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Baseline Study on Microplastics in ASEAN

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Abstract
The ASEAN region has among the highest concentrations of plastic litter globally. The knowledge on microplastic pollution in that region is still limited and needs further investigation for policy implementation. To support the implementation of the Regional Action Plan for combatting marine debris, the proposed Regional ASEAN Baseline Study on Microplastics is intended as a summary report that examines existing studies, sources, knowledge gaps, projects and policies that pertain to microplastics in the ASEAN region. Microplastic pollution is unequally investigated among the 10 countries of the region, constituting a first major knowledge gap. In addition, studies often focused on the same environments or matrices, i.e. marine and freshwaters, beach sediment and marine organisms (mostly fish). Microplastic contamination in top predators, air, river sediment, terrestrial ecosystems (including organisms), and wastewater treatment plants are largely unknown. Modeling and experimental studies are also lacking, resulting in a lack of knowledge on the fate and impacts of microplastic contamination on species and ecosystems. These fields need to be further investigated to implement relevant and efficient mitigation measures.

Keywords: Microplastic, ASEAN, sources, plastic pollution, regional policies
Emneord: Mikroplast, ASEAN, kilder, plastforurensning, regionale policier

Abbreviation List

AHEG: Ad hoc experts group

ALFDG: abandoned, lost or otherwise discarded fishing gear

AMS: ASEAN Member States

ASEAN: Association of Southeast Asian Nations

ASPEN: ASEAN Strategic Plan on Environment

AWGCME: ASEAN Working Group on Coastal and Marine Environment

BPA: bisphenol A

BRIN: Indonesian Research Centre for Oceanography

CE: circular economy

CER: circular economy roadmap

CFR: collected for recycling

COBSEA: the Coordinating Body on the Seas of East Asia

CSEAS: Centre for South-East Asia Studies

EIA: Environmental impact assessment

EPC: ethylene/propylene copolymer

EPDM: ethylene/propylene/diene rubber

EPR: extended producer responsibility

ESR: extended stakeholder responsibility

FAO: Food and Agriculture Organization

FDA: Food and Drug Administration, Philippines

GCRF: Global Challenges Research Fund

GESAMP: Group of Experts on the Scientific Aspects of Marine Environmental Protection

GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit

GPA: Global Programme of Action for the Protection of the Marine Environment from Land-based Activities

GPML: Global Partnership on Marine Litter

HCMUT: Ho Chi Minh University of Technology

HDPE: High density polyethylene

IGES: Institute for Global Environmental Strategies

ILBI: International-legally Binding Instrument

IOCAS: Institute of Oceanology, Chinese Academy of Sciences

IRD: French National Research Institute for Sustainable Development

JAIF: Japan-ASEAN Integration Fund

LDPE: Low density polyethylene

MCDC: Mandalay City Development Committee

MoEF: Ministry of Environment and Forestry, Indonesia

MP: microplastic

MPW: mismanaged plastic waste

MRC: Mekong River Commission

NDC: First Nationally Determined Contribution

NESAP: Cambodia's National Environment Strategy and Action Plan

NIVA: Norwegian Institute for Water Research

NMLPAP: National Marine Litter Policy and Action Plan

NPCSAP: National Pollution Control Strategy and Action Plan

NPOA-ML: National Plan of Action for the Prevention, Reduction, and Management of Marine Litter

NWMSMP: National Waste Management Strategy and Master Plan

OECD: Organization for Economic Co-operation and Development

PA: polyamide

PAK: polyacrylate

PAP4SCP: Philippine Action Plan for Sustainable Consumption and Production

PD: Presidential Decree

PDR: People's Democratic Republic

PEMSEA: Partnerships in Environmental Management for the Seas of East Asia

PET: polyethylene terephthalate

PP: polypropylene

PS: polystyrene

PU: polyurethane

PVS: polyvinyl stearate

RAP: Regional Action Plan

RAP MALI: Regional Action Plan

RC3S: Regional Capacity Center on Clean Seas

SAC: State Administration Council

SBR: styrene/butadiene rubber

SCP: sustainable consumption and production

SCS: South China Sea

SEAFDEC: Southeast Asian Fisheries Development Center

SIWRR: Southern Institute of Water Resource Research

SUP: single-use plastic

WWTP: wastewater treatment plant

YCDC: Yangon City Development Committee

Table of contents

Preface

This baseline report presents an overview of knowledge, policies and projects focusing on microplastic pollution in Southeast Asian Nations (ASEAN). This report was funded by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and led by NIVA, under the "Reduce, Reuse, Recycle to Protect the Marine Environment and Coral Reefs" project. Dr. Luca Nizzetto and Dr Hans Nicolai Adam are project leads for NIVA's 3ProMar project component, which is a collaboration with the IKHAPP (International Knowledge Hub Against Plastic Pollution) platform. Dr France Collard lead the scientific analysis and writing of this report in collaboration with Kristin Galtung and Marianne Mosberg (NIVA).

We want to thank Mr. Phong Giang and Ms. Revina Indra Putri, as well as the 3RproMar project team, and Dr Amila Abeynayaka from the Technical University of Denmark for providing useful information for the "projects" section. We hope this baseline will provide useful insights for policy implementation future research and subsequently, help tackling the microplastic issue in ASEAN.

Tromsø, 07 May 2024

Summary

Plastic pollution has been observed for decades but it is only in the recent past that microplastic (< 5 mm) pollution gained increasing attention in the scientific community, civil society, among politicians but also industry. Microplastics are more mobile than macroplastics and are often more broadly and homogeneously dispersed by aerial and marine transport. Because of these characteristics, microplastics are ubiquitous and found in many environmental compartments such as soils, air, freshwater and marine waters. The ASEAN region has among the highest concentrations of plastic litter globally but the knowledge on microplastic pollution in that region is still limited and needs further investigation for policy implementation. Therefore, microplastics are a key component of the ASEAN Regional Action Plan (RAP) for Combating Marine Debris.

To support the implementation of the RAP, the proposed Regional ASEAN Baseline Study on Microplastics is intended as a summary report that will examine existing studies, sources, knowledge gaps, projects and policies that pertain to microplastics in the ASEAN region. To do so, the Web of Science database was searched for relevant scientific literature and other policy databases were screened separately for the review of the existing policies.

Microplastic pollution is unequally investigated among the 10 countries of the region, constituting a first major knowledge gap. The majority of scientific articles (87%) included in this baseline review stem from Indonesia, Thailand, Viet Nam and Malaysia. In addition, studies often focused on the same environments or matrices, i.e. marine and freshwaters, beach sediment and marine organisms (mostly fish). Microplastic contamination in top predators, air, river sediment, terrestrial ecosystems (including organisms), and wastewater treatment plants are largely unknown. Modeling and experimental studies are also lacking, resulting in a lack of knowledge on the fate and impacts of microplastic contamination on species and ecosystems.

Human exposure to microplastic is an important research topic that still needs to be addressed. Humans are indeed exposed to microplastic, but studies about human exposure and impacts are incomplete, nascent and include usually very few participants. Monitoring human exposure and contamination in the ASEAN region constitutes a potential pathway to identify the sources of such exposure.

Sources of microplastics have been identified globally and are in fact quite well known from various regions: fragmentation and degradation of macrolitter including lost or discarded fishing gear, tear-and-wear of tires, washing machine effluents, cosmetics, textiles, among others.

Tackling microplastic pollution is a major global challenge, including in ASEAN. In this report we propose several potential mitigation measures and research fields to be promoted in order to act against this pollution. Those mitigation measures can target microplastics specifically or a source of these, such as plastic waste.

3RproMar (Reduce, Reuse, Recycle to Protect the Marine Environment and Coral Reefs) is an ASEAN-German cooperation project implemented by GIZ GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) and in coordination with the ASEAN Secretariat. The present study was developed in the frame of the 3RproMar's Regional Knowledge Partnership for Marine Litter Prevention.

Sammendrag

Plastforurensing har blitt observert i flere tiår, men det er først i nyere tid at oppmerksomheten rundt forurensing av mikroplast (< 5 mm) har økt både blant forskere, forbrukere, politikere og i den generelle befolkningen. I tillegg har mikroplastpartikler større mobilitet enn makroplast og blir derfor oftere spredt både mer vidt og homogent via luft - og marin transport. På grunn av disse egenskapene finner vi mikroplast overalt, i mange ulike miljøer, som i jord, luft, ferskvann og marine farvann. ASEAN-regionen står ovenfor noen av de høyeste konsentrasjonene av plastforurensning på global skala, men kunnskapsnivået om mikroplastforurensningen i denne regionen er fortsatt begrenset. Det trengs ytterligere forskning for å kunne implementere politiske tiltak. Derfor er mikroplast en nøkkelkomponent i "ASEAN Regional Action Plan (RAP) for Combating Marine Debris".

For å støtte implementeringen av RAP er denne studien om mikroplast i ASEAN-regionen ment som en oppsummeringsrapport som tar for seg eksisterende studier, kilder, kunnskapshull, prosjekter og policy om mikroplast i regionen. For gjennomgang av vitenskapelig litteratur ble Web of Science databasen brukt som søkemotor, mens for å vurdere eksisterende policyer på området ble policy-databaser gjennomgått separat.

Forskningen på mikroplastforurensing varierer mellom de 10 landene i regionen, noe som har ført til et betydelig kunnskapshull. Fire av disse landene, Indonesia, Thailand, Vietnam og Malaysia, står for hele 87% av de vitenskapelige artiklene som er inkludert i dette kunnskapsgrunnlaget. I tillegg fokuserer studiene ofte på de samme miljøene og matriksene, som salt- og ferskvann, strandsedimenter og marine organismer (hovedsakelig fisk). Mikroplastforurensningen hos toppredatorer, i luften, elvesedimenter, terrestriske økosystemer (inkludert organismer) og i renselegg for avløpsvann, er i stor grad ukjent. Det er også mangel på modellering- og eksperimentelle studier, noe som fører til kunnskapsmangel om skjebnen til mikroplastforurensingen og dens påvirkning på arter og økosystemer.

Menneskelig eksponering for mikroplast er et viktig tema globalt, som fortsatt må adresseres. Mennesker utsettes for mikroplast, men studier på dette området er ofte punktuelle og inkluderer vanligvis svært få deltakere. Overvåkning av menneskelig eksponering og forurensing blant ASEAN-befolkningen utgjør én måte å identifisere kildene til eksponering på.

Kilder til mikroplast er identifisert og velkjent fra studier i andre regioner, og inkluderer for eksempel degradering av makrosøppel som inkluderer tapt eller kastet fiskeutstyr, slitasje fra dekk, utslipp fra vaskemaskiner, kosmetikk, tekstiler, for å nevne noen.

Å bekjempe mikroplastforurensing er en betydelig global utfordring, og denne utfordringen kan til og med være enda større i ASEAN-regionen. Vi har her derfor foreslått flere tiltak for å begrense mikroplastforurensing og identifisert forskningsområder som bør prioriteres for å bekjempe denne type forurensning. Disse tiltakene kan rette seg spesifikt mot mikroplast eller mot kildene, som for eksempel plastavfall.

3RproMar (Reduce, Reuse, Recycle to Protect the Marine Environment and Coral Reefs) er et ASEAN-tysk samarbeidsprosjekt som gjennomføres av GIZ GmbH på vegne av det tyske forbundsdepartementet for økonomisk samarbeid og utvikling (BMZ) og i samarbeid med ASEAN-sekretariatet. Denne studien ble utviklet innenfor rammen av 3RproMars regionale kunnskapspartnerskap for forebygging av marin forsøpling.

1 Introduction

Plastic pollution has been observed for decades but it is only much later that microplastic pollution gained an increasing attention of the of in the scientific community, civil society, among politicians and but also industry (Fig. 1). The term "microplastic" was firstly mentioned in an article published in 2004 (Thompson et al., 2004). From there, microplastic pollution was increasingly investigated in many regions of the world, including southeast Asia. Overall, microplastic pollution is a recent topic when considering other pollutants. It is well known that microplastics are a prominent component of plastic pollution, but in some aspects or some regions, it is still poorly understood.

Microplastics are defined among the scientific community as plastic pieces ranging in size from 1 µm to 5 mm (Arthur et al., 2009; Andrady, 2011; GESAMP, 2015). By mass, 90% of the plastic released to the environment is in the form of macroplastics or mesoplastics but smaller elements (such as microplastics) are numerically prevalent. Microplastics are either manufactured in the micro-size range or a result of the degradation and fragmentation of larger plastic items (meso- and macroplastics, i.e. from 5 to 25 mm, and from 25 mm and larger, respectively). The first category, if directly released into the environment, are called primary microplastics (Boucher and Friot, 2017). They can be a voluntary addition to products such as scrubbing agents in toiletries and cosmetics (e.g. shower gels). Microplastics originating from the fragmentation of larger plastic objects are called secondary microplastics (UNEP, 2016).

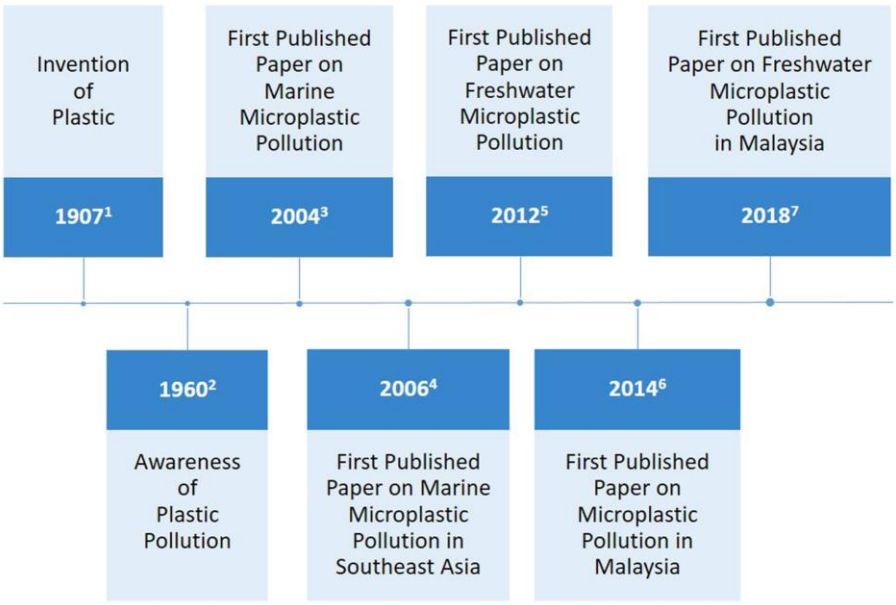

Figure 1. Key milestones in the history of plastic waste and knowledge of its environmental effects. Indicative papers for key points in the timeline are: [1]Thompson et al. (2009); [2]Ostle et al. (2019) [3]Thompson et al. (2004); [4]Ng and Obbard (2006); [5]Faure et al. (2012); [6]Barasathi et al. (2014); [7]Sarijan et al. (2018). From Chen et al. (2021).

Microplastics are also more mobile than macroplastics and are often more broadly and homogeneously dispersed by aerial and marine transport. Because of these characteristics, microplastics are ubiquitous pollutants contaminating all environmental compartments including soils (e.g. Rillig et al., 2017), air (Dris et al., 2016), freshwater and marine environments (e.g. Eerkes-Medrano et al., 2015; Gago et al., 2018), with yet scarcely understood implications for ecosystems and ecosystem services. Finally, because of their abundance, ubiquity and size, microplastics have a high chance for uptake by biota and humans with potential adverse health consequences (e.g. Andrady, 2011; Smith et al., 2018).

Monitoring and managing releases and flows of microplastics is an integral element of the endeavor of combatting plastic pollution. These pollutants will be addressed by the upcoming International-legally Binding Instrument (ILBI) on Plastic Pollution, including in the Marine Environment (Rognerud et al., 2023) and countries will have to equip themselves with knowledge and tools to understand the emission and contribution of microplastics to the overall level of plastic pollution. Because of the higher potential for long-range transboundary atmospheric and marine transport, the ability of a country or region to demonstrate good management and progress in abating releases of microplastics will be important in international policy instruments, including in the member countries of the Association of Southeast Asian Nations (ASEAN).

The ASEAN region includes a coastline of around 150,000 km long with thousands of islands. The region hosts 25-33% of the world's mangrove forests (Spalding et al., 2010) and around one third of the coral reefs on earth (Burke et al., 2002), making it a biodiversity hotspot. This diverse biota is threatened by several stressors, including plastic pollution. The ASEAN region has among the highest concentrations of plastic litter globally, with four of those countries contributing to around a third of marine plastic pollution in the world's ocean (Jambeck et al., 2015). Even though microplastic pollution in the region is less obvious than macroplastic pollution, if not cleaned out of the environment, the macroplastics will eventually fragment into microplastics that negatively impact exposed organisms. Actions are therefore needed to monitor and tackle the threat microplastic constitutes for both biota and humans.

Microplastics are a key component of the ASEAN Regional Action Plan (RAP) for Combating Marine Debris, with Action 9 directly focusing on microplastics. This RAP was developed from October 2019 to July 2020, led by Thailand and with the support of the World Bank. It highlights the current status and challenges faced by ASEAN Member States (AMS), as well as identifies potential solutions along the value chain to overcome unsustainable plastic consumption, waste management and marine debris pollution The understanding of microplastics, land and sea-based leakage to the overall marine debris challenge in ASEAN is currently limited, and only a few ASEAN Member States (AMS) have measures in place to tackle this. There is a need for improving knowledge in ASEAN on quantifying and monitoring plastic marine debris; and to contribute to global research efforts to better understand the sources and impact of microplastics.

To support the implementation of the ASEAN RAP, the proposed Regional ASEAN Baseline Study on Microplastics is intended as a summary report that will examine existing studies, sources, and policies that pertain to microplastics in the ASEAN region.

2 Materials and methods

To perform the stocktaking of the published scientific articles on microplastic pollution in the ASEAN region, the Web of Science platform was used (https://www.webofscience.com/wos/woscc/basic-search). A systematic search was performed using several search strings limited to the topic of the scientific articles. Firstly "microplastic ASEAN", and after: "microplastic Indonesia", "microplastic Singapore" and similarly for all the 10 countries of the ASEAN region. This search was performed early January 2024. Our literature search was performed in English. Consequently, only articles written in English were covered by our search and are included in this baseline. Reports and conferences' proceedings are not included in this study. The first search led to 156 results and altogether, those searches led to 415 results with several of them in duplicate. A thorough screening of those articles was performed to exclude irrelevant results and duplicates. After, a 'snowball search' allowed us to add 13 more scientific articles. In the end, 260

papers were selected for this report, including articles on experimental and modeling studies, as well as field studies and reviews. A full list can be found in the Appendix (Table S1).

To perform the stocktaking of policy measures against microplastic pollution in the ASEAN region, a combination of systematic database searches and snowball sampling was used. A systematic search in four policy databases was first conducted: the Global Plastic Policy Reviews by the University of Portsmouth[1], the Plastics Policy Inventory by the Nicholas Institute for Energy, Environment & Sustainability[2], FAOLEX Database by the Food and Agriculture Organization[3], and the Global Plastic Laws[4]. This yielded 123 results of plastics-related policies, wherein 75 were deemed relevant to be included in this policy review. Following this, a 'snowball search' was conducted to identify relevant policies that had not been identified through the first round of database searches. This involved following references to other policies in the documents already identified, relevant academic and non-academic papers and policy reviews, and online searches. This yielded an additional 73 results, but some of these were excluded in the review process as they were deemed insufficiently relevant for microplastics. This led to an inventory of 100 policy documents across the ASEAN region targeting micro- and macroplastics and solid waste management which were analyzed qualitatively for this baseline study (see full list in the appendix).

3 Knowledge on microplastic pollution

In this section we summarized ongoing research on microplastic pollution by country, with a focus in a few studies with outstanding findings or showing novelties considering the field and the region. Overall, there was a remarkable increase in the number of published scientific articles over the past years (Figure 2). Before 2020, few studies were conducted, with 11 articles in 2019, almost three times more articles were published in 2020, likely marking a shift in microplastic research in ASEAN. However, ASEAN countries are not equally represented in those studies as there is a big difference in both the numbers of articles and the environment or matrices studies.

[1] *Available at: https://plasticspolicy.port.ac.uk/*

[2] *Available at: https://nicholasinstitute.duke.edu/plastics-policy-inventory/search*

[3] *Available at: https://www.fao.org/faolex/en/*

[4] *Available at: https://www.globalplasticlaws.org/map*

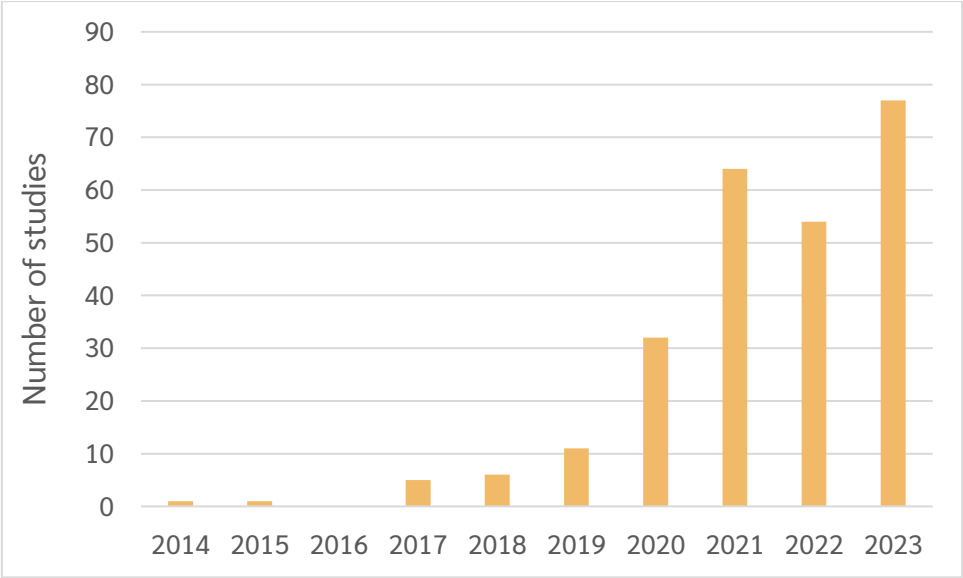

Figure 2. Evolution of the number of microplastic studies focusing on ASEAN since 2014.

3.1 Brunei Darussalam

Only one study on microplastics (MPs) from Brunei was found in our literature search (Lee et al., 2022). The study investigated accumulation of MPs in oysters (*Saccostrea cucullate*), sampled along the Bornean coastline in the South China Sea (SCS). The microplastic average concentrations between sites ranged between 0.43 to 7.20 particles/g oyster tissue, and concentrations declined along the study estuary, seawards. Results showed that fragments dominated the samples (74.9%), followed by fibers (22.1%) and pellets (3.0%). Black polypropylene fragments (< 50 µm) predominated among the particles found (Figure 3). According to the authors, the large presence of black polypropylene fragments, which might originate from items such as food containers and bottle lids (Jong et al., 2022) supports that the sources of marine microplastic pollution are from domestic plastic waste.

The findings are similar to other MP concentrations found in oysters in other regions in the SCS (Curren et al., 2021; Ding et al., 2021; Liao et al., 2021), but represents an order of magnitude greater than concentrations reported outside of the SCS, such as in the USA and Australia (Lee et al., 2022 and refs therein).

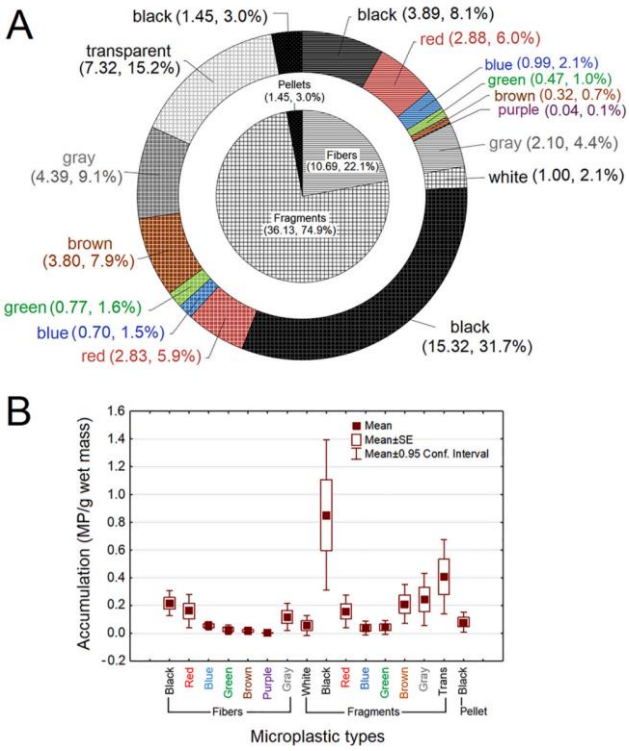

*Figure 3. A: Relative percentage of the distribution of microplastic shape and adherent color found in oysters (*Saccostrea cucullate*) along the Bornean coastline, B: Showing the accumulation of microplastics/gram wet mass by microplastic categories. From Lee et al. (2022).*

3.2 Cambodia

Two studies were found during our search for microplastic studies in Cambodia. One study was from Phnom Penh analysing plastic loads in the Mekong River, both macro- and microplastics (Haberstroh et al., 2021), while the other was a larger study analysing soil for MPs and plastic additives from dumping sites in Cambodia and five other Asian countries, all of which were from the ASEAN region, except India (Tun et al., 2022) (Figure 4).

In the water in Mekong River, 65% of the plastic particles were smaller than 1 mm and the dominant polymer types found were polypropylene (69%) and polyethylene (12%), followed by polystyrene (4%) and polyethylene (4%).

The soil samples from Cambodia were collected in the cities, Phnom Penh and Siem Reap and had the highest mean abundance among all study countries, with 26,749 ± 67,488 pieces/kg dry weight and the highest abundance of 218,182 pieces/kg in a single sample. Notably, the single result was derived from identification of 48 MPs in 0.22 gram of sample, and no MPs were detected in two other samples collected at the same sampling site. In Cambodian samples (n = 89), polyethylene (50%) was the dominant polymer of MPs, followed by polypropylene (26%), polyethylene terephthalate (18%) and polystyrene (2%). Polyethylene and polypropylene were the most common polymers found in both studies, even though detected in different matrixes.

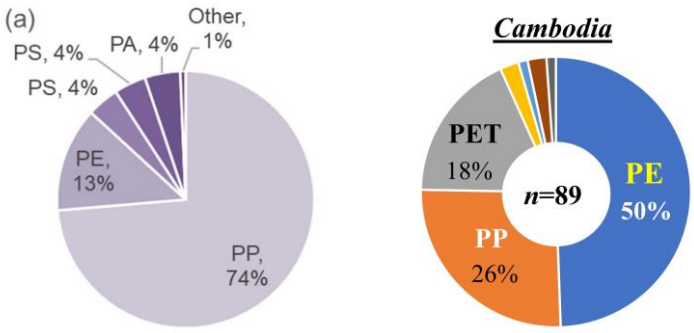

Figure 4. The polymer type distribution analyzed in samples from Mekong River (a), Haberstroh et al. (2021) and in samples from dumping site soils in Cambodia (n = 89) (Cambodia, Tun et al. (2022)). PET: Polyethylene terephthalate, PP: polypropylene, PE: polyethylene, PS: polystyrene, PA: polyamide/nylon and others.

3.3 Indonesia

Indonesia is the country in ASEAN with the most numerous studies on MPs (n=80, Table S1). In a study from 2019 (Lestari and Trihadiningrum, 2019), only 10 studies had focused on microplastic pollution in Indonesia back then (Figure 5). Our search led to 80 relevant articles on microplastic pollution in Indonesia showing the growing interest for this topic in this country.

Figure 5. Distribution of plastic pollution studies in Indonesia. Circle diameter in each site relates to plastic particle abundance. Map source: Google Image, 2018. From Lestari and Trihadiningrum 2019.

Indonesia is estimated to be the second highest contributor to marine plastic waste in the world (Jambeck et al., 2015). Globally, 3.22 million metric tons/year of mismanaged plastic waste is generated, and Indonesia is estimated to generate a range of 0.48-1.29 million metric tons/year. Given the mismanaged plastic waste could eventually reach the ocean via rivers or stormwater drains, microplastics (whether from primary or secondary sources) may also occur abundantly in freshwater systems. Among the ASEAN countries, Indonesia has the highest number of published studies on microplastics based on our literature search.

Microplastic studies from Indonesia cover a wide range of topics, including the presence of MP pollution in different environments, including terrestrial, marine water, freshwater, brackish water, atmospheric,

indoor, wetlands, wastewater treatment plants, dumping sites and even animal husbandry. In addition to the different matrices analyzed as represented in Figure 6, a modeling study was published, focusing on the Java Sea (Handyman et al., 2019). Fish was the most studied animal group (e.g. Andreas et al., 2021; Buwono et al., 2021) followed by a great variety of other groups such as sponges (Girard et al., 2021), corals (Sabdono et al., 2022), zooplankton (Adji et al., 2022), bivalves (Asadi et al., 2022; Irnidayanti et al., 2023), gastropods (Mardiansyah et al., 2022), crabs (Patria et al., 2020), shrimps (Watiniasih et al., 2023), sea urchins (Rahmawati et al., 2023) and sea cucumbers (Sulardiono et al., 2023). Even though most of the species studied were from aquatic environments, one study investigated MPs in husbandry ducks (Susanti et al., 2021) and one study the uptake in pneumatophores of the tropical mangrove *Avicennia alba* (Moniuszko et al., 2023).

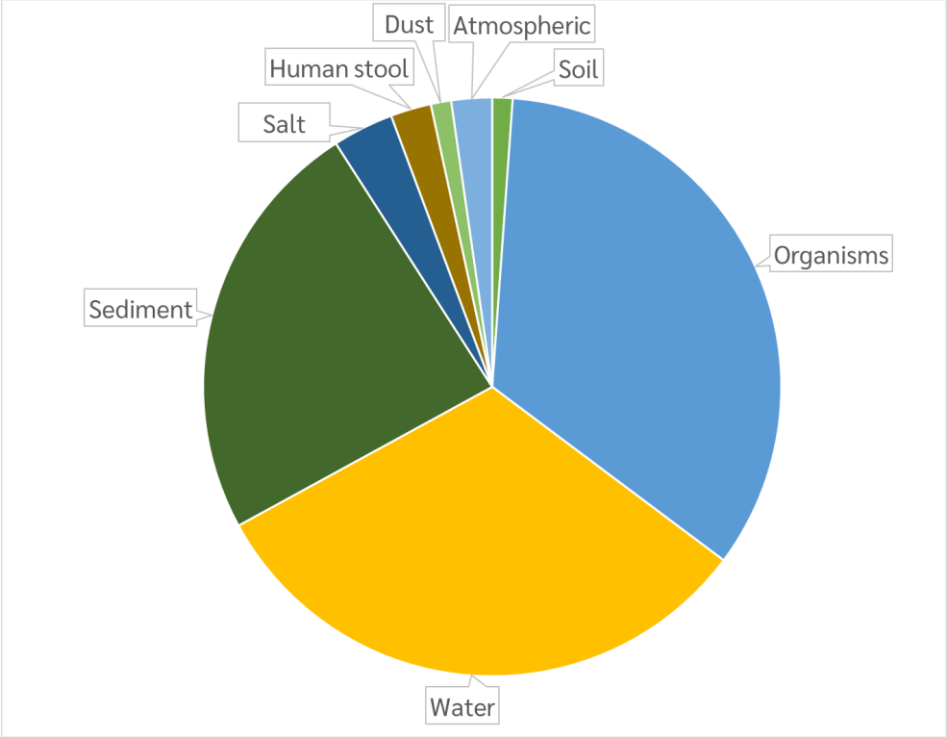

Figure 6. Distribution of different matrixes analyzed in microplastics studies from Indonesia (n = 80 articles).

