based on reported material flows, (ii) allows comparison across countries and regions, (iii) is repeatable annually, (iv) allows trends to be monitored and (v) can inform policymakers on where in the value chain to make interventions—interventions informed by polymer-specific data as well as data on industry structure and the dynamics of national, regional and global trade flows.

At the local and regional levels, detailed waste mass and characterization efforts are now being selectively undertaken—notably, through public-private partnerships—as governments and industry seek to fund and build sustainable waste management systems (e.g. Project STOP in Indonesia). Exciting advances are also being made in using satellite imagery, combined with machine-learning algorithms, to identify accumulations and (ultimately, it is hoped) provide a near-real-time measure of plastic pollution both on land and at sea (Biermann *et al*. 2020).

On waste management and fate pathways for plastic pollution: Across the Asia Pacific region, the degree to which waste is managed in formal versus informal settings is highly variable and co-dependent on the degree of economic development. The shortcomings in current measures of waste generation, described above, spill over into the understanding of formal waste collection and sorting rates (Kaza *et al*. 2018), while informal collection rates across countries and regions are at an even higher degree of estimation. Knowledge of the sources for plastic losses to the environment are increasingly well-understood at the conceptual level (UNEP 2018; Lau *et al*. 2020), but there are no consistent and comparable measurements being made from the field across countries in the region. The same applies to the understanding of pathways for environmental losses, where important advances in the modelling transport of plastic pollution to the ocean have been made recently (Lebreton *et al*. 2017; Meijer *et al*. 2021).

Table 5 provides the most recent data for those countries analysed in this section regarding their plastic waste generation, waste management practices and marine plastic waste emissions.

Data on municipal solid waste and single-use plastic generation, waste collection and plastic ocean leakage, by country

Table 5 /

Country	Population (in millions estimated for 2019) [1,2]	MSW generation Volume (in million tons for latest-available year) [3,4]	MSW generation Rate (in kg/capita/day for latest-available year) [3,4]	Single-use plastic waste generation (in million tons for 2019) [6]	Single-use plastic waste generation (in kg/capita/ year for 2019) [6]	Waste collection coverage (% for total population) [5]	Plastic leakage into the ocean (in tons) [7]
Bangladesh	163.05	14.78 (2012)	0.26 (2012)	0.28	1.71	44.30%-76.47% (in urban areas)	24,460
Brunei Darussalam	0.43	0.22 (2016)	1.40 (2016)	..	..	50%-70%	134
Cambodia	16.49	1.09 (2014)	0.20 (2014)	0.08	4.63	0%-80%	1,113
China	1,433.78	220.4 (2015)	0.41 (2015)	25.36	17.92	94%	70,707
India	1,366.42	62 (2015)	0.43 (2001)	5.58	4.12	..	126,513
Indonesia	270.62	65.2 (2016)	0.68 (2016)	2.26	8.47	45%	56,333
Japan	126.86	43.17 (2016)	0.95 (2015)	4.71	37.04	99.9%	1,835
Democratic People's Republic of Korea	25.67	0.58 (2009)*	..	..	..	..	50
Republic of Korea	51.23	19.63 (2016)	0.98 (2014)	2.25	43.86	99.92%	387
Malaysia	31.95	12.98 (2014)	1.18 (2014)	0.51	16.01	..	73,098
Maldives	0.53	0.21 (2015)	1.42 (2015)	..	..	38.2%	0
Myanmar	54.05	4.68 (2000)	0.39 (estimate, 2016)	0.28	5.15	60%	2,544
Pakistan	216.57	30.76 (2017)	0.44 (2017)	0.73	3.66	Up to 68%	873
Philippines	108.12	14.63 (2016)	0.39 (2016)	1.00	9.35	Up to 100%	356,371
Singapore	5.80	2.05 (2010)	1.11 (2010)	0.44	75.64	100%	164
Sri Lanka	21.32	2.63 (2016)	0.34 (2016)	0.08	4.02	..	9,654
Thailand	69.63	27.8 (2018)	1.15 (2018)	1.26	18.14	..	22,806
Timor-Leste	1.29	0.06 (2016)	0.14 (2016)	..	..	..	715
Viet Nam	96.62	13.2 (2014)	1.0 (2010)	1.90	19.65	72%	28,221

Sources: Compiled from multiple sources, including: [1] UNDESA 2019; [2] ASEAN Up (2018); [3] Kaza *et al.* (2018); [4] UNEP (2017); [5] Liu *et al.* (2018); [6]Minderoo Foundation (2021) and Meijer *et al.*(2021).
Abbreviation note: .., data not available.
Notes: Korea DPR data on 2009 MSW generation is only for Pyongyang. All population estimatess of 1 July 2019.

Bangladesh

Bangladesh had an estimated population of about 163.05 million in 2019 and municipal solid waste (MSW) generation estimated at 14.78 million tons in 2012 (Kaza *et al*. 2018) and 4.84 million tons of collected MSW in 2014 (United Nations, Statistics Division [UNSD] 2018). The discrepancy between the figures on generated and collected waste, together with the sharp increase in waste generation (estimated at 5.78 million tons in 2004 by Hoornweg and Bhada-Tata [2012]), are trends requiring strong interventions. With a high share of mismanaged waste, a coastline of 580 km and a costal population of over 70 million, Bangladesh has been cited as one of the main contributors of plastic marine litter in the world (Jambeck *et al*. 2015).

State of marine litter management

Bangladesh is characterized by swiftly flowing rivers in the Ganges-Brahmaputra-Meghna river system, the largest in Asia and the most populated river system in the world (Ericson *et al*. 2006). Bangladesh also has the world's third-longest natural sandy beach at Cox's Bazar. The rapidly growing population and industrial activities—for instance, the ship-breaking and textile industries, the dumping of MSW directly into the oceans—coupled with surface water run-off, frequent floods, tropical cyclones, tornadoes and tidal-bores-caused flood tides, make the coastlines of Bangladesh highly exposed to marine litter issues (Islam *et al*. 2014). In fact, evidence suggests that marine pollution has damaged sand dune fauna, vegetation and the soil properties of the coastal regions in Bangladesh (Hossain *et al*. 2015).

The Ganges River, flowing through Bangladesh into the Bengal Bay, is ranked as the world's second-largest contributing river for ocean plastics, according to the Lebreton *et al*. (2017) study. In fact, Bangladesh was identified as contributing 63 per cent of total marine plastic waste (United Nations Environmental Assembly [UNEA] 2019) in the Ganges River.

Table 6 provides data and information on the distribution of land-based marine litter in Bangladeshi inland waterways and the coasts of the Bay of Bengal. Included are the sources, sampling types and methods and findings by year of sampling collection.

Background information on MSW and data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 7 and Figure 2.

Studies on marine litter distribution in Bangladesh and the Bay of Bengal

Table 6 /

Year	Type	Findings	Method	Source
2015	Cox's Bazar Beach, Bangladesh	Microfibres: 12.3 pieces/25g sample Dominant type: microfibres	Sand was collected from 1m seaward of the high-tide line at 0-1 cm depth within a 20 x 20-cm square.	Balasubramaniam and Phillott (2016)
2017–2018	Marine fishes (*n*=75) from northern Bay of Bengal	Number of microfibres observed: 68–84 items/kg biomass Dominant microplastic type: fibres (50%–55%) Dominant polymer type: polyamide(*n*=66) and polyethylene (*n*=13) Dominant size: <500 µm (22%–43%), 500 µm to 1 mm (35%–41%) and 1–5 mm (20%–43%)	Gastrointestinal tracts of fishes (*n*=25 per species) were examined for microplastics, following alkali digestion protocol, with microscopic observations and chemical analyses by micro-Fourier-transform Infrared Spectroscope (µ-FTIR).	Hossain *et al*. (2019a)
2017–2018	Shrimp (*n*=150) from offshore and shallow coastal waters of Chittagong	Microfibres: 3.40–3.87 items/g gastrointestinal tract Dominant microplastic shape: filament (57%–58%) Dominant polymer type: polyamide-6 (*n*=13) and rayon polymers (*n*=6) Dominant size: <250 µm (7%, *n*=3), 250–500 µm (36%, *n*=15), 500 µm–1 mm (40%, *n*=15) and 1–5 mm (17%, *n*=6)	Gastrointestinal tract of shrimps (*n*=150) were examined for microplastics following alkali digestion protocol, and microscopic observation and chemical analyses by micro-Fourier-transform Infrared Spectroscope (µFTIR).	Hossain *et al*. (2019a)
2013	Surface water of Bay of Bengal	Microplastics: 1 263.18–365 519.43 items/km^2 or 0.23–481.99 g/km^2	AVANI trawl (18 sample sites for each trawl) was used with rectangular aperture 60-cm high ×14-cm wide, 4 m-long net, mesh size of 335 µm with (i) 30 × 10 cm^2 cod end and (ii) manta trawl with rectangular aperture 16-cm high × 61-cm wide, 3-m long 335 µm net with a 30- × 10-cm^2 cod end. Manta trawl deployments were each 60-minutes long, at an approximate speed of 2.0 knots. AVANI trawl was deployed for longer times and distances, often overnight; longest trawl tow exceeded 130 km, with speed at 4–6 knots, but occasionally would increase to 7–8 knots.	Eriksen *et al*. (2017)
2012 (May–June)	Visual observation of oceanic surface waters of Bay of Bengal	Number of litter items observed: 537 items, of which 95.5% are plastic items and 4.5% non-plastic items, such as wood, paper, glass and tin Density of litter: 8.7 ± 1.4 items/km^2 (overall), 21.9 ± 5.5 items/km^2 (northern area), 4.3 ± 0.8 items/km^2 (oceanic waters) and 13.2 ± 2.8 items/km^2 (coastal transect)	Floating marine debris was counted (during a research cruise aboard the R.V. Marion Dufresne) from 24 May to 15 June 2012. Observations were conducted throughout daylight hours (while ship was under way) from bridge wing or from deck above bridge, 10–13 m above sea level and 57 m from ship's bow. Marine litter was counted from only one side of bow, detected mostly with naked eye, but regular scans of waters away from ship were made with 10x32 binoculars to detect more distant debris. Images taken	Ryan *et al*. (2013)

(Continued)

Table 6 *(Continued)*

Year	Type	Findings	Method	Source
		Dominant size of litter (overall): 36.6% (<5 cm), 37.8% (5–15 cm), 15.9% (15–30 cm), 6.7% (30–60 cm) and 3.0% (>60 cm) Dominant type of litter: packaging (54.6%), plastic fragments (30.5%), fishing/boating (6.3%) and user items (4.1%)	with a digital single-lense reflex camera with 500-mm telephoto lens to identify litter items, but some submerged items could not be identified. To compensate for patchy nature of floating debris at sea, data were pooled into transects of roughly 50 km, with sample 2.5 km^2 of sea surface given effective transect width of 50 m. Total length covered in Bay of Bengal was 2 162 km of transect.	

State of municipal solid waste management

With an estimated population of 163.05 million, Bangladesh is particularly challenged by rural waste management because 63.4 per cent of the Bangladeshi are rural residents and only 36.6 per cent are urban.

Actions on combating marine litter

Bangladesh was the first nation to phase out polyethylene bags in 2002 (Jalil, Mian and Rahman 2013). In 2010, the Government of Bangladesh launched its National 3R Strategy for Waste Management and implemented the Mandatory Jute Packaging Act 2010, which came into force in 2014, providing for

Data on single-use plastics generation and MSW management in Bangladesh

Table 7 /

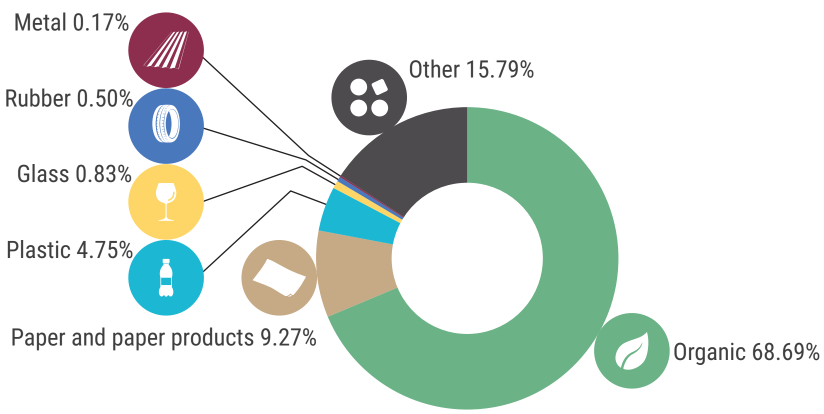
MSW background information [1] [3]	
Population	163.05 million (2019)
MSW generation	14.78 million tons/year (2012)
MSW per capita	0.26 kg/person/day, increasing to 0.41 kg/person/day for urban areas and to 0.56 kg/person/day for Dhaka City
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP, PET resin)	0.00 million tons (2019)
Polymer exports	0.00 million tons (2019)
Polymer imports	0.76 million tons (2019)
Domestic conversion of polymers into single-use applications	0.30 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.15 million tons (2019)
Single-use plastic Imports (as bulk packaging and in finished goods)	0.14 million tons (2019)
Domestic single-use plastic waste generation	0.28 million tons (2019)
Single-use plastic waste generation per capita	1.71 kg (2019)
MSW collection and treatment [3]	
MSW collection coverage	44.30%—76.47% in urban areas
Method of treatment	42% landfilled; 56% uncollected or undisposed

Sources: Compiled from multiple sourcs, including:[1] Kaza, Bhada-Tata and Van Woerden (2018); [2] Minderoo Foundation (2021); and [3] UNEP (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

selected commodities to have jute cellulose packaging. By reducing consumption of plastic single-use items and packaging, both regulations had positive impact on reducing the generation of plastic waste. Improving the nation's waste management system has also been an important task in its Seventh Five-year Plan (2016–2020). Currently, Bangladesh has been implementing Bangladesh Delta Plan 2100, a hundred-year plan to make the country climate-resilient.

NGOs from around the world have also supported the fight against marine litter. For instance, some International Coastal Cleanup campaigns have been carried out in Bangladesh, creating awareness among the masses about the negative impacts of marine pollution and driving behavioural change (Xanthos and Walker 2017). It was reported that 520 people participated in the 2018 campaign events, collecting 1,201 kg or 20,884 pieces of litter from 5 km of coastline (Ocean Conservancy 2019). In 2016, the NGO Project Aware has organized divers and volunteers to remove marine debris off Saint Martin's Island.

Other clean-up activities have been carried out by government organizations, including the Delegation of the European Union to Bangladesh (9 October 2019, Gulshan Lake, Dhaka). Also, with support from the Norwegian Agency for Development Cooperation, the Secretariats of the Basel, Rotterdam and Stockholm Conventions have also launched in Bangladesh and Ghana a two-year project titled "Sound management, prevention and minimization of plastic waste" focused on preventing and significantly reducing source transmission of marine litter and microplastics. The project has three components: (i) plastic waste crossing national borders (global trade), (ii) environmentally sound management of plastic waste and (iii) management of sources of plastic waste (Norway, Ministry of Foreign Affairs 2019).



Source: UNEP (2017).

MSW composition in Bangladesh

Figure 2 /

Brunei Darussalam

Water plays a vital role in the society and economy of Brunei Darussalam. With a coastline that extends about 161 km along the South China Sea, about 80 per cent of the population (433,000 people, according to a 2019 estimate) lived in the coastal region and about 10 per cent lived in water villages built directly on rivers and supported with stilts.

State of marine litter management

To date, a limited number of scientific publications exist on marine litter in Brunei Darussalam (Table 8). Despite the limited amount of data on marine litter, clean-up operations have been organized by the Ministry of Development of Brunei Darussalam, and local NGOs in Negara frequently reported a high volume of litter recovery from beaches and riverbanks.

In a May 2016 pioneer study, Qaisrani *et al*. (2018) surveyed four beaches that were under the impact of riverine discharge and land-based (tourism) and sea-based activities. The study found that plastics composed 91.46 per cent of litter on Brunei beaches, discovering that most litter found on beaches is generated by local tourism and commercial activities, highlighting the importance of better waste management infrastructure and public education on sound waste disposal. A previous study by the same author reported on the high amount of litter flow in the Kedayan River, discovering a positive correlation between rainfall and litter flow. Comprising mostly plastics (29.89 per cent during the dry season and 65.6 per cent during the rainy season), the litter most likely originated from inadequate waste management practices along the riverbank.

State of municipal solid waste management

Brunei Darussalam generated 216,253 tons of MSW in 2016 (Kaza *et al*. 2018). The Department of Environment, Parks and Recreation (referred to in-country as “JASTRe”) of the Ministry of Development reported in 2015 that Brunei Darussalam disposed 189,000 tons of MSW each year, with 16 per cent being plastics. With economic growth and industrialization, pressure on local waste management systems grows rapidly.

Studies on marine litter distribution in Brunei Darussalam — Table 8 /

Year	Type	Findings	Method	Source
2016	Litter on four sea beaches, Brunei Darussalam	Total number collected from all four beaches: 2,050 items with aggregate weight of 176.09 kg Plastic litter abundance: 0.011kg/m^2 or 0.16 pieces/m^2 Plastic as share of total litter: 91.46% by count and 37.62%	Selected study areas were first cleaned for visible debris. Next, on each day, visible debris was completely collected in selected areas—that is, 110 m x 30 m for Muara and Tunku beaches, 110 m x 25 m and 110 m x 27 m for Lumut and Seri Kenangan beaches, respectively.	Qaisrani *et al.* (2018)

The Department also estimated that 1 million plastic bags are issued to consumers each month (JASTRe 2018).

According to the Strategic Plan 2018–2023, published by the Ministry of Development of Brunei Darussalam, maintaining clean water quality, increasing the recycling rate and reducing generated waste are its environment priorities. Thus, the Plan aims to reduce per-capita waste generated to 1 kg per capita per year by 2023.

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 9.

Actions on combating marine litter

The country's close connection to water has resulted in a high level of policy awareness in Brunei Darussalam on aquatic environment protection, with a particular focus on plastic litter in recent years (Table 10). In June 2019, the Brunei Government and other ASEAN Member States jointly signed the Bangkok Declaration on Combating Marine Debris in the ASEAN Region and the ASEAN Framework of Action on Marine Debris. Thus, these States have carried out a series of actions to prevent and control marine debris from the source, including reduction in the consumption of single-use plastics and plastic foams, enforcement of the "polluter pay system", the introduction of relevant laws to prevent solid waste from polluting the ocean, and so forth.

In 2016, the Brunei Government issued Environment Protection and Management Order, 2016, which states that "control of land pollution, including industrial waste, domestic waste and littering…Waste treatment and disposal". In 2005, the Brunei Government promulgated the Prevention of Pollution of the Sea Order", which provides a legal basis for preventing and reducing various

Data on MSW generation and management in Brunei Darussalam — Table 9 /

MSW background information [1] [2]	
Population (2016)	0.43 million
MSW generation	0.22 million tons/year (2016)
MSW per capita	1.40 kg/person/day (2016)
MSW collection and treatment [2]	
MSW collection coverage	50%–70% (2016)
Polymer exports	0.00 million tons (2019)

Sources: [1] Kaza, Bhada-Tata and Van Woerden (2018); [2] UNEP (2017).

Government action on environmental and marine pollution prevention and management in Brunei Darussalam

Table 10 /

Environment and plastic waste management	
2005	Constitution of Brunei Darussalam on the Prevention of Pollution of the Sea Order, 2005 (Notification No. S 18)
2016	Constitution of Brunei Darussalam the Environmental Protection and Management Order, 2016 (Notification No. S 63)
Solid waste management	
2018	Ministry of Development Strategic Plan 2018–2023

types of marine pollution, including those resulting from improper MSW management, plastic products and packaging from land- and sea-based activities. In May 2000, the Environment Unit of the Brunei Ministry of Development issued an official response to an open letter calling for the following: awareness on the degradation of the Brunei River—mainly owing to direct discharge of sewage and municipal solid waste—and for community efforts on safeguarding the environment.

In terms of source reduction, according to Brunei Government statistics, 1 million plastic bags of various kinds are consumed in Brunei each month, and plastic waste accounts for about 20 per cent of the country's total solid waste production. To curb the consumption and raise awareness of single-use plastic products, the JASTRe has initiated the "No Plastics Weekend" campaign since March 2011, with plastic bags banned during weekends in participating shops and supermarkets. The initiative has gathered 50 participating stores by 2018, and the JASTRe plans to gradually expand the number of so-called no plastic days. Also, in April 2018, JASTRe hired a contractor who collected more than 20,000 bags of litter from the Brunei River, mostly plastic bags and bottles (Lyons, Su and Neo 2019).

On Earth Day, 5 June 2018, the JASTRe launched the "Plastic Bottle Free Initiative", eliminating the use of plastic bottles in daily ministerial operations as part of a national effort to "reduce and reuse" plastic materials and products. Furthermore, in January 2019, the Brunei Government upgraded the operation to "No Plastics Every Day" and promised to extend the operation to all businesses nationwide.

In addition to background information on MSW, 2020 data on MSW composition, collection and treatment and on single-use plastic waste generation in Cambodia are shown in Table 11 and Figure 3.

Cambodia

Cambodia had an estimated population of 16.45 million people in 2018. The country generated 1.09 million tons of MSW in 2014 (Kaza *et al*. 2018) and collected about 461,000 tons of MSW in 2012 (UNSD 2018). With a coastline of 443 km, it contributed more than 8,000 tons of plastic marine litter in 2010 (Jambeck *et al*. 2015).

State of marine litter management

To date, limited research activities exist on marine litter in Cambodia. With not enough research data in this country, marine litter monitoring has mainly relied on citizen science, NGOs and data generated by beach clean-ups. Results from the 2018 International Coastal Cleanup Campaign showed that 109 volunteers collected 1,402 kg or 14,739 pieces of litter on 2.1 km of coastline (Ocean Conservancy 2019). In 2015, Cambodia reportedly had an average 1,072 pieces of litter recovered per person, a number higher than for any other participating country that same year, although uncertainty exists due to the limited number of participants and the variations in the amount collected at different locations (Ocean Conservancy 2016). A research survey carried out by M.V. SEAFDEC from September to October 2018 found a large number of squid traps in Cambodian coastal waters, in line with this country's high per capita fish catch and per capita fish consumption, that is, 63.15 kg/capita/year, according to the Food and Agriculture Organization (FAO 2018).

State of municipal solid waste management

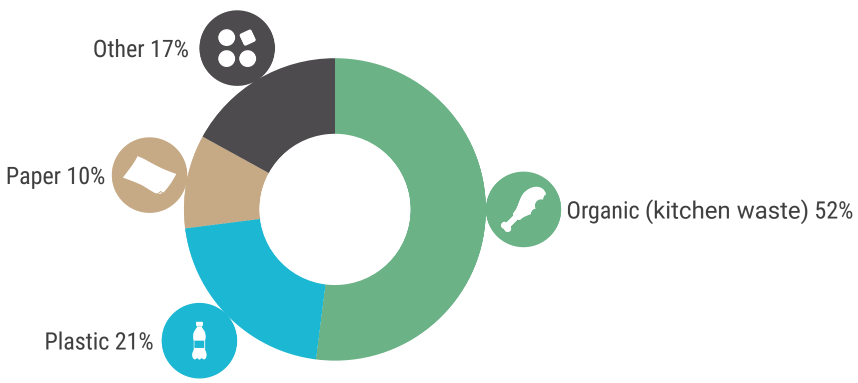
Regarding solid waste management in Cambodia to deal with the increasing demand for municipal solid waste disposal, in 2015, the Cambodian Government issued Second Order No. 113 on Municipal Waste and Solid Waste Management, following an order issued in 1999. While per-capita MSW in the country was estimated at 0.2 kg per day, per capita, the rate of MSW production in Phnom Penh, the Cambodian capital,

Data on single-use plastic waste generation and MSW management in Cambodia

Table 11 /

MSW background information [1] [4]	
Population	16.45 million (2018)
MSW generation	1.09 million tons/year (2014)
MSW per capita	0.2 kg/capita/day, increasing to 0.73 g/capita/day for Phnom Penh (2015)
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	0.00 million tons (2019)
Polymer exports	0.00 million tons (2019)
Polymer imports	0.06 million tons (2019)
Domestic conversion of polymers into single-use applications	0.03 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.02 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.06 million tons (2019)
Domestic single-use plastic waste generation	0.08 million tons (2019)
Single-use plastic waste generation per capita	4.63 kg (2019)
MSW collection and treatment [3] [4]	
MSW collection coverage	0%–80% (Phnom Penh: 80%) (2015)
Method of treatment	42% landfilled; 56% uncollected or undisposed
Number of treatment and disposal facilities	72 open dump sites

Sources: Compiled from multiple sources, including: [1] Bhada-Tata and Van Woerden (2018); [2] Minderoo Foundation(2021); and [3] Singh *et al*. (2020); [4] Sethy (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.



Source: Singh *et al*. (2020).

MSW composition in Cambodia

Figure 3 /

Government action on the environment and on waste management in Cambodia

Table 12 /

Year	Title
1996	Law on Environmental Protection and Natural Resources Management ("Environment Law")
1999	Royal Government of Cambodia: Subdecree on Solid Waste Management (1999) (No. 36/ANKr. BK)
2015	Royal Government of Cambodia: Subdecree on Solid Waste Management in Urban Areas (No. 113/ANKr. BK)
2016	Royal Government of Cambodia: Subdecree on Management of Electronic and Electrical Equipment Waste (No. 16/ANKr. BK)
2017	National Environment Strategy and Action Plan (NESAP), 2016–2023

was estimated at 0.73 kg per day, per capita (Asia Foundation and National Council of Sustainable Development 2018).

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation in Cambodia is shown is shown on Table 11 and Figure 3..

As population growth and urbanization continue to accelerate in Cambodia, solid waste generation is also growing at an annual rate of 10 per cent. Currently, Cambodia generally lacks systems for the management of solid waste and the infrastructure for its disposal and treatment. Apart from small amounts of recyclable materials collected by waste collectors and some local NGOs, large quantities of waste is disposed into open dumps without any treatment. Among the 72 landfills throughout Cambodia, no sanitary landfill is present; thus, a large amount of MSW has also been illegally dumped on land and in the waterways. Only Phnom Penh has a harmless treatment facility for its MSW.

In terms of solid waste management, Cambodia's main policy tool is Sub-decree on Solid Waste Management (No. 36/ANKr. BK), originally issued in 1999. The intent of this sub-decree is to achieve, through technological means, the proper and safe disposal of waste materials. It provides for specific requirements for the disposal, storage, collection, transport, recycling and dumping of solid waste and hazardous waste, such as prohibiting the disposal of waste in public places or any unauthorized location. The sub-decree also requires that hazardous waste from industrial and medical sources be disposed of separately from domestic waste.

In 2015, the Cambodian Government issued the Sub-decree on Solid Waste Management in Urban Areas (No. 113/ANKr. BK). To limit single-use plastics, in some Cambodian supermarkets, 400 riel is charged per plastic bag (equivalent to about $0.10). In July 2019, Cambodia returned a batch of foreign rubbish containers from Canada and the United States.

Actions on combating marine litter

In 1999, the Cambodian Government issued the Sub-decree on Water Pollution Control (No. 27 ANKr BK), which aims to control, prevent and reduce water pollution in the public waters of Cambodia. According to Article 8, strictly prohibited is the disposal of solid waste or any rubbish or hazardous substances into public water areas or into public drainage systems, as is the storage or disposal of these items in a manner leading to pollution of public water areas.

In terms of international cooperation, Cambodia participated in the five-year

Government action on the water environment in Cambodia

Table 13 /

Year	Title
1999	Royal Government of Cambodia: Subdecree on the Control of Water Pollution (1999) (No. 27/ANKr. BK)
2007	Law on Water Resource Management of the Kingdom of Cambodia

project "Improving Waste Management", funded in 2015 by a $7.5 million Global Environment Facility. The participating countries include Cambodia, Laos, Mongolia, the Philippines and Vietnam. From 2012 to 2015, the European Union, SWITCH, and the SNV Netherlands Development Organisation invested more than 2 million euros to fund a solid waste-to-energy utilization (WtE) project to help the Cambodian rice processing industry use waste rice husks to generate electricity.

Other international cooperation initiatives have focused on consumer behavior. For instance, in 2014, the Italian NGO Fondazione ACRA invested more than 1.3 million euros to launch a project on reducing plastic bags in Cambodia; they did so by helping to change consumer behaviour in major Cambodian cities from 2014 to 2017. In addition, UNESCO, the Ministry of the Environment, the Ministry of Tourism and the Cambodian Youth Federation have jointly organized the "Cambodian Anti Plastic Bag Campaign" campaign in 2016 to raise awareness of plastic pollution and recycling and to promote changes in consumption habits and behaviours—namely, reduced dependence on single-use plastics.

Many local NGO-initiated activities focusing on waste minimization have also been recorded in the country. Some examples include a school in Phnom Penh built with "trash", such as plastic bottles and old shoes. In this case, students can use proceeds from plastic waste they collected to pay for school tuition. Another is the Rubbish Café built in the suburbs of Phnom Penh with recycled tyres and glass or plastic bottles.

Government actions towards protecting environment via effective solid waste management are shown in Table 12. Also, those actions towards protecting the marine and water environment are listed in Table 13.

China

China is the world's most populous country, with an estimated population of 1.433 million in 2019 (UNSD 2018), and with estimated MSW generation of about 220.4 million tons in 2015 (Kaza *et al*. 2018) and MSW collection of 191.42 million tons.

State of marine litter management

Marine litter has drawn attention from the scientific community as well as the Government of China since the early 2000s. Scientists have conducted extensive research on this environmental issue, covering the methodology, distribution, eco-toxicological effects, transport, sink, fate and management of marine litter and microplastics. Up to now, more than 20 per cent of peer-reviewed scientific papers studying this topic were published by Chinese scientists and scholars, who have been actively engaged in various international scientific organizations, including UNEP, NOWPAP, UNESCO IOC-WESTPAC and the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, as well as in multilateral and bilateral collaborations with Japan, the Republic of Korea, Norway, Thailand, the United Kingdom and the United States.

Moreover, Chinese scientists have led some international and regional projects, such as the UNESCO IOC-WESTPAC Asia-Pacific regional project titled "Distribution, Source, Fate and Influence of Marine Microplastics", aimed at establishing harmonized methodologies for microplastic research and conducting collaborative research across 10 countries of the Asia-Pacific. This project is the first attempt around the world to apply standard methods for marine microplastics and promote global cooperation between regions for generating comprehensive international influence.

The Chinese Government has also given substantial support to research on marine litter and microplastics and has funded over 100 national scientific undertakings, including the national key research and development program titled "Monitoring and Ecological Risk Assessment of Microplastic Marine Debris". These efforts and achievements have elevated China as a leader in marine litter and microplastic research in the region.

Besides, since 2007, the State Oceanic Administration has organized programmes to monitor marine litter in coastal sediments, surface water and water columns regularly. Moreover, since 2016, the Administration started microplastics monitoring, results of which are published annually in the *Bulletin of Marine Ecology and Environmental Status of China*.

For microplastics, results of 2018 monitoring of four transects in the Bohai Sea, Huanghai Sea and South China Sea revealed an average concentration of 0.42 pieces per cubic meter, with the highest concentration being mainly fragments, fibres and lines, and the composition being mainly polypropylene (PP), polyethylene (PE) and polyethylene terephthalate (PET).

The distribution and characteristics of marine litter and microplastics has been reported in various environmental compartments across the coasts and regional seas of China, such as river estuaries (Mai *et al*. 2019; Zhao *et al*. 2019), the East China Sea (Xu *et al*. 2018; Zhao *et al*. 2019), the Yellow Sea (Sun *et al*. 2018), the Bohai Sea (Zhang *et al*. 2017) and the South China Sea (Zhao *et al*. 2015). The research focus is on the whole cycle of marine litter and microplastics, including their sources, transport, pathways, fluxes, sink, fate and ecological impacts.

Zhao *et al*. (2019) conducted condensed seasonal in situ monitoring on microplastics in the Yangtze Estuary and its adjacent East China Sea, using harmonized methodology; they estimated annual microplastics exported from the Yangtze River as 537–906 tons, without considering the impacts of tides. Mai *et al*. (2019) did similar studies in the Pearl River Estuary; they found the abundance of microplastics in the studied region was 0.005–0.7 items per cubic metre and estimated that about 2,400–3,800 tons of plastic litter were exported to the coastal ocean by the Pearl River.

A physical transport model of microplastics was developed to study their transport pathway from the coast of China (Zhang *et al*. 2019). Based on this model, less than 18 per cent of terrestrial microplastics were eventually transported from the coast to the Pacific Ocean, whereas the rest were mainly trapped in coastal waters owing to complex hydrodynamic processes.

Selected studies on the distribution of marine litter in China are listed in Table 14.

Studies on marine litter distribution in China

Table 14 /

Year	Type	Findings	Method	Source
2009–2010	Floating marine debris, beached marine debris and seafloor marine debris	Floating marine debris density: 4.947 (0.282–16.891) items/km^2, with plastics (44.9%) and Styrofoam™ (23.2%) dominating	Trawl net and visual observation	Zhou *et al.* (2011)
2007–2013	Floating macroplastics, beached marine debris and submerged marine debris	Mean number and weight densities of beached marine debris and submerged marine debris: 4.30, 0.13 items/100 m^2 and 133.80, 22.60 g/100 m^2 from 2007 to 2014, respectively Average density of large-sized floating macroplastics: 0.0024 items/100 m^2 Composition of marine debris: primarily plastic, including Styrofoam; wood, glass, rubber, fabric/fibre and metal	Trawl net, visual observation, submarine navigation and diving	Zhou *et al.* (2016)
2010	Marine litter	Dominant debris type: plastic, particularly polystyrene Marine debris was more abundant on rocky shores than on sandy beaches and fishing ports, with most originating from recreational activities. No significant difference between seasons and tides.	Trawl net, diving facility, diver, snorkelling, sonar, and manta tow Strip transect	Kuo and Huang (2014)
2014	Small plastic debris	Abundance of small plastics items: more than 60% of total by number Most common polymer composition: polypropylene and polyethylene	Transect, visual identification	Zhao *et al.* (2015a)
2014	Estuarine microplastics	Dominant plastic item size: microplastic (<5 mm) comprised more than 90% of total Dominant shape: fibres and granules	Pump	Zhao *et al.* (2015b)
2015	Microplastics in beach sand	Surface samples (2 cm) contained higher microplastic concentrations than deep samples (20 cm).	Sand sampling	Yu *et al.* 2016
2016	Microplastics in seawater	Average microplastic concentration: 0.33 ± 0.34 particles/m^3 Main microplastic types: polyethylene, polypropylene and polystyrene	Surface tow (330 μm)	Zhang *et al.* (2017)
2015	Microplastics in estuarine sediments	Mean concentration of items: 121 ± 9 items per kg of dry weight Dominant microplastic type: fibre (93%), transparent items (42%) and small microplastics (<1 mm) (58%)	Box core	Peng *et al.* (2017)
2017	Microplastics in estuarine seawater	Areas around aquaculture farms were regarded as "hotspots" of microplastic pollution.	Pump	Xu *et al.* (2018)
2015	Microplastics in seawater	Average microplastics concentration: 0.13 ± 0.20 pieces/m^3 Major polymer type: polypropylene and polyethylene	Bongo nets	Sun *et al.* (2018)
2017	Microplastics in estuarine sediments	Annual microplastics exported from Yangtze River: 537–906 tons Average microplastics mass: 0.000033 g/particle Density stratification in cellulose significantly influenced surface abundances of microplastics.	Pump	Zhao *et al.* (2019)

State of municipal solid waste management

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 15.

Actions on combating marine litter

The Chinese Government attaches great importance to the prevention and control of marine litter. Intensive work has been done in the prevention and control of the sources of waste, collection and clean-up of marine litter, monitoring and evaluation, public dissemination, international cooperation and so forth. Since the inclusion of "Protection of Ecology Environment" in the report of its Nineteenth National Congress, environmental protection has become one of the fundamental national strategies of China. Some nationwide campaigns have been launched and governing actions taken to identify and eliminate sources of pollution, as shown in Table 16.

The Chinese Government was one of the earliest to take measures in preventing plastic pollution. As early as 2007, the State Council issued the "Notice on Ban Production, Sale and Use of Plastic Bags", which prohibits the production, sale and use of all thin plastic bags with a thickness less than 0.025 mm. Moreover, all supermarkets, shopping malls and village markets are banned from providing free plastic bags.

Many relevant laws and regulations ensued, including the following:

- Law on the Prevention and Control of Environment Pollution Caused by Solid Wastes (1995)

Data on single-use plastics waste generation and MSW management in China

Table 15 /

MSW background information [1] [3]	
Population	1,433.78 million (2019)
MSW generation	220.4 million tons/year (2015)
MSW per capita	0.41 kg/person/day (2015)
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	51.41 million tons (2019)
Polymer exports	3.55 million tons (2019)
Polymer imports	20.91 million tons (2019)
Domestic conversion of polymers into single-use applications	34.53 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	11.83 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	2.71 million tons (2019)
Domestic single-use plastic waste generation	25.37 million tons (2019)
Single-use plastic waste generation per capita	17.92 kg (2019)
MSW collection and treatment [3]	
MSW collection coverage	94% (2015)

Sources: Compiled from multiple sources, including: [1] Kaza, Bhada-Tata and Van Woerden (2018); [2] Minderoo Foundation(2021); and [3] UNEP (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

Government action on combating marine litter in China

Table 16 /

Year	Policy name	Key plastics-related action
1995	Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution	Gradually increased content of waste plastics via repeated amendments to the law
1999	Emergency Notice on the Immediate Cessation of the Production of Disposable Foamed Plastic Tableware, issued by State Economic and Trade Commission	Completely prohibited nationwide by end of 2000, production and application of disposable foamed plastic dinnerware and utensils
2004	Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution	Encouraged use of regenerated biomass energy and degradable plastics
2007	Administrative Measures for Recycling of Renewable Resources, jointly issued by Ministry of Commerce, National Development and Reform Commission, Ministry of Public Security, Ministry of Construction, State Administration for Industry and Commerce, and State Environmental Protection Administration	Encouraged whole society (from all walks of life, both urban and rural residents) to accumulate and sell renewable resources, recycle and treat renewable resources in an environmentally sound manner, and carry out scientific research, technological development and popularization on the recycling and treatment of renewable resources
2007	Notice of the General Office of the State Council on Restricting the Production, Sale and Use of Plastic Shopping Bags	Banned (since 1 June 2008) the production, sale and use of plastic shopping bags with thickness less than 0.025 mm nationwide, and implemented system of paying for use of plastic shopping bags in retail stores
2008	Circular Economy Promotion Law of the People's Republic of China	Put forward "improve the network, improve capacity"
2011	Opinions on the Establishment of a Complete and Advanced System for Recycling Waste Commodities, issued by General Office of the State Council	Improved the system with attention to recycling of nine key waste commodities, including waste plastics
2012	Law of the People's Republic of China on Cleaner Production Promotion	Considered life-cyle impact of product and package design on human health and the environment, and gave priority to packages that are non-toxic, non-hazardous and easy to degrade or recycle
2012	Petrochemical and Chemical Industry Development Plan during the Twelfth Five-Year Plan Period, issued by Ministry of Industry and Information Technology	Proposed the development of poly (lactic acid) (PLA) and poly (butylene succinate) (PBS) degradable plastics
2012	Guiding Opinions on China Plastics Processing Industry "Twelfth Five-Year" Development Plan, issued by China Plastics Processing Industry Association	Proposed to promote biodegradable materials and products, personalized packaging film logo design, functional materials and products, etc.
2015	Medium- and Long-Term Plan for the Construction of Renewable Resources Recovery System (2015–2030), issued by the Ministry of Commerce, National Development and Reform Commission, Ministry of Land and Resources, Ministry of Housing and Urban-Rural Development and General Supply and Marketing Cooperatives	Introduced comprehensive plan for establishment of renewable resources recovery system, and recognized main misconceptions regarding renewable resources, such as the following: • Wrong understanding that renewable resources are equal to waste • Recycling work is not promoted • Failure to do a good job in classifying sources and improving subsequent recovery cost • Lack of clarity on responsibilities of all parties, and weak policy matching • Waste plastics have no clear system requirements
2015	Implementation of the Action Plan for Prevention and Control of Water Pollution	Aimed to prevent and control water pollution
2015	Release of the Implementation Scheme of the Special Action for Prevention and Control of Pollution from Ships and at Ports (2015–2020), issued by Ministry of Transport	Promoted prevention and control of pollution from ships and ports in an all-round way

(Continued)

Table 16 *(continued)*

Year	Policy name	Key plastics-related action
2016	Implementation of the Soil Pollution Prevention and Control Action Plan	Aimed to prevent and control soil pollution
2016	Release of the Opinions on Promoting the River Chief System in an All-Round Way	
2017	Implementation Plan of Domestic Waste Classification System	Created a systm to classify domestic waste
2017	Circular Development Leading Action, jointly issued by National Development and Reform Commission, Ministry of Science and Technology and 14 other departments	Put forward main targets by 2020: output rate of major resources was to increase by 15% compared with that of 2015, and recycling utilization rate of major wastes was to reach about 54.6%
2017	Prohibit the Entry of Foreign Garbage and Promote the Implementation Plan for the Reform of the Import Management System of Solid Waste, issued by General Office of the State Council	Adjusted management catalogue of imported solid waste by end of July 2017 Banned imports of household waste plastics, unsorted wastepaper, textile waste and vanadium slag by end of 2017
2017	Development Guiding Opinions on Plastics Processing Industry Technological Progress during the Thirteenth Five-Year Plan, compiled by China Plastics Processing Industry Association	Promoted research and development of cutting-edge technologies and emerging processes, promoted development of energy-saving and environment-friendly materials and technologies, and improved recycling and processing system for waste plastics
2019	Release of the Guiding Opinions on Launching the Pilot Mechanism of the Gulf Chief System (2017)	
2017	Three-year Action Plan for Improving the Rural Living Environment, released by State Council	Improved living environment in rural areas
2017	Guiding Opinions on Collaborative Promotion of Green Packaging in the Express Industry, jointly issued by the State Post Bureau, National Development and Reform Commission, Ministry of Science and Technology and other 10 departments	Increased share of biodegradable green packaging materials to 50% by 2020
2017	Conditions of Specification for Agricultural Film Industry (2017 version), issued by Ministry of Industry and Information Technology	Emphasized that agricultural film products should not be produced with inferior recycled plastics as raw materials. Specified that product quality should meet national and industrial standards and that the qualified rate of products should reach 100%
2018	National Standard for Express Packaging Products Series, issued by General Administration of Quality Supervision, Inspection and Quarantine and Standardization Administration of the People's Republic of China (as revised, improved standard)	States that mail and delivery packaging materials should be made of biodegradable plastic to reduce white pollution, as of 1 September 2018
2018	Announcement on Adjustment, jointly issued by Ministry of Ecology and Environment, Ministry of Commerce, National Development and Reform Commission and General Administration of Customs	Requires that waste plastics from industrial sources be transferred from the *Restricted Import of Solid Waste,* which can be used as raw materials, to the *Prohibited Import of Solid Waste Catalogue*, implemented on 31 December 2018 (meaning that the era of waste plastics import is coming to an end)
2019	Action Plan for the Uphill Battles for Integrated Bohai Sea Management (2018), implemented by Ministry of Ecology and Environment	Significantly reduced the volume of land-based pollutants dumped into the sea in three years
2019	Implementation of the Plan for Pilot Development of Solid Waste-Free Cities	Established cities free of solid waste

(Continued)

Table 16 *(continued)*

Year	Policy name	Key plastics-related action
2019	Guiding Catalogue of Industrial Structure Adjustment (2019 version), issued by National Development and Reform Commission	Phases out disposable foam-plastic tableware and disposable plastic swabs by 2021 Banned both (i) production of daily chemical products containing plastic microbeads by end of 2020 and (ii) sale of plastic microbeads by end of 2022 Phased out (i) ultrathin plastic bags with a thickness of less than 0.025 mm and (ii) polyethylene agricultural mulching film with a thickness of less than 0.01 mm
2019	Biodegradable Plastic Shopping Bags (GB/T 38082-2019)	Stipulated definition requirements, test methods, inspection rules, packaging, transportation and storage of biodegradable plastic shopping bags
2020	Opinions on Further Strengthening Plastic Pollution Control, issued by National Development and Reform Commission and Ministry of Ecology and Environment	Proposed ban and restricted production, sale and use of some plastic products in an orderly way, and actively promoted alternative products
2020	Notice on Solid Advancement of the Control of Plastic Pollution, jointly issued by State Development and Reform Commission, Ministry of Ecology and Environment, Ministry of Industry and Information Technology, Ministry of Housing and Urban-Rural Development, Ministry of Agriculture and Rural Affairs, Ministry of Commerce, Ministry of Culture and Tourism, State Administration for Market Regulation, and All-China Federation of Supply and Marketing Cooperation	Banned the production and sale of disposable plastic cotton swabs, disposable foamed plastic tableware, rinsing cosmetics and toothpastes with plastic microbeads added on purpose nationwide, as of 1 January 2021 Prohibited production and sale of thin plastic shopping bags with thickness of less than 0.025 mm and polyethylene agricultural mulching film with thickness of less than 0.01 mm Banned non-biodegradable plastic shopping bags in some cities and public places as of 1 January 2021
2020	Announcement on Relevant Matters Concerning the Comprehensive Ban on the Import of Solid Waste, jointly issued by Ministry of Ecology and Environment, Ministry of Commerce, National Development and Reform Commission and General Administration of Customs	Prohibited import of solid waste in any form as of 1 January 2021

- Cleaner Production Promotion Law of the People's Republic of China (2002)
- Notice of the General Office of State Council on Restricting the Production, Sale and Use of Plastic Shopping Bags (2008)
- Circular Economy Promotion Law of the People's Republic of China (2009)
- Announcement on Issuing the Administrative Provisions on the Environmental Protection of the Imported Waste Plastics (2013)
- Notice of the General Office of the State Council on Issuing the Implementation Plan for Prohibiting the Entry of Foreign Waste and Advancing the Reform of the Solid Waste Import Administration System (2017)

The State Council issued a notice in 2018 on the Zero Waste City Pilot Program to reduce the amount of plastic waste produced at source, ensure resource utilization of plastic waste and strengthen its recycling programmes. Among the 11 pilot Zero Waste cities, 5 are within 50 km of the coast.

