Review of **Current Knowledge and Data on Marine Litter** in Asia

ISBN No:
Job No:

Suggested citation
To be added

Production

Regional Office for Asia and the Pacific | United Nations Environment Programme | UN Building | Rajdamnern Avenue, Bangkok 10200, Thailand

Tel: +66 2 2882314 | Email: uneproap@un.org | www.unenvironment.org/regions/asia-and-pacific

Supported by

Government
of Noway

COBSEA
COORDINATING BODY ON THE SEAS OF EAST ASIA

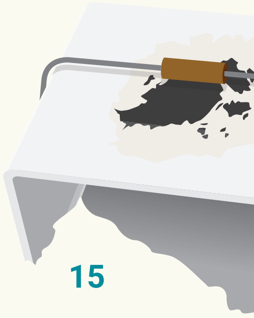
UNEP promotes
environmentally sound
practices globally and
in its own activities. Our
distribution policy aims to reduce
UN Environment's carbon footprint.

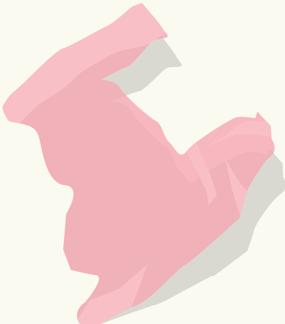
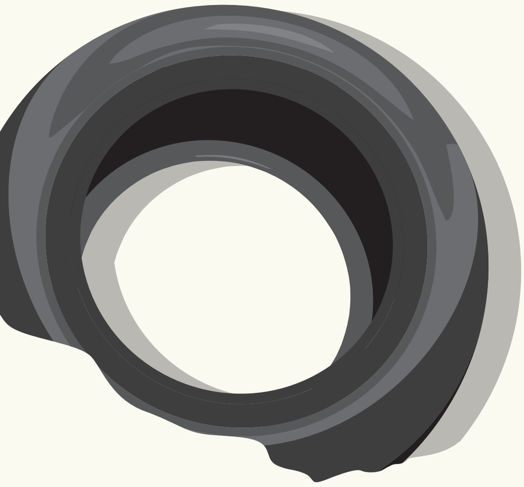
Images from https://www.cleanseas.org

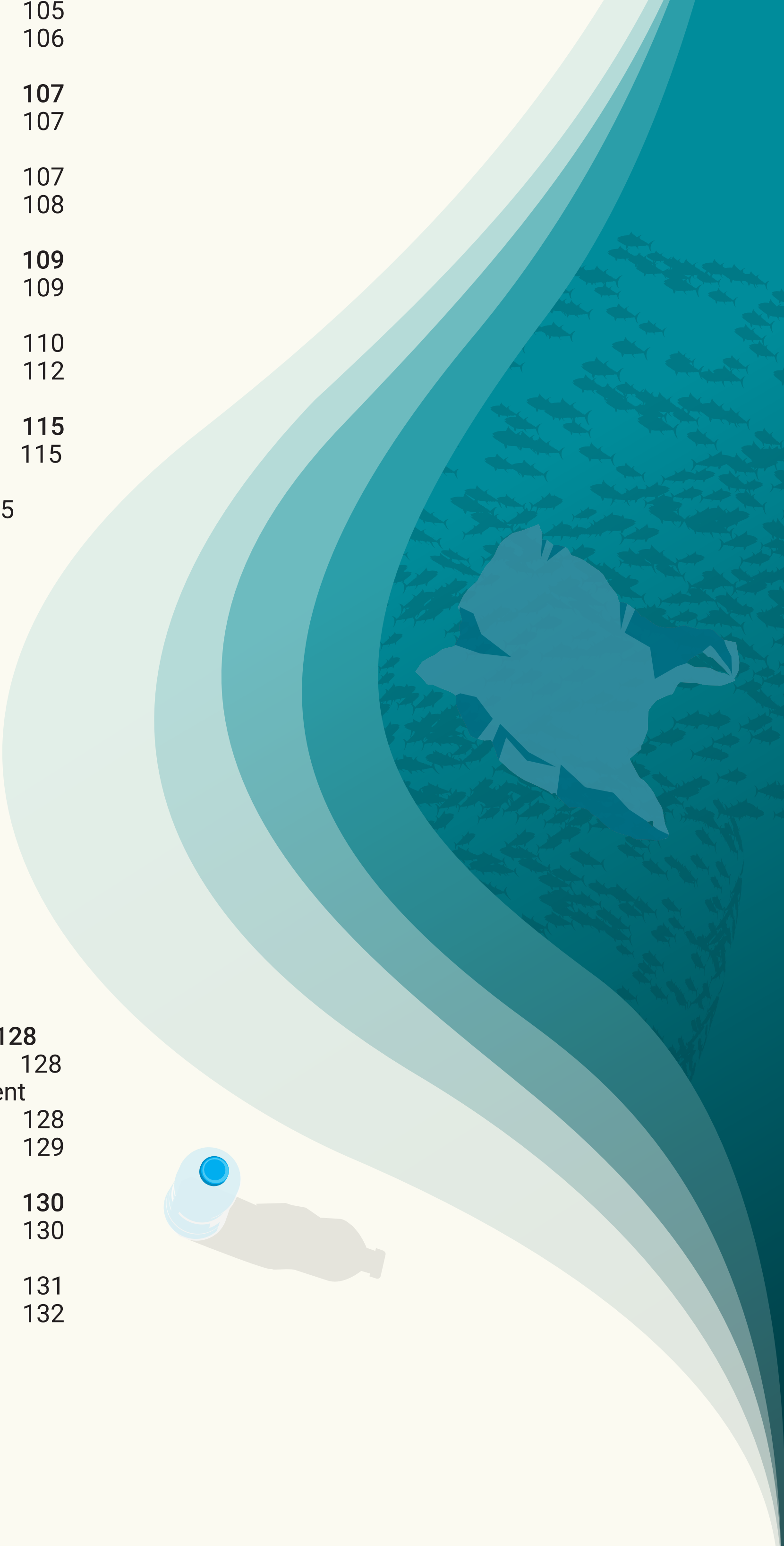
Review of Current Knowledge and Data on Marine Litter in Asia

Preview Edition

Table of Contents



List of Figures

List of Tables

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 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, complicating treatment and disposal capacities. While fighting the pandemic, the pollution challenge on both land and in the seas has deepened. 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 will serve as an essential resource guiding discussions of the Inaugural Session of Asia-Pacific Science-Policy-Business Forum on the Environment, held virtually on 5 October 2021. This report will also inform the fourth session of the Forum of Ministers and Environment Authorities of the Asia-Pacific, co-hosted by UNEP and 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

ACKNOWLEDGEMENTS

Supported by

Royal Norwegian Ministry of Climate and Environment

East China Normal University

Minderoo Foundation Trust

COBSEA

Lead authors

Daoji Li (*East China Normal University, China*), Lixin Zhu (*East China Normal University, China*), Dominic Charles (*Minderoo Foundation, Australia*), Siyuan Chang (*East China Normal University, China*), Hui Wu (*East China Normal University, China*), Yunxuan Zhou (*East China Normal University, China*) and Ljubomir Jeftic (*independent consultant, Croatia*).

Contributing authors

Laurent Kimman (*Minderoo Foundation, Australia*), Nakul Saran (*Minderoo Foundation, Australia*), Pei Xu (*East China Normal University, China*), Feng Zhang (*East China Normal University, China*), Mengyu Bai (*East China Normal University, China*), Changjun Li (*East China Normal University, China*), Xiaohui Wang (*East China Normal University, China*), Changxing Zong (*East China Normal University, China*), Nian Wei (*East China Normal University, China*), Shuzhen Song (*East China Normal University, China*), Jiayi Xu (*East China Normal University, China*), Kai Liu (*East China Normal University, China*), Guyu Peng (*East China Normal University, China*), Zhangyu Song (*East China Normal University, China*), Zhiwei Zhang (*East China Normal University, China*), Ana Vukoje (*UNEP*) and Jinhua Zhang (*UNEP*)

Reviewers

Arum Prajanti (*Ministry of Environment and Forestry, Indonesia*), Lihui An (*Chinese Research Academy of Environmental Sciences, China*), Valerie Chia (*Ministry of the Environment and Water Resources, Singapore*), Mahatma Lanuru (*Hasanuddin University, Indonesia*), Keiichi Uchida (*Tokyo University of Marine Science and Technology, Japan*), Ning Liu (*Northwest Pacific Action Plan, UNEP*), Heidi Savelli Soderberg (*UNEP*), Win Colton Cowger (*University of California – Riverside, United States*), Britta Denise Hardesty (*CSIRO Ocean and Atmosphere, Australia*), Marcus Eriksen (*The Gyres Institute, United States*), Kanako Sato (*Ministry of the Environment, Japan*), Percie Otico (*the Philippines*), Shufeng Ye (*East China Sea Environmental Monitoring Center of SOA, China*), Ren Xu (*Polar Research Institute of China, China*), Anglv Shen (*Shanghai Ocean University, China*), Jonas R. Leones (*Department of Environment and Natural Resources, the Philippines*), Annette Wallgren (UNEP), Jinhua Zhang (UNEP)

UNEP coordination team

Ning Liu, Heidi Savelli-Soderberg, Jerker Tamelander (upto May 2021), Ana Vukoje (September 2019–June 2021), Panvirush Vittayapraphakul and Jinhua Zhang

ACRONYMS AND ABBREVIATIONS

APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
COBSEA	Coordinating Body on the Seas of East Asia
DA	Development Alternatives
FAO	Food and Agriculture Organization of the United Nations
FTIR	Fourier-transform infrared spectroscopy
GPML	Global Partnership on Marine Litter
GDP	Gross Domestic Product
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
ha	Hectare (=10 000 m^2)
IMO	International Maritime Organization (of the UN)
IOC-UNESCO	Intergovernmental Oceanographic Commission of UNESCO
MP	Microplastic
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration (United States)
NORAD	Norwegian Agency for Development Cooperation
NOWPAP	North West Pacific Action Plan
NSWMC	National Solid Waste Management Commission (of the Philippines)
RAP MALI	Regional Action Plan on Marine Litter
ROV	Remotely Operated Vehicles
RSP	Regional Seas Programme (UNEP)
SACEP	South Asia Co-operative Environment Programme
SDG	Sustainable Development Goal
SOA	State Oceanic Administration (People's Republic of China)
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
WBG	World Bank Group

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, quickly gains attention globally, the understanding of its sources, transportation and fate is still poor, 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), it becomes a priority to improve the understanding of the status of marine litter and waste management in Asia. This is an imperative to coordinate an effective mitigation strategy.

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 impacts of the pandemic on marine litter in Asia, available data has shown a significant increase in the single use of 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 negatively affecting the profitability of plastic recycling, these factors have resulted in a decrease of recycling rates compared with pre-pandemic levels (UNEP 2021).

As recognized in the 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, 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). The Fourth Session of UN Environment Assembly, with the adoption of Resolution 4/6, acknowledges the need for high-quality data and effective monitoring of land- and sea-based sources, of quantities and the fate, and of distribution and impact of marine litter to foster effective action. This resolution also requests UNEP to strengthen scientific and technological knowledge regarding marine litter, through measures including compiling available scientific and other relevant data and information to prepare an assessment on the source, distribution and fate of marine litter, including plastic litter and microplastics, in rivers the seas and oceans.

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. It presents a summary and data of the latest peer-reviewed scientific publications on marine litter distribution and impacts, its land-based sources, waste management and end-of-life fate pathways, 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)—through 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 (DPR) of Korea, Republic of Korea, Malaysia, the Maldives, Myanmar, Pakistan, the 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 14.8 Increase scientific knowledge, research and technology for ocean health Develop research capacity and transfer marine technology, 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

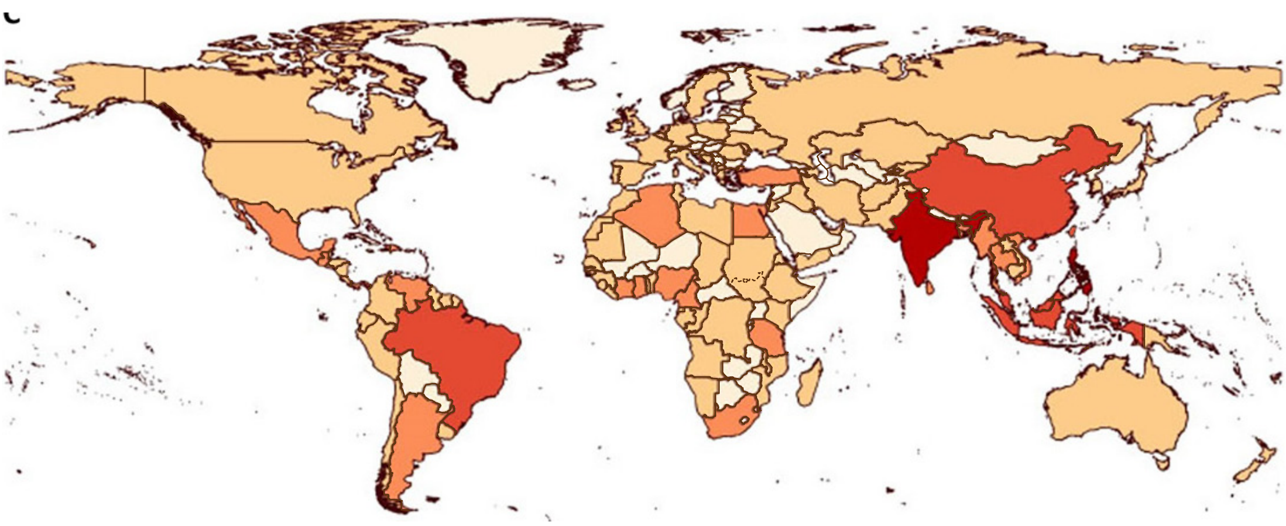
Reviewing the state of the current knowledge and available data on marine litter in Asia is an issue of great urgency and global importance. Measures of the total accumulation and negative impacts of marine plastic litter *at any level* (national, subregional, regional or global) are elusive and challenging. Previous independent research in 2010 has, however, estimated the annual flows of plastic entering the ocean between 4.8 and 12.7 million metric tonnes 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, the rapid industrialization, economic growth, booming population and social development as well as natural factors such as wind, current, waves, 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, 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— eight countries have been listed among the world's top-20 contributors to increased marine plastic litter emissions by 2030.

Geospatial distribution of plastic entering the ocean through rivers

Figure 1 /



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

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

Adapted from Meijer *et al*. (2021)

However, although by viewing global maps, it may seem that Asia is the primary contributor of marine litter, it is important to note that the 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 import of non-industrial plastic waste, an estimated 111 million metric tonnes of plastic waste was exported to that country (Brooks *et al*. 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 has been taken through active regional seas programmes (for example, Coordinating Body on the Seas of East Asia [COBSEA], the Northwest Pacific Action Plan [NOWAP] and

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	●			●

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: 1) COBSEA Regional Action Plan on Marine Litter 2) NOWPAP Regional Action Plan on Marine Litter 3) G20 Blue Ocean Vision: G20's Osaka Blue Ocean Vision that aims to reduce the amount of new marine plastic waste to zero by 2050; 4) Bangkok Declaration on Combating Marine Debris in ASEAN Region

the South Asian Seas Programme [SASP]) as well as under the framework of the and 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, Republic of Korea, Singapore, Thailand and Viet Nam. COBSEA has been active on the issue of marine litter, with the Regional Action Plan on Marine litter (RAP MALI) approved in 2008. Despite the high awareness on the issue of marine litter in the region, financial constraint has so far limited the implementation of relevant activities. The updated and revised plan was adopted in June 2019.

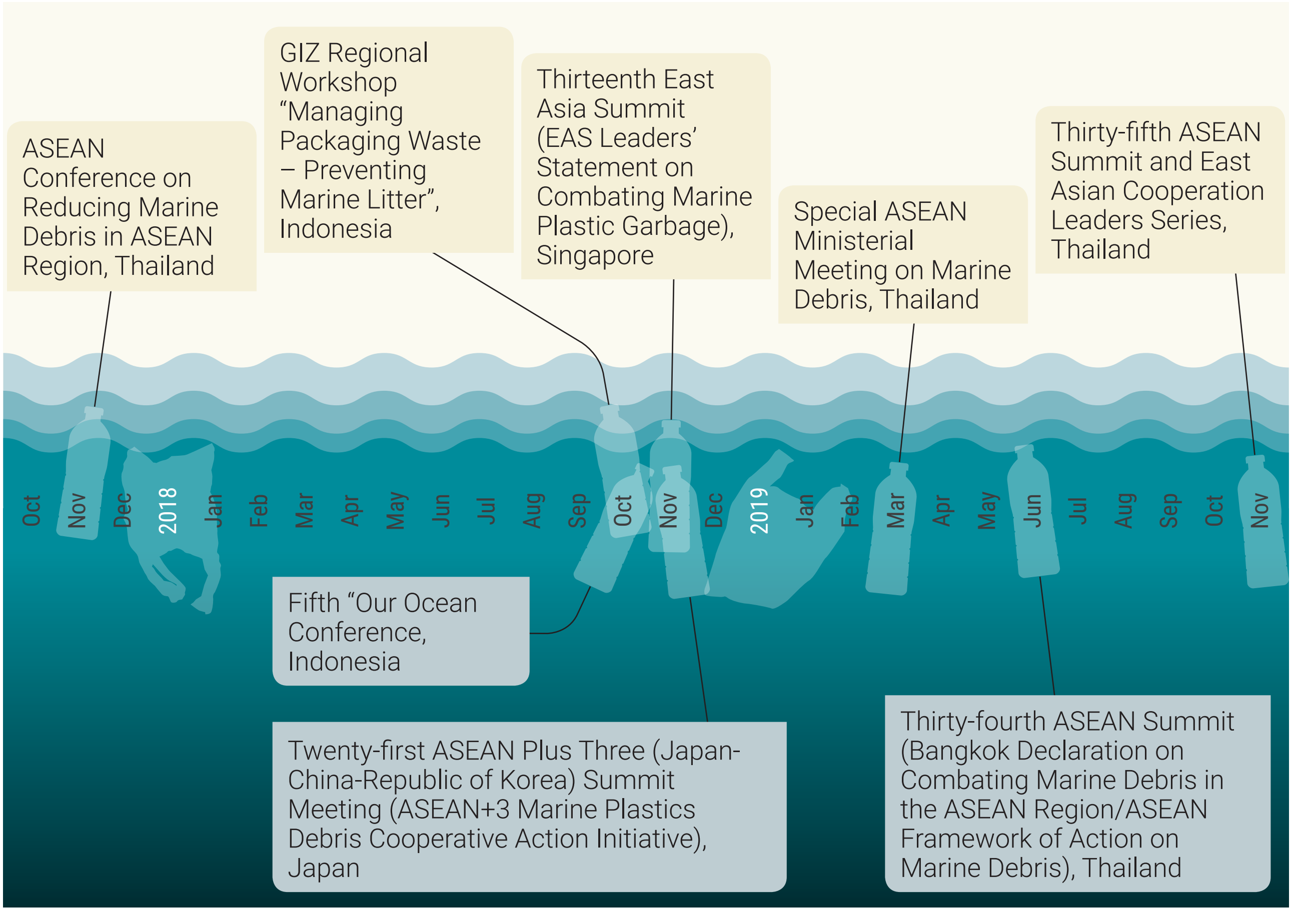
The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) was adopted in 1994 by China, Japan, the Republic of Korea and Russia as a part of the Regional Seas Programme of UNEP. NOWPAP has been active on the issue of 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 Asia Seas Region Programme 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. South Asia Seas Region Programme has been engaging on the issue of marine litter mostly through the development of a report on marine litter in the region, which included a review of the status of marine litter in the region as well as a framework for marine litter management, in 2007, and the development of a Regional Marine Litter Action Plan in 2017. The Plan, prepared by the South Asia Co-operative Environment Programme (SACEP) with the support of UNEP-GPA, is envisaged as an implementation guide and reference tool.

In 2007, the United Nations Coordinating Body on the Seas of East Asia (COBSEA), which includes most of ASEAN's maritime members as participants, held a seminar in Jakarta, Indonesia, on marine litter in East Asian waters and initially formed the COBSEA Regional Action Plan on Marine Litter. Based on this seminar, in 2008, COBSEA published its first report on the pollution status of marine debris in the East Asian seas. Moreover, its working group focusing on improving ASEAN coast's marine environment has been instrumental in controlling marine debris in ASEAN countries. 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 (GPA) was held in Manila, the Philippines, and adopted 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 governments of Asian countries, and ASEAN countries have gradually shifted towards including

Meetings relating to marine litter in ASEAN Table 3 /



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, the Philippines, Vietnam, Thailand and Malaysia 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 includes the protection of the marine environment. In November 2017, the ASEAN Conference on Reducing Marine Debris in ASEAN Region in Phuket, Thailand, focused on marine debris. 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 13th East Asia Summit in Singapore, and the Marine Plastics Debris Cooperative Action Initiative was announced at the 21st ASEAN-China-Japan-Korea Leadership Summit in Japan.

In March 2019, the ASEAN Ministerial Meeting issued a joint statement on marine litter management in Bangkok, Thailand, calling on all Member states to cooperate and take effective measures to improve waste management, prevent land-based pollution from entering the sea and formulate action plans. Through this Declaration, ASEAN also announced the founding of Regional Knowledge Centre for Marine Plastic Debris, which was 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.

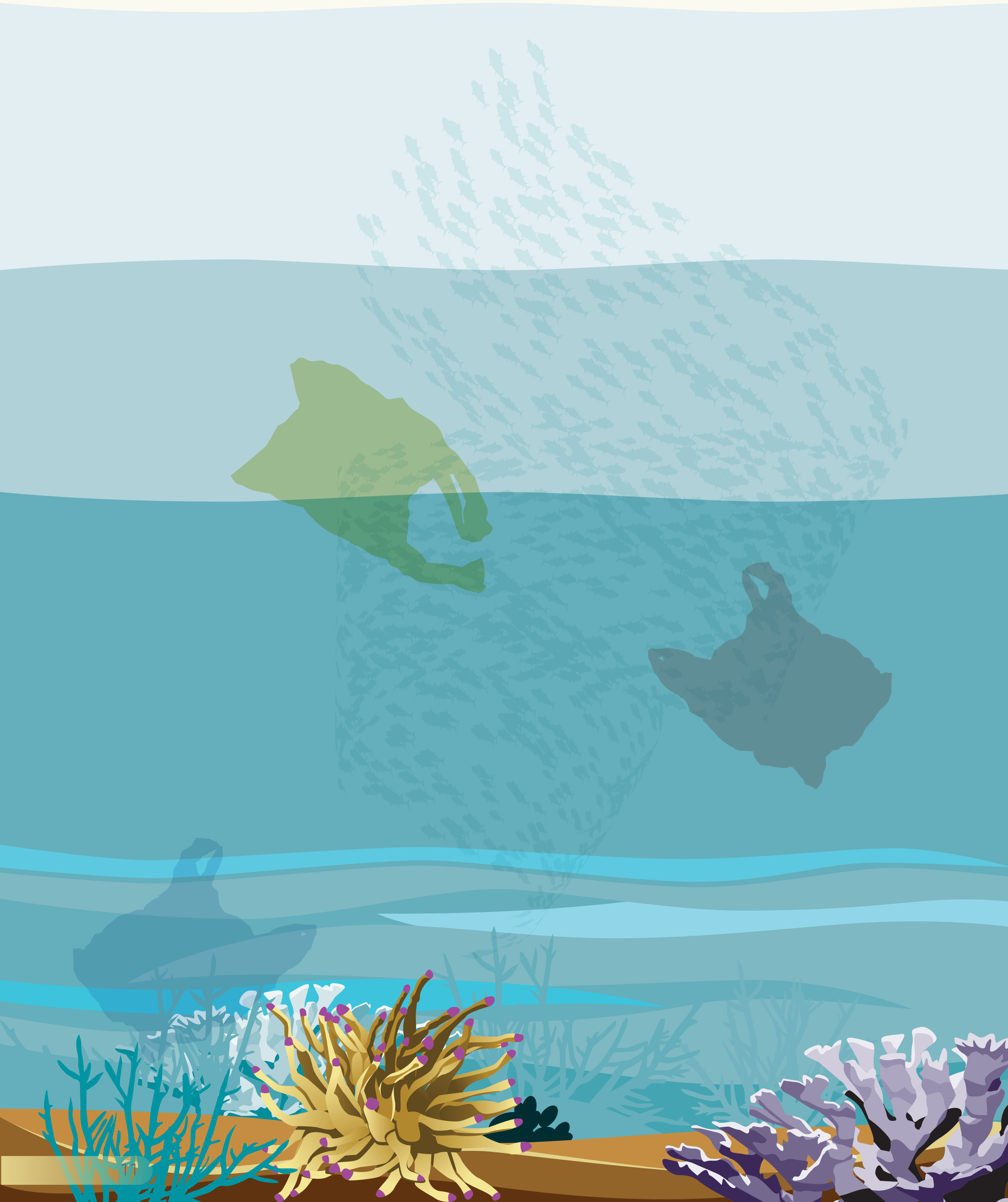
In April 2019, the IOC- Subcommission for the Western Pacific (IOC-WESTPAC) established the UNESCO/IOC Regional Network of Training and Research Centers on Marine Science in the Western Pacific and its adjacent regions. Hosted by East China Normal University, the Network's objective is to (i) improve 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 is 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, including 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 the 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 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. 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 the 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 foreign waste import ban came into effect in 2018, Malaysia, Thailand and other ASEAN countries have become emerging destinations for waste exports from Western countries. According to statistics, from January to July 2018 alone, Malaysia imported 456,000 tonnes of plastic

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



waste, a rapid increase in imports from 168,000 tonnes in 2016 and 316,000 tonnes in 2017. A large amount of foreign waste comprises a large percentage of its original recycling treatment system, making it impossible to recycle a large amount of domestic rubbish and increasing the possibility of it entering the ocean. Therefore, the issue of marine debris management has attracted ASEAN's attention. Regarding the import of foreign waste, 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 that it would stop issuing licences for importing plastic waste, and the Thai Government discussed their goal to stop importing plastic waste in 2021.