Several studies focused on environments and matrices that have relevance to human health, such as table salt, indoor dust, and commercial seafood species, some even purchased at fish markets. One review paper focuses on the presence of MPs in the Indonesian environment and its effects on health (Mulyasari et al., 2023). By contrast with other ASEAN countries, two studies on human stool were performed in Indonesia. These studies reported average MP concentrations of 10.19 µg/g of stool and a range between 3.33 - 13.99 µg/g of stool, respectively (Luqman et al., 2021; Wibowo et al., 2021).

3.4 Lao People's Democratic Republic (PDR)

Our literature search revealed limited research activity on microplastics in Laos, with only two papers on the topic. One study has risk assessed MP dispersion and studied the accumulation of MPs in urban canals and especially in the sub-river Mark-Hiao River to the water environment in Vientiane (Noudeng et al.,

2023). Another larger study which analyzed soil for MPs from dumping sites included several sampling sites in Laos (Tun et al., 2022).

In Noudeng et al. (2023), the authors made assumptions about the sources of the MPs detected. Transparent plastic sheets could originate from plastic cups and food containers, semi-transparent microplastic sheets from grocery and market bags. Colored fibers were found as seen in Figure 7 (f-i) and were assumed to originate from residential and commercial applications, such as artificial turf, blue tarpaulin and plastic ropes.

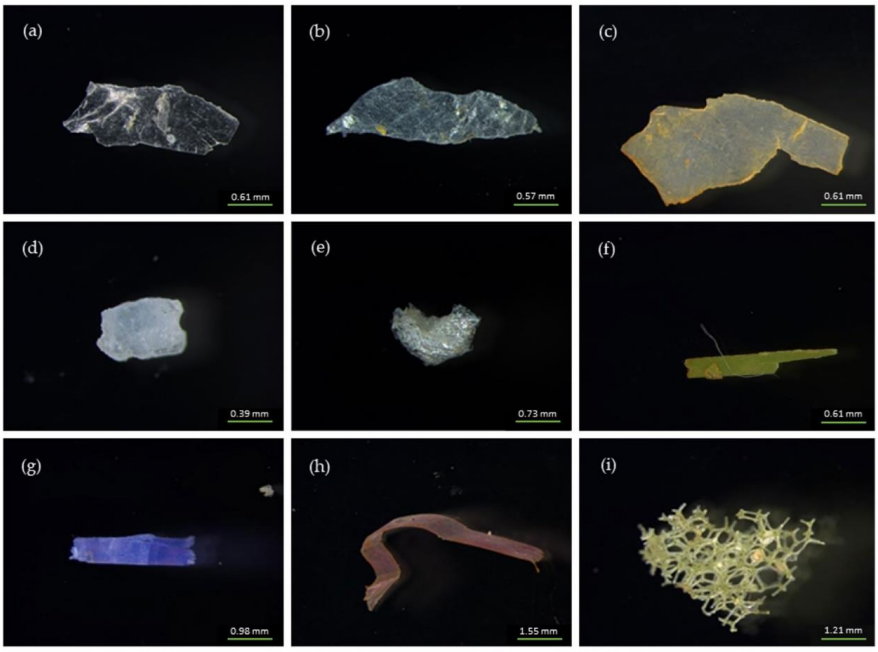

Figure 7. Microplastics identified in the urban canals and sub-river in Vientiane, Laos. Film (a-b), fragment (c), foam (d) and fiber (f-i). From Noudeng et al. (2023).

3.5 Malaysia

In Malaysia there is microplastic research activity, with a majority of studies investigating the presence of particles in water and organisms. Within studies focusing on organisms, a wide range of animal groups and species have been investigated, primarily marine. Several of the studied species are commonly consumed as seafood in Malaysia, such as different fish (Karbalaei et al., 2019; Karbalaei et al., 2020; Foo et al., 2022), sharks (Matupang et al., 2023), sea cucumbers (Husin et al., 2021; Mazlan et al., 2023), and crabs (Abd Rahim et al., 2023). Seafood species were sampled with different approaches, some caught in wild environments while some were purchased at fish markets. By investigating commercial exploited species increase the relevance to MP exposure for humans, as contaminated seafood might negatively impact human health upon consumption. However, several of the studies investigated the gastrointestinal tract of the organisms (Abd Rahim et al., 2023), and not the fillet, flesh or other parts which are mainly consumed by humans. Additionally, to some studies on soils and sediments, matrices as human colon tissue, laundry water and personal care products have been analyzed for MPs (Suardy et al., 2020; Ibrahim et al., 2021; Praveena et al., 2021) (Figure 8). Malaysia is the only country in the ASEAN region where studies on personal care product have been performed (Praveena et al., 2018; Suardy et al., 2020; Rahim et al., 2021).

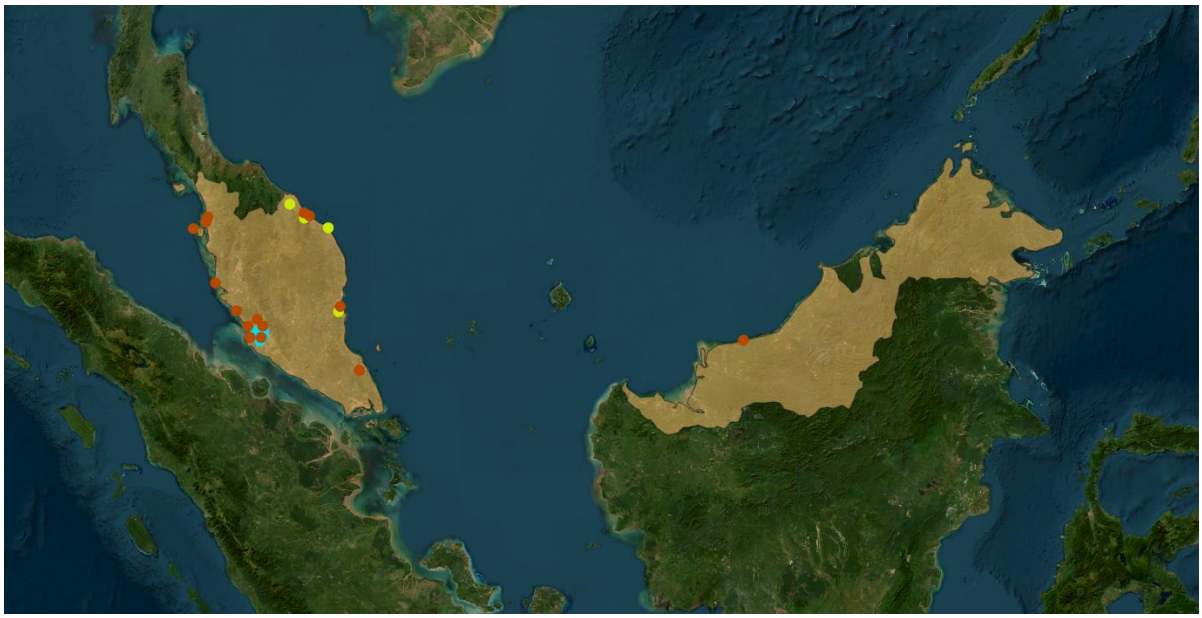

Figure 8. Map showing the distribution of sampling locations for microplastic pollution research in seafood (orange), human tissues (yellow) and personal care products or laundry water (blue). Two studies on personal care product are not represented as they did not perform in situ *sampling (Praveena et al. 2018, Rahim et al. 2022).*

Several studies have sought to draw links between environmental microplastic pollution and their potential sources in Malaysia. For instance, Zainuddin et al. (2022) identified high abundances of MPs in surface waters in coastal and estuarine zones and associated the findings with anthropogenic activities such as tourism and the presence of fishing centres and ramp jetties. In that study, cellophane dominated the samples (54 %), followed by polyester (33 %) and polyethylene (2 %). Also, a higher abundance of MPs in fish was detected at a site with higher anthropogenic activity compared to a site with lower activity (Lim et al., 2023). When analysing gastropods in the Klang River estuary, fibers clearly dominated, especially black ones (Zaki et al., 2021). Findings indicated that MPs originated from urbanized areas of the estuary, from fibers, tyres, and fishing gear.

In general, sampling at different sites and analysing different matrices shows differences in MP polymer type and morphological characteristics among the studies.

3.6 Myanmar

Our search showed only one study performed in Myanmar (Littman et al., 2020). This study did not focus on MPs but rather on microdebris, which included MPs, from water, sediment and oyster tissues (Figure 9), and their associated human bacterial pathogens that are commonly associated with terrestrial runoff of human and agricultural waste. This contamination in both microdebris and pathogens are influenced by coastal urbanization (Littman et al., 2020).

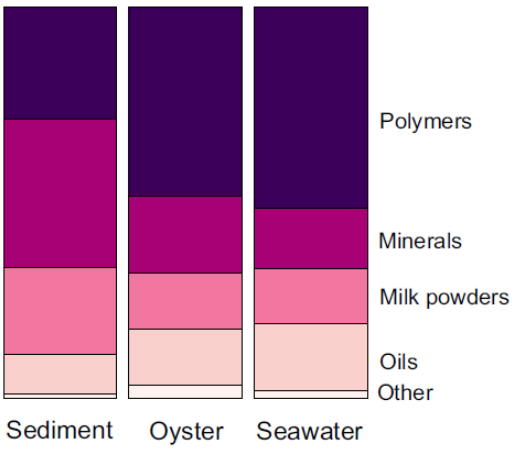

Figure 9. Proportions of classes of microdebris contaminants quantified from seawater, sediment and oyster tissues from Myanmar. From Littman et al. (2020).

3.7 The Philippines

There is an even distribution between studies focusing on freshwater and marine environment (7 against 9), as well as using sediment, water or organism (6, 4 and 4, respectively) as the matrix of interest. By contrast, among the organisms investigated, most of them were fish, and only one study used mollusks (bivalves) as their target animal group (Palermo et al., 2020; Cabansag et al., 2021; Paler et al., 2021; Bonifacio et al., 2022; Similatan et al., 2023). All the fish and mollusks studied are used for human consumption. Similatan et al. (2023) found an average of 5.40 and 10.27 items per stomach of milkfish *Chanos chanos*, from Nasipit and Butuan, respectively. That study reported a higher contamination in MPs than another study on milkfish from Indonesia (Sembiring et al., 2020). Knowledge on other fauna, such as large predators or crustaceans, from the Philippines is lacking. Beside studies on the aquatic environment in the Philippines, one study performed in 2023 evidenced the occurrence of suspended atmospheric MPs at all sampling locations in the National Capital Region, also called “Metro Manila” (Romarate et al., 2023) (Figure 10). The global average number and concentration of atmospheric MPs was 9.11 and 0.021 per cubic meter. The most common type of MPs in Metro Manila air is polyester fiber, leading the authors to conclude that textiles constitute an important source of airborne MPs (Romarate et al., 2023). Airborne microplastics can be directly inhaled by humans constituting a possible health risk (Gasperi et al., 2018). This first study on MPs in air in the Philippines is supporting the need for a greater knowledge, for example on the influence of the seasons, using higher numbers of samples and replicates, to further identify the sources and prevent potential health risks to the Filipinos (Romarate et al., 2023).

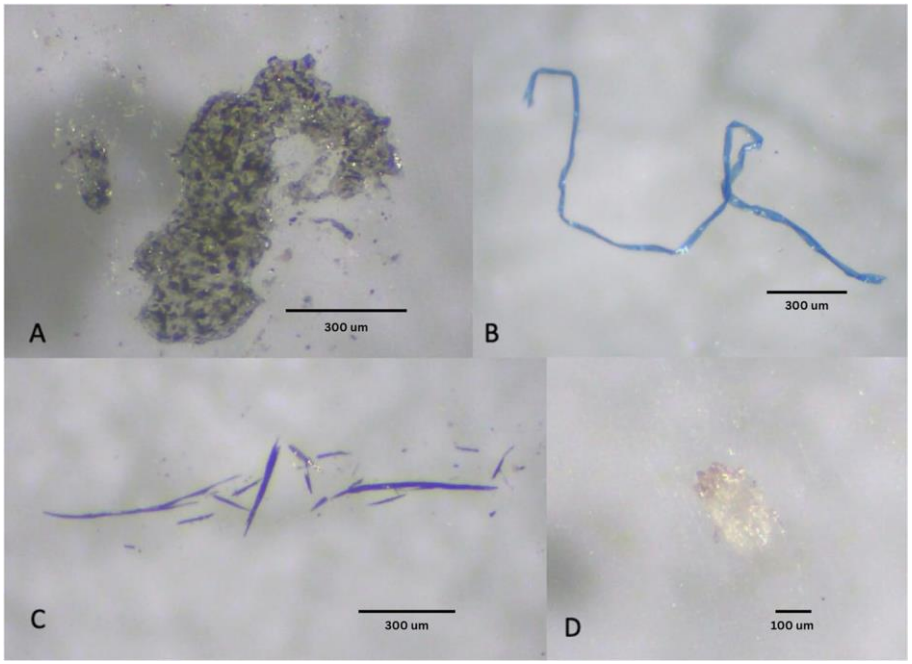

Figure 10. Examples of microplastics found in air in Metro Manila. From Romarate et al. (2023).

3.8 Singapore

Even though few studies were carried out in Singapore, their focus is widespread: a plant species, water, sand, seafood and sediment were each part of at least one article (Curren and Leong, 2019; Curren et al., 2020; Curren and Leong, 2023). Wheat, *Triticum æstivum*, was used in an experimental study to understand how MPs from polyethylene bottle caps affect the grain crop (Pflugmacher et al., 2021). Those were collected in two very different cities: Lahti in Finland and in Singapore. MPs derived from Lahti bottle caps exhibited more severe effects than Singapore. The authors explained this finding with the difference in climate between both regions; MPs from warmer regions would have less toxic chemicals adsorbed as warm temperatures induce the leaching of those chemicals. The wheat exposed to "cleaner" MPs from Singapore would then be less affected than the one exposed to MPs from Finland (Pflugmacher et al., 2021).

Similarly to other countries, several seafood species were investigated. In this case the focus was put on shrimps (Curren et al., 2020). Shrimps, like small fish, are very interesting to study as they are consumed by many organisms, such as humans, with or without the gut, and therefore play a vital role in the trophic transfer of MPs (Curren et al., 2020). The study was performed on three shrimp species (the Pacific white leg shrimp *Litopenaeus vannamei*, the Argentine red shrimp *Pleoticus muelleri* and the Indian white shrimp *Fenneropenaeus indicus*) purchased in supermarkets in Singapore, but only two species were imported from other countries of the ASEAN region: the Pacific white leg shrimp and the Indian white shrimp. The authors found large variations in MP concentrations, ranging from 13 to 7050 items per gram (wet weight). Figure 11 details those results into the different shapes of MPs in each species separately. This indicates that shrimps constitute a route of human exposure to MPs through seafood. The extent of this route for exposure is still to be determined as the intake of MPs by citizens of Singapore through other seafood is currently unknown.

Species	Location	Number of fibers /g w.w.	Number of fragments /g w.w	Number of film /g w.w.	Number of spheres /g w.w.
L. vannamei	Malaysia	1.20 ± 1.06	1.60 ± 1.72	205 ± 37.9	1.31 ± 0.275
	Ecuador	$8.66 \times 10^{-3} \pm 6.77 \times 10^{-4}$	$0.861 \pm 7.41 \times 10^{-2}$	25.3 ± 1.59	$8.93 \times 10^{-3} \pm 5.18 \times 10^{-4}$
P. muelleri	Argentina, Southwest Atlantic, FAO 41	468 ± 104	4930 ± 1110	3190 ± 643	32800 ± 793
F. indicus	Indonesia, Eastern Indian ocean, FAO 57	1100 ± 51.5	4990 ± 334	8950 ± 515	21500 ± 805

Figure 11. Abundances of several plastic shapes in the three species of shrimps investigated. From Curren et al. (2020).

3.9 Thailand

With around 60 articles retrieved from our systematic search, Thailand is one of the most studied countries regarding MP pollution. Sediment, water and biota have almost equally been investigated, and so were the marine and freshwater environments of Thailand. Comparing to other countries, more studies focused on urban environments and data are available for urban canals, tap water, stormwater runoffs, wastewater and sludge from wastewater treatment plant (Chanpiwat and Damrongsiri, 2021), even though each of these matrices were the topic of very few studies globally in Thailand. Almost one third of those studies focused on edible species (Goh et al., 2021; Pradit et al., 2021), including fish, shrimps and mollusks. Among those, Ta et al. (2022) collected blood cockles (*Tegillarca granosa*) and green mussels (*Perna viridis*) from aquaculture farms and markets in the central region of Thailand. The number of MPs did not differ from farmed cockles and wild cockles purchased in markets, by contrast with the green mussels from markets which showed a significant higher contamination in MPs than farmed mussels. The authors hypothesized that the higher contamination of commercial bivalves compared to farmed bivalves was perhaps due to the packaging and transportation of those commercial bivalves (Ta et al., 2022), although it could be due to different exposures at the collection sites.

There are only four studies in ASEAN having investigated MP contamination in tap or drinking water (Chanpiwat and Damrongsiri, 2021; Luqman et al., 2021; Kasim et al., 2023; Radityaningrum et al., 2023), one of them focusing on Bangkok tap water (Chanpiwat and Damrongsiri, 2021), the others were performed in Indonesia. Chanpiwat and Damrongsiri (2021) studied the efficiency of MP removal by the water supply systems by collecting freshwater from two sites in Bangkok before treatment, and by collecting treated water from the same sites, for human consumption. At both sites, the average concentrations of MPs do not differ between freshwater and tap water (Figure 12). In addition, the MPs' characteristics were similar before and after treatment, fragments being more abundant than fibers, and polyethylene and polyester being the most abundant polymers (Chanpiwat and Damrongsiri, 2021). Given the occurrence of MPs larger than 100 µm, the authors suggested the treatment system could contaminate water. Besides, their study reported low MP removal efficiencies by the water supply systems, raising concern about tap water as a source of MPs to the inhabitants of Thailand and recommended to monitor on the long-term MP contamination in fresh- and treated water (Chanpiwat and Damrongsiri, 2021).

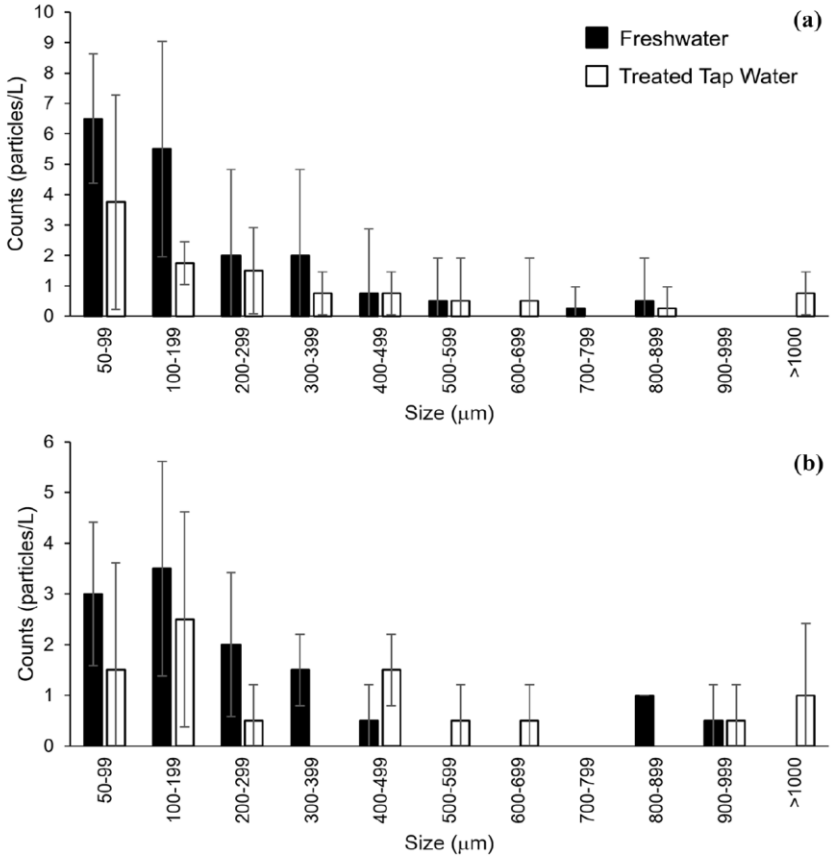

Figure 12. Abundances of microplastics per size category in treated and freshwater from the eastern (a) and the western (b) water supply treatment system. From Chanpiwat and Damrongsiri (2021).

Beach sediments were studied a couple of times in Thailand so far, the most recent one sampled four different beaches at two different seasons (rainy and dry seasons) in the eastern Gulf of Thailand, two of them are in a conservation area and therefore undisturbed, while the two others are open to tourism (Jualaong et al., 2021) (Figure 13). Globally, MP abundances ranged between 0 and 1698 pieces per square meter, and between 0 and 33 pieces per kilo (dry weight). MP contamination was significantly higher during the dry season than during the rainy one. Unexpectedly, both undisturbed beached showed the highest abundance of MPs during the dry season and rainy season (Jualaong et al., 2021). This finding supports the assumption that those MPs come from the marine environment instead of local land-based activities. The currents along those beaches could transport MPs from polluted areas, where sources could be tourism and fishing activities (Jualaong et al., 2021).

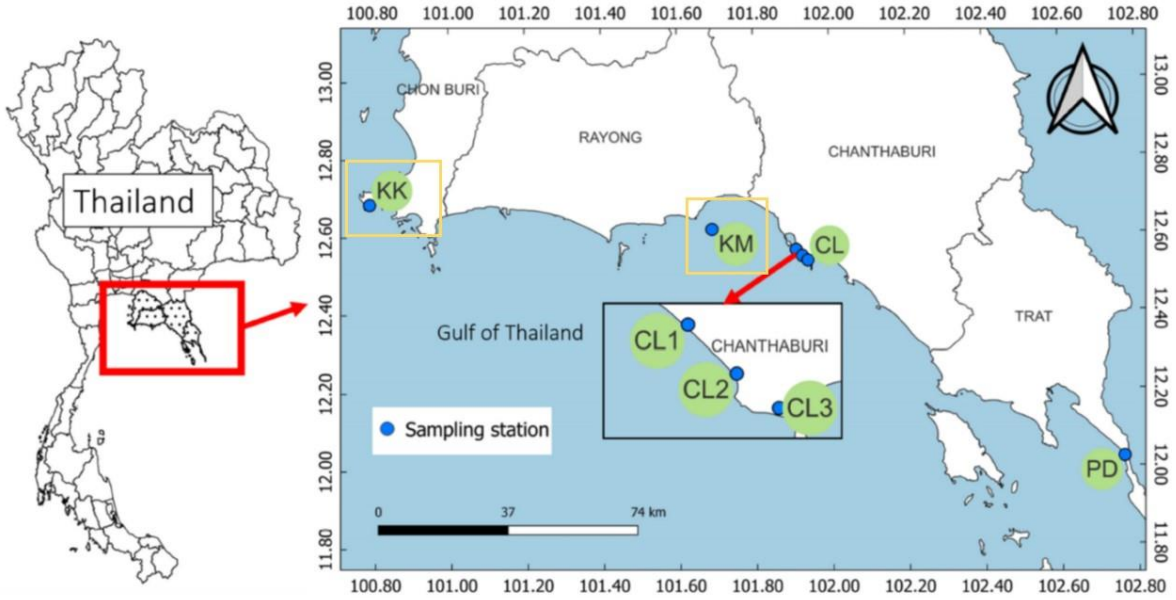

Figure 13. Map showing the location of sampled beaches along the eastern part of the Gulf of Thailand. Yellow rectangles show undisturbed beaches within a conservation area. Modified from Jualaong et al. 2023).

3.10 Viet Nam

Viet Nam was investigated quite broadly, and similarly to Thailand, several ecosystems were sampled: wetlands, estuarine, marine and freshwater, and sludge, biota, water, wastewater, soil, sediment and dust were collected for microplastic research purposes (Table S1).

A study aimed at quantifying MPs from road dust from several countries including Viet Nam. This is the only study to have focused on road dust in ASEAN (Yukioka et al., 2020), even though another one touched upon the roads and car tires as potential sources of MPs (Xue et al., 2023). Yukioka et al. (2020) collected road dust samples in three countries; Japan, Viet Nam and Nepal. They reported the highest average abundance in Da Nang, Viet Nam (2.0 ± 1.6 pieces/m^2 (n=12) in Japan, 19.7 ± 13.7 pieces/m^2 (n=12) in Da Nang, and 12.5 ± 10.1 pieces/m^2 (n=13) in Kathmandu). They also reported the smallest average size of MPs (605 µm) compared to the two other sites. The authors classified several polymers under the "Rubber-MPs" category and several others under the "Container/packaging-MPs" (Figure 14). The latter comprises polymers often used in packaging and bags, such as polyethylene and polypropylene, while the former includes styrene/butadiene rubber (SBR) and ethylene/propylene/diene rubber (EPDM), among others. The average abundance of "rubber-MPs" was the highest in Da Nang. The authors concluded that abundances were higher in Da Nang due to the proximity of dumping sites and shops, and therefore, indirectly due to poor waste management (Yukioka et al., 2020).

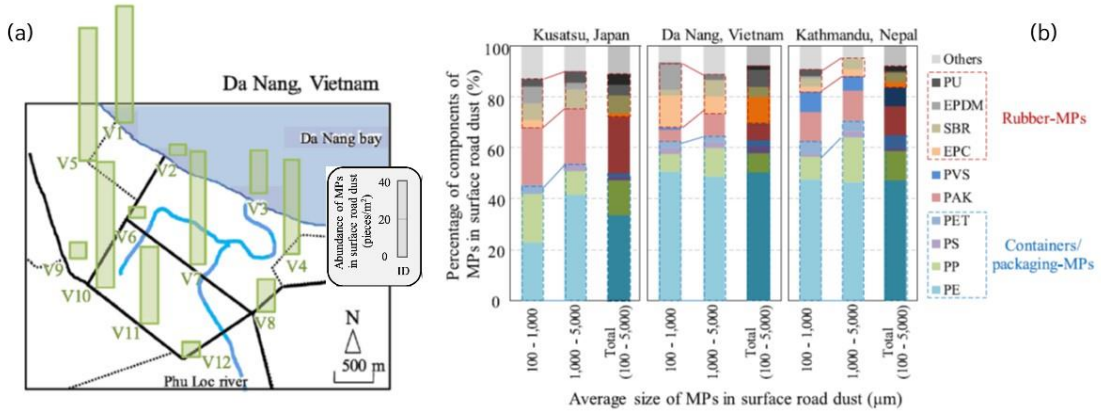

Figure 14. The abundance of MPs (100 μm-5 mm) in surface road dust in Da Nang, Viet Nam (n = 12). Composition of polymer types of MPs (100 μm-5 mm) in surface road dust in Kusatsu, Da Nang, and Kathmandu. Polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), polyacrylate (PAK), Polyvinyl stearate (PVS), ethylene/propylene copolymer (EPC), styrene/butadiene rubber (SBR), ethylene/propylene/diene rubber (EPDM), and polyurethane (PU). From Yukioka et al. 2020.

4 Main sources of microplastics

To understand the sources and the inputs of MPs in the environment, they are classified into either primary or secondary microplastics. Primary MPs are "particles that have been manufactured to a particular size to carry out a range of specific functions" (UNEP, 2016). Secondary MPs are formed from the fragmentation of larger items through a combination of physical, chemical and biological processes. For example, mechanical abrasion during the washing of synthetic clothing and other textiles causes the breakdown and release of plastic fibers to wastewater (UNEP, 2016). This classification is useful as distinction to specify possible sources and arrange mitigation steps in reducing microplastics pollution (Ali et al., 2021).

Globally, almost all the MPs ending in the marine environment come from land-based sources (UNEP, 2016) (Figure 15). The pathways of those MPs are through water streams and wind transfer (Boucher and Friot, 2017). In this baseline study we could identify multiple sources of microplastics to the environment of the ASEAN region, most of them being the same than anywhere else in the world. We identified several major sources of microplastics in the ASEAN environment: solid waste, fishing activities, tourism, tires or roads and wastewater, among others (Table 1). Solid waste includes household, food, drink and hygiene waste. Almost all of those major sources are actually sources of secondary MPs. This is not surprising since the ASEAN region has among the highest concentrations of plastic litter globally (Jambeck et al., 2015) and some ASEAN countries have a high percentage of mismanaged plastic waste (Jambeck et al., 2015; Omeyer et al., 2022; Sin et al., 2023). Beside the degradation and fragmentation of mismanaged plastic litter, other secondary MPs such as textile fibers enter the ASEAN environment through wastewater, for example.

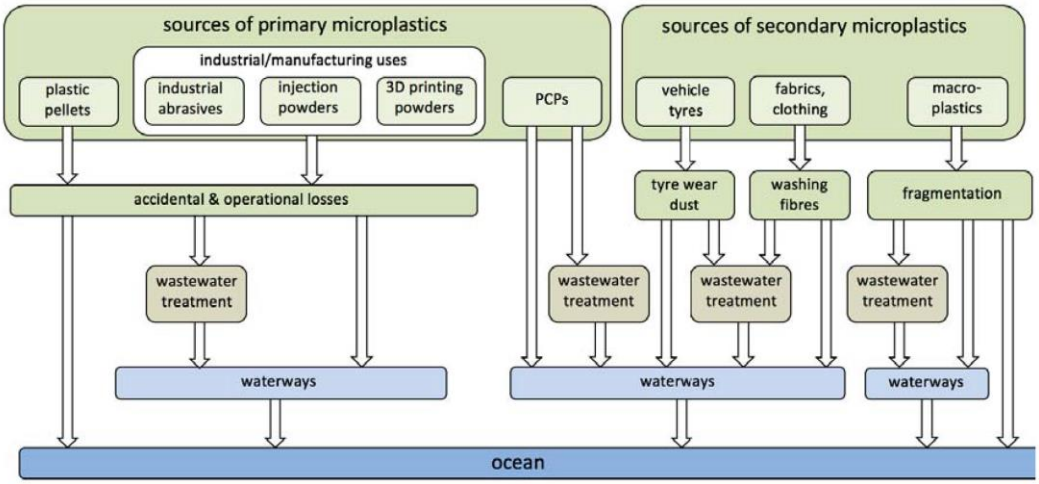

Figure 15. Land-based sources of microplastics and pathways to the ocean (original by P.J. Kershaw). From UNEP 2016.

Table 1. Overview of sources of microplastics according to a selection of studies. "Freshwater" gathers all types of non-saline water such as riverine, runoff, urban, discharge from industries, etc. In bold, the two most cited sources of microplastics.

Studies	Matrices						
	Freshwater	*Marine water*	*Sediment*	*Beach sediment*	*Biota*	*Air*	*Human*
Curren et al. (2021)	-	Settlements Harbours	**Solid waste** Aquaculture Tourism **Fishing** Wastewater	Tourism **Fishing** Aquaculture	**Fishing** **Solid waste** Aquaculture	-	-
Chen et al. (2021)	Wastewater Agriculture **Solid waste**	-	-	-	-	-	-
Mulyasari et al. (2023)	-	-	-	-	-	Urban dust Tyres Textiles	-
Ali et al. (2021)	Water runoff Wastewater **Solid waste** **Fishing**	Rivers **Solid waste** Agricultural Wastewater	-	-	-	-	-
Vriend et al. (2021)	-	Rivers	-	-	-	-	-
Nguyen et al. (2023)	Wastewater **Solid waste**	-	-	-	-	-	-
Choong et al. (2021)	**Solid waste**	**Solid waste**	-	-	-	-	-
Sulaiman et al. (2023)	-	Wastewater Industry Agriculture Urban areas **Fishing** Tourism	-	-	-	-	-
Abd Rahim et al. (2023)	-	**Solid waste** **Fishing**	-	-	**Fishing**	-	-

		Maritime activities					
Lestari and Trihadiningrum (2019)	-	**Fishing** Leisure activities Settlements	-	-	-	-	-
Zhu et al. (2023)	-	**Solid waste** (packing materials) Textiles **Fishing** Aquaculture	-	-	-	-	-
Lee et al. (2022)	-	-	-	-	**Solid waste**	-	-
Zaki et al. (2021)	-	-	-	-	Textiles Tyres **Fishing**	-	-
Chen et al. (2022)	Culverts (roads)	-	-	-	-	-	-
Matsushita et al. (2022)	-	Rivers	-	Rivers	-	-	-
Xue et al. (2023)	Tyres **Solid waste** (construction, transport & packaging)	-	-	-	-	-	-
Suzuki et al. (2022)	Recycling facilities	-	-	-	-	-	-
Wibowo et al. (2021)	-	-	-	-	-	-	Food (tempeh, salt) Hygiene products (toothpaste)
Kasim et al. (2023)							Drinking water

4.1 Freshwater

Here we refer to freshwater as "non-saline" water such as riverine, runoff, urban, wastewater, etc., with riverine waters dominating the studied ecosystems. Several reviews and case studies have made the hypothesis that solid waste was one of the main contributors to microplastic pollution in the freshwater ecosystems of ASEAN globally (Chen et al., 2021) or in specific regions (Ali et al., 2021; Choong et al., 2021; Nguyen et al., 2023; Xue et al., 2023). Plastic loads in rivers, both micro- and macroplastic, are positively correlated to the mismanaged plastic waste in the river catchments (Schmidt et al., 2017), supporting the assumptions made hereabove.