Since 2019, laws on compulsory waste categorization have been enforced and were intended to be adhered to by 46 Chinese cities by 2020. With the threat of both financial and credit penalties for inadequate waste categorization practices, citizens and businesses are required to properly dispose their own waste by type, thus preventing the generation of inadequately managed waste—and, thus, marine litter.

China has introduced and implemented a series of actions, including the Action Plan for Prevention and Control of Water Pollution and the Action Plan for the Bohai Sea environmental protection, aimed at comprehensive improvement of water quality, including the control and clean-up of marine litter on watersheds and coastlines. For example, Xiamen, a coastal city in southeast China, has established a marine sanitation system and exemplified itself as the "Xiamen Model" for preventing and controlling marine litter. Besides, China has introduced innovative policies of which marine litter monitoring and control is an important part, such as the "River Captain" and "Bay Captain" systems as well as the "Ecologically Protected Red Line" regulations.

Relevant national projects have been funded to study the impacts of marine litter and microplastics. In 2017, Microplastic Monitoring and Eco-Environmental Evaluation Technologies, one of the key national research projects of the Ministry of Science and Technology, was launched to (i) investigate microplastic distribution along the coast and (ii) study its pathway, fate and toxicity. These projects are expected to explore novel methods for marine litter and microplastic monitoring and ecological risk assessment.

The Chinese Government proactively engages fully in the international process for addressing marine plastic litter and microplastics. For example, the Chinese Government participates in regional sea action plans under the UNEP Framework and abides fully by the principles set out in the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. Control of marine litter has also been included in some bilateral and multilateral cooperation documents with ASEAN, Canada, Germany, the G20, the United States and so on.

Finally, the public is encouraged to join the activities of collecting and cleaning marine litter on beach. For example, some campaigns had been organized in Dalian, Rizhao, Yantai and other coastal cities to raise public awareness in preventing marine pollution and reducing the use of disposable plastics.Further, activities for the national monitoring programme on marine litter and microplastics are carried out regularly to monitor such pollution in critical areas. Monitoring data is available for the public via the *Bulletin of Marine Ecology and Environmental Status of China*.

Catalogue for guiding industry restructuring

On 6 November 2019, the National Development and Reform Commission of the Chinese Government released the *Catalogue for Guiding Industry Restructuring* (2019 version, effective 1 January 2020). According to the catalogue, the "encouraged industries" include (i) development and production of degradable polymers and biodegradable polyester; (ii) development, production and application of biodegradable plastics and their products; (iii) development, production and application of new polyesters and fibres, such as biobased polyamides and biobased furan rings; (iv) production of new-solvent-method regenerated cellulose fibre (Lyocell); bacterial cellulose fibre; regenerated cellulose fibre, using novel renewable resources such as bamboo and hemp as raw material; polylactic acid fibre; seaweed fibre; chitosan fibre; polyhydroxyalkanoate; and animal and plant protein fibre, using a green, environment-friendly process and equipment; and (v) development and application of recycling and reutilization technology and equipment of waste materials such as waste plastics, waste textile and textile scraps, and waste rubber, and so forth.

Moreover, in the catalogue, "limited industries" include: (i) polyvinyl chloride ordinary artificial leather production line; (ii) polyurethane foam production line and continuous extrusion polystyrene foam production line, using hydrochlorofluorocarbons as controlled refrigerant, foaming agent, fire extinguishing agent, solvent, cleaning agent, processing aid; and (iii) polyvinyl chloride plastic wrap.

Furthermore, the “obsolete industries” include: (i) backyard oil refinery process, using waste rubber and plastics with outdated methods; (ii) the production of ultrathin (less than 0.025 mm) plastic shopping bags; (iii) the production of polyurethane, polyethylene and polystyrene foams, using chlorofluorocarbons as blowing agents; (iv) disposable foamed plastic tableware and disposable plastic cotton swabs (effective 31 December 2020); (v) household chemical products and toiletries containing microplastic beads (production ended on 31 December 2020 and sales/distribution ends on 31 December 2022); and (vi) ultrathin plastic bag with thickness less than 0.025 mm and polyethylene agricultural mulch with thickness less than 0.01 mm.

Waste categorization in 46 pilot cities in China

In July 2019, the Shanghai municipal government began enforcing the city’s new regulation on the categorization and management of domestic waste, making it compulsory for citizens of Shanghai to categorize and sort their domestic waste according to four types: dry waste, wet (compostable kitchen waste), recyclables and hazardous waste. Failure to comply with the prescribed waste categorization may result in a penalty of ¥200 for individuals and up to ¥50,000 for companies or institutions. Shanghai’s strict legislation on this matter marks the beginning of a nationwide campaign on waste categorization in China. According to the Ministry of Housing and Urban-Rural Development, 46 pilot cities including Beijing, Shanghai and Shenzhen have been selected, and each should have completed the construction of a functioning waste categorization system by the end of 2020. For the other cities at or above the prefecture level, 2022 is the deadline for a functioning waste categorization system in at least one of the districts, and 2025 is that for a functioning waste categorization system.

Waste categorization has several benefits: (i) construction of a functioning waste categorization system requires a comprehensive upgrade in the waste management system in general, including more organized disposal, storage, transportation and treatment of domestic waste as well as a higher level of government spending on waste management services and infrastructure; (ii) better-sorted waste means more recyclables can be taken out of the waste stream and more resources can be reused (e.g. for composting); (iii) better-sorted waste gives waste treatment service providers more options when deciding the best harmless treatment method, that is, incineration plants can reach higher efficiency owing to the better calorific value of waste feed with less waste going to landfills; and (iv) categorization provides a good opportunity to educate and force consumers to rethink the huge amount of waste generated in daily life and learn about 3Rs (reduce, reuse, recycle) and zero waste principles, thus potentially beneficial to reducing the generation of marine litter.

India

India is the second most populous country in the world, with a population estimated at 1.366 million people in 2019. The country has a coastline of 7,517 km (UNEP and Development Alternatives 2014), with a coastal population of about 187.49 million.

State of marine litter management

India has been cited as one of the world's main sources of marine plastic litter, with 600,000 tons of mismanaged plastic waste generation in 2010 alone (Jambeck *et al*. 2015). More recently, the river Ganges has been ranked as the second river in the world regarding plastic emissions (Lebreton *et al*. 2017). Additionally, Jayasiri *et al*. (2013) recorded an average distribution concentration of plastic litter of 11.6 items/m^2 or 3.24 grams/m^2.

Noteworthy, a significant source of marine plastics in India is the ship-breaking industry. In the intertidal sediments found in the Alang-Sosiya ship-breaking yard (the world's largest), an average of 81 microplastic particles were discovered (Reddy *et al*. 2006). Ship-breaking also generates all kinds of scraps, including metals, rubber and plastic litter. In 2015, Indian Government's Central Pollution Control Board has identified 302 polluted rivers in the country. Four plastic bags were recovered from a beached Longman's beaked whale, which highlighted the increasing risk to the marine fauna posed by marine litter (Wesch *et al*. 2016). Among them, plastics are the major composition of marine litter. Moreover, the literature suggested that two main sources of marine litter in India are fishing activities and coastal recreational activities (tourism reflecting the inadequate waste disposal practices and littering behaviour) (Krishnakumar *et al*. 2018).

The sampling methods and findings for various types of samples are presented in Table 17.

Studies on marine litter distribution in India

Table 17 /

Year	Type	Findings	Method	Source
1982	Plastic pellets on Caranzalem Beach, Goa, India	Plastic pellet abundance: 50–300/m^2 along high watermark Plastic pellet properties: 3–5 mm broad and 1–4 mm long Identified potential origin: industrial (plastic factories) and maritime (cargo loss during sea transport)	Visual identification and collection	Nigam (1982)
2004	Small plastic debris in intertidal sediments of world's largest ship-breaking yard at Alang-Sosiya, India	Small plastic fragment abundance: 81.43 ± 0.49 mg/kg sediment Dominant types: polyurethane, nylon, polystyrene, polyester and glass wool	Intertidal sediments were sampled thrice during 2004 at 10 stations. At each station, 5–10 kg samples were collected at five stations, using stainless-steel scoop, up to depth of ~5 cm between high- tide line to low watermark. Sediment samples were also collected from two other stations (SS1 and SS12), one on either side of the yard and about 10 km apart. Sediments were dried and sorted according to size. To 1 kg of sieved material sediment, 4 litres of 30% NaCl solution were added. Contents were stirred for 1–2 h and allowed to settle for 15 minutes. Supernatant solution was filtered through Whatman GF/A (Thompson *et al*. 2004). Filters were dried at room temperature and sealed in Petri dishes. Particles were analysed, via microscope for examination and sorting, FTIR spectrometer for recording IR, and scanning electron microscope for morphological characterization.	Reddy *et al*. (2006)

(Continued)

Table 17 *(continued)*

Year	Type	Findings	Method	Source
2006 – 2008	Marine litter on beaches in the northern part of Gulf of Mannar, south-east coast of India	Shoreline marine litter abundance: 61 items weighing 3,655 g per 100m^2 area of northern Gulf of Mannar, with 52.8% being plastics Maximum shoreline marine litter: 94–95 items of 5,409–6,588 g noticed during May–June 2007 Minimum shoreline marine litter: 42 items of 2,088 g noticed in February 2008 Dominant shoreline marine litter type: plastics (48%), polystyrene (18%) and cloth (15%) Shoreline marine litter potential origin: Fishing (33.9%), tourism/ recreation (30.5%), sewage-related debris (13%), run-off (3.8%) and medical sources (0.4%) Factors in quantity of marine litter accumulation: Proximity to dense population centre, pilgrim activity and southwest monsoon	All anthropogenic debris was categorized according to material type—that is, as cloth, glass/ceramic, metal, leather, fabric, plastics (including polystyrene), paper, rubber and wood. At each site along 50-km shoreline in northern Gulf of Mannar, four 100 m^2 transects were chosen at random along top wet strandline parallel to the beach. GPS location and permanent structures were recorded to allow same shoreline to be surveyed over subsequent months. All litter items within each of 100 m^2 transect were collected, and natural debris was not removed. Marine litter items were categorized, according to likely litter sources, on Gulf's marine litter pictorial survey sheet. Percentage of source contributed to total debris was then estimated, using matrix scoring method described by Whiting (1998). Weight and number of litter items collected within each transect were recorded on established form, identifying its composition or specific identification or both. Observations of dead, entangled or stranded animals were noted, and relevant authorities informed. Statistical analysis was done, using two-way analysis of variance.	Ganesapand, Manikandan and Kumaraguru (2011)
2011 – 2012	Plastic litter in four sandy beaches in Mumbai, India	Plastic litter mean abundance: 11.6 items/m^2 (0.25–282.5 items/m^2) or 3.24 g/m^2 (0.27–15.53 g/m^2) Plastic litter size: 80% of plastic particles were within 5–100 mm size range, both by number and weight Microplastics dominance: Juhu Beach (55.3%)	Triplicates of 2 m × 2 m (4 m^2) quadrats were sampled in each beach, for total of 72 quadrats. In laboratory, plastic debris was washed with fresh water to remove sand, shells and other debris, and air-dried for 24 h to remove moisture. Then, plastic debris was sorted and classified into classes and then counted and weighed.	Jayasiri, Purushothaman, and Vennila. (2013)
2013 – 2014	Plastic/beach litter on 254 selected beaches along maritime States of peninsular coast of India as well as the Union Territories of Andaman and Lakshadweep Islands, India	Beach litter abundance: 0.31 g/m² (Odisha coastline) – 205.75 g/m² (Goa coastline) Plastic litter abundance: 0.08 g/m² (Odisha coastline) – 25.47 g/m² (Goa coastline) Share of plastic verus total litter: 14% (national mean), with range of (i) 7%–81% on peninsular coasts and (ii) 40% (Lakshadweep) – 47% (Andamans) on island union territories	Along stretch of coastline, sampling beaches (sandy and open beaches) were selected systematically at about 10 km intervals. Beach litter samples were sampled, using rope quadrate (10 m x 10 m), operated in triplicate from each station with 100 m interval on a line transect. Beach litter collected from three quadrates were pooled together, cleaned of adhering sand and moisture and then weighed, using a top pan balance, and finally sorted into six categories.	Kaladharan *et al.* (2017)

(Continued)

Table 17 *(continued)*

Year	Type	Findings	Method	Source
2014	Plastic debris in stranded adult female Longman's beaked whale near off Sutrapada, Veraval, Gujarat coast, India	Four, thick plastic sheets of shopping bags (190 g) had blocked intestinal passage of food. Hence, it was believed that death could be due to choking by plastic bag ingestion.	On 4 March 2014, one carcass of Longman's beaked whale (Indopacetus pacificus, Longman 1926) was spotted by local fishermen on shore off Sutrapada (near Veraval). Displaying no external injury or damage, carcass was about 4.38 metres in length and weighed 1 ton. Necropsy was conducted by officials from Forest Department and Wildlife Treatment Centre, Sasan Gir, Gujarat.	Kaladharan (2014)
2014	Plastic resin pellets (0.1 to 0.5 cm in diameter) in sandy beach sediments around Agatti Island, India	Total plastic resin pellets collected: 2,702 Dominant colours: white > black > yellow > grey > blue	Plastic resin pellet samples were collected from 10 locations of sandy beaches around Agatti Island. Samples included only microplastic resin pellets. Collected pellets were individually classified according to colour; total of five major categories were used, corresponding to colours "white", "black", "yellow", "grey" and "blue". Once classified, pellets were weighed, using an analytical balance, and their size were measured, using a calliper. Final storage was in separate glass containers, by colour. Subsamples of collected pellets were used to characterize major oxidation features on pellet surface. Nikon SMZ1500 stereomicroscope, coupled with digital camera, was used to this end.	Mugilarasan, Venkatachalapathy and Sharmila (2015)
2015	Microplastic pellets from six tropical beaches along Goa coastline, India	Total microplastic pellets collected: 3,000 (i.e. , that is, 1 655 pellets in June and 1 345 in January) Microplastic pellet dominant type: polyethylene and polypropylene Microplastic pellet dominant colour: white Microplastic pellet suspected origin: primarily from ocean-based sources	About 100 microplastic pellet (MPP) samples were collected from high-tide line of sandy surface of each beach, using pre-cleaned stainless-steel tweezers. MPPs were wrapped in aluminium foils, put into paper envelopes and transported to the laboratory. To assess amount of MPPs entered into Arabian Sea from rivers of Goa, neuston samples were collected from Mandovi, Zuari, Chapora and Sal rivers, using cylindroconical WP2 net with 50 cm-mouth diameter, 1.5m long and 100 mm mesh. Microplastic pellet samples collected from six sandy beaches were categorized based on colour and polymer types, using stereoscope microscope and Fourier-transform infrared spectroscopy (FTIR-ATR), respectively.	Veerasingam *et al.* (2016a)

(Continued)

Table 17 *(continued)*

Year	Type	Findings	Method	Source
2015	Microplastic pellets from Chennai coastline, India	Total microplastic pellets collected: 1,200 items of microplastic pellet, with size ranging from 2 to 5 mm with mean mass of 25 mg Surface properties of microplastic pellets: cracked, yellowish-white surfaces with more signs of oxidation (highest degree of degradation) Dominant shape of microplastic pellets: ovoid, spheroids, disc and cylindrical rods	For quantification of MPPs along beach high-tide lines, 1 m × 1 m quadrants were sampled. MPPs were wrapped in aluminium foil, put into paper envelopes and transported to the laboratory. Subsamples of collected MPPs were examined with Nikon SMZ1500 stereomicroscope, coupled with digital camera, to characterize major surface oxidation features. MPPs were analysed using Shimadzu FTIR, coupled with attenuated total reflectance diamond crystal attachment, to identify polymer compositions of MPPs.	Veerasingam *et al*. (2016b)
2015	Marine debris along Marina Geach, Chennai, India	Average marine litter abundance: 171.8 items/100 m and 3.24 kg/100 m along shoreline transect Total marine litter collected: 6,872 pieces or 129.67 kg Dominant marine litter type, by count: plastic (44.89%), lumber and processed wood (28.94%) were most numerous followed by metal, rubber, cloth and other types	Debris was collected twice monthly, on four occasions, between March 2015 and April 2015 from 10 transects, each 5-m wide and 100-m long, sorted and categorized by type, quantity and concentration rate along coastline. Before sampling, all existing marine debris on beach were removed (at end of February 2015 to remove possible effects of accumulation during past months). Samples were collected along 10 transects, each 5-m wide and 100-m long, from high-tide line towards vegetation line, covering 5,000 m^2 area. For each survey, recorders walked back and forth along 100-m transects and collected all visible anthropogenic litter in individually labelled plastic bags. Only surface debris was removed, and no attempt was made to exhume buried items unless they protruded through beach surface.	Kumar *et al*. (2016)

(Continued)

Table 17 *(continued)*

Year	Type	Findings	Method	Source
2016	Microplastics in lake and estuary sediment of Vembanad Lake, India	Microplastic mean abundance: 252.80 ± 25.76 items/m^2, with range of 96– 496 particles/m^2 Microplastic dominant type: Low-density polyethylene (26%–91%), high-density polyethylene, polystyrene and polypropylene	Sediment samples were collected from 10 sites along southern part of Vembanad Lake. Two sediment samples were collected from each site, using a Van Veen grab (25 cm^2), yielding total of 20 sediment samples. Wet samples were sieved through 5-mm mesh to remove large debris and retain particles of <5 mm size. Sieved samples were air-dried in glass trays covered with aluminium foil. Dried samples were disaggregated and sieved again through 5-mm sieve to ensure no particles greater than 5 mm remain in sample. Samples were then processed for microplastic extraction through density separation. In detail, samples were subjected to wet peroxide oxidation process, with 30% hydrogen peroxide, to digest organic matter present in samples. This mixture was then subjected to saltwater density separation (Galgani *et al*. 2013), using NaCl (d = 1.3 g/ml) to separate microplastics through floatation. Supernatant was then filtered, using Whatman GF/A filter paper (25 mm). Filters were air-dried and examined under compound microscope at 10 x resolution. Polymer components of microplastics were identified, using micro-Raman spectroscopy.	Sruthy and Ramasamy (2017)
2017	Coastal debris from Nallathanni Island, Gulf of Mannar Biosphere Reserve, south-east coastline of India	Beach debris abundance: 17–82 items per quadrant Beach debris dominant type: polyethylene, polyvinyl chloride, polystyrene, nylon and other	Maximum marine debris was observed and collected from coastline's seaward side (size was 0.83×0.02 km). Nine sampling quadrants were marked between berm and coast's high-tide line. Amount of marine debris per quadrant was counted by visual identification and microscopic examination.	Krishnakumar *et al*. (2018)

(Continued)

Table 17 *(continued)*

Year	Type	Findings	Method	Source
2017	Plastic debris in coastal sediments of Rameswaram Island, Gulf of Mannar, India	Total plastic debris sampled: 403 microplastic particles, with range of 1–71 particles per site Plastic debris dominant type: polypropylene (~39.7%), polyethylene (~17.9%), polystyrene (~15.6%), nylon (~14.6%), and polyvinyl chloride (~12.2%) Plastic debris dominant size: micro 1.01–4.75 mm (60.8%), meso 4.76–200 mm (~30%) and macro >200 mm (~9.2%) Microplastics dominant shape: irregular-shaped (~69.2%), fibrous-shaped (~17.9%) and pellet-shaped (~12.9%) Microplastics dominant colour: white (43.4%), green (21.6%) and blue (16.9%) Potential sources identified: tourism activities and fishing practices	Marine sediment samples were collected from 20 locations along coastal areas of study region, up to depth of 3 cm from top. Homogenized beach sediments were air-dried and sieved, using 2-mm mesh. Thirty grams of sediment sample were treated with hydrogen peroxide solution overnight to remove naturally available organic material from sediment matrix. Twenty-five millilitres of pre-prepared hydrochloride (4.5%) were added to samples before performing floatation techniques. Microplastic materials were separated by filtration metho, using 1.2 µm nitrocellulose-membrane filter paper. Distribution and characterization study was carried out by visual examination followed by FTIR spectroscopy.	Vidyasakar *et al*. (2018)
2014	Microplastic resin pellets from beaches of Chennai (metropolitan city on east coast) and from Tinnakkara Island, Lakshadweep archipelago (remote island), India	Total number of pellets collected: 201 from Chennai and 603 from Tinnakkara Dominant colours: Chennai, 47% yellow and 44% white; Tinnakkara, 15% yellow and 36% white Other observations: In Chennai coast, yellow pellets with significant surface oxidation features were plentiful, which indicates high photo-oxidative damage and longevity in marine environment. In Tinnakkara Island, white pellets were most abundant with less oxidation, confirming short residence time in marine environment and likely nearby sources.	Sampling protocols based on those of Thompson *et al*. (2004), McDermid *et al*. (2004), Jayasiri *et al*. (2013) and Acosta-Coley *et al*. (2015). Samples included only microplastic resin pellets. Collected pellets were individually classified according to colour. Once classified, pellets were weighed, using an analytical balance, and their sizes were measured with calliper. Final storage was in separate glass containers, by colour. Subsamples of collected pellets were used to characterize major oxidation features on pellet surface. Nikon SMZ1500 stereomicroscope, coupled with digital camera, was used to this end.	Mugilarasan *et al*. (2017)
2018	Microplastics presence (25 samples) in commercial marine sea salts at Tuticorin, Gulf of Mannar, South India	An elevated level of microplastics waste was found in sea salt sample (nos. 16–21) from Chennai coast. Microplastics dominant type: polyethylene (41.5%), polypropylene (22.7%), cellulose (11.2%) and nylon (8.7%) Microplastics dominant size: small (< 2 mm) Microplastics dominant type: fragments (55%), fibre (42%) and sheet (3%)	Each sample was collected to weight of 1.5 kg in standard packet. In Tuticorin region, salt manufacturing process involves. Once, clearing action was completed, the afloat present was clarified; it formed a 47-mm, 0.2 µm artificial nitrate film to which 10–14 mL of 5 M NaI was added. This mixture was placed in antiseptic Petri dishes (density = 1.6 g/ml). Type of various MPs particles was analysed applying µ-FTIR.	Selvam *et al*. (2020)

(Continued)

Table 17 *(continued)*

Year	Type	Findings	Method	Source
2018	Microplastics in coastal waters (14 locations), beach sediments (22 locations) and marine fishes (11 locations) from state of Kerala, south-west coastline of India	Microplastics abundance in beach sediment: mean microplastics abundance was 1.25 ± 0.88 particles/m^3 in coastal waters and 40.7 ± 33.2 particles/m^2 in beach sediments with higher concentrations in the southern coast of India Microplastics dominant type in coastal water and beach sediment: polyethylene and polypropylene Microplastics dominant shape in coastal water and beach sediment: fragments, fibre/line and foam Identified potential origin for microplastics in coastal water and beach sediment: river run-off and proximity to urban agglomeration Microplastics abundance in fish digestive tract: Digestive tracts of 15 out of 70 commercially important fishes studied; they contained 22 microplastic particles. Microplastics dominant type in fish digestive tracts: polyethylene (38.46%) followed by cellulose (23.08%), rayon (15.38%), polyester (15.38%) and polypropylene (7.69%)	Coastal water samples were collected ~1 km (3–5 m depth) offshore along coast. Boat was equipped with manta trawl net (300 µm mesh size) with opening of 30 x 15 cm) (Hydro-Bios, Germany) that was hauled horizontally for 20 minutess at speed of 2–3 knots. Beach sediments were collected, using quadrat and size fractional method of sieving, as described in Karthik *et al*. (2018). At end of each sampling, net was thoroughly rinsed with filtered seawater to ensure collection of all plastic debris into collection bag. Immediately after sampling, coarse non-plastic materials (various organic or inorganic material) were sorted visually and removed with stainless-steel forceps, and potential microplastics were stored in glass bottles. Sediment samples were collected from 1 x 1 m quadrat, using stainless-steel scoop up to a depth of 5 cm. Before conducting sieve analysis, all samples were stored in pre-cleansed stainless-steel containers of about 15 L. To separate different-sized fractions of microplastics (e.g. 0.3–0.6, 0.6–1.18, 1.18–2.36 and 2.36–4.75 mm), 10 L filtered (0.45 µm Whatman glass fibre) seawater was added to each container and stirred for 10 minutes. To determine microplastic type, samples were examined under stereomicroscope (SMZ 25; zoom range: 0.63× - 15.75×) fitted with digital camera. Commercially important marine fishes were collected from small traditional fishing boats, at major landing centres (11 locations) of Kerala coast. Fish samples were transported to laboratory in ice box and placed in cold storage (–20°C). Samples were thawed at room temperature and identified to genera or species where possible, before dissection. To determine presence of microplastics in gut content, all these containers were filled with 10% KOH (potassium hydroxid) solution and incubated for 24 h at 60°C. Digested gut content of each sample was examined carefully in Petri dish, with Nikon SMZ 25 stereomicroscope to ascertain microplastic presence. All materials suspected to be anthropogenic particles were photographed (with digital camera), and debris morphometrics were digitally measured, using image processing software (NIS-Elements).	Robin *et al*. (2019)

(Continued)

Table 17 *(continued)*

Year	Type	Findings	Method	Source
2018	Marine litter on beaches along South Juhu water channel	In total, three samplings conducted during February 2018. A total of 989 pieces, weighing 59.98 kg and falling in seven major categories, were collected during first month period of sampling conducted along South Juhu water channel. Marine debris abundance of first, second and third sampling was by count 269, 232 and 488, respectively, and by weight 10.09 kg, 12.23 kg and 37.65 kg, respectively. Identified marine litter origin: spring tide (carrying litter from recreational area) and excessive fishing vessel discharge, lacking appropriate polices	Sampling was carried out during ebb tide time for easy sample collection. Litter was collected by hand, and marine (or riverine) debris was collected and removed from channel. Marine and plastics debris was characterized according to standard protocol of Lippiatt (2013). Particles were classified as "micro" (<5 mm), "meso" (5–20 mm), "macro" (21–100 mm) and "mega" (> 100 mm) (Barnes *et al*. 2009; Stevenson 2011). Collected samples were washed with fresh water to remove salt and were properly sundried. Collected marine and plastic debris (<5 mm) were dried and quantified in terms of number and weight (g)	Manickavasagam, Chellamanimegalai and Dhayanath (2019)
2014	Nylon rope and e-waste in the coastal water of Veedhalai, Gulf of Mannar, India	Two different species of sponges were observed to have grown around the litter in the benthic marine environment. Weight of dry sponge and nylon fishing line were about 80g and 40 g, respectively.	During routine snorkelling and skin diving in nearshore area of Veedhalai (N 0915 06.43; E 79 06.33.71) in Gulf of Mannar	Ramakritinan, Ramkumar and Kumaraguru (2015)
2017–2018	Fishing-related plastic debris along beaches in Kerala Coast, India	A total of 15,360 items, weighing 497.6 kg were recorded in three seasonal surveys conducted on six beaches, out of this, 11,335 items (73%) weighing 298.2 kg (59.9%) were plastics. Of total debris recorded, 5,540 pieces (36%), weighing 198.4 kg (39.8%), were fishing-related trash. On average, 14.4 ± 12 fishing-related items/100 m^2, corresponding to mean weight of 0.55 ± 0.7 kg/100 m^2, were recorded from these beaches. Identified debris origin: higher fishing intensity, monsoon season	Site selection: Six beaches were selected for beach litter survey, along 590-km Kerala coastline (in south-west India). A pair of both high- and low-fishing-intensity beaches were chosen from north, central and south Kerala by stratified random sampling. Selection of fishing activity beaches depended on number ($n \geq 100$) and operation frequency (more than 20 days/month) of fishing vessels on the beach Sampling method: Every beach was sampled once during three seasons: pre-monsoon (February–May 2017), monsoon (June–September 2017) and post-monsoon (October–January 2017) for a total of 18 surveys. During survey, four transects of 5-m width were randomly selected on 100-m stretch of each beach parallel to waterline, as prescribed by U.S. National Oceanic and Atmospheric Administration for standing stock studies (Opfer *et al*., 2012). Along each transect, all anthropogenic surface debris items that measured over 2.5 cm (~bottle cap size) were collected by walking along width of selected transect and were then sorted, counted and weighed	Daniel, Thomas, and Thomson (2020)

State of municipal solid waste management

The 2013–2014 Environment Status Report of the Bombay Municipal Corporation showed that plastic accounted for about 675 metric tons (9%) of the total daily waste generated at that time (Manickavasagam, Chellamanimegalai and Dhayanath 2019).

With the marked population growth experienced in recent decades, the lack of strict regulations and an increase in anthropogenic activities, there has been an increase in coastal and estuarine pollution, including marine litter. Some major causes of marine litter in India are mismanaged municipal sewage, untreated industrial effluents, fish-processing industries, solid waste dumping and the aquaculture industry.

According to a study carried out by the Central Pollution Control Board, about 25,940 tons of waste are generated every day in the country. Total MSW generation in the country has been unequivocally estimated at 40 million tons in 2006 (Hoornweg and Bhada-Tata 2012), increasing to 62 million tons in 2015 (Sharma and Jain 2019). Despite differences in some estimations, it is certain that the increasing trends in MSW generation has been evident in more recent years and that this will continue in the near future. With a limited waste treatment capacity, a significant share of waste is directly dumped into the rivers and finally finds its way into the oceans, thereby rendering them highly polluted and a threat to worldwide economies and human health.

Data on single-use plastic waste generation and MSW management in India

Table 18 /

MSW background information [1]	
Population	1,310.2 million (2015)
MSW generation	52 million tons (2015)
MSW per capita	Limited data. Estimated at up to 0.53 kg/person/day in major urban centres
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	11.76 million tons (2019)
Polymer exports	2.31 million tons (2019)
Polymer imports	2.88 million tons (2019)
Domestic conversion of polymers into single-use applications	6.40 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	1.48 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.68 million tons (2019)
Domestic single-use plastic waste generation	5.58 million tons (2019)
Single-use plastic waste generation per capita	4.12 kg (2019)
MSW collection and treatment [3] [4]	
MSW collection coverage	70%–90%
MSW recycling rate	27% (2015)

Sources: Compiled from multiple sources, including: [1] Kaza *et al*. (2018); Liu *et al*. (2018); [2] Minderoo (2021); UNEP (2017); [3] Liu *et al*. (2018); and [4] UNEP (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 18.

Actions on combating marine litter

The Indian Government has taken many actions to address the issue of marine pollution. The most recent is the National Marine Litter Policy, an action plan to check plastic waste flowing into the oceans that aligns with the UNEP Global Clean Seas Campaign that the Indian subcontinent joined on the World Environment Day 2018 (Kripa *et al*. 2016). Also, the Ministry of Earth Sciences oversees the Marine Pollution Monitoring Program that highlights the issues of coastal and marine pollution in India; in action since 1991, the program has been helpful in assessing the health of the country's seas.

Other government actions include the enactment of The Water (Prevention and Control of Pollution) Act in 1974 and The Environment Protection Act in 1986 established by the Ministry of Environment, Forests and Climate Change. Government of India has developed a comprehensive Policy Statement for Abatement of coastal pollution and derived "Sea Water Quality Criteria" for toxic heavy metals and pesticides. These have been prescribed for enforcing an amendment in the existing Ministry's Gazette Notification (India, Ministry of Environment, Forests and Climate Change [MoEFCC] 1998). Moreover, India was the host country for the 2018 World Environment Day, themed "Beat Plastic Pollution". In October 2019, the Indian Government's Directorate General of Shipping announced a ban of all single-use plastic products on all ships, local or foreign alike. And for a final example of governmental action, in Mumbai, the Municipal Corporation of Greater Mumbai funds daily beach clean-ups on its coast (Jayasiri 2013).

In the field of public engagement, the Ministry of Environment, Forest and Climate Change of the Indian Government and the Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) jointly launched the Climate Literacy and Marine Litter Management campaign, which carried out a variety of education and communication campaigns to raise local awareness on climate change adaptation and marine litter management.These campaigns included discussions, exhibitions, pilot climate change proofing measures and beach clean-ups in more than 300,000 local communities in more than 280 villages along the east coast of India.

Indonesia

Indonesia is the world's fourth most populous country, with a population estimated at 270.62 million in 2019. The country generated 65.2 million tons of MSW in 2016 (Kaza *et al*. 2018).

State of marine litter management

With a coastline of 54,716 km and about 60 per cent of the population living in coastal regions (Hillmann *et al*. 2015), Indonesia faces severe marine litter challenges. Back in 2010, Indonesia was listed as one of top contributors of plastic marine litter (Jambeck *et al*. 2015), with limited studies conducted by Indonesian scientists since that time (Syakti *et al*. 2017).

Selected studies on the distribution of marine litter in Indonesia are listed in Table 19.

State of municipal solid waste management

Indonesia had generated 65.03 million tons of MSW in 2015 and 65.2 million tons in 2016 (Kaza *et al*. 2018). However, MSW collection covered, in general, 40%–50% of the population, with 6.03 million tons collected from provincial capitals in 2015 (UNSD 2018); this figure is in line with estimates according to which less than half of the population is served by collection services (Lestari and Trihadiningrum 2019). According to the Indonesian Government (Indonesia, Ministry of Environment and Forestry 2020), 79 per cent of waste is landfilled, 12 per cent incinerated and 9 per cent recycled. Landfilling remains a common practice in Indonesia, while new types of waste management infrastructure have been introduced in recent years, including 12 waste-to-energy (WtE) power stations.

Data on MSW composition, collection and treatment and on single-use plastic waste generation, as well as background information, are shown in Table 20 and Figure 4.

Studies on marine litter distribution in Indonesia

Table 19 /

Year	Area	Abundance	Method	Source
May 1985	Beach sediment from 24 islands of Thousand Island, Indonesia	Macroplastics abundance: 54–22 items/m^2 (according to Syakti *et al.* 2018) Items of litter per meter of strand line: polythene bags (0.1-6.4 items/m along transect), polystyrene blocks (0.1-4.8 items/m along transect) and plastics and glass bottles (0.1-0.9 items/m along transect). Of the 27,600 items noted in survey, 42% were polythene bags; 28%, footwear; 23%, polystyrene blocks; 3%, bottles; 2%, tins; 1%, fishing gear; and 1%, lamp bulbs.	Standard procedure consisted of measuring 50-m section of strand line and simply counting numbers for each category of litter present. Transects were made at regular intervals around each island, allowing 50 m –250 m between consecutive transects, depending on island size. Counted during this survey were items of man-made materials, including plastics, polystyrene, rubber, nylon, glass and metal items.	Willoughby *et al.* (1986)
1993	Coastal areas of Ambon Island, Eastern Indonesia	Overall, mean density of objects was 4.6 items/m^2, consisting predominantly of organic matter and synthetic items, especially plastics. Abundance of synthetic materials (items): food wrappings (206), string/rope (163), cloth (179), plastic fragments (136), carrier bags (104), sandals (100), plastic bottles (70), polystyrene (70), tin cans (66), hessian sacks (60), polyethylene (57), cigarette boxes (45), scrap metal (39), aluminium cans (38), plastic cartons (30), shoes (27), table coverings (21) and tin foil (20) Mean number per m^2: 2.8 items/m^2 Percentage cover: 8.3%	In surveying 56 sites, shores were sampled by making transects 100-m long immediately above and parallel to strand line. There were 10 equally spaced quadrats along each transect. These were normally 1 m x 1 m, but where area above strand line was foreshortened (by for instance, rocky outcrops or sea defences), quadrats measured 0.5 m × 2.0 m. Records were kept of numbers of litter items per quadrat, and percentage of items in four litter categories: synthetic materials (metal and plastic objects), organic materials (including faecal material), glass (including ceramics) and paper (including cardboard). Human population size in towns and villages adjacent to study sites were obtained from Statistics of Malukus 1992. Shores were also categorized qualitatively by eight types in relation to their exposure to wave action and substrata.	Evans *et al.* (1995)

(Continued)

Table 19 *(continued)*

Year	Area	Abundance	Method	Source
June and July 1994	Litter on beaches at Pulau Seribu Archipelago (to the north and west of Jakarta), Indonesia	Recorded types of litter: plastic bags, footwear, polystyrene blocks, bottles, tin cans, ropes and nets, and light bulbs Density and abundance: not presented Influencing litter factors identified: surface currents that reverse in Java Sea during two monsoon seasons Other findings: amount of litter on shores has increased substantially since 1985, presumably reflecting both accumulation of slowly degrading plastics in coastal environment and increased use of plastics during the past decade	Number of litter items were recorded along transects measuring 10 m x 1 m, immediately above strandlines of shores. There were between 5 and 20 transects for each island, depending on its size and typography. They were spread at about equal intervals around island's circumference. Litter was categorized in the same way as Willoughby (1986).	Uneputty and Evans (1997a)
September 1995	Beach litter on 23 islands in Jakarta Bay, Indonesia	Nearly 34,000 items of litter, belonging to 11 categories, were counted. Polystyrene blocks, plastic bags and discarded footwear made up 80% of items counted. White polystyrene and plastic bags accounted for, respectively, 38% and 27% of total beach litter. The mean density of litter on beaches ranged from 0.3 items/m to 29.1 items/m. Weight of litter was estimated via visual observation to be less than 1.0 t/km/yr. Identified potential sources are either waste emitted in urban Jakarta, passing ships or local residents or island tourism.	Strandline litter: Method used to assess strandline litter was similar to that described in Willoughby (1986). Ninety-nine transects were carried out on 23 islands visited. Sea surface litter: As boat carried team around islands returned to Jakarta, counts were made for 5 minutess at a time, recording pieces of sea surface litter within an estimated 3 m from starboard side. Because boat was moving at calculated 12 km hr/t, thus, area covered during each five-rain period was 3,000 m^2.	Willoughby, Sangkoyo and Lakaseru (1997)
1994–1995	Tidal flats	Number of items: 0.27 ±0.08 items/ m^2 at Poka; 0.21 ± 0.04 at Waiheru; 0.69 ± 0.10 at Halong; 0.38 ± 0.06 at Airsalobar; and 0.05 ± 0.02 items/ m^2 at Seilale.	Litter item count was recorded along transects, measuring 10 m x 1 m immediately above strandlines. For each island, there were between 5 and 20 transects spread at about equal intervals.	Uneputty and Evans (1997b)
2013	Seafloor coral reef in Sulawesi, West Papua and Bali, Indonesia	Microplastic abundance: — Sulawesi: 13.3 ± 8.4 items/100m^2 (510 m^2 surveyed, 6 sites) — Bali: 25.6 ± 12.2 items/100m^2 (480 m^2 surveyed, 8 sites) — West Papua: 25.3 ± 6.9 items/100m^2 (440 m^2 surveyed, 9 sites) Suspected origin: 71% of plastic debris surveyed was associated with textiles, household goods, packaging and consumable items, while remaining 29% was discarded fishing gear	Three belt transects laid along reef contours at 3 m–4 m in depth and about 20 m apart, using globally standardized protocols. Belt transects were either 10 m, 15 m or 20 m × 2 m (area surveyed at each reef ranged between 60 m^2 to 120 m^2).	Lamb *et al.* (2018)

(Continued)

Table 19 *(continued)*

Year	Area	Abundance	Method	Source
2014	Fishes (*n*=76) on sale in Makassar, Indonesia	Microplastic abundance: 21 items (28%) of plastic found in gastrointestinal tracts of 76 individual fish Average length: 3.5 mm (±1.1 SD) Dominant shape: 63 plastic fragments (60%), 39 plastic foam pieces (37%), 2 plastic films (2%) and 1 plastic monofilament line (1%)	Gastrointestinal tract was placed into individual polypropylene sample jars; these were filled to three times volume of tissue with a 10% KOH (potassium hydroxid) solution in ultrapure water, which was incubated overnight at 60°C to digest organic material.	Rochman *et al.* (2015)
May 2015	Deep-sea sediment samples (*n*=10) taken at depths ranging from 66.8 m to 2,182 m at western Sumatera, eastern Indian Ocean	Microplastic abundance: 41 particles in form of granule (35 particles) and fibre (6 particles) found in 8 out of 10 sampling sites Though most of 20 microplastics were found at depths less than 500 m, they were also present at more than 2,000 m deep.	Samples were retrieved at 10 stations, using 60 cm x 40 cm x 50 cm box core. Microplastic extraction was conducted with modified floatation method, using concentrated saline solution at 1.18 g/l and double-distilled deionized water. Sediments were oven-dried (60°C, 24 h). To remove organic matters, sediments were added with H_2O_2 and heated (90°C), and then visible froth was removed. Dried sediment samples, weighing 62.5 g, were put in Erlenmeyer bottle with 250 mL concentrated saline solution; they were then stirred, using mechanical shaker (200 rpm, 10 minutes). After 6 hours, supernatant was extracted from mixture and filtered into Whatman cellulose filter paper (dØ 47 mm; pore size 0.45 μm).	Cordova and Wahyudi (2016)
May 2013/ May 2014/ May 2015	Beach sediment samples from Cilacap Coastal, Indonesia	Microplastic abundance: 0.12 items/m^3 with weight 2.5 mg/m^3 Microplastic abundance: 16.8–41.6 items/m^2 Dominant polymer type: polypropylene (68%) and low-density polyethylene (11%)	Seventy students were tasked with marking sampling quadrats and then sorting and counting plastic litter in quadrats. Chosen were 24 quadrats (from 8 transects), based on accessibility and orientation with respect to dominant south-easterly winds. At each sampling transect, 30-m-long transect line was delineated, and three quadrats, measuring 2 m × 2 m, were delineated alongside transect parallel to shoreline. Sampling points were located 1–1.5 km from one another.	Syakti *et al.* (2017)

(Continued)