Relevant provisions of the international legal framework

Even though the general public's high awareness of the issue of marine litter is a relatively recent phenomenon, many provisions of the international legal framework are of direct relevance to this issue. The Convention on the Prevention

image

of Marine Pollution by Dumping of Wastes and Other Matter (the London Convention) came into force in 1975 with the objective of providing an effective control of all sources of marine pollution and to prevent pollution by dumping at sea.

Eighty-seven countries are currently Parties to the London Convention, while only 46 countries are party 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 (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 (MARPOL) entered into force in 1983. MARPOL covers prevention of marine pollution by ships from operational or accidental causes. Of its six technical annexes, Annex V, Prevention of Pollution by Waste from Ships, entered into force in 1988, is of relevance because it bans the disposal into the sea of all forms of plastics. Annex V has been ratified by 16 out of the 19 countries analysed in this review, 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 in the country analysis section, 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 (GPA), adopted in 1995, is a voluntary intergovernmental partnership hosted by UNEP. The GPA 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. This programme of action 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 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 as: (i) reducing the impacts of 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, their fate and impacts. The Partnership involves cooperation and coordination with intergovernmental organizations, governments, non-governmental organizations, the private sector and academia (Global Partnership on Marine Litter [GPML] 2017).

Under the Global Partnership on Marine Litter Framework, the UN Environment Programme 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 GPML in 2021.

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

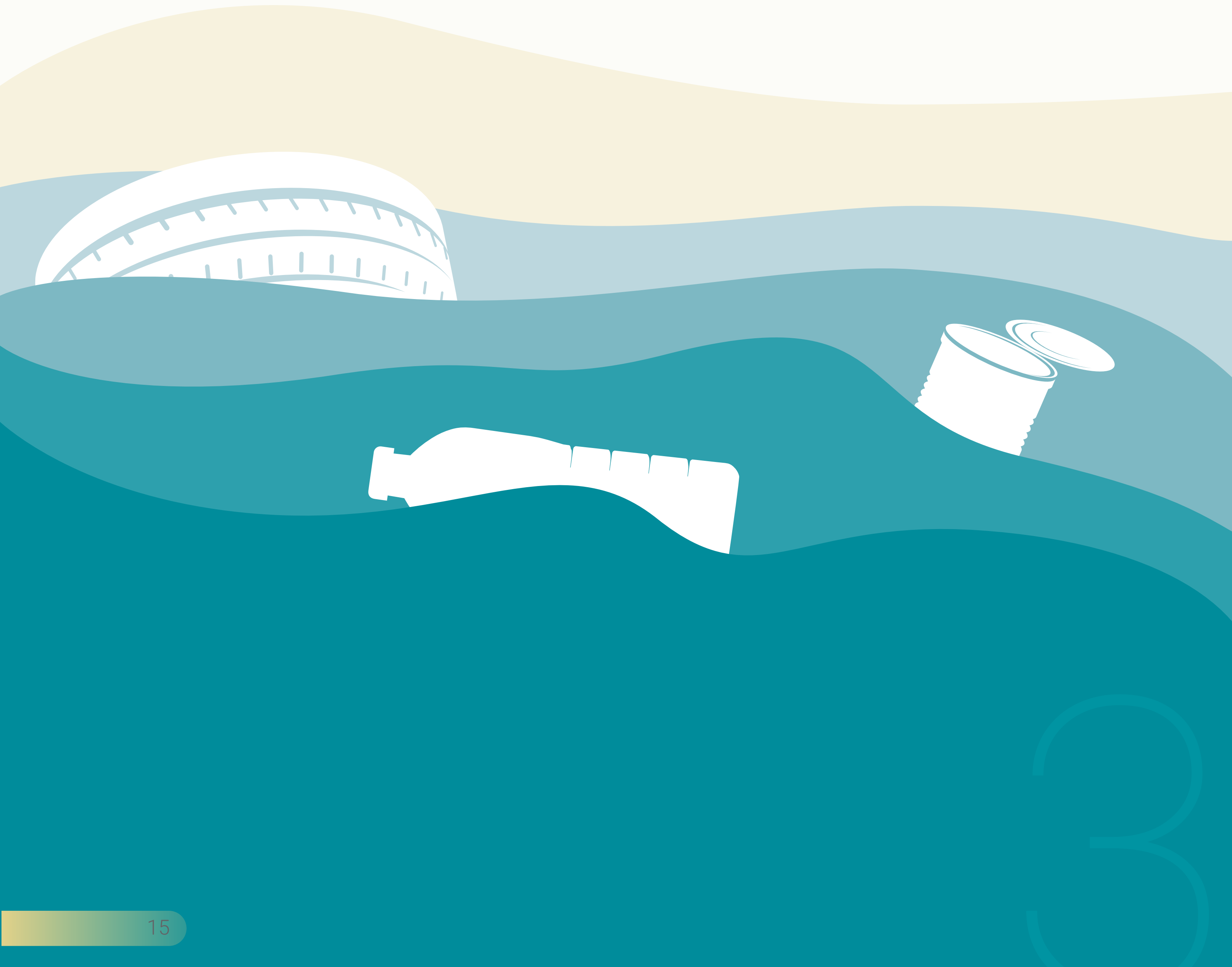
Status of country ratification of relevant global legal agreements

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: 1) UNCLOS: United Nations Convention on the Law of the Sea; 2) 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); 3) London Convention and the London Agreement (LP): the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention), and the protocol thereof (London Protocol), which was formulated in 1996 and entered into force in 2006; Basel Convention: 4) 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 impacts on marine ecosystems and its land-based sources, waste management and the fate pathways of plastic pollution. Since 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), 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 the 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 abundance of microplastics reported, mainly a result of the differences in the types and mesh size of the net used, collection media, sorting criteria and size categorizations (Chae *et al*. 2015; Hidalgo-Ruz *et al*. 2012; Song *et al*. 2015a; Song *et al*. 2015b). 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 – while tyre abrasion and textiles 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—and, specifically, the plastic proportion—have recognized 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 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. As a result, 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 and 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 by tracking 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 plastic losses to the environment and of marine litter. The Minderoo 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 on both land and ocean (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 with 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 plastic waste generation, waste management and marine plastic waste emissions.

image

Data on generation and collection of municipal solid waste and single-use plastic and marine plastic waste emission for selected countries

Table 5 /

Country	Population (2019 estimates) (in millions) [1,2]	MSW generation (in million tonnes) (latest available year) [3,4]	MSW generation rate (in kg/ capita/ day) (latest available year) [3,4]	Single-use plastic waste generation (in million tonnes) (2019) [6]	Single-use plastic waste generation (in kg/ capita/ year) (2019) [6]	Waste collection coverage (share of total population, in %) <YR?> [5]	Mismanaged plastic waste emitted into the ocean (in tonnes) [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

Abbreviation note: .., data not available.
Notes: Korea DPR data on 2009 MSW generation is only for Pyongyang. All population estimates as of 1 July 2019.
Source: This information is compiled from multiple sources, including: [1] UNDESA 2019; [2] ASEAN Up, "4 ASEAN infographics: Population, market, economy" 26 March 2018; [3] S. Kaza and others, *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050* (Washington, DC: World Bank, 2018); [4] United Nations Environment Programme, *Asia Waste Management Outlook* (Bangkok, 2017); [5] C. Liu and others, *State of the 3Rs in Asia and the Pacific — Experts' Assessment of Progress in Ha Noi 3R Goals* (Nagoya, United Nations Centre for Regional Development, 2018); [6] Minderoo (2021). *The Plastic Waste Makers Index*. Broadway Nedlands: Western Australia: Minderoo Foundation; and [7] L.J.J., Meijer and others, "More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean", *Science Advances, vol*. 7, No.18, eaaz5803.

IMAGE

Bangladesh

Bangladesh had an estimated population of about 163.05 million in 2019 and an municipal solid waste (MSW) generation estimated at 14.78 million tonnes in 2012 (Kaza *et al*. 2018) and 4.84 million tonnes 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 in 2004; Hoornweg and Bhada-Tata [2012]), are trends requiring strong interventions. With a high share of mismanaged waste, a coastline of 580 kilometres 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 municipal solid waste directly into the oceans—coupled with surface water run-off, frequent flood, 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 marine plastic waste (United Nations Environmental Assembly [UNEA] 2019).

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. These include sources, sampling types and methods and findings by year of sampling collection.

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

Year	Type	Findings
2015	Cox's Bazar Beach, Bangladesh	Microfibres: 12.3 pieces/25g sample. Dominant type: microfibres
2017–2018	Marine fishes (*n*=75) from northern Bay of Bengal	Microfibres: 68–84 items/kg biomass Dominant microplastic (MP) 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%)
2017–2018	Shrimp (*n*=150) from offshore and shallow coastal waters of Chittagong	Microfibres: 3.40–3.87 items/g gastrointestinal tract Dominant MP 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)
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
2012 (May–June)	Visual observation of oceanic surface waters of Bay of Bengal	Number of litter items observed in Bay of Bengal: 537 items, of which 95.5% are plastics and 4.5% non-plastic items such as wood, paper, glass, tin Density category of litter in Bay of Bengal: 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), 13.2 ± 2.8 items/km^2 (coastal transect); Dominant size of litter in Bay of Bengal (overall): 36.6% (<5cm), 37.8% (5–15 cm), 15.9% (15–30 cm), 6.7% (30–60 cm), 3.0% (>60 cm) Dominant type of litter in Bay of Bengal: packaging (54.6%), plastic fragments (30.5%), fishing/boating (6.3%) and user items (4.1%)

State of municipal solid waste management

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

Waste management is particularly a challenge in rural Bangladesh, because with an estimated population of 163.05 million, 63.4 per cent of the Bangladeshi are rural residents and only 36.6 per cent are urban.

In 2010 Bangladesh launched its National 3R Strategy for Waste Management. Improving the nation's waste management system has also been an important task in the Seventh Five-year Plan (2016–2020).

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 implemented the Mandatory Jute Packaging Act 2010, which came into force

Table 6 /

Method	Source
Sand was collected from 1m seaward of the high-tide line at 0-1cm depth within a 20x20cm square.	Balasubramaniam, and Phillott (2016)
Gastrointestinal tracts of fishes (*n*=25 per species) were examined for microplastics following alkali digestion protocol, microscopic observations and chemical analysis by micro-Fourier-transform Infrared Spectroscope (μ-FTIR).	Hossain *et al.* (2019a)
Gastrointestinal tract of shrimps (*n*=150) were examined for MP following alkali digestion, microscopic observation and chemical analysis by micro-Fourier- Transform Infrared Spectroscope (μFTIR).	Hossain *et al.* (2019b)
AVANI trawl with rectangular aperture 60 cm high ×14 cm wide, 4 m-long net, mesh size of 335 μm with a 30 × 10 cm^2 cod end, and manta trawl with rectangular aperture that is 16 cm high × 61 cm wide, 3 m long 335 μm net with a 30 × 10 cm^2 cod end. 18 sample sites from each trawl. Manta trawl deployments were each 60 min 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)
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 the ship was under way, and they were made from bridge wing or from deck above bridge, 10–13 m above sea level and 57 m from the 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 10x32 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 Bay of Bengal is 2 162 km of transect.	Ryan *et al.* (2013)

in 2014, providing for selected commodities to have jute cellulose packaging. By reducing consumption of single-use and packaging plastics, both regulations had positive impact on reducing the generation of plastic waste. Currently, Bangladesh has been implementing Bangladesh Delta Plan 2100, a hundred-year plan to make the country climate-resilient.

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 other organizations, including the Delegation of the European Union to Bangladesh (9 October 2019, Gulshan Lake, Dhaka).

Data on MSW generation and management in Bangladesh

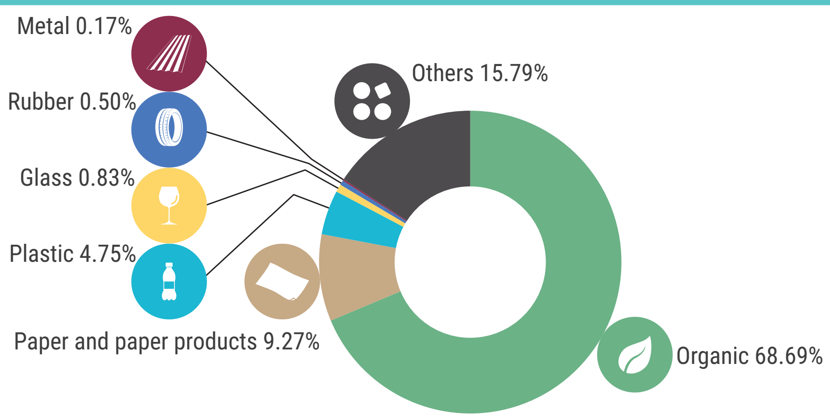
Table 7 /

MSW background information [1] [3]	
Population	163.05 million (2019)
MSW generation	14.78 million tonnes (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, polypropylene, PET resin)	0.00 million tonnes (2019)
Polymer exports	0.00 million tonnes (2019)
Polymer imports	0.76 million tonnes (2019)
Domestic conversion of polymers into single-use applications	0.30 million tonnes (2019)
Single-use plastic Exports (as bulk packaging and in finished goods)	0.15 million tonnes (2019)
Single-use plastic Imports (as bulk packaging and in finished goods)	0.14 million tonnes (2019)
Domestic single-use plastic waste generation	0.28 million tonnes (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;

Source: [1] Kaza (2018): What a Waste 2.0; [2] Minderoo (2021): *The Plastic Waste Makers Index*; [3] UNEP (2017): *Asia Waste Management Outlook*.

Bangladesh MSW composition

Figure 2 /



Source: UNEP (2017): *Asia Waste Management Outlook*

With support from the Norwegian Agency for Development Cooperation (NORAD), the Secretariat of the Basel, Rotterdam and Stockholm Conventions has 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).

IMAGE

Brunei Darussalam

Water plays a vital role in the society and economy of Brunei Darussalam. With a coastline that extends about 161 kilometres 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, and it found that plastics composed 91.46 per cent of litter on Brunei beaches. The study also discovered 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 litter flow and rainfall. Comprising mostly of plastics (29.89 per cent during 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 tonnes of MSW in 2016 (Kaza *et al*. 2018). JASTRe reported in 2015 that Brunei Darussalam disposes 189,000 tonnes of municipal solid waste each year, with 16 per cent being plastics. With the growing economy and industrialization, the pressure on local waste management systems grows rapidly. JASTRe also estimated

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

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

that one 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, and it aims to reduce waste generated per capita 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 is shown on 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 (Framework of Action). Thus, they 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", and the introduction of relevant laws to prevent solid waste from polluting the ocean, and so forth. In April 2018, the Department of Environment, Parks and Recreation (JASTRe) of the Ministry of Development of Negara Brunei Darussalam hired a contractor who collected more than twenty-thousand bags of litter from the Brunei River, mostly plastic bags and bottles (Lyons, Su and Neo 2019). In 2016,

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

MSW background information [1] [2]	
Population	0.43 million
MSW generation	0.22 (2016)
MSW per capita	1.40 (2016)
MSW collection and treatment [2]	
MSW collection coverage	50%-70%
Polymer exports	0.00 million tonnes (2019)

Source: Kaza (2018): What a Waste 2.0; [2] UNEP (2017): *Asia Waste Management Outlook*;

Government action on the environment and on managing plastic/solid waste 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

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

IMAGE

Cambodia

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

State of marine litter management

To date, there are limited research activities on marine litter in Cambodia. With not enough research data, marine litter monitoring in Cambodia 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

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

Regarding solid waste management in Cambodia, currently the key legislation is the "Second Order on Solid Waste Management" issued in 1999. To deal with the increasing demand for municipal solid waste disposal, in 2015, the Cambodian Government issued the "Second Order No. 113 on Municipal Waste and Solid Waste Management". While per capita MSW in the country is estimated at 0.2 kg per day, per capita, the rate of MSW

Data on MSW generation and management in Cambodia

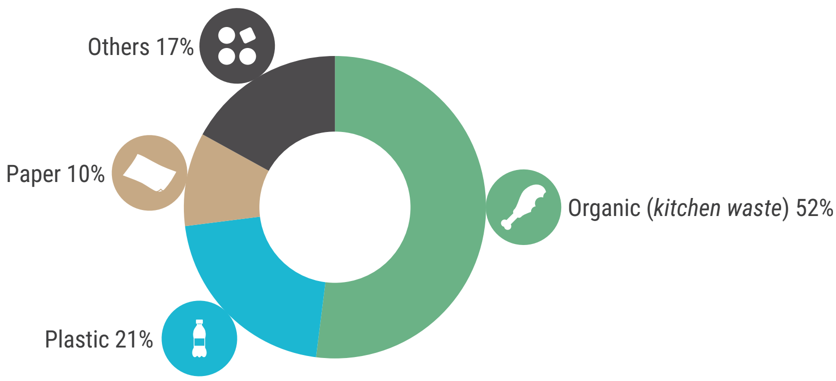
Table 11 /

MSW background information [1] [4]	
Population	16.45 million (2018)
MSW generation	1.09 million tonnes (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, polypropylene, PET resin)	0.00 million tonnes (2019)
Polymer exports	0.00 million tonnes (2019)
Polymer imports	0.06 million tonnes (2019)
Domestic conversion of polymers into single-use applications	0.03 million tonnes (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.02 million tonnes (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.06 million tonnes (2019)
Domestic single-use plastic waste generation	0.08 million tonnes (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

Source: [1] Kaza (2018): What a Waste 2.0; [2] Minderoo (2021): *The Plastic Waste Makers Index*; [3] Singh *et al*. (2018): *State of Waste Management in Phnom Penh, Cambodia*; [4] Sethy (2017): Country chapter: The Kingdom of Cambodia. *State of the 3Rs in Asia and the Pacific*.

Cambodia MSW composition (2020)

Figure 3 /



Source: Singh *et al*. (2018)

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

production in Phnom Penh, the Cambodian capital, is estimated at 0.73 kg per day, per capita (The Asia Foundation and National Council of Sustainable Development 2018).

Government actions towards protecting the water environment via effective solid waste management is shown on Table 12.

As population growth and urbanization continue to accelerate in Cambodia, its solid waste generation is also growing at an annual rate of 10 per cent. At present, Cambodia generally lacks systems for the management of solid waste and the infrastructure for its disposal and treatment. Apart from a small amount of recyclable materials collected by waste collectors and some local NGOs, a large quantity 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 municipal solid waste has also been illegally dumped on land and in the waterways. Only Phnom Penh has a harmless treatment facility for its municipal solid waste.

In terms of solid waste management, Cambodia's main policy tool is the 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, and it 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). For control of single-use plastics, in some supermarkets in Cambodia, 400 riel is charged per plastic bag (equivalent approximately to USD 10 cents). In July 2019, Cambodia returned a batch of foreign rubbish containers from the United States and Canada.

Actions on combating marine litter

Government actions towards protecting the marine environment are listed on Table 13.

The Cambodian Government issued the Subdecree No. 27 on the Control of Water Pollution (1999) (No. 27/ANKr/ BK) on water pollution control in 1999, which aims to control, prevent and reduce water pollution in public waters of Cambodia. According to Article 2 (8), "The disposal of solid waste or any rubbish or hazardous substances into public water areas or into public drainage system shall be strictly prohibited. The storage or disposal of solid waste or any

Government action on the water environment in Cambodia

Table 13 /

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

rubbish and hazardous substances that lead to the pollution of water of the public water areas shall be strictly prohibited."

In terms of international cooperation, Cambodia participated in the five-year 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 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 (MoE), 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 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.

IMAGE

China

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

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 the management of marine litter and microplastics. Up to now, more than 20 per cent of peer-reviewed scientific papers studying marine litter and microplastics 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, United Kingdom and 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 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 column regularly, and started microplastics monitoring since 2016, results of which are published annually in the *Bulletin of Marine Ecology and Environmental Status of China*.

For microplastics, monitoring results of four transects in Bohai Sea, Huanghai Sea and South China Sea in 2018 revealed an average concentration of 0.42 pieces per cubic meter, with the highest concentration being vmainly fragments, fibres and lines, and the composition are 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 condense seasonal *in situ* monitoring on microplastics in the Yangtze Estuary and its adjacent East China Sea, using harmonized methodology: they estimated the annual microplastics exported from the Yangtze River is 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 MPs in the studied region was 0.005–0.7 items per cubic metre and estimated that about 2,400–3,800 tonnes of plastic litter were exported to the coastal ocean by the Pearl River.

A physical transport model of microplastic was developed to study the transport pathway of microplastics 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.

A selected list of studies on the distribution of marine litter in China is shown in Table 14.