Rivers play two roles in MPs' fate: a transport medium towards the oceans and an accumulation zone. At first, it was thought that rivers were simply conveying plastic litter, including microplastics, towards estuaries and oceans but an increasing number of studies suggests that plastic does accumulate in water streams as well (Schmidt et al., 2017). In freshwater, both primary and secondary MPs can be found, the latter being more important. An overview of sources and pathways of MPs in freshwater is shown in Figure 16.

Other studies mentioned MP contamination in wastewater, constituting then a major source of MPs to rivers (Ali et al., 2021; Chen et al., 2021; Nguyen et al., 2023). Wastewater is indeed contaminated in both primary and secondary MPs. The primary MPs in rivers are mostly constituted by microbeads from personal care products (toothpaste, facial scrubs) and were evidenced in Malaysia (Praveena et al., 2018; Suardy et al., 2020). Those products are mostly used in houses and end up in household wastewater. In addition to microbeads, wastewater also contains loads of textile fibers originating from the tear-and-wear of clothes during washing cycles or directly from textile factories (Kataoka et al., 2019; Ali et al., 2021; Curren et al., 2021). Removal efficiencies of wastewater treatment plants (WWTPs) in Malaysia ranged between 31 and 70%, leading to a relatively high release of MPs into water streams compared to studies from other regions of the world (Chen et al., 2022). The MPs retained by WWTPs end up in sludge. The occurrence of MPs in sludge is of high concern in ASEAN as in many countries used processed sewage sludge as a fertilizer for agriculture. This sludge could therefore become a source of MPs to the terrestrial environment (Nizzetto et al., 2016).

Plastic litter also undergoes degradation in freshwater systems resulting in an increasing number of secondary MPs over time. Depending on the seasons, precipitations and other factors, those MPs are then transported to the marine environment. While true for every part of the worlds, this problem is exacerbated in ASEAN due to the rapid development and expansion of many cities, combined with the limited capacity of drainage systems (Chen et al., 2021).

Rubber particles coming from car tires were also mentioned as a contributor to MP pollution in Thailand by one study on freshwater (Xue et al., 2023). That study focused on urban stormwater runoff north of Bangkok. One sample site seemed much more contaminated in black rubber fragments than the others: the transportation site. That study shows local sources of tire particles in Thailand but the extent of such source could be much broader. Indeed, in other parts of the world, car tires, together with the tear and wear of roads and other tires, are one of the major sources of MPs in the aquatic environments (Boucher and Friot, 2017; Kole et al., 2017). A percentage of those rubber particles pass the WWTP and are allowed to reach the aquatic environment (Magnusson, 2014; Leslie et al., 2017). The release of tire rubber particles in ASEAN is yet to be evaluated, as is the efficiency of the WWTPs.

In conclusion, the main sources of MPs to freshwater -and in particular to waste- and riverine water- are secondary MPs from mismanaged plastic waste and textile. Tire particles could be a major contributor as well, but this has yet to be studied.

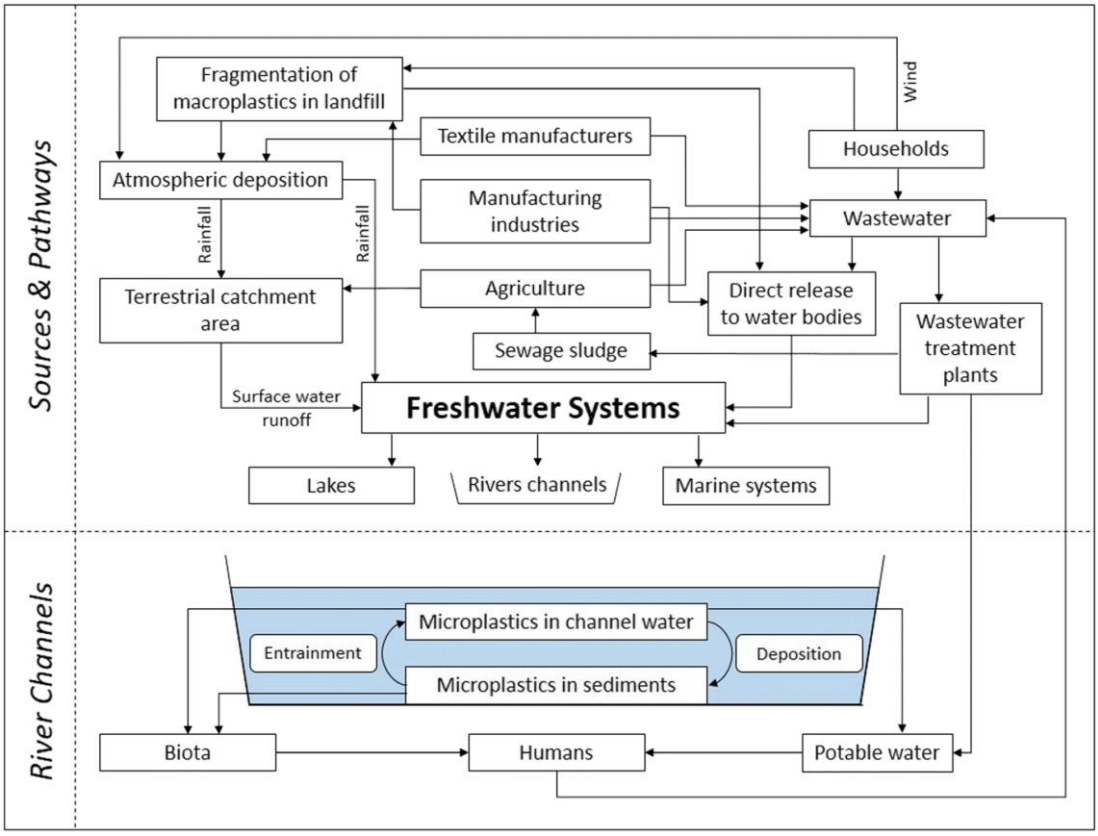

Figure 16. Pathways of microplastics into freshwater systems and conveyance to marine systems. The lower part of the figure shows more details of dynamics and pathways within river channels. From Chen et al. 2021.

4.2 Marine water

As mentioned earlier, rivers play two major roles in the transport and fate of MPs in the environment, one being to convey plastic waste and microplastics to the seas and oceans. Rivers have indeed been identified as major pathways for land-based plastic litter -both micro- and macrolitter- towards the marine environment of the ASEAN region by both modeling and *in situ* studies (Ali et al., 2021; Matsushita et al., 2022) (Table 1). About 70-80% of plastic debris found in marine are transported to the sea via rivers (Horton et al. 2017). Two previous studies estimated global estimates of around 1 to 2 million tons of plastic roughly, with a dominant contribution from rivers of the Asian continent (Figure 17 and Figure 18) (Lebreton et al., 2017). The study from Meijer et al. (2021), however, provided a new ranking of top contributing rivers, where the Pasig in the Philippines is now the most polluting river (Figure 18). This new ranking gathers 14 rivers in ASEAN within the top 20 of the most polluting rivers (Meijer et al., 2021).

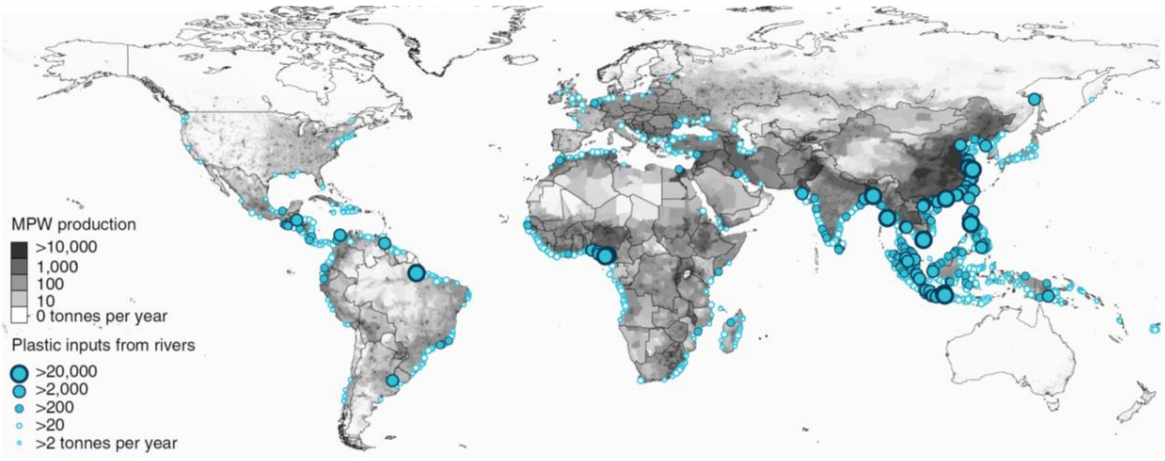

Figure 17. Mass of river plastic flowing into oceans in tons per year. MPW: Mismanaged plastic waste. From Lebreton et al. 2017.

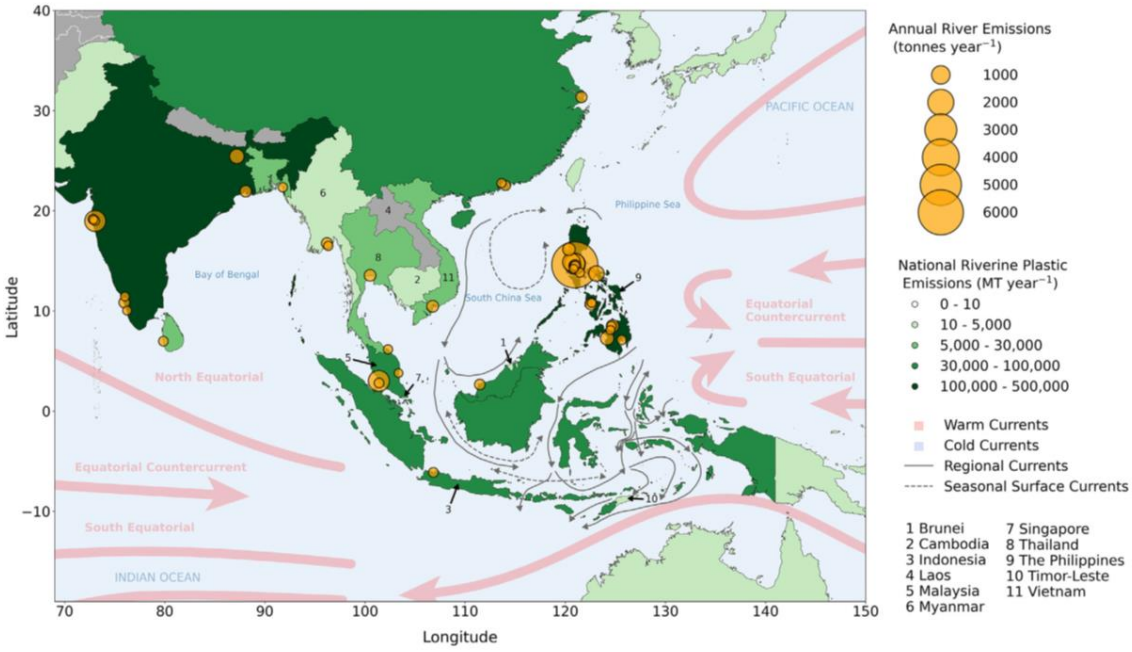

Figure 18. Map of Southeast Asia showing the principal ocean currents of the region and plastic emissions per country and river. Data on plastic emissions from Meijer et al. (2021). From Omeyer et al. 2022.

Unsurprisingly, sources of MPs in rivers are therefore also sources of MPs into the marine environment, including waters. These encompass solid waste and wastewater, for example (Ali et al., 2021; Choong et al., 2021; Abd Rahim et al., 2023). MP pollution was proven to be higher closer to large settlements with high levels of anthropogenic activities (reviewed in Lestari and Trihadiningrum, 2019; and in Curren et al.,

2021). Compared to freshwater, other activities seem to play a larger role in contributing to MP pollution, such as tourism and leisure activities (Lestari and Trihadiningrum, 2019; Sulaiman et al., 2023), probably because they are more common along the coastline rather than inland. While freshwaters are mostly polluted by land-based sources, marine waters are polluted by both land-based and sea-based sources. Fishing activities and aquaculture are probably the most important sea-based sources of plastic pollution worldwide (FAO, 2020; UNEP, 2021). While the occurrence of lost or discarded fishing gear is unknown in ASEAN, several studies have concluded that fishing activities and aquaculture were a source of secondary microplastics in marine waters (Lestari and Trihadiningrum, 2019; Abd Rahim et al., 2023; Sulaiman et al., 2023).

4.3 Sediment

This section will include both benthic and beach sediment.

There are far less studies reviewing MP sources in sediment than in fresh- or seawater (Table 1). A couple of articles listed the potential sources (Curren et al., 2021; Matsushita et al., 2022), with one modeling study highlighting the role of rivers as sources of non-buoyant MPs to the surrounding deep areas and basins (Matsushita et al., 2022). Those potential sources are quite numerous. This is expected as the sea bottom is a sink for plastics where 94% of all marine plastic litter is estimated to have settled (Eunomia, 2016), with many different sources from both sea- and land-based and from both local and long-range sources. However local sources are assumed to constitute the most important source in Thailand according to a study by Jualaong et al. (2021). MPs found in beach sediment came from textiles (fibers) and plastic bags (sheets) based on the shapes of the extracted MPs. Based on the polymer composition, the same study confirmed daily products such as from the food sector as a source, but also suggested fishing equipment as an additional source due to the high occurrence of polyamide fibers (Jualaong et al., 2021). This highlights the importance of a complete characterization of the microplastics extracted from environmental matrices.

4.4 Biota

Studies on microplastic ingestion by biota are increasing in the ASEAN region but identification of sources are scarce (Table 1). An organism will ingest plastic if it is exposed to it and therefore, that exposure will depend on its living habitat, among other factors. If a benthic organism lives underneath a fishing area, one might expect this organism to ingest a high percentage of thread-like particles made of polyamide or polyethylene from fishing nets for example. However, important factors such as the feeding ecology of the organism, the size or the color of the MP might influence the behavior and decision to eat or not. For example, in a study by Abd Rahim et al. (2023), the feeding ecology was hypothesized to be the driving factor for MP ingestion. In this study, several crab species were investigated for MPs in their stomach. The predatory species was found to have the highest number of ingested MPs while the detritivore species had the lowest (Abd Rahim et al., 2023). A study investigating MP ingestion in the blue panchax fish (*Aplocheilus* sp.) in Indonesia observed a high diversity in shapes and sizes in the ingested MPs (Cordova et al., 2020). The authors mentioned several possible sources such as larger plastic debris including plastic bags, containers, food wrappers, etc., but also clothing material, ropes and fishing lines, fish storage box,

single-use Styrofoam and handicrafts classified under tourism, fishing and household activities. Those sources are potentially the most important in ASEAN and it reflects in the MPs ingested by biota. Understanding the sources of those ingested MPs requires to identify all the sources to a given area and to include many other parameters related to the organism into consideration such as the feeding ecology, habitat and morphology, but also the characteristics of the MPs such as their size, shape and color.

4.5 Direct human exposure

This section will focus on the MP sources of matrices directly in contact, inhaled or ingested by humans such as air and food. Few studies have investigated human exposure to MP in ASEAN and only a few mentioned the potential sources discussed hereafter (Wibowo et al., 2021; Kasim et al., 2023; Sulaiman et al., 2023). MPs in air is also a topic that is scarcely studied in ASEAN but is gaining attention in Europe since the last decade. A review study stated that urban dust, erosion of vehicle tire rubber and synthetic fabric fibers were the main sources of MPs in air globally (Mulyasari et al., 2023), but possible specificities to the ASEAN region are yet to be estimated. The impacts of MP inhalation or ingestion on humans are still poorly unknown even though negative impacts on the cellular levels were reported (Hwang et al., 2019; Goodman et al., 2021). In order to understand and measure those possible impacts, the extent of the exposure through air, food, drinking water and daily products must be evaluated, quantified and characterized.

MP occurrence and concentration in seafood have been studied in ASEAN, mostly in fish and bivalves, and it is known that many edible species are contaminated with MPs (e.g. Rochman et al., 2015; Karbalaei et al., 2019; Karbalaei et al., 2020; Foo et al., 2022 and previous sections). Therefore, the occurrence of MPs in the human body is expected. This was confirmed by Wibowo et al. (2021) who analyzed human stool from 11 Indonesians from a farming community (Figure 19). They also collected possible sources of those MPs, namely drinking water, staple foods, table salt and toothpaste. MPs were detected in stool and one type of staple food; tempeh (Wibowo et al., 2021). This study showed the presence in MPs in both the human body and food consumed in Indonesia.

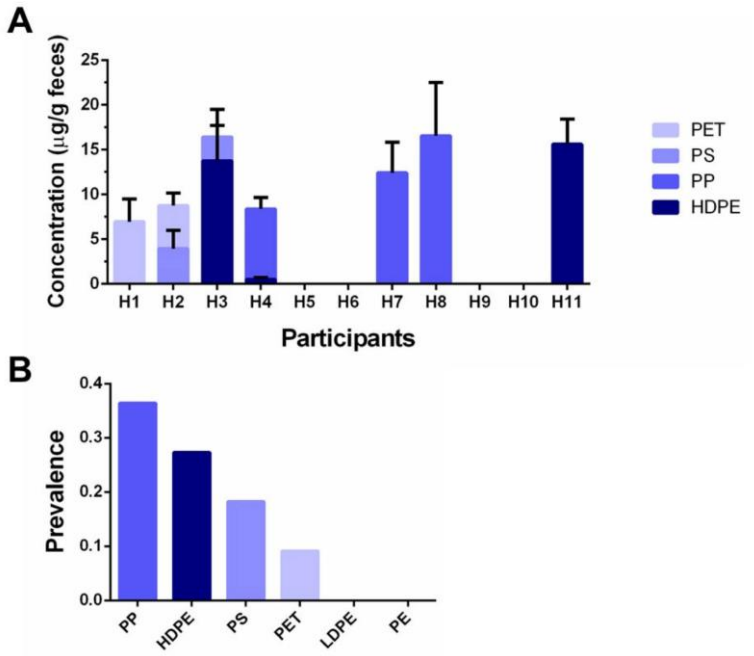

*Figure 19. (**A**) Microplastic concentration and (**B**) prevalence in stool samples collected from a farming community in Pacet, Mojokerto, Indonesia. From Wibowo et al. 2021.*

Drinking water was also investigated, also in Indonesia and subsequent average intake rate was calculated (Kasim et al., 2023). Only fibers, of different colors, were reported in drinking water. The median intake rate provided in that study is 210 mg/kg/day with a frequency of exposure of 350 days. Kasim et al. (2023) showed that humans, at least in Makassar City, Indonesia, are almost daily exposed to MPs through drinking water and almost on a daily basis.

Even though few studies focused on direct exposure to humans in ASEAN, there is evidence that the populations are exposed to MPs. Seafood is logically the first potential direct source of MP ingestion in ASEAN, but also around the world, that comes to mind, likely due to the awareness about marine plastic pollution. An experimental study on edible bivalves showed that all the individuals (n=360) exposed had ingested MPs after 7 days of exposure (Bonifacio et al., 2022). Another study, from Viet Nam, showed microplastic ingestion and a high bioconcentration factor of oysters exposed to the lower MP concentration (10 MPs/L) (Dao et al., 2023). However, other types of food and drinks, such as table salt (e.g. Karami et al., 2017), beer (e.g. Liebezeit and Liebezeit, 2014), honey (e.g. Diaz-Basantes et al., 2020), milk (e.g. Diaz-Basantes et al., 2020) and bottled water (e.g. Mason et al., 2018) are reported to be contaminated in MPs. Food and drinks in the ASEAN region are also very likely contaminated, and further research to evaluate and characterize this contamination is needed. Sizes, polymers and sources must be investigated to get a better picture of this contamination and take preventive measures to limit it.

5 Projects on microplastic pollution

This section provides an overview of past and ongoing projects, or project components, focusing -at least partly- on microplastic pollution in ASEAN. Table 2 provides a non-exhaustive list with corresponding details such as duration and project partners and is followed by a short summary for each of those projects.

Numerous projects across the ASEAN region are committed to investigating the extent of microplastic pollution. Some countries like Viet Nam and Indonesia have higher research activity on MPs compared to others, such as Malaysia and Brunei. These projects vary in scope and scale, with several larger initiatives including multiple countries, such as ASEANO, PoDIWM-2 and the Mekong River Commission. One example is the Mekong River commission, where four countries along the Mekong River have established monitoring programs, with sampling and analysis of microplastic in water and biota from the river, every five years. Even though there are some collaborative efforts across borders, systematic and large coordinated projects for microplastic in ASEAN are rarely conducted.

Projects within the ASEAN exhibit different aims and research focuses. For instance, PoDIWM-2 specifically targets MP pollution in wastewater management in Viet Nam, while 3SPI2C takes a multidisciplinary approach to explore MP sources, sinks, and solutions. Additionally, capacity-building projects like COMPOSE incorporate environmental sampling and analysis intro their initiatives, contributing to gathering data. ECOTON stands out for its incorporation of citizen science in microplastic sampling efforts. Similarly, JEAI PLASTIC also assesses ecotoxicological risks of microplastics to aquatic organisms and humans. There are also collaborations across continents, such as the ASEANO projects with collaborators from Norway, or the University of Hull which has a research project in Viet Nam.

While projects like PTTEP and COMPOSE conduct hands-on sampling activities, others, such as IGES Microplastic Capacity Building work, Viet Nam and ASEAN), are assessing the current knowledge and research activity. The IGES projects investigate knowledge gaps and identifies training and facility requirements through online surveys. There is a broad variety of focus and activity within the microplastic projects found in this study.

Table 2. Overview of existing projects on microplastic pollution in the ASEAN region.

Title	Funding source	Year(s)	Country	Partners	Website
3SIP2C	Natural Environment Research Council - NERC	2021 - 2025	Viet Nam	• Heriot-Watt University (Lead Research Organization) • Hanoi University (Collaboration, Project Partner) • Other partners	Homepage - 3SIP2C
ANSO-project	ANSO	2023 - 2025	Indonesia	• The Institute of Oceanology, Chinese Academy of Sciences (IOCAS) • BRIN (The Indonesian Research Center for Oceanography) • The University of the Philippines • The University of Papua New Guinea	ANSO Project
ASEANO	Norwegian Development Program to Combat Marine Litter and Microplastics	2019 - 2022	ASEAN	• NIVA (The Norwegian Institute for Water Research) • The Centre for Southeast Asian Studies Indonesia (CSEAS) • The ASEAN Secretariat	ASEANO
ASEANO 2	Norwegian Development Program to Combat Marine Litter and Microplastics	2023 – 2027	ASEAN	• NIVA (The Norwegian Institute for Water Research) • The Centre for Southeast Asian Studies Indonesia (CSEAS) • The ASEAN Secretariat	ASEANO 2
Assessment of plastic debris and of microplastics in different specimen (...) in selected aquatic	National Research Council of the Philippines		Philippines	Information is lacking	THE GROWING THREAT OF MICROPLASTICS AND PLASTICS - Home

environments in Mindanao and exploration of relative stress biomarkers					
COMPOSE	French Ministry of Europe and Foreign Affairs	2019 - 2021	Viet Nam	• French Embassy in Viet Nam • French National Research Institute for Sustainable Development (IRD)	COMPOSE project
ECOTON	-	-	Indonesia	• ECOTON • Aliansi Zero Waste Indonesia • #break free from plastic	ECOTON
JEAI PLASTIC	-	2019 - 2021	Viet Nam	• Ho Chi Minh University of Technology • French National Research Institute for Sustainable Development (IRD)	JEAI PLASTIC
MyMip			Malaysia	• The Malaysian Microplastics Network	MyMiP
National Geographic River of Plastic project	The National Geographic Society	-	Viet Nam Cambodia Laos	• University of Hull • Southern Institute of Water Resource Research (SIWRR), Viet Nam • Newcastle University • Pannasastra University, Cambodia	River of Plastic (hull.ac.uk)
Paradise lost: Microplastic pollution on a remote coral island in the South China Sea	The National Geographic Society	2020 - 2022	Viet Nam	• University of Hull	University of Hull researcher uncovering extent of plastic pollution in Viet Nam
Pirika			Thailand Viet Nam Cambodia Laos	• The Nippon Foundation • Environmental Restoration and Conservation Agency	Pirika
PoDIWM-2	Japan–ASEAN Integration Fund	2022 - 2023	ASEAN countries	• IGES (Institute for Global Environmental Strategies)	PoDIWM-2

				• NWRB (National Water Resources Board) • Asean • ASEAN-Japan • JAIF (Japan-ASEAN Cooperation) • From the People of Japan	
PTTP	-	2020 - 2021	Thailand	• PTTEP • The Kasetsart University	PTTEP Ocean Data Platform
SEAFDEC-led project	Japan-ASEAN Integration Fund	2021 – 2022 2022 - 2023	ASEAN Japan	• Southeast Asian Fisheries Development Center (SEAFDEC) • Japan-ASEAN Integration Fund (JAIF)	SEAFDEC – Southeast Asian Fisheries Development Center
-	-	-	Thailand Viet Nam Cambodia Laos	• Mekong River Commission	Protocol for Riverine Macroplastic Monitoring

3SIP2C – Sources, Sinks, and Solutions for the Impact of Plastics on Coastal Communities in Viet Nam

3SPI2C is a multidisciplinary project in Viet Nam carried out by researchers in the UK and Viet Nam. The project has 5 work areas: Pathways, business, health, policy and community. The main objectives in "pathways" are to investigate the movement of microplastics in the aquatic environment in The Red River, The Mekong River and Around Cat Ba Island. Water, sediment and aquatic organism-samples will be taken and analyzed for physical and biochemical properties and contaminants, such as POPs, heavy metals and pathogens. A model will be developed on how plastics travel along the river, into the marine environment, and eventually where they are likely to accumulate along the coast or be transported elsewhere. "Business" will investigate economic impacts of plastic waste on coastal communities and key industries. "Health" will examine how pathogens and contaminants affect the health of aquatic ecosystems; how contaminated aquatic products are with microplastics. "Policy" will involve examination of how to reduce plastic production, reduce everyday use of plastic, especially single-use plastics, and how to enhance the reuse and recycling of multi-use plastics. Through "Community" the project aims to link all the research activity together and work with coastal communities, businesses, education, and public sectors to better understand how plastic pollution affects them and how plastic plays an important role in people's lives.

ANSO-project - Assessment and response to the impact of marine microplastic pollution on ecological security in the Coral Triangle

ANSO is short for "The Alliance of National and International Science Organizations for the Belt and Road Regions" and has an ongoing project named "Assessment and response to the impact of marine microplastic pollution on ecological security in the Coral Triangle", a project in the Coral Triangle. The Institute of Oceanology, Chinese Academy of Sciences (IOCAS), leads the projects in collaboration with The Indonesian Research Centre for Oceanography (BRIN), The University of the Philippines, and the University of Papua New Guinea. This is a collaborative research project with a focus on investigating the status on MP pollution in the Coral Triangle and its impact on marine biology, ecosystems, and development of technology of MPs degradation using microorganisms. The project will conduct field surveys and joint cruises collecting MPs samples. The project will establish a MP database and data-sharing platform.

ASEANO and ASEANO2

The ASEAN-Norwegian cooperation project on regional capacity building for reducing plastic pollution (ASEANO) was a regional capacity building project led by NIVA and the Center for Southeast Asian Studies Indonesia (CSEAS), in collaboration with Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) and the ASEAN secretariat, under the purview of the endorsing ASEAN sectoral body ASEAN Working Group on Coastal and Marine Environment (AWGCME). The project was funded by the Norwegian Development Program to Combat Marine Litter and Microplastics launched by the Norwegian government in 2018, for the period 2019-2022.

ASEANO activities targeted three countries in ASEAN: Indonesia, the Philippines and Viet Nam. The project strengthened the collaboration in the ASEAN region to reduce plastic pollution, disseminate and share knowledge between countries and contribute to meeting sound reduction targets both nationally and regionally. Effective measures in these countries have a great potential for reducing the plastic pollution input not only on a local and regional scale, but also globally. The ASEANO project also aimed at building capacity, and at raising awareness to tackle plastic pollution from key sources in the ASEAN region by developing a strong network and close interactions with industries and businesses, governmental bodies and other stakeholders, other projects as well as NGOs. Core objectives included illuminating driving forces of plastic pollution and its implications for economy, development, environment, and human well-being, with focus on local municipality/city level sustainability.

The ongoing project ASEANO2 (2023 – 2027) is building on the established previous project ASEANO. The Norwegian Institute for Water Research (NIVA) and the Centre for Southeast Asian Studies Indonesia (CSEAS) lead the ongoing project, in collaboration with the ASEAN Secretariat. Similarly to ASEANO, ASEANO2 aims to build and enhance capacity and knowledge to measure, evaluate and address plastic pollution from key terrestrial sources through improved understanding of sources, emissions, transport, and fate of particles. This project focuses on both macro- and microplastics, and mostly on Viet Nam and Cambodia.

Assessment of plastic debris and of microplastics in different specimen (fish, sediment, water, benthic organisms) in selected aquatic environments in Mindanao and exploration of relative stress biomarkers

This was a project funded by NRCP. This project sampled milkfish from Butuan and Nasipit Fish Cage (nrcp.dost.gov.ph), as well as clams from mangroves along Butuan Bay. Both fish and clams were found to be contaminated in microplastics.

COBSE-led initiatives –

The Coordinating Body on the Seas of East Asia (COBSEA) is a regional Seas program and is administered by the United Nations Environment Programme (UNEP) and the Secretariat is hosted by Thailand. COBSEA is a collaboration which includes nine countries, some of which are from the ASEAN region, such as Cambodia, Indonesia, Malaysia, the Philippines, Thailand, Singapore and Viet Nam. The aim of the collaboration is to address marine pollution, including microplastics. For example, together with partners, COBSEA has developed a manual for training of trainers on monitoring and assess marine plastic litter and microplastics. This training was held in Bali, Indonesia in 2019, organized by COBSEA together with the Global Partnership on Marine Litter (GPML) and the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), and co-hosted by the Regional Capacity Center on Clean Seas (RC3S) and the Ministry of Environment and Forestry of Indonesia. The training was based on guidelines developed by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP).

COMPOSE - Creating an Observatory for Measuring Plastic Occurrences in Society and Environment

COMPOSE were a capacity building project where they also investigated microplastic concentrations in urban lake environments of Hanoi, Northern Viet Nam. The project lasted between 2019 – 2021. Microplastic concentrations were sampled using a net with a mesh size of 80 µm (Figure 20), analyzing particles with a size range between 300 µm – 5 mm in Ho Tay Lake, Yen So Lake and Bay Mau Lake of Hanoi. The project was funded by the French Ministry of Europe and Foreign Affairs and implemented by the French Embassy in Viet Nam and French National Research Institute for Sustainable Development (IRD).

Figure 20. Picture of the microplastic sampling net used in the COMPOSE project in several lakes in Northern Viet Nam.