Table 19 *(continued)*

Year	Area	Abundance	Method	Source
December 2015	Sediment samples (*n*=10) at coral reef habitats in Sekotong, Lombok, Indonesia	Microplastic abundance: 35 to 77 particles per-kg, with average 48.3±13.98 (SD) particles per-kg Dominant shape: foam (41.20%), fragment (32.51%), granule (22.77%) and fibre (3.52%) Dominant polymer type: polystyrene, polyethylene and polypropylene Suspected origin: fishing devices as well as food and beverage packages, including Styrofoam™	Sediment samples were taken, during December 2015 east monsoon season, by diving in coral reef habitats (depth range 3–5 m) (Figure 1). Ten stations were spread out throughout Sekotong Bay. Sediment samples (1,000 g) were taken, using stainless steel shovel within sediment surface (5–10 cm). Samples were added with 30% H_2O_2 and heated on a hot plate (80°C–90°C), and then visible froths were removed. Sediment was put in Erlenmeyer bottle with 250 mL concentrated saline solution (1.18 g/L NaCl on double-distilled deionized water) and then was stirred, using mechanical shaker (1,000 rpm, 10 minutess). After 6 hours, supernatant was extracted from mixture and then filtered into Whatman cellulose filter paper (dØ: 47 mm; pore size 0.45 μm).	Cordova, Hadi and Prayudha, (2018)
March to July 2015	Microplastics in digestive tract of specimen in commercial fisheries off Pantai Indah Kapuk coast, Jakarta, Indonesia	Abundance: microplastics were found in 169 of 174 (97.13%) of examined fish. Total of 2,063 microplastic particles were collected with average number of 12.21 ± 9.76 particles per individual. Highest number (20.0 ± 8.0 particles/individual) was found in Sardinella fimbriata, and the lowest (4.9 ± 4.7 particles/individual) was found in Oreochromis mossambicus. Dominant types of ingested particles: fibres (89.63%), fragments (6.24%) and films (4.13%) Dominant colour of ingested particles: transparent particles (79.20%), followed by blue (7.03%), red (3.54%), black (2.86%) and green (2.71%) Other findings: highest number of fibres by size was <20–100 μm (55.03%); films, 100–1,000 μm (33.93%); and fragments, <100 μm (25.25%)	Fish were collected in six stations along Pantai Indah Kapuk coastline from March to July 2015. Six gillnets (30 m ×1.5 m) with 2 x 2 cm mesh size were operated in each station. After cleaning and dissection, digestive tract content was diluted in NaCl saturated solution to extract microplastic particles. Digestive tract content was examined for natural prey, with microplastics examined under microscope (10 x10 magnification). Microplastic particles were identified by abundance (particles individual-1) and categorized by type (film, fibre, fragment and pellet); colour (transparent, blue, red, black, green, orange, yellow and purple); and micrometre size (<20-100 μm [55.03%] for fibre, 100–1000 μm (33.93%) for film, and <100 μm for fragment).	Hastuti, Lumbanbatu and Wardiatno (2019)

(Continued)

Table 19 *(continued)*

Year	Area	Abundance	Method	Source
March 2016	Marine litter on Selayar Island Coast, South Sulawesi, Indonesia	Average density of organic waste by weight: 4,978.3 ± 3,342.5 g/m^2 Number of pieces: 7.7 ± 1.8 items/m^2 Inorganic waste density: 14.3 ± 2.97 items/m^2 (number of pieces) and 564.8 ± 196.1 g/m^2 (waste weight) Daily accumulation: 1,445 ± 1,743 g/m/day, of which: — number of pieces =14.3 ± 8 item/m/day — cubication = 0.0187 ± 0.019 m^3/m/day Inorganic litter composition: rubber and plastic, including Styrofoam™ (lighter material than organic litter) Influencing factors of litter identified: presence of estuary and slope of shore	Marine litter data was collected by line-transect method to determine types, weights, quantities and spreads of area. Size of samples that were observed > 2.5 cm or macrolitter. Sampling was done in transect with 5-m width and length by following the beach width. Observations were conducted at low-tide water level and repeated three times plot every site (Lippiatt, Opfer and Arthur 2013). Floating litter was observed via visual survey, according to UNEP (2009). Marine litter was counted on the ground. Floating litter was observed by snorkelling over 17 days, from 5 to 22 March 2016, and 2-m width. Daily accumulation rate of marine litter determined by line-transect method, starting from coast to slope. After stranded marine litters were collected and sorted, the amount, types, weights, density and composition were analyzed (Walalangi [2012]; Eriksson *et al.* [2013]).	Hermawan, Damar and Hariyadi (2017)
2017	Microplastics in sediment samples from riverbed in Pluit and Ancol areas in Jakarta Bay, Indonesia	Microplastic abundance in sediment: 18,405 to 38,790 particles/kg dry sediment Fragment sized 100-500 μm was most abundant microplastic type in two locations. Majority of polymer found in sediment was low-density polypropylene.	Microplastics were separated using graded filter (5,000 μm, 1,000 μm and 30 μm) following these processes: drying, volume reduction, density separation, filtration and visual sorting (Hildago-Ruz *et al.* 2012). Smaller microplastic samples (30–100 μm) were separated using a monocular microscope (magnification 10 x 10).	Manalu *et al.* (2017)
2017	Mussels (*n*=30) collected from high salinity (36 ppb, 5 km from shore), low salinity (33 ppb, 0.5 km from shore) and brackish water at Java Sea in Tambak Lorok, Indonesia	Microplastic abundance: 4–20 n/g wet tissue weight Average microplastic size: 211.163 μm	Mussels were removed from shell and fed into 200 mL 30% H_2O_2 saturated saline solution (1.2 g/mL). After mixing and standing, overlying water was filtered (with filter paper) for analysis, using scanning electron microscopy with energy-dispersive X-ray analysis (also referred to as "SEM/EDX").	Khoironi, Anggoro and Sudarno (2018)

(Continued)

Table 19 *(continued)*

Year	Area	Abundance	Method	Source
2017	Micro- and macrolitter in intertidal zone of Jaring Halus Village, Langkat Regency, North Sumatra Province, Indonesia	Total macroplastics items collected from 3 stations (divided into 27 observation plots) was 308 items with total weight of 3 689.87 grains. Highest macroplastic density found in Station 2 ranged from 18.33 to 190.33 species/ m^2, with weights ranging from 246.33 to 2 103 grains. Lowest density found in Station 3 ranged from 3.33 to 11.67 species/ m^2, with weights ranging from 13.46 to 117.67 grains. (Note: 1 grain = 64.79891 milligrams) Microplastic dominant shape: film (52.30%), fibre (24.88%), fragment (22.74%) and pellet (0.1%)	To conduct macrodebris survey, samples (> 20mm) were collected with transects (1 m × 1 m) from each substation with highest and lowest tidal boundaries divided into three sections. Samples are collected into sacks and labelled by macrodebris composition group: plastics and foams, including Styrofoam™, as well as fabrics, glass, metal, rubber and wood. Items (to further explain the flakes) in each macrodebris group were collected, dried, calculated and weighed. Parameters taken include number of items (items/m^2) and weight (g/m^2). To conduct microdebris survey, sediment sampling (1L) was performed with core based on three stratified depths (0–30 cm). Core placement was performed at substations on three sections (top, middle and bottom edge) at both highest and lowest tides. Sediments from microplastic particles (0.045–5 mm) were processed over several stages, namely, drying, volume reduction, separation of density, filtration and visual sorting. Drying was done at 105°C oven temperature for 72 hours. Dry-sediment volume reduction was performed by filtration (5 mm in size) [17]. Density separation step was carried out by mixing dry-sediment sample (1 kg), saturating with NaCl (3L) solution, and then stirring mixture for 2 minutes. Floating plastics were polystyrene, polyethylene and polypropylene. Filtration stage was carried out by filtering supernatant (size 45 µm).	Bangun *et al*. (2018)
2017	Sediment (*n*=81) and benthic animal samples (*n*=51, including 17 echinoderms, 18 bivalves, 16 gastropods) from Spermonde Archipelago, Indonesia (average water depth 4 m–6 m)	Microplastics discovered in 22 of 81 sediment samples, with abundance from 2.96 to 28.29 items/kg Nineteen microplastics discovered in 10 of 51 benthic animal samples, with abundance range from 0.30 to 0.50 items/individual Dominant shape was line (filament): 84% in sediment samples and 95% in benthic animal samples	Oven-dried sediments (100 g) were passed through sieve-net with gradient mesh, reducing size down from 2 mm to 0.063 mm. Benthic animals were all subjected to 10% KOH (potassium hydroxid) at three times of sample volume and left at 60°C overnight. Microplastics were identified with stereomicroscope (magnification 4.5 x 10).	Tahir *et al*. (2019)

(Continued)

Table 19 *(continued)*

Year	Area	Abundance	Method	Source
October–November 2017	River surface and sediment samples (*n*=10) in slum and industrial areas in Ciwalengke River, Indonesia	Microplastic abundance in surface water: 5.85 ± 3.28 items/litre Microplastic abundance in sediment: 3.03 ± 1.59 items/100g dry sediments Dominant polymer type: polyester and nylon fibre	Sediment samples were collected at centre of river, using Ekman grab sampler on river sediments and shovels for rocky sedimentary river conditions. Dissolved were 100 g of sediment sample with 400 mL 30% NaCl solution. Stirred for 2 minutess and left standing, then filtered using vacuum pump on Whatman GF/C (glass microfibre filter 1.2µm) filter paper. Water samples were collected at centre of river (at about 45 cm from surface), using grab sampling method with 1 L glass container. Sample of 500 mL water was filtered, using Whatman GF/C (glass microfibre filter 1.2µm) paper. Microplastic particles were identified, using binocular microscope, and categorized by shape and size. Raman spectroscopy was then used to determine polymer type.	Alam *et al.* (2019)
June 2018	Macrodebris in Savu Sea Marine National Park (Kupang, Rote, and Ndana Beaches), East Nusa Tenggara, Indonesia	Debris collected from sampling sites weighed 52.14 kg with abundance 4.447 ± 1.131 kg/m^2 and 215.417 ± 35.609 item/m^2 Dominant type: food wrapper and plastic bag Influencing factors identified: population activities and maritime transport	Six beaches were assessed on this study, comprised of total of 12 transects. Using line transect between 100 m on each side, all debris > 2 cm (macrodebris) were collected, categorized, counted and weighed. Team of 5–10 persons collected debris over 2–3 hours, with surveyors divided into several groups of 3–5 persons. Interviews with locals were also carried out to gain more information.	Purba *et al.* (2018)
2018	Beach sediment samples (*n*=11) from small islands in Bintan Regency, Riau Island Province, Indonesia	Average number of floating microplastics (from 11 beach stations around Bintan Island): 122.8 ± 67.8 pieces per station, with concentration 0.46 ± 0.25 pieces/m^3 Dominant polymer type: polyethylene (17.3 ± 8.3%), low-density polyethylene (17.6 ± 5.5%), oxidized low-density polyethylene (< 0.1%), polypropylene (54 ± 13%), polypropylene atactic (< 0.4%), polypropylene isotactic (< 0.2%) and polystyrene (10.4 ± 9.1%)	Samples were collected from 11 sampling stations, using a specially designed Neuston net (75 cm × 50 cm), opening to rigid frame equipped by four successive different-sized grids, towed along 1.8 km of imaginary transect lines at boat speed of 1–1.5 mi/hr (about 1.61 km – 2.41 km/hr). After towing, microplastic particles trapped in mesh (sized 1 mm–5 mm) were separated and collected with a beaker glass containing 1% of H_2O_2. After 24 hours, plastics were then floated in 3M of $ZnCl_2$ to separate plastic from non-plastic material. Other microplastics were obtained by washing filter screen with sufficient volume of $ZnCl_2$ salt solution (3 M) and then filtered, using of 0.2 µm nitrocellulose filter (Whatman) before counting and shape determination.	Syakti *et al.* (2018)

(Continued)

Table 19 *(continued)*

Year	Area	Abundance	Method	Source
2018	Beach of Bintan Island, Indonesia	Abundance of stranded macroplastic: 1.2–4.7 items/m^2 Rate of stranded macroplastic apportionment: 0.09 ± 0.05 items/m^2 per day Dominant polymer type: low-density polyethylene (22.9%), polystyrene (19.5%), polypropylene (16.6%), polyethylene terephthalate (10.4%), high-density polyethylene (9.2%), polyvinyl chloride (7.2%), polyurethane (4.9%), polyester (4.7%), polyamide (4.3%) and styrene/butadiene (0.3%)	Plastics were enumerated in a 180 m^2 permanent quadrat (6 m × 30 m) in intertidal zone. Polymers were also identified directly on-site, using mobil-IR portable FTIR spectrometer. Each site was visited at least three times over 45 days, with a minimum waiting time of 7 days between each visit.	Syakti *et al.* (2019)
2018	Sediment samples (*n*=5) from Wonorejo Coast, East Java	Microplastic abundance in sediment: 590 particles/kg dry weight Microplastic dominant shape: fibre (57%), film (36%) and fragment (7%) Microplastic dominant polymer type: 56.7% polyester, 24.6% low-density polyethylene and 18.8% polypropylene Microplastic dominant colour: 43% transparent, 21% black, 14% blue, 10% white, 8% red and 4% yellow	Sediment samples from five sites in the estuary and the adjacent coast were collected in replicates using Ekman dredge sampler. MP particles were extracted using density separation method. Then MP particles were counted and categorized according to shape, size and colour under a Zeiss Discovery V.12 stereomicroscope. Identification was done using Thermo Scientific Nicolet iS10 FTIR Spectrometer.	Firdaus, Trihadiningrum and Lestari (2019)
May 2018 –January 2019	Marine water and digestive tracts of Grey-eel catfish (Plotosus canius, *n*=15) from three stations in Tanjungpinang Water, Riau Islands, Indonesia	MPs abundance in marine water: 4.98 piece/m^3 (Sei Jang, with dense population), 4.13 piece/m^3 (Teluk Keriting, with coastal community) and 6.87 piece/m^3 (Pelantar KUD, watershed with dense community over water) Plastic abundance in fish: 17 items/individual (mesoplastic, 5 mm–2 cm) and 162 items/individual (microplastics, 50µm–5mm)	Surface seawater was sampled using Neuston net called CetoRhiNet, towed for 1 nautical mile at 1 knot speed. After being filtered with Millipore paper, samples were inspected with microscope to count number of plastics. P. canius digestive tracts were soaked in H_2O_2, and MPs were separated using $ZnCl_2$ based on their density prior to analysis under a light microscope.	Lubis, Melani and Syakti (2019)

Regarding solid waste management, on the one hand, Indonesia has established a good legal framework for waste management (OECD 2019). For instance, Indonesia issued the Roadmap towards the 2025 Clean-from-Waste Indonesia (Presidential Decree No. 97/2017) in 2017, aiming to reduce its solid waste production by 30 per cent and to prevent solid waste from entering landfills through reuse and recycling.

On the other, Indonesia has been combating the challenge of the illegal import and pirate plastic waste imported from developed nations. In July 2019, Indonesia returned foreign rubbish that did not qualify as recyclables to developed countries, including Australia, France, Germany and the United States.

Another waste management challenge is the often deeply ingrained practice of dumping and burning uncollected waste, with over 50 per cent of Indonesian urban households and almost 90 per cent of rural households burning waste. According to an environmental behaviour study by the Central Bureau of Statistics, a 2013 survey of 75,000 Indonesian households across all provinces found that between 10 and 18 per cent of Indonesian households dump their waste directly into waterways and an additional 10 to 30 per cent dump it into a site from which it can leak into waterways. In fact, 18.5 million Indonesians use waterways as their primary trash disposal method, and many millions more use waterways as one of several methods of disposing trash.

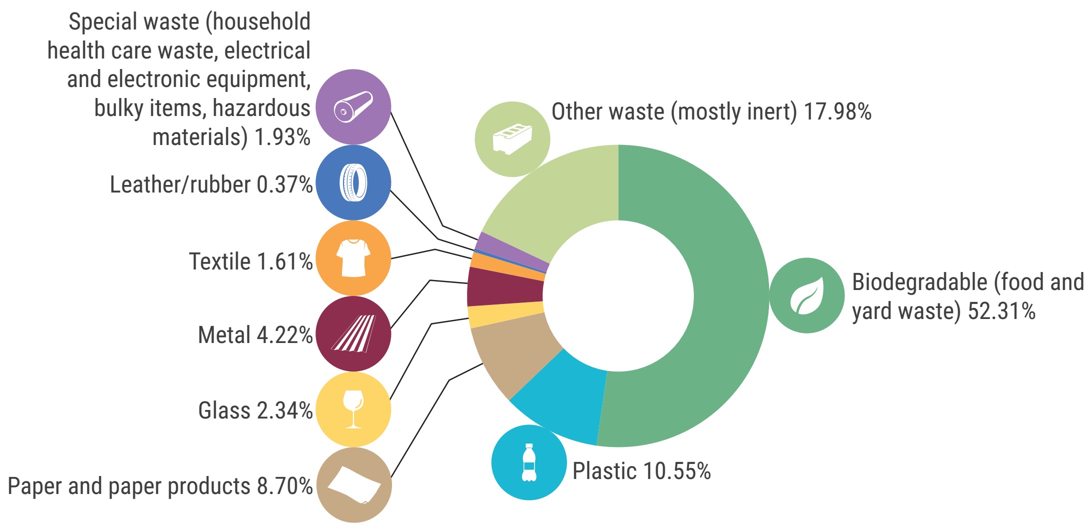
In Indonesia, the governmental level of institutional oversight over solid waste management is based on the source and flow of waste (e.g. land-based versus waterway). At the local level, MSW management is typically under the jurisdiction of each district's Cleansing Department (Seksi Kebersihan), with household-level collection delegated to the local government. On the

Data on single-use plastics generation and MSW management in Indonesia

Table 20 /

MSW background information [1]	
Population	270.62 million (2019), with 55.3% urban population
MSW generation	65.2 million tons/year (2016)
MSW per capita	0.68 kg/person/day (2016) on average 0.70–0.80 kg/person/day in urban areas (1.31 kg/person/day in Jakarta) 0.45 kg/person/day in rural areas/islands (2008)
MSW generation growth	2%–4% annually
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	1.91 million tons (2019)
Polymer exports	0.42 million tons (2019)
Polymer imports	2.60 million tons (2019)
Domestic conversion of polymers into single-use applications	2.30 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.72 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.68 million tons (2019)
Domestic single-use plastic waste generation	2.26 million tons (2019)
Single-use plastic waste generation per capita	8.47 kg (2019)
MSW collection and treatment [3]	
MSW collection coverage	40%–50% (2015)/40% (2001) 56% in urban areas/5% in rural areas
Method of treatment	14% diverted from disposal (recycled/composted/WtE/biogas) 66.4% landfilled 19.6% unmanaged
Number of treatment and disposal facilities	5,244 temporary solid waste storage and recycling points (waste banks); 242 compost sites; 24 sanitary landfills; and 52 controlled dumpsites

Sources: Compiled from multiple sources, including: [1] Kaza, Bhada-Tata and Van Woerden (2018); [2] Minderoo Foundation(2021); and [3] Borongan and Kashyap (2018).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.



Source: Borongan and Kashyap (2018a).

MSW composition in Indonesia

Figure 4 /

other hand, MSW flows in waterways is handled by different departments, depending on the city (Shuker and Cadman 2017).

On the national scale, the Ministry of Environment and Forestry has the responsibility to develop policies, formulate regulations and coordinate efforts in waste collection and recycling. Moreover, the responsibilities of the Ministry of Public Works and Housing is generally limited to providing technical advice, promoting pilot projects, and constructing and supervising large-scale off-site solid waste facilities (landfills). Although the ministries offer sectoral inter-linkages across departments, persistent overlaps in their roles and responsibilities adversely affect the efficiency and effectiveness of the execution of mandates and institutional responsibilities (Shuker and Cadman 2017).

Actions on combating marine litter

Marine litter has gained a high degree of awareness among policymakers in Indonesia. Multiple policy actions have been introduced, including presidential decrees, government policies prohibiting the use of plastic bags and action plans against marine litter. Policy actions taken by the Government of Indonesia in combating marine litter are shown in Table 21.

For instance, as early as February 2017, the Indonesian Government joined the UNEP Clean Seas Campaign at the fourth World Ocean Summit in Bali, promising "to reduce marine plastic waste by 70% by 2025" and pledging $1billion in funding each year to support a range of programmes on land, coast and sea to realize such objectives.

To this end, the Government published "Indonesia's National Plan of Action on Marine Plastic Debris 2018–2025", a Plan with five pillars—that is, improving behavioural change, reducing land- and sea-based leakage, reducing the production and use of plastics and enhancing funding mechanisms, policy reform and law enforcement.

Towards these goals, the Plan focuses on the following areas:

- At the local government level, the river catchment authority must provide human and financial resources for improving plastic waste management infrastructure

Table 21 / Government action on combating marine litter in Indonesia

Year	Directive
2017	Indonesia's Plan of Action on Marine Plastic Debris 2017–2025
2018	National Plan of Action to Combat Marine Debris 2018–2025 (Presidential Decree No. 83/2018)

and drive behavioural change through integrated coastal waste management projects.

- At the national level, plastic waste education, waste-to-energy projects, plastic bag fee policy, reuse of waste plastics (for instance, to make asphalt mix for "plastic tar road") and comprehensive regulations on plastic waste are the main areas of focus.
- Regional and bilateral cooperation.
- For the industrial sectors, the use of biodegradable plastics as well as foreign investments in the biodegradable plastics industry are encouraged, while "circular economy" and "3R" principles are promoted.
- For academia and community service organisations, the main areas of action are research and development, campaign and "Waste Bank".

Some innovative measures have been taken in Indonesia to manage plastic pollution. For instance, in 2017, the Indonesian Government tried to use asphalt with plastic waste as a raw material for pavements. For another example, the "Plastic Bus" project, launched in 2019, allows passengers to exchange rubbish in exchange for tickets. Since 2018, "Plastic Bank" has been set up in various locations in Indonesia in partnership with SC Johnson to encourage people to use plastic waste in exchange for household goods, a project that has contributed to an improved recycling rate in Indonesia.

Specifically, Indonesia actively seeks technologies that can effectively remove or manage marine plastic litter. In June 2019, nearly 8,000 people, including citizen cleaning teams, army staff and government officials, were mobilized by the Government to participate in Jakarta's "Ciliwung River Cleanup" campaign. Since 2014, the Indonesian Government has installed blocking grids in rivers in various places, collected by mechanical hydraulic devices and cleared by sanitation workers. In May 2019, with support from the Indonesian and Dutch governments and the French Danone Group, the Dutch organization The Ocean Cleanup Foundation placed a floating plastic litter interception and collection device in the Jakarta River, which collects up to 1.8 tons of litter per day. In November 2019, the Indonesian social enterprise "Waste4Change" cooperated with the German NGO One Earth One Ocean to clean up river litter in West Java with semi-automatic collection boats designed to collect about 100 kg of river litter daily.

Japan

An archipelagic state, Japan has a coastline of 29,751 km, and its 2019 population was estimated at 126.86 million. In terms of total MSW, generation was 43.17 million tons in 2016 (Organisation for Economic Cooperation and Development 2019) and collection was at 44.32 million tons in 2014 (UNSD 2018).

State of marine litter management

Japan has extensive expertise on this issue, having been a leader on both research and global policy on marine litter management. The Japan Agency for Marine–Earth Science and Technology (JAMSTEC) has constructed a "Deep-sea Debris Database", providing remotely operated vehicle imagery and video records of marine litter at deep-sea from over 4,860 dives of deep-sea observation tools, such as manned submersibles, remotely operated vehicles, autonomous underwater vehicles and deep-sea observation systems that date back to as early as 1982 (Miyake, Shibata and Furushima 2011).

The research on marine litter in Japanese inland and offshore waterways can be dated back to the 1990s (Kanehiro, Tokai and Matsuda 1995). The research objects include the seafloor, surface seawater, beaches, moat sediment and so on. Actual studies were conducted in offshore Tokyo Bay (Kanehiro, Tokai and Matsuda 1995; Kuriyama *et al*. 2002), Hiroshima Bay (Fujieda and Sasaki 2005), Sagami Bay (Kuriyama *et al*. 2002) and the North Pacific region of the open sea.

Selected studies on the distribution of marine litter in Japan are listed in Table 22.

Among studies, a Hiroshima Bay study on microplastics reported a high abundance of microplastics, 56,500 million pieces per square kilometre, mainly polystyrene foam from buoys used in oyster culture. On Ookushi Beach, an inaccessible beach facing the East China Sea, several litter monitoring studies have been conducted, owing to the minimal impact of human activity on land (Kako, Isobe and Magome

Studies on marine litter distribution in Japan

Table 22 /

Year	Type	Method	Source
1972	Litter on ocean surface of central North Pacific	Observation made from vessel.	Venrick *et al.* (1973)
1963–1986	Litter ingestion by stranded odontocete cetaceans	Survey of prior food habits analyses conducted on 10 species of odontocete cetaceans. All species combined, a total of 1,790 stomachs were examined.	Walker and Coe (1990)
1985–1988	Ocean surface near Japan	Ring/Neuston net (0.5mm mesh size) was used.	Day *et al.* (1990)
1989–1991 and 1993	Marine litter on seabed of fishing grounds in Tokyo Bay, Japan	Each trawl was pulled for 25–90 minute duration, covering 6.5 m-wide path (length of beam). Over 4 years, 148 hauls were carried out: in 1989, 20 hauls; in 1990, 39 hauls; in 1991, 48 hauls; and in 1993, 41 hauls.	Kanehiro *et al.* (1995)
1997 and 2001	Microplastics in sediment core of moat from Imperial Palace, Tokyo, Japan	Gravity corer of 11-cm i.d. and 50-cm length, sliced at 5-cm intervals on-site, stored individually in stainless-steel containers and frozen until analysis. To identify microplastics, 10 g of freeze-dried sediment (or wet sediment corresponding to 10 g of dry sediment) were analysed for microplastics. To remove biofilms from surface of microplastics, 150 mL of 30% H_2O_2 were added to sediment in glass beaker. After reaction ceased, normally after 1 week, sediment was passed through 315 µm, mesh-size nylon sieve.	Matsuguma *et al.* (2017)
1997–1998	Pellets on coastal beaches, Japan	Resin pellets were collected in 1997 and 1998 from four coastal sites in Japan: Kasai Seaside Park and Keihin Canal in Tokyo Bay, Kugenuma Beach facing the Pacific Ocean and Shioda Beach facing the Sea of Japan. Resin pellets were sampled above high-tide line or with bare hands.	Mato *et al.* (2001)
May–June 2000	Visual observation in north Pacific (ca. 56 km off Japan coastline)	Sighting survey was conducted from dawn to dusk during May–June 2000, on research vessel "Daini Kyoshin Maru" with deck height about 5 m above waterline. During navigation at about 10 knots, two or three observers surveyed from bridge on both sides of vessel. They continuously focused on vessel's port or starboard, reporting any observed item and immediately recording type, size, number and distance of each item as well as angle of item from bow and ancillary data (date, time, location, surface temperature, etc.). Strip transect method was used for estimating density of floating marine debris, based on number of items seen, transect length and perpendicular distance to transect for each item.	Shimoto and Kameda (2005)

(Continued)

Table 22 *(continued)*

Year	Type	Method	Source
July 1998 – November 2000	Grounded and buried plastic debris on beaches of Kagoshima, Japan	Sand samples were collected by gathering grounded and buried debris at 77 strand lines on 68 beaches from 30 July 1998 to 26 November 2000. After sand was stirred in water, floating debris was scooped up with testing sieve (0.3 mm openings). Debris items were then sorted, dried and divided into three size-groups, using testing sieves (4.0 mm and 10.0 mm openings); finally, their numbers were counted.	Fujieda (2002)
In Japanese	Sea surface at Kagoshima Bay, Japan	In Japanese	Fujieda (2003)
September–November 2000	Litter on 26 beaches along Sea of Japan	Two types of litter (stranded and buried) were measured. To evaluate amount of stranded litter on beach quantitatively, 10-m by 10-m survey units (100 m^2) were continuously set from water edge to backshore zone of beaches. Usually, two or three lines of units were set parallel to coastal line. A maximum of 10 units per beach were set, depending on beach geography. In each unit, litter was collected and sorted into categories (plastics, including Styrofoam™, as well as rubber, paper, cloth, glass/pottery, metals and other non-organic items). Litter items were also classified according to their use and country of origin, if possible. Finally, they were counted and weighed on-site. For buried litter, three sampling points were selected outside of survey units for stranded litter. To collect buried litter, 8 L of sand was raked from 40 cm × 40 cm space to depth of 5 cm, using box-shaped stainless-steel frame (after removing any visible stranded litter from sand) and put into bucket. Sand was mixed with seawater and stirred, then supernatant was filtered with net (0.3- mm mesh) to collect floating plastic particles. Plastic particles were placed into plastic bags and sent for sorting to Toyama Prefectural University. Buried litter was also identified; classified according to size (from less than 1 mm × 1 mm to over 10 mm × 10 mm); counted; and weighed after drying.	Kusui and Noda (2003)
May 2000 – May 2001	Litter in subtropical mangrove in Okinawa Island, South Japan	Litter fall study was conducted to quantify amount of litter falling on sediments and to assess its impact on adjacent intertidal flat-surface sediments in Oura Bay estuary. Litter traps (50 cm x 50 cm), each made of nylon net of 1 mm aperture, were suspended under mangrove trees, ensuring they were above maximum tide height and positioned to ensure maximum catch of litter. Seven such traps were randomly distributed at each site, for total sampling area of 3.5 m^2.	Mfilinge *et al.* (2005)
2000–2001	Ocean surface	Neuston net (mesh size 1.00 mm × 1.64 mm)	Uchida *et al.* (2016)

(Continued)

Table 22 *(continued)*

Year	Type	Method	Source
2001	Ocean surface of the east coast of Japan	Neuston net; surface trawl nets on transects of 10 minutes at two knots with net opening of 50 cm and mesh size of 333 μm	Yamashita and Tanimura (2007)
1999–2002	Deposited fishing gear in East Sea, Japan	Not specified	Inoue (2004)
2001 and 2002	Plastic pellets from 47 beaches, Japan	Sixty resin pellets were collected from beach in Kasai Seaside Park, Tokyo, along high-tide line within a range of 30 m, using solvent-rinsed stainless-steel tweezers. Besides, resin pellets were collected from 47 beaches.	Endo *et al*. (2005)
2002	Resin pellets on beaches (*n*=30) of Tokyo Bay and Sagami Bay, Japan	In Japanese	Kuriyama *et al*. (2002)
2002	Beach: stranded debris on 34 beaches of Eta Island and Kurahashi Island in Hiroshima Bay, Japan	In Japanese	Fujieda and Sasaki. (2005)
March, May and November 2003	Litter on anageme beaches of Kikai, Okinoerabu and Yoron islands (of Amami Archipelago), Japan	Research areas were chosen in two beaches, each in northern and southern parts of each island. Research was carried out during low tide. Emerged area (from terrestrial fringe to wave break point in each beach in Yoron and Okinoerabu islands) was divided into three tidal levels (upper, middle and lower). Quadrate (10 m x 10 m) was fixed in each level. However, quadrate (30 m x 30 m) in Kikai Island was fixed at middle intertidal level. Only pieces larger than 3 cm x 3 cm x 3 cm were counted.	Kei (2005)
May 2003 –October 2005	Seabed litter at eight stations in Kagoshima Bay, Japan	Sampling surveys, using a small trawl net, were conducted 118 times (May 2003–October 2005) to estimate distribution and composition of seabed litter at eight stations established in Kagoshima Bay.	Fujieda *et al*. (2009)
2005	Litter in Ryukyu Trench (7,100 m) and in basin of Okinawa Trough, Japan	Faunal samples were taken, using ORE-type beam trawl of 4-m span with inner net 6.3 mm in mesh size. From nine trawl samples taken at eight stations, anthropogenic litter of visible size (> a few cm) was collected as far as possible, while faunal samples were extracted from net and washed. In laboratory, litter was kept in plastic container under room temperature for 10 years.	Shimanaga *et al*. (2016)
March–October 2009	Litter on Ookushi Beach, Goto Islands, Nagasaki, Japan	Two webcams monitoring beach litter were placed on Ookushi Beach. Litter was identified from photographs taken by webcam.	Kako *et al*. (2010)

(Continued)

Table 22 *(continued)*

Year	Type	Method	Source
October 2009	Litter on Ookushi Beach, Goto Islands, Nagasaki, Japan	First, total area covered by beach litter was calculated, using balloon photography of digital-camera images of beach. Second, mass of beach litter per unit area on Ookushi Beach was estimated by collecting and weighing all litter, except microplastics smaller than 1 cm^2 within each of 10 (2 m × 2 m) boxes. Third, total beach litter mass was estimated by multiplying total litter-covered area obtained from balloon photography by average mass of beach litter per unit area among 10 boxes.	Nakashima *et al*. (2011); Nakashima *et al*. (2012)
September 2007–September 2009	Litter (plastic bottle caps) on Hassakubana Beach of Goto Islands, Japan	Beach surveys were carried out every 2 months from September 2007 through September 2009 (13 surveys in total). Tens of citizens and researchers took part in each beach survey, and beach litter (plastic bottle cap, disposable lighter, polystyrene buoys and so forth) on 350-m long beach was all retrieved and counted over 2 days. Beach litter number counted on day of each survey (except for first survey) was regarded as total number of litter reaching Hassakubana Beach over 2 months (i.e. interval between each beach survey).	Kako *et al*. (2011)
Not applicable	Litter in deep-sea trenches offshore Iwate, Japan	JAMSTEC Deep-sea Debris Database	Miyake, Shibata and Furushima (2011)
2003, 2004 and 2011	Marine litter on seafloor of continental slope off the Pacific coastline of Iwate, northern Japan	Seafloor anthropogenic marine debris were collected from bottom trawl surveys carried out (by tug R/V Iwate-maru) in 2003, 2004 and 2011. Surveys were conducted on upper continental slope, ranging from 183 m to 521 m depth, between 39°N and 40°10N. Samples were collected, using otter trawl net with following structural components and dimensions: stainless-steel otter board, footrope composed of rubber bobbins and chain, 11.7-m opening width, 12.5-m body length and 4.0-cm cod-end mesh (Nichimo Co. Ltd.). Each tow was conducted for 30 minutess from contact of footrope on seafloor, with swept area (km^2) calculated on basis of net opening width and towing distance.	Goto *et al*. (2015)
August 2011	Wadahama Beach, on West coast of Niijima Island, Japan	Images were taken every 2 hours by webcam system installed on beach's northern hinterland.	Kataoka *et al*. (2013)
2010–2012	Microplastics and mesoplastics in surface water of Hiji River mouth, in Iyo, Uwa and Hyuga seas, Japan	Neuston net (350 µm mesh size)	Isobe *et al*. (2014)

(Continued)

Table 22 *(continued)*

Year	Type	Method	Source
2011–2012	Marine litter on seafloor near Japan	Deep-sea survey conducted by side-scan sonar, deep-tow submergible cameras and remotely operated vehicle system. Observations made at video-surveyed study sites.	Yamakita *et al.* (2015)
2012	Seafloor of Kuril-Kamchatka area of Northwest Pacific, Japan	20 box cores (0.25 m^2) (Agassiz trawl, camera epi-benthic sledge)	Fischer *et al.* (2015)
2012–2014	Sediment core in canal in Tokyo Bay, Japan	Gravity corer of 11-cm (inside diameter) and 50-cm (length), sliced at 5-cm intervals on-site, stored individually in stainless-steel containers and frozen until analysis. To identify microplastics, 10 g of freeze-dried sediment (or wet sediment corresponding to 10 g of dry sediment) were analysed. To remove biofilms from surface of microplastics, 150 mL of 30% H_2O_2 were added to sediment in glass beaker. After reaction ceased, normally after 1 week, sediment was passed through 315-lm, mesh-size nylon sieve.	Matsuguma *et al.* (2017)
2013–2014	Surface water, Tokyo Bay, Japan	Neuston 315-lm nylon mesh net, sized 30-cm (inside diameter) and 1-m (length), was deployed for 20 minutes from side of boat at speed of 2 mi per hour. Contents were passed through 5-mm stainless-steel mesh sieve and then 1-mm stainless-steel mesh sieve and 315-lm nylon mesh sieve.	Matsuguma *et al.* (2017)
July–September 2014	Microplastics in East Asian Sea coastline, Japan	Neuston net (350 µm mesh size)	Isobe *et al.* (2015)
1982–2015	Seafloor of western North Pacific, near Japan	JAMSTEC Deep-sea Debris Database	Chiba *et al.* (2018)
September–October 2015	Microplastics in Tokyo Bay, Suruga Bay, Ise Bay and Seto Inland Sea, Japan	Neuston nets (5,552; RIGO Co., Ltd., Tokyo, Japan) were used to collect small plastic fragments near sea surface. Mouth dimensions, length and mesh size of each net were 75 cm × 75 cm, 3 m and 0.35 mm, respectively. Boats towed neuston nets for 20 minutes at constant speed of 2–3 knots.	Isobe (2016)

(Continued)

Table 22 *(continued)*

Year	Type	Method	Source
August 2015	Japanese anchovy (Engraulis japonicus, *n*=64) in Tokyo Bay, Japan	Japanese anchovy (Engraulis japonicus) were caught by fishing (using Sabiki rigs) from pier in Tokyo Bay (N 35°25'43" and E 139°41'15") (Figure 1) from 7 a.m. to 2 p.m. on 23 August 2015. Water depth was about 15 m to 20 m, and fish were caught at range of 5 m to 10 m from surface. On same day, 64 anchovies collected were put in iced water and dissected at laboratory the same day. After measuring their body length (112.5 mm ± 6.4 mm), entire digestive tract was removed (from top of oesophagus to anus) and put into 10-mL glass vial that had been baked in advance for 4 h at 550°C. Each vial then received 7–8 mL (>3× volume of gut) of 10% KOH (potassium hydroxide) solution to digest organic material. Vials were incubated at 40°C for 10 days, during which time digestion was observed to be completed in 3 to 4 days. Each vial was then shaken about 20 times to break up mass of indigestible materials (e.g. shells of zooplankton), and all floating material was collected in another vial. Pieces larger than 200 μm were clearly visible. Precipitate that remained in vial was put on Petri dish glass and examined under microscope, but no particles not resembling natural prey were observed. Because target fish (anchovy) is commonly caught by recreational fishers and then eaten, researchers' procedure of fishing and dissection was exactly same as that used in standard fishing and cooking, without introducing any ethical issues. Thus, procedure of measuring microplastics in digestive tract did not conflict with ethical rules for university animal experiments. All floating items suspected to be plastic polymers were photographed individually, with color and shape recorded. Suspected plastic was further analysed by FTIR.	Tanaka and Takada (2016)
2017	Ocean surface of Northwest Pacific, near Japan	Floating microplastics were collected from 18 stations (Figure 1) in Northwest Pacific from August 25 to 26 September 2017, using a surface manta trawl with mesh size of ~330 μm and width of 1 m. Manta trawl was deployed to sea surface via reel-operated lift on side of research vessel. Angle between trawling and shipping route was about 20°. Microplastics at ocean surface were sampled at each field station by trawling horizontally between 50 and 240 minutes at speed of 1.0 to 3.0 knots. For analysis, water samples in sampling bottle were poured through stacked stainless-steel sieves with mesh sizes of 5.0-mm and 0.3-mm, respectively. Residues on 5.0-mm sieves were collected.	Pan *et al*. (2019)

Data on single-use plastics generation and MSW management in Japan

Table 23 /

MSW background information [1]		
Population	126.86 million (2019)	
MSW generation	43.17 million tons/year (2016)	
MSW per capita	0.95 kg/person/day (2015)	
Single-use plastic waste generation [2]		
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)		5.31 million tons (2019)
Polymer exports		0.85 million tons (2019)
Polymer imports		1.68 million tons (2019)
Domestic conversion of polymers into single-use applications		3.57 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)		1.52 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)		2.66 million tons (2019)
Domestic single-use plastic waste generation		4.71 million tons (2019)
Single-use plastic waste generation per capita		37.04 kg (2019)
MSW collection and treatment [3]		
MSW collection coverage	99.9%	

Sources: Compiled for multiple sources, including: [1] Kaza, Bhada-Tata and Van Woerden (2018); [2] Minderoo Foundation (2021); and [3] UNEP (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

2010; Kako *et al*. 2011; Nakashima *et al*. 2011; Nakashima *et al*. 2012).

Marine litter in Japan may originate from the fishing and aquaculture industries and then transported by currents, winds and waves as well as natural disasters such as tsunamis and earthquakes. In recent years, numerous activities have been carried out in Japan on the prevention and research of marine litter under international cooperation frameworks, such as G7, G20 and NOWPAP.

Since 2009, the Ministry of Environment of Japan has been conducting surveys to estimate the total quantity of marine litter accumulated on beaches countrywide. A Ministry survey found that of all litter recovered on the beaches in 2015, about 62 per cent was composed of plastics (Figure 5).

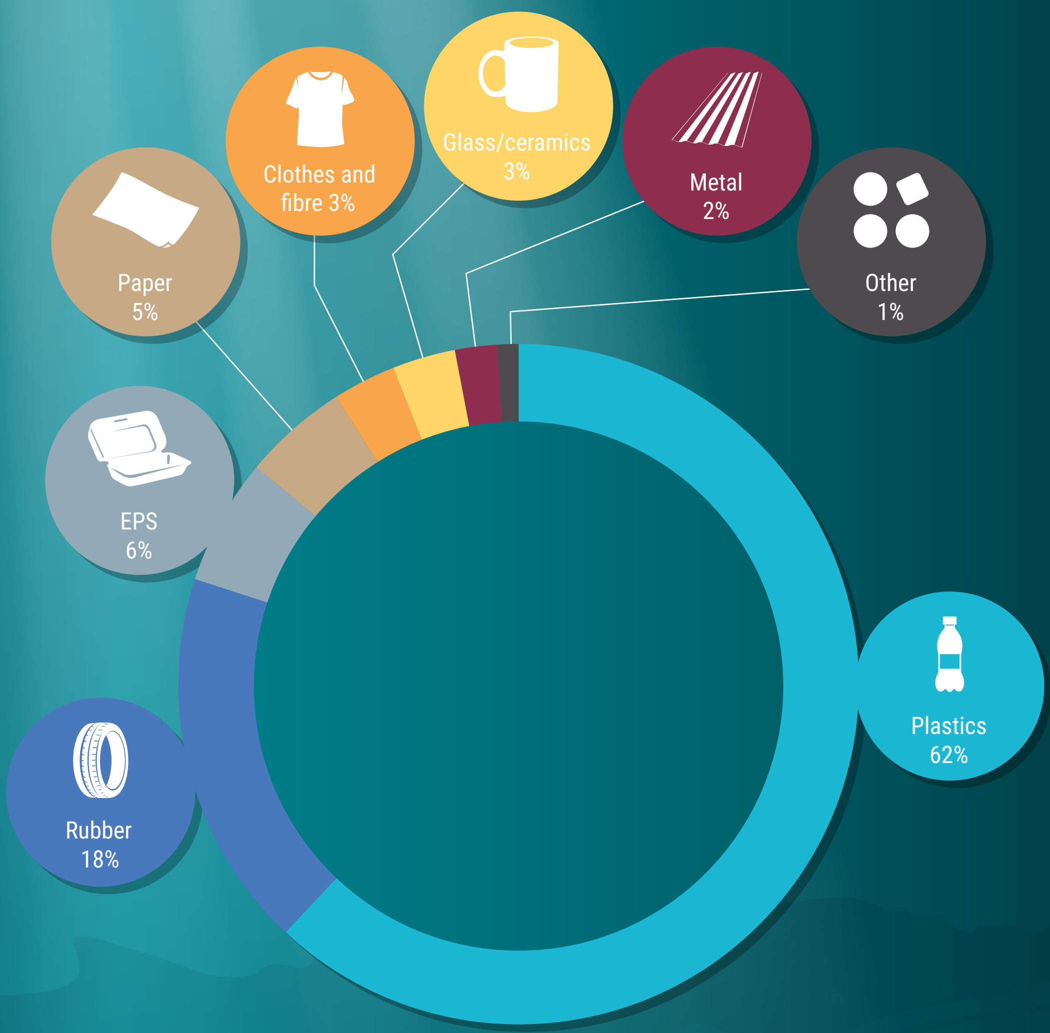
State of municipal solid waste management

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 23.