IMAGE

Selected studies on the distribution of marine litter in China

Table 14 /

Year	Type	Findings	Method	Source
2009–2010	Floating marine debris, beached marine debris and sea floor marine debris	Floating marine debris density was 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 were 4.30, 0.13 items/100 m^2 and 133.80, 22.60 g/100 m^2 in China from 2007 to 2014, respectively. Average number density of the large- size floating macroplastics was 0.0024 items/100 m^2. Marine debris primarily was comprised of plastic, Styrofoam, wood, glass, rubber, fabric/fibre and metal.	Trawl net, visual observation, submarine navigation and diving	Zhou *et al.* (2016)
2010	Marine litter	Marine debris was higher on rocky shores than sandy beaches and fishing ports. No significant difference between season and tide. Dominant debris was plastic-type, followed by polystyrene. Most debris originated fromrecreational activities.	Trawl net, diving facility, diver, snorkelling, sonar, and manta tow Strip transect	Kuo and Huang (2014)
2014	Small plastic debris	Small plastics accounted for more than 60% of total plastic by number. Polypropylene and polyethylene were most common polymer composition.	Transect; Visual identification	Zhao *et al.* (2015a)
2014	Estuarine microplastics	MP (<5 mm) comprised more than 90% of total number plastics. Fibres and granules were primary shapes.	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 was 0.33 ± 0.34 particles/m^3. Main types of microplastics were polyethylene, polypropylene and polystyrene.	Surface tow (330 μm)	Zhang *et al.* (2017)
2015	Microplastics in estuarine sediments	Mean concentration was121 ± 9 items per kg of dry weight. Fibre (93%), transparent (42%) and small microplastics (<1 mm) (58%) were most abundant types.	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 concentration is 0.13 ± 0.20 pieces/m^3. Major polymer types are polypropylene and polyethylene.	Bongo nets	Sun *et al.* (2018)
2017	Microplastics in estuarine sediments	Annual MPs exported from Yangtze River is 537–906 tons. The average mass of MP was 0.000033 g/particle. Density stratification in CE significantly influenced the surface MP abundances.	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 is shown on 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, the 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 document entitled Notice on Ban Production, Sale and Use of Plastic Bags. According to this notice, the production, sale and use of all thin plastic bags with a thickness less than 0.025 mm are prohibited. 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)
- Cleaner Production Promotion Law of the People's Republic of China (2002)

Data on MSW generation and management in China

Table 15 /

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

Source: [1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, World Bank; [2] Minderoo (2021); *The Plastic Waste Makers Index*; [3] UNEP (2017): *Asia Waste Management Outlook*;

Government actions, policies and regulations combating marine litter in China

Year	Policy name
1995	Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution
1999	Emergency Notice on the Immediate Cessation of the Production of Disposable Foamed Plastic Tableware, issued by State Economic and Trade Commission
2004	Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution
2007	Administrative Measures for Recycling of Renewable Resources, jointly issued by the Ministry of Commerce, National Development and Reform Commission, Ministry of Public Security, Ministry of Construction, the State Administration for Industry and Commerce, and State Environmental Protection Administration
2007	Notice of the General Office of the 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
2011	Opinions on the Establishment of a Complete and Advanced System for Recycling Waste Commodities, issued by the General Office of the State Council
2012	Law of the People's Republic of China on Cleaner Production Promotion
2012	Petrochemical and Chemical Industry Development Plan During the TwelfthFive-Year Plan Period, issued by Ministry of Industry and Information Technology
2012	Guiding Opinions on China Plastics Processing Industry "Twelfth Five-Year" Development Plan, issued by China Plastics Processing Industry Association
2015	Medium- and Long-Term Plan for the Construction of Renewable Resources Recovery System (2015–2030), issued by the Ministry of Commerce, the National Development and Reform Commission, the Ministry of Land and Resources, the Ministry of Housing and Urban-Rural Development and the General Supply and Marketing Cooperatives
2015	Implementation of the Action Plan for Prevention and Control of 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.
2016	Implementation of the Soil Pollution Prevention and Control Action Plan
2016	Release of the Opinions on Promoting the River Chief System in an All-Round Way (2016)
2017	Implementation Plan of Domestic Waste Classification System (2017)
2017	Circular Development Leading Action, jointly issued by The National Development and Reform Commission, the Ministry of Science and Technology and other 14 departments
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 the General Office of the State Council
2017	Development Guiding Opinions on Plastics Processing Industry Technological Progress during the 13th Five-Year Plan, compiled by the China Plastics Processing Industry Association
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

Table 16 /

Key plastics-related action
Gradually increased the content of waste plastics via repeated amendments to the law
Completely prohibited nationwide by the end of 2000, the production and application of disposable foamed plastic catering utensils nationwide
Encouraged the use of regenerated biomass energy and degradable plastics
Encouraged the whole society (from all walks of life, both urban and rural residents) to accumulate and sell renewable resources, to recycle and treat renewable resources in an environmentally sound manner, and to carry out scientific research, technological development and popularization on the recycling and treatment of renewable resources
Banned (since 1 June 2008) the production, sale and use of plastic shopping bags with thickness less than 0.025 mm nationwide, and implemented the system of paying for the use of plastic shopping bags in retail stores
Put forward “improve the network, improve capacity”
Improved the system with attention to the recycling of nine key waste commodities including waste plastics
Considered the impact of the design of products and packages on human health and the environment during the life cycle, and gave priority to packages that are non-toxic, non-hazardous easy to degrade or recycle
Proposed the development of poly (lactic acid) (PLA) and poly (butylene succinate) (PBS) degradable plastics
Proposed to promote biodegradable materials and products, personalized packaging film logo design, functional materials and products, etc.
Introduced a comprehensive plan for the 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 paid attention to • Fail to do a good job in the source classification, improve the subsequent recovery cost • The responsibilities of all parties are not clear, and the policy matching is not strong • Waste plastics have no clear system requirements
Aimed to prevent and control water pollution
Promoted the prevention and control of pollution from ships and ports in an all-round way
Aimed to prevent and control soil pollution
Waste classification
Put forward main targets by 2020, the output rate of major resources was to increase by 15% compared with that of 2015, and the recycling utilization rate of major wastes was to reach about 54.6%
Adjusted the management catalogue of imported solid waste by the end of July 2017 Banned imports of household waste plastics, unsorted wastepaper, textile waste and vanadium slag by the of 2017
Promoted the research and development of cutting-edge technologies and emerging processes, promoted the development of energy-saving and environment-friendly materials and technologies, and improved the recycling and processing system of waste plastics.
Improved the living environment in rural areas

Year	Policy name
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
2017	Conditions of Specification for Agricultural Film Industry (2017 version), issued by Ministry of Industry and Information Technology
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
2018	Announcement on Adjustment, jointly issued by the Ministry of Ecology and Environment, Ministry of Commerce, National Development and Reform Commission and General Administration of Customs
2019	Action Plan for the Uphill Battles for Integrated Bohai Sea Management (2018), implemented by Ministry of Ecology and Environment
2019	Implementation of the Plan for Pilot Development of Solid Waste-Free Cities (2019)
2019	Guiding Catalogue of Industrial Structure Adjustment (2019 version), issued by National Development and Reform Commission
2019	Biodegradable Plastic Shopping Bags, GB/T 38082-2019
2020	Opinions on Further Strengthening Plastic Pollution Control, issued by The National Development and Reform Commission and the Ministry of Ecology and Environment
2020	Notice on Solid Advancement of the Control of Plastic Pollution, jointly issued by the State Development and Reform Commission, the Ministry of Ecology and Environment, the Ministry of Industry and Information Technology, the Ministry of Housing and Urban-Rural Development, the Ministry of Agriculture and Rural Affairs, the Ministry of Commerce, the Ministry of Culture and Tourism, the State Administration for Market Regulation, and the All-China Federation of Supply and Marketing Cooperation
2020	Announcement on Relevant Matters Concerning the Comprehensive Ban on the Import of Solid Waste, jointly issued by the Ministry of Ecology and Environment, the Ministry of Commerce, the National Development and Reform Commission and the General Administration of Customs

- 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 the 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

	Key plastics-related action
	Increased the share of biodegradable green packaging materials to 50% by 2020
	Emphasized that agricultural film products should not be produced with inferior recycled plastics as raw materials. Specified that the quality of products should meet national and industrial standards and that the qualified rate of products should reach 100%
	States that mail and delivery packaging materials should be made of biodegradable plastic to reduce white pollution, as of 1 September 2018
	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
	Significantly reduced the volume of land-based pollutants dumped into the sea in three years.
	Established solid waste-free cities.
	Phases out disposable foam-plastic tableware and disposable plastic swabs by 2021 Banned both (i) the production of daily chemical products containing plastic microbeads by the end of 2020 and (ii) the sale of plastic microbeads by the end of 2022. Phased out ultrathin plastic bags with a thickness of less than 0.025 mm and polyethylene agricultural mulching film with a thickness of less than 0.01 mm
	Stipulated the definition requirements, test methods, inspection rules, packaging, transportation and storage of biodegradable plastic shopping bags
	Proposed a ban and restricted the production, sale and use of some plastic products in an orderly way, and actively promoted alternative products
	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 the production and sale of thin plastic shopping bags with a thickness of less than 0.025 mm and polyethylene agricultural mulching film with a thickness of less than 0.01 mm Banned non-biodegradable plastic shopping bags in some cities and public places from 1 January 2021
	Prohibited the import of solid waste in any form 1 January 2021

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, aiming at comprehensive improvement of the 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.

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 in reducing the use of disposable plastics.

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*.

Relevant national projects have been funded to study the impacts of marine litter and microplastics. In 2017, the project of Microplastic Monitoring and Eco-Environmental Evaluation Technologies, one of the key national research projects of Ministry of Science and Technology, was launched to investigate microplastic distribution along the coast and to 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 been included in some bilateral and multilateral cooperation documents with ASEAN, Canada, Germany, G20, the United States and so on.

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; 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; and (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; 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 etc;

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; iii) polyvinyl chloride plastic wrap.

Furthermore, the “obsolete industries” include: (i) backyard oil refinery process, using waste rubber and plastics with outdated methods; (ii) production of ultrathin (less than 0.025 mm) plastic shopping bags; iii) production of polyurethane, polyethylene and polystyrene foams, using chlorofluorocarbons as blowing agents; iv) disposable foamed plastic tableware and disposable plastic cotton swabs (effective 31December 2020); v) household chemical products and toiletries containing microplastic beads (production ends on 31 December 2020 and sales/distribution ends on 31 December 2022); 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 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 CNY 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 complete 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) waste categorization is a good education opportunity to force consumers to rethink the huge amount of waste generated in daily life and learn about the "3R (reduce, reuse, recycle)" and "zero waste" principles, thus potentially beneficial to reducing the generation of marine litter.

IMAGE

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 kilometres (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 tonnes 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 Boardhas 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 the distribution of marine litter 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 (loss of cargo 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 the year 2004 at 10 stations. At each station, 5-10 kg samples were collected using a stainless-steel scoop up to a depth of ~5 cm between the high tide line to low watermark at five locations. Sediment samples were also collected from two other stations (SS1 and SS12), one on either side of the yard andabout 10 km apart. The sediments were dried and sorted according to size. To 1 kg of the sieved material sediment, 4 litres of a 30% NaCl solution were added. Contents were stirred for 1-2 h and allowed to settle for 15 min. The supernatant solution was filtered through Whatman GF/A (Thompson *et al*. 2004). The filters were dried at room temperature and sealed in Petri dishes. The particles are analysed using a microscope for examination and sorting, a FT-IR spectrometer for recording IR, and a scanning electron microscope for morphological characterization.	Reddy *et al*. (2006)

Year	Type	Findings
2006 – 2008	Marine litter on beaches in the northern part of Gulf of Mannar, Southeast coast of India	Shoreline marine litter abundance: 61 items weighing 3 655 g per 100m^2 area of the northern Gulf of Mannar, with 52.8% being plastics Maximum shoreline marine litter was 94–95 items of 5 409–6 588 g noticed during May–June 2007, and the minimum shoreline marine litter was 42 items of 2 088 g noticed in February 2008 Shoreline ML dominant type: Plastics (48%), polystyrene (18%) and cloth (15%) Shoreline marine litter potential origin: Fishing (33.9%), tourism/recreation (30.5%), sewage-related debris (13%), LInd run-off (3.8%) and medical sources (0.4%) Factors in ML accumulation quantity: Proximity to dense population centre, pilgrim and southwest monsoon
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 the size range of 5–100 mm both by number and weight Percentage of MPs in litter: Juhu Beach (55.3%)
2013 – 2014	Beach litter on 254 selected beaches along the maritime States of Peninsular coast of India as well as the Union Territories of Andaman and Lakshadweep Islands	Beach litter abundance: 0.31 g/m² (Odisha coast) – 205.75 g/m² (Goa coast) Plastic litter abundance: 0.08 g/m² (Odisha coast) – 25.47 g/m² (Goa coast) Plastic percentage over total litter: 14% (national mean), with range (i) 7%–81% being plastics on Peninsular coasts and (ii) 40% (Lakshadweep) – 47% (Andamans) on island union territories
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 (190g) had blocked passage of food to the intestine. Hence, it was believed that death could be due to choking by plastic bags ingested while feeding.
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 colour: white > black > yellow > grey > blue

Method	Source
All anthropogenic debris were categorized according to the material type as cloth, glass/ ceramic, metal, leather, fabric, plastics, polystyrene, paper, rubber and wood. At each site along the 50 km stretch of shoreline in the northern Gulf of Mannar region, four 100 m^2 transects along the top wet strandline parallel to the beach were chosen at random, recording GPS location and permanent structures to allow the same stretch of beach to be surveyed over subsequent months. All litter items within each of the 100 m^2 transect were collected and natural debris were not removed. Marine litter items were categorized according to likely litter sources, in the gulf's marine litter pictorial survey sheet. The percentage of source contributed to the total debris was then estimated using the matrix scoring method described by Whiting (1998). Weight and the number of litter items collected within each transect were recorded on the established form as to its composition and/or specific identification. 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)
Triplicates of 2×2 m (4 m^2) quadrats were sampled in each beach with a total of 72 quadrats. In the laboratory, the plastic debris was washed with fresh water to remove sand, shells and other debris, and air-dried for 24 h to remove the moisture. Then, the plastic debris was sorted and classified into classes and counted and weighed.	Jayasiri, Purushothaman, and Vennila. (2013)
Along a stretch of coastline, sampling beaches (sandy and open beaches) were selected systematically at about 10 km intervals. Beach litter samples were sampled using a rope quadrate of (10 x 10m) operated in triplicate from each station with 100 m interval on a line transect. Beach litter collected from within the three quadrates were pooled together, cleaned of adhering sand and moisture and then weighed using a top pan balance then sorted into six categories.	Kaladharan *et al.* (2017)
On the morning of 4 March 2014, one carcass of a Longman's beaked whale (Indopacetus pacificus, Longman, 1926) was spotted on the shore off Sutrapada near Veraval by the local fishermen without any external injury or damage to it. The carcass was about 4.38 metres in length and weighed one. The tonne necropsy conducted on the carcass by the officials from Forest Department and Wildlife Treatment Centre, Sasan Gir, Gujarat.	Kaladharan (2014)
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. A total of five major categories were used, corresponding to the 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 the pellet surface. This was accomplished using a Nikon stereomicroscope SMZ1500 coupled with a digital camera.	Mugilarasan, Venkatachalapathy and Sharmila (2015)

Year	Type	Findings
2015	Microplastic pellets (MPP) from six tropical beaches along the Goa coast	Total microplastic pellets collected: 3 000, with 1 655 pellets in June and 1 345 in January Microplastic pellet dominant type: polyethylene (PE) and polypropylene (PP) Microplastic pellet dominant colour: white Microplastic pellet suspected origin: primarily from ocean-based sources
2015	Microplastic pellets (MPP) from Chennai coast	Total MPPs collected: 1 200 items of MPPs, with size ranging from 2 to 5 mm with mean mass of 25 mg; MPPs Surface properties: yellowish white cracked surfaces with more signs of oxidation (highest degree of degradation) MPPs Dominant shapes: ovoid, spheroids, disc and cylindrical rods;
2015	Marine debris along Marina beach, 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; ML Dominant type by count: plastic (44.89%), lumber and processed wood (28.94%) occur in the greatest number followed by metal, rubber, cloth and others;
2016	Microplastics in lake and estuary sediment of Vembanad Lake, Kerala, India	MPs mean abundance: 252.80 ± 25.76 items/m^2, with range of 96 - 496 particles/m^2; MPs Dominant type: Low-density polyethylene (LDPE) (with 26%-91%), HDPE, PS, PP
2017	Coastal debris from Nallathanni Island, Gulf of Mannar Biosphere Reserve, Southeast coast of India	Beach debris abundance: 17–82 items per quadrant; Beach debris dominant type: Polyethylene, PVC, Polystyrene, Nylon, Others

Method	Source
About 100 Microplastic pellet samples were collected from the high-tide line of the sandy surface of each beach using pre-cleaned stainless-steel tweezers. The MPPs were wrapped in aluminium foils, put into paper envelopes and transported to the laboratory. To assess the amount of MPPs entered into the Arabian Sea from the rivers of Goa, neuston samples were collected from Mandovi, Zuari, Chapora and Sal rivers using a 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 FTIR-ATR spectroscopy, respectively.	Veerasingam *et al*. (2016a)
For the quantification of MPPs along the high-tide line of beaches, 1 m × 1 m quadrants were sampled. The MPPs were wrapped in aluminium foil, put into paper envelops and transported to the laboratory. Subsamples of collected MPPs were examined through a Nikon tereomicroscope SMZ1500 coupled with a digital camera to characterize the major surface oxidation features. MPPs were analysed using a Shimadzu FTIR coupled with Attenuated Total Reflectance (ATR) diamond crystal attachment to identify the polymer compositions of MPPs.	Veerasingam *et al*. (2016b)
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 the coastline. Before sampling, all existing marine debris on the beach were removed at the end of February 2015 to remove possible effects of accumulation during the past months. The samples were collected along 10 transects each 5 m wide and 100 m long from the high tide line towards the vegetation line covering an area of 5 000 m^2. For each survey, recorders walked back and forth along the 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 the beach surface.	Kumar *et al*. (2016)
Sediment samples were collected from 10 sites along the southern part of Vembanad Lake. Two sediment samples were collected from each site using a Van Veen grab (25 cm^2) giving a total of 20 sediment samples. Wet samples were sieved through 5 mm mesh to remove large debris, and to retain particles of <5 mm size. The sieved samples were air-dried in glass trays covered with aluminium foil. The dried samples were disaggregated and sieved again through 5 mm sieve to make sure no particles greater than 5 mm remain in the sample. The samples are then processed for microplastic extraction through density separation. In detail, the samples were subjected to wet peroxide oxidation (WPO) process, with 30% hydrogen peroxide, to digest organic matter present in the samples. The WPO mixture was then subjected to saltwater density separation (Galgani *et al*., 2013) using NaCl (d = 1.3 g/ml) to separate MPs through floatation. The supernatant was then filtered using Whatman GF/A filter paper (25 mm). Filters were air-dried and examined under a compound microscope at 10x resolution. Identification of the polymer components of MPs was done using micro-Raman spectroscopy.	Sruthy and Ramasamy (2017)
The maximum marine debris was observed and collected from the seaward side of the coast (size of the seaward side of the coast 0.83×0.02 km). The nine sampling quadrants were marked between the berm and high-tide line of the coast. The amount of marine debris per quadrant was counted by visual identification and microscopic examination.	Krishnakumar *et al*. (2018)

Year	Type	Findings
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 (PP) (~39.7%), polyethylene (PE) (~17.9%), polystyrene (PS) (~15.6%), nylon (~14.6%), and polyvinyl chloride (PVC) (~12.2%) Plastic debris dominant size: Micro 1.01–4.75mm (60.8%), meso 4.76–200mm (~30%) and macro >200mm (~9.2%) MPs dominant colour: irregular-shaped (~69.2%), fibrous-shaped (~17.9%) and pellet-shaped (~12.9%) MPs dominant colour: White (43.4%), Green (21.6%), Blue (16.9%) Potential sources identified: Tourism activities and fishing practices
2014	Microplastic resin pellets from beaches of Chennai (metropolitan city on east coast) and from Tinnakkara Island, Lakshadweep archipelago (remote island), India	ENTER TYPE AS ABOVE abundance: Total number of pellets collected from Chennai and Tinnakkara were 201 and 603, respectively Dominant colours: In Chennai, 47% yellow and 44% white; in Tinnakkara, 15% yellow and 36% white Other observations: Yellow pellets with significant surface oxidation features were plentiful in Chennai coast, 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.
2018	Microplastic presence (25 samples) in commercial marine sea salts at Tuticorin, Gulf of Mannar, South India	An elevated level of MP waste was found in Tuticorin city sea salt sample (nos. 16–21). MPs dominant type: Polyethylene (PE) (41.5%), polypropylene (PP) (22.7%), cellulose (CL) (11.2%) and nylon (Ny) (8.7%) MP dominant size: Small microplastic (< 2 mm) MP dominant type: fragments (55%), fibre (42%) and sheet (3%)
2018	Microplastics in coastal waters (14 locations), beach sediments (22 locations) and marine fishes (11 locations) from state of Kerala, southwest coast of India	MP abundance in beach sediment: mean microplastic 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 MPs dominant type in coastal water and beach sediment: polyethylene (PE) and polypropylene (PP) Dominant shape in coastal water and beach sediment: fragments, fibre/line and foam Identified potential origin for MPs in coastal water and beach sediment: river run-off and proximity to urban agglomeration MPs abundance in fish digestive tract: Digestive tracts of 15 out of 70 commercially important fishes studied; they contained 22 microplastic particles. MPs dominant type in fish digestive tracts: Polyethylene (PE) 38.46% followed by cellulose (CE) 23.08%, rayon (RY) 15.38%, polyester (PL) 15.38% and polypropylene (PP; 7.69%)

Method	Source
Marine sediment samples were collected from 20 locations along the coastal areas of the study region up to a depth of 3 cm from the top. The homogenized beach sediments were air-dried and sieved using a 2 mm mesh. Thirty grams of the sediment sample was treated with hydrogen peroxide solution overnight to remove the naturally available organic material from the sediment matrix. Twenty-five millilitres of pre-prepared HCl (4.5%) were added to samples before performing floatation techniques. Microplastic materials were separated by the filtration method with a 1.2 μm nitrocellulose membrane filter paper. The distribution and characterization study was carried out by visual examination followed by FTIR spectroscopy.	Vidyasakar *et al*. (2018)
The sampling protocols followed are: (Thompson *et al*. 2004; McDermid *et al*. 2004; Jayasiri *et al*. 2013; 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 using a calliper. Final storage was in separate glass containers, by colour. Subsamples of collected pellets were used to characterize major oxidation features on the pellet surface. This was accomplished using a Nikon stereomicroscope SMZ1500 coupled with a digital camera.	Mugilarasan *et al*. (2017)
Each sample was collected to a weight of 1.5 kg in a standard packet. In the Tuticorin region, the salt manufacturing process involves. Once, the clearing action was completed, the afloat present was clarified, it and formed a 47 mm 0.2 μm artificial nitrate film to add 10–14 mL of 5 M NaI and was placed in antiseptic Petri dishes (density = 1.6 g/ml) The type of various MPs particles was analysed by μ-FT-IR.	Selvam *et al*. (2020)
Coastal water samples were collected ~1 km (3-5 m depth) offshore along the coast using a boat equipped with a manta trawl net (300 μm mesh size; opening dimensions of 30 x 15 cm) (Hydro-Bios, Germany) hauled horizontally for 20 minutes at the speed of 2-3 knots. Beach sediments were collected by quadrat and size fraction sieving method as described in Karthik *et al*. (2018). The net was thoroughly rinsed at the end of each sampling with filtered seawater to ensure collection of all plastic debris into the collection bag. Immediately after sampling, coarse non-plastic materials (various organic or inorganic material) were sorted visually and removed with stainless-steel forceps and the potential microplastics were stored in glass bottles. Sediment samples were collected from 1x1 m quadrat using a stainless-steel scoop up to a depth of 5 cm. All the samples were stored in pre-cleansed stainless-steel containers of about 15 L until sieve analysis. To separate different size 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 was stirred for 10 minutes. To determine the microplastic type, samples were examined under a stereomicroscope (SMZ 25; zoom range: 0.63× - 15.75×) fitted with a 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 the laboratory using an 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 the presence of microplastics in the gut content, all these containers were filled with 10% KOH (potassium hydroxid) solution and incubated for 24h at 60°C. Digested gut content of each sample was examined carefully in a Petri dish using a stereomicroscope (Nikon SMZ 25) to ascertain the presence of microplastics. All materials suspected to be anthropogenic particles were photographed using a digital camera and morphometrics of the debris were digitally measured using image processing software (NIS-Elements).	Robin *et al*. (2019)

Year	Type	Findings
2018	Marine litter on beaches along South Juhu water channel	In total, three samplings carried out 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 by count of 269, 232 and 488 and by weight of 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
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.
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 an 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

State of municipal solid waste management

The 2013–2014 Environment Status Report of the Bombay Municipal Corporation showed that plastic accounted for about 675 MT (9%) of the total daily waste generated at that time (Manickavasagam *et al*. 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 tonnes of waste are generated every day in the country. The total MSW generation in the country has been unequivocally estimated at 40 million tonnes in 2006 (Hoornweg *et al*. 2012), increasing to 62 million tonnes 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.