ECOTON - Ecological Observation and Wetlands Conservation

ECOTON is a foundation dedicated to combatting river pollution in Brantas River in East Java, Indonesia. The foundation has undertaken several initiatives, including campaigns, conducting educational activities, and engaging in research efforts. ECOTON focuses on both macro and microplastics, and one of their inventions is the MisticScan (Figure 21), a can for sampling microplastics from river water. The innovation has been integrated into community-based research and citizen science projects. They have also published several E-books and guidelines. Through volunteer communities formed by the project, microplastic pollution has been reported in several rivers, such as Brantas River, Bengawan Solo, Ciliwung, Citarum, and Ciujung with a range of 62-198 MPs/100L. Additionally, findings have shown contamination in fish from the Brantas River, Bengawan Solo River and Citarum River, with contamination ranging from 20 – 68 MPs/fish (Budiarti, 2022). They have also an app, "Beat the Microbead app", which can scan personal care and cosmetic products to get information about plastic ingredients.

Figure 21. The front page of a Guideline book introducing the "Misticscan" for identifying microplastic in Rivers in citizen science projects (Budiarti, 2022).

IGES Microplastic Capacity Building work (Viet Nam and ASEAN)

This study aims to assess the training and facility needs for microplastic research in Viet Nam (Kieu-Le et al., 2022). Knowledge on the topic was collected through online surveys concerning MP studies at universities, institutes and in private companies. Data was synthesized on analysis of microplastics in water/wastewater, sediment, biota, and sludge, availability of equipment, and human resources from different organizations. The study revealed that MP research in Viet Nam is not that widespread and mainly takes place in leading institutes and universities in large cities. A notable issue with the research is the lack of comparable data, due to the use of different protocols for sampling, digestion, observation, and chemical composition tests.

JEAI PLASTIC – Plastic in the Aquatic environment

JEAI PLASTIC was a collaboration between Ho Chi Minh University of Technology (HCMUT) and The French National Research Institute for Sustainable Development (IRD) within the project period 2019 - 2021. The

project focused on understanding sources, transport, ingestion by organisms and MP contamination. The aims with the project were to provide a holistic point of view of MP pollution at the river-ocean interface in Viet Nam and its consequences on aquatic organisms and human health risks. This entailed assessing contamination, fate, and transport of MPs in three Vietnamese river basins: Red River-Delta, Saigon Dongnai Rivers and Mekong Delta - by characterizing specific plastic emission activities, evaluate the risk of MPs to aquatic organisms and humans by conducting ecotoxicological exposure assessments. Additionally, they had a focus on adaptation of water treatment technologies to decrease MPs inputs to the rivers.

MRC-led initiatives

The *Protocol for Riverine Macroplastics Monitoring* was published at the end of November 2023 by The Mekong River Commission (MRC). The commission is an agreement on the Cooperation for the Sustainable Development of the Mekong River basin between the governments of Cambodia, Loas, Thailand and Viet Nam. The methodology consists of three monitoring protocols, two of which includes monitoring of riverine microplastics and microplastic in fish. Monitoring of both matrixes should be conducted every five years along the Mekong mainstream and at the river's major tributaries. Samples should be taken by relevant national research institutes or line ministries of the four member countries.

MyMiP - The Malaysian Microplastics Network

MyMiP is a multidisciplinary network for microplastic research joining academia, industry partners and policymakers across Malaysia. The aim with the project is to identify and quantify the distribution of microplastics and assess the potential environmental risks. The established network is a sub-project of the Global Research Translation Awards (GRTA) program and funded by the UK government's Global Challenges Research fund (GCRF) which was granted to the University of East Anglia. Through the ongoing work, a cheap and quick methodology has been developed to measure microplastics across different ecosystems, which has been shared on their YouTube-channel.

National Geographic River of Plastic project

This project is also led by the University of Hull, with several international partners involved: Southern Institute of Water Resource Research (SIWRR), Viet Nam, Newcastle University and Pannasastra University, Cambodia. The project studied the Mekong River and three surrounding countries: Viet Nam, Laos and Cambodia. The project aimed at applying a coupled physical and social approach to understand plastic waste transport throughout the Mekong River in Cambodia and Viet Nam to the South China Sea. This project was funded by the National Geographic Society as well.

Paradise lost: Microplastic pollution on a remote coral island in the South China Sea

This is a research project led by the PhD student Freija Mendrick, to uncover the impact of microplastic pollution on the coral reefs of the Con Dao islands in Viet Nam. The area is highly influenced by water flowing from the Mekong River, one of the most polluted rivers in the world. The coral reef health will be assessed, and the extent of coral cover, biodiversity, microplastic concentration levels and sources. This project was funded by the National Geographic Society.

Pirika

Pirika is a non-profit organization which has developed "Albatross", a microplastic survey service. The survey investigates outflow mechanisms to stop the leakage of plastics and essential leakage paths. They had a project in 2020 and have continued survey activity. Sample collections was developed by small survey devices. Surveys have been conducted in Thailand, Viet Nam, Cambodia and Laos as a part of the

CounterMEASURE project under UNEP (Figure 22). On their website they have a microplastics leakage database where sampling sites and data can be further investigated.

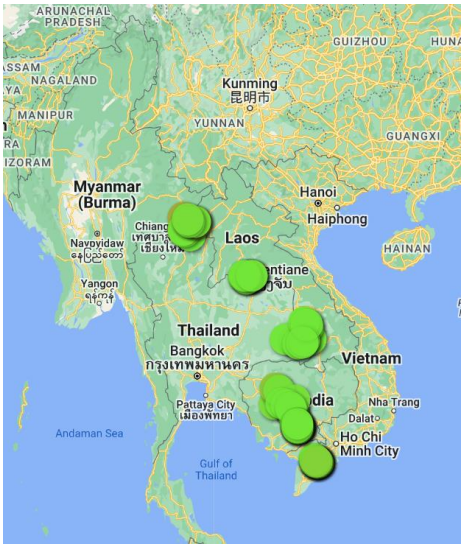

Figure 22. Microplastic surveys conducted by Pirika in 2021 and later in Cambodia, Laos, Thailand and Viet Nam.

PoDIWM-2

PoDIWM-2 is an ASEAN cooperation project by the Japan-ASEAN Integration Fund. The project name stands for "Strengthening Capacity Development for Local Governments in ASEAN to Tackle Microplastics and Water Pollution through Decentralized Wastewater Management Approach" which is an extension of the first project, PoDIWM. The first project lasted between 2018 – 2020 and was about "Policy Dialogue and Network Building of Multi-stakeholders on Integrated Decentralized Domestic Wastewater Management in ASEAN Countries". PoDIWM-2 aims to address the emerging challenge of microplastic pollution in relation to wastewater treatment systems in ASEAN countries. See Table 2 for partners involved in the project.

PTTEP

PTTEP stands for PTT Exploration and Production Public Company Limited and is in business with petroleum exploration, development, and production. Together with The Kasetsart University they have conducted a baseline study and monitored microplastics to define the marine debris situation in the Gulf of Thailand. Since 2020 the project has collected seawater for microplastics and analyzed abundance and characterization of particles. The project was completed in 2021 around the offshore petroleum fields in the Gulf. Findings revealed the highest concentration near the Chao Phraya River estuary (Figure 23). This supported assumptions that coastal areas close to communities will have a higher amount of microplastics compared to other areas.

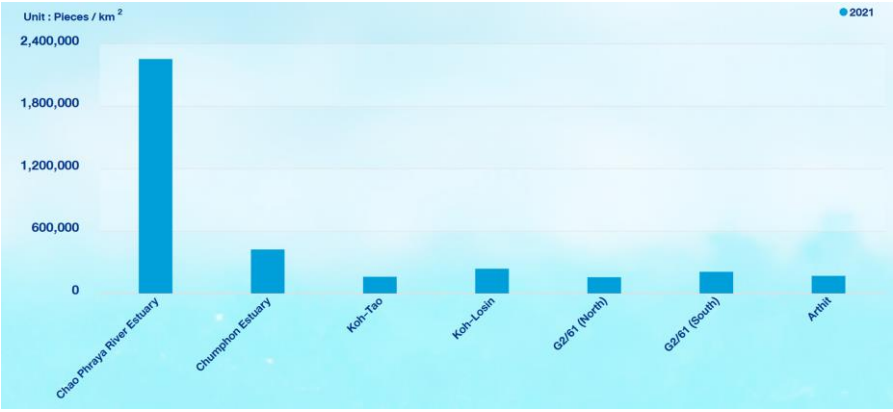

Figure 23. Microplastic volume found in 2021 from the microplastic baseline study and monitoring locations from offshore (G2/61 (North), G2/61 (South), and Arthit in the Gulf of Thailand), midshore (Koh Tao of Surat Thani Province and Koh Losin of Pattani Province) and nearshore (Chao Phraya Rier Estuary of Samut Prakarn Province and Chumphon Estuary of Chumphon). (PTTEP Ocean Data Platform)

SEAFDEC-led initiatives

SEAFDEC (Southeast Asian Fisheries Development Center) has been addressing the issue of marine litter, including microplastics in the Southeast Asian region. It is an intergovernmental organization and includes 11 member countries: Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam. They have initiated various projects and initiatives. One of them is entitled "Regional Collaborative Research and Capacity Building for Monitoring and Reduction of Marine Debris from Fisheries in Southeast Asia" and was running between 2021-2022. The project was financial supported from Japan-ASEAN Integration Fund (JAIF) and coordinated by SEAFDEC/Inland Fishery Resources Development and Management Department. Along with several activities against macroplastics (e.g. ALDFG), the project integrates surveys in the Gulf of Thailand to assess the impacts of microplastics on fishery resources, and assessments of microplastic presence in marine and freshwater fish (Kaban et al., 2021). Additionally, the project has aimed to implement efforts of capacity building of officers and researchers from the ASEAN Member States on the study methods for management of marine debris and microplastics. A newer project bearing the same title (indicates that this is a continuation of the previous established project), has a scheduled timeframe between 2022 – 2023. The objectives of the project are to enhance regional collaborative research and capacity building in the sector, applicate scientific knowledge of regional policies, and monitoring the four priority areas of the "ASEAN Framework of Action on Marine Debris".

6 Policy measures against microplastic pollution

Fourteen regional and national policies have been enacted in ASEAN to tackle the problem of microplastic pollution. These include policies at the regional level (5), in Indonesia (1), Malaysia (1), the Philippines (1), Singapore (1), Thailand (1), and Viet Nam (4) (summarized in Table 3 below). These policies employ a combination of regulatory and information-based policy instruments, such as bans, research,

technological innovation and awareness raising campaigns, to reduce the production, mismanagement, and leakage of microplastics to the sea (summarized in Table 4 below).

In this baseline study, we have reviewed a total of 101 policy documents related to micro- and macroplastics and waste management in ASEAN to assess their relevance for tackling microplastic pollution (see Appendix for the full list of reviewed policy documents). While only 14 of these policies contain measures directly targeting microplastics (summarized in Tables 3 and 4), measures and targets included in the other policies could also have an impact on microplastic pollution. This report therefore provides an overview of existing microplastic policies, as well as the most relevant plastic and waste management policies in each of the ASEAN countries in the following sections. This serves as a useful starting point for a gap analysis of the microplastics policy landscape, and the development of recommendations to improve policy measures against microplastic pollution in the ASEAN region, discussed further in section 7.

Table 3. Overview of existing policies on microplastic pollution in the ASEAN region.

Geographical coverage	Title	Year	Key policy objectives on microplastics	Types of policy instruments[5]
ASEAN Regional	The ASEAN Regional Action Plan for Combating Marine Debris (2021-2025)	2021	Conduct a regional study on microplastics, including an investigation into the linkages to human health.	Information (Research)
Regional	The COBSEA Regional Action Plan on Marine Litter 2019 (RAP MALI)	2019	Activity 3.2.: develop regional and national marine litter and microplastic monitoring programmes, a metadatabase/portal, and regional reports on marine litter and microplastics.	Information (Record keeping, data reporting)
Regional	The ASEAN Framework of Action on Marine Debris	2019	Enhance research on marine debris, including plastics and microplastics, and promote public awareness on status and impacts of marine debris and microplastics.	Information (Research, Education or outreach)
Regional	The Bangkok Declaration on Combating Marine Debris in ASEAN Region	2019	Combat, prevent and significantly reduce marine debris, particularly from land-based activities.	Regulatory – affirmative (Plan/commitment, Post-leakage plastic capture, Responsible handling of plastic)
Regional	Action Plan of the ASEAN Working Group on Coastal and Marine Environment (AWGCME)	2016	Gain an overview of the regional status of marine debris, including microplastics, by sharing knowledges, experiences and good practices, identifying needs and gaps, and exploring regional collaborative activities. Develop recommendations on way forward and a regional management plan for marine debris, including microplastics.	Information (Knowledge sharing) Regulatory – affirmative (Plan)
Indonesia	The Food and Drug Monitoring Agency Regulation No. 23 of 2019 on Technical	2019	Banning the use of plastic microbeads in cosmetics.	Regulatory – prohibitive (Ban)

[5] Typology of policy instruments from Karasik, R., J Bering, M. Griffin, Z. Diana, C Laspada, J. Schachter, et al. 2022. "Annual Trends in Plastic Policy: A Brief." NI PB 22-01. Durham, NC: Duke University.

	Requirements for Cosmetic Ingredients			
Malaysia	National Marine Litter Policy and Action Plan (NMLPAP) 2021 - 2030	2021	By 2023: Enhance research on microplastics and promote public awareness on the impacts of microplastics. By 2024: Establish 'Plastic-Free Islands' where microbeads-based products are prohibited. By 2026: Explore safety standards for microplastics. By 2027: Incorporate marine litter (incl. microplastics) in education and activities in schools. By 2028: Ban the most common or damaging types of plastic marine litter such, as microbeads.	Information (Research, Education and outreach) Regulatory – prohibitive (Ban)
Philippines	National Plan of Action for the Prevention, Reduction and Management of Marine Litter	2021	a) Establish a national program on monitoring and assessment of marine litter and micro-plastics, b) Coordinate with international bodies on marine litter and microplastics, and c) Carry out a national baseline assessment on waste leakage and accumulation of litter in the marine environment incl. microplastics.	Information (Research, Record keeping, Education and outreach)
Singapore	National Action Strategy Addressing Marine Litter in Singapore	2022	Confirms Singapore's commitment to tackling marine litter, including microplastics, through water treatment technologies and waterway clean-up measures.	Regulatory – affirmative (Develop new, or improve existing process or product)
Thailand	Roadmap on Plastic Waste Management plan 2018-2030	2019	Phase I: in 2019, ban the use of plastic microbeads.	Regulatory – prohibitive (Ban)
Viet Nam	Decree No. 08/2022/ND-CP on elaboration of several Articles of the Law on Environmental Protection	2022	The production and import of products and goods containing microplastics shall be gradually reduced. After December 31, 2030, the production and import of products and goods containing microplastics shall be terminated.	Regulatory – prohibitive (Ban and limit)
Viet Nam	Law No. 72/2020/QH14 on Environmental Protection	2020	The Government shall introduce a roadmap for reducing production and import of single-use plastic products, non-biodegradable plastic packaging and products and goods containing microplastics.	Regulatory – affirmative (Plan/commitment)
Viet Nam	Directive No. 33/CT-TTg dated August 20, 2020 on regarding strengthening of management, reuse, recyciling, disposal and reduction of plastic waste	2020	a) Research and build environmental technical barriers to products and commodities containing microplastics, nanoplastics and plastic bags, b) Research and propose a roadmap to ban the use of microplastics in the production of cosmetics, garments, and fertilizers, etc. and c) Conduct a review and announcement of domestically produced and imported products containing microplastics, nanoplastics for consumers' information.	Information (Research, Education and outreach) Regulatory – affirmative (Plan/commitment)
Viet Nam	National Action Plan for Management of Marine	2020	Identify solutions to plastic microbeads from wastewater of urban areas and industrial parks and conduct more research	Information (Research)

	Plastic Litter by 2030		on the pollution risks and impacts of plastic litter, especially plastic microbeads.	Regulatory - affirmative (Develop new, or improve existing process or product)

Table 4. Summary of microplastic policy instruments by region/country in ASEAN.

Policy instruments by country	Regulatory, affirmative	Regulatory, prohibitive	Economic	Information-based
ASEAN regional policies	X			X
Brunei				
Cambodia				
Indonesia		X		X
Laos				
Malaysia		X		X
Myanmar				
Philippines				X
Singapore	X			
Thailand		X		
Viet Nam	X	X		X

6.1 ASEAN Regional policies

At the ASEAN regional level, five policy frameworks have in recent years been introduced to tackle the problem of microplastic pollution: four developed by the ASEAN, and one by the Coordinating Body on the Seas of East Asia (COBSEA). Although these frameworks lack binding targets for the member countries, they promote high national ambitions and strong regional cooperation through regulatory (affirmative) and information-based policy measures. These policies notably emphasize the need for increased research and monitoring of microplastics, including their effects on human health, as stated in the 2019 ASEAN Framework of Action on Marine Debris, the ASEAN Regional Action Plan for Combating Marine Debris (2021-2025), and the COBSEA Regional Action Plan on Marine Litter (RAP MALI). The 2019 ASEAN Framework also underscores the necessity for public awareness campaigns on microplastics. Additionally, the 2016 Action Plan for the ASEAN Working Group on Coastal and Marine Environment (AWGCME) highlights the need for information sharing, knowledge exchange, and regional collaboration to identify gaps, needs, and a way forward to address microplastics.

At the 34th ASEAN Summit in Bangkok, Thailand in June 2019, emerging regional efforts to tackle marine debris culminated in the adoption of two significant regional policy frameworks: **the Bangkok Declaration on Combating Marine Debris in ASEAN Region and the ASEAN Framework of Action on Marine Debris.** In the Bangkok Declaration, the ASEAN member states declared their commitment to combat, prevent and significantly reduce marine debris, particularly from land-based activities, through an integrated land-to-sea approach, strengthened national laws and regulations, enhanced regional and international, inter-sectoral and multi-stakeholder coordination and cooperation, and private sector engagement and investment, including through public-private partnerships. Furthermore, the members agreed to promote innovative solutions and approaches such as circular economy and 3R (reduce, reuse, recycle) to enhance plastics value chains and improve resource efficiency, as well as to improve research capacity and application of scientific knowledge, particularly through support to science-based policy and decision

making, and increase public awareness and education to encourage behavior change toward a prevention and reduction of marine debris. The ASEAN member states also adopted a Framework of Action to put these ambitions into practice, focusing on four priority areas: (i) policy support and planning; (ii) research, innovation, and capacity building; (iii) public awareness, education, and outreach; and (iv) private sector engagement. With regards to microplastics, this Framework specifically encourages ASEAN Member States to implement UN Environment Assembly resolutions 3/7 on Marine Litter and Microplastics, enhance research on marine debris, including plastics and microplastics, as well as to promote public awareness on status and impacts of marine debris and microplastics.

As a follow up to these efforts, **the ASEAN Regional Action Plan for Combating Marine Debris (2021-2025)** aims "to enhance coordination at the regional and international levels for achieving sustainable management of coastal and marine environments through responding to marine plastic pollution" (p. 20). The focus areas of the action plan mirror those in the 2019 Framework of Action and seeks to address three key stages of the plastic waste value chain, including the input, collection, and reuse/recycling stage. With regards to microplastics, the key objective of the 2021-2025 regional action plan is to conduct a regional study on microplastics, including an investigation into the linkages to human health.

Furthermore, the ASEAN Strategic Plan on Environment (ASPEN) 2016-2025 includes a strategic focus on coastal and marine environment and outlines an **Action Plan for the ASEAN Working Group on Coastal and Marine Environment (AWGCME).** The aim of this Action Plan is to promote sustainable management and conservation of ASEAN's coastal and marine environments, reduce anthropogenic threats to ecosystems, enhance inter-agency and inter-sectoral coordination at the regional and international levels, and respond to transboundary issues through good management practices and strengthened policies. With regards to microplastics, the AWGCME Action Plan Programme 4 seeks to mitigate coastal and marine pollution, including from microplastics. In particular, the policy seeks to clarify the regional status of marine debris, including microplastics, by sharing knowledges, experiences and good practices, identifying needs and gaps, and exploring regional collaborative activities. It also sets out to develop recommendations on a way forward and a regional management plan for marine debris, including microplastics. Thailand is the lead country for this activity under Program 4.

In addition to these four ASEAN policy frameworks, the **Coordinating Body on the Seas of East Asia (COBSEA) Regional Action Plan on Marine Litter (RAP MALI),** also seeks to address microplastic pollution in the region. The COBSEA brings together seven of the ASEAN countries, including Cambodia, Indonesia, Malaysia, the Philippines, Thailand, Singapore and Viet Nam, as well as the People's Republic of China and the Republic of Korea. The ASEAN Member states Myanmar, Laos and Brunei are, however, not members of the COBSEA, and they are therefore not covered by this regional action plan. The RAP MALI was originally developed in January 2008, but revised and adopted in June 2019 at a meeting in Bali, Indonesia. Key objectives of the 2019 version are to prevent and reduce marine litter from land- and sea-based sources through legal and economic instruments, national planning and policy frameworks, integrated waste management, removal of existing litter and its disposal, regional and international cooperation and reporting activities, and the establishment of an expert group, regional and national marine litter monitoring programs and research activities. The COBSEA RAP MALI directly targets microplastics under action plan activity 3.2., which seeks to develop regional and national marine litter and microplastic monitoring programs that are harmonized across the region. Data on marine litter and microplastics from these monitoring programs will feed into a metadatabase or portal, that will be used to develop regional reports on marine litter and microplastic that tracks progress against relevant goals and targets such as the SDGs.

6.2 Brunei Darussalam

The Sultanate of Brunei Darussalam, situated on the island of Borneo, currently does not have any government policies in place explicitly addressing microplastics.

For this baseline study, nine national policies related to plastics or general waste management in Brunei (see Appendix for full list and references), have been identified and reviewed. Although these policies do not explicitly mention microplastics, they introduce measures that could indirectly impact microplastic pollution. These measures include the implementation of a 5% excise tax on plastic products[6], the ambition to enforce 3R (reduce, reuse, recycle) initiatives[7], and the prohibition of discarding plastics into the sea[8], as further described below. Beyond these formal policies, the Government of Brunei Darussalam has launched the 'No Plastic Bag Everyday'[9] and 'Plastic Bottle Free'[10] campaigns to reduce plastic use. Introduced in 2011 and expanded in 2018, these initiatives aim to reduce plastic waste through reduced consumption.

According to ASEAN (2021: 39), Brunei is also currently developing its first Waste Management Regulation for non-hazardous solid waste management, but this has not been included here as it has not yet been made available online. The following sections provide a summary of the most important policy measures related to plastic waste management in Brunei.

The most recent policy identified in this study, was **the Brunei Darussalam Tariff and Trade Classification amendment**, 2023, which increased the excise tax on plastic and plastic projects to 5%, effective from May 17, 2023. This may have an impact on reducing plastic use in the country. In 2022, the **Environmental Protection and Management Act, Chapter 240**, was revised, and it clarifies that waste treatment and disposal are prescribed activities of the government. This act is linked to the **Brunei Environmental Protection and Management Order of 2016,** which empowered the Ministry of Environment to introduce regulations on industrial and domestic waste and littering.

In 2020, Brunei Darussalam also introduced a **National Climate Change Policy**, which does not mention plastics specifically, but aims to reduce municipal waste to landfills to 1kg per person per day. It also suggests promoting and implementing 3R (reduce, reuse, recycle) initiatives and programs, adopting waste-to-energy technology options, and enhancing public education and awareness. Additionally, **Brunei Vision 2035** outlines the aspiration for Brunei Darussalam to be globally recognized by 2035 for its educated and highly skilled populace, high quality of life, and dynamic, sustainable economy [11]. Efforts going into achieving this vision could potentially be leveraged for addressing micro- and macro-plastic pollution in Brunei.

In 2013, the **Hazardous Waste (Control of Export, Import and Transit) Order** was introduced, giving effect to the Basel Convention, ratified by Brunei Darussalam in 2002, and stipulating that wastes from the use of plasticizers or surface treatment of plastics are subject to trade control. In 2009, a revised version of the **Brunei Natural Park Act** (Act No. 161 of 1957), prohibited the dumping or disposal of waste "in such manners as give remarkably unpleasant feelings to those utilizing the National Park or Quasi-national Park concerned" (p. 25).

[6] The Brunei Darussalam Tariff and Trade Classification amendment, 2023.

[7] The Brunei Darussalam National Climate Change Policy, 2020.

[8] The Prevention of Pollution of the Sea (Garbage) Regulations, 2008.

[9] Available at: http://www.env.gov.bn/SitePages/NO%20PLASTIC%20BAG%20EVERYDAY%20INITIATIVE.aspx

[10] Available at: http://www.env.gov.bn/SitePages/PLASTIC%20BOTTLE%20FREE%20INITIATIVE.aspx

[11] Available at: https://www.wawasanbrunei.gov.bn/sitepages/Home.aspx

The first policy related to plastic pollution in Brunei Darussalam identified in this study, was **the Prevention of Pollution of the Sea Order**, enacted in 2005. This order made it illegal to dispose of or discharge plastics in packaged form from a ship into Brunei Darussalam waters. If such an incident occurs, the ship's owner is liable for the clean-up. This regulation was expanded in 2008 by the **Prevention of Pollution of the Sea (Garbage) Regulations**, which prohibited the disposal of all plastics into the sea.

6.3 Cambodia

The Kingdom of Cambodia currently does not have any national government policies in place directly targeting microplastics, although one policy document mentions the potential adverse environmental and health impacts of microplastics as background information [12].

For this baseline study, 15 national policies related to microplastics, plastics, or general waste management in Cambodia were identified, however, only 12 were available in English and included in this review (see Appendix for full list). The final three, available only in Khmer, are mentioned at the end of this section, with reference to secondary literature. While these policies do not explicitly target microplastics, they introduce measures that could indirectly reduce microplastic pollution, such as reducing the use of plastic bags in the country [13], fostering the implementation of 4R initiatives (reduce, reuse, recycle, recover) and reducing the use of plastics in agriculture [14], prohibiting the import of certain types of plastic bags [15], improving waste management systems [16], and developing Extended Producer Responsibility (EPR) Schemes and plastic production standards [17].

According to OECD (2022) and ASEAN (2021), Cambodia has also developed a National Waste Strategy and Action Plan (2018-2030) which focuses on segregation of plastic waste, management of plastic bags and improvement of waste collection in urban areas, but we have been unable to find an online version of this document, and we have therefore not included it in this in this baseline study. A GIZ-report from 2019 also reported that a new sub-decree to regulate single-use plastics and foam containers was being formulated in Cambodia (GIZ, 2019), and in June 2023, the Khmer Times reported that "the committee on plastic management will meet this week to consider the proposal for banning single-use plastics (SUPs), a major source of pollution in the country. The proposal is to ban SUPs effective 2024" [18]. We have, however, failed to identify further updates on this, and it is also not included in this study.

Among the most relevant policies for plastic waste management in general in Cambodia, is the **Circular Strategy on Environment (2023-2028)**, enacted in 2023 to support sustainable development. Plastics are explicitly mentioned under the mission of the strategy, which is to: "Promote green investment through infrastructure construction, clean energy systems, smart production, green transportation, solid waste management, plastics and hazardous waste, wastewater treatment, air quality management, protected area management, green space expansion and supporting local community economy." The strategy outlines multiple measures to address plastics, including plastic bag reduction campaigns, developing a sub-decree on the management of single-use plastic products and plastic waste, fostering the implementation of the 4R Principle (Refuse, Reduce, Reuse and Recycle), disseminating and strengthening the implementation of legal instruments related to the management of plastic wastes,

[12] The Circular Economy Strategy and Action Plan, 2021.

[13] Cambodian Sustainable Development Goals (CSDGs) Framework (2016 – 2030).

[14] The Circular Strategy on Environment (2023-2028)

[15] Anukret (Sub Decree) of 2020 on the Enforcement of the List of Prohibited and Restricted Goods.

[16] Cambodia's National Environment Strategy and Action Plan, 2016–2023 (NESAP).

[17] The Circular Economy Strategy and Action Plan, 2021.

[18] Available at: https://www.khmertimeskh.com/501306321/plastic-control-key-for-cambodia-to-create-circular-economy/

capacity building on plastic waste management, reducing the use of plastics for agricultural products and plants, and introduce further measures to avoid and/or remove plastic waste from the environment.

Related to this, Cambodia also introduced **the Circular Economy Strategy and Action Plan in 2021**, to create an enabling environment for the economic, social, and environmental transformations required to realize a circular economy in the country. Key strategic objectives include the enhancement of waste collection and recycling, and effective management of residual waste. Specific actions directly targeting plastics include promotion of alternatives to Single-Use Plastic (SUP) and development of Extended Producer Responsibility (EPR) schemes and plastic production standards.

The import, export, and transit of plastics in Cambodia are also regulated under the **Anukret (Sub Decree) of 2020 on the Enforcement of the List of Prohibited and Restricted Goods**. This sub-decree stipulates that plastic bags with handle of less than 0.03 millimeter in thickness, and its bottom width of less than 250 millimeters, plastic waste (HS code 3915.90.00) is prohibited to import. Other plastic items require a permit for import.

In 2018, the Council of Ministers approved the **Cambodian Sustainable Development Goals (CSDGs) Framework (2016 – 2030)** to support sustainable development in Cambodia. In the CSDGs Framework, the reduction of plastic bags used is included as an indicator to measure progress on Goal 11.6, which seeks to: "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" (p. 16).

In 2017, **Cambodia's National Environment Strategy and Action Plan, 2016–2023 (NESAP)** was adopted, to identify priority sectors and projects that "demonstrate opportunities and benefits in shifting to sustainable and inclusive development" (p. 27). The document states that "Much more effort is required to further improve the solid waste management in all municipalities and localities, especially in addressing hazardous waste, persistent organic pollutants and newly emerging electronic and electrical wastes, as well as plastic waste" (p. 15). The NESAP does not mention microplastics, but in relation to plastics in general, it seeks to "support national line institutions and sub-national administrations in improving waste management and 3R (Reduce, Reuse and Recycle) targets", and "promote public awareness for minimizing plastic bag use and unorderly disposal" (p. 32).

In 2015, a **Sub-decree on the Management of Garbage and Solid Waste in Downtown areas** was adopted, with an aim to enhance solid waste management in urban areas. The Sub-decree stipulated that state authorities should take measures to prevent the disposal or burning of garbage and solid waste "on public streets, fields, in sewage system or public water sources or on privately-owned land" in downtown areas (p. 6). The document only mentions plastics once, noting that the owners of solid waste in downtown areas are responsible for the proper storage of waste in plastic bags that do not lead or emit bad smell.

The 2015 **Climate Change Action Plan in Tourism Sector (2015-2018)** seeks to reduce the impacts of climate change on people and the tourism sector in Cambodia, but also ensures that tourism does not contribute to higher greenhouse gas emissions. Plastic waste is mentioned specifically under Action 4, which intends to turn the four main tourism destinations in Cambodia into 'clean cities' and 'districts of excellence'. Relevant activities under this action includes efforts to reduce waste generation by creating "No Plastic Bag Campaign" and implement 3R initiatives (Reduce, Reuse, and Recycle), as well as the establishment of community-based solid waste management system, which will recycle waste and manage separating facilities, and produce consumer goods such as handbags for sale to tourists and households.

In 2013, the Royal Cambodian government released the **National Strategic Plan on Green Growth (2013-2030)** as part of broader Green Growth strategic initiatives. The strategic plan does not mention

microplastics, but the chapter on 'Blue Economy Development and Sustainability' aims to improve the management of marine pollution, including plastic disposal, to protect marine health and biodiversity.

In 2006, **Environmental Guidelines on Solid Waste Management in Kingdom of Cambodia** were published, to promote the 3Rs principle of reduce, reuse and recycle, and encourage the development of a waste management plan. The guidelines do not mention microplastics, but in relation to plastics in general, the guidelines promote environmental education in kindergartens to ensure that children are able to identify types of waste like plastic bags and develop the practice of disposing waste properly into rubbish bins.