Government action on environmental and plastic waste management in Japan

Table 24 /

Year	Title
2009	Act on Promoting the Treatment of Marine Debris Affecting the Conservation of Good Coastal Landscapes and Environments to Protect Natural Beauty and Variety (No. 82 of 2009)



Source: Adapted from NOWPAP MERRAC (2017).

Marine litter composition in Japan

Figure 5 /

Actions on combating marine litter

The Japanese Government has given high policy priority to addressing marine litter (Table 24). Moreover, committing to allocate $167 million to build monitoring technology for marine litter at the Our Ocean Conference 2018, the Government has initiated its “MARINE Initiative” in 2019, focusing on waste management, litter recovery, innovation and empowerment—all towards realizing the “Osaka Blue Ocean Vision”, agreed under the Japanese G20 presidency in 2019, to reduce additional marine plastic pollution to zero by 2050 through a comprehensive life-cycle approach (Japan, Ministry of Foreign Affairs 2019).

Besides, many NGOs have been active in combating marine litter in Japan. Since 2003, the NGO JEAN (Japan Environmental Action Network) hosted an annual national conference on marine litter in Japan, often with governments of the local prefectures. Civic engagement projects such as the International Pellet Watch have also gained sizeable influence worldwide.

Democratic People's Republic of Korea

The population of the Democratic People's Republic of Korea was estimated at 25.67 million in 2019 with more than two thirds inhabiting the coasts that span 2,495 km. As such, although marine litter has the potential to be an important issue for this country, limited scientific data exists on marine litter. The only data available is found in reports on beached items in the neighbouring countries, such as the Republic of Korea and Russia. Despite the lack of recent reliable data on MSW generation (Table 25 and Figure 6, for instance, show 2009 data), Korea's capital city of Pyongyang generated 580,000 tons of MSW in 2009 (Korea [Democratic People's Republic], Ministry of Land and Environment Protection 2012). Plastics contributed only 2 per cent to the reported generated amount.

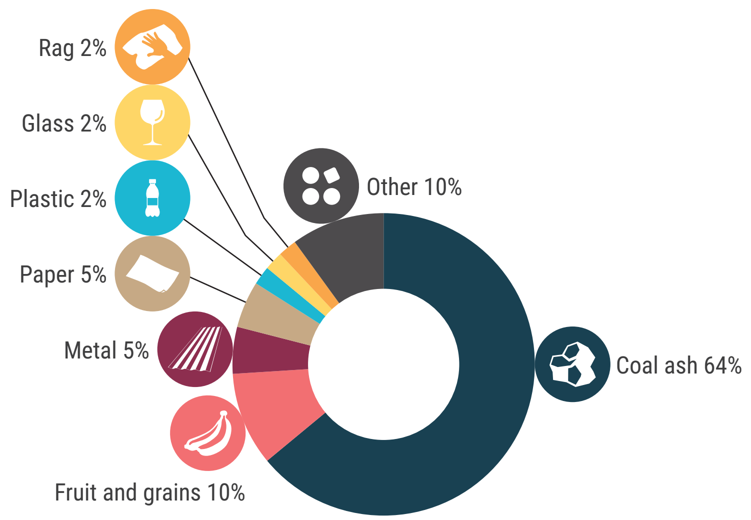
Management of municipal solid waste

Data on MSW generation and management in the Democratic People's Republic of Korea

Table 25 /

MSW background information	
Population	25.67 million
MSW generation	0.58 million tons/year (2009) (data only for Pyongyang)
MSW per capita	..
MSW collection and treatment	
MSW collection coverage	..
Method of treatment	

Source: [1] UNEP (2017a) and [2] Korea (DPR) Ministry of Land and Environment Protection (2012).
Source: Abbreviation: ".." means no data or data not reported separately.



Source: Korea (DPR), Ministry of Land and Environment Protection (2012).

MSW composition in Korea DPR

Figure 6 /

Republic of Korea

The Republic of Korea had an estimated population of 51.23 million in 2019 situated along a 2,413-km coastline. In this context, MSW generation was estimated at 19.63 million tons in 2016 (OECD 2019).

State of marine litter management

The Government estimates that a total of 176,000 tons of marine litter was generated annually in the Republic of Korea during 2014–2018, of which 118,000 tons originated from land-based activities and 58,000 tons from sea-based sources, including 44,000 tons of fishing gears (Suh 2018).

Selected studies on the distribution of marine litter in the Republic of Korea are listed in Table 26.

To study the distribution and environmental impact of marine litter, the Ministry of Oceans and Fisheries of the Republic of Korea started nation-wide monitoring of marine litter at 20 sites along the coastline in 2008, expanding to 40 sites in 2015. In 2017, monitoring data showed that plastic made up more than 70 per cent of marine litter. According to the Ministry's 2016 statistics, a total of 70,840 tons of marine litter has been recovered from the oceans and along coastlines, with an annual growth rate of 2.5 per cent (Korean National Marine Litter Monitoring Program 2017).

In 2014, a nationwide study estimated the annual flow and stock of marine litter (> 25 mm) in the Republic of Korea (Jang *et al*. 2014c). Of the samples collected at six beaches, 55 litter types were found, and 56 per cent appeared to result from ocean-based activities. Also, another study reported on the characteristics of the distribution of different size classes (large micro-, meso- and macro-) of plastic marine litter on 12 beaches in South Korea (Lee 2006). In this study, the abundances of the large microplastics were strongly correlated with that of mesoplastics for most plastic types.

Studies on marine litter distribution in the Republic of Korea

Table 26 /

Year	Type	Findings	Method	Source
1996–2005	Litter on seabed of East China Sea and coast of South Sea, Republic of Korea	Litter density in Korean coastal waters: 109.8 kg/km^2 (offshore Yeosu); 30.6 kg/km^2 (East China Sea) Litter composition: fishing gear (e.g. pots, nets, octopus jars and fishing lines) 42%-72% in East China Sea and 37%-62% in South Sea of Korea	East China Sea: Bottom trawl of the Dong-baek was used (float line: 53.0 m; sinker line: 62.7 m; total net length: 69.7 m) South Sea: Trawl of the Ka-ya was used (float line: 46.1 m; sinker line: 61.5 m; total net length: 70.0 m) Net mesh size was similar (i.e. 60 mm x 65 mm).	Lee, Cho Jeong *et al.* (2006)
Spring 2013	Plastic litter on six beaches, Republic of Korea	Litter composition: total of 752 items (12,255 g) of debris comprised of fibre and fabric (415 items, 6,909 g), hard plastic (120 items, 4,316 g), Styrofoam™ (93 items, 306 g), film (83 items, 464 g), foamed plastic (other than Styrofoam) (21 items, 56 g) and other polymer (20 items, 204 g) Source of litter: Observed 56% are ocean-based and 44% are land-based	Samples larger than 25 mm were collected from 10 quadrats, measuring 5 m × 5 m.	Jang *et al.* (2014a)
May and July 2012	Microplastics on sea surface microlayer near Geoje Island, Republic of Korea	Microplastic abundance: 16,000 ±14,000 items/m^3 Dominant types: alkyds (81%) and poly(acrylate/styrene) (11%) Other findings: paints and fibre-reinforced plastic matrix used on ships are likely sources of microplastics	Bulk surface water filtering, hand net (50 μm mesh) and Manta trawl net (330 μm mesh).	Song *et al.* (2014)
2003 to 2007	Nearshore coastal waters (such as fishing ports, commercial ports, wetlands and fishing grounds), Republic of Korea	Amount of litter removed: 29,790 tons (deposited litter in shallow coastal waters), 8,057 tons (in offshore coastal waters) and 3,444 tons (in blue crab fishing grounds at 40 m depth)	Depth of fishing ports, commercial ports and fishing grounds are so shallow that deposited marine debris was surveyed by side-scan sonar and bottom trawling. Deposited marine debris was removed from seabottom by bottom-trawling in coastal waters and using grabs and cranes in commercial ports and fishing ports.	Cho *et al.* (2011)
1996–2005	Litter on seabed of Eastern China Sea and south coast, Republic of Korea	Litter density in Korean coastal waters: 109.8 kg/km^2 (offshore port city of Yeosu); 30.6 kg/km^2 (East China Sea) Litter composition: fishing gear (e.g., pots, nets, octopus jars and fishing lines) 42%–72% in East China Sea and 37%–62% in South Sea of Korea	In East China Sea, bottom trawl of Dong-baek (float line: 53.0 m; sinker line: 62.7 m; total net length: 69.7 m) was used, and in South Sea waters of Korea, trawl of the Ka-ya (float line: 46.1 m; sinker line: 61.5 m; total net length: 70.0 m) was used. Net mesh size was similar (i.e. 60 mm x 65 mm).	Lee, Cho Jeong *et al.* (2006)

(Continued)

Table 26 *(continued)*

Year	Type	Findings	Method	Source
Spring 2013	Plastic litter on six beaches, Republic of Korea	Litter composition: total of 752 items (12,255 g) of debris comprised of following: fibre and fabric (415 items, 6 909 g); hard plastic (120 items, 4,316 g); Styrofoam™ (93 items, 306 g); film (83 items, 464 g); foamed plastic, other than Styrofoam (21 items, 56 g); and other polymer (20 items, 204 g) Source of litter: 56% observed as ocean-based and 44% as land-based	Samples larger than 25 mm were collected from 10 quadrats measuring 5 m × 5 m.	Jang *et al.* (2014a)
May and July 2012	Microplastics in sea surface microlayer near Geoje Island, Republic of Korea	Microplastic abundance: 16,000 ±14,000 items/m^3 Dominant types: alkyd (81%) and poly (acrylate/styrene) (11%) Other findings: paints and fibre-reinforced plastic matrix used on ships are likely sources of microplastics	Bulk-surface water filtering, hand net (50 μm mesh) and Manta trawl net (330 μm mesh) were used.	Song *et al.* (2014)
2003 to 2007	Nearshore coastal waters, such as fishing ports, commercial ports, wetlands and fishing grounds, Republic of Korea	Amount of litter removed: 29,790 tons (deposited litter in shallow coastal waters), 8,057 tons (in offshore coastal waters) and 3,444 tons (in blue crab fishing grounds at 40 m depth)	Depth of fishing ports, commercial ports and fishing grounds are so shallow that deposited marine debris was surveyed by side-scan sonar and bottom trawling. Deposited marine debris was removed from seabottom by bottom trawling in coastal waters and using grabs and cranes in commercial ports and fishing ports.	Cho *et al.* (2011)
March 2008 to November 2009	Litter on 20 beaches along the eastern, western and southern coasts of Republic of Korea	Abundance of beach litter: 480.9 (±267.7) items/100 m (number); 86.5 (±78.6) kg/100 m for weight; and 0.48 (±0.38) m^3 /100m (volume) Dominant material composition: plastics and Styrofoam (66.7% by number and 62.3% by volume) Identified sources of litter: fishing activities, including commercial fisheries and marine aquaculture (62.3%), with biggest contributor of litter being Styrofoam buoys from aquaculture	Total of 220 surveys were carried out every 2 months (at end of odd-numbered months ± 5 days) from end of March 2008 to end of November 2009. A 100-m-long survey line was located with GPS coordinates on each beach. All debris items larger than 2.5 cm in diameter—that occurred between low-tide mark and beginning of vegetation on dunes or artificial barriers—were collected and classified into 12 categories. Debris items in each category were counted and weighed to nearest 0.1 kg, using portable scale on survey sites in their wet or dry conditions. Volumes were estimated based on number of rubbish bags of known volume used to collect beach debris.	Hong *et al.* (2014)
2009 and 2010	Derelict fishing gears in deep seabed from East Sea, Republic of Korea	Total of 207.8 and 252.2 tons of marine debris in 2009 and 2010, respectively, were removed from seabed, mostly derelict fishing gears	Korean Government has started to remove derelict fishing gears from East Sea deep seabed by bottom trawling with ropes and heavy hooks (50–80 kg).	MLTM *et al.* (2008)

(Continued)

Table 26 *(continued)*

Year	Type	Findings	Method	Source
February 2011	Plastic litter (>2mm) on Heungnam Beach, eastern coast of Geoje Island off southern coast of Korean Peninsula	Mean abundances of small plastics: 976 ± 405 particles/m^2 at high strandline in upper tidal zone along shoreline; 473 ± 866 particles/m^2 at cross section perpendicular to shoreline Dominant polymer type: Styrofoam (expanded polystyrene) spherules accounted for 90.7% of total plastic abundance in high strandline and 96.3% in the cross section	Random sampling was conducted by generating random numbers within 50-m stretch of linear shoreline at high strandline from upper tidal zone, using 10 quadrats of 0.25 m^2 area and 5-cm depth. Cross-sectional sampling was carried out with total of 49 quadrats of 0.25 m^2 without intervals between them. To collect small plastic debris, 2-mm sieve was used, sorting and identification of which could be performed without microscope.	Heo *et al.* (2013)
May and July 2012	Floating debris around mouth of Nakdong River in south-eastern seas of Republic of Korea	Microplastic abundance: 0.62–57 particles/m^3 before rainy season (May); 0.64–860 particles/m^3 after rainy season (July) Other findings: dominant types were fibres (polyester), hard plastic (polyethylene), paint particles (alkyd) and Styrofoam (expanded polystyrene)	Manta trawl (330µm mesh) and hand net (50 µm) were used to analyze floating debris.	Kang *et al.* (2015)
May and September 2012	Plastic litter on beaches in Republic of Korea	Abundances of each size category in May (before rainy season) and in September (after rainy season) were 8,205 and 27,606 particles/ m^2 for large microplastics, 238 and 237 particles/m^2 for mesoplastics and 0.97 and 1.03 particles/m^2 for macroplastics, respectively. Styrofoam was most abundant item both in micro- and mesoplastic debris, while intact plastics were most common in macroplastic debris. Abundances of meso- and microplastics were most strongly correlated.	Large 10 m ×10 m quadrats were placed (in locations that visually appeared as having maximum/ minimum amounts of beached debris) along strandline, and all macroplastic items (>25 mm) within large quadrats were collected. Within each large quadrat (10 m × 10 m), five small quadrats (0.5 m × 0.5 m) were randomly selected for microplastic and meso-plastic sampling. All natural and artificial debris within depth of 5 cm in quadrats was sieved onshore sequentially, using 5-mm and 1-mm Tyler sieves (CISA Sieving Technologies [CISA], Spain).	Lee *et al.* (2013)
July 2013	Microplastics (50-5 000µm size) on high tidal coastal beaches (*n*=3) of Soya Island in Korea, ~ 68 km south-west of the Han River estuary and about 48 km southwest of the Incheon city/harbour, facing Yellow Sea to the west	Abundance of microplastics (*n* = 21): 56–285,673 (46,334 ± 71,291) particles/ m^2, corresponding to highest level globally Prevalent driving forces: winds and currents	At each station, hole surface sediment in grid (50 cm [length], 9-50 cm [width] and 9-2 cm [depth]) was skimmed off and sequentially sieved through stainless- steel sieves with nominal pore sizes of 5,000 and 1,000 mL. Total samples of 5,000 and 1,000–5,000 mL and 1 mL of homogenized samples\1,000 mL, were each stored in polyethylene bags and transported to laboratory.	Kim *et al.* (2015)

(Continued)

Table 26 *(continued)*

Year	Type	FIndings	Method	Source
August 2013	Microplastics in surface seawaters near- and offshore of Incheon/ Kyeonggi Coastal Region, western coast of the Republic of Korea	Microplastic abundance in surface microlayer: 152,688 ± 92,384 particles/ m^3 Microplastic abundance in surface seawater: 1,602 ± 1,274 particles/m^3 (hand net) and 0.19 ± 0.14 particles/m^3 (zooplankton trawl net) Dominant microplastic type: ship paint particles (mostly alkyd resin polymer), indicating marine-based origin of microplastics	After flooding season, seawaters of two different layers (i.e. sea surface microlayer and subsurface waters) were collected in August 2013 at 12 stations in the Incheon/Kyeonggi coastal region, which represents mid-western coastal area of Korean Peninsula. Samples of sea surface microlayer were collected by gently touching stainless-steel sieve (2-mm mesh size; 20-cm diameter) to seawater surface. At each station, on-board sieve collection was repeated 120 times, and total of 2.57 ± 0.29 L was obtained. Thickness of sea surface microlayer was estimated at 100µm. Subsurface sea water was collected, using both hand net (30 cm i.d. and 20-lm mesh) and zoo- plankton trawl net (60-cm i.d. and 330-lm mesh size). For SSW hand-net samples, about 0.1 m^3 of subsurface water was manually obtained 30 cm below surface, using plastic bucket and filtered through hand net on-board. Zooplankton trawl net, equipped with flow meter, was towed around sampling station at speed of 2 knots (approximately 1 m/s) for 15 minutes with 2 kg-weight so that mouth of net remained submerged below, at about 30 cm, to avoid collecting sea surface microlayer.	Chae *et al*. (2015)
2013 and 2014	Plastic litter on 12 beaches in the Republic of Korea	Abundance of large micro- (1–5 mm), meso- (5–25 mm), and macroplastics (>25 mm) were 880.4, 37.7 and 1.0 particles/m^2, respectively. Styrofoam was most abundant debris type for large micro- and mesoplastics (99.1% and 90.9%, respectively). Fibres (including fabric) were most abundant type (54.7%). Abundance of large microplastics was strongly correlated with that of mesoplastics for most material types. Other findings: Surveying of mesoplastics with 5-mm sieve is efficient, useful way to determine “hotspots” on beaches contaminated with large microplastics.	In 2013, at each site, macroplastics were collected from within 10 large randomly placed quadrats, measuring 595 m along centre of high strandline. In centre of large quadrats, one small quadrat was placed, measuring 0.5 9 0.5 m from which sand was collected from a depth of up to 2 cm and sieved sequentially with 5-mm^2 and 1-mm^2 Tyler sieves (CISA, Barcelona, Spain).	Lee *et al*. (2015)

(Continued)

Table 26 *(continued)*

Year	Type	Findings	Method	Source
Not specified	Plastic litter on 20 beaches, Republic of Korea	Mean abundance: 13.2 items/m^2 Mean weight: 1.5 g/m^2 Dominant microplastics type: hard plastic (32%) and Styrofoam (48.5%).	All the beaches were sandy beaches. At each beach, three 100-m-long survey lines (backshore, middle line and water edge) were placed between vegetation or artificial structure line of backshore and water edge, the latter defined as "dry surface area closest to water edge". Each survey line was divided into 25-m intervals, and quadrat of 50 cm (length) × 50 cm (width) × 2.5 cm (depth). It was randomly placed within each 25-m interval. Middle line was located at midpoint between backshore and water edge. In 12 quadrats (3 lines × 4 quadrats) per beach, any macrodebris particle larger than 25 mm was removed on the spot, and surface sand was collected to depth of 2.5 cm. After sieving sand through 5-mm Tyler sieve (CISA, Spain), remnants—except plastic—on sieve were picked out with naked eye, and mesoplastic marine debris (5–25 mm) was collected and stored in polyethylene bags and transported to laboratory.	Lee *et al*. (2017)
March–May 2016	Microplastics in 20 sand beaches, Republic of Korea	Microplastic abundance: Large microplastics (particles, 1e5 mm): 0-2,088 n/m^2; small microplastics (particles, 0.02e1 mm): 1,400-62,800 n/m^2 Dominant size range: 100 mm–150 mm Dominant polymer type: expanded polystyrene accounted for 95% of large particles, whereas small particles were predominantly composed of polyethylene (49%) and polypropylene (38%) Identified factors of spatial distribution of small microparticles: population, precipitation, proximity to river mouth and abundance of macroplastic debris on beach	Three 100-m stretches parallel to shoreline were selected to collect representative samples at each beach. Each stretch line was divided into four sections at 25-m intervals, and quadrat (0.5 m × 0.5 m) was randomly placed in each section (4 quadrats in line, for total of 12 quadrats per beach). Sand in each quadrat was scooped to depth of 25 mm and sieved sequentially, using 5-mm and 1-mm metal sieves (Tyler sieve, CISA, Spain).	Eo *et al*. (2018)
April–October 2017	Marine litter in coastal areas, Republic of Korea	Total amount of marine debris stock in natural coastal areas was estimated to be about 17,000 tons. This suggests that about 60% of marine debris can be cleaned from 10% of coastline.	Rapid assessment of marine debris on coasts of Republic of Korea, using visual scoring indicator.	Lee *et al*. (2017)

(Continued)

Table 26 *(continued)*

Year	Type	FIndings	Method	Source
2016–2017	Microplastics > 20 μm at surface (0 m – 0.2 m) and in water column (3–58 m depth) of six semi-enclosed bays and two nearshore areas of Republic of Korea	Average microplastic abundance of 41 stations at all sampling depths was 871 particles/m^3, and microplastic abundance near urban areas (1,051 particles/m^3) was significantly higher than that near rural areas (560 particles/m^3). Although average microplastic abundances in mid-column (423 particles/m^3) and bottom water (394 particles/m^3) were about four times lower than that of surface water (1,736 particles/m^3), microplastics prevailed throughout the third water column in concentrations of 10–2,000 particles/m. Average sizes of fragment and fibre type microplastics were 197 μm and 752 μm, respectively. Dominant material composition is polypropylene and polyethylene. Middle and bottom water samples contained higher abundances of microplasticsMPs.	Bulk sampler: 100 L of surface water from top 20 cm, including surface microlayer. Submersible water pump: (PD-272, Wilo) Flow rate: 140 L/min) The 100-L surface, middle and bottom seawater samples were filtered through portable hand nets (20-μm mesh) on-board vessel.	Song *et al*. (2018)

A 2014 survey of beach waste on 13 beaches in South Korea showed that 35 per cent of marine litter originated from fisheries and marine aquaculture activities, 20 per cent from household activities and 12 per cent from leisure activities (Hong *et al*. 2014). Among them, plastic waste (e.g. plastic bottles) accounted for 70 per cent of the total volume of marine litter, especially that collected in the summer between July and September. Other waste included foam plastic, accounting for 14 per cent; wood, 5 per cent; and metals, 4 per cent. The results were reported in particles/m^2. A high concentration of extruded polystyrene foam (commonly referred to as Styrofoam™) was discovered, indicating an origin from marine aquaculture activities.

A 2015 study used a remote-sensing technique to monitor beach litter with a network camera, which could be a useful tool for future beach litter management (Jang *et al*. 2017).

In 2018, the Republic of Korea participated in the International Coastal Cleanup Campaign, with more than 4,276 volunteers collecting 152,052 kg, or 75,530 pieces of litter, on 82.4 km of coastline (Ocean Conservancy 2019).

Other beach studies, using bottom trawl, have explored the distribution characteristics of marine litter on the seabed of the East China Sea and the South Sea of Korea (Lee, Cho and Jeong 2006). The results were reported in kg/km^2. The mean distribution densities were found to be higher in the coastal seas, with fishing gear as the most abundant litter type. In 2007, results of the national efforts on the harbours and fishing areas were reported, indicating that the Korean coasts had been severely polluted by marine litter (Jung *et al*. 2010). The study identified ship-based rather than land-based activities as the main contributor to these findings.

Studies have reported that beaches on the eastern coast of Geoje Island receive hundreds of tons of natural and anthropogenic litter each year, especially during the summer rainy season, with the primary origin identified as the Nakdong River. The Nakdong is the largest river entering the South Sea of Korea and discharges 3,000 tons of litter annually (Heo *et al*. 2013; Jang *et al*. 2014c). An estimated

91,195 tons of litter entered the sea in Korea, of which 36 per cent (32,825 tons) originated from land-based sources and 64 per cent (58,370 tons) from sea-based sources, leading to a $29–$37 million loss in 2011 tourism value in the Geoje Beach of Korea (Jang *et al*. 2014b).

State of municipal solid waste management

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 27.

Actions on combating marine litter

The Korean Government has begun to act on marine litter in the 1990s (Hong *et al*. 2014). Since 2003, the Ministry of Marine Affairs and Fisheries of the Republic of Korea has introduced a Marine Litter Repurchase Plan that provides financial subsidies to encourage Korean fishermen to bring marine litter, such as abandoned fishing nets, back to shore (Morishige 2010; Cho *et al*. 2011). Subsequently, in 2007, the Republic of Korea introduced the Marine Environmental Management Act, which specified the responsibility of state

Data on single-use plastics generation and MSW management in the Republic of Korea — Table 27 /

MSW background information [1]	
Population	51.23 million
MSW generation	19.63 million tons/year (2016)
MSW per capita	0.98 kg/person/day (2014)
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	10.42 million tons (2019)
Polymer exports	6.61 million tons (2019)
Polymer imports	0.53 million tons (2019)
Domestic conversion of polymers into single-use applications	2.43 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	1.80 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	1.63 million tons (2019)
Domestic single-use plastic waste generation	2.25 million tons (2019)
Single-use plastic waste generation per capita	43.86 kgs (2019)
MSW collection and treatment [3]	
MSW collection coverage	99.92%

Sources: Compiled from multiple sources including:[1] Kaza, Bhada-Tata and Van Woerden (2018); Van Woerden (2018); [2] Minderoo Foundation (2021); and [3] UNEP (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

Government action on combating marine litter in the Republic of Korea — Table 28 /

Year	Title
2008	Revision of the Marine Environment management Act

and local administrators and individuals to prevent and control marine litter.

From 2003 to 2007, the Government carried out a clean-up project to remove litter in coastal waters, removing in total 29,790 tons of deposited marine litter. Since 2007, the Government has funded small-scale removal of derelict fishing gears from fishing grounds in the East Sea (Cho *et al*. 2011). The Government has also set up a floating debris containment boom at major river mouths (Cho *et al*. 2011).

In 2008 (Table 28), the Government implemented the National Marine Litter Management Plan, with the third such plan covering 2019–2023; all have introduced and carried out numerous innovative measures and programmes to tackle marine litter, such as the introduction of the Styrofoam Volume Reduction System, marine litter collection barges and youth education programmes.

Malaysia

Malaysia had an estimated population of 31.95 million in 2019 and total MSW generation estimated at 12.98 million tons in 2014 (Pariatamby 2017).

Malaysia has a coastline of 4,675 km and a coastal population of over 20 million, of which 98 per cent of which live within 100 km of its coastline (Khairunnisa, Fauziah and Agamuthu 2012).

State of marine litter management

Malaysia was cited in 2019 as one of the world's main sources of plastic marine litter (Jambeck *et al*. 2015). In fact, studies have been conducted at four Peninsular Malaysia beaches on the composition and volume of litter on selected beaches sites (Agamuthu, Fauziah and Khairunnisa 2012). These sites were selected to assess the amount and distribution of marine litter on eight sandy public beaches. Plastics were the most abundant type of litter found on all beaches, including plastic bags and wrappers, hard plastics, polystyrene and abandoned fishing nets. The density of litter on Malaysian beaches was found to be comparable to other beaches worldwide, that is, in the range of 0.142–0.884 items/m^2 or 1.119–32.351 g/m^2, with plastics the most common type of marine litter (Agamuthu, Fauziah and Khairunnisa 2012; Fauziah, Liyana and Agamuthu 2015; Mobilik, Ling, Husain and Hassan 2015).

Selected studies on the distribution of marine litter in Malaysia are listed in Table 29.

In 2010–2011, the Maritime Institute of Malaysia (MIMA) introduced a new approach for beach cleanliness assessment, based on the Clean Coast Index (CCI), as a tool for evaluating the actual coast cleanliness as well as the prospects of applying the Indifferent Consumers-Pay Principle to waste management in Malaysia.

Studies on marine litter distribution in Malaysia

Table 29 /

Year	Type	Findings	Method	Source
2010	Litter on coastal areas in Malaysia	Percentage plastic litter: 66% of overall litter collected	Clean Coast Index (CCI) for cleanliness assessment	Hagir *et al*. (2013)
2014–2015	Plastic litter on Sungai Lurus Beach and Minyakbeku Beach in Batupahat, Johor, Malaysia	Litter abundance: 94.56 kg/m^3 (Minyak Beku Beach); 66.15 kg/m^3 (Sungai Lurus Beach) Dominant composition (Sungai Lurus Beach): plastics (80% by count and 54% by weight), paper (13% by count), glass (2%), rubber (2%), metal (1%), cloth (1%) and wood (1%) Dominant composition (Minyak Beku Beach): glass (60% by count and 39% by weight) and plastics (33% by count) Dominant shape: plastic bag, plastic bottle, polystyrene disposable dinnerware and sweet wrapper, all originating from beachgoers and local community	All visible debris was collected by walking randomly along length of 500 m x 50 m transect and parallel to waterline. To maximize sample collection, sampling process was conducted during low-tide period and suitable weather.	Kadir *et al*. (2015)
2013–2014	Seberang Takir Beach and BatuBurok Beach, Malaysia	Litter composition at Seberang Takir: plastics (75%), glass (9%), paper (5%) and others (10%) Litter composition at BatuBurok: plastics (57%), paper (10%) and others (29%)	Plastic types in this study were related to functions of particular beaches. Recreational beaches have abundant quantities of plastic film, foamed plastic, including polystyrene, and plastic fragments; 879 items m-2 were found on Seberang Takir Beach and 780 items m-2 on BatuBurok Beach.	Fauziah *et al*. (2015)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
September 2006	Microplastics in sediment core of coastal zone, Straits of Johor, Malaysia	Higher abundance of microplastics was detected in 2–4-cm layer (about 300 pieces/kg dry sediment, with 200 pieces being polypropylene and 100 being polystyrene) than in 48–50 cm layer (about 100 pieces/kg dry sediment, all of which were polyethylene) of sediment core collected from the Straits of Johor, Malaysia.	Sediment cores were collected at four locations, using a gravity corer of 11 cm i.d. and 1 m in length. Cores were sliced on-site at 1 or 2 cm intervals. Slices were stored individually and subsequently freeze-dried. Selected slices from cores were analysed for this study. Ten grams of freeze-dried sediment (or wet sediment, corresponding to 10 g of dry sediment) were analysed for microplastics. To remove biofilms from surface of microplastics, 150 mL of 30% H_2O_2 was added to sediment in glass beaker. After reaction ceased, normally after 1week, sediment was passed through 315-lm, mesh-size nylon sieve. Particles retained in sieve were suspended in 500 mL of 5.3 M NaI solution (density: 1.6 g/cm^3), stirred for 2 minutes and allowed to stand for 3 h; 100 mL aliquot of supernatant was then removed. This process was repeated, and combined supernatant was then centrifuged at 2,000 rpm for 10 minutes. The supernatant was passed through 5-mm mesh-size stainless-steel sieve and then through 1-mm, mesh-size, stainless-steel sieve and 315-lm, mesh-size nylon sieve. All retained particles on meshes were dried in a desiccator with activated silica gel for 1week, picked up one-by-one, using stainless-steel tweezers, and subjected to Fourier-transform infrared spectroscopy (FTIR).	Matsuguma *et al.* (2017)
January to March 2010	Marine debris on six beaches in Port Dickson, Kuala Terengganu and Kota Kinabalu, Malaysia	Beach debris abundance: 138 items/10m^2 by count and 15.5g/m^2 by weight with plastics being most abundant type	Three different sites with 20 m x beach width (low-tide line to first vegetation/ concrete) were sampled on each beach to give a total area of 60 m x beach width. This method was applied to all beaches except Pasir Panjang Beach. For Pasir Panjang, entire area was sampled because beach length is less than 60 m. All visible debris in sampling area was collected and sorted.	Khairunnisa (2012a)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
January to March 2010	Marine debris on a recreational area (Teluk Kemang) and fishing beach (Pasir Panjang) in Port Dickson, Malaysia	Teluk Kemang Beach: 0.262 ± 0.045 items/m^2, weighing 2.067 ± 1.238 g/m^2, with plastics 80% by count (including polystyrene) and 49% by weight (including polystyrene) Pasir Panjang Beach: 0.495 ± 0.108 items/m^2, weighing 46.079 ± 12.507 g/m^2, with plastics 61% by count (including polystyrene) Identified potential factors in accumulation: abandoned fishing gear, presence of daily clean-up activity	Every sampling event was done during low tide for broader sampling area and neap tide for bias prevention. Area sampled was 10% of actual length, which was determined using data provided by Port Dickson municipality (Teluk Kemang = 1.8 km and Pasir Panjang = 1.0 km). It was assumed that debris was randomly disposed along beach, and all visible anthropogenic debris within area was collected. Number of items and fresh weight of each debris type were recorded.	Khairunnisa *et al.* (2012b)
November–December 2011	Litter on beaches of Likas Bay (Teluk Likas), Sabah, Malaysia	Litter abundance: 3,396 items/100m^2 with weight of 14,499.36g/100m^2 Litter rate of accumulation: 40 items/100m^2, weighing 172.62g/100m^2 Plastic percentage in total litter collected: 94.38% in numbers and 65.29% in weight Factors regarding sea-swept litter included physical condition and bay position.	Six transects that measured 10 m x 10 m were randomly selected along stretch of Likas Bay Beach. Beach along the transect was first-cleaned, then debris collection was conducted after 24 hours. All debris pieces found in each transect equal to or larger than 2 cm were collected in separate bin bags and later were counted, classified and recorded in the lab.	Adnan *et al.* (2015)
May–June 2012	Visual observation of oceanic surface waters of the Strait of Malacca (off coast near Kuala Lumpur), Malaysia	Number of litter items observed in Strait of Malacca: 17,524 items, of which 98.8% were plastics and 1.2% non-plastic items (e.g. wood, paper, glass and tin) Density of litter: 577.9 ± 219.1 items/km^2 Dominant size of litter: 25.1% (<5 cm), 51.6% (5 cm–15 cm), 17.5% (15–30 cm), 4.8% (30–60 cm) and 1.0% (>60 cm) Dominant type of litter: Packaging (93.3%), plastic fragments (3.4%), fishing/ boating items (1.4%) and user items (0.7%) Other findings: out of 17,524 items observed in Strait of Malacca, 14,154 items (98.9% plastics) were observed on 24 May 2021, with litter concentrated in drifting lines on calm sea	Floating marine debris was counted during research cruise aboard the R.V. Marion Dufresne from 24 May to 15 June 2012. Throughout daylight hours, observations were conducted, while ship was under way, from bridge wing or from deck above bridge, 10 m–13 m above sea level and 57 m from ship's bow. Only debris on one side of bow was counted. Litter was mostly detected with naked eye, but regular scans of waters away from ship were made with 10" x 32" binoculars to detect more distant debris. Binoculars or images taken with a digital SLR camera with a 500-mm telephoto lens were used to identify litter items, but some submerged items could not be identified. To compensate for patchy nature of floating debris at sea, data were pooled into transects of roughly 50 km, which sample 2.5 km^2 of sea surface given an effective transect width of 50 m. Total length covered in Strait of Malacca is 1,113 km of transect.	Ryan *et al.* (2013)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
October 2012	Marine litter during the Northeast monsoon on beaches of Pandan (Lundu), Pasir Pandak (Santubong), Temasyah (Bintulu) and Tg. Lobang (Miri), Malaysia	Total litter collected: 2,914 items of litter, weighing 166 kg Litter density: 730 item/km of debris at 42 kg/km Abundance of marine litter: Pasir Pandak beach received highest quantities of debris (1,120 items/km or 44.1 kg/km) Dominant marine litter type: plastic (90.70%), wood (3.53%), rubber (2.20%), glass (1.78%), metal (1.58%) and cloth (0.21%) Source of litter: 23.99% from marine sources, 11.67% from terrestrial sources and 64.34% from common sources	Shoreline of survey sites stretches between 1 km to 6 km in length and between 20 m to 60 m in width. Identification of starting point of beach surveyed was marked by hammering polyvinyl chloride pipe into sand above high-tide mark. During low tide, all anthropogenic debris other than fragments smaller than 0.25 cm^2 covering from high-tide mark to low-tide mark at each survey site was collected, weighed and then classified by their categories and sources.	Mobilik *et al.* (2014)
Not specified	Marine litter on four beaches (recreational, fisheries and shipping lanes beaches) in Peninsular Malaysia	Abundance of marine litter: 0.142 – 0.884 items/m^2 or 1.119 – 32.351 g/ m^2 Dominance of plastic debris: most abundant type of debris found on all beaches with percentage of weight, ranging from 36% to 94% Dominant litter types: Plastic bags and wrappers, hard plastics, polystyrene and abandoned fishing nets	Four beaches (recreational, fisheries, and shipping lanes beaches) in Peninsular Malaysia were selected for waste composition and abundance studies. On each beach, three field sampling events were conducted to determine composition and abundance of beach debris. Based on strips transect, debris from area of 60 m x total width were collected. Debris found within area were separated based on types, weighed and recorded. Public surveys were also conducted during each sampling event.	Agamuthu *et al.* (2012)
2013	Marine litter on beaches of Saujana (in State of Negeri Sembilan) and Batu Rakit (in State of Terengganu) in Peninsular Malaysia	Total debris items collected: 4,682 items weighing 231.4 kg, with density ranging from 40.4±13.0 to 815±717 items/km and 21 - 56.5 kg/km Seasonal variations in litter density: south-west monsoon (1,122±737 items/km), north-east monsoon (825±593 items/ km) and intermediate monsoon (394±4 items/km) Other findings: Plastic category was largest share of items collected (88%), including packaging, plastic fragments, cups, plastic shopping bags, plastic food wrappers and clear plastic bottles	Beach survey standing crop method (Cheshire *et al.* 2009) was used during northeast monsoon, intermediate monsoon and southwest monsoon seasons. Ship rubbish sampling: All solid waste other than fragments smaller than 0.25 cm^2 at container and general cargo vessels rubbish station were identified, weighed, classified and sorted.	Mobilik *et al.* (2015)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
June–July 2014	Marine litter on four beaches at Port Dickson, Peninsular Malaysia	Marine litter weighing 169.8 kg, or 13,193 items, were collected from four surveyed beaches, with average density ranging from 0.0083 kg/m^2 (Saujana Beach) to 0.1064 kg/m^2 (Nelayan Beach). Three items of highest frequency were cigarette butts, foamed fragments and food wrappers. Plastic debris scaled high at up to 41% of total debris. Factors contributing to less accumulation: high energy conditions on beaches such as wind and waves.	Waste quantification meant debris density and categorization of debris, both which were carried out on the spot and entered onto data cards. Debris data card was based on the OSEAN/AMETEC Protocol, from KIOST (Korea Institute of Ocean Science and Technology). At site, length and width of shoreline was measured, using meter ruler, according to beach topography. Every beach was measured for sampling. Selected area was divided equally into two segments. Each section was labelled from left to right. Every quadrant started from water's edge to back of shoreline with each transect was traversed by foot. Every debris item was collected in plastic bag, and later, categories were recorded by weight on debris density data sheet. Snapshots of debris items were taken in each transect. Sampling was carried out progressively for 8 consecutive Saturdays, over 2 months at different time zones, from morning until evening.	Yi and Kannan (2016)
Not specified	Plastic debris buried in sand at recreational and fishing beaches in Malaysia	Total of 2,542 pieces (265.30 g m-2) of small plastic debris were collected from all six beaches, with the greatest quantity found in Kuala Terengganu (Seberang Takir Beach with 879 items/m^2 followed by Batu Burok Beach with 780 items/m$^{2)}$. Other four beaches had lower quantities, ranging from 192 items m-2 to 249 items/m^2. Recreational beaches sampled averaged 399 items m-2 of plastic debris, while fishing beaches averaged 446 items m-2.	Sediment sampling: Plastic debris sampling was conducted once a month for three consecutive months (January, February and March) at 28-day interval, as recommended by Lettenmaier (1978). At each site, triplicates of 12.5 L sediment, consisting of sand or small gravel, was scooped up; this was done using small shovel within 50 × 50 cm^2 quadrate to depth of about 5 cm, from low tide (*X*) and high tide (*Y*) water level as well as from berm area (*Z*) of beach within three belts transects. Sieving: Sand in bucket was mixed with seawater, stirred and sieved through set of nested sieves. Sieves were 200 mm in diameter with aperture sizes of 4.75 mm, 2.80 mm and 1.00 mm, arranged in order of decreasing size from top to bottom. Particles, with overall size range of 1–30 mm, were retained from each sieve tray and placed in separate labelled plastic bags for sorting purposes.	Fauziah *et al.* (2015)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
December 2015 – May 2016	Stranded, floating and micromarine debris on beaches of and surface water around Sebatik Island, Tawau, Sabah, Malaysia	In study area, 14 types of stranded macromarine debris and 9 types of floating marine debris were found. Dominant types of stranded and floating debris: Discarded plastic, organic debris and plastic bottles Dominant micromarine types: fragments, fibre, films and polystyrene Abundance of debris types: 80 items/m^2 (SMD), 94 items/m^2 (FMD) and 22 items/ml (MMD)	Transect line method modified from Velander and Mocogni (1999) was used to assess stranded macromarine debris. A transect of 50 m was laid and divided into three parts. Each part was marked, and 2.5-m gap drawn at particular angle. Floating macrodebris was evaluated by surveys of the selected areas, using boat navigated at speed of 4–10 knots. Once floating macrodebris was seen on sea surface, coordinates of places where this type of debris occurred were recorded. Density separation technique was applied to extract micromarine debris from sediment samples taken. Five scoops of sediment samples were randomly collected at 5 cm depth of 0.5 m x 0.5 m quadrate. Sediment samples were sieved, using 1-mm mesh size and placed in a tray. Composite sediment sample weighing 50 g was taken, mixed with 150 mL NaCl solution, allowed to stand undisturbed for 10 minutes before vigorously shaking. Supernatant was collected in 100 mL beakers and stored for 24 hours. Subsequently, all samples were filtered using 47-mm sized membrane filter and then dried in oven for 3 hours at 60˚C. Observations on types of microdebris were made with stereomicroscope.	Estim and Sudirman (2017)
2018	Microplastic particles in 10 personal care products and cosmetics in Malaysia	Total of 0.199 trillion microplastics are expected to be released annually into marine environment in Malaysia. From 214 respondents, particles found in facial cleaner/scrub and toothpaste were both coloured and colourless with predominance of granular shapes. Particles in toothpaste were found between 3 µm and 145 µm, while particles in facial cleaner/scrub were between 10 µm and 178 µm.	Total of 10 personal care products and cosmetics were selected based on questionnaire survey results provided by Malaysians in their daily life usage. Using modified extraction and enumeration method, study resulted in total of 2 g weighed and dissolved in a glass conical flask, containing 150 mL boiling water. Then, mixture was stirred, using glass rod until fully dissolved and filtered using 0.45 µm Whatman filter paper by vacuum filtration. After filtration process, 50 mL of deionized water was added to further dissolve solution and purify particles. Once particles underwent purification, residue containg microplastics was oven-dried at 50°C to constant weight. As soon as microplastics were dry, particle mass was weighed, using analytical balance and stored in glass vials for further analysis. To obtain representative results, this step was repeated 10 times.	Praveena *et al.* (2018)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
October–November 2018	Anthropogenic marine debris in two urban and two peri-urban mangroves on Penang Island, Malaysia	Highest abundance of anthropogenic marine debris: recorded at Jelutong, near landfill and dense residential area, at total of 7,312 items, where 92.5% were plastics and remaining 7.5% were non-plastics Types of plastic anthropogenic marine debris at Jelutong: plastic bags (2,046; 30.3%), plastic sheets (1,343; 19.9%) and plastic cutlery (995; 14.7%) Dominant non-plastic materials: mainly glass and ceramic (261; 47.5%), followed by cloth (161; 29.3%) and rubber (81; 14.8%)	Two urban and two peri-urban mangroves were sampled at different periods over 2 mo, with differences constrained by possible changes in their wind fields and neap-spring tidal development. Debris were counted and classified across transects parallel to coastline at progressively higher watermarks. Assessments were carried out between October and November 2018 over monsoon transition period. For all four sites, three transects were placed parallel to coastal edge. Transect at low tidal level ran as close as possible to edge of sea (referred to as "practical edge"), and other two transects were placed in main body of mangroves at mid- and high-tidal levels. Assessments of total number and types of anthropogenic marine debris for three 10 m x 10 m (100 m^2) quadrats were completed on each transect, totalling in nine quadrats per sampling site. For more effective data-collection, these quadrats were divided into 100 1 m^2 subquadrats.	Yin *et al.* (2019)
April–May 2019	Floating plastics in Klang River	Mean floating plastic density identified from unmanned aerial vehicle imagery: about 0.8–7.9 items/m^2 (downstream flow); 0.6-1.7items/m^2 (upstream flow)	Identification made by unmanned aerial imagery and trawling method, as described in van Emmerik *et al.* (2018).	Geraeds *et al.* (2019)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
Not specified	Microplastics in viscera and gills of commercial marine fish from Malaysia	Of 11 species of fish, 9 contained plastic debris. Extracted plastic particle sizes ranged from 200 to 34,900 µm (mean = 2,600 µm ± 7.0 *SD*). Dominant debris type: of 56 isolated particles, 76.8% were plastic polymers, 5.4% were pigments and 17.8% were unidentified	Total of 110 individual fish from 11 commercial fish species (fish per species *n* = 10) sold for human consumption were collected from local fish market in Seri Kembangan, Malaysia. After dissection and separation, viscera and gills of fish were collected and placed in pre-cleaned, zippered plastic bags (rinsed twice with deionized water and once with ethanol). They were then transferred to the laboratory of aquatic toxicology at Universiti Putra Malaysia and maintained at −20°C. Plastic isolation from viscera and gills of sampled fish was performed according to method of Karami *et al*. (2017c). Excised organs and gills of fish were placed together in 250 mL DURAN® lab bottle (Schott, Germany) that was sealed with premium cap and pouring ring (Schott, Germany). Then 200 mL of KOH (potassium hydroxide) (10% w/v) was added to each bottle and subsequently incubated at 40°C for 72 h. Digestates were filtered over 149 µm filter membrane, using a vacuum pump (Gast vacuum pump, DOA-P504-BN, United States) connected to a filter funnel manifold (Pall Corporation, United States). To separate potential plastic particles from other digestion resistant materials (e.g. exoskeleton of invertebrates), the 149 µm filter membrane was soaked in 10–15 mL NaI solution (4.4 M, 1.5 g/mL) and sonicated at 50 Hz for 5 minutes, agitated on an orbital shaker at 200 rpm for 5 minutes, and eventually centrifuged at 500 × g for 2 minutes. Finally, supernatant of mixture containing plastic particles was filtered through another filter membrane (pore size: 8 µm). To ensure total isolation of plastic debris, this stage was performed twice. Filter papers were dried at 40°C and stored in Petri dishes for visual identification of particles. Visual inspection of 8 µm filter membranes was conducted using Motic SMZ-140 stereomicroscope (×110 magnification). All particles resembling plastic debris were sampled, based on morphological characteristics including shape and size. Sampled particles were photographed with camera (AxioCam, ERc 5S, Germany) equipped with stereomicroscope. Extracted particles were then assessed and analysed, using Raman spectroscopy and FESEM-EDX.	Karbalaei *et al*. (2019)

(Continued)

Table 29 *(continued)*

Year	Type	Findings	Method	Source
Not applicable	GIS-based analysis of plastic waste leakage in parts of Selangor State (Pateling, Cheras, Kajang and Semenyih), Malaysia	Plastic litter abundance in study area: 29 items/10m^2 to above 300 items/10m^2	Geospatial technology (i.e. consisting of multiple thematic maps based on geo-environmental factors, statistical data and consumer behaviour) were integrated to model plastic leakage in parts of Selangor State (Kajang, Petaling, Cheras and Semenyih) in Malaysia. Geo-environmental factors (e.g. land-use, study area of hydrological networks and topography) were considered and prepared in ArcGIS platform to produce land-use map, drainage density map, and digital elevation map, respectively. Statistical data was used to develop plastic waste density map, and litter characteristic of study area was used to develop plastic waste leakage model.	Chukwuma *et al.* (2019)

Litter density is thought to be highly dependable on the economic activities of the particular beaches (Khairunnisa, Fauziah and Agamuthu 2012) as well as lack of cleaning activities (Fauziah, Liyana and Agamuthu 2015).