Method	Source
The sampling was carried out during the ebb tide time for easy collection of samples, where litter are collected by hand and collection and removal of plastic and marine (or riverine) debris from channel. Characterization of plastics and marine debris was done according to standard protocol of Lippiatt (2013). The particles were classified as micro (<5mm), meso (5- 20mm), macro (21-100mm) and mega (> 100mm) (Stevenson, 2011; Barnes *et al*., 2009). The collected samples were washed with fresh water to remove salt and were properly sundried. The collected marine and plastic debris (<5mm) were dried and quantified in terms of number and weight (g).	Manickavasagam *et al*. (2019)
During the regular snorkelling and skin diving in the nearshore area of Veedhalai (N 09º15 06.43; E 079º06.33.71) of Gulf of Mannar.	Ramakritinan *et al*. 2015
Site selection: Six beaches were selected for beach litter survey, along the 590 km stretch of Kerala coast, in the south west region of India. A pair of high and low fishing intensity beaches each, were chosen from north, central and south Kerala by stratified random sampling. The selection of fishing activity beaches depends on the number (n ≥ 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) with a total of 18 surveys. During the survey, four transects of 5 m width were randomly selected on a 100 m stretch of each beach parallel to the waterline as prescribed by U.S. National Oceanic and Atmospheric Administration (NOAA) 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 the width of the selected transect and were then sorted, counted and weighed.	Daniel *et al*. 2020

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation is shown on 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, and these have been prescribed for enforcing of 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

Data on MSW generation and management in India

Table 18 /

MSW background information [1]	
Population	1 310.2 million (2015)
MSW generation	52 million tonnes (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, polypropylene, PET resin)	11.76 million tonnes (2019)
Polymer exports	2.31 million tonnes (2019)
Polymer imports	2.88 million tonnes (2019)
Domestic conversion of polymers into single-use applications	6.40 million tonnes (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	1.48 million tonnes (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.68 million tonnes (2019)
Domestic single-use plastic waste generation	5.58 million tonnes (2019)
Single-use plastic waste generation per capita	4.12 kgs (2019)
MSW collection and treatment [3] [4]	
MSW collection coverage	70%–90%
MSW recycling rate	27% (2015)

Source: [1] Kaza *et al*. (2018); Liu *et al*. (2018); [2] Minderoo (2021); UNEP (2017); [3] Liu *et al*. (2018); [4] UNEP (2017).

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 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.

IMAGE

Indonesia

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

State of marine litter management

A selected list of studies on the distribution of marine litter in China is Indonesia in Table 19.

With a coastline of 54,716 kilometres 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).

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 is shown on Table 20 and Figure 4.

The country had an MSW generation of 65.03 million tonnes in 2015 and 65.2 million tonnes in 2016 (Kaza *et al*. 2018), while the MW collection covers in general 40%–50% of population, at 6.03 million tonnes from provincial capitals in 2015 (UNSD 2018), which 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 Indonesia Ministry of Environment and Forestry (MEF 2020), 79 per cent of waste are sent to landfill, 12 per cent incinerated, and 9 per cent recycled. Landfill remains a common practice in Indonesia, while new types of waste management infrastructure have been introduced in recent years, including 12 waste- to-energy (W2E) power stations.

Selected studies on the distribution of marine litter in Indonesia

Year	Area	Abundance
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 m of strand line: Polythene bags (0.1-6.4 items/m along transect), polystyrene blocks (0.1-4.8 items/m along transect), 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.
1993	Coastal areas of Ambon Island, Eastern Indonesia	Overall, the mean density of objects was 4.6 items/m^2, consisting predominantly of synthetic items, especially plastics, and organic matter. 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), tin foil (20). Mean number per m^2: 2.8 items/m^2 Percentage cover: 8.3%
June and July 1994	Litter on beaches at Pulau Seribu Archipelago to the north and west of Jakarta	Recorded types of litter: Plastic bags, footwear, polystyrene blocks, bottles, tin cans, ropes and nets, light bulbs Density and abundance: not presented Influencing litter factors identified: Surface currents that reverse in the Java Sea during the 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.
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 the 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 through 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.
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.
2013	Seafloor coral reef (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.

Table 19 /

Method	Source
Standard procedure consisted of measuring a 50 m section of strand line and simply counting the 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. Items of man-made materials, including plastics, polystyrene, rubber, nylon, glass and metal items, were counted during this survey.	Willoughby *et al*. (1986)
Surveyed 56 sites. Shores were sampled by making transects 100 m long immediately above and parallel to the 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)
Number of litter items were recorded along transects measuring 10 m x l 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 the island's circumference. Litter was categorized in the same way as Willoughby (1986).	Uneputty and Evans (1997a)
Strandline litter: Method used to assess the strandline litter was similar to that described in Willoughby (1996). Ninety-nine transects were carried out on 23 islands visited. Sea surface litter: Count was made as boat carrying the team around islands returned to Jakarta. These counts were made for 5 minutes at a time, recording pieces of litter on the sea surface within an estimated 3 m from starboard side of boat. As boat was moving at a calculated 12 km hr/t, this meant that area covered during each five-rain period was 3 000 m^2.	Willoughby, Sangkoyo and Lakaseru, (1997)
Numbers of litter items were recorded along transects measuring 10 mx l m, immediately above strandlines. There were between 5 and 20 transects for each island, spread atabout equal intervals.	Uneputty and Evans (1997b)
Three belt transects laid along reef contours at 3 m – 4 m in depth andabout 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)

Year	Area	Abundance
2014	Fishes (*n*=76) on sale in Makassar, Indonesia	Microplastic abundance: 21 items (28%) of plastic found in gastrointestinal (GI) tracts of 76 individual fish. Average length: 3.5 mm (±1.1 SD) Dominant shape: 63 plastic fragments (60%), 39 pieces of plastic foam (37%), 2 plastic films (2%) and 1 plastic monofilament line (1%)
May 2015	Deep-sea sediment samples (*n*=10) taken at depths ranging from 66.8 m to 2 182 m at westernSumatera, eastern Indian Ocean	Microplastic abundance: 41 particles of microplastic in form of granule (35 particles) and fibre (6 particles) present in 8 out of 10 sampling sites. Most of 20 MPs found at depths less than 500 m, while MPs also present at more than 2 000 m deep.
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 MP abundance: 16.8–41.6 items/m^2. Dominant polymer type: polypropylene (68%) and low-density polyethylene (11%).
December 2015	Sediment samples (*n*=10) at coral reef habitats in Sekotong, Lombok – Indonesia	MPs 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: usage of Styrofoam™, food and beverage packages, also fishing devices
March to July 2015	Microplastics in digestive tract of specimen in commercial fisheries off Pantai Indah Kapuk coast, Jakarta, Indonesia	Abundance: 169 of 174 (97.13%) of examined fish had microplastics. A total of 2 063 microplastic particles were collected with the average number of 12.21 ± 9.76 particles per individual. The highest number (20.0 ± 8.0 particles/individual) was found in Sardinella fimbriata and the lowest one (4.9 ± 4.7 particles/individual) was found in Oreochromis mossambicus. Dominant types of ingested particles: fibres (89.63%), fragments (6.24%), films (4.13%). Dominant colour of ingested particles: transparent particles (79.20%), followed by blue (7.03%), red (3.54%), black (2.86%), green (2.71%). Other findings: The highest number of fibres by size was <20-100 μm (55.03%), films were 100 - 1 000 μm (33.93%), and fragments were <100 μm (25.25%).

Method	Source
GI tract was placed into individual polypropylene sample jars, which were filled to three times volume of tissue with a 10% KOH (potassium hydroxid) solution in ultrapure water and incubated overnight at 60 °C to digest organic material.	Rochman *et al*. (2015)
Samples were retrieved using a 60 cm x 40 cm x 50 cm box core at 10 stations. Microplastic extraction was conducted with modified floatation method by using a concentrated saline solution at 1.18 g/l and double-distilled deionized water. Sediments were oven-dried (60°C, 24h). To remove organic matters, sediments were added with H_2O_2 and heated (90°C), and then visible froth was removed. Dried sediment samples weighted 62.5 g were put on Erlenmeyer bottle with 250 mL concentrated saline solution, and then stirred using a 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)
Seventy students were tasked with marking sampling quadrats and then sorting and counting the plastic litter in the quadrats. Chosen were 24 quadrats (from eight transects), based on accessibility and orientation with respect to domina/nt south-easterly winds. At each sampling transect, a 30-m-long transect line was delineated, and three quadrats measuring 2 m × 2 m were delineated alongside the transect parallel to the shoreline. The sampling points were located 1 km –1.5 km from one another.	Syakti *et al*. (2017)
Sediment samples were taken on east monsoon season on December 2015 by diving in coral reef habitats (depth range between 3 and 5 m) in Sekotong, Lombok Island, Indonesia (Figure 1). There were 10 stations spreading in the bay of Sekotong. Sediment samples (1 000 g) were taken, using stainless 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 on 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 minutes). After 6 hours, supernatant was extracted from mixture, and then was filtered into Whatman cellulose filter paper (dØ: 47 mm; pore size 0.45 μm)	Cordova, Hadi and Prayudha, (2018)
Fish were collected in six stations along Pantai Indah Kapuk coast from March to July 2015. Six gillnets (30 m ×1.5 m) with 2x2 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 into natural prey and microplastics under a microscope (10x10 magnifications). Microplastic particles were identified by abundance (particles individual-1) and categorized by type (film, fibre, fragment, dan pellet), colour (transparent, blue, red, black, green, orange, yellow, and purple), and micrometre size (<20 - 5 000 μm for fibre, <200 - >100.000 μm for film, and <100 - >5 000 μm for fragment).	Hastuti, Lumbanbatu and Wardiatno (2019)

Year	Area	Abundance
March 2016	Marine litter on Selayar Island Coast, South Sulawesi, Indonesia	Average density of organic waste by weight was 4 978.3 ± 3 342.5 g/m^2 and number of pieces was 7.7 ± 1.8 items/m^2. Inorganic waste density is 14.3 ± 2.97 items/m^2 for the number of pieces and 564.8 ± 196.1 g/m^2 for waste weight. Daily accumulation was about 1 445 ± 1 743 g/m/day, the number of pieces 14.3 ± 8 item/m/day, cubication 0.0187 ± 0.019 m^3/m/day. Inorganic litter composition: plastic, Styrofoam and rubber that lighter material than organic litter. Identified influencing factors of litter: presence of estuary, slope of shore.
2017	Microplastics in sediment samples from riverbed in Pluit and Ancol areas in Jakarta Bay	Microplastic abundance in sediment: 18 405 to 38 790 particles/kg dry sediment. Fragment with size of 100-500 μm was the most abundant microplastics in the two locations. Majority of polymer found in the sediment were low-density polypropylene (PP).
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 MPs size: 211.163 μm
2017	Micro- and macrolitter in intertidal zone of Jaring Halus Village, Langkat Regency, North Sumatra Province, Indonesia	Total number of macroplastic collected from three stations (divided into 27 observation plots) was 308 items with total weight of 3 689.87 gr. Highest macroplastic density found in Station 2 ranged from 18.33 to190.33 species / m^2 with weights ranging from 246.33 to 2 103 gr. The 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 gr. (Note: 1 grain = 64.79891 milligrams) Microplastic dominant shape: film (52.30%), fibre (24.88%), fragment (22.74%), and pellet (0.1%)
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)	MPs discovered in 22 of 81 sediment samples, with abundance from 2.96 to 28.29 items/kg. 19 MPs discovered in 10 of 51 benthic animal samples, with abundance range from 0.30 to 0.50 items/individual Dominant shape: line (filament) 84% in sediment samples and 95% in benthic animal samples

Method	Source
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 in transect with 5 m width and length by following the beach width. Observations was conducted at low tide water level and repeated 3 times plot every site (Lippiatt *et al*. 2013). Observation of floating litter according to (UNEP, 2009) with a visual survey. Marine litter was taken and counted on the ground. Floating litter was observed with line-transect method by start from coast to slope and 2 m width, observed by snorkelling. Daily accumulation rate of marine litter determined by line-transect method. Observed during 17 days, from 5 to 22 March 2016. Stranded marine litter were taken and sorted, then analysed the amount, types, weights, density and composition of marine litter (Eriksson *et al*. 2013; Walalangi, 2012)	Hermawan, Damar and Hariyadi (2017)
Microplastics were separated by the following steps: (a) drying, (b) volume reduction, (c) density separation, (d) filtration, and (e) visual sorting (Hildago-Ruz *et al*. 2012). Separation was done with the graded filter (5 000 μm, 1 000 μm, and 30 μm). Smaller microplastic samples (30-100 μm) were separated using a monocular microscope (magnification 10 x 10).	Manalu *et al*. (2017)
Mussels were removed from skin 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 SEM/EDX analysis.	Khoironi, Anggoro and Sudarno (2018)
Macrodebris survey: The macrodebris samples (> 20mm) were collected with transects (1× 1 m) from each substation with the highest tidal boundaries and the lowest tidal boundaries divided into three sections. The macrodebris composition is grouped into plastics, fabrics, foams, Styrofoam, glass, metal, rubber and wood. Samples are collected into sacks and labelled. The items (to further explain the flakes) in each macrodebris group are collected macroplastic, dried, calculated and weighed. The parameters taken include the number of items (items/m^2) and weight (g/m^2). Microdebris survey: Sediment sampling (1L) was performed with core based on three stratified depths (0-30 cm). The core placement is performed on three sections (top, middle and bottom edge) at the substations at the highest tide and lows. The separation of microplastic particles (0.045-5 mm) from the sediments was carried out by several stages, namely (a) drying, (b) volume reduction, (c) separation of density, (d) filtration, and € visual sorting. Drying was done with 105 ° C oven for 72 hours. The dry-sediment volume reduction step was performed by filtration (5 mm in size) [17]. The density separation step is carried out by mixing the dry-sediment sample (1 kg) and the saturated NaCl (3L) solution and the mixture are stirred for 2 minutes. Floating plastics are polystyrene, polyethylene and polypropylene. The filtration stage is carried out by filtering the supernatant (size 45 μm).	Bangun *et al*. (2018)
Oven dried sediments (100 g) were subjected to sieve-net with gradient mesh size down from 2 mm to 0.063 mm. Benthic animals were all subjected to 10% KOH (potassium hydroxid) 3 times of sample volume and left at 60° C overnight. MPs identified with stereo microscope with magnification 4.5 x 10.	Tahir *et al*. (2019)

Year	Area	Abundance
October–-November 2017	River surface and sediment samples (*n*=10) in slum and industrial areas in Ciwalengke River, Indonesia	MP abundance in surface water: 5.85 ± 3.28 items/litre MP abundance in sediment: 3.03 ± 1.59 items/100g dry sediments Dominant polymer type: polyester, nylon fibre
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
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 was 122.8 ± 67.8 pieces per station, with concentration 0.46 ± 0.25 pieces/m^3 Dominant polymer type: Polyethylene (PE) (17.3 ± 8.3%), low density PE (17.6 ± 5.5%), oxidized LDPE (< 0.1%), polypropylene (PP) (54 ± 13%), PP Atactic (< 0.4%), PP isotactic (< 0.2%) and polystyrene (PS) (10.4 ± 9.1%)
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: LDPE (22.9%), PS (19.5%), PP (16.6%), PET (10.4%), HDPE (9.2%), PVC (7.2%), PU (4.9%), polyester (4.7%), polyamide (4.3%) and styrene/butadiene (0.3%)
2018	Sediment samples (*n*=5) from Wonorejo Coast, East Java	MP abundance in sediment: 590 particles/kg dry weight MP dominant shape: Fibre (57%), film (36%) and fragment (7%) MP dominant polymer type: 56.7% polyester, 24.6% low-density polyethylene and 18.8% polypropylene MP dominant colour: 43% transparent, 21% black, 14% blue, 10% white, 8% red and 4% yellow
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)

Method	Source
Sediment samples were collected at centre of river, using Ekman grab sampler on river sediments and shovels for rocky sedimentary river conditions. 100 g of sediment sample were dissolved with 400 mL 30% NaCl solution. Stirred for 2 minutes and left standing, then filtered using a 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 500mL 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)
Six beaches were assessed on this study, comprised of total 12 transects. Using line transect between 100 metres 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 consisting of 3–5 persons. Interviews with locals were also carried out to gain more information.	Purba *et al*. (2018)
Samples were collected from 11 sampling stations, using a specially designed Neuston net (75 cm × 50 cm), opening to a rigid frame equipped by four successive different-sized grids, towed along 1.8 km of imaginary transect lines at a boat speed of 1–1.5 miles/hour (about 1.61 km – 2.41 km/hour). After towing, Microplastic trapped in the mesh (sized 1mm to 5mm) 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 the filter screen with a 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)
Plastics were enumerated in a 180 m^2 permanent quadrat (6 m × 30 m) in intertidal zone. The polymers were also identified directly on-site, using a 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)
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)
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)

Data on MSW generation and management in Indonesia

Table 20 /

MSW background information [1]	
Population	270.62 million (2019), with 55.3% urban population
MSW generation	65.2 million tonnes per 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, polypropylene, PET resin)	1.91 million tonnes (2019)
Polymer exports	0.42 million tonnes (2019)
Polymer imports	2.60 million tonnes (2019)
Domestic conversion of polymers into single-use applications	2.30 million tonnes (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.72 million tonnes (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.68 million tonnes (2019)
Domestic single-use plastic waste generation	2.26 million tonnes (2019)
Single-use plastic waste generation per capita	8.47 kgs (2019)
MSW collection and treatment [3]	
MSW collection coverage	40–50% (2015); 40% in 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; 52 controlled dumpsites;

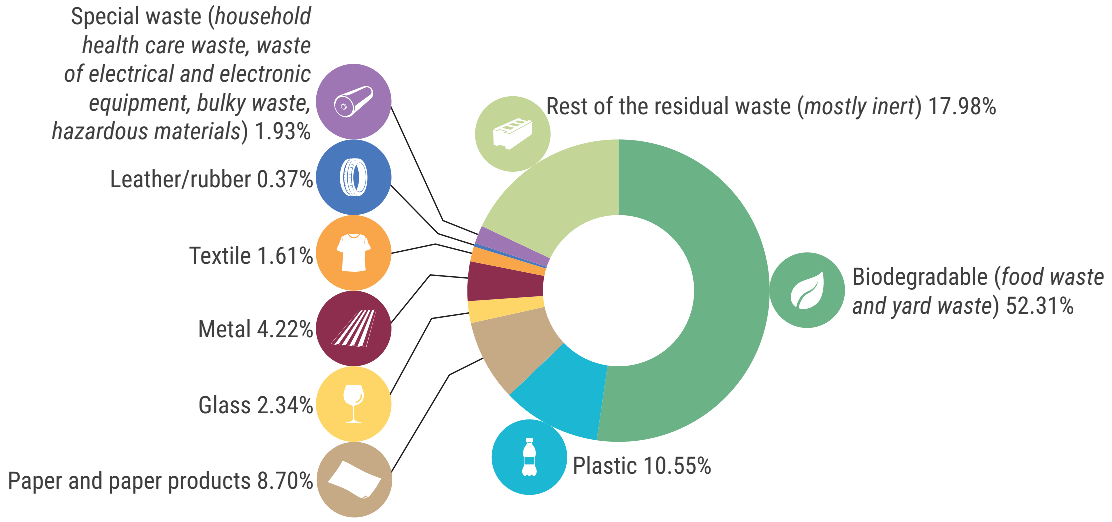
Source: [1] Kaza *et al*. (2018); [2] Minderoo (2021); [3] Borongan, G. and Kashyap, P. (2018)

Regarding solid waste management, on the one hand, Indonesia has established a good legal framework for waste management (OECD 2019). 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 illegal import and pirate plastic waste import from developed nations. In July 2019, Indonesia returned the foreign rubbish that did not qualify as recyclables to developed countries, including Australia, France, Germany and the United States.

Another additional waste management challenge for Indonesia is the often deeply ingrained habit of dumping and burning to deal with uncollected waste, with over 50 per cent of urban households and almost

Indonesia MSW composition

Figure 4 /



Source: Borongan, G. and Kashyap, P. (2018)

90 per cent of rural households burning waste. According to a study by the country's Central Bureau of Statistics on environmental behaviour, 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 in an environment where it can leak into waterways. In fact, 18.5 Indonesians use waterways as their primary trash disposal method, and many millions more use waterways as one of a several methods of disposing trash.

In Indonesia, institutional oversight differs for the management of solid waste from household and in waterways. At the local scale, municipal solid waste (MSW) management is typically done by the Cleansing Department (Seksi Kebersihan) of each district, with household level collection delegated to the local government. On the other hand, managing MSW 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. 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 efficiency and effectiveness of the execution of mandates and institutional responsibilities (Shuker and Cadman 2017).

Actions on combating marine litter

Policy action taken by the Government of Indonesia in combating marine litter is shown in Table 21.

Marine litter has gained high policy awareness in Indonesia. Multiple presidential decrees, government policies prohibiting of plastic bags, as well as action plans against marine litter, have been introduced. As early as February 2017, the Indonesian Government joined the UNEP Clean Seas Campaign in 2017 at the fourth World Ocean Summit in Bali, promising "to reduce marine plastic waste by 70% by 2025" and pledged US$ 1billion in funding each year to support a range of programmes on land, coast and sea to realize such objective.

Government action on combating marine litter in Indonesia

Table 21 /

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)

The Government published the Indonesia's National Plan of Action on Marine Plastic Debris 2017–2025", a plan with five pillars including 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.

Toward the 2025 goals, the Plan focuses on the following areas:

- On the local government level, authority of the river catchment shall provide human and financial resources for improving plastic waste management infrastructure and drive behavioural change through integrated coastal waste management projects.
- At the national level, plastic waste education, waste-to-energy projects, paid plastic bag policy, use of waste plastics 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 the academics and community service organisations (CSO), the main areas of action are Research and Development, Campaign and "Waste Bank".

Some innovative measures have been taken in Indonesia to manage the plastic pollution. For instance, in 2017, the Indonesian Government tried to use asphalt with plastic waste as a raw material for pavements. The "Plastic Bus" project 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 improve the 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 cleaning teams, the army 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, under 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 tonnes 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.

IMAGE

Japan

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

State of marine litter management

A selected list of studies on the distribution of marine litter in Japan shown in Table 22.

Japan has an 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 as early as to1982 (Miyake *et al*. 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 (Kuriyama *et al*. 2002; Kanehiro, Tokai and Matsuda1995), Hiroshima Bay (Fujieda 2005), Sagami Bay (Kuriyama *et al*. 2002) and the North Pacific region of the open sea. Among studies, a Hiroshima Bay study on microplastics reported a high abundance of microplastics, of 56,500 million pieces per square kilometre, mainly polystyrene foam from oyster culture.