In 1999, two sub-decrees were introduced that are relevant for plastic waste management. First, the **Sub-Decree No: 72.ANRK.BK on Environmental Impact Assessment Process** lists the types of projects or developments that require an environmental impact assessment (EIA). Plastics factories of all sizes are included in the list of projects requiring an EIA. Secondly, the **Sub-Decree No. 36 ANK.BK. of 27 April 1999 on Solid Waste Management** was introduced to regulate solid waste management in a safe way, using proper technology, to ensure the protection of human health and the conservation of biodiversity. The document defines plastic waste from production or use of plasticizers as hazardous waste, and states that the export of hazardous waste (including plastic waste) is permitted under certain conditions, with permission from the relevant authorities, while import is strictly prohibited.

In 1996, the government of Cambodia published a **Law on environmental protection and natural resource management**, but it did not mention plastics. However, the law had an overall objective to prevent, reduce and control pollution to protect public health and upgrade environmental quality.

The three Cambodian policy documents that are not available in English includes the Sub-Decree No. 168 GNKR.BK on the Management of Plastic Bags from 2017, Notification 1278 from 2017, and the Urban Solid Waste Management Policy 2020-2030. A UNEP report from 2018 refers, however, to these policies and summarizes that: "Cambodia does not have an outright ban but rather requires a permit from the ministry of environment for the manufacture or import of plastic bags with thickness of 30 microns, with exemption given for the non-commercial importation of less than 100 kilograms" (UNEP, 2018: 17). These regulations also stipulate that "Importation and production of bag or packaging material produced from biodegradable or bioplastic substances shall have preferential tax rates" (UNEP, 2018: 20). In addition, "Customers will pay for plastic bags from supermarkets, commercial centers, and all business and service locations", and "Legislation requires encouragement of use of renewable materials and minimization of waste generation" (UNEP, 2018: 31).

6.4 Indonesia

To tackle the problems of microplastic pollution, Indonesia has banned the use of plastic microbeads (solid plastic particles that have a size of ≤ 5 mm and are used as an exfoliant or body cleanser) in cosmetic products, as stipulated in the Food and Drug Monitoring Agency Regulation No. 23 of 2019 on Technical Requirements for Cosmetic Ingredients. This regulation followed from the growing concern about the extensive use of plastic microbeads in cosmetics, globally as well as in Indonesia, and recognized the need to adjust the technical requirements for cosmetic ingredients due to developments in science and technology [19].

[19] The Food and Drug Monitoring Agency Regulation No. 23 of 2019 on Technical Requirements for Cosmetic Ingredients, available at: https://notifkos.pom.go.id/upload/informasi/20190911074902.pdf (accessed 12.02.2024).

Besides this, the Government of Indonesia have passed a variety of laws, regulations and strategies targeting plastic pollution or waste management in general, which may have an indirect impact on microplastic pollution. These measures include ambitions to reduce marine plastic debris by 70% in 2025[20], reduce the amount of plastic waste in Indonesia by 30% and the amount of mismanaged plastic waste by up to 70% by 2025[21], and prohibit the use of plastic bags and single-use plastic products by 2030[22].

For this baseline study, 22 national policies related to plastics or general waste management in Indonesia were identified, however, only 9 of these were available in English and thereby included in this review (see Appendix for full list). The remaining 13 are mentioned at the end of this section. A summary of the most relevant policy measures related to plastic waste management in Indonesia is included below.

In 2022, Indonesia submitted their **Enhanced Nationally Determined Contribution** to the UNFCCC Paris Agreement, as a follow-up to the **First Nationally Determined Contribution (NDC)** submitted in 2016. While the first NDC only mentioned waste management in general, the enhanced NDC specifically mentions plastic pollution in a section on ecosystem and landscape resilience, aiming to: "Enhance coastal zone and ocean pollution control, including marine litter and plastic debris" (p. 39).

Importantly, in 2020, the **National Plastic Waste Reduction Strategic Actions for Indonesia** was published, with an ambitious aim to reduce the amount of plastic waste by 30 percent and the amount of mismanaged plastic waste by up to 70 percent by 2025. The latter of these goals seeks to ensure that a higher proportion of plastic waste is properly managed, to reduce the emission of marine debris into the ocean. The strategy seeks to reduce plastic waste generation and reinforcing the plastic recycling system through implementing EPR programmes, promoting sustainable import, production, and consumption of plastics, using the best available, and enhancing involvement, responsibility, and initiatives from the private sector and society through programmes such as EPR, CSR, and 3Rs.

Another important strategy for plastic waste management in Indonesia, is **the Ministry of Environment and Forestry Decree No. P.75/2019 on Roadmap to Waste Reduction by Producers**, introduced in 2019. This Decree aims to prohibit the use of plastic bags, plastic products, packaging, and / or containers, disposable eating and drinking equipment, including spoons, forks and straws, and flexible plastic (sachets) used for packaging products with sizes less than 50 ml or 50 gr from January 1, 2030. The Decree also outlines a variety of 3R activities that producers can implement to reduce, reuse and recycle plastic waste, such as using 100% recyclable materials, using colorless plastic for mineral water packaging and using packaging that can be reused.

In 2017, **Indonesia's Plan of Action on Marine Plastic Debris (2017-2025)** was launched, with an overall aim to reduce marine plastic debris by 70 % in 2025. The plan of action consists of 5 main pillars and 5 strategy programs, which include measures such as through awareness raising activities, waste plastics managements from land to the coastal area, marine plastic debris management, capacity building and enhancing funding mechanisms.

In 2016, the **Ministry of Trade Regulation No. 31/2016 on Non-Hazardous Waste Import** included 'remains, waste and scrap, of plastic' in the list of non B3 wastes able to be imported, and clarifies that non B3 Wastes can be imported if they: "a. do not come from landfill activity or not in the form of garbage; b. are not contaminated with B3 and/or B3 Wastes; and/or c. are not mixed with other waste which is not regulated in this Regulation of Minister" (p. 5).

[20] Indonesia's Plan of Action on Marine Plastic Debris (2017-2025).

[21] The National Plastic Waste Reduction Strategic Actions for Indonesia, 2020.

[22] The Ministry of Environment and Forestry Decree No. P.75/2019 on Roadmap to Waste Reduction by Producers.

In 2013, **the Ministry of Public Works Regulation No. 3/2013 on Implementation of Solid Waste Infrastructure and Facilities** was formulated to ensure effective waste management infrastructure and facilities, improve coverage of waste handling services, and reconsider waste as resource, to improve public health and environmental quality and protect water resources, land, and air from pollution. The policy document mentions plastics once, in terms of categorizing plastic as a type of waste that can be recycled.

Furthermore, while 'plastics' are not mentioned in the **Law on Environmental Protection and Management No. 32/2009**, the law does provide provisions on waste management in general that may be of relevance to microplastics as well. Specifically, the law prohibits dumping of waste and/or substances to environmental medium without permission (article 60), and prohibit people from bringing B3 (hazardous) wastes into the territory of the Republic of Indonesia (article 69).

Similarly, **the Waste Management Act No. 18 from 2008** does not mention plastics but regulates waste management in Indonesia more broadly. Article 29 prohibits everybody from bringing in and importing waste into the jurisdiction of the Republic of Indonesia, mixing waste with hazardous and toxic waste, causing pollution and/or environmental damage from waste management, disposing waste in improper manner and not in provided areas, open dumping at final processing site, and/or burning waste not according to technical requirements. Article 6 also outlines that the tasks of the national and local government in waste management, which include, among others, to increase public awareness on waste management, develop and facilitate the application of technology for reducing and managing waste, develop and facilitate efforts to reduce, handle, and utilize waste, carry out and provide infrastructure for waste management, and coordinate efforts by government institutions, society, and industry towards integrated waste management.

Besides these policy documents, which are readily available online in English, the Government of Indonesia has adopted a variety of other policies that may have an impact on microplastics, as it relates to plastic pollution or waste management in general. These include:

1) Regulation of the Minister of Trade no. 40 of 2022 concerning Amendments to Regulation of the Minister of Trade No. 18 of 2021 concerning Export of Prohibited Goods and Import of Prohibited Goods
2) Government Regulation no. 22 of 2021 on Environmental Protection, Organization and Management
3) Regulation of the Minister of Trade no. 18 of 2021 concerning Export and Import of Prohibited Goods
4) Indonesian Sustainable Consumption and Production Strategy Framework for 2020-2030
5) Food and Drug Monitoring Agency Regulation No. 23 of 2019: Technical Requirements for Cosmetic Ingredients
6) Producer Responsibility Regulation (Ministry of Environment and Forestry Regulation No 75/2019)
7) Presidential Decree no. 83 of 2018 about Marine Debris Management
8) Presidential Regulation No. 35/2018 Presidential Regulation on Acceleration of Development of Waste-to-Energy Installation using Environmentally-sound Technology
9) Presidential Regulation No.97/2017 on National Policy & Strategy on Management of Household Waste and Household-like Waste (JAKSTRANAS)
10) No. 101/2014 Government Regulation on Hazardous Waste Management
11) MoEF decree No.13/2012 on Guidelines for implementation of Reduce, Reuse and Recycle through Waste Bank
12) Government regulation on waste management of household waste and household-like waste, No. 81/2012, 12)
13) Presidential Decree No. 61/1993 and No. 47/2005 on Ratification of the Basel Convention on the Control of the Transboundary Movement of Hazardous Waste and Their Disposal

Furthermore, the National Plastic Waste Reduction Strategic Actions for Indonesia (2020) also mentions that a Government Regulation on Excise Tax on Plastics, and a MoEF decree on Restricted Single-Use

Plastic are currently in progress, but these have not yet been published online. ASEAN (2021: 39) also notes that "The Ministry of National Development Planning (Bappenas) is developing a national circular economy roadmap, with a focus on plastic packaging".

6.5 Lao People's Democratic Republic (PDR)

The Lao People's Democratic Republic (Laos) currently does not have any government policies in place that directly address microplastic pollution.

For this baseline study, we identified six national policies related to plastics and waste management in Laos, all of which are included in this review (see Appendix for the full list). Although none of these mention microplastics directly, they introduce measures that may indirectly have an effect on microplastic pollution, such as ambitions to reduce waste generation rates and increase garbage reuse and treatment rates[23], reduce water and air pollution by 30%[24], and strengthening capacity to address plastic pollution[25].

The **9th Five-Year National Socio-Economic Development Plan (2021-2025)** was published in 2021 by the Government of Lao PDR. While the plan does not mention microplastics specifically, it aims to "strengthen capacity to address the problem of pollution caused by the use of plastics" in general (p. 81). The plan also outlines that the government will continue to implement an ongoing project on management and reduction of waste and plastics funded through the state budget.

Furthermore, the 2018 **National Green Growth Strategy of the Lao PDR till 2030** aims to promote green and sustainable growth of Lao PDR through focusing on 3 areas or pillars of the socio-economic development, including the (1) Economic area or pillar, (2) Social area or pillar, and (3) Environmental area or pillar. Within the environmental pillar, the strategy aims to reduce the average production of garbage or waste per person from 237 kg/person/year in 2015 to 210 kg by 2025 and 180 kg by 2030. Increase the percentage of garbage or wastes which are reused or disposed through proper methods and sites from 50% in 2015 to 65 % in 2025 and 80% in 2030.

In 2017, the Government of Lao PDR published a **National Pollution Control Strategy and Action Plan 2018-2025, with Vision to 2030 (NPCSAP)**. The overarching target of the strategy was to "halt environmental pollution acceleration, remedy degraded areas and improve the environment quality and ensure sustainable development of the country be achieved; guarantee that all the people are entitled to live in the environment, landscapes and other environmental components with the good quality of air, land, and water measuring up to standards stipulated by the State" (p. 30). In terms of plastic pollution, the aim of the strategy was to establish recycling plants for materials like plastics through a Public Private Partnership approach. For pollution in general, the strategy sought to raise public awareness, ensure compliance to legal provisions, ensure comprehensive waste (pollutants) Management, strengthen institutional mechanisms, mainstream pollution prevention measures into all development efforts, minimize/reduce waste at source, enhance accountability of decision makers, make polluters pay, and address trans-boundary pollution issues.

In 2015, the Government of Lao PDR promulgated **the Natural Resources and Environment 10 year Strategy (2016-2025**), which has an overall aim of ensuring green economic growth and sustainable resilient development. Target two of the strategy, which aims to make Lao PDR clean and beautiful,

[23] National Green Growth Strategy of the Lao PDR till 2030.

[24] The Natural Resources and Environment 10-year Strategy (2016-2025).

[25] The 9th Five-Year National Socio-Economic Development Plan (2021-2025).

contains several objectives that may have implications for plastic pollution, including: "Reduce water and air pollution for industries and services by 30%, protect water quantity and quality in 10 river basins to satisfy water quality and quantity standards to ensure minimum negative impact; reduce the waste generation in the municipal areas across the country by 30%; 50% of household in the municipalities in the six priority provinces and household along the national road implement proper waste separation practices; and main roads and public areas in municipalities and the important tourist areas have effective and efficient clean up waste collection system" (p. 19).

The same year, **the Ministerial instructions on pollution control, 2015**, stipulated that projects or activities that contribute to air, water or soil pollution may be subject to Environmental Impact Assessment (EIA). To control the emission of pollutants, project owners and entrepreneurs have the responsibility to ensure proper treatment before releasing pollutants into areas such as natural water sources or man-made water sources, rice fields, public areas and rivers, and to use appropriate technology from the beginning of manufacturing to reduce raw material and energy and reduce pollutants.

Similarly, the **Environmental Protection Law (2012)** stipulated that operators in sectors such as industry, agriculture, forestry, energy, mining, and handicrafts shall strictly apply pollution control measures, such as the use of appropriate technology and equipment. Furthermore, the law specifies that the disposal of general waste shall be separation for different purposes such as recycle, reuse, reprocess as new products. In terms of general prohibitions: the law prohibits to "Burn, burry, dispose and demolish wastes, release and discharge wastewater into canals, rivers, natural water sources or any sites without treatment based on the technical standards" (p. 13).

While it is not included in this review, it is also relevant to mention that at a sub-national level, an ambitious Sustainable Solid Waste Management Strategy and Action Plan for Vientiane Capital (2021-2030) was published in 2021, which seeks to improve waste collection services, waste-to-resources facilities, reduce waste generation rates, and integrate informal waste pickers into the formal waste management system.

6.6 Malaysia

Malaysia has set an ambitious goal to ensure that microplastics or harmful substances do not remain in the environment and explore the potential to phase out other biodegradable polymers that generate microplastics, as outlined in the National Marine Litter Policy and Action Plan (NMLPAP) 2021-2030. The challenges related to microplastics are also mentioned in the Plastics Sustainability Roadmap 2021-2030, but this policy does not introduce additional measures targeting microplastics.

For this baseline study, we identified seven national policies related to plastics and waste management in Malaysia, all of which are included in this review (see Appendix for the full list). A summary of the most relevant policy measures related to plastic waste management are included below. Besides the policy that directly addresses microplastics, these other policies also introduce measures that may indirectly have an effect on microplastic pollution, such as introducing a voluntary EPR scheme from 2023-2025, before making it mandatory in 2026, phasing out Single-Use Plastic products and increase recycling rates[26], address marine litter pollution[27] and introducing a tax on plastic bags[28]. A summary of these policies is provided here below.

[26] Malaysia Plastics Sustainability Roadmap 2021-2030.

[27] The National Marine Litter Policy and Action Plan (NMLPAP) 2021-2030.

[28] National Roadmap Towards Zero Single-Use Plastics 2018-2030.

The **National Marine Litter Policy and Action Plan (NMLPAP) 2021-2030,** was introduced in 2021, and focuses on two core themes: a) Strengthening "the evidence base for informed decision making to address marine litter by building national capacities to monitor plastic value chain and assessing waste leakage hotspots in line with global best practices", and b) Deploying "practical actions in phases to tackle sources of marine litter pollution in Malaysia in-line with the latest global innovations, further developed over time through enhanced evidence-based strategies" (p. 11). The policy has five pillars: I) policy adoption and implementation, II) deployment of technologies, innovation and capacity building, III) improve monitoring and data collection on marine litter, IV) communication, education & public awareness, and V) adopting whole-of-nation and multi-stakeholders approach in harmonizing cross-cutting objectives. With regards to microplastics, the policy aims to ensure that no microplastics or harmful substances are left behind in the environment. By 2023, it aims to enhance research on microplastics, and promote public awareness on the status and impacts of microplastics. By 2024: 'Plastic-Free Islands' will be established, where microbeads-based products will be prohibited. By 2026, safety standards for microplastics will be explored, and by 2028, the most common or damaging types of plastic marine litter such, as microbeads, will be banned. The NMLPAP 2021-2030 will be implemented alongside the Plastic Sustainability Roadmap 2021-2030 and the National Roadmap Towards Zero Single-Use Plastics 2018-2030.

The **Plastics Sustainability Roadmap 2021-2030** aims to sustainably address plastic pollution in Malaysia, by promoting a circular economy approach, improving product design, providing guidance and sustainable business practices, and harmonizing actions along plastic value chain through a life cycle approach, to ensure economic development, environmental protection, and societal wellbeing. The sustainability Roadmap covers four types of resin: PP, PET, HDPE and LDPE/LLDPE, which are the most produced and disposed of in Malaysia. Importantly, the Roadmap introduces an Extended Producer Responsibility scheme for plastic products, which will be implemented in a phased approach The implementation of the EPR scheme will begin with a voluntary scheme from 2023 to 2025, before transitioning to a mandatory EPR scheme in 2026. Furthermore, the Roadmap stipulates that problematic Single-Use Plastic products will be phased out between 2023 and 2030, and several ambitious targets are declared: By 2025, 50 % of plastic packaging will be recycled, and by 2030, 100 % of plastic packaging will be recycled. Moreover, by 2030, plastic products include a minimum of 15% recycled content, and the collected-for-recycling (CFR) rate increases to 76%. The sustainability Roadmap does not stipulate any specific activities or objectives related to microplastics but notes that "The need to tackle plastic pollution in general and microplastics specifically is live and urgent", and "Malaysia is looking forward to technologies where plastics do not degrade into microplastics and harm the people and planet" (p. 14, 29).

The **National Roadmap Towards Zero Single-Use Plastics 2018-2030** outlines the overall vision of achieving zero single-use plastics in Malaysia by 2030. Proposed actions of the Roadmap includes the drafting and revision of legal framework, introduction of a pollution charge on single-use plastic bags by states (at fixed premises) by 2019 and at non-fixed premises by 2022, adding a federal pollution levy on plastic manufacturers, and a Circular Economy Roadmap (CER) for plastics will be launched by 2020. States will also impose a pollution charge at a minimum of RM0.20 for plastic bags, to be implemented nationwide by end of 2021. The policy does not mention microplastics, however.

Besides these policies, Malaysia also mentions plastic waste (not microplastics) in **the Twelfth Malaysia Plan, 2021-2025.** The plan promises to enhance efforts to reduce single-use plastics, support a circular economy in the waste sector, extend the Extended producer responsibility (EPR) approach also to plastic waste, and review regulations on import and export of waste, i.e. enforcement of the need for prior consent from importing countries before transboundary shipping of waste takes place from exporting countries.

The Customs (Prohibition of Imports) Order 2017, and **the 2012** version, stipulates that " Waste, paring and scrap of plastics" should not be imported into Malaysia except with an Import License issued by the Ministry of International Trade and Industry.

Finally, the **Malaysia Solid Waste and Public Cleansing Management Act No. 672 of 2007** regulates solid waste management in the country and prohibits the unauthorized disposal, treatment, etc., of controlled solid waste.

6.7 Myanmar

The Republic of the Union of Myanmar currently does not have any government policies in place directly targeting microplastics, although the National Waste Management Strategy and Master Plan for Myanmar (NWMSMP) (2018-2030) acknowledges the potential long-term detrimental effects of terrestrial microplastic pollution in soils, sediments, and freshwater on ecosystems.

For this baseline study, we identified five national policies related to plastics or waste management in Myanmar, all of which are included in this review (see Appendix for the full list). While none of these target microplastics directly, they introduce measures that could indirectly have an effect on microplastic pollution, such as the ambition to achieve a zero waste, circular and sustainable society by 2030 where 100% of all citizens have access to sound waste collection services [29]. A summary of the most relevant policy measures related to plastic waste management is included below. We also mention four additional sub-national policies, which are primarily focused on the cities of Yangon and Mandalay, at the end of this section.

In 2019, a new **National Environmental Policy of Myanmar** was introduced by the Government of Myanmar. The policy does not mention plastics, but it stipulates that “Every person and citizen living in Myanmar has the right to access a clean and healthy environment, and the duty to protect the environment." (p. 6). The policy also outlines that pollution and waste are to be avoided and minimized at the source, and enterprises will be encouraged to adopt clean production principles and best practices.

The **National Waste Management Strategy and Master Plan for Myanmar (NWMSMP) (2018-2030)** aimed to achieve the goal of a “zero waste, circular and sustainable society by 2030” (p. ii). The aim of the NWMSMP is to improve the quality and coverage of waste collection services, eliminate open burning and uncontrolled disposal of waste, reduce waste through the 3Rs (reduce, reuse, recycle), support a circular economy of waste, ensure sustainable financing mechanisms for waste management, ensure the compliance, monitoring, enforcement and recognition of regulatory frameworks, and awareness raising. The strategy also states that states and regions in Myanmar ought to develop sustainable waste management strategies. Importantly, the NWMSMP has introduced the target to achieve sound waste collection service for 70% of all citizens by 2020, 85% by 2025, and 100% by 2030.

The **Environmental Conservation Rules 2014** does not mention plastics or microplastics directly, but it stipulated that “Nobody shall carry out any activity which can damage the ecosystem and the natural environment which is affected due to such system, except for the permission of the Ministry for the interests of the people” (p. 15). This means that activities that may have negative environmental impacts needs special permission from the Ministry. **The Environmental Conservation Law, 2012**, also does not mention plastics or microplastics directly, but stipulates that it is the Ministry of Environmental Conservation and Forestry that is responsible for prescribing environmental quality standards on solid

[29] The National Waste Management Strategy and Master Plan for Myanmar (NWMSMP) (2018-2030).

waste and laying down guidelines for the management of environmental matters, such as the management of non-depleting substances (p. 8-9).

In 2015, the **Environmental Impact Assessment Procedures** stipulated that all development projects that have the potential to cause adverse impacts, are required to undertake Initial Environmental Examination or Environmental Impact Assessment or to develop an Environmental Management Plan, which shall address and satisfy relevant environmental management and monitoring issues such as waste, hazardous waste, wastewater and storm water, air quality, and water quality.

Solid waste management, and the day-to-day operation of waste collection and treatment is, however, implemented by Development Committees at the city and township levels. To support these efforts, policies and regulations have been developed at the sub-national level as well as the national. In Yangon city, for instance, the 2018 Yangon City Development Law provided information about waste management regulations, prohibited activities and associated penalties. This law stipulated, for instance, that the disposal of solid waste in places other than designated bins and landfills is prohibited and subject to a fine of 30,000 to 300,000 Myanmar kyats. Similarly, the Mandalay City Development Law from 2014 clarified the responsibility of the Mandalay City Development Committee (MCDC) in waste management. MCDC "prohibited the production, trading and use of thin plastic bags in its administrative area", while the Yangon City Development Committee (YCDC) "officially announced a ban on businesses manufacturing, importing, trading and distribution of HDPE plastic bags" in 2009 (p. 8, 13). These endeavors were followed up with efforts to reduce the production and sale of polyethylene bags in 2011 in Mandalay.

However, following the 2021 coup d'état in Myanmar, the State Administration Council (SAC) has introduced a state of emergency, and most policies and government strategies developed during the political reforms era of the 2010s are currently not being implemented in the country. In 2021, shortly after the coup, two Laws amending the Yangon[30] and Mandalay[31] City Development Laws were enacted by the SAC, deeming several chapters of the existing laws ineffective. This likely has an effect on the waste management system in the two cities, as in the country more broadly.

6.8 The Philippines

The Philippines has set an ambitious goal of becoming free of marine litter by 2040, with zero waste discharge into Philippine waters, as outlined in the National Plan of Action for the Prevention, Reduction, and Management of Marine Litter 2021 (NPOA-ML). Focusing on microplastics specifically, the NPOA-ML includes three information-based policy measures, stipulating that the Philippines will create a national monitoring program of microplastics, coordinate with international bodies such as the UNEA Ad Hoc Experts Group (AHEG) on Marine Litter and Microplastics, and conduct a baseline assessment on marine litter, including microplastics.

For this baseline study, we identified 29 national and sub-national policies related to plastics and waste management in the Philippines. However, only 15 of these were included in this review, as they were readily available in English (see Appendix for the full list). While most of these policies do not target microplastics directly, they introduce measures that could indirectly have an effect on microplastic pollution as well, such as the ambition to phase out single-use plastic products within four years[32], institutionalize an EPR system and ensure that 80% of plastic products are recovered by 2028[33], and adopt

[30] Available at: https://www.gnlm.com.mm/state-administration-council-law-no-1-2021-law-amending-yangon-city-development-law/ (accessed 21.02.2024).

[31] Available at: https://www.gnlm.com.mm/state-administration-council-law-no-2-2021-law-amending-mandalay-city-development-law/ (accessed 21.02.2024).

[32] The Single-Use Plastic Products Regulation Act HB9147, 2021.

[33] The Extended Producer Responsibility Act, 2022.

circular economy solutions and prevent leakage of marine litter from collected or disposed waste [34]. It has also been prohibited to dump waste and other matter into Philippine waters that could cause harm to marine life and human health since 1976 [35], and supermarkets and restaurants have been prohibited from using non-biodegradable plastic bags since 2011 [36]. The following sections provides a summary of the most significant policies that may directly and indirectly have an effect on microplastic pollution in the Philippines.

The most recent policy in this review, the **Philippine Action Plan for Sustainable Consumption and Production (PAP4SCP),** was published in 2023. The PAP4SCP does not mention microplastics specifically, but in terms of plastics in general, it seeks to pursue "choice-editing (e.g., addressing single-use plastics, and unsustainable packaging) and choice-influencing (e.g., establishment of sustainable mobility solutions and active transport) strategies to steer behavioral change", and "develop and adopt green technologies and circular economy solutions to improve resource use, efficiency and transform waste/residuals into other usable products" (p. XIII). In the short-term period, by 2023, it aims to research and develop alternatives to single-use plastics to support a phase-out, and by 2030, it will scale-up business models for waste minimization and technology that utilize recycled materials, including plastics.

In 2022, the **Extended Producer Responsibility Act** was enacted, institutionalizing the extended producer responsibility (EPR) mechanism as an effective approach to waste management. This approach is grounded in the principles of sustainable consumption and production, circular economy, and producer responsibility. Under the EPR system in the Philippines, large enterprises generating plastic packaging waste were required to establish or phase in EPR programs for plastic packaging within six months of the Act's commencement in 2022. Micro, small, and medium enterprises producing plastic packaging waste are encouraged to voluntarily practice EPR or join a network of organizations implementing EPR. As a result, product producers are expected to recover or offset their plastic packaging footprint. To facilitate the implementation of the EPR system, a tax incentive scheme has been introduced. The Act has also set annual targets for the recovery of plastic product footprint, starting from 20% by December 31, 2023, and reaching 80% by December 31, 2028. Enterprises that fail to register or comply with this Act will be subject to fines.

In 2021, **the National Plan of Action for the Prevention, Reduction and Management of Marine Litter** was introduced, with the overarching goal: "Zero waste to Philippine waters by 2040" to support the vision of "A Philippines free of marine litter" (p. 14). To address microplastic pollution specifically, the plan of action seeks to: a) Establish a national program on monitoring and assessment of marine litter and micro-plastics, b) coordinate with international bodies on marine litter and microplastics, and c) Carry out a national baseline assessment on waste leakage and accumulation of litter in the marine environment that also includes information on microplastics. In terms of plastics more generally, the action plan intends to develop and implement an Extended Stakeholder Responsibility (ESR) system, mainstream circular economy (CE) and sustainable consumption and production (SCP) initiatives, enhance recovery and recycling coverage and markets, prevent leakage from collected or disposed waste, reduce maritime sources of marine litter and manage litter that is already existing in the riverine and marine environments, enhance the development and enforcement of policies for marine litter prevention and management, develop and implement strategic and targeted social marketing and communications campaigns, ensure sufficient financing, and build local capacity.

Furthermore, **the Single-Use Plastic Products Regulation Act HB9147, 2021**, mandates a phase-out of non-compostable single-use plastic products such as cutlery, plates, and sachets within a four-year period. Additionally, single-use plastic products like drinking straws and confetti are to be phased out within one

[34] The National Plan of Action for the Prevention, Reduction and Management of Marine Litter, 2021.

[35] The Marine Pollution decree of 1976.

[36] The Total Plastic Bag Ban Act of 2011.

year from the Act's implementation. This implies that the production, import, sale, distribution, provision, or use of these plastic products will be prohibited after these periods. The phase-out timeline will be supported by measures such as raising public awareness, making alternative products available, implementing producer responsibility schemes, and providing rewards and incentives. Businesses that fail to comply with this Act will be subject to fines and penalties.

The Total Plastic Bag Ban Act of 2011 also prohibited groceries, supermarkets, public markets, restaurants, fast food chains, department stores, retail stores and other similar establishments from using non-biodegradable plastic bags.

Moreover, under the provisions of **FDA Circular No. 2019-004,** the production, import, and distribution of infant feeding bottles and sippy cups containing Bisphenol A (BPA) are prohibited. All relevant establishments are granted a six-month phase-out period to withdraw from the market all infant feeding bottles and sippy cups containing BPA. Any establishment found to be in breach of this directive will face sanctions and penalties.

Philippine Ecological Solid Waste Management Act of 2000 (Republic Act (RA) 9003) also aimed to formulate and implement a National Solid Waste Management Framework that would include a recycling program for plastics.

Finally, already in 1976, **the Marine Pollution Decree of 1976, Presidential Decree (PD) 979** was formulated to prevent and control pollution of the seas in the Philippines. This Decree prohibited the dumping of wastes and other matter that could harm human health and marine life.

6.9 Singapore

Singapore currently has one national government policy in place directly addressing microplastics: The National Action Strategy Addressing Marine Litter in Singapore, 2022, which confirms Singapore's commitment to tackling microplastics by reducing land-based sources of litter, promoting research and development, and employing innovative technologies such as Membrane Bioreactor (MBR) systems at water reclamation plants.

For this baseline study, we identified 12 national policies related to micro- and macroplastics or waste management in Singapore, all of which are included in this review (see Appendix for the full list). While only one of these policies directly target microplastics, other policy measures may also indirectly have an effect on microplastic pollution, such as Singapore's vision of becoming a Zero Waste Nation through adopting circular economy and 3R principles (The Singapore Green Plan 2030), reduce the amount of waste sent by landfills by 30% and reach a recycling rate of 70% by 2030 (The Zero Waste Masterplan Singapore 2019), and introduce a Producer Responsibility Scheme (The Singapore Resource Sustainability Act 2019 (Revised in 2021). The following sections provides a summary of the most significant policies that may directly and indirectly have an effect on microplastic pollution in Singapore.

The National Action Strategy Addressing Marine Litter in Singapore, 2022, summarizes and outlines Singapore's actions and measures to combat the issue of marine litter, categorized into six priority areas: 1) Reduction of Land-Based Sources of Litter, 2) Reduction of Sea-Based Sources of Litter, 3) Circular Economy Approach, 4) Research and Development, 5) Maintaining and Strengthening Outreach and Stakeholder Engagement, and 6) International Engagement and Collaboration. With regards to microplastics, the Strategy document outlines that Singapore's National Water Agency already ensures all wastewater is collected and treated at water reclamation plants (WRPs) in line with internationally recognized discharge standards. During this treatment process, microplastics, including microbeads, are extracted as sludge and subsequently incinerated. The National Water Agency is planning to expand the

use of membrane bioreactor (MBR) technology systems at its WRPs to further reduce the discharge of microplastics into the sea. The Action Strategy also proudly notes that "Singapore has a range of waterway clean-up measures that prevent litter or plastic waste, regardless of source, from being washed into the ocean" (p. 7). Furthermore, the Strategy outlines various research projects on microplastics that it has engaged in. Beyond the promotion of research and use of technologies, the Strategy does not introduce any specific policy measures on primary microplastics, or plastics in general.