In fact, Fauziah, Liyana and Agamuthu (2015) pointed out that the volume of plastic litter in the coastal environment in Malaysia is affected by shipping activities and the actions of waves, with main factors being the failure of implementing proper waste management systems (including the lack of recycling and proper waste treatment). Besides, limited appropriately compiled information exists on the absolute quantification of beach litter.

Moreover, a 2013 case study identified four factors in the amount of marine litter accumulation in Semporna, Malaysia: (i) intensity of tourism activity, (ii) seasonality, (iii) accessibility and (iv) sewage and solid waste management (Prabhakaran, Nair and Ramachandran 2013). The study also presented an “indicator system” regarding marine litter in a tourism environment, identifying the following indicators of marine litter management at this location: (i) sufficient capacity for collecting solid waste; (ii) community involvement in solid waste management, such as waste separation, waste reuse and recycling; (iii) promotion of environmental activities to raise awareness and encourage involvement of hotel staff, clients and suppliers in marine litter management; (iv) cost for coastal contamination; and (v) development control (of marine litter) and enforcement (Prabhakaran, Nair and Ramachandran 2013).

State of municipal solid waste management

According to the 2005 National Strategic Plan for Solid Waste Management, the goal of Malaysian Government was to (i) achieve overall waste reduction with a recovery rate of 17 per cent and (ii) raise the plastic recovery target to 20 per cent by 2020.

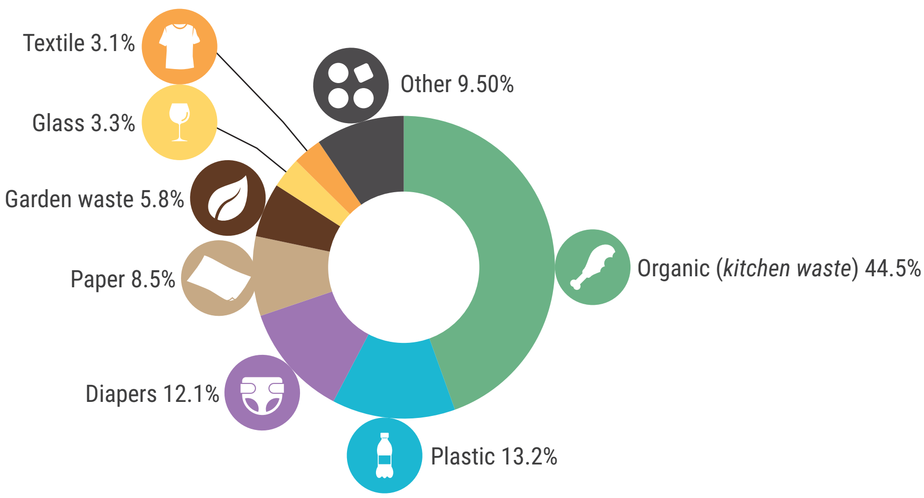
In Malaysia, solid waste management is fully privatized at the municipal level, where it is regulated by local governments. Beach waste is managed mostly by local governments or appointed private contractors (Agamuthu, Fauziah and Khairunnisa 2012). In Pasir Pnadak, regular beach litter collection on the Temasyah and Tg Lobang beaches is carried out at least twice a week by private contractors (Mobilik *et al*. 2014).

Data on single-use plastics generation and MSW management in Malaysia

Table 30 /

MSW background information [1]		
Population	30.23 million (2014)	
MSW generation	12.98 million tons/year (2014)	
MSW per capita	1.1 kg/person/day (2014)	
Single-use plastic waste generation [2]		
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)		1.67 million tons (2019)
Polymer exports		1.34 million tons (2019)
Polymer imports		1.81 million tons (2019)
Domestic conversion of polymers into single-use applications		1.12 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)		1.55 million tons (2019)
Single-use plastic liports (as bulk packaging and in finished goods)		0.95 million tons (2019)
Domestic single-use plastic waste generation		0.51 million tons (2019)
Single-use plastic waste generation per capita		16.01 kg (2019)
MSW collection and treatment [3]		
MSW collection coverage	70%	
Method of treatment	79% land-filled; 21% recycled	

Sources: Compiled mainly from: [1] Pariatamby (2017); [2] Minderoo Foundation(2021); [3] Borongan, Kashyap and Renaud (2018); and [4] UNEP (2017) .
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.



Source: UNEP (2017).

MSW composition in Malaysia

Figure 7 /

Government action on combating marine litter in Malaysia

Table 31 /

Year	Title
2018	Malaysia Roadmap Towards Zero Single-Use Plastics (2018–2030)

In line with the National Strategic Plan, local implementation of solid waste policies is targeted to reduce sources and prevent generation of waste; include waste diversion, which includes recycling and composting and conversion technologies; and feature other types of solid waste facilities like transfer stations, rail-loading facilities, material recovery facilities and waste-to-energy facilities. Beach rubbish clean-ups are mainly initiated by NGOs, local governments and marine-related bodies as well as hoteliers. Such activity is commonly carried out in Malaysia with much public participation, resulting in increased public awareness and good rubbish management practices along the beaches.

In terms of foreign waste imports, the Malaysian Government issued a ban on the import of plastic waste in 2018 and announced that it will gradually stop importing other types of plastic products by 2021. In May 2019, Malaysia returned a batch of plastic waste from Australia, Canada, Japan and the United States.

In addition to background information on MSW in Malaysia, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 30 and Figure 7.

Actions on combating marine litter

In 2018, the Malaysian Ministry of Energy, Science, Technology, Environment and Climate Change released the Malaysia Roadmap Towards Zero Single-Use Plastics (2018–2030) (Table 31). This Roadmap is this country's first comprehensive, integrated plastic pollution management plan; it includes a series of action plans, such as additional environmental pollution levies on manufacturers of plastic products (e.g. plastic bags and straws, tableware, lunch boxes), research and development of plastic alternatives, and public education and awareness approaches like promoting environmentally friendly alternatives and a circular economy for disposable plastics. In addition, the Malaysian Government is studying related policies and systems based on extended producer responsibility, thus encouraging plastics producers to take responsibility for collecting, recycling and disposing of waste.

To control beach litter, the Malaysian Government has promulgated that beach littering offenders are subject to a RM 500 penalty, although enforcement in public spaces such as beaches has been difficult to implement (Karbalaei *et al*. 2019).

In October 2019, the Dutch NGO The Ocean Cleanup deployed automatic interception and collection devices for rubbish floating in three rivers in Malaysia.

Maldives

The Maldives is an archipelagic Small Island Developing State comprised of over 1,000 coral islands with a total coastline of more than 820 km (UNEP and Development Alternatives 2014). The Maldives had an estimated population of 531,000 in 2019 and 1.39 million registered overnight visitors in 2017. The country had an MSW generation of 211,506 tons in 2015 (Kaza *et al*. 2018). This number more than doubled between 1998 and 2015 and was expected to further increase, partly owing to an increase in tourism. MSW generation could already be higher than reported, considering MSW collection was reported at 325,410 tons in 2014 (UNSD 2018).

State of marine litter management

The abundance of marine litter in the Maldives is affected by anthropogenic activities, especially considering the large number of tourists in recent decades. Densely populated localities such as Addu City, Fuvahmulah and Malé are highly polluted by marine litter. Moreover, the island of Thilafushi is also a hotspot of marine litter, owing to the improper waste management (Saliu *et al*. 2018). The abundance correlates positively with population density and with other intensive anthropogenic activities—that is, commercial activities such as fishing, shipping, manufacturing and so on. In addition to these key indicators for marine litter in the Maldives, another key indicator is the waste disposal rate.

In fact, international tourism and fishing are the dominant economic activities in the Maldives (Kamaludeen 2020; Saleem 2020). Considering these industries, marine litter is most likely to accumulate at beaches, in coastal oceans and around islands. Thus, marine litter has greatly reduced not only the aesthetic value of coastal beaches but also the quality of fish products (Table 32). In fact, the Maldives is facing declines in tourist numbers and associated revenues owing to marine litter, particularly plastics that threaten the reputation of islands as sought-after tourist destinations.

In this country's marine environments, the accumulation rate of flotsam is 2.6 items per kilometre per year, 43 per cent of which is man-made and 41 per cent colonized by biota (Barnes 2004). The abundance of long-term accumulation of plastic on the beaches has been recorded as 1,029±1,134 pieces/m^2 (Imhof *et al*. 2017).

Studies on marine litter distribution in the Maldives

Table 32 /

Year	Type	Findings	Method	Source
June 2015	Plastic litter in beaches on south shore of Vavvaru, a remote coral island of the Maldives, Indian Ocean	Average long-term accumulation abundance: 1,029 ± 1,134 plastic particles/m^2 in the natural accumulation zones of organic material and marine debris Size distribution: 98% of the particles larger than 5 mm were mesoplastic (5–25 mm) and only 2% were macroplastic (N25 mm) Dominant type: polyethylene, polypropylene and polystyrene, but polyurethane, polyamide, polyvinyl alcohol and polyvinyl chloride Dominant shape: expanded polystyrene (61%), fragments of foil remnants (20%) and larger plastic products (15%) Daily abundance of intertidal plastics: 35.8 ± 42.5 plastic particles/m^2 Dominant size of daily intertidal plastics: 94% of the particles larger than 5 mm were mesoplastic (5 –25 mm) and only 6% were macroplastic (N25 mm) Dominant type of daily intertidal plastics: majority of particles consisted of polyethylene or polypropylene, while only few polystyrene (expanded polystyrene) particles were detected Dominant shape of daily intertidal plastics: most particles were fragments of larger plastic debris (52%) but raw pellets (17% of particles) were also present. Identified potential origin of plastic litter: from "landfill islands" of nearby inhabited islands or tourist islands, or transport from the Indian Ccean	Two sampling experiments were conducted for this study. (i) Long-term accumulation: Six sites were determined on shoreline in areas where floating organic material and marine debris had aggregated (n = 6). At each site, existing accumulated material within grid of 1 m^2 (1 × 1 m) was collected once, resulting in six samples, and analysed for plastic particles as described below. (ii) Daily abundance: In second experiment, researchers assessed daily abundance of plastic particles at high-tide drift line of south-facing shoreline. Sampling was performed on seven consecutive days from 21–27 June 2015 at six evenly allocated and geographically fixed sampling sites along shoreline of ~ 100 m (6 sample sites × 7 days resulted in 42 samples). Upper surface layer (about 1 cm) of the sampling area was collected using stainless-steel shovel. This method allows for freshly buried debris but excludes particles from deeper layers that may have been washed ashore in the past (Browne *et al*. 2011). Resulting sample was sorted by size, using stainless-steel laboratory sieves with 5 mm and 1 mm mesh size (RETSCH GmbH, Germany). Sample fraction 1 mm – 5 mm was transferred to laboratory for further examination. All potential plastic particles N5 mm were stored in Ziploc® bags until analysis. In the laboratory, all samples were visually screened for potential plastic particles. Stereo microscopes (Leica M50, Leica Microsystems GmbH, Germany) were used for pre-sorting the 1–5 mm fraction, and FITR-ATR spectrometer was used to identify plastic particles and their polymeric structure.	Imhof *et al*. (2017)

For large marine litter items, it was estimated that 3 per cent of hooks set on tuna longlines were lost (Macfadyen, Huntington and Cappell 2009). According to a two-year summary of turtle entanglements in the Maldives, specimens of green turtles, leatherback turtles, hawksbill turtles and olive ridley turtles have been found entangled in ghost gear (Stelfox and Hudgins 2015).

The abundance of microplastics in surface water and beach sediments has been recorded as 0.32±0.15 pieces/m^3 and 22.8±10.5 pieces/m^2, respectively (Saliu *et al.* 2018).

State of municipal solid waste management

In the past, solid waste in the Maldives was collected in an ad hoc manner and dumped at the shore, disposed of in the ocean, or transported to Thilafushi Island for open incineration (Saliu *et al*. 2018). As a result, anthropogenic materials have been accumulating on the ocean surface, in the water column and on the seabed. It was not until May 2009 that the Maldives began to develop an integrated waste management system.

The areas where marine litter issues in the Maldives have been investigated include Ari Atoll (Barnes 2004), Vavvaru Island (Imhof *et al*. 2017) and Faafu Atoll (Saliu *et al*. 2018). The results of these studies are hardly comparable owing to the different learning objects and the different methods applied. Recent results that have found that the abundance of plastic particles in Vavvaru Island seems to be significantly inferior to those of more populous regions. Imhof *et al.* (2017) strengthens the well-established conclusion that their abundance correlates positively with population density and other intensive anthropogenic activities.

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 33.

Actions on combating marine litter

The Strategic Action Plan 2019–2023 of the Government of the Maldives highlights national development policy targets and priorities, with one being to reduce plastics pollution by phasing out single-use plastics. To this end, the national phaseout implementation plan comprises six policy objectives: (i) banning the import, production and sale of specific single-use plastics, (ii) introducing market-based instruments, (iii) strengthening the national waste database and setting reduction targets for plastic packaging, (iv) supporting extended producer responsibility, (v) ensuring the sustainable provision of alternatives and (vi) engaging in public education and awareness.

Civil society organizations have been active in marine environment conservation in the Maldives. A growing number of islands have already gone plastic-free, with the movement spearheaded by volunteers and school children. For instance, divers with the NGO Olive Ridley Project removed more than 1,400 ghost nets and recorded 812 entangled turtles in this country between 2013 and 2019.

Data on MSW generation and management in the Maldives

Table 33 /

MSW background information [1]	
Population	0.53 million
MSW generation	0.21 million tons/year (2015)
MSW per capita	1.42 kg/person/day (2015)
MSW collection and treatment [2]	
MSW collection coverage	38.2%

Sources: Compiled from multiple sources including: [1] Kaza,Yao, Bhada-Tata ; Van Woerden (2018) and [2] UNEP (2017).

Myanmar

Myanmar had an estimated population of 54.05 million in 2019 and a coastline of 1,930 km.

State of marine litter management

According to a recent UN FAO-commissioned report issued by the EAF–Nansen Programme, a first-of-its-kind programme that surveys fisheries resources and the marine ecosystem, more than 28,000 pieces of microplastic particles per square km were found at Myanmar Beach, an accumulation over three times higher than that for India (8,000 pieces/km^2) (Table 34).

A Fauna and Flora International (also known as "FFI") survey estimated that as much as 90 tons of litter are discharged into the ocean in Myanmar through the Ayeyarwady River and 29 tons through the Yangon River, a combined area home to more than 60 per cent of the country's population (Jeske 2019). In fact, the Ayeyarwady ranks as the world's ninth-largest contributing river to marine plastic pollution, according to Lebreton *et al*. (2017). Moreover the FFI survey also reported that the concentration of riverine plastics is 17 times higher in the dry season, suggesting strong seasonal variation of litter content and influence of river run-off.

Studies on marine litter distribution in Myanmar — **Table 34 /**

Year	Type	Findings	Method	Source
2014	Seafloor Coral Reef (Myeik Archipelago), Myanmar	Microplastic abundance: 6.4 ± 2.8 items/100 m^2 (2 660 m^2 surveyed, 38 sites)	Three belt transects laid along reef contours at 3–4 m in depth and approximately 20 m apart, using globally standardized protocols. Belt transects were either 10 m, 15 m or 20 m x 2 m (area surveyed at each reef ranged between 60 m^2 to 120 m^2).	Lamb *et al*. (2018)

Government action on combating marine litter and managing solid waste in Myanmar

Table 35 /

Year	Title
2017	National Waste Management Strategy and Action Plan for Myanmar (2017–2030)

State of municipal solid waste management

While it is difficult to find reliable, recent data on MSW generation for Myanmar, it is widely known that inadequate solid waste management practices in Myanmar contribute to a high level of marine litter, and it is widely accepted that rapid economic growth in Myanmar has resulted in an increasing volume of solid waste generation.

In fact, Myanmar still relies mainly on landfills as a waste management practice, and open dumping remains a common practice. These practices have been certainly identified as a cause for the high amount of litter in the Ayeyarwady River. MSW generation was 2.04 million tons in 2012 (Borongan, Kashyap and Renaud 2018). And in Yangon, the national capital, an estimated 1 million tons of litter are left on streets each year (Huisman *et al*. 2017).

Data on single-use plastics waste generation and MSW management in Myanmar

Table 36 /

MSW background information [1] [4]	
Population	54.05 million (2019)
MSW generation	2.04 million tons/year (2000)
MSW per capita	0.39 kg/person/day (estimate, 2016)
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	0.00 million tons (2019)
Polymer exports	0.00 million tons (2019)
Polymer imports	0.39 million tons (2019)
Domestic conversion of polymers into single-use applications	0.19 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.05 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.13 million tons (2019)
Domestic single-use plastic waste generation	0.28 million tons (2019)
Single-use plastic waste generation per capita	5.15 kg (2019)
MSW collection and treatment [3] [4]	
MSW collection coverage	60%, up to 92% in Yangon and Irrawaddy rivers
MSW recycled	8%
MSW disposal	92%

Sources: Compiled from multiple sources including:[1] Kaza, Bhada-Tata and Van Woerden (2018); Van Woerden (2018); [2] Minderoo Foundation(2021); [3] UNEP (2017); and [4] Borongan, Kashyap and Renaud (2018).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

In 2017, the Government issued the National Waste Management Strategy and Action Plan for Myanmar (2017–2030), committed to improving its overall waste management status.

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 36.

Actions on combating marine litter

The Government of Myanmar has aimed towards a national policy framework and strategic direction conducive to moving from conventional to sustainable waste management based on the 3Rs (reduce, reuse and recycling) via its National Waste Management Strategy and Master Plan (2018–2030). The Master Plan comprises a series of strategies and practical actions towards achieving a zero waste, circular economy and a sustainable society by 2030; these actions include those on sustainable plastic waste management. To implement the Master Plan, Myanmar needs to set the plastic emissions baseline—focused on river basins—and conduct national source inventories.

Pakistan

Pakistan had an estimated population of 216.57 million in 2019 and an estimated MSW generation of 30.76 million tons in 2017 (Kaza *et al*. 2018). With a coastline of 1,046 km and a coastal population of 14.6 million, Pakistan was cited in 2010 as one of world's highest sources of mismanaged plastic waste by mass (Jambeck *et al*. 2015).

State of marine litter management

Marine litter distribution along the Arabian Sea coastline of Pakistan was first reported in a 2015 study (Qari and Shaffat 2015) (Table 37). After applying the quadrate frame method to four beaches, the study reported high concentrations of marine litter on all four beaches and discussed the possible relationship between litter composition and the function of sampling sites (Qari and Shaffat 2015).

State of municipal solid waste management

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 38.

Studies on marine litter distribution in Pakistan — Table 37 /

Year	Type	Findings	Method	Source
2012	Marine litter along the Coast of Karachi (Arabian Sea), Pakistan	Total amount of debris collected: 12,277.45 g Nine different types of debris collected: plastic items, glasses, thermophores, clothing, rubber, paper, cooking pot pieces and cigarette filters. High quantity of plastic was found at all four Karachi beaches.	Quadrate method was used for estimating debris amount. In 2012, total of 40 quadrates were made for collecting debris on four beaches: Sandspit, Buleji, Paradise Point and Korangi Creek.	Qari *et al*. 2015

Data on single-use plastic waste generation and MSW management in Pakistan

Table 38 /

MSW background information [1]		
Population	216.57 million (2019)	
MSW generation	30.76 million tons/year (2017)	
MSW per capita	0.44 kg/person/day (2017)	
Single-use plastic waste generation [2]		
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)		0.42 million tons (2019)
Polymer exports		0.18 million tons (2019)
Polymer imports		1.06 million tons (2019)
Domestic conversion of polymers into single-use applications		0.69 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)		0.09 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)		0.14 million tons (2019)
Domestic single-use plastic waste generation		0.73 million tons (2019)
Single-use plastic waste generation per capita		3.66 kg (2019)
MSW collection and treatment [3]		
MSW collection coverage	Up to 60% in Karachi and 68% in Lahore	

Sources: Compiled from multiple sources including: [1] Kaza, Bhada-Tata and Van Woerden (2018); [2] Minderoo Foundation(2021); and [3] UNEP (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

Actions on combating marine litter

Marine litter-related activities in Pakistan have been mainly conducted by environmental organizations. For instance, the WWF (World Wildlife Fund) worked closely with local fishermen, retrieving over 1,000 kg of ghost nets from sea. Moreover, represented by the Professional Association of Diving Instructors, the Pakistani diving community has also been actively engaged in marine litter removal (Project AWARE 2019).

During the First Meeting of the UNEP Ad Hoc Open-ended Expert Group on Marine Litter and Microplastics (held on 29–31 May 2018), Pakistani representatives stated that a plastic bag ban could not be instituted owing to opposition from some stakeholders.

Philippines

The Philippines is an archipelagic country with 7,641 islands and 36,289 km of coastline, one of the longest coastlines among ASEAN Member States. The country's population was estimated at 108.12 million in 2019, projected to grow to 125.4 million by 2030 (Sri Lanka and United Nations 2018), with more than 60 per cent currently living along its coastline (Taguiam 2014).

State of marine litter management

The Philippines is one of 18 mega-biodiverse countries of the world, albeit with some 700 threatened species (Table 39). Abreo (2019a) identified that owing to the high level of biodiversity in the Philippines, it is likely a hotspot for marine litter interaction with marine organisms. In fact, plastic litter has been found in macroaquatic animals, such as green turtles, whale sharks and beaked whales (Abreo 2016a; Abrea 2016b; Abreo 2019b).

The Manila Bay coastal area has been identified as an accumulation zone of marine litter in the Philippines (Ocean Conservancy 2017). The Port of Manila, the country's largest seaport, may also contribute to the occurrence and transport of marine litter. Situated across the Pacific typhoon belt, a great quantity of marine litter washes up each year on the coast of Manila Bay during typhoon seasons.

In 2016, 1,482 tons of litter, 79 per cent of which were plastics, were collected at the Manila Bay via waste audits by waste picker groups and NGOs (the EcoWaste Coalition, Cavite Green Coalition, Global Alliance for Incinerator Alternatives, Greenpeace and Mother Earth Foundation) (EcoWaste Coalition 2019).

Currently, no study exists for the Philippines on microplastics and its implications on health and food security (Abreo 2019b).

State of municipal solid waste management

With municipal solid waste (MSW) generation estimated at 14.63 million tons in 2016 (Kata *et al.* 2018), a total of 9.1 million tons of MSW collected in 2009 (UNSD 2018),

Studies on marine litter distribution in the Philippines

Table 39 /

Year	Type	Findings	Method	Source
2013	Fore stomach of female Risso's dolphin (Grampus griseus) reported from mangrove area, Purok Scorpio, Lasang, Davao City, Philippines	Three pieces of plastic debris (carry bags) were discovered in fore stomach.		Philippines, Bureau of Fisheries and Aquatic Resources (BFAR) (2013)
2018	Plastic litter in shallow subtidal area in Mayo Bay, Mati City, Davao Oriental, Philippines			Abreo *et al*. 2019a
2019	Litter interaction with marine species reported on social media platform (Facebook) in the Philippines	Results showed 32 specimen from 17 species were affected by marine litter in country. Furthermore, ingestion (61%) was most frequent interaction reported. Mindanao was also identified as hotspot for marine litter interactions.	Social media (Facebook) was scanned for posts on interaction between litter and marine species in the Philippines.	Abreo *et al*. 2019a

and a coastal population of 83.4 million, the country was cited in 2010 as one of the world's top contributors of marine plastic waste (Jambeck *et al*. 2015).

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 40 and Figure 8.

Poor-quality waste management systems largely result in a significant mass of untreated waste that eventually becomes marine litter. The Pasig River, which drains into Manila Bay, has been reported to have one of the world's highest level of riverine plastic emission (Lebreton *et al*. 2017), with the daily per-capita waste generation rate in Metro Manila at 3.00 kg in 2007 (Hoornweg and Bhada-Tata 2012).

Most waste in the Philippines is classified as "biodegradable waste" (52.31%), "recyclable waste" (27.78%) or "residual waste" (17.98%). Plastics comprise about 10.55 per cent of the total recyclables or 3 per cent of the total waste generated (Philippines, Environment Management Bureau 2018). A third-party study conducted by Jambeck *et al*. (2015) reported that mismanaged plastic waste generated in 2010 by Filipino coastal residents amounted to 1.88 million metric tons, reflecting among plastic products a very high level of plastic bag consumption. Waste audits in 2006 and 2010 confirmed that plastic bags were the main marine litter contributor in terms of volume.

Continued increases in volume is expected owing to a growing population and per-capita consumption associated with economic growth, especially in urban areas in the Philippines and other lower-middle-income countries.

However, it is worth noting that the Philippines has remarkably high waste collection rates, that is, a nationwide average of roughly 85 per cent, possibly owing to local communities' extensive involvement. The collection rate nears 90 per cent in some densely populated urban areas such as Metro Manila. Rates are at 80 per cent or lower in less densely populated areas, but even some very rural areas have collection rates above 40 per cent. Despite these relatively high collection rates, the use of open dumpsites near waterways results in leakage.

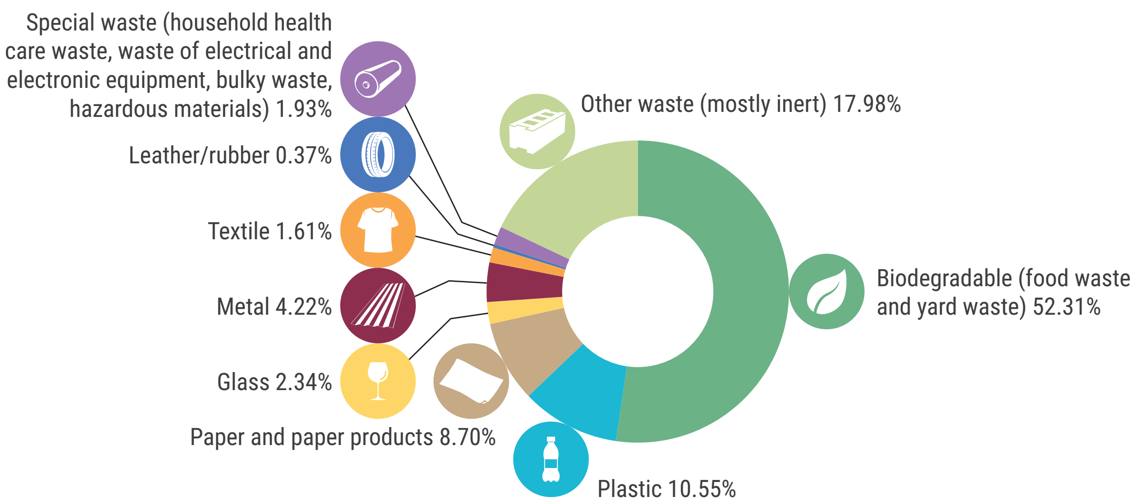
To date, the Philippines is the first and only country in the world to pass legislation opposing waste incineration. According to the Philippines Clean Air Act of 1999 (Republic Act 8749) and the Ecological Solid Waste Management Act of 2000

Data on single-use plastics generation and MSW management in the Philippines

Table 40 /

MSW background information [1]	
Population	108.12 million (2019), with 44.4% urban population
MSW generation	14.63 million tons/year (2016)
MSW per capita	0.39 kg/person/day (2016) on average: 0.79 kg/person/day in urban areas; 0.10 kg/person/day in rural areas
MSW generation growth	1.70% from 2015
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	0.60 million tons (2019)
Polymer exports	0.12 million tons (2019)
Polymer imports	0.63 million tons (2019)
Domestic conversion of polymers into single-use applications	0.53 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.17 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.64 million tons (2019)
Domestic single-use plastic waste generation	1.00 million tons (2019)
Single-use plastic waste generation per capita	9.35 kg (2019)
MSW collection and treatment [3] [4]	
MSW collection coverage	40%–85%, up to 90% in Metro Manila and up to 100% in Quezon City and Cebu 70% total population served by MSW collection in 2009 (UNSD 2018)
Method of treatment	47% diverted from disposal (recycling/composting/WtE/biogas); 53% disposed (2016)
Number of treatment and disposal facilities	9,883 material recovery facilities (MRFs); 103 sanitary landfills; 130 controlled dumpsites; 403 open dumpsites (2016)

Sources: Compiled from various sources, including [1] Borongan and Kashyap (2018b); [2] Minderoo Foundation (2021); [3] Liu *et al.* (2018); and [4] Borongan, Kashyap and Renaud (2018).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.



Source: UNEP (2017).

MSW composition in the Philippines **Figure 8 /**

(Republic Act 9003), all sources of biological, biomedical and hazardous waste incineration are prohibited.

However, comprehensive ecological solid waste management is encouraged through measures such as rubbish sorting, recycling and composting, while advanced, safe and environmentally friendly non-combustion technologies are used for heated waste disposal as well as for non-biodegradable solid waste, biomedical waste and hazardous waste.

As the main entities responsible for solid waste treatment, local government units in the Philippines should fully recognize the value of solid waste as a renewable resource, and they should also emphasize that source reduction, resource recovery and recycling are the primary tasks of solid waste management.

Regarding solid waste management and control policies, Republic Act 9003 is currently the Philippines' most systematic, comprehensive national policy for managing ecological solid waste. Moreover, the National Solid Waste Management Commission adopted Resolution 60, Series of 2013, that provides recommendatory measures for mandatory solid waste, segregation at source and segregated collection and recovery. The Resolution also prescribes fines and penalties for associated violations. Resource recycling stations have already been established in each administrative district.

In May 2014, former Philippine President Benigno Aquino III announced the designation of January as "Zero-Waste Month" (Presidential Announcement No. 760, 2014). This designation aimed to promote citizens' environmental awareness and actions to change their lifestyle and consumption habits, while also participating in developing local and national solid waste management and in promoting the systematic avoidance of waste generation based on the design and management of product development and production processes. It also promoted resource conservation and recycling along with the prevention of waste from being improperly disposed of or incinerated.

In May 2019, current Philippine President Rodrigo Duterte recalled the country's Ambassador to Canada owing to issues with Canada not reclaiming rubbish it had sent to the Philippines about six years earlier. Duterte demanded that Canada take more than 100 shipping containers containing electronic waste, kitchen waste and other non-recyclables back to Canada.

Actions on combating marine litter

The Philippines has used public policy measures to promote the management of marine plastic pollution (Table 41). The Government has done so by formulating relevant laws and regulations to impose taxes or penalties on enterprises and individuals that cause marine plastic pollution.

Marine litter-related policies, including reducing disposable plastic products and improving solid waste management, are mainly implemented by local governments units. For instance, the Biodiversity Management Bureau of the Department of Environment and Natural Resources has identified marine debris as a priority concern for offshore and marine projects. The Bureau has advocated against the use of single-use plastic products that cause marine pollution and harm marine life. Thus, in some large Filipino cities, public markets and large supermarkets have introduced "bring your own bag" policies to encourage shoppers to use reusable bags. In May 2019, the Bureau hosted in Manila its ocean-month themed event "Close the Loop", calling for a public-private partnership to bring together government and business to tackle marine litter.

In 2000, the Philippines passed the Republic Act No. 9003 (RA–9003), known as the

Government action on plastics and MSW waste management in the Philippines

Table 41 /

Year	Title
Plastic waste management	
1992	National Integrated Protected Areas System Act of 1992 (Republic Act No. 7586)
2011	Senate Bill of the Fifteenth Congress, titled Total Plastic Bag Ban of 2011: An Act Prohibiting the Use of Plastic Bags in Groceries, Restaurants, and Other Establishments, and Providing Penalties for Violations Thereof (SB-2759) [Status: Pending in the Committee (05/09/2011)]
2011	Philippines National Standard: Biodegradable Plastic (PNS-2092:2011)
2012	Local Regulations: Quezon City Regulations on Prohibiting the Use of Plastic and Polystyrene Foam in Certain Public Service Facilities (SP-2147)
2012	Local Regulation: Plastic Bag Reduction Ordinance (Quezon City Ordinance No. SP-2140)
2014	Philippines National Standard: Plastic Shopping Bag (PNS-2097:2014)
2018	Senate Bill of the Seventeenth Congress titled Plastic Straw and Stirrer Ban of 2018: An Act Prohibiting the Use of Plastic Straws and Stirrers In Restaurants and other Establishments, and Providing Penalties For Violations Thereof (SB-1866) [Status: Pending in the Committee (7/25/2018)]
2019	House Bill of the Seventeenth Congress titled Ban on Single-use Plastic Products: An Act Banning the Production, Import, Sale and Use of Single-use Plastic Products, Providing Funds therefor and for Other Purposes (HB-08692) [Status: Not enacted]
Solid waste management	
1999	The Philippines Clean Air Act of 1999 (Republic Act No. 8749)
2000	Ecological Solid Waste Management Act of 2000 (Republic Act No. 9003)
2010	National Solid Waste Management Commission Resolution No. 47 of 2010, Adoption of a National Framework Plan for the Informal Solid Waste Treatment Industry
2013	National Solid Waste Management Commission Resolution No. 60 of 2013, Resolution Guide on Mandatory Source Separation, Collection and Recovery of Solid Wastes
2014	Presidential Proclamation No. 760 declaring every month of January as "Zero-Waste Month" (PROC-760, S. 2014)

Ecological Solid Waste Management Act No. 9003 of 2000, which stipulates that solid waste is a renewable resource and clarifies methods used to manage it. The Act's priorities are source reduction, resource recovery, recycling and reuse, with local governments being its main implementers. However, two decades after the statute's enactment, the Philippines still faces many challenges in solid waste management. A World Bank report shows that Metro Manila generates nearly 25 per cent of the country's solid waste. At present, the Philippines faces the following solid waste management challenges: (i) rapid increase of solid waste production, (ii) change of solid waste composition and (iii) change of solid waste disposal methods. Research shows that the recovery rate of solid waste in the Philippines is high, reaching 80 per cent in some cities. In addition, according to a study by WWF Philippines, the National Solid Waste Management Commission and the World Bank reported collected waste was the source of 74 per cent of plastic leaks flowing into water.

In 2012, Quezon City introduced the Plastic Bag Reduction Ordinance (SP-2140), which includes several initiatives aimed at controlling the use of plastic bags in commercial establishments, such as banning plastic bags less than 15 microns thick for use in shopping malls and supermarkets. The Ordinance also involves collecting plastic bag deposits, providing green checkout channels for customers who recycle plastic bags, and other incentives. Moreover, it prohibits the free distribution of plastic bags by street vendors, hawkers and other informal businesses. In addition, in the same year, Quezon City also issued the Ordinance on Prohibiting the Use of Plastic and Polystyrene Foam in Certain Public Service Facilities (SP-2147), prohibiting the use of disposable plastic and polystyrene foam products in key public places such as hospitals, theatres and government buildings.

In January 2019, the House of Representatives introduced a bill banning the production, import, sale and use of disposable plastic products (HB-08692), which discourages the use of disposable products and encourages producers to make sustainable, environmentally friendly products. In addition, the bill aimed to prohibit businesses, such as stores and restaurants, from using disposable plastic products including straws, cups, food containers. It also calls for the establishment of recycling centres to increase consumer awareness of recycling, while plastic packaging manufacturers are required to track and collect disposable plastic products to recycle and properly dispose of them.

The Philippine Government has implemented several innovative actions to reduce its generation of marine debris from the source. In May 2019, the Biodiversity Management Bureau hosted the “Closing the Loop” event to conclude the “Month of the Ocean” celebration in Manila, calling for a public-private partnership project aimed at mobilizing government and enterprises to promote effective marine litter treatment and to enhance environmental awareness. In August 2019, the village of Bayanan launched an innovative policy through which residents can exchange 2 kg of plastic waste for 1 kg of rice at a government-owned recycling station. This policy encourages locals to actively clean up plastic waste and give it to the government for treatment.

In addition to government action, other organizations in the Philippines are working to reduce sources of marine debris. In July 2019, the United States Agency for International Development (also known as “USAID”) announced that it would provide about $400,000 to two Philippine NGOs: the Mother Earth Foundation and the Ecological Waste Coalition of the Philippines (EcoWaste Coalition). This funding was provided through special allocations from USAID’s Municipal Waste Recycling Program and was intended to support the agency’s projects in the Philippines on solid waste management and water recycling at the local and national levels. During an 18-month project period, the Mother Earth Foundation used this funding to build 30 “no waste villages”, and EcoWaste Coalition funded surveys on plastic pollution and on the efficiency of solid waste removal in Manila.

However, in the Philippines, interest in research on and monitoring of marine plastics pollution is limited, completed research is rarely published and relevant government funding opportunities are seemingly non-existent. Despite conducting surveys of marine litter, the Philippine Government mainly relies on NGOs for beach clean-up activities and scientific research survey data. Thus, no official information exists in relation to the status of marine litter. In 2019, the NGO Bounties Network launched a rubbish collection operation in Manila Bay, issuing cryptocurrency as an incentive for volunteers who participated. More work in this area is necessary because the country relies on the ecosystem services that the marine environment provides.

Singapore

With an estimated population of about 5.8 million in 2019, the island state of Singapore has a coastline of 193 km and had MSW generation of 2.05 million tons in 2010 (Singapore, Ministry of the Sustainability and the Environment 2018).

State of marine litter management

International Coastal Cleanup Singapore coordinates the annual beach and mangrove clean-ups conducted by some 70–90 educational, corporate, ground-up and religious groups, involving more than 4,000 participants. The data collected annually on marine trash are publicly available on the organization's web page (**http://coastalcleanup.nus.edu.sg/results/index.html**). In 2018, through the NGO's clean-up and data-collection exercise, 13,096 kg (161,897 pieces) of marine debris were collected (Ocean Conservancy 2021). The average weight of marine debris collected per volunteer per kilometre has increased by 22 per cent from 0.23 kg/person/km in 2008 to 0.28 kg/person/km in 2018 (Ocean Conservancy 2021). The top five most common marine debris items collected in 2018 were styrofoam pieces, cigarette butts, plastic pieces, plastic beverage bottles and straws/stirrers.

While a share of the litter on the shores of Singapore originate from land-based activities (Table 42), this country's comprehensive waste management system ensures that waste from land does not enter riverine waterways and eventually the ocean.

State of municipal solid waste management

Compared with other ASEAN countries, Singapore has developed strict domestic laws and regulations on land-based pollution control and waste management; examples are the Extended Producer Responsibility Framework, Environmental Protection and Management Act, Environmental Public Health Act, Prevention of Pollution of the Sea Act and Singapore Packaging Agreement.

Studies on marine litter distribution in Singapore

Table 42 /

Year	Type	Findings	Method	Source
2004	Coastal beach sediments and seawater	Microplastics were discovered in sediment and seawater samples. Microplastic types: polyethylene, polypropylene, polystyrene, nylon, polyvinyl alcohol and acrylonitrile butadiene styrene	Beach sediments were collected from nine different locations around the coastline at 0.5 m away from tideline. Of these, 26 kg beach sediments were taken at surface (top 1 cm), while 8 kg were taken at depth of 10–11 cm. Low-density microplastics were separated from sediments by floatation. From two sites, collected 10 L of surface microlayer at 50–60 μm and subsurface water at 1 m. Polymer types were identified using Fourier-transform infrared spectrometry.	Ng and Obbard (2006)
2014	Coastline sediments	Microplastic abundance: 36.8±23.6 items/kg sediment Dominant type: fibres and grain fragments		Nor and Obbard (2014)

In addition, Singapore has established an integrated waste management system to prevent littering, illegal dumping and waste discharge into the ocean and to collaborate with stakeholders to reduce, reuse and recycle.

The Ministry of Sustainability and the Environment designated 2019 as the “Year Towards Zero Waste”, committed to achieving the 3Rs (reduction, reuse and recycling). In addition, Singapore has established an integrated waste management system to prevent littering, illegal dumping and waste discharge into the ocean and to collaborate with stakeholders to follow the 3Rs. Since 1990, all municipal solid waste in Singapore has been collected and incinerated at solid waste-to-energy utilization facilities, and the resulting slag and fly ash are disposed of at marine landfills. In August 2019, Singapore launched its Zero Waste Masterplan, espousing important goals in waste management, including by 2030, reducing the volume of daily per-capita land-filled waste by 30 per cent and achieving a 70 per-cent overall recycling rate.