On Ookushi Beach, an inaccessible beach facing the East China Sea, several studies have been conducted on the monitoring of litter, owing to the minimum impact of human activity on land (Kako, Isobe and Magome 2010;

Selected studies on the distribution of marine litter in Japan

Year	Type	Findings
1972	Litter on ocean surface of the Central North Pacific	Litter abundance: 4.24 items/km^2 (large debris, according to Dufault *et al*. 1994); 0.5 plastic bottles per km^2 Total findings: Total of 53 man-made objects was recorded in the 156 km or 12.5 km^2 of ship travel
1963–1986	Litter ingestion by stranded animals (Odontocete Cetaceans)	Total of 40 incidences of debris ingestion in 16 species of stranded odontocete cetaceans. Plastic debris was prevalent, with a total occurrence of 80.0%. Plastic bags and plastic sheeting were the most prevalent items (62.5%).
1985–1988	Ocean surface near Japan	7.47e4 items/ km^2 3 007.9 g/km^2 near the Subarctic Front east of Japan, 1 979.1 g/km^2 in Transitional Water east of Japan MPs abundance: 128.2±172.2 items/km^2 (according to Bergman *et al*. 2015)
	Chichishima Island, Japan	Mean plastic litter abundance: 186.3 items/m^2, with minimum size 0.3mm and 53% are foamed plastics.
1989–1991 and 1993	Marine litter on seabed of fishing grounds in Tokyo Bay, Japan	Mean abundance of litter in 1990: 4.0 items/hectare, with weight 151.1 g/hectare. Plastics (synthetic polymer resin) made up 80–85% of the total. Dominant type of litter: plastics, textiles and fishing gear
1997 and 2001	Microplastics in sediment core of moat from Imperial Palace, Tokyo, Japan	Abundance of MPs: 7 228 pieces/kg dry sediment in surface layer (0-2cm), and 1 100 pieces/kg dry sediment in middle layer (38-40cm);
1997–1998	Pellets on coastal beaches, Japan	No data on distribution of plastics were reported.
1995–2000	Sea floor of Tokyo Bay, Japan	Litter abundance: 338 items/km^2 weighing 20.1 kg/km^2 in 1995, and 185 items/km^2 weighing 10.4 kg/km^2 in 2000.
May–June 2000	Visual observation in north Pacific ca. 56km off Japan	0.1-0.8 items/km^2 at size >5cm Abundance of floating marine debris (FMD): 0.37±0.51 items/km^2, with max quantity recorded of 3.31 items/km^2 Percentage plastics (including Styrofoam™): 45.5% of all floating marine litter (calculated value) and 70% of all manufactured FMD Floating plastic litter abundance: 0.26 items/km^2 (calculated value)

Table 22 /

Method	Source
Observation from vessel	Venrick *et al*. (1973)
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)
Ring/Neuston net (0.5mm mesh size)	Day *et al*. (1990)
	Ogi (1995)
Each trawl was pulled for 25–90 min duration and covered a 6.5m (length of beam) Wide path. In 1989, 20 hauls; in 1990, 39 hauls; in 1991, 48 hauls and in 1993, 41 hauls; tota1 148 hauls over 4 years were carried out.	Kanehiro *et al*. (1995)
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 the MPs, 10 grams of freeze-dried sediment or wet sediment corresponding to 10 g of dry sediment was analysed for microplastics. To remove biofilms from the surface of microplastics, 150 mL of 30% H_2O_2 was added to the sediment in glass beaker. After reaction ceased, which was normally after 1 week, sediment was passed through 315μm, mesh-size nylon sieve.	Matsuguma *et al*. (2017)
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 the high- tide line or with bare hands.	Mato *et al*. (2001)
	Kuriyama *et al*. (2003)
Sighting survey was conducted from dawn to dusk, navigating about 56 km miles off the Japanese coast during May–June 2000, using the research vessel “Daini Kyoshin Maru (372 t)” with about 70 m length and deck height of about 5 m above the waterline. During navigation at speed of about 10 knots, team of two or three observers on bridge surveyed both sides of the vessel: observers continuously focused on the port or starboard of vessel reporting any observed item and immediately recording type, size, number and distance of each item and angle of item from bow as well as ancillary data (date, time, location, surface temperature, etc.). The strip transect method was used for estimating the density of FMD, based on number of items seen, perpendicular distance to transect for each item and transect length.	Shimoto and Kameda (2005)

Year	Type	Findings
July 1998 – November 2000	grounded and buried plastic debris on beaches of Kagoshima, Japan	Total beach litter collected: 80 655 pieces, with 99.9% being plastics, and 92.6% being foamed plastic fragments, majority (91%) of which are of the size range 0.3 mm–4.0 mm Density of litter: 290.4 pieces/litre Stranded plastic density on protected beach: 9 673.1 items/m^2, with maximum of 69 168.8 items/m^2 and 96.8% being foamed plastics Stranded plastic density on offshore beach: 2 722.5 items/m^2, with maximum of 29 331.3 items/m^2 and 81.8% being foamed plastics Minimum size of stranded foamed plastics on both beaches are 0.3 mm Identified origin of foamed plastics: Fenders of fishing boats and floats of aquaculture pens, washed ashore and weathered into small fragments
In Japanese	Sea surface: Kagoshima Bay, Japan	Plastic abundance: 24 500 items/km^2; minimum size is 1 mm and 32.9% are foamed plastics
September–November 2000	Litter on 26 beaches along Sea of Japan	Total of 213 290 g and 32 212 items of litter were found in this survey of the Japanese beaches Mean abundance of litter on Japanese beaches: 3.41 items/m^2, ranging from 0.41– 12.72 items/m^2 by count and 21.44 g/m^2, ranging from 1.44-73.29 g/m^2 by weight Abundance of pellets: 0.52 items/m^2 Fragments: 1.1 items/m^2, Dominant stranded litter composition in Japan: Plastics, including Styrofoam™ (92.2% by count and 57.2% by weight) Mean abundance of buried litter: 13.6 g/m^2 and 2 610 items per m^2 (in Japan); 8.78 g/m^2 and 31.3 items per m^2 (in Russia) Other findings: Resin pellets were found on 12 Japanese beaches but on none of Russian beaches
May 2000 – May 2001	Litter in subtropical mangrove in Okinawa Island, South Japan	Mean annual litter production was 12.95 ± 2.95 t/ha (dry weight) with leaf fall contributing more than 70% of total litter production
2000–2001	Ocean surface	203–663 items/hectare
2001	Ocean surface of the east coast of Japan	1.41e5 items/ km^2 MPs abundance: 174 000 ± 467 000 items/km^2, Size of plastic pieces captured ranged from 1 m to 280 mm. Pieces >11 mm accounted only for 8%, and particles of 1 mm–3 mm accounted for 62% at total average litter mass of 3 600 g/km^2

Method	Source
Sand samples were collected for 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 materials were scooped up with testing sieve (0.3 mm openings), then sorted, dried and divided into three size groups with testing sieves (4.0 mm and 10.0 mm openings), and their numbers were counted.	Fujieda (2002)
In Japanese	Fujieda (2003)
Two types of litter (stranded and buried) were measured. To evaluate the amount of stranded litter on the 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, the litter was collected and sorted into categories (plastics, rubber, Styrofoam™, paper, cloth, glass/pottery, metals and other artificial 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 the survey units for stranded litter. To collect the buried litter, the sand of 8L, from a 40 cm × 40 cm space to a depth of 5 cm, was raked by using box-shaped stainless-steel frame (after removing any visible stranded litter on the sand) and put into bucket. The sand was mixed with seawater and stirred, then supernatant was filtered with net (0.3- mm mesh) to collect floating plastic particles. The plastic particles were put into plastic bags and sent to Toyama Prefectural University for sorting. 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)
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, making sure that they were above the maximum tide height and at a position that ensured maximum catch of litter. Seven such traps were randomly distributed at each site, making a total sampling area of 3.5 m^2.	Mfilinge *et al.* (2005)
Neuston net (mesh size 1.00 mm × 1.64 mm)	Uchida *et al.* (2016)
Neuston net; surface trawl nets on transects of 10 min at two knots with a net opening of 50 cm and a mesh size of 333 µm	Yamashita and Tanimura (2007)

Year	Type	Findings
1999–2002	Deposited fishing gear in the East Sea, Japan	Amount of litter removed: 2 759 tons
2001 and 2002	Plastic pellets from 47 beaches, Japan	Pellets <5mm: More than 100 pellets were collected from each of 47 beaches
2002	Resin pellets on beaches (n=30) of Tokyo Bay and Sagami Bay, Japan	Dominant composition: Polyethylene (60%) and olypropylene (35%)
2002	Beach: stranded debris on 34 beaches of Eta Island and Kurahashi Island in Hiroshima Bay, Japan	5.65e10 items/ km^2 Plastic debris mean density: 44 521.3 items/m^2 with maximum of 282 681.3 items/m^2, 98.6% of which are foamed plastic fragments
March, May and November 2003	Litter on anageme beaches of Kikai Island, Okinoerabu Island and Yoron Island of Amami Islands, Japan	Plastic materials were the most abundance type of litter Dominant types of plastic: pieces and fishing floats
May 2003 – October 2005	Seabed litter at eight stations in Kagoshima Bay, Japan	Sediments collected from the sea bottom contained 54 388 items, 76.9 kg of natural objects and seabed litter. Average density of seabed litter was 2 517 items/km^2 and 30.3 kg/km^2 accounting for 3.7 of total sediments by number. Dominant type of deposited litter on sea bottom was filmy plastic, including plastic bags accounting for 49.0 per cent of seabed litter by number. Seabed litter was found at all stations in Kagoshima Bay whether or not the station was in a fishing ground. Density distribution of filmy plastic was higher in innermost and central area of this bay similar to the distribution of plant leaves.
October 2004–November 2005	Swaji Island, Japan	Litter categories: Fragments of plastic, ceramics, etc. (n=22 626 at all three sites) Land: Debris generated from land, for example, cigarettes (n=4 316 at all three sites) Sea: Debris generated from sea, for example, fishing nets (n=1 246 at all three sites) Local items: Debris related to local industries, for example, roof tiles, onions (n=293 at all three sites)
2005	Litter in Ryukyu Trench (7 100 m) and in the basin of the Okinawa Trough, Japan	Density of litter: 1 200 to 7 100 items/km^2, or 7.5–121.4 kg/km^2, 100 — 600 items/km^2; 0.03–9.2 kg/km^2 (adjacent shallower continental slopes or abyssal plain) Other findings: trenches and troughs function as “depocenters” for anthropogenic litter because of their deeper and enclosed topographies

Method	Source
Not specified	Inoue (2004)
Sixty resin pellets were collected from a beach in Kasai Seaside Park, Tokyo, along the high-tide line within a range of 30 m, using solvent-rinsed stainless-steel tweezers. Besides, resin pellets were collected from 47 beaches in 2001 and 2002.	Endo *et al.* (2005)
In Japanese	Kuriyama *et al.* (2002)
In Japanese	Fujieda *et al.* (2005)
Research areas were chosen in two beaches each in the 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). A quadrate (10 m x 10 m) was fixed in each level. On the other hand, a quadrate (30 m x 30 m) was fixed in the middle intertidal level in Kikai Island. Only pieces larger than 3 cm x 3 cm x 3 cm were counted.	Kei (2005)
Sampling surveys using a small trawl net were conducted 118 times (May 2003–October 2005) to estimate the distribution and composition of seabed litter at eight stations established in Kagoshima Bay.	Fujieda *et al.* (2009)
The study was conducted on three beaches with different geographical characteristics. Researchers chose two areas 10 m wide and 20 m deep at each beach, collecting only man-made debris by hand. Type and number of items found were then recorded.	anagem *et al.* (2008)
Faunal samples were taken using ORE type beam trawl of 4-m span with an 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 the faunal samples were extracted from net and washed. In the laboratory, litter was kept in plastic container under room temperature for 10 years.	Shimanaga *et al.* (2016)

Year	Type	Findings
March–October 2009	Litter on Ookushi Beach, Goto Islands, Nagasaki, Japan	Other findings: White polystyrene buoys are prevalent in the litter composition
October 2009	Litter on Ookushi Beach, Goto Islands, Nagasaki, Japan	Average mass of litter per unit area: 5.8 kg/m^2, with the total mass of beach litter estimated at 716±259 kg Plastic percentage: 74 ± 10% of all litter, with weight being 530 ± 207 kg
September 2007–September 2009	Litter (plastic bottle caps) on Hassakubana beach of Goto Islands, Japan	Litter quantity: About 30 to over 200 bottle caps, and 20 to 150 polystyrene buoys were discovered on beach Other findings: Strong correlation between intense winds such as typhoons with drifting litter motion.
Not applicable	Litter in deep-sea trenches of offshore Iwate, Japan	Litter density: 15.9 items/h with most of the litter being plastics Percentage plastics: 42.8% Other findings: Places where deep-sea litter accumulated was almost always on a muddy sediment bottom with small tidal currents where sea cucumbers were found frequently.
2003, 2004 and 2011	Seafloor: Marine litter on continental slope off the Pacific coast of northern Japan	Marine litter abundance: 54–94 items/km^2 (in 2003 and 2004), 233–332 items/ km^2 (in 2011, after the March 2011 Tohoku earthquake)
August 2011	Wadahama Beach is on the west coast of Nii-jima Island, Japan	Other findings: Diffusion of beach litters depend on hydrodynamic statistics and beach geomorphology as well as on dimensions and density of items
2010–2012	Microplastics and mesoplastics in surface water of the Hiji River mouth, in the Iyo Sea, the Uwa Sea and the Hyuga Sea, Japan	Number of plastic litter items collected: 418 items (Hiji River mouth), 346 items (Iyo Sea), 137 items (the Uwa Sea) and 90 items (the Hyuga Sea) Other findings: Small plastic fragments larger than a few mm rapidly disappeared when surveyors moved offshore. Meanwhile, microplastics, especially those smaller than 1 mm were spread widely in an offshore direction.

Method	Source
Two webcams monitoring beach litter were placed on Ookushi Beach in Goto Islands, Japan. Litter is identified from photographs taken by webcam.	Kako *et al*. (2010)
First, total area covered by beach litter was calculated, using the 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, the total litter mass over the beach was estimated by multiplying the total litter-covered area obtained from the balloon photography by the averaged mass of beach litter per unit area among 10 boxes.	Nakashima *et al*. (2011); Nakashima *et al*. (2012)
Beach surveys were carried out every 2 months from September 2007 through September 2009 (13 surveys in total). Some 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 the 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 the total number of litter reaching Hassakubana Beach over the course of 2 months (i.e. the interval between each beach survey).	Kako *et al*. (2011)
JAMSTEC Deep-sea Debris Database	Miyake *et al*. (2011)
Seafloor anthropogenic marine debris were collected from bottom trawl surveys carried out by the R/V Iwatemaru off Iwate Prefecture, Pacific coast of northern Japan, in 2003, 2004 and 2011. Surveys were conducted on the upper continental slope, ranging from 183 m to 521 m depth, between 39°N and 40°10N. Samples were collected, using an 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 a period of 30 mins from contact of footrope on seafloor, swept area (km^2) being calculated on basis of net opening width and towing distance.	Goto *et al*. (2015)
Images are taken every two hours by webcam system installed on the beach northern hinterland.	Kataoka *et al*. (2013)
Neuston net (350 μm mesh size)	Isobe *et al*. (2014)

Year	Type	Findings
2011–2012	Marine litter on seafloor near Japan	Average number of debris items (at 10 main, video-surveyed study sites at depths from 289 m to 890 m and at distances from 11 km to 57 km from coastline) was 5 195 (standard deviation [SD] = 5 133) per km^2. It was 1 116 per km 2 (SD = 961) at the five sites in deeper areas near the trench (>1 000 m depth), which were over 100 km from the coastline. In canyon areas, the average number of debris items per km^2 was 6 761 (SD = 3 528), and this was higher than at other areas of similar depth that we studied (mean = 3 629, SD = 6 381). Of the observed debris categories, "plastics" were most numerous (113), followed by "wood and paper" (85). A large subset of the debris (over 237 items) was unclassifiable. Other findings: Accumulations of tsunami debris were found mainly in submarine canyons.
2012	Seafloor: Kuril-Kamchatka area (NW Pacific), Japan	2.02e9 items/ km^2 MPs abundance: 60-2 000 microplastics/m^2 Other findings: From trawl sampling, most plastic litter are fishing gear.
2012–2014	Sediment Core of Canal in Tokyo Bay, Japan	Microplastics: 1 900 pieces/kg dry sediment, with range 1 845–5 385 pieces/kg-dry sediment Stocks of MPs per unit area: PE (6e4 pieces/m^2), PP (2e4 pieces/m^2) Dominant shape: Fragments (75%), fibres (15%) and beads (4%)
2013–2014	Surface water, Tokyo Bay, Japan	Stocks of MPs per unit area: PE (1.7–3.2pieces/m^2) and PP (0.7pieces/m^2)
July–September 2014	East Asian seas around Japan	MP abundance: 1.72e6 items/km^2
1982–2015	Seafloor of the Western North Pacific near Japan	Total debris number: 3 370 items, out of which 1 108 items were plastics. Of the plastics identified, 89% were single-use plastics. Total dive number: 4 552. Maximum depth of plastics: 10 898 m
September–October 2015	MPs in Tokyo Bay, Suruga Bay, Ise Bay and the Seto Inland Sea, Japan	In total 4 929 pieces of microplastics were discovered, out of which 45 (0.9%) were microbeads.

Method	Source
Deep-sea survey conducted by side scan sonar, deep-tow submergible cameras and remotely operated vehicle system	Yamakita *et al*. (2015)
20 box cores (0.25 m^2) (Agassiz trawl, camera epi- benthic sledge)	Fischer *et al*. (2015)
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 the MPs, 10 grams of freeze-dried sediment or wet sediment corresponding to 10 g of dry sediment was analysed for microplastics. To remove biofilms from the surface of microplastics, 150 mL of 30% H_2O_2 was added to sediment in a glass beaker. After reaction ceased, normally after 1 week, sediment was passed through a 315-lm, mesh-size nylon sieve.	Matsuguma *et al*. (2017)
A Neuston net (30-cm i.d. and 1-m length) of 315-lm nylon mesh size was deployed from the side of a boat at a speed of 2 miles per hour for 20 min. The contents were passed through a 5-mm, mesh-size, stainless-steel sieve, and then a 1-mm, mesh-size, stainless-steel sieve and 315-lm, mesh-size nylon sieve.	Matsuguma *et al*. (2017)
Neuston net (350 µm mesh size)	Isobe *et al*. (2015)
JAMSTEC Deep-sea Debris Database	Chiba *et al*. (2018)
Neuston nets (5 552; RIGO Co., Ltd., Tokyo, Japan) were used to collect small plastic fragments near the 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 min at a constant speed of 2–3 knots.	Isobe (2016)

Year	Type	Findings
August 2015	Japanese anchovy (Engraulis japonicus, n=64) in Tokyo Bay	Microplastics was detected in digestive tracts of 49 out of 64 fish (77%). Abundance of MPs: 2.3±2.5 n/individual Dominant polymer type: polyethylene (52.0%), polypropylene (43.3%). Dominant shape: fragments (86.0%), beads (7.3%). Dominant size: 150 μm–1 000 μm (80%).
2017	Ocean surface of Northwest Pacific near Japan	MPs abundance in Northwest Pacific near Japan: 640 — 33 774 items/ km^2 Major composition of MPs near Japan: Polypropylene (which may originate from the nearby land along the coast of Japan)

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 some 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 over the entire country. One recent Ministry survey found that of all litter recovered on the beaches, about 62 per cent was composed of plastics (Figure 5).

	Method	Source
	The Japanese anchovy (Engraulis japonicus) were caught by fishing (using Sabiki rigs) from a pier in Tokyo Bay (35°25'43"N 139°41'15"E) (Figure 1) from 7 a.m. to 2 pm on 23 August 2015. Water depth was about 15 m to 20 m, and the fish were caught at a range of 5 m to 10 m from the surface. The 64 collected were put in iced water and dissected at the laboratory the same day. After measurement of their body length (112.5mm± 6.4mm), entire digestive tract was removed (from top of the oesophagus to the anus) and put it into a 10-mL glass vial that had been baked for 4 h at 550°C in advance. Each vial then received 7–8mL (>3× the volume of the gut) of 10% KOH (potassium hydroxid) solution to digest organic material. The vials were incubated at 40 °C for 10 days, during which digestion was observed to be completed in 3 to 4 days. Each vial was then shaken about 20 times to break up the 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 a microscope, but no particles not resembling natural prey were observed. Because the target fish (anchovy) is commonly caught by recreational fishers and then eaten, the researchers' procedure of fishing and dissection was exactly same as that used in standard fishing and cooking, without introducing any our ethical problem. Thus, the procedure of measuring microplastics in the 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 were recorded. Suspected suspected plastic was further analysed by FT-IR.	Tanaka and Takada (2016)
	Floating MPs were collected from 18 stations (Figure 1) in the Northwest Pacific, using a surface manta trawl with a mesh size of ~330 μm and width of 1 m from August 25 to 26 September 2017. The manta trawl was deployed to sea surface via a reel-operated lift on side of the research vessel. Angle between the trawling and shipping route is about 20°. MPs at ocean surface were sampled by trawling horizontally between 50 and 240 min at speed of 1.0 to 3.0 knots at each field station. For analysis, water samples in the sampling bottle were poured through stacked stainless-steel mesh 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)

State of municipal solid waste management

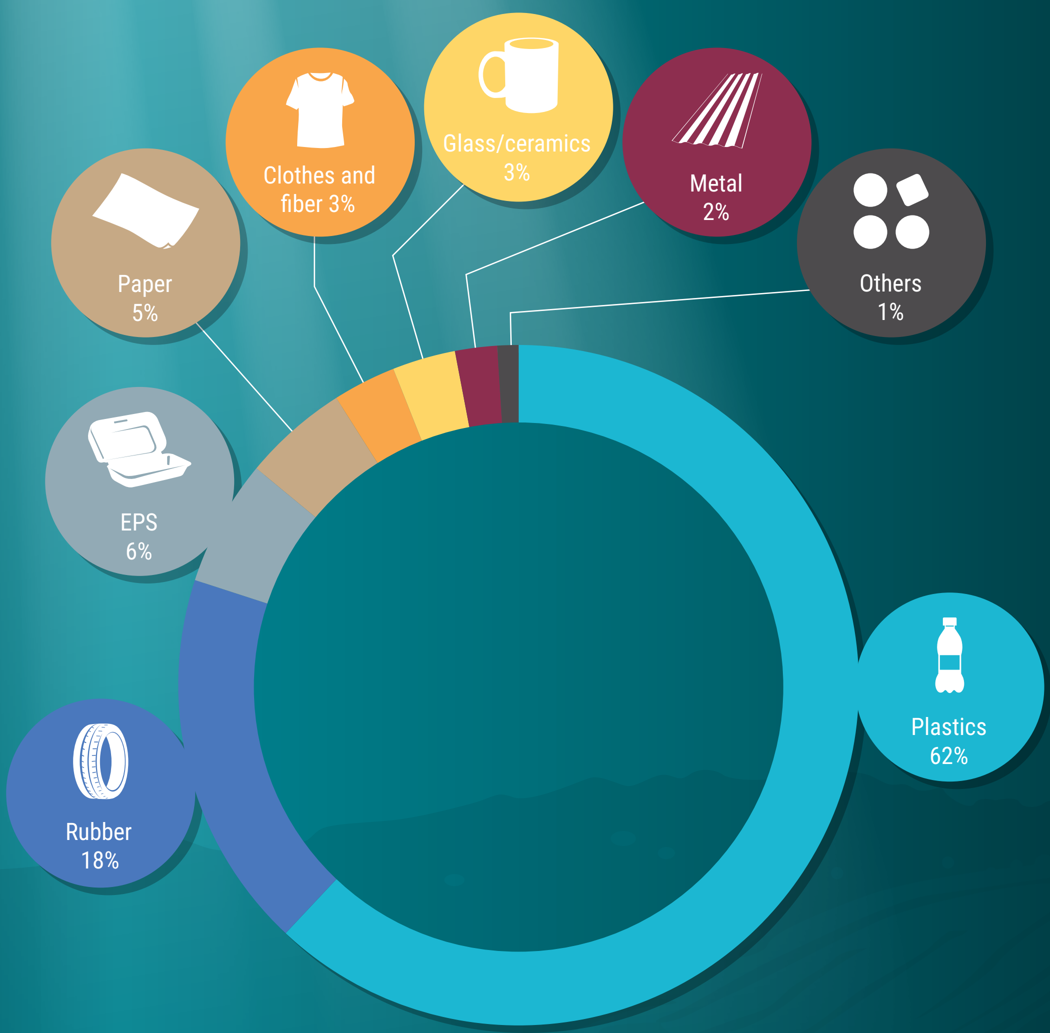
In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation is shown on Table 23.

Actions on combating marine litter

The Japanese Government has given high policy priority to 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 the waste anagement, litter recovery, innovation and empowerment all toward realizing the country's 2019 G20 "Osaka Blue Ocean

Composition of marine litter in Japan (2015)

Figure 5 /



Source: Adapted from NOWPAP MERRAC (2017).

Data on MSW generation and management in Japan

Table 23 /

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

Source: [1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, World Bank; [2] Minderoo (2021); [3] UNEP (2017) Asia Waste Management Outlook

Government action on improving the environment 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)

Vision" to reduce additional marine plastic pollution to zero by 2050 (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 has also gained a sizeable influence worldwide.