In 2021, the **Singapore Green Plan 2030** was introduced to promote sustainable development and environmental protection. The policy confirms Singapore's vision of becoming a Zero Waste Nation powered by a circular economy and 3R principles. The policy set out two key targets: Reduce the amount of waste going to landfill by 20 % per capita per day by 2026, and by 30% by 2030.

The Singapore Prevention of Pollution of the Sea Act 1990 was also revised in 2021, and it prohibits the discharge of waste, incl. plastics, from ships. Violations are subject to a fine not exceeding $20,000 or to imprisonment for a term not exceeding 6 months or to both.

Six policies related to plastics and waste management were introduced or revised in 2020, indicating growing attention to these challenges in the country. Most importantly, this included the **Singapore Resource Sustainability Act 2019 (revised in 2020),** which requires producers of plastic packing to submit a plan to reduce, re-use or recycle packaging in Singapore (whether or not the packaging is imported or used by the producer). The act also introduced a producer responsibility scheme and stipulates that applications for a license to operate a producer responsibility scheme must be made to the Agency.

In 2019, the Zero Waste Masterplan Singapore was enacted, outlining the vision of becoming a Zero Waste Nation. The masterplan set the target to reduce the amount of waste (per capita) sent to landfill by 30% and achieve a 70% overall recycling rate by 2030.

Furthermore, **the Singapore Packing Agreement 2007 (revised in 2017)** may be of relevance to microplastic pollution, as it sets out to reduce packing waste from consumer products, including plastics, through awareness raising activities, and the introduction of supply chain initiatives that foster the sustainable use of resources in packaging.

6.10 Thailand

Thailand has launched ambitious policy measures to address microplastics, including a prohibition on the production, import, and sale of cosmetics containing plastic microbeads, as stipulated in a 2019 amendment to the Cosmetic Product Act, B.E. 2558 (2015). In addition, Thailand's Roadmap on Plastic Waste Management 2018-2030 outlines a phased strategy to ban other products containing microbeads, as further described below.

In this baseline study, 8 national policies related to plastics or general waste management in Thailand were identified, two of these were not available in English and thereby not included for a full review (see Appendix for full list).

The most ambitious policy on plastic pollution is **Thailand's Roadmap on Plastic Waste Management 2018-2030**. The aim of this roadmap is to serve as a framework for preventing and managing plastic waste in the country, through adopting five principles: a life cycle approach, 3R, public private partnership, circular economy, and responsible consumption and production. The implementation of the roadmap has been divided into three phases: Phase I: in 2019, ban the use of cap seal, OXO-degradable plastics and plastic microbeads. Phase II: in 2022, ban foam food containers, plastic straws, plastic bags thicker than

36 micron and plastic cup thicker less than 100 microns. And phase III: by 2027, 100 % of plastic waste will be reusable/recycled[37].

Furthermore, in 2019, the Ministry of Public Health announced an **amendment to the Cosmetic Product Act, B.E. 2558 (2015),** to prohibit the production, import, and sale of cosmetics containing plastic microbeads (small, synthetic, water-insoluble plastics with a particle size of less than 5 millimeters, which do not naturally decompose). This regulation came into effect from 1 January 2020 onwards.

The Public Private Partnership for Sustainable Plastic and Waste Management (PPP Plastics) is a government initiative launched in 2018 to support and promote a roadmap for the plastic waste management to reduce the amount of plastic waste in Thailand's seas by 2027. The PPP Plastics sets out two key goals: 1) Reducing and eliminating the use of target plastics, and 2) Reuse the targeted plastic waste 100% by 2027. To achieve this, the initiative consists of 6 pillars, focusing on: 1) the circular economy, 2) policy and legislative development, 3) developing a plastic waste database, 4) education & communication, 5) innovation and 6) funding.

Beside these policies, the **Marine Fisheries Management Plan of Thailand 2020-2022** aims to reduce the use of plastic bag in commercial fishing vessels to reduce marine debris, while the **Act on the Maintenance of the Cleanliness and Orderliness of the Country, B.E. 2535 (1992)** prohibits the disposal of waste, such as plastic bags, in public places or onto the road or waterway in Thailand. Finally, **the Enhancement and Conservation of National Environmental Quality Act (No. 2) B.E. 2561 (2018)** stipulates that projects without environmental impact assessments (EIA) approval may face penalties, to ensure that development projects evaluate their potential environmental effects.

6.11 Viet Nam

Viet Nam has four policies directly targeting microplastics, aiming to gradually phase out production and import of goods containing microplastics by 2030 (Decree No. 08/2022/ND-CP), identify solutions for plastic microbeads in wastewater andconduct research on pollution risks and impacts of plastic litter (National Action Plan for Management of Marine Plastic Litter by 2030), identify technical solutions to microplastics (Directive No. 33/CT-TTg), introduce a roadmap to reduce production, import and use of microplastics and provide information about products containing microplastics and nanoplastics to consumers (Law on Environmental Protection 2020).

For this baseline study, we identified 16 policies were addressing microplastics, plastics or waste management in Viet Nam, all of which were included in this review (see full list in the Appendix). Besides the four policy measures directly targeting microplastics, Viet Nam has also introduced a variety of other policy measures that may have an effect on microplastics, such as a ban on producing and importing certain types of non-biodegradable plastic bags by 2026 and single-use plastic products by 2030 (Decree No. 08/2022/ND-CP), ensure that all shops, markets and supermarkets in urban areas do not use single-use plastics by 2021 and the whole country by 2025 (Directive No. 33/CT-TTg), and reduce marine plastic litter by 50% by 2025, and by 75% by 2030 (National Action Plan for Management of Marine Plastic Litter by 2030). A summary of the most significant policies that may directly and indirectly have an effect on microplastic pollution in Viet Nam is provided in the following sections.

In 2022, the **Decree No. 08/2022/ND-CP on elaboration of several Articles of the Law on Environmental Protection** was enacted, to further improve measures for protecting the environment. In terms of microplastics, the decree stipulated that the production and import of products and goods containing microplastics shall be gradually reduced and terminated after December 31, 2030. With

[37] Available at: https://enviliance.com/regions/southeast-asia/th/th-waste/th-plastic-waste (accessed 12.02.2024).

regards to plastics in general, Article 64 of the decree also introduced three key activities: 1) As of January 01, 2026, it is not permitted to produce and import non-biodegradable plastic bags with dimensions less than 50 cm x 50 cm and a wall thickness of less than 50 μm. 2) Producers and importers of single-use plastic products and non-biodegradable plastic packaging shall fulfill the responsibility for recycling and treatment. 3) The production and import of single-use plastic products and non-biodegradable plastic packaging shall be gradually reduced. After December 31, 2030, the production and import of single-use plastic products non-biodegradable plastic packaging shall be terminated. (Exemptions apply to item 1 and 3).

In 2022, Viet Nam also adopted a **Scheme for Environmental Protection in Fishery Sector** in the period of 2021-2030, which sought to control, prevent, monitor, and manage pollution and waste (including plastic litter) from fishery activities. This will be achieved by increasing relevant actors' awareness of environmental protection in fishery activities, carrying out scientific development and applying new technologies to improve waste treatment, investing in infrastructure facilities for collection, storage, treatment and transport of waste, monitoring systems, ensure the enforcement of policies and laws on environmental protection, promoting international and national cooperation with relevant stakeholders and mobilizing resources.

In 2020, the Government of Viet Nam adopted two national action plans related to plastic waste and sustainable consumption. The first, **the National Action Plan for Management of Marine Plastic Litter by 2030** was an ambitious plan, aiming to "eliminate plastic litter from land-based and ocean-based sources, and strive to become a pioneering country in mitigation of marine plastic litter in the region" (Government of Viet Nam, 2020a: 6). Importantly, the action plan outlined the specific objectives to reduce marine plastic litter by 50% by 2025, and by 75% by 2030. In terms of microplastics, the Action Plan outlined two key objectives: Developing solutions to plastic microbeads from wastewater of urban areas and industrial parks, and conducting more research on the pollution risks and impacts of plastic litter, especially plastic microbeads.

The National Action Plan on Sustainable Consumption and Production (2021-2030) aimed to develop a policy on promotion of production, distribution and consumption of ecofriendly packaging to replace and limit single-use, non-degradable plastic items at supermarkets and commercial centers and wet markets, reduce resources used for production of plastics, and apply, disseminate, and replicate good practices on efficient use of resources and cleaner productions in the sectors, limit use of single-use, non-degradable plastic items at wet markets, supermarkets & commercial centers, and outlet stores of enterprises. Furthermore, it aimed to develop training materials, deliver training, communication, and guidelines on implementation of circular economy models for waste, particularly waste in sectors like plastics, and develop economic/technical norms, guidelines on audit of use efficiency of resources, materials, fuel, energies for production establishments in enterprises like plastics. The Action Plan outlined two key objectives: 1) By 2030: 100% of supermarkets and commercial centers distribute and use eco-friendly packaging which gradually replaces single-use, non-degradable plastic items. 2) By 2030: 7-10% decrease in resources and materials used for production sectors such as plastics.

In 2020, **Directive No. 33/CT-TTg called for the strengthening of management, reuse, recycling, disposal and reduction of plastic waste**. This directive had three specific objectives linked to microplastics, aiming to: research and building environmental technical barriers to products and commodities containing microplastics, nanoplastics and plastic bags; research and propose a roadmap to ban the use of microplastics in the production of cosmetics, garments, and fertilizers, etc.; and conduct a review and announcement of domestically produced and imported products containing microplastics and nanoplastics for consumers' information. The directive also confirmed a commitment to work towards the goal of eliminating the use of single-use plastics in the country by 2025. To achieve this, the directive emphasized the importance of ensuring the enforcement of existing laws and regulations related to

plastic waste, issuing new directives or plans to reduce, reuse and recycle plastic waste, promoting a circular economy in plastics, conducting awareness raising and public information campaigns, and working with actors in the private sector and social and international organizations on plastic waste reduction and management, promoting research and technological development. These policy measures will work to ensure that by 2021: shops, markets and supermarkets in urban areas do not use single-use plastics, and by 2025: the whole country do not use single-use plastics.

The Government of Viet Nam also adopted a new **Law on Environmental Protection in 2020**, which aims to introduce a roadmap for reducing the production and import of single-use plastic products, non-biodegradable plastic packaging and products and goods containing microplastics. The law also regulates plastic waste in a variety of ways, aiming to reduce, reuse, recycle and treat plastic waste, prevent and control ocean plastic waste pollution, and stipulates that tourists must limit the generation of plastic waste.

In 2018, the Government adopted **Resolution No. 36NQ/TW on Strategy for Sustainable Development of Viet Nam's Ocean Economy by 2030**, with visions towards 2045, which aimed to prevent, control and dramatically reduce sea pollution, especially from plastic waste, and ensure that 100% of household solid waste is collected and disposed according to environmental standards at coastal provinces and cities. This resolution was followed up by a Master Plan and 5-year implementation plan adopted in 2020, which aimed to improve the management of plastic marine waste, including the formulation and launch of a national action plan for the management of marine plastic waste, the formulation of regional and international cooperation frameworks for prevention, control and reduction of marine plastic litter, and establishment of an international marine plastic litter center in Viet Nam.

Order No. 14/2010/L-CTN on the promulgation of the Law on Environmental Protection Tax introduced an environmental protection tax rate of 30.000-50.000 VND per kg of taxable plastic bags, targeting producers and importers of plastic bags.

Decision No. 491/QD-TTg dated May 07, 2018 approving adjustments to national strategy for general management of solid waste to 2025 with vision towards 2050, introduced a target stipulating that by 2025, 100% environmentally friendly plastic bags would be used in trade centers and supermarkets to replace persistent plastic bags, by 2026, the import, export and provision of types of persistent plastic bags used in daily life would be phased out, and 90% of daily-life solid waste discharged in urban centers will be collected and treated satisfying the environmental protection requirement.

Finally, we will here highlight **Decision No. 2149/QD-TTg - Approving the National Strategy for Integrated Management of Solid Waste up to 2025, with a Vision to 2050**, enacted in 2009. This policy aimed to strive towards the achievement that "by 2050, all arising solid waste will be collected, reused, recycled and thoroughly treated with advanced and environment friendly technologies appropriate to actual conditions of each locality" (p. 1). The policy set out to gradually reduce the quantity of plastic bags used in supermarkets and trade centers by 40% (by 2015), 65% (by 2020) and 85% (by 2025) compared to 2010. To achieve this, incentive regulations and policies to reduce, reuse and recycle waste, would be promulgated, and communication campaigns to raise public awareness would be conducted at schools, communities and business establishments.

7 Knowledge gaps and recommended actions

The microplastic topic has become increasingly important among the ASEAN scientific community, especially since 2020 as mentioned earlier in this report. There are many advances, but also knowledge gaps in the region and we will highlight the most important gaps in this section.

7.1 Regional gaps

Despite the ASEAN region being composed of 10 countries, 87% of the scientific literature included in this baseline came from, or focused on, four countries, namely Indonesia (31.6%), Thailand (24.1%), Malaysia (17.0%) and Viet Nam (14.6%) (Figure 24). Those four countries are among the five largest countries of ASEAN, nevertheless, more research and knowledge are needed in all countries to put efficient regional and national measures in place. This is especially relevant for stakeholders and policies that aim to tackle microplastic pollution in ASEAN globally.

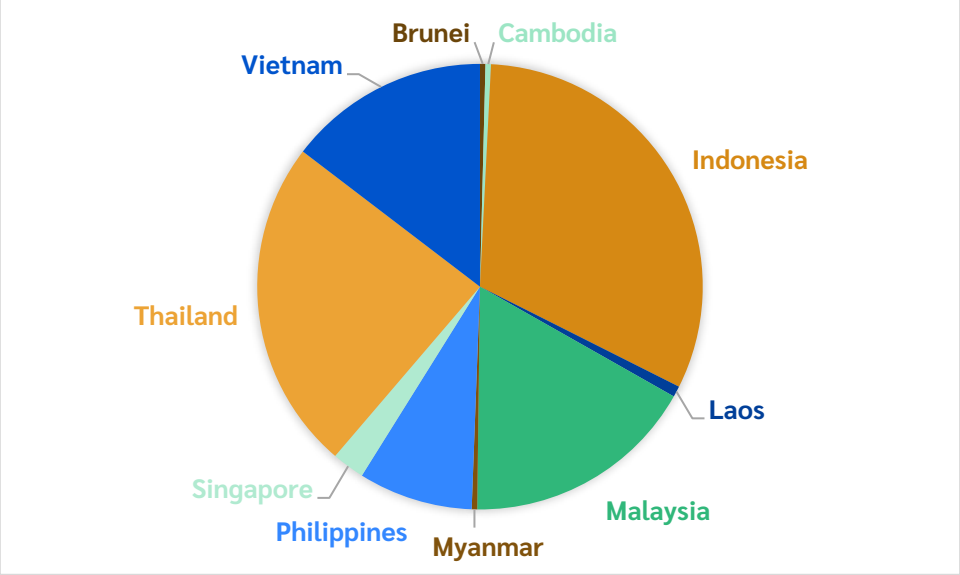

Figure 24. Distribution of scientific studies on microplastic pollution per country.

Within the most studied countries, some regions are greatly studied compared to others. The examples of Malaysia and Indonesia show the spatial heterogeneity of research on microplastic (Figure 8 and Figure 24). In Indonesia, the island of Java and the Aceh region have gathered most of the scientific interest while larger areas such as the Kalimantan provinces show less scientific scrutiny.

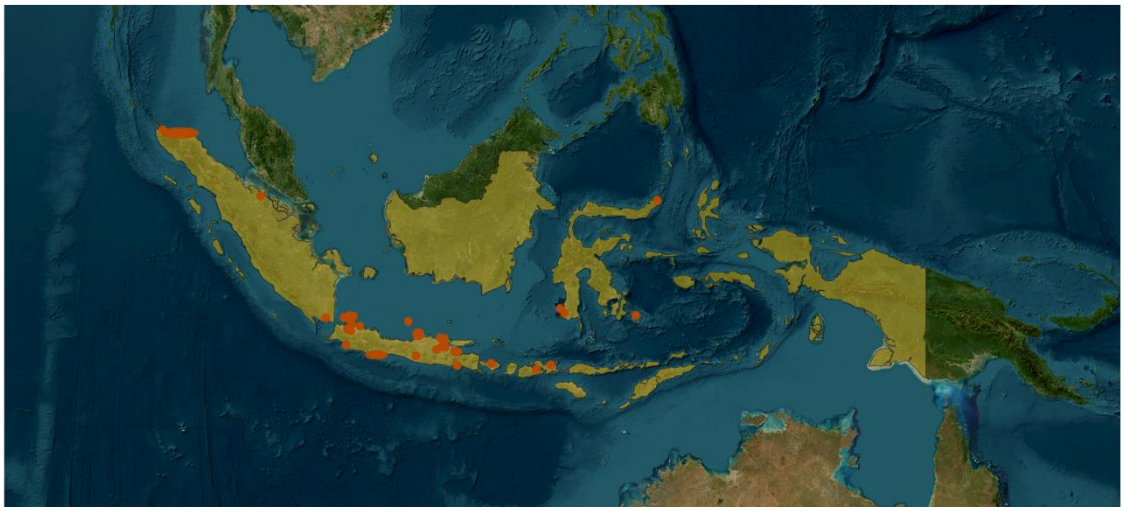

Figure 25. Map showing the spatial distribution of research on microplastic pollution in Indonesia. Each red dot represents a sampling location.

7.2 Abiotic compartments

Studies in Indonesia give a good example on the different matrices sampled and where the focus had been put so far in the region (Figure 6). Considering abiotic compartments only, water and sediment attracted most of the attention of the scientific community.

The word “water” includes here fresh, marine, urban, run-off and wastewater, but fresh -or riverine- and marine waters represent the majority of the studies performed in ASEAN waters. While wastewater constitutes an undoubtedly source of MPs to the environment (Table 1), only a few studies have investigated that source, all ASEAN countries included. Urban and run-off waters also constitute a source of MPs but have also been overlooked. We therefore recommend to further study the concentrations, shapes and polymers occurring in those waters to better understand those sources.

Regarding sediment, beach sediment was more studied than river and marine sediment, probably because an easier access to beaches then river- and seabed. Beaches are known to be accumulation zones for plastic, however river- and, more specifically, marine sediment constitute a sink for plastic, including MP. It is therefore of utmost importance to monitor that compartment, both for macro- and microplastic. The benthic ecosystems are extremely important ecologically, but also economically for the surrounding countries as it provides seafood such as fish, bivalves and crabs.

Terrestrial ecosystems are scarcely studied in ASEAN, following the global trend. Marine and aquatic environments have gained most of the attention so far. However terrestrial ecosystems are contaminated in plastic, a good example being agricultural soils (Nizzetto et al., 2016). Such contamination has negative impacts on soil properties (e.g. Chia et al., 2022) but also on plants growing on these soils, by for example impairing the growth and yield (e.g. Qiu et al., 2023). This pollution should be first understood before measures can be put in place to prevent negative impacts on production. Further studies are needed on soils, and more largely on terrestrial ecosystems.

Directly related to agricultural soils, wastewater and sludge constitute a knowledge gap despite their role as a source of MPs to agricultural soils. WWTPs are not efficient enough to remove all the MPs from the wastewater, with low percentages of removal mentioned in ASEAN (Chen et al., 2022). In addition, the sludge from those WWTPs, that can contain high loads of MPs, is used in land application such as

agriculture (e.g. Reza et al., 2023). The investigation MP contamination in WWTP effluent but also in sludge is still scarce in the region and should be prioritized.

7.3 Biota

Regarding living organisms, several knowledge gaps exist in ASEAN. First, top predators are poorly studied despite that they are sentinel species and they therefore attest of the ecosystems' health. Even though access to those wild animals is challenging to put in place, the use of by-caught and stranded/beached animals could be organized in collaboration with fishermen and local authorities. Similarly to the abiotic compartments, the benthic organisms are overlooked at the moment and their contamination in MPs is unclear. Among those benthic organisms, many are invertebrates. Invertebrates are also scarcely studied in ASEAN as the focus has been put on fish, for obvious reasons. However, those organisms are extremely important as they are part of every food web in the marine environment and are prey of many commercial fish species. Some of those are also directly consumed by humans and could be a direct source of MPs to the ASEAN population.

7.4 Human exposure

The ASEAN population is exposed to MPs in several ways, like anywhere else in the world. Air (e.g. Gasperi et al., 2018), food (reviewed in Wang et al., 2020), drinking water and other beverages (e.g. Liebezeit and Liebezeit, 2014; Diaz-Basantes et al., 2020; Kasim et al., 2023), and hygiene products (e.g. Praveena et al., 2018) constitute major sources of MPs to the human population worldwide. Evidence of MP contamination in air is globally multiplying and there is also evidence that air is contaminated in ASEAN, for example offshore of Viet Nam and the Philippines (Liu et al., 2023), but also in big cities such as Manila in the Philippines (Romarate et al., 2023) and Ho Chi Minh City, in Viet Nam (Truong et al., 2021). However, knowledge is overall lacking in ASEAN and more studies are needed to understand the sources and dynamics of MPs in the atmosphere.

MP contamination in food and beverages is focusing on seafood, and mostly on fish in the ASEAN region. Indonesia and Thailand are leading the research on this topic in terms of number of studies. As mentioned previously, invertebrates are poorly studied throughout the region and MP contamination in bivalves, shrimps, crabs and other invertebrates is a knowledge gap that should be filled in for the sake of food safety.

In addition, when fish are analyzed for MP contamination, it is usually the digestive tract -or a part of it- that is analyzed. However, even though the gut is sometimes eaten, the fillet, or muscle, is certainly more consumed than any other part of the fish. Occurrence of MPs in another tissue than the gut is almost unknown despite its link with food safety.

7.5 Experimental and modeling studies

An overwhelming majority of the scientific articles included in this baseline are research articles investigating in situ samples collected in the field. Those studies are important and constitute the first step towards mitigation measures. They also implement modeling and experimental studies by providing

actual data observed in the field and consequently of ecological relevance to both modeling and experimental studies. Both are lacking in ASEAN. Modeling studies can help to understand the dynamic of MPs in the environment while experimental studies will help in assessing the impacts caused by MPs on certain species for instance. As an example, Pflugmacher et al. (2021) showed that higher numbers or concentrations do not mean higher negative impacts on organisms. They provided an interesting perspective on the impacts MP pollution on wheat plants where they used aged secondary MPs from two different regions (Finland and Singapore). Such studies provide a comprehensive approach on the potential impacts of different MPs on a commercially important species. Both experimental and modeling studies can help in prioritizing vulnerable species, hazardous MPs or punctual sources as parts of a potential mitigation plan. We therefore recommend to develop such studies in ASEAN.

7.6 Recommended actions

Microplastic pollution is a global threat to our environment and health. Due to their ubiquity and persistence, tackling this problem is a huge challenge involving, among others, cross-cutting domains ranging from technology, governance, infrastructure, behavioral change to economic incentives. Nevertheless, we propose several actions as starting points that researchers, stakeholders and policy makers can take to reduce plastic related pollution in ASEAN.

Investigating first the occurrences and quantities of MPs in the organisms or the abiotic compartment is essential to provide numbers that can afterwards be implemented in models and experimental studies. Such information is also necessary to prioritize regions, matrices or species to monitor, to further inform stakeholders. All those baseline studies should use harmonized methods to improve their reliability and the comparability between them. Harmonization of methods is currently lacking in ASEAN and should be the first step in tackling MP pollution in the region. Scientific research on key compartments, key species and main sources cited hereabove should be promoted for a better mapping of this pollution and consequently to set a reliable basis for prioritization of regions, species or matrices to be monitored.

The major sources of microplastics are known and they should be the target of the mitigation measures: marine macroplastic degradation including fishing gear, WWTPs and the related sources (for instance washing machine effluents, cosmetics) and tires, among others. Here after we detail possible mitigation measures towards MP pollution.

- Mitigation strategies on improving management of drainage from roads, re-routing discharges from domestic and industrial areas to waste water treatment plants (WWTP) are needed. Targeted MPs: degradation products from macrolitter and tire rubber particles.

- Upgrading and installation of new WWTPs to improve the removal efficiency of MPs from wastewater. Targeted MPs: microbeads from cosmetics and textile fibers from washing machine effluents.

- Investigation and monitoring of MP contamination in WWTP sludge, and consequent improvement of the WWTP system to prevent a high contamination of MP in sludge that will be further used on agricultural soils. Targeted MPs: microbeads from cosmetics and textile fibers from washing machine effluents.

- Mitigation strategies to prevent macroplastic ending up in the environment. For example:

- More infrastructure to collect, handle and recycle plastic waste are needed. Targeted MPs: degradation products from macrolitter.
- Reduce or ban the use of MPs in cosmetics. Targeted MPs: microbeads from cosmetics.
- Reduce or ban single-use plastics where possible. Targeted MPs: degradation products from macrolitter.
- Outreach measures in schools and public places to raise awareness. Targeted MPs: degradation products from macrolitter.

- Mitigation strategies to remove macroplastic from the environment. For example:
  - More floating barriers along rivers should be set and regularly cleaned. Targeted MPs: degradation products from macrolitter.
  - Clean-up activities in river, riverbanks, beaches, cities, etc. should also be implemented. Targeted MPs: degradation products from macrolitter.
  - More collaboration with fishing vessels of medium and large size is recommended in order to, for example, encourage them to report lost fishing gear. Targeted MPs: degradation products from macrolitter from fishing activities.
  - Establishment of a reward system for fishermen who bring back on land litter they collected while fishing (similar system than *Fishing for Litter*[38] in Europe). Targeted MPs: degradation products from macrolitter from fishing activities.

[38] *Fishing for Litter – Working with fishermen to clean our seas*

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10 Appendix

Table S1. List of all the articles published in English, in scientific journals, focusing on microplastic pollution in ASEAN and considered in this baseline study.

ASEAN Countries	Authors	Year	Title	Location	Environment	Sample type	DOI
Global	Curren et al.	2021	Marine microplastics in the ASEAN region: A review of the current state of knowledge		Marine	Review	10.1016/j.envpol.2021.117776
Global	Omeyer et al.	2023	Interactions between marine megafauna and plastic pollution in Southeast Asia		Global	Review	10.1016/j.scitotenv.2023.162502
Global	Omeyer et al.	2022	Priorities to inform research on marine plastic pollution in Southeast Asia		Global	Review	10.1016/j.scitotenv.2022.156704
Indonesia, Viet Nam, Thailand, Philippines	Sin et al.	2023	A Review of the Current State of Microplastic Pollution in South Asian Countries		Global	Review	10.3390/su15086813
Cambodia, Indonesia, Laos, Philippines, Viet Nam	Tun et al.	2022	Microplastics in dumping site soils from six Asian countries as a source of plastic additives		Dumping sites	Soil	10.1016/j.scitotenv.2021.150912
Viet Nam, Philippines	Matsushita et al.	2022	Fate of river-derived microplastics from the South China Sea: Sources to surrounding seas, shores, and abysses		Marine	Modeling	10.1016/j.envpol.2022.119631
Global	Chen et al.	2021	Microplastic pollution in freshwater systems in Southeast Asia: contamination levels, sources, and ecological impacts		Freshwater	Review	10.1007/s11356-021-15826-x
Brunei	Lee et al.	2022	Microplastic accumulation in oysters along a Bornean coastline (Brunei, South China Sea): Insights into local sources and sinks	Bornean coastline	Marine	Organisms	10.1016/j.marpolbul.2022.113478
Cambodia	Haberstroh et al.	2021	Plastic transport in a complex confluence of the Mekong River in Cambodia	Mekong River	Freshwater	Water	10.1088/1748-9326/ac2198
Indonesia	Rochman et al.	2015	Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption	Makassar	Marine	Organisms	10.1038/srep14340

Indonesia	Manalu et al.	2017	Microplastics abundance in coastal sediments of Jakarta Bay, Indonesia	Jakarta Bay	Marine	Sediment	-
Indonesia	Syakti et al.	2017	Beach macro-litter monitoring and floating microplastic in a coastal area of Indonesia	Coastal area	Marine	Water	10.1016/j.marpolbul.2017.06.046
Indonesia	Syakti et al.	2018	Simultaneous grading of microplastic size sampling in the Small Islands of Bintan water, Indonesia	Small Islands of Bintan water	Marine	Water	10.1016/j.marpolbul.2018.11.005
Indonesia	Alam et al.	2019	Microplastic distribution in surface water and Sediment river around slum and industrial area (case study: Ciwalengke River, Majalaya district, Indonesia)	Ciwalengke River, Majalaya district	Freshwater	Water and Sediment	10.1016/j.chemosphere.2019.02.188
Indonesia	Cordova et al.	2019	Abundance and characteristics of microplastics in the northern coastal waters of Surabaya, Indonesia	Surabaya	Marine	Waters	10.1016/j.marpolbul.2019.03.040
Indonesia	Handyman et al.	2019	Microplastics Patch Based on Hydrodynamic Modeling in The North Indramayu, Java Sea	Java Sea	Marine	Modeling	10.15244/pjoes/81704
Indonesia	Hamra & Patria	2019	Microplastic in Gonggong snails (*Laevistrombus turturella*) and sediment of Bintan Island, Kepulauan Riau Province, Indonesia	Bintan Island	Marine	Sediment and organisms	10.1063/1.5141692
Indonesia	Khoironi et al.	2019	Evaluation of the Interaction Among Microalgae *Spirulina* sp, Plastics Polyethylene Terephthalate and Polypropylene in Freshwater Environment		Freshwater Environment	Organisms	10.12911/22998993/108637
Indonesia	Lestari and Trihadiningrum	2019	The impact of improper solid waste management to plastic pollution in Indonesian coast and marine environment	Java, several locations	Marine	Literature-based data (macro and micro)	10.1016/j.marpolbul.2019.110505
Indonesia	Yona et al.	2019	Microplastics in the surface Sediment from the eastern waters of Java Sea, Indonesia.	Java Sea, eastern waters	Marine	Sediment	10.12688/f1000research.17103.1

Indonesia	Bahrina et al.	2020	An Occupant-Based Overview of Microplastics in Indoor Environments in the City of Surabaya, Indonesia	Surabaya	Atmospheric	Dust	10.12911/22998993/126876
Indonesia	Cordova et al.	2020	Microplastics ingestion by blue panchax fish (*Aplocheilus sp.*) from Ciliwung Estuary, Jakarta, Indonesia	Ciliwung Estuary, Jakarta	Brackish	Organisms	10.1016/j.marpolbul.2020.111763
Indonesia	Falahudin et al.	2020	The first occurrence, spatial distribution and characteristics of microplastic particles in Sediment from Banten Bay, Indonesia	Banten Bay	Marine	Sediment	10.1016/j.scitotenv.2019.135304
Indonesia	Firdaus et al.	2020	Microplastic pollution in the Sediment of Jagir Estuary, Surabaya City, Indonesia	Surabaya City, Jagir Estuary	Brackish	Sediment	10.1016/j.marpolbul.2019.110790
Indonesia	Khoironi et al.	2020	Evaluation of polypropylene plastic degradation and microplastic identification in Sediment at Tambak Lorok coastal area, Semarang, Indonesia	Tambak Lorok coastal area, Semarang	Marine	Sediment	10.1016/j.marpolbul.2019.110868
Indonesia	Lestari et al.	2020	Distribution of microplastics in Surabaya River, Indonesia	Surabaya River	Freshwater	Water	10.1016/j.scitotenv.2020.138560
Indonesia	Patria et al.	2020	Microplastic Ingestion by Periwinkle Snail Littoraria scabra and Mangrove Crab Metopograpsus quadridentata in Pramuka Island, Jakarta Bay, Indonesia	Pramuka Island, Jakarta Bay	Marine	Organisms	10.17576/jsm-2020-4909-13
Indonesia	Sembiring et al.	2020	The Presence of Microplastics in Water, Sediment, and Milkfish (*Chanos chanos*) at the downstream Area of Citarum River, Indonesia	Citarum River	Freshwater	Water, sediment and organisms	10.1007/s11270-020-04710-y
Indonesia	Ali et al.	2021	Existence of Microplastics in Indonesia's Surface Water: A Review		Freshwater and marine	Water	10.30880/ijie.2021.13.03.012