Currently, Singapore has a recycling rate of 97 per cent. To achieve these goals, Singapore mainly focuses on preventing waste generation and promoting recycling. Regarding waste prevention, Singapore has implemented the Singapore Packaging Agreement in 2021 to encourage companies to streamline packaging, prohibit the use of disposable plastic tableware and require companies in the catering and retail industries to submit waste reports each year. Moreover, regarding the promotion of recycling, Singapore has implemented the National Recycling Programme since 2001, which requires domestic household waste to be classified as “recyclable” or “non-recyclable”. To further lower the recycling threshold and increase the recycling rate, the Singapore Government has launched a cellular phone application for waste collection, making it easier for residents to find nearby public trash cans and rubbish stations. For enterprises, Singapore published the “3R Guidebook” to guide commercial waste classification.

In addition to background information on MSW, data on MSW composition, collection

Data on single-use plastics generation and MSW management in Singapore

Table 43 /

MSW background information [1]		
Population	5.8 million	
MSW generation	2.05 million tons/year (2010)	
MSW per capita	1.1 kg/person/day	
Single-use plastic waste generation [2]		
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)		4.09 million tons (2019)
Polymer exports		4.09 million tons (2019)
Polymer imports		0.32 million tons (2019)
Domestic conversion of polymers into single-use applications		0.11 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)		0.51 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)		0.84 million tons (2019)
Domestic single-use plastic waste generation		0.44 million tons (2019)
Single-use plastic waste generation per capita		75.64 kg (2019)
MSW collection and treatment [1] [3]		
MSW collection coverage	100%	
MSW recycling rate	97%	
MSW composition [3]		
Share of plastic, paper, metal and glass in total solid waste		46%

Source: Compiled from various sources, including: [1] Singaptore, Ministry of the Environment and Water Resources (2018); [2] Minderoo Foundation (2021); and [3] Borongan, Kashyap and Renaud (2018).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

and treatment and on single-use plastic waste generation are shown in Table 43.

Actions on combating marine litter

Singapore addresses marine litter as part of a holistic approach to tackling pollution and waste. In fact, Singapore has in place stringent domestic statutes and regulations on both pollution control and waste management, preventing and reducing marine pollution broadly through the management of (i) pollution from land-based sources and (ii) water pollution and quality in inland water bodies and coastal areas.

Singapore's Environment Protection and Management Act (2002), for instance, controls the discharge of pollutants into drains, such as trade effluent, oil, chemicals and sewage, as well as hazardous substances into Singapore's inland waters. These controls are implemented alongside strict anti-littering laws under the Environment Public Health Act (2002). Combined, these statutes prevent land-based litter from entering into Singapore's inland waterways and the ocean.

Accordingly, a comprehensive, integrated solid waste management and collection system in Singapore minimizes waste at source and collects all waste for proper disposal—so that waste will not be washed into the ocean. For instance, litter traps installed at appropriate locations, thus reducing the possibility of any marine litter, including plastic debris, from flowing into the waterways and the ocean.

Singapore was also one of the first countries in Asia to ratify all six Annexes of the International Maritime Organisation's MARPOL Convention, the main international agreement on the prevention of marine environment pollution by ships. As part of Singapore's MARPOL obligations, Singapore prohibits the discharge of rubbish, including all types of plastics, into the sea under the Prevention of Pollution of the Sea Act and its associated regulations.

In addition, under the Sustainable Singapore Blueprint, Singapore unveiled its Zero Waste Masterplan in August 2019, aiming to reduce the total generated amount of land-based solid waste, including plastic waste. The Masterplan lays out key national strategies to build a sustainable, resource-efficient and climate-resilient nation—in line with the UN 2030 Agenda for Sustainable Development (also known as "the 2030 Agenda").

Regarding the control of single-use plastic products, Singapore has not banned their use as the search for superior alternative materials continues. In October 2018, the Singapore Parliament discussed whether the ban on the use of plastic bags can really curb plastic waste; the Government planned to encourage businesses to reduce packaging waste and to require reporting on their use of packaging.

Regarding private sector action, the Alliance for the End of Plastic Waste, a Singapore-based global effort of over 40 companies, aimed to invest $1.5 billion in the East Asian region in 2019 over five years on developing and applying solutions for reducing and managing the use of waste plastics. In addition, "Circulate Capital", also based in Singapore, raised $109 million in 2019 from multinational companies (such as Coca-Cola, Pepsi, Dow Chemical, Danone, Unilever, and Procter & Gamble) to address the marine litter challenge in East Asia. Besides, in 2018, KFC Corporation in Singapore announced it would stop using plastic products, including cups, lids and straws.

Sri Lanka

Sri Lanka is one of the most densely populated countries in the world (Sri Lanka and United Nations 2018). With sustained population growth, the population rose from 14.8 million in the 1980s to an estimated 21.32 million in 2019. The MSW generation was 2.63 million tons in 2016 (Kaza *et al*. 2018).

An island state, Sri Lanka has a coastline length of about 1,585 km (UNEP and Development Alternatives 2014), mostly sandy beaches that are affected by annual monsoon cycles (Duhec *et al*. 2015). With its long coastlines and diverse costal ecosystems, more than 2 million tourists visited Sri Lanka in 2017 (Sri Lanka Tourism Development Authority 2017). The tourism industry has become a key contributor to this country's service-based economy, consisting of 11.6 per cent of its GDP in 2017.

State of marine litter plastic management

With a coastal population of 14.57 million, Sri Lanka was cited as one of the world's top plastic marine litter contributors, with 0.24–0.64 million metric tons of plastic marine litter output in 2010 (Jambeck *et al*. 2015) (Table 44). However, McKinsey (2015) and other studies have suggested that evaluation of plastic leakage quantity moved Sri Lanka to lower rankings, with Thailand replacing it as fifth-largest contributor of marine plastic litter. Significant amounts of marine litter can be found on beaches near river mouths and urbanized areas, owing to input from land and sea-based sources as well as the transport by wind (Hidalgo-Ruz *et al*. 2012; Lee *et al*. 2015), current (Hidalgo-Ruz *et al*. 2012; Eriksen *et al*. 2014; Hidalgo-Ruz *et al*. 2018) and tide (Maximenko, Hafner and Niiler 2012). However, it was mentioned that the proximity to urban areas might have a contrary effect on the accumulation of marine litter owing to the more frequent beach-cleaning effort in those areas.

Currently, no data on marine litter hotspots exists for Sri Lanka. Monitoring data and methodologies, though efficient to provide national estimates, are limited in both duration and scale, possibly owing to lack in funding for research and monitoring.

Studies on marine litter distribution in Sri Lanka

Table 44 /

Year	Type	Findings	Source
2016	Beach	Litter volume: 4 (large items >25mm) and 158 (small 5–25 mm) Litter abundance: 38.8 items/m^2 (Kudawella), 23.2 items/m^2 (Back Bay) Size: >25mm	Jang *et al*. 2018
2016–2017	Mangrove	Unspecified	Jayapala and Jayasiri 2018
2017	Beach	10 pieces per 25 g of field sediment	Koongolla *et al*. 2018
2016–2017	Mangrove	Unspecified	Jayapala and Jayasiri 2018
2017	Beach	10	Koongolla *et al*. 2018

Data on single-use plastic waste generation and MSW management in Sri Lanka

Table 45 /

MSW background information [1] [3]	
Population	21.32 million (2016)
MSW generation	2.63 million tons/year (2016)
MSW per capita	0.34 kg /person/day (2016)
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)	0.00 million tons (2019)
Polymer exports	0.00 million tons (2019)
Polymer imports	0.14 million tons (2019)
Domestic conversion of polymers into single-use applications	0.08 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.00 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.01 million tons (2019)
Domestic single-use plastic waste generation	0.08 million tons (2019)
Single-use plastic waste generation per capita	4.02 kg (2019)
MSW collection and treatment [3]	
MSW collection coverage	No data at country level, up to 93% in Colombo and 100% in Moratuwa

Sources: Compiled from multiple sources, including: [1] Kaza, Bhada-Tata and Van Woerden (2018); [2] Minderoo Foundation (2021); and [3] UNEP (2017).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

It is of interest for Sri Lanka to work more closely with regional or global collaboration and funding frameworks.

State of municipal solid waste management

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 45.

Actions on combating marine litter

On the regional and global levels, Sri Lanka has been actively working with and the South Asian Seas Programme and the South Asia Co-operative Environment Programme (SACEP). This country has also joined the Commonwealth Clean Oceans Alliance—an agreement between Member States to join forces in the fight against plastic pollution—and pledged to eliminate avoidable single-use plastic in an ambitious bid to clean up the world's oceans. Sri Lanka has also worked with the UNEP Clean Seas Campaign in the fight against marine litter and ocean pollution, indicating proper policy awareness of this problem within the region. In December 2017, Sri Lanka joined the UNEP Clean Seas Campaign against marine litter and ocean pollution. A ban on single-use plastic products was enacted on 31 March 2021 by means of Extraordinary Gazette Notification No. 2211/51.

Thailand

With a coastline of 3,219 km, Thailand had an estimated population of 69.63 million in 2019, of which 26.04 million was coastal.

After an increase in MSW generation from 24.11 million tons in 2009 to 27.8 tons in 2018, Thailand took measures to markedly reduce its inappropriately disposed waste (PCD Thailand 2019) from 14.28 million tons in 2009 to 7.15 million tons in 2018. Further improvement was made during 2019–2020. In 2020, total MSW was 27.35 million tons, of which 11.93 million tons were separated at source for recycling and 4.23 million tons were incorrectly disposed (PCD Thailand 2021).

With a waste generation rate of about 1.15 kg per person per day, Thailand was cited as one of the world's main plastic marine litter contributors, generatiing 0.15–0.41 million metric tons of plastic marine litter output in 2010 (Jambeck *et al*. 2015). In fact, in another study, McKinsey and the Ocean Conservancy (2015) ranked Thailand as the world's fifth largest contributor of plastic leakage into the seas.

State of marine plastic litter management

It was estimated that about 70 per cent of marine litter in Thailand is derived from land-based sources in coastal communities, in areas including fishing piers, coastal recreation areas and nearby dumping sites (Thailand, Ministry of Natural Resources and Environment 2019)(Table 46). During the monsoon season, the mass of marine litter usually piles up on beaches with litter first flushed into the rivers and then finally washed ashore.

In 2018, coastal clean-up activities covered 48 areas and collected 33 tons of wastes from beach, coral reef and mangrove forests. Top residual wastes are plastic bags (27.3%), plastic beverage bottles (8.6%) and foam dishes/bowls (6.9%).

The Department of Marine and Coastal Resources of Thailand has surveyed and gathered information on the impact of marine litter on: (i) the beaches of coastal seas (especially at the estuaries) as well as (ii) endangered marine species (noting litter either in the guts of sea turtles, dolphins and whales or entangling such animals).

In the 2016 International Coastal Cleanup campaign, Thailand participated with 3,641 volunteers collecting 12,504 kg or 57,811 items that covered 104.2 km of coastline (Ocean Conservancy 2017). Plastics were the most common type of litter recovered. In addition, the Department of Marine and Coastal Resources has organized regular coastal clean-ups year-round with public participation in 24 coastal provinces.

Studies on marine litter distribution in Thailand

Table 46 /

Year	Type	Findings	Method	Source
2004	Microplastics in sediment core collected in Gulf of Thailand, Thailand	Microplastics mean abundance: 100 pieces/ kg-dry sediment	Gravity corer of 11 cm (depth) and 50 cm (length), sliced at 5-cm intervals onsite, stored individually in stainless-steel containers and frozen until analysis. To identify microplastics, 10 g of freeze-dried or wet sediment, corresponding to 10 g of dry sediment was analysed. To remove biofilms from microplastic surface, 150 mL of 30% H_2O_2 was added to sediment in glass beaker. After reaction ceased, normally after 1week, sediment was passed through 315-lm, mesh-size nylon sieve.	Matsuguma *et al*. 2017
2011	Seafloor coral reef (900 m^2 surveyed, 10 sites) in Koh Tao, Thailand	Microplastics abundance: 11.6 ± 7.4 items/100 m^2	Three belt transects laid along reef contours at 3 m–4 m in depth and about 20 m apart, using globally standardized protocols. Belt transects were either 10 m, 15 m or 20 m x 2 m (area surveyed at each reef ranged between 60 m^2 to 120 m^2).	Lamb *et al.* (2018)
2015 (February-October)	Beach debris (Bangsaen, Angsila and Samaesarn), Thailand	Debris abundance: Bangsaen: 15.5 items/ m^2 Angsila: 8.10 items/m^2 Samaesarn: 5.54 items/ m^2 Dominant debris type: plastics (>45% of all debris) Debris accumulation rate: 5.54–15.50 items/ m^2, weight: 33.34–140.63 g/m^2 Volume: 224.64–1,310.26 cm^3/m^2	Three belt transects (10 m × 2.5 m) on upper and lower stratum. Surface sand of each belt transects was dug (about 5 cm), using fingertips and then sieved using 1-mm sieves.	Thushari, Chavanich and Yakupitiyage (2017)

Data on single-use plastics generation and MSW management in Thailand

Table 47 /

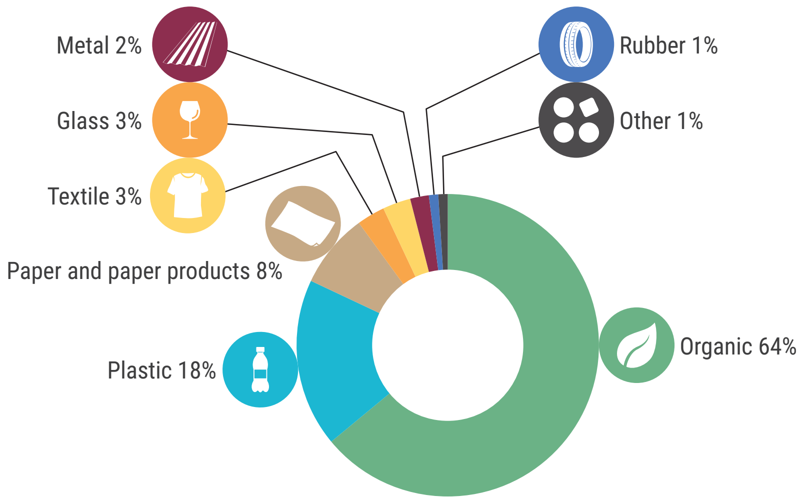
MSW background information [1] [2]		
Population	69.63 million (2019)	
Urban population	33.77 million (2017)	
MSW generation	27.82 million tons/year (2018)	
MSW per capita	1.15 kg/person/day (2018); 1.35 kg/day in urban areas (3.90 kg/day in Pattaya City); 0.91 kg/day in rural (island) areas	
MSW generation growth	0.77% (2015)	
Single-use plastic waste generation [3]		
Domestic polymer production (HDPE, LDPE, LLDPE, PP and PET resin)		6.96 million tons (2019)
Polymer exports		4.26 million tons (2019)
Polymer imports		0.86 million tons (2019)
Domestic conversion of polymers into single-use applications		1.87 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)		1.30 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)		0.68 million tons (2019)
Domestic single-use plastic waste generation		1.26 million tons (2019)
Single-use plastic waste generation per capita		18.14 kg (2019)
MSW collection and treatment [1]		
MSW collection coverage	58% on average; up to 100% in Bangkok	
Method of treatment	31% diverted from waste stream (recycling/composting/converting waste to energy via WtE or biogas); 42.71% landfilled; 26.20% open dumping	
Number of treatment and disposal facilities	45 incinerators, 35 compost sites, 23 mechanical/biological treatment, 109 sanitary dandfills, 465 controlled dumpsites and 2,237 open dumpsites	

Sources: Compiled from multiple sources, including: [1] Borongan and Kashyap (2018c;) [2] Thailand, Government of (2020); and [3] Minderoo Foundation (2021).
Abbreviations: HDPE, high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.

Thushari *et al*. (2017) studied microplastic contamination of the three most abundant sessile and intertidal invertebrates at three beaches of the eastern coasts of Thailand. Their research found a significant accumulation of microplastics in invertebrates at rates of 0.2–0.6 counts/g, indicating higher pollution levels along the coastline. Filter-feeding organisms showed comparatively higher accumulation rates of microplastics. In this study, plastics pollutant prevalence in sessile and intertidal communities corresponded with pollution characteristics of the contaminated beach habitats where these invertebrates live. Thus, bivalves, gastropods and barnacles can be used as indicators for contamination of microplastics in Thailand. This study also demonstrated the need for controlling plastic pollution in Thai coastal areas.

State of municipal solid waste management

Since 2018, Thailand has been determined to ban the import of plastic and electronic waste, when it banned the import of most types of plastic waste and announced it



Source: Borongan and Kashyap (2018c).

MSW composition in Thailand

Figure 9 /

would ban all types in 2021, noting dramatic increases in volume following China's ban of plastic waste imports.

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 47 and Figure 9.

Actions on combating marine litter

Most of marine debris in Thailand comes from inland solid and plastic waste disposed improperly or illegally that eventually flows directly into the ocean. Examples include open dumping in public places or open-air burning at a waste disposal sites.

The lead government agency responsible for remediating such marine litter is the Department of Marine and Coastal Resources, which works in cooperation with the Pollution Control Department; Department of Environmental Quality Promotion; and the Department of National Parks, Wildlife and Plant Conservation as well as the private sector (Table 48).

In 2018, the Thai Government issued the 20-Year Pollution Management Strategy, Pollution Management Plan 2017–2021 and the National Waste Management Master Plan 2016–2021. In accordance with the priority of issues, these strategic policies encourage local governments to implement urban waste management, applying economic measures such as the polluter pays principle, encouraging sustainable production and consumption, coordinating government agency and department cooperation, and supporting the public and stakeholders involved in pollution prevention.

To achieve the above goals, Thailand has formulated six pollution control strategies, including: (i) promoting environmentally friendly products and services; (ii) promoting environmentally friendly consumption; (iii) improving the efficiency of waste treatment and source pollution control; (iv) developing knowledge about pollution management, mechanisms, laws and tools; (v) promoting stakeholder participation and establish pollution control networks; and (vi) implementing relevant agreements and international cooperation.

Thailand has pledged to reduce marine litter by 50 per cent by 2027. In this context, in 2019, Thailand issued its Roadmap on Plastic Waste Management, 2018–2030. The Roadmap aimed to completely ban four types of plastic products by 2022, namely,

Government action on environmental, plastics and solid waste management in Thailand

Table 48 /

Year	Title
2014	Road Map on Waste and Hazardous Waste Management
2016	National Solid Waste Management Master Plan (2016–2021)
2016	Action Plan "Thailand Zero Waste" (2016–2017) according to the Participatory "Civil-State" Principle
2017	Action Plan "Clean Province" (2018)
2018	20-Year Pollution Management Strategy and Pollution Management Plan (2017–2021)
2017	Pollution Control Department (PCD) Pollution Management Plan (2017–2021) (B.E. 2560–2564)
2018	Roadmap for Plastic Waste Management (2018–2030)
2016	National Solid Waste Management Master Plan (2016–2021)

Styrofoam™ food containers, plastic straws, single-use plastic cups and plastic bags less than 36 microns in thickness. It also aimed to make 100 per cent of plastic waste reusable.

To achieve the goal of reducing marine litter by 50 per cent by 2027, the Thai Government has taken many positive measures in managing marine litter and waste. The Department of Marine and Coastal Resources has initiated a pilot port-litter collection facility in Samut Sakhon Province, where the fishermen, especially trawlers, are encouraged to bring back to shore any marine litter collected by the trawl net.

In June 2018, Thailand established a national plastics logistics database to strengthen plastic product monitoring. Also in 2018, Thailand announced the development of a Plastic Debris Management Plan, aimed at developing fiscal and financial tools for plastic waste management, developing and promoting eco-packaging design and environmentally friendly plastic alternatives, and stimulating research and development. A series of innovative methods, approaches and measures were also developed, including material flow models for plastic containers and packaging and public education on the 3Rs (reduction-reuse-recycling) strategies for implementing plastic debris management.

In December 2019, the Thai Cabinet announced the complete ban of plastic bags in 43 chain stores and supermarkets as of 2020, estimating this would save 45 billion plastic bags per year. In addition, the Thai Government is actively negotiating with companies to reduce plastic pollution and exploring solutions, such as levying a "plastic bag tax" and using biodegradable or lightweight materials.

In addition, the Thai private sector has also taken action to reduce the production of plastic waste. Seventy-five member companies affiliated with the Thai Retailers Association jointly launched the "Say No to Plastic Bag" campaign that announced retailers will cease to provide disposable plastic bags to consumers in major member supermarket chains, stores and convenience stores, as of January 2020. Moreover, the hotel and supermarket industries have carried out actions on plastic waste reduction and waste classification. Further, chemical companies with local operations, such as Covestro, have also launched incentive recycling programs for plastic waste.

Regarding source reduction of plastic waste, the Thai Government announced the start of the phase-out period of cap seals on 1 April 2018; total elimination of cap-seal use on 31 December 2019; and the reduction of plastic shopping bags and refill bags in super stores and supermarkets.

The Thai Ministry of Natural Resources and Environment expects that the adoption of the roadmap's policy framework will reduce 740,000 tons of plastic waste annually and save 3.9 billion baht in solid waste management costs each year.

Timor-Leste

Timor-Leste had a population estimated at 1.29 million in 2019 and a coastline of 706 km. The country had an MSW generation of 63,875 tons in 2016 (Kaza *et al*. 2018).

State on marine litter management

Surrounded by some of the world's most biodiverse waters, Timor-Leste faces great challenges from marine litter, including fishing gear and other items flowing into the seas from local, land-based activities and washing ashore by oceanic currents. In 2017, a qualitative beach survey was conducted at Kusu and Dolok Oan, two of the most prominent sites with marine litter (Table 49) (Lopes 2017). At Kusu, a site with low beach usage, 20 volunteers collected 300 kg of litter from the beach, while at Dolok Oan, a site with a higher level of human activity, 130 volunteers collected 2,721 kg of litter. On both beaches, most common litter were plastic and rubber items, and the most common large items were fishing nets and ropes (Lopes 2017).

State of municipal solid waste management

As the youngest country in South-East Asia, waste management practices in Timor-Leste mostly rely on landfilling and recycling. The Government of Timor-Leste gave recycling policy priority. In April 2019, the Government announced a plan to become the world's first plastic-neutral

Studies on marine litter distribution in Timor–Leste — **Table 49 /**

Year	Type	Findings	Method	Source
2017	Beach collection	Marine litter abundance: • Kusu: 20 volunteers collected 300 kg of litter • Dolok Oan: 130 volunteers collected 2,721 kg	Visual identification and collection	Lopes (2017)

Data on MSW management in Timor-Leste Table 50 /

MSW background information [1] [2]	
Population	1.29 million (2016)
MSW generation	0.06 million tons/year (2016)
MSW per capita	0.14 kg/person/day (2016)
MSW collection and treatment	
MSW collection coverage	No data available

Source: Compiled from multiple sources including: [1] Kaza, Bhada-Tata and Van Woerden (2018) and [2] UNEP (2017).

nation; this was to be achieved by introducing facilities deploying Catalytic Hydrothermal Reactor (Cat–HTR) technology, which can process 20,000 tons of plastic waste into 17,000 tons of synthetic fuel annually, enough to cover the 70 tons of daily plastic waste generation in Timor-Leste (Timor-Leste, Government 2019).

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 50.

Actions on combating marine litter

In 2018, USAID/Timor–Leste released a short film "The Sea that Sustains Us", the product of a three-year monitoring programme of this country's near-shore coastal environment. Highlighting marine plastic pollution, the film called for action to protect against marine pollution from land-based activities, especially that from plastic debris (United States Agency for International Development [USAID] 2019). Some NGOs have begun clean-up operations on beaches. On Ataúro Island, a site where the impact of marine litter is the most significant, NGOs have now organized regular weekly beach clean-ups.

Viet Nam

Viet Nam had an estimated population of 96.62 million in 2019, making it the world's fifteenth most populous country. With a coastline of 3,444 km and a dense coastal population of 55.9 million, Viet Nam was cited among the world's top five contributors to plastic marine litter. In fact, in 2010, plastic litter output was 0.28–0.73 million metric tons (Jambeck *et al*. 2015). This output may be attributed to the rapid growth of the plastic industry in Viet Nam since 2010 and to the sharp increase of plastics consumption in the country from 33 kg per capita in 2010 to 41 kg per capita in 2015 (Borongan, Kashyap and Renaud 2018).

State of marine litter management

Selected studies at the national and local scales confirm the high volume of plastic waste entering marine and water ecosystems in Viet Nam (Table 51).

Kieu-Le, Strady and Perset (2016) reported that 1,356 to 2,194 tons of plastic waste were collected each year from the Nhieu Loc-Thi Nghe and Tau Hu canals, two of the major canals joining the Mekong River in Ho Chi Minh city. This assessment was achieved by 50 to 80 environmental workers, who were equipped with a fleet of motorized collection ships and cranks, respectively, to conduct daily cleaning operations in each canal. In 2018, it was further reported that the per-capita rate of plastic waste input into the Nhieu Loc-Thi Nghe canal was 0.35 to 7.27 kg/capita/year, with a median of 1.62 kg/capita/year (Lahens *et al*. 2018). Considering the population living in the canal basin can vary from 522,000 to 1.2 million, the amount of annual plastic waste input into the canal basin can vary greatly, ranging from 182.7 tons to 8,724 tons of input per year (Lahens *et al*. 2018).

Using visual counting of plastic debris and bridge-mounted trawls with 4-cm mesh, van Emmerik *et al*. (2018) estimated that 7,500–13,000 tons of plastic waste enter the ocean from Saigon River each year. In 2019, it was further reported that 2018 plastic waste emission from Saigon River was (i) 1,100 tons per year when only considering the upper 1.3 m water layer and (ii) 1,400–1,600 tons/year if extrapolated over the whole water column (van Emmerik *et al*. 2018).

In a 2018 International Coastal Cleanup campaign, 859 volunteers in Viet Nam collected 2,398 kg or 17,002 pieces

Studies on marine litter distribution in Viet Nam — Table 51 /

Year	Type	Findings	Method	Source
	Plastic pellets			Ogata *et al.* (2009)
2015–2016	Surface river	Microplastic fibres: 1.72e5 items/m^3 (upstream river) to 5.19e5 items/m^3, weighing 31.71 mg/m^3 (site mean)	300 mL bulk water sampler	Lahens *et al.* (2018)
2015–2016	Surface river	Microplastic fragments: 10–223 items/m^3	300 mm mesh-size plankton net	Lahens *et al.* (2018)
2019	Wild bivalve (Perna Viridis, *n*=5) from brackish water in Thanh Hoa Province, Vietnam	Microplastic abundance: 2.60 MP/individual and 0.29 MP/g of wet tissue Dominant type: polypropylene 31% and polyester 23%	Organisms were digested by KOH (potassium hydroxid) 10% solution, then separated using KI 50% solution. Microplastics were identified with micro-Fourier-transform infrared microspectroscopy (μFTIR)	Nam *et al.* (2019)

of beach litter from 10.3 km of coastline (Ocean Conservancy 2019).

State of municipal solid waste management

Besides background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation are shown in Table 52 and Figure 10.

In 2014, total MSW generation in Viet Nam was estimated to be 13.2 million tons/year in 2014 (United Nations Centre for Regional Development [UNCRD] 2017), and waste generation rate per capita per day was 1 kg for urban population. Regarding collection of plastic waste, the rate in urban areas was considerably high (84%–85%) but relatively lower in rural areas (40%–55%).

In May 2018, the Vietnamese Government issued a revision to the "National strategy on integrated management of solid waste to 2025 with a vision to 2050" (Decision 491/QD–TTg of the Prime Minister, dated 7 May 2018). This directive specifies objectives towards comprehensive management of solid waste in Viet Nam, including achieving by 2025 the following: (i) collecting and treating 90 per cent of urban MSW according to proper environmental standards; (ii) replacing nylon bags with environmentally friendly plastic bags; (iii) collecting and properly disposing all hazardous waste generated by industrial production, business activities, medical operations and other activities, collecting and properly disposing 85 per cent of hazardous waste from household and personal sources and (iv) make 80 per cent of MSW in rural areas properly collected and treated.

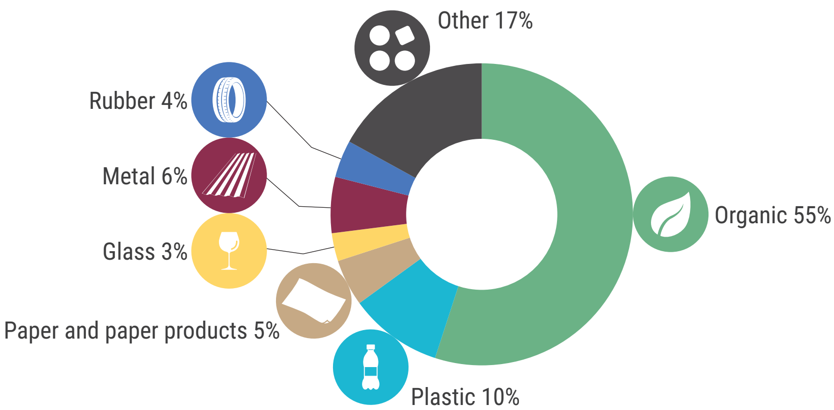
To achieve these goals, the Vietnamese Government aspires to: (i) mobilize investment resources from all sources; (ii) accelerate the formulation and approval of solid waste and hazardous waste collection, removal, storage, and transfer programs in various places; (iii) encourage the strengthening of domestic solid waste collection, transportation, recycling; and ultimately (iv) open the waste treatment market to private operators. The latter would ensure competition for the use of advanced, environmentally friendly technologies, according to local conditions, for the collection, transportation, recycling and harmless treatment of solid waste and

Data on single-use plastics generation and MSW management in Viet Nam

Table 52 /

MSW background information [1] [2]	
Population	96.62 million (2019)
Urban population	33.6 million (2015)
MSW generation	19 million tons/year (2014)
MSW per capita	1.0 kg/person/day (2010)
MSW generation growth	12% (2011–2015)
Single-use plastic waste generation [3]	
Domestic polymer production (HDPE, LDPE, LLDPE, PP, PET resin)	0.85 million tons (2019)
Polymer exports	0.56 million tons (2019)
Polymer imports	3.10 million tons (2019)
Domestic conversion of polymers into single-use applications	1.63 million tons (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.57 million tons (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.84 million tons (2019)
Domestic single-use plastic waste generation	1.90 million tons (2019)
Single-use plastic waste generation per capita	19.65 kg (2019)
MSW collection and treatment [2] [4]	
MSW collection coverage	40%–55% in rural areas; 84%–85% in urban areas (95%–95% in Hanoi and Ho Chi Minh City)
Method of treatment	44% diverted from disposal (recycled/composted/WtE/biogas); 56% landfilled
Number of treatment and disposal facilities	5 incinerators; 12 compost sites; 18 incineration sites (without energy recovery); 1 WtE plant (since 2016); 203 sanitary landfills; and 457 open dumpsites

Sources: Compiled from multiple sources, including: [1] Borongan and Kashyap (2018); [2] Borongan, Kashyap and Renaud (2018); [3] Minderoo Foundation (2021); and [4] Thang (2017).
Abbreviations: high-density polyethylene; LDPE, low-density polyethylene; LLDPE, linear low-density polyethylene; PP, polypropylene; and PET, polyethylene terephthalate.



Source: Borongan and Kashyap (2018d); UNEP (2017).

MSW composition in Viet Nam

Figure 10 /

hazardous waste. It also gives priority to the construction of centralized domestic waste recycling and disposal plants.

Since 2018, Vietnam has banned the issuance of plastic waste import licences in preparation for a complete ban on such importation by 2025.

Actions on combating marine litter

Today, preventing and controlling marine plastic litter at source and improving waste management has become a priority in the environmental agenda of the Vietnamese Government (Table 53). During a June 2018 G7 summit in Canada, Vietnamese Prime Minister Nguyen Xuan Phuc proposed a global cooperation mechanism formed by G7 countries to reduce plastic waste and realize the Plastic Free Ocean vision. In July 2019, the spokesperson for the Viet Nam Ministry of Foreign Affairs reaffirmed that Viet Nam saw marine litter as an urgent global issue and would take concrete countermeasures, such as preventing the import of foreign waste, to fulfil the country's commitments to the Bangkok Declaration on Combating Marine Debris in ASEAN Region.

To materialize the commitments, the Prime Minister approved Decision No. 1746/QD-TTg, on 4 December 2019, promulgating the National Action Plan for Management of Marine Plastic Litter by 2030, in which Viet Nam set forth action via a number of goals and a clear timeline. Specifically, by 2030, Viet Nam committed to: (i) reduce the country's plastic waste discharge into the ocean by 75 per cent; (ii) ensure that 100 per cent of lost fishing gear is collection and that none of the discarded fishing gear enter the ocean; (iii) completely stop the use of disposable plastic products and non-biodegradable plastic bags in all tourism-related establishments and coastal service facilities; and (iv) eliminate plastic pollution in all marine protected areas.

To achieve these goals, the Action Plan commits to annual and routine monitoring of selected estuaries in 11 major river basins and 12 island districts, and it proposes five major tasks, including: (i) increasing publicity and raising public awareness of marine plastic pollution to drive behavioural change in the use and discarding of plastic products; (ii) promoting the classification and recycling of plastic waste from coastal areas and at sea; (iii) reducing the amount of plastic waste entering the ocean from its source; (iv) strengthening the management of marine plastic waste through international cooperation; and (v) investigating and establishing policies, laws and control mechanisms for marine plastic pollution.

Through the introduction and execution of this Action Plan, Viet Nam intends to prevent plastic waste entering the sea from land- and sea-based sources, fulfilling its initiatives and commitments. The Government also ultimately hopes to become a regional leader in managing and controlling marine plastic litter.

To this end, the Vietnamese Government levies an environmental tax on plastic

Government actions on marine and solid waste management in Viet Nam

Table 53 /

Plastic waste management	
2019	National Action Plan on Ocean Plastic Waste Management by 2030 (1746/QD-TTg)
Solid waste management	
2018	National Strategy of Integrated Solid Waste Management up to 2025, Vision towards 2050 (491/QD-TTg)

bags, that is, ₫ 40,000 (about $2) per kilogram. In response, large companies have marketed environmentally friendly bags for consumers. In addition, Vietnam plans to establish a national natural resources and environmental monitoring database to use advanced technology to help decision-making.

Conclusion and Recommendations

4

Countries in Asia are becoming increasingly aware of the serious threat posed by marine litter for the well-being of their people and economies. This phenomenon is even more pronounced in countries where tourism is a vital pillar of the economy—Indonesia is one such example. The growing awareness of marine litter has led to a stronger political will to tackle the issue, with many countries in the region adopting policies and strategies in a similar direction. Strong efforts are currently under way to address marine litter, especially marine plastic litter, in most Asian countries, including China, Japan, the Republic of Korea, India, Indonesia, the Philippines, Singapore and Thailand.

Despite an increase in policy actions aimed at countering marine litter in the region, serious challenges remain. Many challenges are related to solid waste management. Collection services have serious gaps in many countries in the region, with numerous Asian cities having relatively low collection rates that tend to further decrease in rural areas. In fact, open dumping of waste remains the most common waste management approach in most low- and middle-income countries. Overall, many countries in the region would benefit from the strengthening of basic infrastructure for waste collection, treatment and disposal.

However, given the interconnected nature of the “plastics system”, any approach to solving the marine litter challenge should encompass the full lifecycle of the value chain—from polymer producers to users of plastics (converters and brands), consumers and waste managers as well as to other stakeholders and players, including government, civil society groups and the private sector, including the financial and other industries.

When it comes to the issue of marine litter, a major barrier for planning and designing the actions required to manage litter is the inadequate availability of data. Current approaches to map postconsumer waste flows rely predominantly on top-down models and on diverse, partial and often outdated data sets. As a result, estimates of where, how and how much plastics are leaking into nature are characterized by significant uncertainties: not only in terms of differences in geography and waste composition and in total volumes leaking along the supply chain but also in terms of estimates of existing stocks and projections of future flows of plastics in nature.

While these models create awareness and provide starting points for further research, the lack of granularity and the degree of uncertainty also limit their ability to inform targeted waste management interventions and policy design.

Current efforts to model and map postconsumer waste and fate are hindered by the following:

- The fragmented, often-informal nature of the sector. As a result, postconsumer waste flow estimations are constrained by high-level assumptions of waste generation, composition, collection and disposal. This is especially true outside urban areas and in developing Asian countries, where plastic leakage is the highest.
- The absence of a single institution, or collective, that coordinates stakeholders and data-collection efforts. The result being partial, fragmented data sets, typically based on divergent methodologies.
- The absence of a central platform to aggregate, analyze, visualize and

disseminate data and findings limits the impact of existing efforts.

- Waste flow modelling either relies on abstract, archetypical characterizations of waste flows or requires labour-intensive, on-the-ground data-collection in diverse and often remote locations.

More granular, frequently updated data on postconsumer waste flows will inform efforts on multiple fronts: estimates of the social, environmental and economic impacts of plastic pollution; attribution of responsibility and accountability for the problem; the "right-sizing" of waste management systems; and the design of effective waste management policy and interventions.

In this context, progress towards countering marine litter in the region requires the following:

- A coordinated, regional effort to increase data availability and quality, including sex-disaggregated data on impact, when available.
- A shared measurement platform that extends the reach of data and informs decision makers and stakeholders about the "state of the system" as well as the outcomes of current policies and the development of new interventions.
- Tools and technologies for low-cost/effort data-collection and analysis that massively scale data quality, availability and ability to measure waste flows near to real-time. These will likely involve innovative combinations of hardware (e.g. satellite, LIDAR, remote sensing); software (e.g. artificial intelligence and machine-learning-enabled data analysis and visualization); and human networks (e.g. citizen science, crowd-sourced data and open innovation).

Additionally, limited public participation on this issue is a result of: (i) limited knowledge on the cost of impacts on the economy and human health, resource uses and (ii) limited information on the differences between men's and women's needs, capacities, responsibilities and resource uses, coupled with the lack of consumer information.

Special attention should also be given the links between marine litter pollution, gender equality and the human right to a clean, healthy environment. The integration of human rights and gender considerations with policies, business plans, processes and decision-making aimed at not only tackling marine plastic pollution but also discerning the differences between men's and women's needs. To sufficiently ensure that human rights and the needs of women, girls and disadvantaged groups are considered, these decision-making processes should also be supported by public services, health and safety protocols, and social protection benefits both for consumers of plastic materials and for workers in the plastic waste management sector.

To strengthen the science-policy interface on marine environment, there is an urgent need to increase scientific knowledge, develop research capacity and transfer marine technology for improving ocean health and enhancing the contribution of marine biodiversity to the sustainable development of developing countries—in particular, Small Island Developing States and least developed countries.

The attention that has been demonstrated at the national policy level does not always translate to concrete participation at the international level. Of the 19 analysed countries, only 5 are Parties to the London Convention and 4 are Parties to the London Protocol. While 16 out of these 19 countries have ratified Annex V of the MARPOL Convention, so far, only 5 countries have joined the Clean Seas Campaign of the Global Partnership on Marine Litter.

However, the reviewed countries strongly participate in activities related to marine litter at the regional level in particular, through ASEAN, COBSEA and NOWPAP. Both COBSEA and NOWPAP have adopted action plans on marine litter, and while a lack of resources does hinder the implementation of concrete activities especially for what concerns COBSEA, the two intergovernmental mechanisms contribute to maintaining high awareness on the issue in the respective regions. The adoption by ASEAN Member States of the Bangkok Declaration on Combating Marine Debris in the ASEAN Region in 2019 is a welcome step—one that is expected to encourage future concrete action on the issue. ASEAN Member States further adopted the Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021–2025), a scalable, solution-focused strategy to address marine plastic pollution across Southeast Asia. It signifies a renewed, noble collective commitment by ASEAN members to align regional actions with national development agenda towards tackling a burgeoning global environmental crisis.

The limited recent data from in situ monitoring indicates the large discrepancy between the global modelling and estimations—and reality. To translate the high awareness and significant political will into effective action, a systemic effort in Asia is urgently needed to make estimation more accurate and establish a credible baseline for monitoring progress in marine litter control.

Data availability is of great importance in the context of implementation and monitoring of relevant SDG targets, which could be achieved through the following activities, among others:

- Providing stronger support for the monitoring plastic waste and data-collection (which moves beyond the use of a global-scale model) to capture and describe the local impacts of national waste management activities relevant to marine litter.
- Awareness-raising by communicating information to key stakeholders to enable actions by communities and the public.
- Identifying key strategic intervention areas and pathways (hotspots), and developing effective mitigation strategies based on scientific evidence and methodologies.
- Ensuring new research outcomes and knowledge generation in forms of reference for policymaking, detailing the status, source, origin, future trends and impacts of the issue, while providing science-based intervention tools and database.
- Using training materials and references by governments and local authorities in building their capacities.
- Promoting policies and actions by governments and the private sector that advance, protect and promote gender equality and human rights while significantly addressing the challenges and effects of marine plastic litter.

Improved data and greater knowledge enable better, more effective actions and solutions in more places (UNEP 2019). Significant progress would be made in achieving relevant SDG targets (listed in Table 1) by (i) providing reliable open-access data and identifying key intervention points to improve the performance of remediation strategies, (ii) effectively identifying priority strategic action points and (iii) bringing together groups with the experience, expertise and resources that foster effective, efficient execution and management of marine litter. When presented with transparently articulated data, statistics, findings, future scenarios, management and implementation strategies that highlight both challenges and opportunities, there is a higher chance that the public can be more participative, enthusiastic and responsive

(Kirkman 2006). Considering the broad spectrum of stakeholders that need to be involved in implementing solutions to the marine litter problem, it is crucial to ensure that all relevant stakeholders have a level of awareness and the necessary capacities and tools that enable them to take action.

The prevention and control of marine litter also requires supporting mechanisms—at the regional intergovernmental level—that can help to bridge key gaps for what concerns data availability and regional policy priorities (Löhr *et al*. 2017). Encouragingly, several global and regional initiatives and cross-sectoral groups (some showcased in this review) have been working collaboratively to evaluate the impacts of marine litter on our planet. Furthermore, hope for stronger future action may be acheived by increasing public awareness towards, and interest in, both of the following: combating marine litter and developing strategies for the conservation and sustainable use of our oceans in line with Agenda 2030. These actions be further enhanced with a greater attention to these issues by the private sector, including in the region.

References

Abreo, N.A.S., Blatchley, D. and Superio, M.D. (2019). Stranded whale shark (Rhincodon typus) reveals vulnerability of filter–feeding elasmobranchs to marine litter in the Philippines. *Marine Pollution Bulletin* 141, 79–83. https://doi.org/10.1016/j.marpolbul.2019.02.030.

Abreo, N.A.S., Thompson, K.F., Arabejo, G.F.P. and Superio, M.D.A. (2019). Social media as a novel source of data on the impact of marine litter on megafauna: The Philippines as a case study. *Marine Pollution Bulletin* 140, 51–59. https://doi.org/10.1016/j.marpolbul.2019.01.030.

Abreo, N.A.S., Macusi, E.D., Blatchley, D.D. and Cuenca-Ocay, G. (2016a). First evidence of plastic ingestion by the rare deraniyagala's beaked whale (Mesoplodon hotaula). *IAMURE International Journal of Ecology and Conservation* 19, 16–36.

Abreo, N.A.S., Macusi, E.D., Blatchley, D.D. and Cuenca, G.C. (2016b). Ingestion of marine plastic debris by green turtle (Chelonia mydas) in Davao Gulf, Mindanao, Philippines. *Philippine Journal of Science* 145(1), 17–23.

Agamuthu, P., Fauziah, S.H. and Khairunnisa, A.K. (2012). Marine litter on selected Malaysian beaches: Impacts of human ignorance. Paper presented at the Tenth Expert Meeting on Solid Waste Management in Asia and Pacific Islands (SWAPI). 20–22 February 2012. 1–8. http://umexpert.um.edu.my/file/publication/00004264_77696.pdf.