IMAGE

Democratic People's Republic of Korea

The Democratic People's Republic of Korea has a 2019 population estimated at 25.67 million with more than two thirds inhabiting the coasts that span 2,495 kilometres. As such, although marine litter has the potential to be an important issue for this country, little scientific data exists on marine litter. The only data available is from 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), Korea's capital city of Pyongyang generated 580,000 tonnes 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.

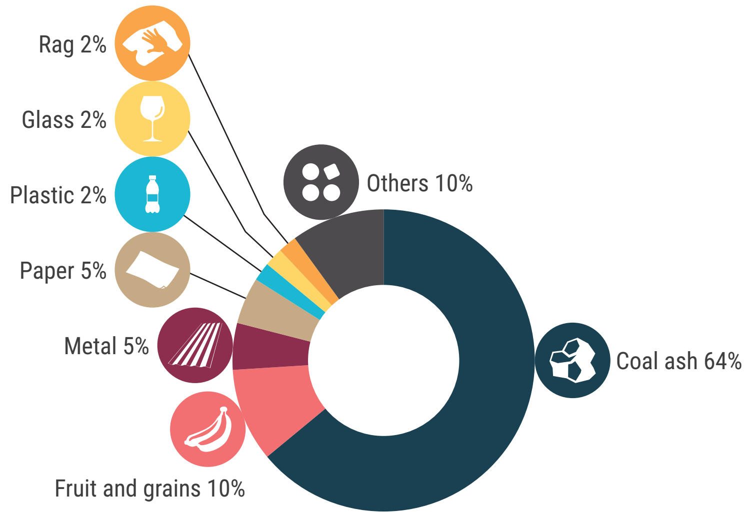
Management of municipal solid waste

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 (2009) (data only for Pyongyang)
MSW per capita	No data
MSW collection and treatment	
MSW collection coverage	No data
Method of treatment	

Source: [1] UNEP (2017a); [2] Korea (DPR) Ministry of Land and Environment Protection (2012)

DPR Korea MSW composition (2009) Figure 6 /



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

IMAGE

Republic of Korea

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

State of marine litter management

A selected list of studies on the distribution of marine litter in the Republic of Korea is shown in Table 26.

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

In 2008, the Ministry of Oceans and Fisheries of the Republic of Korea started nation-wide monitoring of marine litter at 20 sites along the coastline, and expanded to 40 sites in 2015, to study its distribution and environmental impact. 2017 monitoring data shows that plastic made up of more 70 per cent of marine litter. According to the Ministry's 2016 statistics, a total amount of 70,840 tonnes 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, Jiang *et al*. conducted a nationwide study that estimated the annual flow and stock of marine litter (> 25 mm) in the Republic of Korea. Of the samples collected at six beaches, 55 litter types were found, and 56 per cent appeared to result from ocean-based activities. One study (Lee 2006) reported the characteristics of the distribution of different size classes (large micro-, meso- and macro-) of plastic marine litter on 12 beaches in South Korea. Moreover, the abundances of the large microplastics were strongly correlated with that of mesoplastics for most plastic types.

Selected studies on the distribution of marine litter in the Republic of Korea

Table 26 /

Year	Type	FIndings	Method	Source
1996–2005	Litter on seabed of Eastern China Sea and south coast of the 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, such as pots, nets, octopus jars and fishing lines (42%-72% in East China Sea and 37%-62% in South Sea of Korea)	Bottom trawl of the Dong-baek (float line: 53.0 m; sinker line: 62.7 m; total net length: 69.7 m) was used in the East China Sea, and the trawl of the Ka-ya (float line: 46.1 m; sinker line: 61.5 m; total net length: 70.0 m) was used in the South Sea area of Korea. Net mesh size was similar (i.e. 60mm x65 mm).	Lee, Cho and Jeong *et al.* (2006)
Spring 2013	Plastic litter on beaches (*n*=6) in 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 of 5m × 5 m	Jang *et al.* (2014a)
May and July 2012	Microplastics in sea surface microlayer near Geoje Island, Republic of Korea	MPs abundance: 16 000 ±14 000 items/m^3 Dominant types: Alkyds (81%) and poly (acrylate/styrene) (11%) Other findings: Paints and the fibre-reinforced plastic matrix used on ships are likely sources of microplastics	Bulk surface water filtering, hand net (50 μm mesh), and a 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 of Korea	Amount of litter removed: 29 790 tons (deposited litter in shallow coastal waters), 8 057 tonnes (in offshore coastal waters) and 3 444 tonnes (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)

Year	Type	FIndings
1996–2005	Litter on seabed of Eastern China Sea and south coast of the 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, such as pots, nets, octopus jars and fishing lines (42%-72% in East China Sea and 37%-62% in South Sea of Korea)
Spring 2013	Plastic litter on beaches (*n*=6) in 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
May and July 2012	Microplastics in sea surface microlayer near Geoje Island, Republic of Korea	MPs abundance: 16 000 ±14 000 items/m^3 Dominant types: Alkyds (81%) and poly (acrylate/styrene) (11%) Other findings: Paints and the fibre-reinforced plastic matrix used on ships are likely sources of microplastics
2003 to 2007	Nearshore coastal waters, such as fishing ports, commercial ports, wetlands and fishing grounds of Korea	Amount of litter removed: 29 790 tons (deposited litter in shallow coastal waters), 8 057 tonnes (in offshore coastal waters) and 3 444 tonnes (in blue crab fishing grounds at 40 m depth)
March 2008 to November 2009	Litter on beaches (*n*=20) along the eastern, western and southern coasts of Korea	Abundance of beach litter: 480.9 (±267.7) items/100 m for number, 86.5 (±78.6) kg/100 m for weight, and 0.48 (±0.38) m^3 /100m for 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 the biggest contributor of litter being Styrofoam buoys from aquaculture.
2009 and 2010	Derelict fishing gears from the deep seabed of the East Sea	Total of 207.8 and 252.2 tonnes of marine debris in 2009 and 2010, respectively, were removed from the seabed, most of which were derelict fishing gears.
February 2011	Plastic litter (>2mm) on Heungnam beach, eastern coast of Geoje Island off the southern coast of Korean peninsula	The mean abundances of small plastics were 976 ± 405 particles/m^2 at the high strandline in the upper tidal zone along the shoreline and 473 ± 866 particles/m^2 at the cross section perpendicular to the shoreline. Dominant polymer type: Styrofoam (expanded polystyrene) spherules accounted for 90.7% of the total plastic abundance in the high strandline and 96.3% in the cross section
May and July 2012	Floating debris around the mouth of the Nakdong River in the South-eastern Sea of Korea	MP abundance: 0.62–57 particles/m^3 before rainy season (May) and 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).

	Method	Source
	Bottom trawl of the Dong-baek (float line: 53.0 m; sinker line: 62.7 m; total net length: 69.7 m) was used in the East China Sea, and the trawl of the Ka-ya (float line: 46.1 m; sinker line: 61.5 m; total net length: 70.0 m) was used in the South Sea area of Korea. Net mesh size was similar (i.e. 60mm x65 mm).	Lee, Cho and Jeong *et al*. (2006)
	Samples larger than 25 mm were collected from 10 quadrats of 5m × 5 m	Jang *et al*. (2014a)
	Bulk surface water filtering, hand net (50 μm mesh), and a Manta trawl net (330 μm mesh)	Song *et al*. (2014)
	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)
	Total of 220 surveys were carried out every 2 months (at end of odd-numbered months ± 5 days) from the 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 larger than 2.5 cm in diameter—that occurred between low tide mark and beginning of vegetation on dunes or artificial barriers—was collected and classified into 12 categories. Debris in each category was counted and weighed to the nearest 0.1 kg, using a 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)
	The Korean Government has started to remove derelict fishing gears from the deep seabed of the East Sea by bottom trawling with heavy hooks (50 kg–80 kg) and ropes.	MLTM *et al*. (2008)
	Random sampling was conducted by generating random numbers within the 50 m stretch of linear shoreline at the high strandline from the upper tidal zone, using 10 quadrats of 0.25 m^2 area and 5-cm depth Cross- sectional sampling was carried out with a total of 49 quadrats of 0.25 m^2 without intervals between them. A 2-mm sieve was used to collect small plastic debris, the sorting and identification of which could be performed without a microscope.	Heo *et al*. (2013)
	Manta trawl (330μm mesh) and hand net (50 μm)	Kang *et al*. (2015)

Year	Type	FIndings
May and September 2012	Plastic litter on beaches in South 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.
July 2013	Microplastics (50-5 000µm size) on high tidal coastal beaches (*n*=3) of Soya Island in Korea, ~ 68 km southwest of the Han River estuary and about 48 km southwest of the Incheon city/harbour and faces the Yellow Sea to the west	Abundance of microplastics (*n* = 21) measured were 56–285 673 (46 334 ± 71 291) particles/ m^2 corresponding to the highest level globally. Prevalent driving forces: Winds and currents
August 2013	Microplastics in surface seawaters near- and offshore of Incheon/ Kyeonggi Coastal Region, West Coast of Korea	Microplastic abundance in surface microlayer: 152 688 ± 92 384 particles/m^3 MPs 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 MP type: Ship paint particles (mostly alkyd resin polymer), indicating marine-based origin of MPs
2013 and 2014	Plastic litter on beaches (*n*=12) in Republic of Korea	Aundances of large micro- (1mm–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 of macroplastics (54.7%). Abundance of large microplastics was strongly correlated with that of meso- plastics for most material types. Other findings: Surveying of mesoplastics with a 5-mm sieve is an efficient, useful way to determine “hotspots” on beaches contaminated with large microplastics.
Not specified	Plastic litter on beaches (*n*=20) in Korea	Mean abundance was 13.2 items/m^2, and mean weight was 1.5 g/m^2. Hard plastic (32%) and Styrofoam (48.5%) were dominant types.

Method	Source
Large 10 m ×10 m quadrats were placed (in locations that visually appeared as having maximum/minimum amounts of beached debris) along the strandline, and all macroplastic items (>25 mm) within large quadrats were collected. Within each 10m × 10 m large quadrat, five small quadrats (0.5 m × 0.5 m) were randomly selected for microplastic and meso-plastic sampling. All natural and artificial debris within a depth of 5 cm in quadrats was sieved sequentially with 5-mm and 1-mm Tyler sieves (CISA Sieving Technologies [CISA], Spain) onshore.	Lee *et al*. (2013)
Whole surface sediment in a grid of 50 cm (length) 9-50 cm (width) 9-2 cm (depth) at each station 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 the laboratory.	Kim *et al*. (2015)
Seawaters of two different layers, the SML and the SSW, were collected at 12 stations in the Incheon/Kyeonggi coastal region, which represents the mid- western coastal area of the Korean peninsula, in August 2013 after the flooding season. SML seawater samples were collected by gently touching a stainless- steel sieve (2-mm mesh size; 20-cm diameter) to the seawater surface. At each station, on-board sieve collection was repeated 120 times, and a total of 2.57 ± 0.29 L was obtained. The thickness of the SML layer is estimated at 100µm. SSW was collected using both a 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-et samples, about 0.1 m^3 of SSW was manually obtained 30 cm below the surface using a plastic bucket and filtered through a hand net on-board. The zooplankton trawl net, equipped with a flow meter, was towed around the sampling station at a speed of 2 knots (approximately 1 m/s) for 15 min with a 2 kg-weight so that the mouth of the net remained submerged belowabout 30 cm to avoid collecting SML.	Chae *et al*. (2015)
In 2013, at each site, we collected macroplastics from within 10 large randomly placed quadrats measuring 5 9 5 m along the centre of the high strandline. In the centre of the large quadrats, we placed one small quadrat measuring 0.5 9 0.5 m from which we collected sand from a depth of up to 2 cm and sieved the sand sequentially with 5 and 1-mm^2 Tyler sieves (CISA, Barcelona, Spain)	Lee *et al*. (2015)
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. In this study, "water edge" referred to dry surface area closest to water edge. Each survey line was divided into 25-m intervals, and quadrat of 50 (length) × 50 (width) × 2.5 cm (depth) was randomly placed within each 25-m interval. Middle line was located at midpoint between the backshore and water edge. In 12 quadrats (three lines × four quadrats) per beach, any macrodebris larger than 25 mm was removed on the spot, and surface sand was collected to a 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 mm –25 mm) was collected and stored in polyethylene bags and transported to the laboratory.	Lee *et al*. (2017)

Year	Type	Findings
March–May 2016	MPs in sand beaches (*n*=20) of Korea	MPs abundance: Large microplastics (L-MPs; 1e5 mm): 0-2 088 n/m^2; small microplastics (S-MPs; 0.02e1 mm): 1 400-62 800 n/m^2 Dominant size range: 100 mm-150 mm Dominant polymer type: Expanded polystyrene (EPS) accounted for 95% of L-MPs, whereas S-MPs were predominantly composed of polyethylene (49%) and polypropylene (38%) Identified factors of spatial distribution of small MPs: Population, precipitation, proximity to a river mouth and abundance of macroplastic debris on beach
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 tonnes. This suggests thatabout 60% of the marine debris can be cleaned from 10% of coastline.
2016–2017	Microplastics > 20 µm at the surface (0 m – 0.2 m) and in the water column (3–58 m depth) of six semi-enclosed bays and two nearshore areas of South 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) wereabout 4 times lower than that of surface water (1 736 particles/m^3), microplastics prevailed throughout 3 the 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 MPs.

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 origin from marine aquaculture activities.

A 2015 study used a remote sensing technique to monitor the 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 have explored the distribution characteristics of marine litter on the seabed of the East China Sea and the South Sea of Korea using bottom trawl (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

Method	Source
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 a quadrat (0.5 m × 0.5 m) was randomly placed in each section (four quadrats in a line for total of 12 quadrats per beach). Sand sand in each quadrat was scooped to a depth of 25 mm and sieved sequentially, using 5 mm and 1 mm metal sieves (Tyler sieve, CISA, Spain).	Eo *et al*. (2018)
Rapid assessment of marine debris on coasts of South Korea, using a visual scoring indicator.	Lee *et al*. (2017)
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)

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 tonnes of natural and anthropogenic litter each year, especially during the summer rainy season, with the primary origin identified as the Nakdong River; it is the largest river entering the South Sea of Korea and discharges 3,000 tonnes of litter annually (Heo *et al*. 2013; Jang *et al*. 2014c). An estimated 91,195 tonnes of litter entered the sea in Korea, of which 36 per cent (32,825 tonnes) originated from land-based sources and 64 per cent (58,370 tonnes) 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 is shown on Table 27.

Actions on combating marine litter

The Government has begun to act on marine litter since the 1990s (Hong *et al*. 2014). Since 2008 (Table 28), the Korean Government has implemented three National Marine Litter Management Plans, the latest plan covering 2019–2023, all which 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. Since 2003, the

Data on MSW generation and management in the Republic of Korea

Table 27 /

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

Source: This information is compiled from multiple sources including:[1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, World Bank; [2] Minderoo (2021); [3] UNEP (2017) Asia Waste Management Outlook

Ministry of Marine Affairs and Fisheries of the Republic of Korea has introduced a Marine Litter Repurchase Plan to encourage Korean fishermen to bring marine litter, such as abandoned fishing nets, back to shore by providing financial subsidies (Cho 2009; Morishige 2010). Subsequently, in 2007, the Republic of Korea introduced the Marine Environmental Management Act, which specified the responsibility of state 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, and removed in total 29,790 tonnes 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).

Government actions on combating marine litter in the Republic of Korea

Table 28 /

Year	Title
2008	Revision of the Marine Environment management Act

IMAGE

Malaysia

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

State of marine litter management

A selected list of studies on the distribution of marine litter in Malaysia is shown in Table 29.

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

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 on four beaches in Peninsular Malaysia on the composition and volume of litter on the selected beaches (Agamuthu, Fauziah and Khairunnisa 2012); it was designed to assess the amount and distribution of marine litter on eight sandy public beaches in Malaysia. 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 in the range of 0.142 – 0.884 items/m^2 or 1.119 – 32.351 g/m^2, where plastics were the most common type of marine litter (Agamuthu Fauziah and Khairunnisa 2012; Fauziah, Liyana and Agamuthu 2015; Mobilik, Ling, Husain and Hassan 2015). It is 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).

new approach for beach cleanliness assessment, based on the Clean Coast Index (CCI), will be introduced in this study as a tool for evaluating actual coast cleanliness

Selected Studies on the distribution of marine litter in Malaysia

Year	Type	Findings
2010	Litter on coastal areas in Malaysia	Percentage plastic litter: 66% of overall litter collected
Not specified	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 and sweet wrapper, originating from beachgoers and local community
	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 beach: plastics (57%), paper (10%) and others (29%)
	Plastic pellets in Selangor, Malaysia	MPs abundance: <18 items/m^2
September 2006	Microplastics (MPs) in sediment core of coastal zone, Straits of Johor, Malaysia	A higher abundance of microplastics was detected in the 2 cm–4-cm layer (about 300 pieces/kg dry sediment, with 200 pieces being PP and 100 being PS) than in the 48 cm–50-cm layer (about 100 pieces/kg dry sediment, all of which are polyethylene) of the sediment core collected from the Straits of Johor, Malaysia
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 the most abundant type
January to March 2010	Marine debris on a recreational (Teluk Kemang) and fishing beach (Pasir Panjang) in Port Dickson, Malaysia	Teluk Kemang Beach: 0.262 ± 0.045 items/m^2, weighting 2.067 ± 1.238 g/m^2, with 80% by count (including polystyrene) and 49% by weight (including polystyrene) being plastics; Pasir Panjang Beach: 0.495 ± 0.108 items/m^2, weighting 46.079 ± 12.507 g/m^2, with 61% by count (including polystyrene) being plastics. Identified potential factors in accumulation: Abandoned fishing gear, presence of daily clean-up activity

Table 29 /

Method	Source
Clean Coast Index (CCI) for cleanliness assessment	Hagir *et al*. (2013)
All the visible debris was collected by walking randomly along length of 500 m x 50 m transect and parallel to the waterline. To maximize sample collection, sampling process was conducted during a low-tide period and suitable weather.	Kadir *et al*. (2015)
	Agamuthu *et al*. (2012)
	Ismail *et al*. (2009)
Sediment cores were collected at four locations, using a gravity corer of 11 cm i.d. and 1 m length. The cores were sliced at 1 or 2 cm intervals on-site. The slices were stored individually and subsequently freeze-dried. Selected slices from the cores were analysed for this study. Ten grams of freeze-dried sediment or wet sediment, corresponding to 10 g of dry sediment, was analysed for microplastics. To remove biofilms from the surface of microplastics, 150 mL of 30% H_2O_2 was added to sediment in a glass beaker. After reaction ceased, normally after 1 week, sediment was passed through a 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 min, allowed to stand for 3 h, and a 100 mL aliquot of supernatant was then removed. This process was repeated, and combined supernatant was then centrifuged at 2 000 rpm for 10 min. 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 one week, picked up one-by-one, using stainless-steel tweezers, and subjected to Fourier-transform infrared spectroscopy (FTIR).	Matsuguma *et al*. (2017)
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 is applied to all beaches except Pasir Panjang Beach. For Pasir Panjang, the whole area was sampled because the beach length is less than 60 m. All visible debris in the sampling area was collected and sorted.	Khairunnisa (2012a)
Every sampling event was done during low tide for broader sampling area and neap tide for bias prevention. The area sampled was 10% of the actual length, which was determined using data provided by the Port Dickson municipality (Teluk Kemang = 1.8 km and Pasir Panjang = 1.0 km). It was assumed that debris was randomly disposed along the beach, and all visible anthropogenic debris within the area was collected. Number of items and fresh weight of each debris type were recorded.	Khairunnisa *et al*. (2012b)

Year	Type	Findings
November to December 2011	Litter on beaches of Likas Bay (Teluk Likas), Sabah	Litter abundance: 3396 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 Identified origin: brought in from sea (with factors including physical condition and the bay position)
May-June 2012	Visual observation of oceanic surface waters of the Strait of Malacca (off the coast near Kuala Lumpur), Malaysia	Number of litter observed in Strait of Malacca: 17 524 items, of which 98.8% are plastics, 1.2% non-plastic items such as wood, paper, glass and tin Density of litter in Strait of Malacca: 577.9 ± 219.1 items/km^2 Dominant size of litter in Strait of Malacca: 25.1% (<5cm), 51.6% (5 cm–15 cm), 17.5% (15–30 cm), 4.8% (30–60 cm), 1.0% (>60 cm) Dominant type of litter in Strait of Malacca: Packaging (93.3%), plastic fragments (3.4%), fishing/boating (1.4%) and user items (0.7%) Other findings: Out of the 17 524 items observed in Strait of Malacca, 14 154 items (98.9% plastics) were observed on 24 May 2021, where the litter concentrated in drifting lines on a calm sea.
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 kilograms Litter density: 730 item/km of debris at 42 kg/km Abundance: Pasir Pandak beach received the highest quantities of debris (1 120 items/km or 44.1 kg/km Dominant 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% were marine sources, 11.67% from terrestrial sources, 64.34% from common sources
Not specified	Marine litter on four beaches (recreational, fisheries and shipping lanes beaches) in Peninsular Malaysia	Abundance: 0.142 – 0.884 items/ m^2 or 1.119 – 32.351 g/ m^2 Plastic percentage: Most abundant type of debris found on all beaches with percentage of weight, ranging from 36% to 94% Dominant types: Plastic bags and wrappers, hard plastics, polystyrene and abandoned fishing nets
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: Southwest monsoon (SWM) (1 122±737 items/km), northeast monsoon (NEM) (825±593 items/km) and the intermediate monsoon (IM) (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 wrapper and clear plastic bottles

Method	Source
Six transects that measured 10 m x 10 m were randomly selected along the stretch of Likas Bay Beach. The beach along the transect was fist-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)
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 the ship was under way; they were made from the bridge wing or from the deck above the bridge, 10 m–13 m above sea level and 57 m from the ship's bow. Only debris on one side of the bow was counted. Litter was mostly detected with the naked eye, but regular scans of waters away from the ship were made with 10" x32" binoculars to detect more distant debris. Binoculars or images taken with a digital SLR camera with a500- mm telephoto lens were used to identify litter items, but some submerged items could not be identified. To compensate for the 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)
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 a PVC pipe into the sand above the 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 sites were collected, weighed and then classified by their categories and sources.	Mobilik *et al*. (2014)
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 an area of 60 m x total width were collected. Debris found within the area were separated based on types, weighed and recorded. Public surveys were also conducted during each sampling event.	Agamuthu *et al*. (2012)
Beach survey standing crop method (Cheshire *et al*. 2009) was used during northeast monsoon (NEM), intermediate monsoon (IM) and southwest monsoon (SWM) seasons. Ship rubbish sampling: All solid waste other than fragments smaller than 0.25 cm^2 at container (CC) and general cargo (GC) vessels rubbish station were identified, weighed, classified and sorted.	Mobilik *et al*. (2015)

Year	Type	Findings
June to July 2014	Marine litter on four beaches at Port Dickson, Peninsular Malaysia	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, that is, up to 41% of total debris. Factors contributing to less accumulation: High energy conditions on beaches such as wind and waves.
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 (879 items/m^2 on Seberang Takir Beach), 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 had an average of 399 items m-2 of plastic debris, while fishing beaches had an average of 446 items m-2.
December 2015 – May 2016	Stranded, floating and micromarine debris on beaches of and surface water around Sebatik Island, Tawau, Sabah	In study area, 14 types of stranded macromarine debris (SMD) and 9 types of floating marine debris (FMD) were found. Dominant types of SMD and FMD: Discarded plastic, organic debris and plastic bottles Dominant MMD types: fragments, fibre, films and polystyrene Abundance of SMD: 80 items/m^2 (SMD), 94 items/m^2 (FMD) and 22 items/ml (MMD)
2018	Microplastic particles in 10 personal care products and cosmetics in Malaysia	A total of 0.199 trillion microplastics are expected to be released annually to marine environment in Malaysia. From 214 respondents, particles found in facial cleaner/scrub and toothpaste were both coloured and colourless with majority 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.