Indonesia	Andreas et al.	2021	Microplastic contamination in the Skipjack Tuna (Euthynnus affinis) collected from Southern Coast of Java, Indonesia	Southern Coast of Java	Marine	Organisms	10.1016/j.chemosphere.2021.130185
Indonesia	Argeswara et al.	2021	What's in the soup? Visual characterization and polymer analysis of microplastics from an Indonesian manta ray feeding ground	Nusa Penida, Bali	Marine	Water	10.1016/j.marpolbul.2021.112427
Indonesia	Azizi et al.	2021	Microplastic pollution in the sediment of Jakarta Bay, Indonesia	Jakarta Bay	Marine	Sediment	10.1088/1755-1315/930/1/012010
Indonesia	Buwono et al.	2021	Contamination of microplastics in Brantas River, East Java, Indonesia and its distribution in gills and digestive tracts of fish *Gambusia affinis*	Brantas River	Freshwater	Organisms	10.1016/j.emcon.2021.08.002
Indonesia	Buwono et al.	2021	Distribution of microplastic in relation to water quality parameters in the Brantas River, East Java, Indonesia	Brantas River	Freshwater	Water	10.1016/j.eti.2021.101915
Indonesia	Cordova et al.	2021	Characterization of microplastics in mangrove Sediment of Muara Angke Wildlife Reserve, Indonesia	Muara Angke Wildlife Reserve	Wetlands	Sediment	10.1016/j.marpolbul.2021.112012
Indonesia	Dia et al.	2021	Microplastic analysis of big eyes tuna (*Thunnus obesus*) landed at the port of fish in Wakatobi	Wakatobi	Marine	Organisms	10.29244/jitkt.v13i2.34871
Indonesia	Dwiyitno et al.	2021	Influence of various production methods on the microplastic contamination of sea salt produced in Java, Indonesia	West Java (Losarang and Kecamatan Pangenan)		Salt	10.1007/s11356-021-14411-6
Indonesia	Girard et al.	2021	Sponges as bioindicators for microparticulate pollutants?	North Sulawesi	Marine	Organisms	10.1016/j.envpol.2020.115851
Indonesia	Luqman et al.	2021	Microplastic Contamination in Human Stools, Foods, and Drinking Water Associated with Indonesian Coastal Population	Surabaya	Coastal	Human stool	10.3390/environments8120138

Indonesia	Natsir et al.	2021	Analysis on microplastics in dug wells around Tamangapa Landfills, Makassar City, Indonesia	Makassar City, Tamangapa Landfill	Terrestrial	Water	10.1016/j.gaceta.2020.12.024
Indonesia	Nurhasanah et al.	2021	Micro- and mesoplastics release from the Indonesian municipal solid waste landfill leachate to the aquatic environment: Case study in Galuga Landfill Area, Indonesia	Caluga Landfill Area	Terrestrial	Water	10.1016/j.marpolbul.2021.111986
Indonesia	Radityaningrum et al.	2021	Microplastic contamination in water supply and the removal efficiencies of the treatment plants: A case of Surabaya City, Indonesia	Surabaya City	Waste water treatment plants	Water	10.1016/j.jwpe.2021.102195
Indonesia	Sawalman et al.	2021	MICROPLASTIC ACCUMULATION IN ECONOMICALLY IMPORTANT FISH SPECIES FROM BARRANGLOMPO ISLAND WATERS, MAKASSAR	Barranglompo Island Waters, Makassar	Marine	Organisms	10.29244/jitkt.v13i2.34587
Indonesia	Susanti et al.	2021	The Evidence of Microplastic Contamination in Central Javanese Local Ducks from Intensive Animal Husbandry	Central Java Province	Husbandry	Organisms	10.1007/s11270-021-05142-y
Indonesia	Suteja et al.	2021	Spatial and temporal distribution of microplastic in surface water of tropical estuary: Case study in Benoa Bay, Bali, Indonesia	Bali, Benoa Bay	Brackish	Water and Sediment	10.1016/j.marpolbul.2021.111979
Indonesia	Utami et al.	2021	Microplastics as a Sedimentary component in reef systems: A case study from the Java Sea	Kepulauan Seribu	Marine	Sediment	10.1111/sed.12879
Indonesia	Vriend et al.	2021	Plastic Pollution Research in Indonesia: State of Science and Future Research Directions to Reduce Impacts				10.3389/fenvs.2021.692907
Indonesia	Wibowo et al.	2021	Microplastic Contamination in the Human Gastrointestinal Tract and Daily Consumables Associated with an Indonesian Farming Community	Highlands, West Java	Highlands	Human stool	10.3390/su132212840

Indonesia	Wicaksono et al.	2021	Distribution and Seasonal Variation of Microplastics in Tallo River, Makassar, Eastern Indonesia	Tallo River	Freshwater	Water & Sediment	10.3390/toxics9060129
Indonesia	Yoswaty et al.	2021	THE THREAT OF MICROPLASTIC WASTE IN DUMAI WATERS, PROVINCE OF RIAU, INDONESIA	Dumai city	Marine	Water, Sediment & fish	10.26471/cjees/2021/016/183
Indonesia	Adji et al.	2022	Microplastic pollution in Rawa Jombor Reservoir, Klaten, Central Java, Indonesia: accumulation in aquatic fauna, heavy metal interactions, and health risk assessment	Rawa Jombor Reservoir, Klaten, Central Java	Freshwater	Water, Sediment and organisms	10.1007/s11270-022-05572-2
Indonesia	Asadi et al.	2022	Microplastics in Wild Clams Harvested from Coastal Waters of Lamongan, Indonesia	Lamongan	Marine	Organisms	10.5614/j.eng.technol.sci.2022.54.5.6
Indonesia	Buwono et al.	2022	Oxidative stress responses of microplastic-contaminated Gambusia affinis obtained from the Brantas River in East Java, Indonesia	Brantas River in East Java	Freshwater	Organisms	10.1016/j.chemosphere.2022.133543
Indonesia	Buwono et al.	2022	Spatio-temporal patterns of occurrence of microplastics in the freshwater fish Gambusia affinis from the Brantas River, Indonesia	Brantas River	Freshwater	Organisms	10.1016/j.envpol.2022.119958
Indonesia	Cordova et al.	2022	Seasonal heterogeneity and a link to precipitation in the release of microplastic during COVID-19 outbreak from the Greater Jakarta area to Jakarta Bay, Indonesia	Greater Jakarta area to Jakarta Bay	Marine	Water	10.1016/j.marpolbul.2022.113926
Indonesia	Cordova et al.	2022	Spatiotemporal macro debris and microplastic variations linked to domestic waste and textile industry in the supercritical Citarum River, Indonesia	Citarum River	Freshwater	Water	10.1016/j.marpolbul.2022.113338
Indonesia	Liu et al.	2022	Comprehensive Effects of Temperature, Salinity, and Current Velocity on the Microplastic Abundance in Offshore Area	Including Java Island in Indonesia	Marine	Literature-based data	10.15244/pjoes/142389

Indonesia	Mahidin et al.	2022	An overview of the potential risks, sources, and analytical methods for microplastics in soil	Desktop study		Review MP in soil	10.3934/environsci.2022013
Indonesia	Mardiansyah et al.	2022	Microplastics in Grouper Fish (*Genera Epinephelus*) Gastrointestinal Tract from Pramuka Island, Seribu Islands, Indonesia	Seribu Islands	Marine	Sediment & organisms	10.12911/22998993/145466
Indonesia	Purwiyanto et al.	2022	The deposition of atmospheric microplastics in Jakarta-Indonesia: The coastal urban area	Jakarta, Coastal urban area	Terrestrial	Atmospheric	10.1016/j.marpolbul.2021.113195
Indonesia	Riani and Cordova	2022	Microplastic ingestion by the sandfish Holothuria scabra in Lampung and Sumbawa, Indonesia	Lampung and Sumbawa	Marine	Organisms	10.1016/j.marpolbul.2021.113134
Indonesia	Sabdono et al.	2022	First Evidence of Microplastics Presence in Corals of Jepara Coastal Waters, Java Sea: A Comparison Among Habitats Receiving Different Degrees of Sedimentations	Jepara coastal waters, Java Sea, Central Java	Marine	Organisms	10.15244/pjoes/139376
Indonesia	Sulistyowati et al.	2022	The occurrence and abundance of microplastics in surface water of the midstream and downstream of the Cisadane River, Indonesia	Cisadane River	Freshwater	Water and Sediment	10.1016/j.chemosphere.2021.133071
Indonesia	Syafina et al.	2022	Identification of fibrous suspended atmospheric microplastics in Bandung Metropolitan Area, Indonesia	Bandung Metropolitan Area	Atmospheric	Air	10.1016/j.chemosphere.2022.136194
Indonesia	Takarina et al.	2022	Microplastic abundance and distribution in surface water and Sediment collected from the coastal area	Ancol, Muara Baru, and Muara Angke - Muara Karang	Coastal area	Water and Sediment	10.22034/GJESM.2022.02.03
Indonesia	Cordova et al.	2023	Microplastics leaving a trace in mangrove Sediment ever since they were first manufactured: A study from Indonesia mangroves		Mangrove	Sediment	10.1016/j.marpolbul.2023.115517

Indonesia	Dapa Taka et al.	2023	Differences in Microplastic Content in Commercial Salt and Salt at the Semiringkai Coastal Local Center in Kupang City and Kupang Regency.	Kupang City and Kupang Regency		Salt	10.4103/ijcm.ijcm_67_22
Indonesia	Despasari et al.	2023	Temporal Variation of Microplastic Abundances and Characteristics in Surface Water of Banger River of Pekalongan City, Indonesia	Banger River	Freshwater	Water	10.12911/22998993/168249
Indonesia	Deswati et al.	2023	Detection of microplastic contamination in table salts in Padang City, Indonesia, and control strategies for choosing healthy salt	Padang City		Salt	10.1080/03067319.2023.2268523
Indonesia	Fauzi et al.	2023	Distribution of Microplastics in Domestic Wastewater and Microplastics Removal Potential in Wastewater Treatment Plants	Gampong Garot	Waste water treatment plants	Water	10.12911/22998993/172293
Indonesia	Haribowo et al.	2023	Assessment of Small-Scale Microplastics Abundance and Characterization in Urban River: A Case Study in Metro River, Indonesia	Metro River	Freshwater	Water	10.5614/j.eng.technol.sci.2023.55.2.6
Indonesia	Ilmi et al.	2023	Microplastic Risk Assessment in River Sediment along the Cascading Dam System (Case Study: Midstream of the Citarum River, Indonesia)	Citarum region	Freshwater	Water	10.1007/s11270-023-06370-0
Indonesia	Irnidayanti et al.	2023	Microplastics in green mussels (*Perna viridis*) from Jakarta Bay, Indonesia, and the associated hazards to human health posed by their consumption	Jakarta Bay	Marine	Organisms	10.1007/s10661-023-11535-9
Indonesia	Ismanto et al.	2023	A novel report on the occurrence of microplastics in Pekalongan River Estuary, Java Island, Indonesia	Pekalongan River	Brackish	Water & Sediment	10.1016/j.marpolbul.2023.115563
Indonesia	Ismanto et al.	2023	First evidence of microplastics in the water and Sediment of Surakarta city river basin, Indonesia	Surakarta	Freshwater	Water & Sediment	10.1016/j.marpolbul.2023.115677

Indonesia	Kasim et al.	2023	Analysis of environmental health risks from exposure to polyethylene terephthalate microplastics in refilled drinking	Makassar City	Water sources	Water	10.22034/GJESM.2023.09.SI.17
Indonesia	Kasmini et al.	2023	Microplastic contamination and growth pattern of oyster; Crassostrea gigas in a coastline	North & east coast of Aceh Province	Marine	Organisms	10.22035/gjesm.2023.04.07
Indonesia	Lestari et al.	2023	Investigation of microplastic ingestion in commercial fish from Surabaya river, Indonesia	Surabaya river	Freshwater	Organisms	10.1016/j.envpol.2023.121807
Indonesia	Mardiansyah et al.	2023	Potential of Gastropods as Bioassessment of Anthropogenic Litter Pollution in Urban Lake	Situ Gintung, South Tangerang	Lake	Organisms	10.4194/TRJFAS21266
Indonesia	Maulana et al.	2023	Microplastics contamination in two peripheral fish species harvested from a downstream river	Krueng Aceh River, Banda Aceh city		Organisms	10.22034/gjesm.2023.02.09
Indonesia	Moniuszko et al.	2023	Accumulation of Plastics and Trace Elements in the Mangrove Forests of Bima City Bay, Indonesia	Mangrove Forests of Bima City Bay	Wetlands	Soil and organisms	10.3390/plants12030462
Indonesia	Mulyasari et al.	2023	The presence of microplastics in the Indonesian environment and its effects on health		Environment and health effects	Review	10.4081/jphia.2023.2565
Indonesia	Radityaningrum et al.	2023	Performance of Conventional Drinking Water Treatment Plants in Removing Microplastics in East Java, Indonesia	East Java	Waste water treatment plants	Water	10.12911/22998993/162785
Indonesia	Rahmawati et al.	2023	Microplastic contamination in the digestive tract of sea urchins (***Echinodermata: Echinoidea*****) in Kepulauan Seribu, Indonesia**	Kepulauan Seribu	Marine	Organisms	10.1007/s10661-023-11655-2
Indonesia	Sabilillah et al.	2023	Health risk assessment and microplastic pollution in streams through accumulation and interaction by heavy metals	Code and Gajahwong streams	Freshwater	Organisms	10.22034/gjesm.2023.04.05

Indonesia	Sulardiono et al.	2023	Spatial distribution of microplastics ingested by Holothuria atra (Echinodermata: Holothuroidea) in the tourism and marine mariculture development zone, Karimunjawa, Indonesia	Karimunjawa	Marine	Organisms	10.1002/tqem.22045
Indonesia	Sulistiowati et al.	2023	MICROPLASTIC CONTAMINATION AROUND CORAL REEFS DIVING SPOT IN TIDUNG ISLAND, KEPULAUAN SERIBU, JAKARTA	Jakarta	Marine	Sediment	10.26471/cjees/2023/018/263
Indonesia	Watiniasih et al.	2023	Investigation of Microplastic Contamination in Sediment, Water and Aquatic Biota in Lake Beratan,Tabanan Regency, Bali Province-Indonesia	Lake Beratan, Tabanan Regency, Bali	Lake	Sediment, Water, organisms	10.12911/22998993/158819
Indonesia	Widyastuti et al.	2023	Microplastic Contamination in Different Marine Species of Bintaro Fish Market, Indonesia	Bintaro Fish Market	Fish market	Organisms	10.3390/su15129836
Indonesia	Rahmatin et al.	2024	The spatial distribution and physico-chemical characteristic of microplastics in the Sediment and cockle (Anadara granosa) from the coastal waters of East Java, Indonesia, and the health hazards associated with cockle consumption	East Java	Marine	Sediment & organisms	10.1016/j.marpolbul.2023.115906
Laos	Noudeng et al.	2023	Risk Assessment of Microplastics Dispersion and Accumulation in Urban Canals to the Water Environment in Vientiane Capital, Laos	Vientiane	Urban canals	Water	10.1007/s11270-023-06587-z
Malaysia	Auta et al.	2017	Screening of *Bacillus* strains isolated from mangrove ecosystems in Peninsular Malaysia for microplastic degradation	Several locations	Wetlands	Sediment	10.1016/j.envpol.2017.09.043
Malaysia	Khalik et al.	2018	Microplastics analysis in Malaysian marine waters: A field study of Kuala Nerus and Kuantan	Kuala Nerus and Kuantan	Marine	Water	10.1016/j.marpolbul.2018.07.052

Malaysia	Praveena et al.	2018	Exploration of microplastics from personal care and cosmetic products and its estimated emissions to marine environment: An evidence from Malaysia		Marine	Personal care products	10.1016/j.marpolbul.2018.09.012
Malaysia	Karbalaei et al.	2019	Abundance and characteristics of microplastics in commercial marine fish from Malaysia	Fish market	Marine/fish market	Organisms	10.1016/j.marpolbul.2019.07.072
Malaysia	Amin et al.	2020	Microplastic ingestion by zooplankton in Terengganu coastal waters, southern South China Sea	Southern South China Sea	Marine	Organisms	10.1016/j.marpolbul.2019.110616
Malaysia	Hwi et al.	2020	Microplastic abundance, distribution, and composition in Sungai Dungun, Terengganu, Malaysia	Sungai Dungun	Freshwater	Water	10.17576/jsm-2020-4907-01
Malaysia	Karbalaei et al.	2020	Analysis and inorganic composition of microplastics in commercial Malaysian fish meals		Commercial fish meals	Organisms	10.1016/j.marpolbul.2019.110687
Malaysia	Ma et al.	2020	Microplastic Pollution and Health and Relevance to the Malaysia's Roadmap to Zero Single-Use Plastics 2018-2030				10.21315/mjms2020.27.3.1
Malaysia	Periathamby et al.	2020	Status of Microplastic Pollution in Aquatic Ecosystem with a Case Study on Cherating River, Malaysia	Cherating River	Freshwater	Water	10.5614/j.eng.technol.sci.2020.52.2.7
Malaysia	Suardy et al.	2020	Analysis and Characterization of Microplastic from Personal Care Products and Surface Water in Bangi, Selangor	Bangi, Selangor		Personal care products and surface water	10.17576/jsm-2020-4909-21
Malaysia	Tee et al.	2020	Microplastic Abundance, Distribution, and Composition in Sungai Dungun, Terengganu, Malaysia	Sungai Dungun, Terengganu	Freshwater	Water	10.17576/jsm-2020-4907-01
Malaysia	Chen et al.	2021	Spatio-temporal variation of microplastic along a rural to urban transition in a tropical river	Langat River	Freshwater	Water	10.1016/j.envpol.2021.117895

Malaysia	Choong et al.	2021	Abundance and Distribution of Microplastics in the Water and Riverbank Sediment in Malaysia - A Review				10.33263/BRIAC114.1170011712
Malaysia	Choong et al.	2021	Characterization of microplastics in the water and Sediment of Baram River estuary, Borneo Island	, Borneo Island Baram River estuary	Brackish	Water and Sediment	10.1016/j.marpolbul.2021.112880
Malaysia	Hamzah et al.	2021	Ingestion of microplastics by the estuarine polychaete, Namalycastis sp. in the Setiu Wetlands, Malaysia	Setiu Wetlands	Estuarine	Organisms	10.1016/j.marpolbul.2021.112617
Malaysia	Husin et al.	2021	Evaluation of microplastics ingested by sea cucumber *Stichopus horrens* in Pulau Pangkor, Perak, Malaysia	Perak	Marine	Organisms	10.1007/s11356-021-15099-4
Malaysia	Ibrahim et al.	2021	Detection of microplastics in human colectomy specimens	Northeast Malaysia	Coastal	Human tissue (colon)	10.1002/jgh3.12457
Malaysia	Ibrahim et al.	2021	Spatiotemporal microplastic occurrence study of Setiu Wetland, South China	South and North Setiu Wetland in the South China Sea	Marine	Water and Sediment	10.1016/j.scitotenv.2021.147809
Malaysia	Praveena et al.	2021	Microplastic emissions from household washing machines: preliminary findings from Greater Kuala Lumpur (Malaysia)	Kuala Lumpur	Freshwater	Laundry water	10.1007/s11356-020-10795-z
Malaysia	Taha et al.	2021	Microplastics in seawater and zooplankton: A case study from Terengganu estuary and offshore waters, Malaysia	Terengganu estuary and offhsore waters	Brackish and marine	Seawater and organisms	10.1016/j.scitotenv.2021.147466
Malaysia	Zaki et al.	2021	Microplastic pollution in tropical estuary gastropods: Abundance, distribution and potential sources of Klang River estuary, Malaysia	Klang River estuary	Brackish	Organisms	10.1016/j.marpolbul.2020.111866
Malaysia	Zaki et al.	2021	Occurrence, abundance, and distribution of microplastics pollution: an evidence in surface tropical water of Klang River estuary, Malaysia	Klang River estuary	Brackish	Water	10.1007/s10653-021-00872-8

Malaysia	Anuar et al.	2022	Utilizing Pyrolysis-Gas Chromatography/Mass Spectrometry for Monitoring and Analytical Characterization of Microplastics in Polychaete Worms	Setiu wetlands	Wetlands	Organisms	10.3390/polym14153054
Malaysia	Chen et al.	2022	Relative contributions of different local sources to riverborne microplastic in a mixed landuse area within a tropical catchment	South-eastern edge of Greater Kuala Lumpur	Freshwater	Water	10.1016/j.envres.2022.112972
Malaysia	Foo et al.	2022	Microplastic ingestion by commercial marine fish from the seawater of Northwest Peninsular Malaysia	Penang	Fish market	Organisms	10.7717/peerj.13181
Malaysia	Praveena et al.	2022	Microplastics in Malaysian bottled water brands: Occurrence and potential human exposure	Serdang and Seri Kembangan cities	Bottled water	Water	10.1016/j.envpol.2022.120494
Malaysia	Rahim et al.	2022	Microplastics in Cosmetics and Personal Care Products: Impacts on Aquatic Life and Rodents with Potential Alternatives				
Malaysia	Yan et al.	2022	Microplastics and Their Impacts on Organisms and Trophic Chains			Organisms	10.3390/w14244069
Malaysia	Zahari et al.	2022	Identification, Abundance, and Chemical Characterization of Macro-, Meso-, and Microplastics in the Intertidal Zone Sediment of Two Selected Beaches in Sabah, Malaysia	Sabah	Marine	Sediment	10.3390/w14101600
Malaysia	Zainuddin et al.	2022	Occurrence, potential sources and ecological risk estimation of microplastic towards coastal and estuarine zones in Malaysia	Coastal and estuarine zones	Brackish and marine	Water	10.1016/j.marpolbul.2021.113282
Malaysia	Abd Rahim et al.	2023	Commercially important mangrove crabs are more susceptible to microplastic contamination than other brachyuran species	Setiu wetlands	Wetlands	Organisms	10.1016/j.scitotenv.2023.166271

Malaysia	Anuar et al.	2023	A multidimensional approach for microplastics monitoring in two major tropical river basins, Malaysia	Langat River and Kelantan River	Freshwater	Water	10.1016/j.envres.2023.115717
Malaysia	Chen et al.	2023	Microplastic concentrations in river water and bed Sediment in a tropical river: implications for water quality monitoring	Semenyih River	Freshwater	Water and Sediment	10.1007/s10661-022-10856-5
Malaysia	Lim et al.	2023	First evidence of microplastic ingestion by crescent perch (Terapon jarbua) in Malaysia	Several locations	Marine	Organisms	10.1016/j.rsma.2023.103202
Malaysia	Matupang et al.	2023	Tropical sharks feasting on and swimming through microplastics: First evidence from Malaysia		Marine	Organisms	10.1016/j.marpolbul.2023.114762
Malaysia	Mazlan et al.	2023	Evaluation of microplastics isolated from sea cucumber Acaudina molpadioides in Pulau Langkawi, Malaysia	Pulau Langkawi	Marine	Organisms	10.1016/j.heliyon.2023.e16822
Malaysia	Mishra et al.	2023	Spatiotemporal distribution of microplastics in Miri coastal area, NW Borneo: inference from a periodical observation	Miri	Marine	Sediment	10.1007/s11356-023-29582-7
Malaysia	Mohamed et al.	2023	Depth Profiles of Microplastic in Sediment Cores in the Mangrove Area of Kuala Gula Mangrove, Malaysia	Kuala Gula	Wetlands	Sediment	10.3390/jmse11061223
Malaysia	Praveena et al.	2023	Microplastics pollution in agricultural farms soils: preliminary findings from tropical environment (Klang Valley, Malaysia)	Klang valley	Terrestrial	Soils	10.1007/s10661-023-11250-5
Malaysia	Sulaiman et al.	2023	Microplastics in Malaysia's Aquatic Environment: Current Overview and Future Perspectives		Freshwater & marine		10.1002/gch2.202300047
Malaysia	Tan and Zanuri	2023	Abundance and distribution of microplastics in tropical estuarine mangrove areas around Penang, Malaysia	Penang	Freshwater	Water & Sediment	10.3389/fmars.2023.1148804

Malaysia	Tang et al.	2023	Effect of monsoon on microplastic bioavailability and ingestion by zooplankton in tropical coastal waters of Sabah	Sabah	Marine	Water & organisms	10.1016/j.marpolbul.2023.115182
Malaysia	Yusof et al.	2023	First evidence of microplastic pollution in the surface water of Malaysian Marine Park islands, South China Sea during COVID-19	South China Sea	Marine	Water	10.1016/j.marpolbul.2023.115268
Malaysia	Zaki et al.	2023	Microplastic Pollution in Freshwater Sediment: Abundance and Distribution in Selangor River Basin, Malaysia	Selangor River	Freshwater	Sediment	10.1007/s11270-023-06505-3
Myanmar	Littman et al.	2020	Coastal urbanization influences human pathogens and microdebris contamination in seafood	Mergui Archipelago, Tanintharyi Region	Seafood	Organisms	10.1016/j.scitotenv.2020.139081
Philippines	Deocaris et al.	2019	Occurrence of microplastic fragments in the Pasig River	Pasig River	Freshwater	Water	10.2166/h2oj.2019.001
Philippines	Kalnasa et al.	2019	Occurrence of surface sand microplastic and litter in Macajalar Bay, Philippines	Macajalar Bay	Marine	Sediment	10.1016/j.marpolbul.2019.110521
Philippines	Paler et al.	2019	Plastic waste occurrence on a beach off southwestern Luzon, Philippines	Southwestern Luzon	Marine	Sediment	10.1016/j.marpolbul.2019.02.006
Philippines	Bucol et al.	2020	Microplastics in marine Sediment and rabbitfish (Siganus fuscescens) from selected coastal areas of Negros Oriental, Philippines	Negris Oriental	Marine	Sediment and Organisms	10.1016/j.marpolbul.2019.110685
Philippines	Esquinas et al.	2020	Physical characterization of litter and microplastic along the urban coast of Cagayan de Oro in Macajalar Bay, Philippines	Urban coast of Cagayan de Oro in Macajalar Bay	Marine		10.1016/j.marpolbul.2020.111083
Philippines	Limbago et al.	2020	Occurrence and Polymer Types of Microplastics from Surface Sediments of Molawin Watershed of the Makiling Forest Reserve, Los Baños, Laguna, Philippines	Los Baños	Freshwater	Sediment	10.32526/ennrj/19/2020114
Philippines	Palermo et al.	2020	Susceptibility of Sardinella lemuru to emerging marine microplastic pollution	Northern Mindanao	Marine	Organisms	10.22034/gjesm.2020.03.07

Philippines	Cabansag et al.	2021	Microplastics in some fish species and their environs in Eastern Visayas, Philippines	Eastern Visayas	Fresh and marine	Organisms	10.1016/j.marpolbul.2021.112312
Philippines	Castro et al.	2021	Occurrence of microplastics in the sediments of Baseco Port area at Manila Bay, Philippines	Manila Bay	Marine	Sediment	10.1088/1755-1315/958/1/012009
Philippines	Galarpe et al.	2021	The nexus of macroplastic and microplastic research and plastic regulation policies in the Philippines marine coastal environments	Coast	Marine		10.1016/j.marpolbul.2021.112343
Philippines	Osorio et al.	2021	Microplastics Occurrence in Surface Waters and Sediment in Five River Mouths of Manila Bay	Manila Bay	Freshwaters	Water and Sediment	10.3389/fenvs.2021.719274
Philippines	Paler et al.	2021	Low microplastic abundance in Siganus spp. from the Tanon Strait, Central Philippines	Tanon Strait, Central Philippines	Marine	Organisms	10.1016/j.envpol.2021.117166
Philippines	Bonifacio et al.	2022	Microplastic in Sediment and Ingestion Rates in Three Edible Bivalve Mollusc Species in a Southern Philippine Estuary	Southern Estuary	Brackish	Sediment and Organisms	10.1007/s11270-022-05926-w
Philippines	Navarro et al.	2022	Unraveling Microplastic Pollution in Mangrove Sediment of Butuan Bay, Philippines	Butuan Bay	Wetlands	Sediment	10.3390/su142114469
Philippines	Sajorne et al.	2022	Disentangling Microplastic Pollution on Beach Sand of Puerto Princesa, Palawan Island, Philippines: Abundance and Characteristics	Palawan Island	Marine	Sediment	10.3390/su142215303
Philippines	Arcardio et al.	2023	Microplastics in surface water of Laguna de Bay: first documented evidence on the largest lake in the Philippines	Laguna de Bay	Freshwater	Water	10.1007/s11356-022-24261-5
Philippines	Casila et al.	2023	Characterization and Quantification of Surficial Sediment Microplastics and Its Correlation with Heavy Metals, Soil Texture, and Flow Velocity	Pazig River	Freshwater	Sediment	10.1080/00032719.2023.2241090
Philippines	Gabriel et al.	2023	Riverine Microplastic Pollution: Insights from Cagayan de Oro River, Philippines.	Cagayan de Oro River	Freshwater	Water	10.3390/ijerph20126132

Philippines	Romarate et al.	2023	Breathing plastics in Metro Manila, Philippines: presence of suspended atmospheric microplastics in ambient air	Manila	Atmospheric	Air	10.1007/s11356-023-26117-y
Philippines	Similatan et al.	2023	Microplastic ingestion by adult milkfish Chanos chanos (Forsskal, 1775) in aquaculture system: The case of Butuan Bay, Philippines	Butuan Bay	Marine	Organisms	10.1016/j.marpolbul.2023.115409
Philippines	Gabriel et al.	2024	Microplastic Abundance and Distribution in the Sediment of Cagayan de Oro River, Philippines	Oro River	Freshwater	Sediment	10.1080/15320383.2023.2301495
Singapore	Nor and Obbard	2014	Microplastics in Singapore's coastal mangrove ecosystems	Berlayar Creek, Sungei Buloh, Pasir Ris and Lim Chu Kang	Coastal mangrove ecosystems	Sediment	10.1016/j.marpolbul.2013.11.025
Singapore	Curren and Leong	2019	Profiles of bacterial assemblages from microplastics of tropical coastal environments	Johor Strait and Singapore strait	Marine	Sediment and water	10.1016/j.scitotenv.2018.11.250
Singapore	Curren et al.	2020	Evidence of Marine Microplastics in Commercially Harvested Seafood		Supermarket	Organisms	10.3389/fbioe.2020.562760
Singapore	Pflugmacher et al.	2021	Case study comparing effects of microplastic derived from bottle caps collected in two cities on *Triticum aestivum* (Wheat)		Terrestrial	Plant	10.3390/environments8070064
Singapore	Curren and Leong	2023	Spatiotemporal characterisation of microplastics in the coastal regions of Singapore	Johor and Singapore straits	Marine	Water	10.1016/j.heliyon.2023.e12961
Thailand	Matsuguma et al.	2017	Microplastics in Sediment Cores from Asia and Africa as Indicators of Temporal Trends in Plastic Pollution	Gulf of Thailand	Marine	Sediment	10.1007/s00244-017-0414-9
Thailand	Thushari et al.	2017	Effects of microplastics on sessile invertebrates in the eastern coast of Thailand: An approach to coastal zone conservation	Eastern coast of Thailand	Marine	Organisms	10.1016/j.marpolbul.2017.06.010