Akhir, K. (2018). A critical analysis of technological interventions towards the national action plan for marine litter management 2018–2025: Recommendations for addressing marine plastic litter in the "new balis" of sustainably. *World Maritime University Dissertations*. 661. https://commons.wmu.se/all_dissertations/661.

Alam, F.C., Sembiring, E., Muntalif, B.S. and Suendo, V. (2019). Microplastic distribution in surface water and sediment river around slum and industrial area (case study: Ciwalengke River, Majalaya district, Indonesia). *Chemosphere* 224, 637–645. https://doi.org/10.1016/j.chemosphere.2019.02.188.

Alam, M.W. and Xiangmin, X. (2018). Marine pollution prevention in Bangladesh: A way forward for implement comprehensive national legal framework. *Thalassas: An International Journal of Marine Sciences* 35, 17–27.

Amin, A.T.M.N. (2017). Country chapter: The People's Republic of Bangladesh. *State of the 3Rs in Asia and the Pacific*. Nagoya: United Nations Centre for Regional Development. https://www.uncrd.or.jp/State_of_3Rs.

Aminuzzaman, S.M. (2010). Environment policy of Bangladesh: A case study of an ambitious policy with implementation snag. *South Asia Climate Change Forum* 59, 1–18.

Anbumani, S. and Kakkar, P. (2018). Ecotoxicological effects of microplastics on biota: *A review. Environmental Science and Pollution Research* 25(15), 14373–14396. https://doi.org/10.1007/s11356-018-1999-x.

Antonopoulos, I., Faraca, G. and Tonini, D. (2021). Recycling of post-consumer plastic packaging waste in the EU: Recovery rates, material flows, and barriers. *Waste Management* 126, 694–705. https://doi.org/10.1016/j.wasman.2021.04.002.

ASEAN UP (2018). 4 ASEAN infographics: Population, market, economy. March 26. https://aseanup.com/asean-infographics-population-market-economy/.

Azmy, S.A.M. (2013). *Sri Lanka Report on Coastal Pollution Loading and Water Quality Criteria: Country report on pollution-Sri Lanka BOBLME–2011–Ecology-14*. Miththapala, S. (ed.) Mueang Phuket District, Thailand: Bay of Bengal Large Marine Ecosystem Project (BOBLME). https://www.boblme.org/documentRepository/BOBLME-2011-Ecology-14.pdf.

Bai, M., Zhu, L., An, L., Peng, G. and Li, D. (2018). Estimation and prediction of plastic waste annual input into the sea from China. *Acta Oceanologica Sinica* 37(11), 26–39. https://doi.org/10.1007/s13131–018–1279–0.

Balasubramaniam, M. and Phillott, A.D. (2016). Preliminary observations of microplastics from beaches in the Indian ocean. *Indian Ocean Turtle Newsletter* 13–16. http://www.seaturtle.org/library/BalasubramaniamM_2016_IndOceanTurtleNewsletter.pdf.

Bangladesh, Ministry of Environment, Forest and Climate Change (2018). Position paper of Bangladesh, Third Ad Hoc Open-Ended Expert Group on Marine Litter and Microplastics.

Bangun, A.P., Wahyuningsih, H. and Muhtadi, A. (2018). Impacts of macro - and microplastic on macrozoobenthos abundance in intertidal zone. *IOP Conference Series: Earth and Environmental Science* 122, 012102. https://doi.org/10.1088/1755-1315/122/1/012102.

Baran, E., Chheng Phen, Ly Vuthy, Nasielski, J., Saray Samadee, Touch Bunthang, Tress, J. et al. (2014). In *Atlas of Cambodia: Maps on Socio-Economic Development and Environment*. Phnom Penh: Save Cambodia's Wildlife. Chapter 4. 37–48. http://pubs.iclarm.net/resource_centre/WF-3709.pdf.

Barnes, D.K.A. (2004). Natural and plastic flotsam stranding in the Indian Ocean. *The Effects of Human Transport on Ecosystems: Cars and Planes, Boats and Trains*. Davenport, J. and Davenport, J. L. (eds.). Dublin: Royal Irish Academy. 193–205.

Bergmann, M., Gutow, L. and Klages, M. (eds.) (2015). *Marine Anthropogenic Litter*. Heidelberg, Germany: SpringerOpen. https://doi.org/10.1007/978-3-319-16510-3.

Biermann L., Clewley D., Martinez-Vicente V. and Topouzelis K. (2020). Finding plastic patches in coastal waters using optical satellite data. *Scientific Reports* 10, 1–100.

Borongan, G. and Kashyap, P. (2018a). Country profile Indonesia: Managing municipal solid waste and packaging waste. Circular Economy Briefing Series. Background document for the regional workshop "Managing Packaging Waste – Preventing Marine Litter", held 30 October - 1 November 2018 in Bali, Indonesia. Bangkok: Regional Resource Center for Asia and the Pacific at the Asian Institute of Technology (AIT RRC.AP). https://www.giz.de/en/downloads/giz2018_Indonesia-Country-Profile_web.pdf.

Borongan, G. and Kashyap, P. (2018b). Country profile Philippines: Managing municipal solid waste and packaging waste. Circular Economy Briefing Series. Background document for the regional workshop "Managing Packaging Waste – Preventing Marine Litter", held 30 October - 1 November 2018, in Bali, Indonesia. Bangkok: Regional Resource Center for Asia and the Pacific at the Asian Institute of Technology (AIT RRC.AP). https://www.giz.de/en/downloads/giz2018_Philippines-Country-Profile_web.pdf.

Borongan, G. and Kashyap, P. (2018c). Country profile Thailand: Managing municipal solid waste and packaging waste. Circular Economy Briefing Series. Background document for the regional workshop "Managing Packaging Waste – Preventing Marine Litter", held 30 October - 1 November 2018 in Bali, Indonesia. Bangkok: Regional Resource Center for Asia and the Pacific at the Asian Institute of Technology (AIT RRC.AP). https://www.giz.de/de/downloads/giz2018_Thailand-Country-Profile_web.pdf.

Borongan, G. and Kashyap, P. (2018d). Country profile Viet Nam: Managing municipal solid waste and packaging waste. Circular Economy Briefing Series. Background document for the regional workshop "Managing Packaging Waste – Preventing Marine Litter", held 30 October - 1 November 2018 in Bali, Indonesia. Bangkok: Regional Resource Center for Asia and the Pacific at the Asian Institute of Technology (AIT RRC.AP). https://www.giz.de/en/downloads/giz2018_Vietnam–Country–Profile_web.pdf.

Borongan G., Kashyap, P. and Renaud, P. (2018). *Managing Package Waste in the ASEAN Region*. Bonn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://www.switch-asia.eu/resource/managing-packaging-waste-in-the-asean-region/.

Borrelle, S.B., Ringma, J., Law, K.L., Monnahan, C.C., Lebreton, L., McGivern, A. et al. (2020). Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. Science 369, 1515–1518.

Brooks, A.L., Wang, S. and Jambeck, J. (2018). The Chinese import ban and its impact on global plastic waste trade. *Science Advances* 4 (6). https://www.science.org/doi/10.1126/sciadv.aat0131.

Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T. et al. (2011). Accumulation of microplastic on shorelines worldwide: sources and sinks. *Environmental Science & Technology* 45(21), 9175–9. https://doi.org/10.1021/es201811s.

Brunei Darussalam, Ministry of Development (2000). Don't destroy our river. http://mod.gov.bn/SitePages/Don't%20Destroy%20Our%20River.aspx.

Brunei Darussalam, Ministry of Development (2018). Plastic bags in Brunei Darussalam. http://www.env.gov.bn/SitePages/Plastic%20Bags%20in%20Brunei%20Darussalam.aspx. Accessed 31 July 2019.

Cai, A.L., Wang, J., Peng, J., Tan, Z., Zhan, Z., Tan, X. et al. (2017). Characteristic of microplastics in the atmospheric fallout from Dongguan city, China: Preliminary research and first evidence. *Environmental Science and Pollution Research* 24(32): 24928–24935. https://doi.org/10.1007/s11356-017-0116-x.

Campanale, C., Massarelli, C., Savino, I., Locaputo, V. and Uricchio, V.F. (2020). A detailed review study on potential effects of microplastics and additives of concern on human health. *International Journal of Environmental Research and Public Health* 17, 1212. https://doi.org/10.3390/ijerph17041212.

Central Intelligence Agency (CIA) (2019). *The World Factbook*. Mclean, VA. https://www.cia.gov/the-world-factbook/.

Chae, D.H., Kim, I.S., Kim, S.K., Song, Y.K. and Shim, W.J. (2015). Abundance and distribution characteristics of microplastics in surface seawaters of the Incheon/Kyeonggi coastal region. *Archives of Environmental Contamination and Toxicology* 69(3), 269–278. https://doi.org/10.1007/s00244-015-0173-4.

Chamindi, L.P.S., Ranatunga, R.R.M.K.P. and Marasinghe, K. (2018). Marine floating objects as vehicles for dispersing fouling organisms: An example from Negombo, Sri Lanka. *Twenty-fourth Annual Scientific Sessions–2018*. Kelaniya, 08 June 2018. Kelaniya: Sri Lankan Association for Fisheries and Aquatic Resources.

Chen, J., Lee, O. and Man, C.W. (1999). Pearl River estuary pollution project (PREPP)–An integrated approach. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.127.6393&rep=rep1&type=pdf.

Cheshire, A., Adler, E., Barbière, J., Cohen, Y., Evans, S., Jarayabhand, S. et al. (2009). *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter*. Regional Seas Reports and Studies No. 186; IOC Technical Series No. 83. Kenya: United Nations Environment Programme; Paris: Intergovernmental Oceanographic Commission.

Cheung. P.K., Cheung, L.T. and Fok, L. (2016). Seasonal variation in the abundance of marine plastic debris in the estuary of a subtropical macro-scale drainage basin in South China. *Science of The Total Environment* (562): 658–665. https://doi.org/10.1016/j.scitotenv.2016.04.048.

Chiba, S., Saito, H., Fletcher, R., Yogi, T., Kayo, M., Miyagi, S. et al. (2018). Human footprint in the abyss: 30 year records of deep-sea plastic debris. *Marine Policy* (96), 204–212. https://doi.org/10.1016/j.marpol.2018.03.022.

China, State Oceanic Administration. *Bulletin of China Marine Environmental Status*. http://www.nmdis.org.cn/gongbao/nrhuanjing/nr2017/201806/t20180625_37509.html. Accessed 30 November 2019.

Cho, D.-O. (2011). Removing derelict fishing gear from the deep seabed of the East Sea. *Marine Policy* 35(5), 610–614. https://doi.org/10.1016/j.marpol.2011.01.022.

Chung, K.L.T., Strady E. and Perset. M. (2016). Life cycle of floating debris in the canals of Ho Chi Minh City. Working Paper 4 of Urban Development Management Support Centre – PADDI. Ho Chi Minh: Centre de Prospective et d'Etudes Urbaines. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers17-07/010070479.pdf.

Cordova, M.R. and Wahyudi, A. (2016). Microplastic in the deep-sea sediment of southwestern Sumatran Waters. *Marine Research in Indonesia* 41(1), 27–35. https://doi.org/10.14203/mri.v41i1.99.

Cordova, M.R., Hadi, T.A. and Prayudha, B. (2018). Occurrence and abundance of microplastics in coral reef sediment: a case study in Sekotong, Lombok-Indonesia. *Advances in Environmental Sciences* 10(1), 23–29. https://doi.org/10.5281/zenodo.1297719.

Cozar, A., Echevarria, F., Gonzalez–Gordillo, J.I., Irigoien, X., Ubeda, B., Hernandez–Leon, S. et al. (2014). Plastic debris in the open ocean. *Proceedings of the National Academy of Sciences* 111(28), 10239–10244. https://doi.org/10.1073/pnas.1314705111.

Crawford, C.B. and Quinn, B. (2017). *Microplastic Pollutants*. Amsterdam: Elsevier Science. https://doi.org/10.1016/C2015-0-04315-5.

Damanhuri, E. (2017). Country chapter: The Republic of Indonesia. *State of the 3Rs in Asia and the Pacific*. Nagoya: United Nations Centre for Regional Development. https://www.uncrd.or.jp/State_of_3Rs.

Daniel, D.B., Thomas, S.N. and Thomson, K.T. (2019). Assessment of fishing-related plastic debris along the beaches in Kerala Coast, India. *Marine Pollution Bulletin* 110696. https://doi.org/10.1016/j.marpolbul.2019.110696.

De Silva, D.A.M. and Yamao, M. (2007). Effects of the tsunami on fisheries and coastal livelihood: A case study of tsunami–ravaged southern Sri Lanka. *Disasters* 31(4), 386–404. https://doi.org/10.1111/j.1467–7717.2007.01015.x.

Dufault, S. and Whitehead, H. (1994). Floating marine pollution in "the Gully" on the continental slope, Nova Scotia, Canada. *Marine Pollution Bulletin* 28(8), 489–493. https://doi.org/10.1016/0025-326x(94)90522-3.

EcoWaste Coalition (2019). Garbage on Manila Bay breakwater stirs up call for enforcement of waste law. July 19. http://www.ecowastecoalition.org/garbage-on-manila-bay-breakwater-stirs-up-call-for-enforcement-of-waste-law/. Accessed 15 December 2019.

Endo, S., Takizawa, R., Okuda, K., Takada, H., Chiba, K., Kanehiro, H. et al. (2005). Concentration of polychlorinated biphenyls (PCBs) in beached resin pellets: Variability among individual particles and regional differences. *Marine Pollution Bulletin* 50(10), 1103–1114. https://doi.org/10.1016/j.marpolbul.2005.04.030.

Eo, S., Hong, S.H., Song, Y.K., Lee, J., Lee, J. and Shim, W.J. (2018). Abundance, composition, and distribution of microplastics larger than 20 µm in sand beaches of South Korea. *Environmental Pollution* 238, 894–902. https://doi.org/10.1016/j.envpol.2018.03.096.

Ericson, J., Vorosmarty, C., Dingman, S., Ward, L. and Meybeck, M. (2006). Effective sea-level rise and deltas: Causes of change and human dimension implications. *Global and Planetary Change* 50(1–2), 63–82. https://doi.org/10.1016/J.Gloplacha.2005.07.004.

Eriksen, M., Lebreton, L.C.M., Carson, H.S., Thiel, M., Moore, C.J., Borerro, J.C. et al. (2014). Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PLoS ONE 9(12), e111913. https://doi.org/10.1371/journal.pone.0111913.

Eriksen, M., Liboiron, M., Kiessling, T., Charron, L., Alling, A., Lebreton, L. et al. (2017). Microplastic sampling with the AVANI trawl compared to two neuston trawls in the Bay of Bengal and South Pacific. *Environmental Pollution* 232, 430–439. https://doi.org/10.1016/j.envpol.2017.09.058.

Estim, A. and Sudirman, R. (2017). Types and abundance of macro-and micro-marine debris at Sebatik Island, Tawau, Sabah. *Borneo Journal of Marine Science and Aquaculture* 1, 57–64. https://jurcon.ums.edu.my/ojums/index.php/BJoMSA/article/view/992.

Evans, S.M., Dawson, M., Day, J., Frid, C.L.J., Gill, M.E., Pattisina, L.A. et al. (1995). Domestic waste and TBT pollution in coastal areas of Ambon Island (Eastern Indonesia). *Marine Pollution Bulletin* 30(2), 109–115. https://doi.org/10.1016/0025-326x(94)00182-9.

Fallati, L., Polidori, A., Salvatore, C., Saponari, L., Savini, A. and Galli, P. (2019). Anthropogenic marine debris assessment with unmanned aerial vehicle imagery and deep learning: A case study along the beaches of the Republic of Maldives. *Science of The Total Environment* 693, 133581. https://doi.org/10.1016/j.scitotenv.2019.133581.

Fan-Jun, K. and Hsiang-Wen. H. (2014). Strategy for mitigation of marine debris: Analysis of sources and composition of marine debris in northern Taiwan. *Marine Pollution Bulletin* 83(1), 70–80.

Fauziah, S., Liyana, I. and Agamuthu, P. (2015). Plastic debris in the coastal environment: The invincible threat? Abundance of buried plastic debris on Malaysian beaches. *Waste Management & Research* 33(9), 812–821. https://doi.org/10.1177/0734242x15588587.

Firdaus, M., Trihadiningrum, Y. and Lestari, P. (2019). Microplastic pollution in the sediment of Jagir Estuary, Surabaya City, Indonesia. *Marine Pollution Bulletin* 50, 110790. https://doi.org/10.1016/j.marpolbul.2019.110790.

Fischer, V., Elsner, N.O., Brenke, N., Schwabe, E. and Brandt, A. (2015). Plastic pollution of the Kuril–Kamchatka Trench area (NW Pacific). *Deep Sea Research Part II: Topical Studies in Oceanography* 111, 399–405. https://doi.org/10.1016/j.dsr2.2014.08.012.

Fok, L. and Cheung, P.K. (2015). Hong Kong at the Pearl River Estuary: A hotspot of microplastic pollution. *Marine Pollution Bulletin* 99, (1–2), 112–118. https://doi.org/10.1016/j.marpolbul.2015.07.050.

Fok, L., Cheung, P. K., Tang, G. and Li, W.C. (2016). Size distribution of stranded small plastic debris on the coast of Guangdong, South China. *Environmental Pollution* 220 (Pt A), 407–413.

Food and Agriculture Organization of the United Nations (2016). *Abandoned, Lost and Discarded Gillnets and Trammel Nets: Methods to Estimate Ghost Fishing Mortality, and the Status of Regional Monitoring and Management*. FAO Fisheries and Aquaculture Technical Paper 600. Rome. http://www.fao.org/3/i5051e/i5051e.pdf.

Food and Agriculture Organization of the United Nations (2018). *The State of World Fisheries and Aquaculture 2018 – Meeting the Sustainable Development Goals*. Rome. http://www.fao.org/documents/card/en/c/I9540EN/.

Free, C.M., Jensen, O. P., Mason, S.A., Eriksen, M., Williamson, N.J. and Boldgiv, B. (2014). High-levels of microplastic pollution in a large, remote, mountain lake. *Marine Pollution Bulletin* 85(1), 156–163. https://doi.org/10.1016/j.marpolbul.2014.06.001.

Fujieda, S. and Sasaki, K. (2005). Stranded debris of foamed plastic on the coast of Eta Island and Kurahashi Island in Hiroshima Bay. *Bulletin of the Japanese Society of Scientific Fisheries (Japan)*. 71(5), 755–761. https://doi.org/10.2331/suisan.71.755.

Fujieda, S., Ohtomi, J., Higashi, M. and Habano, A. (2009). Distribution and actual condition of seabed litter in Kagoshima Bay. *Nippon Suisan Gakkaishi* 75(1),1927. https://doi.org/1:10.2331/suisan.75.19.

Gall, S.C. and Thompson, R.C. (2015). The impact of debris on marine life. *Marine Pollution Bulletin* 92(1–2), 170–179. https://doi.org/10.1016/j.marpolbul.2014.12.041.

Ganesapand, S., Manikandan, S. and Kumaraguru, A.K. (2011). Marine litter in the Northern Part of Gulf of Mannar, Southeast Coast of India. *Research Journal of Environmental Sciences* 5(5), 471–478. https://doi.org/10.3923/rjes.2011.471.478.

Geraeds, M., van Emmerik, T., de Vries, R. and bin Ab Razak, M.S. (2019). Riverine plastic litter monitoring using unmanned aerial vehicles (UAVs). *Remote Sensing* 11(17), 2045. https://doi.org/10.3390/rs11172045.

Ghina, F. (2003). Sustainable development in small island developing states. *Environment, Development and Sustainability* 5(1/2), 139–165. https://doi.org/10.1023/a:1025300804112.

Ghosh, S.K. (2017). Country chapter: The Republic of India. *State of the 3Rs in Asia and the Pacific*. Nagoya: United Nations Centre for Regional Development. http://www.uncrd.or.jp/content/documents/5688[1121]%20India.pdf.

Godlove, C. and Pak, K. (2018). *Scoping Study Report on Solid Waste Management in Kep Province*. San Francisco: The Asia Foundation; Phnom Penh: National Council for Sustainable Development. https://asiafoundation.org/wp-content/uploads/2020/09/Cambodia_Scoping-Study-Report-on-Solid-Waste-Management-in-Kep-Province_August-2020_EN_.pdf.

Goto, T. and Shibata, H. (2015). Changes in abundance and composition of anthropogenic marine debris on the continental slope off the Pacific Coast of Northern Japan, after the March 2011 Tohoku earthquake. *Marine Pollution Bulletin* 95(1), 234–241.

Gunasekara, A.J.M., Priyadarshana, R.N., Ranasinghe, T.S., Ranaweera, R.P., Fernando, E., Amali, J. et al. (2014). Status of marine litter accumulated in coastal areas of Sri Lanka. *19th International Forestry and Environment Symposium 2014* 19. https://journals.sjp.ac.lk/index.php/fesympo/issue/archive.

Hastuti, A.R., Lumbanbatu, D.T. and Wardiatno, Y. (2019). The presence of microplastics in the digestive tract of commercial fishes off Pantai Indah Kapuk coast, Jakarta, Indonesia. Biodiversitas *Journal of Biological Diversity* 20(5), 1233–1242. https://doi.org/10.13057/biodiv/d200513.

Heo, N.W., Hong, S.H., Han, G.M., Hong, S., Lee, J., Song, Y.K. et al. (2013). Distribution of small plastic debris in cross-section and high strandline on Heungnam beach, South Korea. Ocean *Science Journal* 48(2), 225–233. https://doi.org/10.1007/s12601-013-0019-9.

Hermawan, R., Damar, A. and Hariyadi, S. (2017). Daily accumulation and impacts of marine litter on the shores of Selayar Island Coast, South Sulawesi, Indonesia. *Waste Technology* 5(1), 15–20. http://dx.doi.org/10.12777/wastech.5.1.15-20.

Hidalgo-Ruz, V., Gutow, L., Thompson, R.C. and Thiel, M. (2012). Microplastics in the marine environment: A review of the methods used for identification and quantification. *Environmental Science and Technology* 46(6), 3060–3075. https://doi.org/10.1021/es2031505.

Hidalgo-Ruz, V., Honorato–Zimmer, D., Gatta–Rosemary, M., Nuñez, P., Hinojosa, I.A. and Thiel, M. (2018). Spatio-temporal variation of anthropogenic marine debris on Chilean beaches. *Marine Pollution Bulletin* 126, 516–524. https://doi.org/10.1016/j.marpolbul.2017.11.014.

Hillmann, F. and Ziegelmaye, U. (2015). Environmental change and migration in coastal regions: Examples from Ghana and Indonesia. DIE ERDE: *Journal of the Geographical Society of Berlin* 147, 119–138. http://dx.doi.org/10.12854/erde-147-9.

Hong, S., Lee, J., Kang, D., Choi, H.W. and Ko, S.H. (2014). Quantities, composition, and sources of beach debris in Korea from the results of nationwide monitoring. *Marine Pollution Bulletin* 84(1–2), 27–34. https://doi.org/10.1016/j.marpolbul.2014.05.051.

Hoornweg, D. and Bhada-Tata, P. 2012. *What a Waste: A Global Review of Solid Waste Management*. Urban Development Series Knowledge Papers 15. Washington, D.C.: World Bank. https://openknowledge.worldbank.org/handle/10986/17388.

Hossain, M.M., Kibria, G., Mallick, D., Lau, T.C., Wu, R. and Nugegoda, D. (2015). *Pollution Monitoring in Rivers, Estuaries and Coastal Areas of Bangladesh with Artificial Mussel (AM) Technology — Findings, Ecological Significances, Implications & Recommendations*. https://www.researchgate.net/publication/272170872.

Hossain, M.S., Rahman, M.S., Uddin, M.N., Sharifuzzaman, S.M., Chowdhury, S.R., Sarker, S. and Nawaz Chowdhury, M.S. (2019a). Microplastic contamination in Penaeid shrimp from the Northern Bay of Bengal. *Chemosphere* 124688. https://doi.org/10.1016/j.chemosphere.2019.124688.

Hossain, M.S., Sobhan, F., Uddin, M.N., Sharifuzzaman, S.M., Chowdhury, S.R., Sarker, S. et al. (2019b). Microplastics in fishes from the Northern Bay of Bengal. *Science of The Total Environment* 690, 821–830. https://doi.org/10.1016/j.scitotenv.2019.07.065.

Hsu W., Domenech T. and McDowell W. (2021). How circular are plastics in the EU? MFA of plastics in the EU and pathways to circularity. Cleaner Environmental Systems 2, 100004.

Huisman, H., Breukelman, H. and Keesman, B. (2017). *Scoping Mission on Integrated Solid Waste Management (ISWM) in Myanmar; Report of Findings – June 2017*. The Hague: Netherlands Enterprise Agency. https://www.myanmarwaterportal.com/storage/eb/articles/478/myanmar-waste-scoping-mission-report.pdf.

Ilyas, H., Ilyas, S., Ahmad, S.R. and Nawaz, M. (2017). Waste generation rate and composition analysis of solid waste in Gujranwala City Pakistan. *International Journal of Waste Resources* (7)3. https://doi.org/10.4172/2252-5211.1000297.

Imhof, H.K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S. et al. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin* 116(1–2), 340–347. https://doi.org/10.1016/j.marpolbul.2017.01.010.

Indonesia, Ministry of Environment and Forestry (2020). *National Plastic Waste Reduction Strategic Actions for Indonesia*. Jakarta.

Islam, M.S., Han, S., Ahmed, M.K. and Masunaga, S. (2014). Assessment of trace metal contamination in water and sediment of some rivers in Bangladesh. *Journal of Water and Environment Technology* 12(2), 109–121.

Isobe, A. (2016). Percentage of microbeads in pelagic microplastics within Japanese coastal waters. *Marine Pollution Bulletin* 110(1), 432–437. https://doi.org/10.1016/j.marpolbul.2016.06.030.

Isobe, A., Iwasaki, S., Uchida, K. and Tokai, T. (2019). Abundance of non-conservative microplastics in the upper ocean from 1957 to 2066. *Nature Communications* 10(1). https://doi.org/10.1038/s41467-019-08316-9.

Isobe, A., Kubo, K., Tamura, Y., Kako, S., Nakashima, E. and Fujii, N. (2014). Selective transport of microplastics and mesoplastics by drifting in coastal waters. *Marine Pollution Bulletin* 89(1–2), 324–330. https://doi.org/10.1016/j.marpolbul.2014.09.041.

Isobe, A., Uchida, K., Tokai, T. and Iwasaki, S. (2015). East Asian seas: A hot spot of pelagic microplastics. *Marine Pollution Bulletin* 101(2), 618–623. https://doi.org/10.1016/j.marpolbul.2015.10.042.

Jalil, M.A., Mian, M.N. and Rahman, M.K. (2013). Using plastic bags and its damaging impact on environment and agriculture: An alternative proposal. *International Journal of Learning and Development* 3(4), 1–14.

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A. et al. (2015). Plastic waste inputs from land into the ocean. *Science* 347(6223), 768–770. https://doi.org/10.1017/CBO9781107415386.010.

Jang, S.W., Kim, D.H., Seong, K.T., Chung, Y.H. and Yoon, H.J. (2014a). Analysis of floating debris behaviour in the Nakdong River basin of the southern Korean peninsula using satellite location tracking buoys. *Marine Pollution Bulletin* 88(1–2), 275–283. https://doi.org/10.1016/j.marpolbul.2014.08.031.

Jang, Y.C., Lee, J.S., Hong, S., Lee, J.S., Shim, W.J. and Song, Y.K. (2014b). Sources of plastic marine debris on beaches of Korea: More from the ocean than the land. Ocean *Science Journal* 49(2), 151–162. https://doi.org/10.1007/s12601-014-0015-8.

Jang, Y. C., Lee, J., Hong, S., Mok, J.Y., Kim, K.S., Lee, Y.J. et al. (2014c). Estimation of the annual flow and stock of marine debris in South Korea for management purposes. *Marine Pollution Bulletin* 86(1–2), 505–511. https://doi.org/10.1016/j.marpolbul.2014.06.021.

Jang, Y.C., Ranatunga, R.R.M.K.P., Mok, J.Y., Kim, K.S., Hong, S.Y., Choi, Y.R. et al. (2018). Composition and abundance of marine debris stranded on the beaches of Sri Lanka: Results from the first island-wide survey. *Marine Pollution Bulletin* 128, 126–131. https://doi.org/10.1016/j.marpolbul.2018.01.018.

Jang, M., Shim, W.J., Han, G.M., Rani, M., Song, Y.K. and Hong, S.H. (2017). Widespread detection of a brominated flame retardant, hexabromocyclododecane, in expanded polystyrene marine debris and microplastics from South Korea and the Asia–Pacific coastal region. *Environmental Pollution* 231, 785–794. https://doi.org/10.1016/j.envpol.2017.08.066.

Japan, Ministry of Foreign Affairs (2019). "MARINE Initiative" toward realization of the Osaka Blue Ocean Vision. https://www.mofa.go.jp/files/000493728.pdf.

Jayapala, H.P.S., Jayasiri, H.B., Ranatunga, R. R. M. P. K. and Amarasiri, C. (2018). Marine debris and its potential impacts on mangrove ecosystem in Negombo Lagoon. In *National Aquatic Resources Research and Development Agency (NARA) International Scientific Sessions 2018*. http://www.erepository.nara.ac.lk/handle/1/835.

Jayasiri, H.B., Purushothaman, C.S. and Vennila, A. (2013). Plastic litter accumulation on high-water strandline of urban beaches in Mumbai, India. *Environmental Monitoring and Assessment* 185 (9), 7709–7719. https://doi.org/10.1007/s10661-013-3129-z.

Jeske, F. (2019). Survey on plastic waste in the Ayeyarwady, 2018-2019: Rapid river sampling for first quantitative assessment of floating plastics in Myanmar's great river. Working Paper No. 09 of FFI Myanmar, with Thant Myanmar. Fauna and Flora International , Yangon.

Johari, A., Alkali, H., Hashim, H., Ahmed, S.I. and Mat, R. (2014). Municipal solid waste management and potential revenue from recycling in Malaysia. *Modern Applied Science* 8(4), 37–49. https://doi.org/10.5539/mas.v8n4p37.

Jung, R.-T., Sung, H.G., Chun, T.-B. and Keel, S.-I. (2010). Practical engineering approaches and infrastructure to address the problem of marine debris in Korea. *Marine Pollution Bulletin* 60(9), 1523–1532. https://doi.org/10.1016/j.marpolbul.2010.04.016.

Kadir, A.A. and Sarani, N.A. (2015). Cigarette butts pollution and environmental impact – A review. *Applied Mechanics and Materials* 773–774, 1106–1110. https://doi.org/10.4028/www.scientific.net/amm.773-774.1106.

Kadir, A.A., Hasni, A. and Sarani, N.A. (2015b). Marine debris composition in Batupahat, Johor: A comparison between Sungai Lurus and Minyakbeku beaches. *ARPN Journal of Engineering and Applied Sciences* 10, 6553–57.

Kako, S., Isobe, A., Kataoka, T. and Hinata, H. (2014). A decadal prediction of the quantity of plastic marine debris littered on beaches of the East Asian marginal seas. *Marine Pollution Bulletin* 81(1), 174–184. https://doi.org/10.1016/j.marpolbul.2014.01.057.

Kako, S., Isobe, A. and Magome, S. (2010). Sequential monitoring of beach litter using webcams. *Marine Pollution Bulletin* 60(5), 775–779. https://doi.org/10.1016/j.marpolbul.2010.03.009.

Kako, S., Isobe, A., Magome, S., Hinata, H., Seino, S. and Kojima, A. (2011). Establishment of numerical beach-litter hindcast/forecast models: An application to Goto Islands, Japan. *Marine Pollution Bulletin* 62(2), 293–302. https://doi.org/10.1016/j.marpolbul.2010.10.011.

Kaladharan, P., Asokan, P. K., Koya, M. and Bhint, H. M. (2014). Plastic debris in the stomach of a Longman's Beaked Whale, Indopacetus pacificus (Longman, 1926) stranded off Sutrapada, Veraval, Saurashtra coast, India. *Journal of the Marine Biological Association of India* 56(2), 92–94.

Kaladharan, P., Vijayakumaran, K., Singh, V.V., Prema, D., Asha, P.S., Sulochanan, B. et al. (2017). Prevalence of marine litter along the Indian beaches: A preliminary account on its status and composition. *Journal of the Marine Biological Association of India* 59(1), 19–24.

Kamaludeen, A. (2020). Some thoughts on the Maldivian fisheries sector amid COVID-19. *Maldives Economic Review* 1 (3), 9–11.

Kamuang, M. T. and Siriratpiriya, O. (2017). Country chapter: The Kingdom of Thailand. *State of the 3Rs in Asia and the Pacific*. Nagoya: United Nations Centre for Regional Development. https://www.uncrd.or.jp/State_of_3Rs.

Kanehiro, H., Tokai, T. and Matsuda, K. (1995). Marine litter composition and distribution on the sea-bed of Tokyo Bay. *Journal of Fisheries Engineering* 31(3), 195–199.

Kang, J.H., Kwon, O.Y., Lee, K.W., Song, Y.K. and Shim, W.J. (2015). Marine neustonic microplastics around the southeastern coast of Korea. *Marine Pollution Bulletin* 96(1–2), 304–312. https://doi.org/10.1016/j.marpolbul.2015.04.054.

Karami, A., Golieskardi, A., Keong Choo, C., Larat, V. Galloway, T.S. and Salamatinia, B. (2017). Corrigendum: The presence of microplastics in commercial salts from different countries. *Scientific Reports* 7(1), 46838. https://doi.org/10.1038/srep46173.

Karbalaei, S., Golieskardi, A., Hamzah, H.B., Abdulwahid, S., Hanachi, P., Walker, T.R. et al. (2019). Abundance and characteristics of microplastics in commercial marine fish from Malaysia. *Marine Pollution Bulletin* 148, 5–15. https://doi.org/10.1016/j.marpolbul.2019.07.072.

Karim, S. (2009). Implementation of the MARPOL Convention in Bangladesh. *Macquarie Journal of International and Comparative Environmental Law* 6, 51.

Karim, M.E., Sanjee, S.A., Mahmud, S., Shaha, M., Moniruzzaman, M. and Das, K.C. (2019). Microplastics pollution in Bangladesh: Current scenario and future research perspective. *Chemistry and Ecology* 36 (1), 83–99. https://doi.org/10.1080/02757540.2019.1688309.

Karthik, R., Robin, R.S., Purvaja, R., Ganguly, D., Anandavelu, I., Raghuraman, R. et al. (2018). Microplastics along the beaches of southeast coast of India. *Science of The Total Environment* 645, 1388–1399. https://doi.org/10.1016/j.scitotenv.2018.07.242.

Karunarathna, R. and Ranatunga, R.R.M.K.P. (2017). Prevalence of microplastics in the beach sand of Negombo and the potential accumulation of microplastics in marine fish. Thesis for BSc Special in Aquatic Resources Management, Ranatunga University of Sri Jayewardenepura, Nugegoda. https://doi.org/10.13140/RG.2.2.17559.62885.

Kataoka, T., Hinata, H. and Kato, S. (2013). Analysis of a beach as a time-invariant linear input/output system of marine litter. *Marine Pollution Bulletin* 77(1–2), 266–273. https://doi.org/10.1016/j.marpolbul.2013.09.049.

Kaza, S., Yao, L.C., Bhada-Tata, P. and Van Woerden, F. (2018). What a Waste 2.0: *A Global Snapshot of Solid Waste Management to 2050*. Washington, D.C.: World Bank. https://openknowledge.worldbank.org/handle/10986/30317.

Kei, K. (2005). Beach litter in Amami Islands, Japan. *South Pacific Studies* 26, 15–24.

Khairunnisa, A.K., Fauziah, S.H. and Agamuthu, P. (2012). Marine debris composition and abundance: A case study of selected beaches in Port Dickson, Malaysia. *Aquatic Ecosystem Health and Management* 15(3), 279–286. https://doi.org/10.1080/14634988.2012.703096.

Khoironi, A., Anggoro, S. and Sudarno. (2018). The existence of microplastic in Asian green mussels. *IOP Conference Series: Earth and Environmental Science* 131, 012050. https://doi.org/10.1088/1755-1315/131/1/012050.

Kieu-Le, T.C., Strady, E., Perset, M. (2016). Life cycle of floating debris in the canals of Ho Chi Minh City. hal-02357363. https://hal.archives-ouvertes.fr/hal-02357363/document.

Kim, I.S., Chae, D.H., Kim, S.K., Choi, S.B. and Woo, S.B. (2015). Factors influencing the spatial variation of microplastics on high-tidal coastal beaches in Korea. *Archives of Environmental Contamination and Toxicology* 69(3), 299–309. **https://doi.org/10.1007/s00244-015-0155-6**.

Kirkman, H. (2006). The East Asian Seas UNEP Regional Seas Programme. *International Environmental Agreements: Politics, Law and Economics* 6(3), 305–316. **https://doi.org/10.1007/s10784–006–9011–5**.

Klein, N. (2011). *Maritime Security and the Law of the Sea*. Oxford: Oxford University Press.

Koongolla, J. B., Andrady, A.L., Terney, P.B., Kumara, P. and Gangabadage, C.S. (2018). Evidence of microplastics pollution in coastal beaches and waters in southern Sri Lanka. *Marine Pollution Bulletin* 137 (October), 277–284. **https://doi.org/10.1016/j.marpolbul.2018.10.031**.

Korea (Democratic People's Republic), Ministry of Land and Environment Protection (2012). *Democratic People's Republic of Korea Environment and Climate Change Outlook*. Pyongyang. **http://wedocs.unep.org/bitstream/handle/20.500.11822/9679/-Environment_and_Climate_Change_Outlook-2012ECCO_DPRK_2012.pdf.pdf?sequence=3&isAllowed=y**.

Kozlovskii, N.V., Hong, S.H., Song, Y.K. and Kachur, A.N. (2017). Distribution of beached marine litter and floating microplastics in the Minonosok Inlet of Possiet Bay of the Peter the Great Gulf. Resources, Environment and Regional Sustainable Development in Northeast Asia. *Proceedings of the III International Conference*. Vladivostok, 10–14 October 2016. Vladivostok: Dalnauka. 235–239.

Kripa, V., Kaladharan, P., Prema, D., Jeyabaskaran, R., Anilkumar, P.S., Shylaja, G. and Dhanya, A.M. (2016). National Marine Debris Management Strategy to conserve marine ecosystems. *Marine Fisheries Information Service; Technical and Extension Series* (228), 3–10.

Krishnakumar, S., Srinivasalu, S., Saravanan, P., Vidyasakar, A. and Magesh, N.S. (2018). A preliminary study on coastal debris in Nallathanni Island, Gulf of Mannar Biosphere Reserve, Southeast coast of India. *Marine Pollution Bulletin* 131(February), 547–551. **https://doi.org/10.1016/j.marpolbul.2018.04.026**.

Kumar, A.A., Sivakumar, R., Reddy, Y.S.R., Bhagya Raja, M.V., Nishanth, T. and Revanth, V. (2016). Preliminary study on marine debris pollution along Marina beach, Chennai, India. *Regional Studies in Marine Science* 5, 35–40. **https://doi.org/10.1016/j.rsma.2016.01.002**.

Kumar, V.E., Ravikumar, G. and Jeyasanta, K.I. (2018). Occurrence of microplastics in fishes from two landing sites in Tuticorin, South east coast of India. *Marine Pollution Bulletin* 135, 889–894. **https://doi.org/10.1016/j.marpolbul.2018.08.023**.

Kuo, F.-J. and Huang, H.-W. (2014). Strategy for mitigation of marine debris: Analysis of sources and composition of marine debris in northern Taiwan. *Marine Pollution Bulletin* 83(1), 70–78.

Kuriyama, Y., Konishi, K., Kanehiro, H., Otake, C., Kaminuma, T., Mato, Y. et al. (2002). Plastic pellets in the marine environment of Tokyo Bay and Sagami Bay [Japan]. *Bulletin of the Japanese Society of Scientific Fisheries (Japan)* 68(2), 164–171.

Kusui, T. and Noda, M. (2003). International survey on the distribution of stranded and buried litter on beaches along the Sea of Japan. *Marine Pollution Bulletin* 47(1–6), 175–179.

Lahens, L., Strady, E., Kieu-Le, T.-C., Dris, R., Boukerma, K., Rinnert, E. et al. (2018). Macroplastic and microplastic contamination assessment of a tropical river (Saigon River, Vietnam) transversed by a developing megacity. *Environmental Pollution* 236, 661–671.

Lamb, J.B., Willis, B.L., Fiorenza, E.A., Couch, C.S., Howard, R., Rader, D.N. et al. (2018). Plastic waste associated with disease on coral reefs. *Science* 359(6374), 460–462. **https://doi.org/10.1126/science.aar3320**.

Lau, W.W.Y., Shiran, Y., Bailey, R.M., Cook, E., Stuchtey M.R., Koskella J. et al. (2020). Evaluating scenarios toward zero plastic pollution. *Science* 369(6510),1455–1461. **https://doi.org/10.1126/science.aba9475**.

Lavers, J.L. and Bond, A.L. (2017). Exceptional and rapid accumulation of anthropogenic debris on one of the world's most remote and pristine islands. *PNAS* 114 (23) 6052-6055. **https://doi.org/10.1073/pnas.1619818114**.

Law, K.L., Starr, N., Siegler, T.R., Jambeck, J.R., Mallos, N.J. and Leonard, G.H. (2020). The United States' contribution of plastic waste to land and ocean. *Science Advances* 6, eabd0288.

Lebreton L. and Andrady A. (2019). Future scenarios of global plastic waste generation and disposal. *Palgrave Communications* 5(1). **https://doi.org/10.1057/s41599-018-0212-7**.

Lebreton, L.C.M., van der Zwet, J., Damsteeg, J.-W., Slat, B., Andrady, A. and Reisser, J. (2017). River plastic emissions to the world's oceans. *Nature Communications* 8, 15611. **https://doi.org/10.1038/ncomms15611**.

Lebreton, L.C.-M., Greer, S.D. and Borrero, J.C. (2012). Numerical modelling of floating debris in the world's oceans.*Marine Pollution Bulletin* 64(3), 653–661. **https://doi.org/10.1016/j.marpolbul.2011.10.027**.

Lee, D.-I., Cho, H.-S. and Jeong, S.-B. (2006). Distribution characteristics of marine litter on the sea bed of the East China Sea and the South Sea of Korea. *Estuarine, Coastal and Shelf Science* 70(1–2), 187–194. **https://doi.org/10.1016/j.ecss.2006.06.003**.

Lee, J., Hong, S., Song, Y.K., Hong, S.H., Jang, Y.C., Jang, M. et al. (2013). Relationships among the abundances of plastic debris in different size classes on beaches in South Korea. *Marine Pollution Bulletin* 77(1–2), 349–354. **https://doi.org/10.1016/j.marpolbul.2013.08.013**.

Lee, J., Lee, J., Hong, S., Hong, S.H., Shim, W.J. and Eo, S. (2017). Characteristics of meso-sized plastic marine debris on 20 beaches in Korea. *Marine Pollution Bulletin* 123(1–2), 92–96. **https://doi.org/10.1016/j.marpolbul.2017.09.020**.

Lee, J., Lee, J.S., Jang, Y.C., Hong, S.Y., Shim, W. J., Song, Y. K. et al. (2015). Distribution and size relationships of plastic marine debris on beaches in South Korea. *Archives of Environmental Contamination and Toxicology* 69(3), 288–298. **https://doi.org/10.1007/s00244-015-0208-x**.

Lestari, P. and Trihadiningrum, Y. (2019). The impact of improper solid waste management to plastic pollution in Indonesian coast and marine environment. *Marine Pollution Bulletin* 149, 110505. **https://doi.org/10.1016/j.marpolbul.2019.110505**.

Lettenmaier, D. P. (1978). Design considerations for ambient stream equality monitoring. *Water Resources Bulletin* 14(4): 884–902. **https://doi.org/10.1111/j.1752-1688.1978.tb05586.x**.