Method	Source
Waste quantification meant debris density and categorization of debris, both which were carried out on the spot on 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 the site, the length and the width of the shoreline was measured by using a meter ruler according to the topography of the beach. Every beach was measured for sampling. The selected area was divided equally into two segments. Each section was labelled from left to right. Every quadrant started from the water's edge to the back of the shoreline. Starting from water's edge to the back of the shoreline, each transect was traversed by foot, every debris item was collected in a plastic bag, and later, the categories were recorded by weight on a debris density data sheet. Snapshots of the 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 till evening.	Yi and Kannan (2016)
Sediment sampling: Plastic debris sampling was conducted once a month for three consecutive months (January, February and March) with 28 days interval, as recommended by Lettenmaier (1978). At each site, triplicates of 12.5 L sediment, consisting of sand or small gravel, was scooped up using a small shovel within a 50 × 50 cm^2 quadrate to a depth ofabout 5 cm, from the low tide (*X*) and the high tide (*Y*) water level as well as from the berm area (*Z*) of the beach within three belts transects. Sieving: The sand in the bucket was mixed with seawater, stirred and sieved through a set of nested sieves. The 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 an overall size range of 1mm–30 mm, were retained from each sieve tray and placed in separate labelled plastic bags for sorting purposes.	Fauziah *et al.* (2015)
Transect line method modified from Velander and Mocogni (1999) was used to assess the stranded macromarine debris (SMD). A transect of 50 m was laid and divided into three parts. Each part was marked, and 2.5 m gap drawn at the particular angle. Evaluation of floating macrodebris (FMD) was done by surveys of the selected areas. FMD was surveyed, using a boat navigated at a speed of 4–- 10 knots. Once FMD was seen on the sea surface, the coordinates of the places where FMD occurred were recorded. Density separation technique was applied to extract the micromarine debris (MMD) from the 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. A composite sediment sample weighing 50 g was taken, mixed with 150 mL NaCl solution, allowed to stand undisturbed for 10 min before vigorously shaking. The supernatant was collected in 100 mL beakers and stored for 24 hours. Subsequently, all samples were filtered using a 47-mm sized membrane filter and then dried in an oven for 3 hours at 60˚C. Observations on types of microdebris were made using a stereomicroscope.	Estim and Sudirman (2017)
A total of 10 personal care products and cosmetics were selected based on questionnaire survey results provided by Malaysians in their daily life usage. Using an extraction and enumeration method modified from Cheung and Fok (2017), study had a total of 2 g weighed and dissolved in a glass conical flask, containing 150 mL boiling water. Then, the mixture was stirred, using a 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 the solution and purify the 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)

Year	Type	Findings
October-November 2018	Anthropogenic marine debris (AMD) in two urban and two peri-urban mangroves on Penang Island	Highest abundance was recorded at Jelutong, a location near a landfill and dense residential area, at a total of 7 312 items, where 92.5% were plastic materials and the remaining 7.5% were non-plastics. Types of plastic AMD at Jelutong: Plastic bags (2 046; 30.3%), plastic sheets (1 343; 19.9%) and plastic cutlery (995; 14.7%). Non-plastic materials consisted mainly of glass and ceramic (261; 47.5%), followed by cloth (161; 29.3%) and rubber (81; 14.8%).
April-May 2019	Floating plastics in Klang River	Mean floating plastic density identified from UAV imagery: about 0.8-7.9 items/m^2 (downstream flow), 0.6-1.7items/m^2 (upstream flow).
Not specified	Microplastics in viscera and gills of commercial marine fish from Malaysia	Of 11 species of fish, 9 contained plastic debris. Out of 56 isolated particles, 76.8% were plastic polymers, 5.4% were pigments and 17.8% were unidentified. Extracted plastic particle sizes ranged from 200 to 34 900 µm (mean = 2 600 µm ± 7.0 *SD*).
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

Method	Source
Two urban and two peri-urban mangroves were sampled at different periods over 2 months, with differences constrained by possible changes in their wind fields, and neap-spring tidal development. Debris were counted and classified across transects parallel to the coastline at progressively higher watermarks. Assessments were carried out between October and November 2018 over the monsoon transition period. For all four sites, three transects were placed parallel to the coastal edge. Transect at the low tidal level ran as close as possible to the edge of the sea (henceforth, referred to as the "practical edge"), and the other two transects were placed in the main body of the mangroves at the mid- and high-tidal levels. Assessments of total number and types of AMD for three 10 m x 10 m (100 m^2) quadrats were completed on each transect, totalling in 9 quadrats per sampling site. For more effective data-collection, these quadrats were divided into 100 1 m^2 subquadrats.	Yin *et al*. (2019)
UAV Aerial-imagery identification, and trawling method as described in van Emmerik *et al*. 2018.	Geraeds *et al*. (2019)
A total of 110 individual fish from 11 commercial fish species [fish per species *n* = 10] sold for human consumption were collected from the local fish market in Seri Kembangan, Malaysia. After dissection and separation, the 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 the sampled fish was performed according to the method of Karami *et al*. (2017c). Excised organs and gills of fish were placed together in a 250 mL DURAN glass bottle (Schott, Germany) 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, USA) connected to a filter funnel manifold (Pall Corporation, USA). 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 min., agitated on an orbital shaker at 200 rpm for 5 min, and eventually centrifuged at 500 ×g for 2 min. 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 (AxioCam, ERc 5S, Germany) equipped with a Stereomicroscope. Extracted particles are then assessed and analysed, using Raman spectroscopy and FESEM-EDX.	Karbalaei *et al*. (2019)
Geospatial technology which consists of multiple thematic maps based on geo-environmental factors, statistical data and consumer's 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 (DEM), respectively. Statistical data was used to develop the Plastic Waste Density Map (PWDM), and the litter characteristic of the study area was used to develop the Plastic Waste Leakage Model (PWLM).	Chukwuma *et al*. (2019)

as well as the prospects of applying the Indifferent Consumers-Pay principle to waste management in Malaysia.

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

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

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

Solid waste management is fully privatized at the municipal level, where it is regulated by local governments. In line with the National Strategic Plan, local implementation of solid waste policies is targeted to reduce sources and prevent generation of waste; to include waste diversion, which includes recycling and composting and conversion technologies; and to 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 (i.e. divers) 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.

Actions on combating marine litter

To control beach litter, the Malaysian Government has promulgated that offenders who litter on beaches 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 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 plastic straws, tableware, lunch boxes, taxes), 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

Data on MSW generation and management in Malaysia

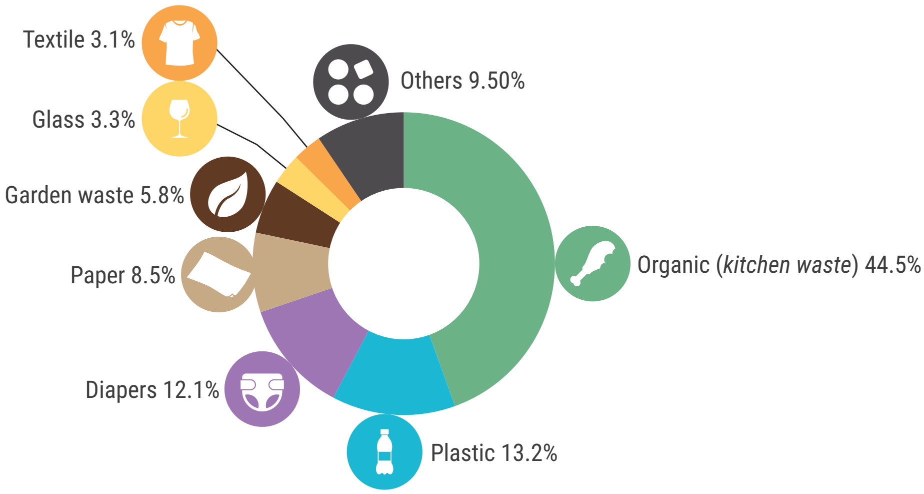
Table 30 /

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

Source: The information is compiled mainly from: [1] Pariatamby, A. (2017). Country chapter. State of the 3Rs in Asia and the Pacific (Malaysia). United Nations Center for Regional Development, Nagoya. [2] Minderoo (2021); [3] GIZ (2018). Managing Package Waste in the ASEAN Region; [4] UNEP (2017) Asia Waste Management Outlook

Malaysia MSW composition

Figure 7 /



Source: UNEP (2017) Asia Waste Management Outlook

Government action on combating marine litter in Malaysia

Table 31 /

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

producer responsibility, encouraging plastics producers to take responsibility for collecting, recycling and disposing of waste.

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

Fauziah, Liyana and Agamuthu (2015) pointed out that plastic litter in coastal environment in Malaysia are 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.

In Malaysia, 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).

IMAGE

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 kilometres (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 tonnes in 2015 (Kaza *et al*. 2018). This number having 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 MW collection was reported at 325,410 tonnes in 2014 (UNSD 2018)

State of marine litter management

International tourism and fishing are the dominant economic activities in the Maldives (Saleem 2003). However, marine litter has greatly reduced the aesthetic value of coastal beaches as well the quality of fish products (Table 32). 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 km 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 beach has been recorded as 1029±1134 pieces/m^2 (Imhof 2017). 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 2018). For the large marine litter, it was estimated that 3 per cent of hooks/set on the Maldives' tuna longline was lost (Macfadyen *et al* 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 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 may be highly polluted by marine litter. Moreover, the island of Thilafushi may also be a hotspot of marine litter, owing to the improper waste management (Saliu *et al*. 2018).

Selected studies on the distribution of marine litter 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 mm–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 mm –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 a few polystyrene (expanded polystyrene) particles were detected. Dominant shape of daily intertidal plastics: Most particles were fragments of larger plastic debris (52% of the particles) but raw pellets (17% of the particles) were also present. Identified potential origin of plastic litter: From "landfill islands" of nearby of inhabited islands or tourist islands, or transport from the Indian Ccean	Two sampling experiments were conducted for this study. 1) 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 a grid of 1 m^2 (1 × 1 m) was collected once, resulting in six samples, and analysed for plastic particles as described below. 2) Daily abundance: In the second experiment (II), researchers assessed daily abundance of plastic particles at high tide drift line of south-facing shoreline. Sampling was performed on seven consecutive days from the 21–27 June 2015 at six evenly allocated and geographically fixed sampling sites along a 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*. 2015). The 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 zip lock 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 mm–5 mm fraction, and FITR-ATR spectrometer was used to identify plastic particles and their polymeric structure.	Imhof *et al*. (2018)

The abundance correlates positively with population density and other intensive anthropogenic activities (fishing, shipping, manufacturing and so on).

Thus, the key indicators for marine litter in the Maldives are population density, tourist industry, fishing activities and aquaculture, and the waste disposal rate. The marine litter in the Maldives is most likely to accumulate at beaches, in coastal oceans and around islands.

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). It was not until May 2009 that an integrated waste management system began to develop. As a result, anthropogenic materials have been accumulating on the ocean surface, in the water column and on the seabed. 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 different learning objects and different methods used. 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 is shown on 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 school children and volunteers. 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 (2015)
MSW per capita	1.42 (2015)
MSW collection and treatment [2]	
MSW collection coverage	38.2%

Source: This information is compiled from multiple sources including: [1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, World Bank; [2] UNEP (2017) Asia Waste Management Outlook

IMAGE

Myanmar

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

State of marine litter management

According to a recent report issued by the EAF–Nansen Programme, a first-of-its-kind program, commissioned by UN FAO, that conducts survey on fisheries resources and the marine ecosystem, more than 28,000 pieces of microplastic particles per square km were found on a 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 tonnes of litter are discharged into the ocean in Myanmar through the Ayeyarwady River and 29 tonnes through the Yangon River, a combined area home to more than 60 per cent of the population (Jeske 2019). In fact, the Ayeyarwady is the world's ninth largest contributing rivers 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 than that in the dry

Selected studies on the distribution of marine litter in Myanmar — Table 34 /

Year	Type	Findings	Method	Source
2014	Seafloor Coral Reef (Myeik Archipelago)	Microplastics abundance Myeik Archipelago: 6.4 ± 2.8 items/100 m^2 (2 660 m^2 surveyed, 38 sites)	Three belt transects laid along reef contours at 3 m – 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)

season, suggesting strong seasonal variation of litter content and influence of river run-off.

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 is shown on Table 36.

While it is difficult to find reliable, recent data on MSW generation in the country, 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, waste management in Myanmar still relies mainly on landfills, 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

Data on MSW generation and management in Myanmar

Table 36 /

MSW background information [1] [4]	
Population	54.05 million (2019)
MSW generation	2.04 million tonnes (2000)
MSW per capita	0.39 (estimate, 2016)
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, polypropylene, PET resin)	0.00 million tonnes (2019)
Polymer exports	0.00 million tonnes (2019)
Polymer imports	0.39 million tonnes (2019)
Domestic conversion of polymers into single-use applications	0.19 million tonnes (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.05 million tonnes (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.13 million tonnes (2019)
Domestic single-use plastic waste generation	0.28 million tonnes (2019)
Single-use plastic waste generation per capita	5.15 kgs (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%

Source: This information is compiled from multiple sources including:[1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, World Bank; [2] Minderoo (2021); [3] UNEP (2017) Asia Waste Management Outlook; [4] GIZ (2018) Managing Package Waste in the ASEAN Region tonnes in 2012 (GIZ 2018). And in Yangon, the national capital, an estimated 1 million tonnes of litter are left on streets each year (Huisman *et al*. 2017).

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.

Actions on combating marine litter

The Government of Myanmar has aimed to provide a conducive national policy framework and strategic direction moving from conventional waste management 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, including those on sustainable plastic waste management. To implement the Master Plan, Myanmar needs to set the baseline on plastic emissions focused on river basins and conduct national source inventories.

IMAGE

Pakistan

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

State of marine litter management

Marine litter distribution along the coastline of Pakistan on the Arabian Sea was first reported in a 2015 study (Qari and Shaffat 2015) (Table 37). After studying four beaches using the quadrate frame method, the study reported high concentration of marine litter on all four beaches and discussed 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-

Studies on the distribution of marine litter 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 comprising of plastics, glasses, thermophore, clothing, rubber, paper, pot pieces and cigarette filters were collected. Plastic was found in high quantity at all four beaches of Karachi.	The quadrate method was used for estimating the debris material. Total 40 quadrates were made for collecting the debris on 4 beaches: Sandspit, Buleji, Paradise Point and Korangi Creek in the year of 2012.	Qari *et al*. 2015

Data on MSW generation and management in Pakistan

Table 38 /

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

Source: This information is compiled from multiple sources including: [1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, World Bank; [2] Minderoo (2021); [3] UNEP (2017) Asia Waste Management Outlook

use plastic waste generation is shown on Table 38.

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 together with the local fisherman, retrieving over 1,000 kg of ghost nets from sea. Moreover, the diving community in Pakistan, represented by the Professional Association of Diving Instructors, has also been actively engaged in the removal of marine litter (Project AWARE 2019).

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

IMAGE

Philippines

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

State of marine litter management

The Philippines is one of 18 mega-biodiverse countries of the world, 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, 2016b, 2019b).

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, 2016b, 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 largest seaport in the Philippines, may also contribute to the occurrence and transportation 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).

Studies on the distribution of marine litter in the Philippines

Table 39 /

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

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

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

With municipal solid waste (MSW) generation estimated at 14.63 million tonnes in 2016 (WGB 2018), a total of 9.1 million tonnes of municipal solid waste collected in 2009 (UNSD 2018), 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).

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), while the daily waste generation rate per capita in Metro Manila was 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 (UNEP/COBSEA 2018; NSWMC, EMB 2019). 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 a very high level of plastic bag consumption. For example, waste audits in 2006 and 2010 showed that among plastic products, 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. It is worth noting that the Philippines has remarkably high waste collection rates with a nationwide average of

Data on MSW generation and management in the Philippines

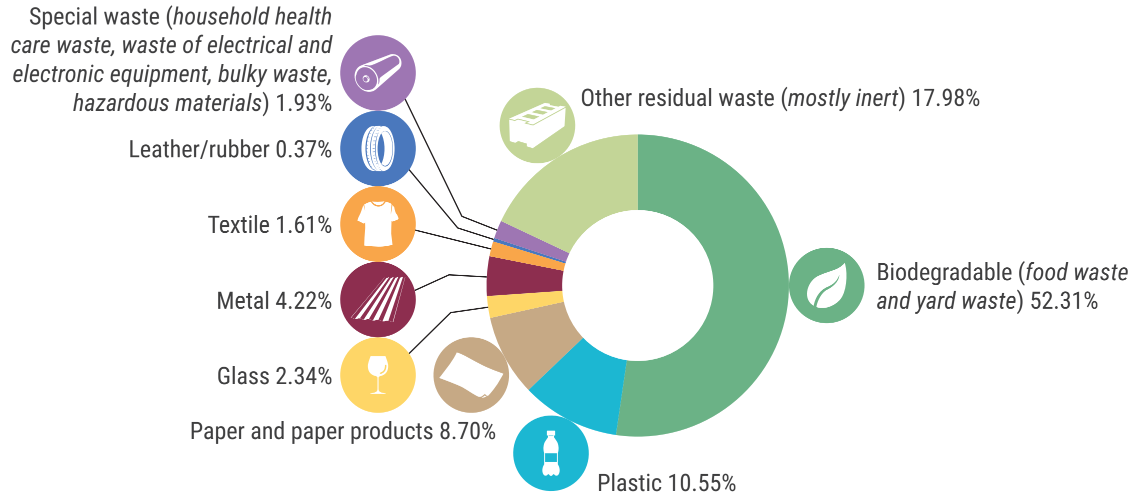
Table 40 /

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

Source: [1] Borongan, G. and Kashyap, P. (2018); [2] Minderoo (2021); [3] Liu *et al.* (2018)

Philippines MSW composition

Figure 8 /



Source: UNEP (2017)

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 (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. Republic Act 9003 is currently the Philippines' most systematic, comprehensive national policy for managing ecological solid waste.

Regarding solid waste management and control, the National Solid Waste Management Commission adopted Resolution 60, Series of 2013 that provides recommendatory measures for mandatory solid waste, segregation at source and for segregated collection and recovery, as well as prescribes fines and penalties for associated violations of this resolution. Resource recycling stations have already been established in each administrative district.

In May 2014, former Philippine President Benigno Aquino III announced that each January is designated as "Zero-Waste Month" (Presidential Announcement No. 760, 2014). It aims 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, as well as systematically avoiding waste generation based on design and management of product and production process, in addition to promoting resource conservation and recycling, along with preventing waste from being improperly disposed of or incinerated.

In May 2019, current Philippine President Rodrigo Duterte recalled the Philippines' 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). It has done so by formulating relevant laws and regulations to impose taxes or penalties on enterprises and individuals that cause marine plastic pollution. The Philippines' 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. In some large Filipino cities, public markets and large supermarkets have introduced "bring your own bag" policies to encourage customers to bring their own reusable bags when shopping. In May 2019,

Government action on managing MSW and plastic waste in the Philippines

Table 41 /

Year	Title
1992	National Integrated Protected Areas System Act 1992 (Republic Act No. 7586 of 1992)
2011	Submitted Senate Bill of the 15th 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 (5/9/2011)]
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 Regulations: Quezon City Ordinance No. SP-2140 or the Plastic Bag Reduction Ordinance (SP-2140)
2014	Philippines National Standard: Plastic Shopping Bag (PNS-2097:2014)
2018	Submitted Senate Bill of the 17th 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	Submitted House Bill of the 17th 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]
Government public policy related to solid waste management in the Philippines	
1999	The Philippines Clean Air Act of 1999 (Republic Act No. 8749)
2000	Ecological Solid Waste Management Act No. 9003 of 2000 (RA 9003)
2010	National Solid Waste Management Commission (NSWMC) Resolution No. 47 of 2010 on the adoption of a national framework plan for the informal solid waste treatment industry
2013	National Solid Waste Management Commission (NSWMC) 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)

the Bureau hosted in Manila its ocean-month themed event "Close the Loop" meeting, calling for a public-private partnership to bring together government and business to tackle marine litter treatment.

In 2000, the Philippines passed the Republic Act No. 9003 (RA–9003), known as the 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, while local governments are 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' solid waste management mainly faces the following 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 the WWF Philippines office, the National Solid Waste Management Commission and the World Bank reported that 74 per cent of plastic leaks flowing into water came from collected waste.

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 free distribution of plastic bags by street vendors, hawkers and other informal businesses. In addition, Quezon City also issued the Ordinance on Prohibiting the Use of Plastic and Polystyrene Foam in Certain Public Service Facilities (SP-2147) in the same year, prohibiting the use of disposable plastic and polystyrene foam products in key public places such as government buildings, hospitals and theatres.

In January 2019, the Philippines' House of Representatives submitted a bill banning the production, import, sale and use of disposable plastic products (HB-08692), which intends to discourage the use of disposable products and encourage producers to make sustainable and environmentally friendly products. In addition, the bill aims to prohibit businesses, such as restaurants and stores, from using disposable plastic products including straws, cups, food containers. Recycling centres have been established 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 to mobilize 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 20 million Philippine pesos (about US$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 their marine litter control projects in the Philippines. These aim to "support solid waste management and water recycling at local and national levels". During an 18-month project period, the Mother Earth Foundation intended to use this funding to build 30 "no waste villages", and EcoWaste Coalition will use it to fund surveys on plastic pollution and on the efficiency of solid waste removal in Manila.

However, in the Philippines, research and monitoring interest on marine plastics pollution is limited, completed research is rarely published and relevant government funding opportunities are seemingly non-existent. While conducting surveys of marine litter, the Philippine Government mainly relies on NGO 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.

IMAGE

Singapore

With an estimated population of about 5.8 million in 2019, the island state of Singapore has a coastline of 193 kilometres and had MSW generation of 2.05 million tonnes 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 (ICCS 2018). 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 (ICCS 2008; ICCS 2018). The top five most common marine debris items collected in 2018 are styrofoam pieces, cigarette butts, plastic pieces, plastic beverage bottles and straws/stirrers (ICCS 2018).

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

Selected studies on the distribution of marine litter in Singapore

Table 42 /

Year	Type	Findings	Method	Source
2004	Coastal beach sediments and seawater	Microplastics were discovered in sediment and seawater samples. Discovered 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. Ten litres of surface microlayer at 50–60 μm and subsurface water at 1 m were collected from two sites. 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, grains fragments		Nor and Obbard (2014)

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. Moreoer, 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 specially launched cellular phone software for waste sorting, 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.

Data on MSW generation and management in Singapore Table 43 /

MSW background information [1]	
Population	5.8 million
MSW generation	2.05 (2010)
MSW per capita	1.1
Single-use plastic waste generation [2]	
Domestic polymer production (HDPE, LDPE, LLDPE, polypropylene, PET resin)	4.09 million tonnes (2019)
Polymer exports	4.09 million tonnes (2019)
Polymer imports	0.32 million tonnes (2019)
Domestic conversion of polymers into single-use applications	0.11 million tonnes (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.51 million tonnes (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.84 million tonnes (2019)
Domestic single-use plastic waste generation	0.44 million tonnes (2019)
Single-use plastic waste generation per capita	75.64 kgs (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: [1] Ministry of the Environment and Water Resources 2018 [2] Minderoo (2021); [3] GIZ (2018). Managing Package Waste in the ASEAN Region

In addition to background information on MSW, data on MSW composition, collection and treatment and on single-use plastic waste generation is shown on 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 (i) pollutants into drafins, such as trade effluent, oil, chemicals and sewage, as well as (ii) 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 Singapore's 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 entering waterways is captured by litter traps installed at appropriate locations. This further reduces 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's 2030 Agenda for Sustainable Development (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, which in 2019 aimed to invest $1.5 billion in the East Asian region 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.

IMAGE

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 tonnes in 2016 (Kaza *et al*. 2018). An island state, Sri Lanka has a coastline length of about 1,585 kilometres (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). 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 tonnes 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 put Sri Lanka to lower rankings, with Thailand replacing it as fifth largest marine plastic litter contributor. Significant amount of marine litter could be found on beaches near river mouths and urbanized areas, owing to input from land and sea-based sourced as well as the transport by wind (Lee *et al*. 2015; Hidalgo-Ruz *et al*. 2012), current (Eriksen *et al*. 2014; Hidalgo-Ruz *et al*. 2012; Hidalgo-Ruz *et al*. 2018) and tide (Maximenko, Hafner and Niiler 2012). However, it was mentioned that the proximity to urban areas might have contrary effect on the accumulation of marine litter owing to the more frequent beach cleaning effort in those areas.