Lippiatt, S., Opfer, S. and Arthur C. (2013). Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment. NOAA Technical Memorandum NOS-OR&R-46. Washington, D.C.: United States Department of Commerce, National Oceanic and Atmospheric Administration.

Liu, C., Hotta, Y., Totoki, Y., Yagasa, R., Aoki-Suzuki, C. and Hengesbaugh, M. (2018). State of the 3Rs in Asia and the Pacific — Experts' Assessment of Progress in Ha Noi 3R Goals. Liu, C. Hotta, Y., Totoki, Y. and Inoue, M. (eds.). Nagoya: United Nations Centre for Regional Development. **https://www.iges.or.jp/en/pub/state-3rs-asia-and-pacific-experts-assessment/en**.

Liu, C., Jin, Y. and Nie, Y. (2017). Country chapter: The People's Republic of China. State of the 3Rs in Asia and the Pacific. Nagoya: United Nations Centre for Regional Development. **http://www.uncrd.or.jp/content/documents/5687[Nov%20 2017]%20China.pdf**.

Liu, T.-K., Wang, M.-W. and Chen, P. (2013). Influence of waste management policy on the characteristics of beach litter in Kaohsiung, Taiwan. Marine Pollution Bulletin 72(1), 99–106. **https://doi.org/10.1016/j.marpolbul.2013.04.015**.

Löhr, A., Beunen, R., Savelli, H., Kalz, M., Ragas, A. and Van Belleghem, F. (2017). Solutions for global marine litter pollution. *Current Opinion in Environmental Sustainability* 28, 90–99. **https://doi.org/10.1016/j.cosust.2017.08.009**.

Lopes, J.D.R. (2017). Final report to the University of Hawai'i at Hilo Marine Option Program: Marine Debris Education and Coastline Cleanup Project in Com and Dili, Timor-Leste. University of Hawai, Hilo. **http://www.uhhmop.hawaii.edu/projects/library/papers/DosReisLopes_Joctan_MOP_FinalPaper_F2017.pdf**.

Lubis, I.E.N., Melani, W.R. and Syakti, A.D. (2019). Plastic debris contamination in Grey-eel catfish (Plotosus canius) in Tanjungpinang water, Riau Islands-Indonesia. *AIP Conference Proceedings* 2094, 020035. **https://doi.org/10.1063/1.5097504**.

Lyons, Y., Su, T. and Neo, M. L. (2019). *A Review of Research on Marine Plastics in Southeast Asia: Who Does What?* Singapore: Centre for International Law, National University of Singapore. **https://www.gov.uk/government/publications/a-review-of-research-on-marine-plastics-in-sea-who-does-what**.

McKinsey Centre for Business and Environment and Ocean Conservancy (2015). *Stemming the Tide. Land-based Strategies for a Plastic–free Ocean*. **https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf**.

Macfadyen, G., Huntington, T. and Cappell, R. (2009). *Abandoned, Lost or Otherwise Discarded Fishing Gear.* UNEP Regional Seas Reports and Studies 185; FAO Fisheries and Aquaculture Technical Paper 523. Rome: United Nations Environment Programme/. **http://www.fao.org/3/i0620e/i0620e00.htm**.

Mai, L., You, S., He, H., Bao, L., Liu, L. and Zeng, E.Y. (2019). Riverine microplastic pollution in the Pearl River Delta, China: Are modeled estimates accurate? *Environmental Science & Technology* 53 (20),11810–11817.

Matsuguma, Y., Takada, H., Kumata, H., Kanke, H., Sakurai, S., Suzuki, T. et al. (2017). Microplastics in sediment cores from Asia and Africa as indicators of temporal trends in plastic pollution. *Archives of Environmental Contamination and Toxicology* 73 (2), 230–239.

Maximenko, N., Hafner, J. and Niiler, P. (2012). Pathways of marine debris derived from trajectories of Lagrangian drifters. *Marine Pollution Bulletin* 65(1–3), 51–62. **https://doi.org/10.1016/j.marpolbul.2011.04.016**.

Minderoo, C. (2021). *The Plastic Waste Makers Index*. Broadway Nedlands, Western Australia: Minderoo Foundation.

Manickavasagam, S., Chellamanimegalai, P. and Dhayanath, M. (2019). Assessment of Marine Litter Based on Tide along Juhu Beach. *International Journal of Current Microbiology and Applied Sciences* 8(7): 1549-1555. **https://doi.org/10.20546/ijcmas.2019.807.184**.

Meijer, L.J.J., van Emmerik, T., van der Ent, R., Schmidt, C. and Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances 7 (18), eaaz5803.

Mfilinge, P.L., Meziane, T., Bachok, Z. and Tsuchiya, M. (2005). Litter dynamics and particulate organic matter outwelling from a subtropical mangrove in Okinawa Island, South Japan. *Estuarine, Coastal and Shelf Science* 63(1–2), 301–313. https://www.sciencedirect.com/science/article/abs/pii/S0272771404003543?via%3Dihub.

Miura, H., Wijeyewickrema, A.C. and Inoue, S. (2006). Evaluation of Tsunami Damage in the Eastern Part of Sri Lanka Due to the 2004 Sumatra Earthquake Using High-Resolution Satellite Images. Paper presented at the Third International Workshop on Remote Sensing for Post-Disaster Response, 12–13 Sep. 2005, Chiba, Japan. http://ares.tu.chiba-u.jp/workshop/Chiba-RS2005/Paper_Miura.pdf.

Miyake, H., Shibata, H. and Furushima, Y. (2011). Deep-sea litter study using deep-sea observation tools. In *Interdisciplinary Studies on Environmental Chemistry—Marine Environmental Modeling and Analysis*. Omori, K., Guo, X., Yoshie, N., Fujii, N., Handoh, I. C., Isobe A. et al. (eds). Tokyo: TERRAPUB. 261–269. https://www.terrapub.co.jp/onlineproceedings/ec/05/pdf/PR_05261.pdf.

Mobilik, J. M., Ling, T.Y., Husain, M.L. and Hassan, R. (2014). Type and abundance of marine debris at selected public beaches in Sarawak, East Malaysia, during the northeast monsoon. *Journal of Sustainability Science and Management* 9(2), 43–51.

Mobilik, J.M., Ling, T.Y., Husain, M.L.B. and Hassan, R. (2015). Seasonal trends in abundance and composition of marine debris in selected public beaches in Peninsular Malaysia. *AIP Conference Proceedings* 1678 (1), 020020.

Moore, C. J., Moore, S.L., Leecaster, M.K. and Weisberg, S.B. (2001). A comparison of plastic and plankton in the North Pacific central gyre. *Marine Pollution Bulletin* 42(12), 1297–1300. https://doi.org/10.1016/S0025-326X(01)00114-X.

Mourshed, M., Masud, M.H., Rashid, F. and Joardder, M.U.H. (2017). Towards the effective plastic waste management in Bangladesh: A review. *Environmental Science and Pollution Research* 24(35), 27021–27046. https://doi.org/10.1007/s11356-017-0429-9.

Mugilarasan, M., Venkatachalapathy, R. and Sharmila, N. (2015). Occurrence of microplastic resin pellets in sediments around Agatti Island, India. *International Journal of Recent Scientific Research* 6, 7198–7201.

Mugilarasan, M., Venkatachalapathy, R., Sharmila, N. and Gurumoorthi, K. (2017). Occurrence of microplastic resin pellets from Chennai and Tinnakkara Island: Towards the establishment of background level for plastic pollution. *Indian Journal of Geo Marine Sciences* 46(06), 1210–1212.

Nakashima, E., Isobe, A., Kako, S., Itai, T. and Takahashi, S. (2012). Quantification of toxic metals derived from macroplastic litter on Ookushi Beach, Japan. *Environmental Science & Technology* 46(18), 10099–10105. https://doi.org/10.1021/es301362g.

Nakashima, E., Isobe, A., Magome, S., Kako, S. and Deki, N. (2011). Using aerial photography and in situ measurements to estimate the quantity of macro-litter on beaches. *Marine Pollution Bulletin* 62(4), 762–769. https://doi.org/10.1016/j.marpolbul.2011.01.006.

Nam, P., Tuan, P., Thuy, D., Quynh, L. and Amiard, F. (2019). Contamination of microplastic in bivalve: First evaluation in Vietnam. *Vietnam Journal of Earth Sciences* 41(3), 252–258. https://doi.org/10.15625/0866-7187/41/3/13925.

Ng, K.L., and Obbard, J.P. (2006). Prevalence of microplastics in Singapore's coastal marine environment. *Marine Pollution Bulletin* 52(7), 761–767. https://doi.org/10.1016/j.marpolbul.2005.11.017.

Nigam, R. (1982). Plastic pellets on the Caranzalem beach sands, Goa, India. *Mahasagar–Bulletin of the National Institute of Oceanography* 15, 125–127. http://ijs.nio.org/index.php/msagar/article/view/2196.

Nor, N.H.M. and Obbard, J.P. (2014). Microplastics in Singapore's coastal mangrove ecosystems. *Marine Pollution Bulletin* 79 (1–2), 278–283. https://www.sciencedirect.com/science/article/abs/pii/S0025326X13007261?via%3Dihub.

Norway, Ministry of Foreign Affairs (2019). The Norwegian Development Program to combat marine litter and microplastics. https://www.regjeringen.no/contentassets/9ea1930ef21d4e8d96536ebef2e71147/marin_litter_202008.pdf. Accessed 11 September 2021.

NOWPAP MERRAC (2017). *Understanding of Floating Marine Litter Distribution in the NOWPAP Region*. MERRAC Technical Report No. 35. Marine Environmental Emergency Preparedness and Response Regional Activity Centre the Northwest Pacific Action Plan (NOWPAP MERRAC), Daejeon, Republic of Korea. https://wedocs.unep.org/20.500.11822/26239.

NOWPAP MERRAC (2018). *Review and Analysis of Floating Marine Litter Prediction Models in the NOWPAP Region*. MERRAC Technical Report No. 36. Marine Environmental Emergency Preparedness and Response Regional Activity Centre the Northwest Pacific Action Plan (NOWPAP MERRAC), Daejeon, Republic of Korea.https://wedocs.unep.org/handle/20.500.11822/26237.

Obusan, M.C.M., Rivera, W.L., Siringan, M.A.T. and Aragones, L.V. (2016). Stranding events in the Philippines provide evidence for impacts of human interactions on cetaceans. *Ocean & Coastal Management* 134, 41–51. https://doi.org/10.1016/j.ocecoaman.2016.09.021.

Ocean Conservancy (2016). 30th Anniversary: *International Coastal Cleanup (ICC) 2016 Annual Report*. Washington, D.C. https://oceanconservancy.org/wp-content/uploads/2017/04/2016-Ocean-Conservancy-ICC-Report.pdf.

Ocean Conservancy (2017). *Stemming the Tide: Land-based Strategies for a Plastic-free Ocean*. Washington, D.C. https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf.

Ocean Conservancy (2019). *The Beach and Beyond: International Coastal Cleanup, 2019 Annual Report*. Washington, D.C. https://oceanconservancy.org/wp-content/uploads/2019/09/Final-2019-ICC-Report.pdf.

Ocean Conservancy (2021). Trash information and data for education and solutions. https://www.coastalcleanupdata.org/reports. Accessed 21 October 2021.

Ogata, Y., Takada, H., Mizukawa, K., Hirai, H., Iwasa, S., Endo, S. et al. (2009). International Pellet Watch: Global monitoring of persistent organic pollutants (POPs) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs. *Marine Pollution Bulletin* 58(10), 1437–1446. https://doi.org/10.1016/j.marpolbul.2009.06.014.

Ogi, H. and Fukumoto, Y. (2000). A sorting method for small plastic debris floating on the sea surface and stranded on sandy beaches. *Bulletin of the Faculty of Fisheries-Hokkaido University (Japan)* 51(2), 71–93. https://agris.fao.org/agris-search/search.do?recordID=JP2001000319.

Orale, R.L., and Fabillar, L.A. (2011). Coastal waste transport in Catbalogan City, Philippines and nearby towns. Iranica *Journal of Energy & Environment* 2(1), 92–103.

Organisation for Economic Co-operation and Development (2019). "Waste: Municipal Waste", OECD Environment Statistics (database). https://www.oecd-ilibrary.org/environment/data/oecd-environment-statistics/municipal-waste_data-00601-en. Accessed 06 September 2019.

Pan, Z., Guo, H., Chen, H., Wang, S., Sun, X., Zou, Q. et al. (2019). Microplastics in the Northwestern Pacific: Abundance, distribution, and characteristics. *Science of The Total Environment* 650 (2), 1913–1922. https://doi.org/10.1016/j.scitotenv.2018.09.244.

Pariatamby, A. (2017). Country chapter: Malaysia. *State of the 3Rs in Asia and the Pacific*. Nagoya: United Nations Centre for Regional Development. https://www.uncrd.or.jp/State_of_3Rs.

Peano L., Kounina A., Magaud V., Chalumeau S., Zgola, M. and Boucher J. (2020). *Plastic Leak Project Methodological Guidelines*. Lausanne: Quantis and EA.

Peng, G., Zhu, B., Yang, D., Lei, S., Shi, H. and Li, D. (2017). Microplastics in sediments of the Changjiang Estuary, China. *Environmental Pollution* 225, 283–290.

Peng, X., Dasgupta, S., Zhong, G., Du, M., Xu, H., Chen, M. et al. (2019). Large debris dumps in the northern South China Sea. *Marine Pollution Bulletin* 142, 164–168. https://doi.org/10.1016/j.marpolbul.2019.03.041.

PlasticsEurope (2018). Plastics–the Facts 2017. *An Analysis of European Plastics Production, Demand and Waste Data*. Brussels. https://www.plasticseurope.org/en/resources/publications/274–plastics–facts–2017.

Perpres 83/2018. (2018). Peraturan Presiden Republik Indonesia No. 83 Tahun 2018. Tentang Penanganan Sampah di Laut.

Philippines, Bureau of Fisheries and Aquatic Resources (BFAR) (2012). BFAR rescued two dolphins in Camarines Sur. 10 February. https://www.bfar.da.gov.ph/newsarchives.jsp?id=200. Accessed 15 December 2019.

Philippines, Department of Environment and Natural Resources, Environment Management Bureau (2018). *National Solid Waste Management Status Report 2018*. Quezon City. https://emb.gov.ph/wp-content/uploads/2019/08/National-Solid-Waste-Management-Status-Report-2008-2018.pdf.

PlasticsEurope (2019). Plastics–the Facts 2019. Brussels. https://www.plasticseurope.org/download_file/force/3183/181.

Poh-Poh, W. (1990). Coastal resources management: Tourism in Peninsular Malaysia. *ASEAN Economic Bulletin* 7(2), 213–221. https://www.jstor.org/stable/25770306.

Prabhakaran, S., Nair, V., and Ramachandran, S. (2013). Marine waste management indicators in a tourism environment. *Worldwide Hospitality and Tourism Themes* 5(4), 365–376. https://doi.org/10.1108/whatt-03-2013-0013.

Project AWARE. (2019). *Project AWARE Annual Report 2018*. Santa Margarita, CA: PADI AWARE Foundation. https://issuu.com/projectaware/docs/2018_impact_report.

Purba, N.P., Ihsan, Y.N., Faizal, I., Handyman, D.I.W., Widiastuti, K.S., Mulyani, P.G. et al. (2018). Distribution of macro debris in Savu Sea Marine National Park (Kupang, Rote, and Ndana Beaches), East Nusa Tenggara, Indonesia. *World News of Natural Sciences* 21, 64–76.

Qaisrani, Z.N., Shams, S. and Guo, Z. (2016). Analysis of debris flow in Kedayan River, Brunei Darussalam. In *Brunei International Conference on Engineering and Technology (BICET), 2016*. Universiti Teknologi Brunei. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/813009/A_review_of_research_on_marine_plastics_in_Southeast_Asia_-_Who_does_what.pdf.

Qaisrani, Z. N., Shams, S., Guo, Z., Reza, D. and Zainuddin, Q. (2018). Quantitative analysis of marine debris along the sea beaches of Brunei Darussalam. Paper presented at Seventh Brunei International Conference on Engineering and Technology (BICET 2018) held 12-14 November 2018 in Bandar Seri Begawan, Brunei. https://doi.org/10.1049/cp.2018.1605.

Qari, R. and Shaffat, M. (2015). Distribution and abundance of marine debris along the coast of Karachi (Arabian Sea), Pakistan. *Pakistan Journal of Scientific and Industrial Research Series B: Biological Sciences* 58(2), 98–103. https://doi.org/10.52763/PJSIR.BIOL.SCI.58.2.2015.98.103.

Ramakritinan, C.M., Ramkumar, B. and Kumaraguru, A.K. (2015). Growth of sponges around nylon rope and E-waste in the coastal water of Veedhalai, Gulf of Mannar, India. *International Journal of Current Microbiology and Applied Sciences* 4(8), 61–65. https://www.ijcmas.com/vol-4-8/C.M.%20Ramakritinan,%20et%20al.pdf.

Ranatunga, R.R.M.K.P. and Karunaratna, K.P. R. (2018). First evidence of microplastics in beach sand from Negombo, Sri Lanka and the potential accumulation in marine fish. Paper presented at the International Conference on Multidisciplinary Approaches in Social Sciences, Islamic & Technology (ICMASIT 2020) held 13-14 December 2020 in Kota Bharu, Kelantan, Malaysia.

Rani, M., Shim, W.J., Han, G.M., Jang, M., Al-Odaini, N.A., Song, Y.K. et al. (2015). Qualitative analysis of additives in plastic marine debris and its new products. *Archives of Environmental Contamination and Toxicology* 69(3), 352–366. https://doi.org/10.1007/s00244-015-0224-x.

Reddy, M.S., Basha, S., Adimurthy, S. and Ramachandraiah, G. (2006). Description of the small plastics fragments in marine sediments along the Alang–Sosiya ship–breaking yard, India. *Estuarine, Coastal and Shelf Science* 68(3–4), 656–660. https://doi.org/10.1016/j.ecss.2006.03.018.

Rios, L.M., Moore, C. and Jones, P.R. (2007). Persistent organic pollutants carried by synthetic polymers in the ocean environment. *Marine Pollution Bulletin* 54(8), 1230–1237. https://doi.org/10.1016/j.marpolbul.2007.03.022.

Robin, R.S., Karthik, R., Purvaja, R., Ganguly, D., Anandavelu, I., Mugilarasan, M. et al. (2019). Holistic assessment of microplastics in various coastal environmental matrices, southwest coast of India. *Science of The Total Environment*, 134947. https://doi.org/10.1016/j.scitotenv.2019.134947.

Rochman, C.M., Tahir, A., Williams, S.L., Baxa, D.V., Lam, R., Miller, J.T. et al. (2015). Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. *Scientific Reports* 5(1). https://doi.org/10.1038/srep14340.

Ryan, P.G. (2013). A simple technique for counting marine debris at sea reveals steep litter gradients between the Straits of Malacca and the Bay of Bengal. *Marine Pollution Bulletin* 69(1–2), 128–136. https://doi.org/10.1016/j.marpolbul.2013.01.016.

Saliu, F., Montano, S., Garavaglia, M.G., Lasagni, M., Seveso, D. and Galli, P. (2018). Microplastic and charred microplastic in the Faafu Atoll, Maldives. *Marine Pollution Bulletin* 136, 464–471. https://doi.org/10.1016/j.marpolbul.2018.09.023.

Saleem, B.I. (2020). Tourism in Maldives: Impact of COVID-19 and the way forward. *Maldives Economic Review* 1 (3), 9–11.

Satake, K., Okal, E.A. and Borrero, J.C. (2007). Tsunami and its hazard in the Indian and Pacific Oceans: Introduction. *Pure and Applied Geophysics* 164(2–3), 249–259. https://doi.org/10.1007/s00024–006–0172–5.

Satyanarayana, B., Van der Stocken, T., Rans, G., Kodikara, K.A.S., Ronsmans, G., Jayatissa, L.P. et al. (2017). Island-wide coastal vulnerability assessment of Sri Lanka reveals that sand dunes, planted trees and natural vegetation may play a role as potential barriers against ocean surges. *Global Ecology and Conservation* 12, 144–157. https://doi.org/10.1016/j.gecco.2017.10.001.

Selvam, S., Manisha, A., Venkatramanan, S., Chung, S.Y., Paramasivam, C.R. and Singaraja, C. (2020). Microplastic presence in commercial marine sea salts: A baseline study along Tuticorin Coastal salt pan stations, Gulf of Mannar, *South India*. *Marine Pollution Bulletin* 150, 110675. https://doi.org/10.1016/j.marpolbul.2019.110675.

Seth, C.K. and Shriwastav, A. (2018). Contamination of Indian sea salts with microplastics and a potential prevention strategy. *Environmental Science and Pollution Research* 25 (30), 30122- 30131. https://doi.org/10.1007/s11356-018-3028-5.

Sethy, S. (2017). Country chapter: The Kingdom of Cambodia. *State of the 3Rs in Asia and the Pacific* Nagoya: United Nations Centre for Regional Development. https://www.uncrd.or.jp/State_of_3Rs.

Shanmugam, P., Neelamani, S., Ahn, Y.H., Philip, L. and Hong, G.H. (2007). Assessment of the levels of coastal marine pollution of Chennai city, Southern India. *Water Resources Management* 21(7), 1187–1206.

Sharma, D.K. and Jain, S. (2019). Overview of municipal solid waste generation, composition, and management in India. *Journal of Environmental Engineering* 145 (3). https://ascelibrary.org/doi/abs/10.1061/%28ASCE%29EE.1943-7870.0001490.

Shaw, D.G. and Ignell, S.E. (1990). The quantitative distribution and characteristics of neuston plastic in the North Pacific Ocean, 1985–88. In *Proceedings of the Second International Conference on Marine Debris: 2–7 April 1989, Honolulu, Hawaii* 154, 182–246. https://nsgl.gso.uri.edu/hawau/hawauw89003/hawauw89003_part4.pdf.

Shimanaga, M. and Yanagi, K. (2016). The Ryukyu Trench may function as a “depocenter” for anthropogenic marine litter. *Journal of Oceanography* 72(6), 895–903. https://doi.org/10.1007/s10872-016-0388-7.

Shimizu, T., Nakai, J., Nakajima, K., Kozai, N., Takahashi, G., Matsumoto, M. et al. (2008). Seasonal variations in coastal debris on Awaji Island, Japan. *Marine Pollution Bulletin* 57(1–5), 182–186. https://doi.org/10.1016/j.marpolbul.2007.10.005.

Shiomoto, A. and Kameda, T. (2005). Distribution of manufactured floating marine debris in near-shore areas around Japan. *Marine Pollution Bulletin* 50(11), 1430–1432. https://doi.org/10.1016/j.marpolbul.2005.08.020.

Shuker, I.G. and Cadman, C.A. (2017). *Indonesia–Marine Debris Hotspot Rapid Assessment: Synthesis Report (English)*. Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/983771527663689822/Indonesia–Marine–debris–hotspot–rapid–assessment–synthesis–report.

Singapore, Ministry of Sustainability and the Environment (2018). *Key Environmental Statistics 2018*. Singapore.

Singh, R.K., Premakumara, D.G.J., Yagasa, R. and Onogawa, K. (2020). *State of Waste Management in Phnom Penh, Cambodia*. Kanagawa, Japan: IGES Centre Collaborating with UNEP on Environmental Technologies (CCET) of Institute for Global Environmental Strategies (IGES). https://www.unep.org/ietc/resources/report/state-waste-management-phnom-penh-cambodia.

Song, Y.K., Hong, S.H., Jang, M., Kang, J.H., Kwon, O.Y., Han, G.M. et al. (2014). Large accumulation of micro-sized synthetic polymer particles in the sea surface microlayer. *Environmental Science and Technology* 48(16), 9014–9021. https://doi.org/10.1021/es501757s.

Song, Y.K., Hong, S.H., Jang, M., Han, G.M. and Shim, W.J. (2015a). Occurrence and distribution of microplastics in the sea surface microlayer in Jinhae Bay, South Korea. *Archives of Environmental Contamination and Toxicology* 69(3), 279–287. https://doi.org/10.1007/s00244-015-0209-9.

Song, Y.K., Hong, S.H., Jang, M., Han, G.M., Rani, M., Lee, J. and Shim, W.J. (2015b). A comparison of microscopic and spectroscopic identification methods for analysis of microplastics in environmental samples. *Marine Pollution Bulletin* 93(1–2), 202–209. https://doi.org/10.1016/j.marpolbul.2015.01.015.

Song, Y.K., Hong, S.H., Eo, S., Jang, M., Han, G.M., Isobe, A. et al. (2018). Horizontal and vertical distribution of microplastics in Korean coastal waters. *Environmental Science & Technology* 52 (21), 12188–12197. https://doi.org/10.1021/acs.est.8b04032.

South Asia Co-operative Environment Programme (SACEP). (2017). South Asia Co-operative Environment Programme. Fact sheet. http://www.sacep.org/pdf/General-Publications/2017.05-SACEP-Leaflet.pdf.

Sri Lanka and United Nations (2018). *MAPS Approach Supporting SDG Implementation in Sri Lanka*. Columbo. https://www.lk.undp.org/content/dam/srilanka/docs/localpublications/MAPS%20Sri%20Lanka%20Report-MAR18.pdf. Accessed 31 July 2019.

Sri Lanka, Department of Statistics (2001). *Brief Analysis of Population and Housing Characteristics*. Columbo. http://www.statistics.gov.lk/pophousat/pdf/p7%20population%20and%20housing%20text-11-12-06.pdf. Accessed 31 October 2019.

Sri Lanka Tourism Development Authority (2017). Monthly statistical bulletins: Monthly tourist arrivals reports 2017. Colombo. https://sltda.gov.lk/en/monthly-statistical-bulletins-2017. Accessed 29 November 2019.

Sruthy, S. and Ramasamy, E.V. (2017). Microplastic pollution in Vembanad Lake, Kerala, India: The first report of microplastics in lake and estuarine sediments in India. *Environmental Pollution* 222, 315–322. https://doi.org/10.1016/j.envpol.2016.12.038.

Stelfox, M. and Hudgins, J. (2015). A two–year summary of turtle entanglements in ghost gear in the Maldives. *Indian Ocean Turtle Newsletter* 22,14–20. https://www.iotn.org/iotn22-06-a-two-year-summary-of-turtle-entanglements-in-ghost-gear-in-the-maldives/.

Street, M.E. and Bernasconi, S. (2021). Microplastics, environment and child health. *Italian Journal of Pediatrics* 47, 75. https://doi.org/10.1186/s13052-021-01034-3.

Su, L., Xue, Y., Li, L., Yang, D., Kolandhasamy, P., Li, D. and Shi, H. (2016). Microplastics in Taihu Lake, China. *Environmental Pollution* 216, 711–719. https://doi.org/10.1016/j.envpol.2016.06.036.

Suh, W. (2018). Progress in addressing marine litter in Korea: Recent policies and efforts to protect the marine environment from marine litter. Presented June 18. https://wedocs.unep.org/bitstream/handle/20.500.11822/26499/ML_Korea.pdf?sequence=1&isAllowed=y.

Sun, X., Liang, J., Zhu, M., Zhao, Y. and Zhang, B. (2018). Microplastics in seawater and zooplankton from the Yellow Sea. *Environmental Pollution* 242, 585–595.

Syakti, A.D., Bouhroum, R., Hidayati, N.V., Koenawan, C.J., Boulkamh, A., Sulistyo, I. et al. (2017). Beach macro-litter monitoring and floating microplastic in a coastal area of Indonesia. *Marine Pollution Bulletin* 122(1–2), 217–225. https://doi.org/10.1016/j.marpolbul.2017.06.046.

Syakti, A.D., Hidayati, N.V., Jaya, Y.V., Siregar, S.H., Yude, R., Suhendy et al. (2018). Simultaneous grading of microplastic size sampling in the Small Islands of Bintan water, Indonesia. *Marine Pollution Bulletin* 137, 593–600. https://doi.org/10.1016/j.marpolbul.2018.11.005.

Syakti, A.D., Jacob, M., Birrien, T., Suhana, M.P., Aziz, M.Y., Salim, A. et al. (2019). Daily apportionment of stranded plastic debris in the Bintan Coastal area, Indonesia. *Marine Pollution Bulletin* 149, 110609. https://doi.org/10.1016/j.marpolbul.2019.110609.

Tahir, A., Samawi, M.F., Sari, K., Hidayat, R., Nimzet, R., Wicaksono, E.A. et al. (2019). Studies on microplastic contamination in seagrass beds at Spermonde Archipelago of Makassar Strait, Indonesia. *Journal of Physics: Conference Series* 1341, 022008. https://doi.org/10.1088/1742-6596/1341/2/022008.

Tanaka, K. and Takada, H. (2016). Microplastic fragments and microbeads in digestive tracts of planktivorous fish from urban coastal waters. *Scientific Reports* 6(1). https://doi.org/10.1038/srep34351.

Teng, J., Wang, Q., Ran, W., Wu, D., Liu, Y., Sun, S. et al. (2018). Microplastic in cultured oysters from different coastal areas of China. *Science of The Total Environment* 653, 1282–1292. https://doi.org/10.1016/j.scitotenv.2018.11.057.

Thailand, Government of (2019).Thailand: Country 3R Progress Report (draft): Voluntary Progress/Achievements/Initiatives in Implementing Ha Noi 3R Declaration (2013-2023). Presented at the Ninth Regional 3R Forum in Asia and the Pacific held 4-6 March 2019 in Bangkok.

Thailand, Ministry of Natural Resources and Environment, Pollution Control Department (2019). *Booklet on Thailand State of Pollution 2018*. Bangkok. http://www.oic.go.th/FILEWEB/CABINFOCENTER3/DRAWER056/GENERAL/DATA0001/00001462.PDF.

Thailand, Ministry of Natural Resources and Environment, Pollution Control Department (2021). Thailand State of Pollution 2020 (B.E. 2563) (press release). March 5. https://www.pcd.go.th/wp-content/uploads/2021/03/pcdnew-2021-03-31_09-59-54_127801.pdf.

Thang, N.T. (2017). Country chapter: The Socialist Republic of Viet Nam. *State of the 3Rs in Asia and the Pacific*. Nagoya: United Nations Centre for Regional Development. https://www.uncrd.or.jp/content/documents/5696[Nov%202017]%20Vietnam.pdf.

Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J. John, A.W.G., McGonigle, D. and Russell, A.E. (2004). Lost at sea: Where is all the plastic? Science 304 (567), 838. https://doi.org/10.1126/science.1094559.

Thushari, G.G.N., Chavanich, S. and Yakupitiyage, A. (2017). Coastal debris analysis in beaches of Chonburi Province, eastern of Thailand as implications for coastal conservation. *Marine Pollution Bulletin* 116(1–2), 121–129. https://doi.org/10.1016/j.marpolbul.2016.12.056.

Thushari, G.G.N, Senevirathna, J.D.M., Yakupitiyage A. and Chavanich, S. (2017). Effects of microplastics on sessile invertebrates in the eastern coast of Thailand: An approach to coastal zone conservation. *Marine Pollution Bulletin* 124 (1), 349-355. https://doi.org/10.1016/j.marpolbul.2017.06.010.

Timor-Leste, Government of (2019). Government prepares partnership for plastic transformation. 3 April. http://timor-leste.gov.tl/?p=21531&lang=en&n=1.

Todd, P.A., Ong, X. and Chou, L.M. (2010). Impacts of pollution on marine life in Southeast Asia. *Biodiversity and Conservation* 19(4), 1063–1082. https://doi.org/10.1007/s10531-010-9778-0.

Uchida, K., Hagita, R., Hayashi, T. and Tokai, T. (2016). Distribution of small plastic fragments floating in the western Pacific Ocean from 2000 to 2001. Fisheries Science 82(6), 969–974.

Uneputty, P.A. and Evans, S.M. (1997a). Accumulation of beach litter on islands of the Pulau Seribu Archipelago, Indonesia. *Marine Pollution Bulletin* 34(8), 652–655. https://doi.org/10.1016/s0025-326x(97)00006-4.

Uneputty, P. and Evans, S.M. (1997b). The impact of plastic debris on the biota of tidal flats in Ambon Bay (eastern Indonesia). *Marine Environmental Research* 44(3), 233–242. https://doi.org/10.1016/s0141-1136(97)00002-0.

United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects 2017– Data Booklet (ST/ESA/SER.A/401). https://population.un.org/wpp/Publications/Files/WPP2017_DataBooklet.pdf. Accessed 10 September 2017.

United Nations, Department of Economic and Social Affairs, Population Division (2019). *World Population Prospects 2019* (online edition, rev. 1). New York. https://population.un.org/wpp/Download/Standard/Population/. Accessed 10 December 2019.

United Nations, Economic and Social Commission for Asia and the Pacific (2021). *Asia and the Pacific SDG Progress Report 2021*. Bangkok. https://www.unescap.org/kp/2021/asia-and-pacific-sdg-progress-report-2021.

United Nations Environment Assembly (2019). National Statement of Bangladesh at the Fourth Session of the United Nations Environment Assembly, Delivered by H.E. Mr. Shahab Uddin Minister for Environment, Forest and Climate Change of Bangladesh held 11–15 March 2019 in Nairobi. http://web.unep.org/environmentassembly/bangladesh-0. Accessed 15 December 2019.

United Nations General Assembly. *Oceans and the law of the sea* (A/RES/72/73 5 December 2017). https://undocs.org/en/a/res/72/73.

United Nations, Statistics Division (UNSD) (2018). *UNSD Environmental Indicators*. New York.https://unstats.un.org/unsd/envstats/qindicators.cshtml.

United Nations Environment Programme (1995). Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. UNEP (OCA)/LBA/IG.2/7 (adopted 5 December 1995).

United Nations Environment Programme (2009). *Marine Litter: A Global Challenge. Nairobi*. https://wedocs.unep.org/20.500.11822/7787.

United Nations Environment Programme, Coordinating Body on the Seas of East Asia (2011). *Spatial Planning in the Coastal Zone of the East Asian Seas Region: Integrating Emerging Issues and Modern Management Approaches*. Interim Publication. Bangkok.

United Nations Environment Programme (2017). *Asia Waste Management Outlook*. Bangkok. https://www.unep.org/ietc/resources/publication/asia-waste-management-outlook.

United Nations Environment Programme (2017a). *Summary Report: Waste Management in ASEAN Countries*. Nairobi. https://wedocs.unep.org/handle/20.500.11822/21134.

United Nations Environment Programme (2018). *Mapping of Global Plastics Value Chain and Plastics Losses to the Environment (with a Particular Focus on Marine Environment)*. Nairobi.

United Nations Environment Programme (2019). *Global Environment Outlook – GEO-6 Healthy Planet, Healthy People*. Ekins, P., Gupta, J. and Boileau, P. (eds.) Nairobi. https://wedocs.unep.org/handle/20.500.11822/27539.

United Nations Environment Programme (2021). *NEGLECTED: Environmental Justice Impacts of Marine Litter and Plastic Pollution*. Nairobi. https://www.unep.org/resources/report/neglected-environmental-justice-impacts-marine-litter-and-plastic-pollution.

United Nations Environment Programme and Development Alternatives (2014). *South Asia Environment Outlook 2014*. Bangkok: UNEP; Kathmandu: South Asian Association for Regional Cooperation; and New Delhi: Development Alternatives. http://www.sacep.org/pdf/Reports-Technical/2014-South-Asia-Environment-Outlook-2014.pdf. Accessed 15 December 2019.

United Nations Centre for Regional Development (2018). *State of the 3Rs in Asia and the Pacific. Nagoya*. https://www.uncrd.or.jp/content/documents/6777[full%20document]%20State%20of%20the%203Rs%20in%20Asia%20and%20the%20Pacific.pdf.

United States Agency for International Development. (2019). The sea that sustains us. [online video]. Washington, D.C. https://www.usaid.gov/timor-leste/videos/the-sea-that-sustains-us.

van Emmerik, T., Kieu-Le, T.-C., Loozen, M., van Oeveren, K., Emilie, S., Bui, X.-T. et al. (2018). A methodology to characterize riverine macroplastic emission into the ocean. *Frontiers in Marine Science* 5, 372. https://doi.org/10.3389/fmars.2018.00372.

Veerasingam, S., Mugilarasan, M., Venkatachalapathy, R. and Vethamony, P. (2016b). Influence of 2015 flood on the distribution and occurrence of microplastic pellets along the Chennai coast, India. *Marine Pollution Bulletin* 109(1), 196–204. https://doi.org/10.1016/j.marpolbul.2016.05.082.

Veerasingam, S., Saha, M., Suneel, V., Vethamony, P., Rodrigues, A.C., Bhattacharyya, S. and Naik, B.G. (2016a). Characteristics, seasonal distribution and surface degradation features of microplastic pellets along the Goa coast, India. *Chemosphere* 159, 496–505. https://doi.org/10.1016/j.chemosphere.2016.06.056.

Velander, K. and Mocogni, M. (1999). Beach litter sampling strategies: Is there a '"best"' method? *Marine Pollution Bulletin* 38(12), 1134–1140. https://doi.org/10.1016/S0025-326X%2899%2900143-5.

Venrick, E.L., Backman, T.W., Bartram, W.C., Platt, C.J., Thornhill, M.S. and Yates, R.E. (1973). Man-made objects on the surface of the central North Pacific Ocean. *Nature* 241(5387), 271. https://doi.org/10.1038/241271a0.

Vidyasakar, A., Neelavannan, K., Krishnakumar, S., Prabaharan, G., Sathiyabama Alias Priyanka, T., Magesh, N.S. et al. (2018). Macrodebris and microplastic distribution in the beaches of Rameswaram Coral Island, Gulf of Mannar, Southeast coast of India: A first report. Marine *Pollution Bulletin* 137, 610–616. https://doi.org/10.1016/j.marpolbul.2018.11.007.

Weiss, L., Ludwig, W., Heussner, S., Canals, M., Ghiglione, J., Estournel, C. et al. (2021). The missing ocean plastic sink: Gone with the rivers. Science 373, 107–111.

Wenger, M. (2019). Olive Ridley Project – PADI distinctive specialty, July 29. https://pros-blog.padi.com/2019/07/29/olive-ridley-project-padi-specialty/.

Wesch, C., Bredimus, K., Paulus, M. and Klein, R. (2016). Towards the suitable monitoring of ingestion of microplastics by marine biota: A review. *Environmental Pollution* 218, 1200–1208.

Willoughby, N.G. (1986). Man-made litter on the shores of the Thousand Island archipelago, Java. *Marine Pollution Bulletin* 17(5), 224–228. https://doi.org/10.1016/0025-326x(86)90605-3.

Willoughby, N.G., Sangkoyo, H. and Lakaseru, B.O. (1997). Beach litter: An increasing and changing problem for Indonesia. *Marine Pollution Bulletin* 34(6), 469–478. https://doi.org/10.1016/s0025-326x(96)00141-5.

World Bank (2007). Demographic trends, the profile of old people, and the emerging issues.

World Travel and Tourism Council (2018). *Travel and Tourism Economic Impact 2018 Sri Lanka*. London.

Xanthos, D. and Walker, T.R. (2017). International policies to reduce plastic marine pollution from single–use plastics (plastic bags and microbeads): A review. *Marine Pollution Bulletin* 118(1–2), 17–26.

Xiong, X., Zhang, K., Chen, X., Shi, H., Luo, Z. and Wu, C. (2018). Sources and distribution of microplastics in China's largest inland lake–Qinghai Lake. *Environmental Pollution* 235, 899–906.

Xu, P., Peng, G., Su, L., Gao, Y., Gao, L. and Li, D. (2018). Microplastic risk assessment in surface waters: A case study in the Changjiang Estuary, China. *Marine Pollution Bulletin* 133, 647–654.

Yamaguchi, H. and Yokoyama, Y. (1998). Coastal pollution by foreign drifted garbages. *Proceedings of the Symposium on Global Environment* 6, 269–278. https://doi.org/10.2208/proge.6.269.

Yamakita, T., Yamamoto, H., Yokoyama, Y., Sakamoto, I., Tsuchida, S., Lindsay et al. (2015). Distribution of the marine debris on seafloor from the primary report of five cruises after the Great East Japan Earthquake 2011. *In Marine Productivity: Perturbations and Resilience of Socio-ecosystems: Proceedings of the 15th French-Japanese Oceanography Symposium*. Ceccaldi, H.-J., Hénocque, Y., Koike, Y., Komatsu, T., Stora, G., Tusseau-Vuillemin, M.-H. (eds.) London: Springer Nature B.V. 101–109.

Yamashita, R. and Tanimura, A. (2007). Floating plastic in the Kuroshio current area, western North Pacific Ocean. *Marine Pollution Bulletin* 4(54), 485–488.

Yi, C.J., and Kannan, N. (2016). Solid waste transportation through ocean currents: Marine debris sightings and their waste quantification at Port Dickson Beaches, Peninsular Malaysia. *Environment Asia* 9(2), 39–47. https://doi.org/10.14456/ea.2016.6.

Yin, C.S., Chai, Y.J., Carey, D., Yusup, Y. and Gallagher, J.B. (2019). Anthropogenic marine debris and its dynamics across peri-urban and urban mangroves on Penang Island, Malaysia. *bioRxiv* 756106. https://www.biorxiv.org/content/10.1101/756106v1.full.pdf.

Yu, X., Peng, J., Wang, J., Wang, K. and Bao, S. (2016). Occurrence of microplastics in the beach sand of the Chinese inner sea: The Bohai Sea. *Environmental Pollution* 214, 722–730.

Zhang, K., Gong, W., Lv, J., Xiong, X. and Wu, C. (2015). Accumulation of floating microplastics behind the Three Gorges Dam. *Environmental Pollution* 204, 117–123.

Zhang, K., Xiong, X., Hu, H., Orcid, C.W., Bi, Y., Wu, Y. et al. (2017). Occurrence and Characteristics of Microplastic Pollution in Xiangxi Bay of Three Gorges Reservoir, China. *Environmental Science & Technology* 51(7), 3794–3802.

Zhang, K., Su, J., Xiong, X., Wu, X., Wu, C. and Liu, J. (2016). Microplastic pollution of lakeshore sediments from remote lakes in Tibet plateau, China. *Environmental Pollution* 219, 450–455.

Zhang, W., Zhang, S., Wang, J., Wang, Y., Mu, J., Wang, P. et al. (2017). Microplastic pollution in the surface waters of the Bohai Sea, China. *Environmental Pollution* 231(1), 541–548. https://doi.org/10.1016/j.envpol.2017.08.058.

Zhang, Z., Wu, H., Peng, G., Xu, P. and Li, D. (2020). Coastal ocean dynamics reduce the export of microplastics to the open ocean. *Science of The Total Environment* 713, 136634. https://doi.org/10.1016/j.scitotenv.2020.136634.

Zhao, S., Wang, T., Zhu, L., Xu, P., Wang, X., Gao, L. et al. (2019). Analysis of suspended microplastics in the Changjiang Estuary: Implications for riverine plastic load to the ocean. Water Research 161, 560–569.

Zhao, S., Zhu, L. and Li, D. (2015a). Microplastic in three urban estuaries, China. Environmental Pollution 206, 597–604. Zhao, S., Zhu, L. and Li, D. (2015). Characterization of small plastic debris on tourism beaches around the South China Sea. *Regional Studies in Marine Science* 1, 55–62. https://doi.org/10.1016/j.rsma.2015.04.001.

Zhou, P., Huang, C., Fang, H., Cai, W., Li, D., Li, X. et al. (2011). The abundance, composition and sources of marine debris in coastal seawaters or beaches around the northern South China Sea (China). *Marine Pollution Bulletin* 62(9), 1998–2007.

Zhou, C., Liu, X., Wang, Z., Yang, T., Shi, L., Wang, L. et al. (2016). Assessment of marine debris in beaches or seawaters around the China Seas and coastal provinces. *Waste Management* 48, 652–660.

Zhu, L., Bai, H., Chen, B., Sun, X., Qu, K. and Xia, B. (2018). Microplastic pollution in North Yellow Sea, China: Observations on occurrence, distribution and identification. *Science of The Total Environment* 636, 20–29

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