Currently, there is no existing marine litter hotspot data for Sri Lanka. The 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. It is of interest for Sri Lanka to work more closely with regional or global collaboration and funding frameworks.

Studies on the distribution of marine litter in Sri Lanka

Table 44 /

Year	Type	Findings	Source
2016	Beach	4 (large items >25mm) and 158 (small 5–25mm) 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	M Yearangrove	Unspecified	Jayapala and Jayasiri 2018
2017	Beach	10	Koongolla *et al*. 2018

Data on MSW generation and management in Sri Lanka

Table 45 /

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

Source: This information is compiled from multiple sources including: [1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050,World Bank; [2] Minderoo (2021); [3] UNEP (2017) Asia Waste Management Outlook

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 is shown on Table 45.

Actions on combating marine litter

On the regional and global levels, Sri Lanka has been actively working with the South Asia Co-operative Environment Programme (SACEP) and the South Asia Seas Program. 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 Extraordinary Gazette Notification No. 2211/51 in January 2021.

IMAGE

Thailand

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

With increase in MSW generation, which grew from 24.11 million tonnes in 2009 to 27.8 tonnes in 2018, Thailand took measures to reduce its inappropriately disposed waste markedly (PCD Thailand 2019), from 14.28 million tonnes in 2009 to 7.15 million tonnes in 2018. Further improvement was made in 2019-2020 on MSW. In 2020, The total MSW was 27.35 million tonnes, of which 11.93 million tonnes separated at sources for recycling, and 4.23 million tonnes 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, with 0.15–0.41 million metric tonnes of plastic marine litter output in 2010 (Jambeck *et al*. 2015). In fact, in another study, McKinsey and 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 (PCD Thailand 2019)(Table 46), in such areas as coastal communities, including fishing piers, coastal recreation areas and dumping sites near these areas. The mass of marine litter usually piles up on beaches during monsoon, with the litter first flushed into the rivers and then finally washed ashore. In 2018, coastal clean up activities covered 48 areas and collected 33 tonnes 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 the information impact of marine litter either on (a) the beaches of coastal seas (especially at the estuaries) as well as (b) endangered marine species (in the guts of sea turtles, dolphins, whales, or litter that entangled such animals)

In the 2016 International Coastal Cleanup campaign, Thailand participated with 3,641 persons, collected 12,504 kg, covered 104.2 km of coastline and collected 57,811 items (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 the distribution of marine litter in Thailand

Table 46 /

Year	Type	Findings	Method	Source
2004	Microplastics (MPs_ in sediment core collected in Gulf of Thailand	MPs mean abundance: 100 pieces/kg-dry sediment	Gravity corer of 11-cm i.d. and 50-cm length, sliced at 5-cm intervals onsite, stored individually in stainless-steel containers and frozen until analysis. To identify MPs, 10 grams of freeze-dried sediment or wet sediment corresponding to 10 g of dry sediment was analysed for MPs. To remove biofilms from surface of MPs, 150 mL of 30% H_2O_2 was added to sediment in glass beaker. After reaction ceased, normally after 1 week, sediment was passed through a 315-lm, mesh-size nylon sieve.	Matsuguma *et al.* 2017
2011	Seafloor Coral Reef (Koh Tao), (900 m^2 surveyed, 10 sites)	MPs abundance at Koh Tao: 11.6 ± 7.4 items/100 m^2	Three belt transects laid along reef contours at 3m – 4 m in depth and about 20 m apart, using globally standardized protocols. Belt transects were either 10m, 15m 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. Debris abundance Angsila: 8.10 items/m^2. Debris abundance 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: 224.64–1310.26 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 *et al.* (2017)

Data on MSW generation and management in Thailand

Table 47 /

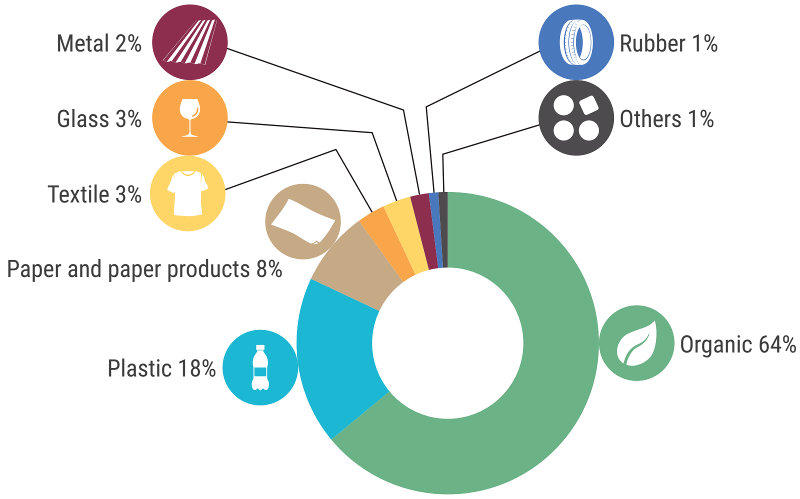
MSW background information [1] [2]	
Population	69.63 million (2019)
Urban population	33.77 million (2017)
MSW generation	27.82 million tonnes per year (2018)
MSW per capita	1.15 kg/person/day (2018); 1.35 kg/day in urban Areas (3.90 kg/day in Pattaya City); 0.91 kg/day in rural (island) areas
MSW generation growth	0.77% from 2015
Single-use plastic waste generation [3]	
Domestic polymer production (HDPE, LDPE, LLDPE, polypropylene, PET resin)	6.96 million tonnes (2019)
Polymer exports	4.26 million tonnes (2019)
Polymer imports	0.86 million tonnes (2019)
Domestic conversion of polymers into single-use applications	1.87 million tonnes (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	1.30 million tonnes (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.68 million tonnes (2019)
Domestic single-use plastic waste generation	1.26 million tonnes (2019)
Single-use plastic waste generation per capita	18.14 kgs (2019)
MSW collection and treatment [1]	
MSW collection coverage	58% on average, up to 100% in Bangkok
Method of treatment	31% Diverted from Disposal (Recycled/Composted/WtE/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 Landfills; 465 controlled dumpsites; 2 237 Open Dumpsites;

Source: The information is compiled from multiple sources, including: [1] GIZ (2018a), Country Profile Thailand [2] Piyapanphong, S. (2019). "Thailand Country 3R Progress Report (draft): Voluntary Progress/Achievements/Initiatives in Implementing Ha Noi 3R Declaration (2013~2023)", [3] Minderoo, *The Plastic Waste Makers Index* (2021)

A study of microplastic contamination of the three most abundant sessile and intertidal invertebrates at three beaches of the eastern coasts of Thailand revealed a significant accumulation of microplastics in the invertebrates at rates of 0.2–0.6 counts/g, indicating higher pollution levels along the coastline (Thushari *et al*. 2017). Filter-feeding organisms showed comparatively higher accumulation rates of microplastics. The plastic pollutant prevalence in sessile and intertidal communities corresponded with pollution characteristics of contaminated beach habitats where they 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 (Thushari *et al*. 2017).

Thailand MSW composition

Figure 9 /



Source: GIZ (2018a), Country Profile Thailand

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 is shown on Table 47 and Figure 9.

Most of the marine debris in Thailand comes from inland plastic waste and solid 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.

Since 2018, Thailand has determined to ban on importing plastic and electronic waste, and expanded its scope. It banned the import of most types of plastic waste in 2018, and will ban all types of plastic waste imports in 2021.

Actions on combating marine litter

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

Thailand has pledged to reduce marine litter by 50 per cent by 2027. Regarding marine litter control, in 2019, Thailand issued its Roadmap on Plastic Waste Management, 2018–2030. The Roadmap aimed to completely ban four kinds of plastic products by 2022, namely plastic bags less than 36 microns in thickness, Styrofoam™ food containers, plastic straws and single-use plastic cups. It also aimed to make 100 per cent of plastic waste reusable.

In 2018, the Thai Government issued the 20-Year Pollution Management Strategy, Pollution Management Plan 2017–2021 and 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,

Government actions on combating marine litter and improving 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)
Government public policy related to solid waste management in Thailand	
2018	Roadmap for Plastic Waste Management (2018– 2030)
2016	National Solid Waste Management Master Plan (2016–2021)

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.

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 the marine litter collected by the trawl net to shore. 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, 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 they 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 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.

On the source reduction of plastic waste: Start of the phase-out period of cap seals on 1 April 2018; total elimination of cap seal use in Thailand on 31 December 2019; reduce 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 tonnes of plastic waste annually and save 3.9 billion baht in solid waste management costs each year.

IMAGE

Timor–Leste

Timor–Leste had a population estimated at 1.29 million in 2019 and a coastline of 706 kilometres. The country had an MSW generation of 63,875 tonnes 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 washed up ashore with oceanic currents from local land-based activities. 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 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 in Timor-Leste mostly relies on landfills and recycling. The Government of Timor-Leste gave recycling policy priority. In April 2019, the Government announced a plan

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

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

Data on MSW generation and management in Timor-Leste Table 50 /

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

Source: This information is compiled from multiple sources including: [1] Kaza, S; Yao, L; Bhada-Tata, P; Van Woerden, F. (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, World Bank; [2] UNEP (2017) Asia Waste Management Outlook.

to become the world's first plastic-neutral nation; this was to be achieved by introducing facilities deploying a technology called "Catalytic Hydrothermal Reactor (Cat–HTR)", which can process 20,000 tonnes of plastic waste into 17,000 tonnes of synthetic fuel annually, enough to cover the 70 tonnes 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 is shown on 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 program of this country's near-shore coastal environment. Highlighting marine plastic pollution, the film called for action to protect the marine environmental from land-based activities resulting in pollution, especially that from plastic debris (United States Agency for International Development [USAID] 2019). Some NGOs have begun clean-up operations on beaches. Ataúro Island, a site where the impact of marine litter is the most significant, NGOs have now organized regular weekly beach clean-ups.

IMAGE

Viet Nam

Viet Nam had an estimated population of 96.62 million in 2019 and was the world's fifteenth most populous country. With a coastline of 3,444 kilometres and a coastal population of 55.9 million, Viet Nam was cited among the world's top five contributors to plastic marine litter, with 0.28–0.73 million metric tonnes of plastic litter output in 2010 (Jambeck *et al*. 2015). In addition to its long coastline and densely populated coastal cities, Viet Nam's plastic industry grew rapidly since 2010, and Plastics consumption in Viet Nam increased sharply from 33 kg per capita in 2010 to 41 kg per capita in 2015 (GIZ 2018).

State of marine litter management

Selected studies at national and local scales confirm the high volume of plastic waste entering marine and water ecosystems in Viet Nam (Table 51). Kieu-le *et al*. (2016) reported that 1,356 to 2,194 tonnes 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 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. It was further reported in 2018 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 tonnes to 8724 tonnes of input per year (Lahens *et al*. 2018). Using Visual Plastic Debris Counting and bridge-mounted trawls with 4 cm mesh, van Emmerik *et al*. (2018) estimated 7,500–13,000 tonnes of plastic waste enter the ocean from Saigon River per year. In 2019, it was further reported that the emission of plastic waste from Saigon River in 2018 was 1,100 tonnes per year when only considering the upper 1.3 m water layer, and 1,400–1, 600 tonnes/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 of beach litter from 10.3 km of coastline (Ocean Conservancy 2019).

Studies on the distribution of marine litter 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/gram of wet tissue. Dominant type: Polypropylene (PP, 31%) and polyester (PS, 23%)	Organisms were digested by KOH (potassium hydroxid) 10% solution, then separated using KI 50% solution. MPs are identified with micro-Fourier-transform infrared Microspectroscopy (µFTIR)	Nam *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 is shown on Table 52 and Figure 10.

In Viet Nam, total municipal solid waste generation was estimated to be 13.2 million tonnes/year in 2014 (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), which specifies objectives towards comprehensive management of solid waste in Viet Nam, including by 2025, achieve the following: (i) collect and treat 90 per cent of urban MSW according to proper environmental standards; (ii) replace nylon bags with environmentally friendly plastic bags; (iii) collect and properly dispose all hazardous waste generated by production, business activities, medical facilities and others, collect and properly dispose 85 per cent of hazardous waste from household and personal sources and 4) 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 , thus ensuring through competition the use of advanced and environmentally friendly technologies according to local conditions for the collection, transportation, recycling and harmless treatment of solid waste and hazardous waste. It also gives priority to the construction of centralized domestic waste recycling and disposal plants.

Data on MSW generation and 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 tonnes/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, polypropylene, PET resin)	0.85 million tonnes (2019)
Polymer exports	0.56 million tonnes (2019)
Polymer imports	3.10 million tonnes (2019)
Domestic conversion of polymers into single-use applications	1.63 million tonnes (2019)
Single-use plastic exports (as bulk packaging and in finished goods)	0.57 million tonnes (2019)
Single-use plastic imports (as bulk packaging and in finished goods)	0.84 million tonnes (2019)
Domestic single-use plastic waste generation	1.90 million tonnes (2019)
Single-use plastic waste generation per capita	19.65 kgs (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; 457 open dumpsites

The information is compiled from multiple sources, including: [1] AIT RRC.AP and GIZ, Country Profile Viet Nam, Regional Workshop "Managing Packaging Waste – Preventing Marine Litter; [2] GIZ (2018) Managing Packaging Waste in the ASEAN Region; [3] Minderoo (2021); [4] Thang, N. T. (2017)

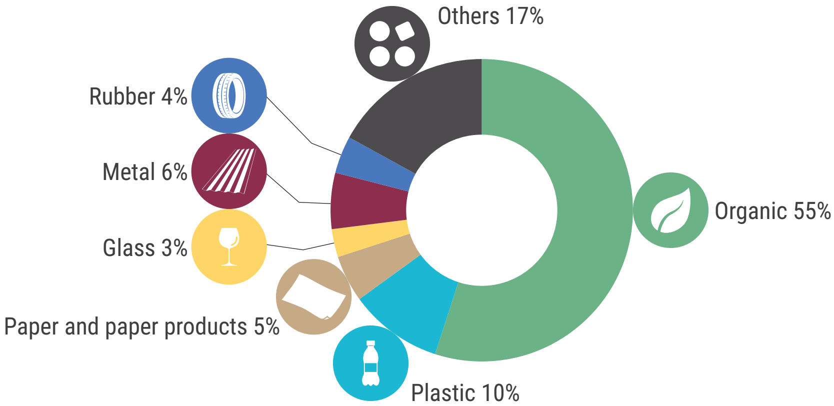
Started in 2018, Vietnam has banned the issuance of plastic waste import licences in preparation for a complete ban on such importation by 2025.

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 reaffirms that Viet Nam sees marine litter as an urgent global issue

Viet Nam MSW composition

Figure 10 /



Source: AIT RRC.AP and GIZ, Country Profile Viet Nam, Regional Workshop "Managing Packaging Waste – Preventing Marine Litter; UNEP (2017). Asia Waste Management outlook

and will 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, on 4 December 2019, the Prime Minister approved Decision No. 1746/ QD-TTg, 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. By 2030, Viet Nam committed to: (i) reduce the country's plastic waste discharge to the oceans by 75 per cent; (ii) make sure 100 per cent of lost or discarded fishing gear is collected and none 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 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.

Public policy on combating marine litter and improving 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)

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 bags, that is, VND 40,000 (about USD2) per kilogram. In response, large companies have launched 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 similar direction. Strong efforts are currently under way to address marine litter, especially marine plastic litter, in most Asian countries such as China, Japan, Republic of Korea, India, Indonesia, 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. 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 industry, the finance sector, government and civil society groups.

When it comes to the issue of marine litter, a major barrier for planning and designing the actions required for the management of marine litter is the inadequate availability of data. Current approaches to map postconsumer waste flows rely predominantly on top-down models, diverse, partial and often outdated data sets. As a result, estimates of where, how and how much plastics are leaking to nature are characterized by significant uncertainties: in terms of total volumes leaking along the supply chain, geographical differences and waste composition as well as 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, analyse, 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 and 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 interventions and policy.

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

- A coordinated, regional effort to increase data availability and quality.
- 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, crowdsourced data and open innovation).

Additionally, limited knowledge on the cost of impacts on the economy and human health, coupled with the lack of consumer information, often results in limited public participation on this issue.

The attention that has been demonstrated at a policy level nationally, 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. There is, however, a strong participation of the reviewed countries 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 maintain 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 that is expected to encourage future concrete action on the issue. ASEAN member states further adopted a **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 and 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 in effective action, a systemic effort in Asia is urgently needed to make more accurate estimation and establish credible baseline for monitoring the progress in marine litter control.

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

- 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.
- Identification of key strategic intervention areas and pathways (hotspots), and development of effective mitigation strategies based on scientific evidence and methodologies.
- 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.
- Use of training materials and references by governments and local authorities in building their capacities.

Improved data and greater knowledge enable better and more effective actions and solutions in more places (UNEP 2019). Significant progress would be made in achieving relevant SDGs targets (identified in Table (i) by providing reliable open-access data and identifying key intervention points to improve the performance of remediation strategies, effectively identifying priority strategic action points, and bringing together groups with experience, expertise and resources that foster effective and 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 regional intergovernmental supporting mechanisms 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 also showcased in this review, have been working collaboratively to evaluate the impacts of marine litter on our planet. Furthermore, increasing public awareness towards and interest in combating marine litter and in developing strategies for the conservation and sustainable use of our oceans in line with Agenda 2030, coupled with a greater attention paid to these issues by the private sector, including in the region, give hope for stronger action in the future.

References

Abreo, N.A.S., Thompson, K.F., Arabejo, G.F.P. and Superio, M.D.A. (2019a). 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., Blatchley, D. and Superio, M.D. (2019b). 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., 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 *10th 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 Indonesia 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.

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, 3rd Ad Hoc Open-Ended Expert Group on Marine Litter and Microplastics. Accessed 15 December 2019.

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.

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. (2018). 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. (2018). 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. (2018). Country Profile Thailand, 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. (2018). 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.

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., Jambeck, J. (2018). The Chinese import ban and its impact on global plastic waste trade. 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://www.env.gov.bn/SitePages/Don't%20Destroy%20Our%20River.aspx. Accessed 31 July 2019.

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.

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. http://wedocs.unep.org/bitstream/handle/20.500.11822/10739/MarineLitterSurveyandMonitoringGuidelines.pdf?sequence=1andisAllowed=y. Accessed 30 November 2018.

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.

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. Accessed 10 November 2018.

Daniel, D.B., Thomas, S.N. and Thomson, K.T. (2020). Assessment of fishing-related plastic debris along the beaches in Kerala Coast, India. https://www.sciencedirect.com/science/article/abs/pii/S0025326X19308525?via%3Dihub.

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/.

Food and Agriculture Organization of the United Nations. https://www.researchgate.net/publication/341756075_Pollution_Monitoring_in_rivers_estuaries_and_coastal_area_of_Bangladesh_with_Artificial_Mussel_Technolgy_Finding_implications_Recommendations_p61

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., HIGASHI, J., Habano, M. and Habano, A. (2009). Distribution and actual condition of seabed litter in Kagoshima Bay. Nippon Suisan Gakkaishi. 75(1):19-27. DOI: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.

GIZ (2018). Managing Package Waste in the ASEAN Region. https://www.switch-asia.eu/resource/managing-packaging-waste-in-the-asean-region/

GIZ (2018a). Country Profile Thailand: managing municipal solid waste and packaging waste. https://www.giz.de/de/downloads/giz2018_Thailand-Country-Profile_web.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., 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. doi: 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. file:///C:/Users/jhzhang/Downloads/293-Article%20Text-810-1-10-20160630%20(1).pdf.

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*. Rome.

Hossain, M.S., Rahman, M.S., Uddin, M.N., Sharifuzzaman, S.M., Chowdhury, S.R., Sarker, S. and Nawaz Chowdhury, M.S. (2019b). 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*. (2019a). 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.

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

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, 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.

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.

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. and Jayasiri, H.B. (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*. 33.

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. (2015a). 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. 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., 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., 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.

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. and 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 Advisor: RRMKP 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 MR, Koskella J. et al. (2020). Evaluating scenarios toward zero plastic pollution. *Science* 369(6510),1455–1461. https://doi.org/10.1126/science.aba9475.

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., c 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.

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. 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?* 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, 48. 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 No.185; FAO Fisheries and Aquaculture Technical Paper, No. 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. (2021). *The Plastic Waste Makers Index.* Broadway Nedlands: Western Australia: Minderoo Foundation.

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

Manickavasagam, S., Chellamanimegalai, P. and Dhayanath, M. (2019). Assessment of Marine Litter Based on Tide along Juhu Beach https://www.ijcmas.com/8-7-2019/S.%20Manickavasagam,%20et%20al.pdf.

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 J.P. Obbard (2014). Microplastics in Singapore's coastal mangrove ecosystems. 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.

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.* Washingyon, D.C. https://oceanconservancy.org/wp-content/uploads/2017/04/2016-Ocean-Conservancy-ICC-Report.pdf. Accessed 30 November 2018.

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. Accessed 30 November 2018.

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. Accessed 30 November 2019.

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

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.

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. Accessed 30 November 2018.

Purba, N.P., Ihsan, Y., Faizal, I., Dannisa, I. Handyman, D. & Widiastuti, K.S *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.

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.

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.

PCD Thailand (2019). Booklet on Thailand State of Pollution 2018. http://www.oic.go.th/FILEWEB/CABINFOCENTER3/DRAWER056/GENERAL/DATA0001/00001462.PDF

PCD Thailand (2021). Thailand State of Pollution 2020. https://www.pcd.go.th/wp-content/uploads/2021/03/pcdnew-2021-03-31_09-59-54_127801.pdf

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.

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). *BFA*R rescued two Dolphins in Camarines Sur. 10 February. https://www.bfar.da.gov.ph/newsarchives.jsp?id=200. Accessed 15 December 2019.

PlasticsEurope (2019). Plastics–the Facts 2019. Brussels. https://www.plasticseurope.org/download_file/force/3183/181. Accessed 30 November 2019.

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. Accessed 30 November 2019.

Purba, N.P., Ihsan, Y.N., Faizal, I., Handyman, D.I., 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. et al. (2016). Qaisrani, Z., 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 (UTB). 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. Seventh Brunei International Conference on Engineering and Technology (BICET 2018). 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. DOI:10.52763/PJSIR.BIOL.SCI.58.2.2015.98.103.

C.M. 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. 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). Kota Bharu, Kelantan, Malaysia. 13-14 December 2020.

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.

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. Accessed 30 November 2018.

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. UNEP and 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. Accessed 15 December 2019.

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*. 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 WEBPAGE 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.

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.

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/.

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. 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.

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.

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.

The Asia Foundation and National Council of Sustainable Development (2018). Scoping Study Report on Solid Waste Management in Kep Province. https://asiafoundation.org/wp-content/uploads/2020/09/Cambodia_Scoping-Study-Report-on-Solid-Waste-Management-in-Kep-Province_August-2020_EN_.pdf.

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. et al (2017a). Effects of microplastics on sessile invertebrates in the eastern coast of Thailand: An approach to coastal zone conservation. https://www.sciencedirect.com/science/article/pii/S0025326X17304903?via%3Dihub .

Timor-Leste, Government of (2019). Government prepares partnership for plastic transformation, 3 April. http://timor-leste.gov.tl/?p=21531&lang=en&n=1. Accessed 31 July 2019.

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 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, Nairobi, 11–15 March 2019. http://web.unep.org/environmentassembly/bangladesh-0. Accessed 15 December 2019.

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). https://papersmart.unon.org/resolution/uploads/1995-gpa.pdf.

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.* Paul Ekins, 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, 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 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 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 General Assembly Resolution 72/73. *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 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.* 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.

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.

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/. Accessed 15 December 2019.

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. http://siteresources.worldbank.org/INTSRILANKA/Resources/LKAgingChapI.pdf.

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.

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.

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.**

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.

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., 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., 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*. **https://doi.org/10.1016/j.envpol.2017.08.058.**

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.