Thailand	Azad et al.	2018	FIRST EVIDENCE OF EXISTENCE OF MICROPLASTICS IN STOMACH OF SOME COMMERCIAL FISHES IN THE LOWER GULF OF THAILAND	Songkhla province	Marine	Organisms	10.15666/aeer/1606_73457360
Thailand	Azad et al.	2018	FIRST EVIDENCE OF EXISTENCE OF MICROPLASTICS IN STOMACH OF SOME COMMERCIAL FISHES IN THE LOWER GULF OF THAILAND	The Lower Gulf of Thailand	Marine	Organisms	10.15666/aeer/1606_73457360
Thailand	Bissen and Chawchai	2020	Microplastics on beaches along the eastern Gulf of Thailand - A preliminary study	Eastern Gulf of Thailand	Marine	Sediment	10.1016/j.marpolbul.2020.111345
Thailand	Hongprasith et al.	2020	IR microspectroscopic identification of microplastics in municipal wastewater treatment plants		Waste water treatment plants	Water	10.1007/s11356-020-08265-7
Thailand	Kasamesiri et al.	2020	MICROPLASTICS INGESTION BY FRESHWATER FISH IN THE CHI RIVER, THAILAND	Chi River	Freshwater	Organisms	10.21660/2020.67.9110
Thailand	Klangnurak and Chunniyom	2020	Screening for microplastics in marine fish of Thailand: the accumulation of microplastics in the gastrointestinal tract of different foraging preferences	Gulf of Thailand, Andaman Sea	Marine	Organisms	10.1007/s11356-020-09147-8
Thailand	Pradit et al.	2020	Occurrence of microplastics on beach Sediment at Libong, a pristine island in Andaman Sea, Thailand	Andaman Sea	Marine	Sediment	10.2306/scienceasia1513-1874.2020.042
Thailand	Sukhsangchan et al.	2020	Suspended microplastics during a tidal cycle in sea-surface waters around Chao Phraya River mouth, Thailand	Chao Phraya River mouth	Freshwater	Water	10.2306/scienceasia1513-1874.2020.091
Thailand	Ta and Babel	2020	Microplastic contamination on the lower Chao Phraya: Abundance, characteristic and interaction with heavy metals	Bangkok, the lower Chao Phraya River	Freshwater	Water and Sediment	10.1016/j.chemosphere.2020.127234
Thailand	Wang et al.	2020	Occurrence and distribution of microplastics in surface Sediment from the Gulf of Thailand	Gulf of Thailand	Marine	Sediment	10.1016/j.marpolbul.2020.110916

Thailand	Akkajit et al.	2021	Occurrence and distribution of microplastics in beach Sediment along Phuket coastline	Phuket	Marine	Sediment	10.1016/j.marpolbul.2021.112496
Thailand	Chanpiwat and Damrongsiri	2021	Abundance and characteristics of microplastics in freshwater and treated tap water in Bangkok, Thailand	Bangkok	Freshwater and tap	Freshwater and tap water	10.1007/s10661-021-09012-2
Thailand	Chanpiwat et al.	2021	Abundance and characteristics of microplastics in freshwater and treated tap water in Bangkok, Thailand	Bangkok	Freshwater	Water	10.1007/s10661-021-09012-2
Thailand	Chinfak et al.	2021	Abundance, composition, and fate of microplastics in water, Sediment, and shellfish in the Tapi-Phumduang River system and Bandon Bay, Thailand	Tapi-Phumduang River system and Bandon Bay	Freshwater and marine	Water, Sediment and organisms	10.1016/j.scitotenv.2021.146700
Thailand	Goh et al.	2021	Microplastic Abundance in Blood Cockles and Shrimps from Fishery Market, Songkhla Province, Southern Thailand	Songkhla Province	Fishery market	Organisms	10.17576/jsm-2021-5010-05
Thailand	Imasha et al.	2021	Microplastics Contamination in Commercial Green Mussels from Selected Wet Markets in Thailand		Fish market	Organisms	10.1007/s00244-021-00886-4
Thailand	Jiwarungrueangkul et al.	2021	Seasonal microplastic variations in estuarine Sediment from urban canal on the west coast of Thailand: A case study in Phuket province	Phuket province	Brackish	Sediment	10.1016/j.marpolbul.2021.112452
Thailand	Jualaong et al.	2021	Type and Distribution of Microplastics in Beach Sediment along the Coast of the Eastern Gulf of Thailand	Gulf of Thailand	Marine	Sediment	10.3390/jmse9121405
Thailand	Kasamesiri et al.	2021	ASSESSMENT ON MICROPLASTICS CONTAMINATION IN FRESHWATER FISH: A CASE STUDY OF THE UBOLRATANA RESERVOIR, THAILAND	Ubolratana reservoir	Freshwater	Organisms	10.21660/2020.77.6108
Thailand	Oo et al.	2021	Horizontal variation of microplastics with tidal fluctuation in the Chao Phraya River Estuary, Thailand	Chao Phraya River Estuary	Brackish	Water	10.1016/j.marpolbul.2021.112933

Thailand	Phaksopa et al.	2021	Presence and Characterization of Microplastics in Coastal Fish around the Eastern Coast of Thailand	Rayong, Chanthaburi and Trat provinces	Marine	Organisms	10.3390/su132313110
Thailand	Pradit et al.	2021	OCCURRENCE OF MICROPLASTICS AND TRACE METALS IN FISH AND SHRIMP FROM SONGKHLA LAKE, THAILAND DURING THE COVID-19 PANDEMIC	Songkhla Lake	Freshwater	Organisms	10.15666/aeer/1902_10851106
Thailand	Suttacheep et al.	2021	The particles of microplastics in shrimp paste from the Gulf of Thailand and the Andaman Sea	Gulf of Thailand and Andaman Sea	Marine	Processed food	-
Thailand	Tadsuwan et al.	2021	Microplastic contamination in a conventional wastewater treatment plant in Thailand	Bangkok	Wastewater	Water and sludge	10.1177/0734242X20982055
Thailand	Thepwilai et al.	2021	Testing the factors controlling the numbers of microplastics on beaches along the western Gulf of Thailand	Western Gulf	Marine	Sediment	10.1016/j.marpolbul.2021.112467
Thailand	Akkajit and Khongsang	2022	Distribution of Microplastics along Mai Khao Coastline, Phuket	Phuket	Marine	Sediment	10.5614/j.eng.technol.sci.2022.54.1.5
Thailand	Eamrat et al.	2022	Assessment of Microplastics Distribution and Related Water Quality in an Urban Canal, Thailand	?	Freshwater	Urban canal	10.22059/POLL.2022.340679.1407
Thailand	Maneechan and Prommi	2022	Occurrence of microplastics in edible aquatic insect Pantala sp. (Odonata: Libellulidae) from rice fields	Nakhon Pathom province	Terrestrial (rice fields)	Organisms	10.7717/peerj.12902
Thailand	Ounjai et al.	2022	Assessment of microplastic contamination in the urban lower Chao Phraya River of Bangkok city, Thailand	Chao Phraya River of Bangkok city	Freshwater	Waters	10.2166/wh.2022.130
Thailand	Pradit et al.	2022	Low occurrence of microplastic contamination in anchovies, a transboundary species, in Thai waters	Gulf of Thailand, Andaman Sea	Marine	Organisms	10.2306/scienceasia1513-1874.2022.069
Thailand	Pradit et al.	2022	The first evidence of microplastic presence in pumice stone along the coast of Thailand: A preliminary study	Gulf of Thailand	Marine	Sediment	10.3389/fmars.2022.961729

Thailand	Pradit et al.	2022	The Occurrence of Microplastics in Sediment Cores from Two Mangrove Areas in Southern Thailand	Songkhla and Pattani provinces	Wetlands	Sediment	10.3390/jmse10030418
Thailand	Prarat et al.	2022	Microplastic pollution in surface seawater and beach sand from the shore of Rayong province, Thailand: Distribution, characterization, and ecological risk assessment	Rayong province	Marine	Seawater and sediment	10.1016/j.marpolbul.2021.113200
Thailand	Ruangpanupan et al.	2022	Microplastics in the surface seawater of Bandon Bay, Gulf of Thailand	Bandon Bay, Gulf of Thailand	Marine	Water	10.1016/j.marpolbul.2022.113664
Thailand	Sarin et al.	2022	Spatial and seasonal distribution of microplastic in surface water of Bueng Boraphet Wetland-a Ramsar wetland in Thailand	Bueng Boraphet Wetland-a Ramsar wetland	Wetlands	Water and Sediment	10.1007/s10661-022-10578-8
Thailand	Soe et al.	2022	Feeding Habits and the Occurrence of Anthropogenic Debris in the Stomach Content of Marine Fish from Pattani Bay, Gulf of Thailand	Pattani Bay	Marine	Organisms	10.3390/biology11020331
Thailand	Suttivirya et al.	2022	Contamination and ecological risk of microplastics and phthalates in the surface water of the Tha Dee Sub-River basin, Nakhon Si Thammarat Province, Thailand	The Dee Sub-River basin, Nakhon Si Thammarat Province	Freshwater	Water	10.1080/10934529.2022.2076512
Thailand	Ta et al.	2022	Investigation of microplastic contamination in blood cockles and green mussels from selected aquaculture farms and markets in Thailand	Central region of Thailand	Aquaculture farms and markets	Organisms	10.1016/j.chemosphere.2022.134918
Thailand	Tadsuwan et al.	2022	Microplastic abundance and removal via an ultrafiltration system coupled to a conventional municipal wastewater treatment plant in Thailand	Bangkok	Waste water treatment plants	Water	10.1016/j.jece.2022.107142

Thailand	Vibhatabanduhu et al.	2022	Abundance and Characteristics of Microplastics Contaminating the Surface Water of the Inner Gulf of Thailand	Inner Gulf of Thailand	Marine	Water	10.1007/s11270-022-05531-x
Thailand	Vibhatabanduhu et al.	2022	Influence of seasonal variations on the distribution characteristics of microplastics in the surface water of the Inner Gulf of Thailand	Inner Gulf of Thailand	Brackish and marine	Water	10.1016/j.marpolbul.2022.113747
Thailand	Akkajit et al.	2023	Microplastics accumulation and human health risk assessment of heavy metals in Marcia opima and Lingula anatina, Phuket	Phuket	Brackish	Organisms	10.1016/j.marpolbul.2022.114404
Thailand	Cjaisanguansuk et al.	2023	Preliminary study on microplastic abundance in mangrove Sediment cores at Mae Klong River, upper Gulf of Thailand	Mae Klong River	Wetlands	Sediment	10.3389/fenvs.2023.1134988
Thailand	Jendanklang et al.	2023	Distribution and flux assessment of microplastic debris in the middle and lower Chao Phraya River, Thailand	Chao Phraya River	Freshwater	Water and Sediment	10.2166/wh.2023.013
Thailand	Jualaong et al.	2023	Type and distribution of microplastic contamination in beach sediment along the coast of the lower gulf of Thailand	Songkhla province	Marine	Sediment	10.3390/jmse9121405
Thailand	Kasamesiri et al.	2023	Spatial-Temporal Distribution and Ecological Risk Assessment of Microplastic Pollution of Inland Fishing Ground in the Ubolratana Reservoir, Thailand	Ubolratana Reservoir	Freshwater	Water and Sediment	10.3390/w15020330
Thailand	Noppradit et al.	2023	MICROPLASTIC DISTRIBUTION IN RIVER Sediment: A CASE STUDY AT U-TAPHAO, SOUTHERN THAILAND	U-Taphao	Freshwater	Sediment	10.15666/aeer/2105_45634576
Thailand	Noppradit et al.	2023	THE DISTRIBUTION OF MICROPLASTIC IN Sediment AT KHUAN KHI SIAN WETLAND, SOUTHERN THAILAND	Khuan Khi Sian	Wetlands	Sediment	10.15666/aeer/2105_44754488

Thailand	Oo et al.	2023	Seasonal effects, spatial distribution, and possible sources of microplastics in the Chao Phraya River estuary, Thailand	Chao Phraya river	Brackish	Water	10.1080/10934529.2023.2184618
Thailand	Phaksopa et al.	2023	Assessment of Microplastics in Green Mussel (*Perna viridis*) and Surrounding Environments around Sri Racha Bay, Thailand	Sri Racha Bay	Marine	Organisms	10.3390/su15010009
Thailand	Pradit et al.	2023	Microplastic Accumulation in Catfish and Its Effects on Fish Eggs from Songkhla Lagoon, Thailand	Songkhla province	Fish market	Organisms	10.3390/jmse11040723
Thailand	Pradit et al.	2023	Occurrence of Microplastics in River Water in Southern Thailand	U-Taphao river	Freshwater	Water	10.3390/jmse11010090
Thailand	Sooksawat et al.	2023	Microplastic accumulation in local dominant shellfish from the Khwae Noi Basin in Western Thailand and its environmental factors	Khwae Noi basin	Marine	Organisms	10.2306/scienceasia1513-1874.2023.030
Thailand	Ta and Babel	2023	Occurrence and spatial distribution of microplastic contaminated with heavy metals in a tropical river: Effect of land use and population density	Chao Phraya River	Freshwater	Water and Sediment	10.1016/j.marpolbul.2023.114919
Thailand	Tanaviyutpakdee and Karnpanit	2023	Exposure Assessment of Heavy Metals and Microplastic-like Particles from Consumption of Bivalves	Markets Samut Sakhon and Samut Songkhram provinces		Organisms	10.3390/foods12163018
Thailand	Tee-hor et al.	2023	Identification of anthropogenic debris in the stomach and intestines of giant freshwater prawns from the Trang River in southern Thailand	Trang River	Freshwater	Organisms	10.7717/peerj.16082
Thailand	Xue et al.	2023	Land use-based characterization and source apportionment of microplastics in urban storm runoffs in a tropical region	Pathum Thani province	Urban stormwater runoff	Runoff	10.1016/j.envpol.2023.121698

Thailand	Jittalerk and Babel	2024	Microplastic contamination in Thai vinegar crabs (Episesarma mederi), giant mudskippers (Periophthalmodon schlosseri), and their surrounding environment from the Bang Pu mangrove forests, Samut Prakan province, Thailand	Bang Pu	Wetlands	Water, Sediment & organism	10.1016/j.marpolbul.2023.115849
Thailand	Srisiri et al.	2024	Microplastic contamination in edible marine fishes from the upper Gulf of Thailand	Gulf of Thailand	Fish market	Organisms	10.1016/j.marpolbul.2023.115785
Viet Nam	Lahens et al.	2018	Macroplastic and microplastic contamination assessment of a tropical river (Saigon River, Viet Nam) transversed by a developing megacity	Saigon River	Freshwater	Water	10.1016/j.envpol.2018.02.005
Viet Nam	Strady et al.	2020	Temporal dynamic of anthropogenic fibers in a tropical river-estuarine system	Saigon River	Brackish	Water	10.1016/j.envpol.2019.113897
Viet Nam	Thinh et al.	2020	Preliminary assessment on the microplastic contamination in the atmospheric fallout in the Phuoc Hiep landfill, Cu Chi, Ho Chi Minh city	Ho Chi Minh City	Terrestrial	Atmospheric	10.31276/VJSTE.62(3).83-89
Viet Nam	Yukioka et al.	2020	Occurrence and characteristics of microplastics in surface road dust in Kusatsu (Japan), Da Nang (Viet Nam), and Kathmandu (Nepal)		Surface road	Dust	10.1016/j.envpol.2019.113447
Viet Nam	Dung et al.	2021	Depth Profiles of Microplastics in Sediment Cores from Two Mangrove Forests in Northern Viet Nam	Northern Viet Nam	Wetlands	Sediment	10.3390/jmse9121381
Viet Nam	Ha et al.	2021	Microplastic contamination in commercial sea salt of Viet Nam	Several provinces		Salt	10.15625/2525-2518/59/3/15718
Viet Nam	Hue et al.	2021	ASSESSMENT OF MICROPLASTICS CONTAMINATION IN COMMERICIAL CLAMS IN THE COASTAL ZONE OF VIET NAM	Ban Sen and Gia Thuy communes	Marine	Organisms	10.15666/aeer/1906_49774991

Viet Nam	Khuyen et al.	2021	Investigating the Correlation of Microplastic Pollution Between Seawater and Marine Salt Using Micro-Raman Spectroscopy	Long Dien		Salt	10.3389/fmars.2021.735975
Viet Nam	Oanh et al.	2021	Preliminary results on microplastics in surface water from the downstream of the Day River	Day River	Freshwater	Water	10.15625/2615-9783/16504
Viet Nam	Strady et al.	2021	Baseline assessment of microplastic concentrations in marine and freshwater environments of a developing Southeast Asian country, Viet Nam	9 cities and provinces	Marine and freshwater	Literature-based data	10.1016/j.marpolbul.2020.111870
Viet Nam	Truong et al.	2021	Microplastic in atmospheric fallouts of a developing Southeast Asian megacity under tropical climate	Ho Chi Minh City	Atmospheric	Atmospheric	10.1016/j.chemosphere.2021.129874
Viet Nam	Tran-Nguyen et al.	2022	Urban drainage channels as microplastics pollution hotspots in developing areas: A case study in Da Nang, Viet Nam	Da Nang	Urban drainage channels	Water and Sediment	10.1016/j.marpolbul.2022.113323
Viet Nam	Da Le et al.	2022	First observation of microplastics in surface Sediment of some aquaculture ponds in Hanoi city, Viet Nam	Hanoi city	Freshwater	Sediment	10.1016/j.hazadv.2022.100061
Viet Nam	Do et al.	2022	Abundance of microplastics in cultured oysters (Crassostrea gigas) from Danang Bay of Viet Nam	Da Nang Bay	Marine	Organisms	10.1016/j.marpolbul.2022.113800
Viet Nam	Do et al.	2022	Distribution and occurrence of microplastics in wastewater treatment plants	Da Nang city	Waste water treatment plants	Water	10.1016/j.eti.2022.102286
Viet Nam	Duong	2022	Selection of a density separation solution to study microplastics in tropical riverine Sediment	The Red River Delta	Freshwater	Sediment	10.1007/s10661-021-09664-0
Viet Nam	Kieu-Le	2022	Anthropogenic fibers in white clams, Meretrix lyrata, cultivated downstream a developing megacity, Ho Chi Minh City, Viet Nam	Ho Chi Minh City		Organisms	10.1016/j.marpolbul.2021.113302

Viet Nam	Nam et al.	2022	Contamination of microplastic in bivalve: first evaluation in Viet Nam	Tinh Gia	Marine	Organisms	10.15625/0866-7187/41/3/13925
Viet Nam	Nguyen et al.	2022	Characteristics of Microplastics and Their Affiliated PAHs in Surface Water in Ho Chi Minh City, Viet Nam	Ho Chi Minh City	Freshwater and marine	Water	10.3390/polym14122450
Viet Nam	Nguyen et al.	2022	Occurrence and distribution of microplastics in peatland areas: A case study in Long An province of the Mekong Delta, Viet Nam	Mekong Delta		Sediment	10.1016/j.scitotenv.2022.157066
Viet Nam	Suzuki et al.	2022	Mechanical recycling of plastic waste as a point source of microplastic pollution	Hung Yen Province and Ung Hoa District	Inputs and effluent outputs of mechanical recycling facilities	Water	10.1016/j.envpol.2022.119114
Viet Nam	Vu et al.	2022	Coaggregation of micro polystyrene particles and suspended minerals under concentrated salt solution: A perspective of terrestrial-to-ocean transfer of microplastics	2 universities			10.1016/j.marpolbul.2022.114317
Viet Nam	Dao et al.	2023	Microplastic accumulation in oysters: Insights from aquaculture and laboratory conditions	Cha Va river	Freshwater	Water, Sediment & organism	10.1016/j.rsma.2023.103251
Viet Nam	Doan et al.	2023	Microplastic accumulation in bivalves collected from different coastal areas of Viet Nam and an assessment of potential risks	Thai Binh, Nam Dinh and Phu Yen provinces	Marine	Organisms	10.1007/s10661-023-12087-8
Viet Nam	Doan et al.	2023	Preliminary results on microplastic pollution from agricultural soil in Viet Nam: Distribution, characterization, and ecological risk assessment	Bac Ninh, Ha Nam and Ha Noi provinces	Terrestrial	Soil	10.15625/2615-9783/18616
Viet Nam	Ganzha et al.	2023	Risk of Expanded Polystyrene Ingestion by Climbing Perch *Anabas testudineus*	Central Viet Nam	Freshwater	Organisms	10.3390/w15071294
Viet Nam	Kieu-Le	2023	Baseline concentration of microplastics in surface water and Sediment of the northern branches of the Mekong River Delta, Viet Nam	Mekong River Delta	Brackish	Water and Sediment	10.1016/j.marpolbul.2023.114605

Viet Nam	Le et al.	2023	Evaluation of microplastic removal efficiency of wastewater-treatment plants in a developing country, Viet Nam	Ho Chi Minh City, Thu Dau Mot and Da Lat	Waste water treatment plants	Water	10.1016/j.eti.2022.102994
Viet Nam	Le et al.	2023	Microplastics in the Surface Sediment of the main Red River Estuary	Red River estuary	Brackish	Sediment	10.15625/2615-9783/17486
Viet Nam	Le et al.	2023	Risk assessment of microplastic exposure: A case study near a refinery factory at the central coast of Viet Nam	Binh Tri	Marine	Sediment	10.1016/j.marpolbul.2023.115636
Viet Nam	Liu et al.	2023	Occurrence of microplastics in the seawater and atmosphere of the South China Sea: Pollution patterns and interrelationship	South China Sea	Marine	Water, air	10.1016/j.scitotenv.2023.164173
Viet Nam	Mai et al.	2023	Distribution of microplastics in surface water of tropical urban lakes: A case study in Ha Noi, Viet Nam	Ha Noi	Freshwater	Water	10.15625/2615-9783/18595
Viet Nam	My et al.	2023	Micro-debris Accumulated in Marine Fishes Collected from Central Viet Nam: Characteristics and Implication for Human Health Risk	Thua Thien Hue	Fish market	Organisms	10.1007/s11270-023-06650-9
Viet Nam	Nguyen et al.	2023	Emergence of microplastics in the aquatic ecosystem and their potential effects on health risks: The insights into Viet Nam				10.1016/j.jenvman.2023.118499
Viet Nam	Quynh et al.	2023	Abundance of Microplastics in Two Venus Clams (*Meretrix lyrata* and *Paratapes undulatus*) from Estuaries in Central Viet Nam	Estuaries in Central Viet Nam	Brackish	Organisms	10.3390/w15071312
Viet Nam	Tran et al.	2023	Ingestion and accumulation of microplastics in small marine fish and potential human exposure: case study of Binh Dinh, Viet Nam	Binh Dinh	Marine	Organisms	10.1080/10807039.2023.2268208
Viet Nam	Tran et al.	2023	Potential contamination of microplastic from plastic recycling enterprises in Ho Chi Minh City, Viet Nam	Ho Chi Minh City	Wastewater treatment plants	Water, sludge	10.1080/10807039.2023.2228414

Table S2. List of policy documents in ASEAN reviewed in this baseline study.

ASEAN Countries	Title	Year	Number of mentions of microplastics	Key objectives on microplastics	Key objectives on plastic pollution and/or waste management	URL
Regional	The ASEAN Regional Action Plan for Combating Marine Debris (2021-2025)	2021	23	Conduct a regional study on microplastics, including an investigation into the linkages to human health.	Enhance coordination at the regional and international levels for achieving sustainable management of coastal and marine environments through responding to marine plastic pollution.	https://asean.org/wp-content/uploads/2021/05/FINAL_210524-ASEAN-Regional-Action-Plan_Ready-to-Publish_v2.pdf
Regional	The COBSEA Regional Action Plan on Marine Litter 2019 (RAP MALI)	2019	9	Activity 3.2.: develop regional and national marine litter and microplastic monitoring programmes, a metadatabase/portal, and regional reports on marine litter and microplastics.	Prevent and reduce marine litter from land- and sea-based sources through legal and economic instruments, national planning and policy frameworks, integrated waste management, removal of existing litter and its disposal, regional and international cooperation and reporting activities, and the establishment of an expert group, regional and national marine litter monitoring programmes and research activities	https://wedocs.unep.org/bitstream/handle/20.500.11822/30162/RAPMALI_19.pdf?sequ%E2%80%A6
Regional	The ASEAN Framework of Action on Marine Debris	2019	3	Enhance research on marine debris, including plastics and microplastics, and promote public awareness on status and impacts of marine debris and microplastics.	Focus on four priority areas: (i) policy support and planning; (ii) research, innovation, and capacity building; (iii) public awareness, education, and outreach; and (iv) private sector engagement.	https://asean.org/asean2020/wp-content/uploads/2021/01/3.-ASEAN-Framework-of-Action-on-Marine-Debris-FINAL.pdf
Regional	The Bangkok Declaration on Combating Marine Debris in ASEAN Region	2019	4	Combat, prevent and significantly reduce marine debris, particularly from land-based activities.	Promote innovative solutions and approaches such as circular economy and 3R (reduce, reuse, recycle) to enhance plastics value chains and improve resource efficiency, as well as to improve research capacity and application of scientific knowledge, particularly through support to science-based policy and decision making, and increase public awareness and education to encourage behavior change toward a prevention and reduction of marine debris	https://asean.org/asean2020/wp-content/uploads/2021/01/2.-Bangkok-Declaration-on-Combating-Marine-Debris-in-ASEAN-Region-FINAL-1.pdf

Regional	Action Plan of the ASEAN Working Group on Coastal and Marine Environment (AWGCME)	2016	2	Gain an overview of the regional status of marine debris, including microplastics, by sharing knowledges, experiences and good practices, identifying needs and gaps, and exploring regional collaborative activities. Develop recommendations on way forward and a regional management plan for marine debris, including microplastics.	Promote sustainable management and conservation of ASEAN's coastal and marine environments, reduce anthropogenic threats, enhance inter-agency coordination, and respond to transboundary issues through good management practices and strengthened policies.	https://environment.asean.org/coastal-and-marine-environment/initiatives
Brunei Darussalam	Brunei Darussalam Tariff and Trade Classification, amendment 2023	2023	0	None	Increased the excise tax on plastic and plastic products to 5% to reduce the use of plastics	https://tradingacrossborders.mofe.gov.bn/PublishingImages/SitePages/home/PRESS%20RELEASE%20ON%20PLASTIC%20TAX%20(ENGLISH).pdf
Brunei Darussalam	Environmental Protection and Management Act, Chapter 240 (Revised edition 2022)	2022	0	None	Stipulates that waste treatment and disposal are prescribed activities of the government.	http://www.env.gov.bn/Shared%20Documents/EPMA%20CHAPTER%20240.pdf
Brunei Darussalam	Brunei Darussalam National Climate Change Policy	2020	0	None	Aims to promote and implement 3R initiaties and programmes, pursue and adopt waste-to-energy technology options and increase public education and awareness.	https://faolex.fao.org/docs/pdf/bru216749E.pdf
Brunei Darussalam	Brunei Vision 2035	2016	0	None	Aims to ensure a Clean and Green Environment.	https://www.wawasanbrunei.gov.bn/en/SitePages/wawasan-brunei-2035.aspx
Brunei Darussalam	Brunei Environmental Protection and Management Order, 2016 (Article 83(3) of the Constitution of Brunei Darussalam)	2016	0	None	Stipulates that the ministry can introduce regulations on industrial and domestic waste and littering.	https://faolex.fao.org/docs/pdf/bru162820.pdf
Brunei Darussalam	Hazardous Waste (Control of Export, Import and Transit) Order, 2013	2013	0	None	Gives effect to the Basel Convention, and notes that wastes from the use of plasticizers or surface treatment of plastics are subject to control.	https://www.agc.gov.bn/AGC%20Images/LAWS/Gazette_PDF/2013/EN/S094.pdf

Brunei Darussalam	Brunei Natural Park Act (Act No. 161 of 1957), Last revision: Act No. 47 of June 3, of 2009	2009	0	None	Prohibits the dumping or disposal of waste “in such manners as give remarkably unpleasant feelings to those utilizing the National Park or Quasi-national Park concerned”.	https://faolex.fao.org/docs/pdf/bru153916.pdf
Brunei Darussalam	The Prevention of Pollution of the Sea (Garbage) Regulations	2008	0	None	Stipulates that it is prohibited to dispose of all plastics into the sea.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/1056_N_2008_Sea_Garbage.pdf
Brunei Darussalam	The Prevention of Pollution of the Sea Order	2005	0	None	Stipulates that it is illegal to dispose of or discharge plastics in packaged form from a ship in Brunei Darussalam waters, and if it happens, the owner of the ship is liable to pay for the clean-up.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/2223_N_2005_Prevention_of_Pollution.pdf
Cambodia	Circular strategy on environment 2023-2028	2023	0	None	Promote green investment through plastic waste management. Introduce plastic bag reduction campaigns, foster the implementation of the 4R Principle, disseminate and strengthen implementation of legal instruments related to the management of plastic wastes, capacity building, reduce the use of plastics for agricultural products and plants, avoid and/or remove plastic waste from the environment.	https://data.opendevelopmentcambodia.net/km/dataset/f6d84193-b286-4d82-a130-a16cd5205b48/resource/2bf29585-4f2f-4340-b831-4cda055ceb10/download/circular_strategy_on_environment_2023_2028_en__15.11.2023.pdf.pdf
Cambodia	Circular Economy Strategy and Action Plan	2021	2	None *(only mentions the adverse environmental and health effects of microplastics).*	Enhance waste collection and recycling, and effective management of residual waste. Promote alternatives to Single-Use Plastic (SUP) and develo Extended Producer Responsibility (EPR) schemes and plastic production standards.	https://www.undp.org/sites/g/files/zskgke326/files/2022-06/Circular%20Economy%20Strategy%20and%20Action%20Plan%202021%20%282%29.pdf
Cambodia	Anukret (Sub Decree) of 2020 on the Enforcement of the List of Prohibited and Restricted Goods	2020	0	None	Stipulates that plastic bags with handle of less than 0.03 millimeter in thickness, and its bottom width of less than 250 millimeters is prohibited to import. Other plastic items require a permit for import.	https://faolex.fao.org/docs/pdf/cam217519.pdf
Cambodia	Cambodian Sustainable Development Goals (CSDG) Framework 2016-2030	2018	0	None	Reduce the use of plastic bags in the country.	https://faolex.fao.org/docs/pdf/cam219295.pdf

Cambodia	Cambodia's National Environment Strategy and Action Plan, 2016–2023 (NESAP)	2017	0	None	Improve waste management and 3R targets, promote public awareness.	https://policy.asiapacificenergy.org/sites/default/files/National%20Environment%20Strategy%20and%20Action%20Plan_NESAP_2016-2023.pdf
Cambodia	Sub-Decree No. 113 on ANK.BK. of 27 September 2015, Sub-decree on Management of Garbage and Solid Waste of Downtowns	2015	0	None	Stipulates that owners of solid waste in downtown areas are responsible for the proper storage of waste in plastic bags that do not lead or emit bad smell.	https://faolex.fao.org/docs/pdf/cam217075.pdf
Cambodia	Climate Change Action Plan in Tourism Sector 2015-2018	2015	0	None	Reduce waste generation by creating "No Plastic Bag Campaign" and implement 3R initiatives. Establish community-based solid waste management system, which will recycle waste and manage separating facilities, and produce consumer goods.	https://faolex.fao.org/docs/pdf/cam219289.pdf
Cambodia	National Strategic Plan on Green Growth 2013-2030	2013	0	None	Improve the management of marine pollution, including plastic disposal, to protect marine health and biodiversity.	https://faolex.fao.org/docs/pdf/cam199476.pdf
Cambodia	Environmental Guidelines on Solid Waste Management in Kingdom of Cambodia	2006	0	None	Promote the 3Rs principle, develop a waste management plan, promote environmental education in Kindergartens.	https://faolex.fao.org/docs/pdf/cam217085.pdf
Cambodia	Sub-Decree No. 36 ANK.BK. of 27 April 1999 on Solid Waste Management	1999	0	None	Defines plastic waste from production or use of plasticizers as hazardous waste and stipulates that the export of plastic waste is permitted under certain conditions, with permission from the relevant authorities, while import is strictly prohibited.	https://faolex.fao.org/docs/pdf/cam47644.pdf
Cambodia	Sub-Decree No: 72.ANRK.BK on Environmental Impact Assessment Process	1999	0	None	Plastics factories of all sizes are subject to Environmental Impact Assessments (EIA).	https://faolex.fao.org/docs/pdf/cam27446.pdf
Cambodia	Law on environmental protection and natural resource management, Preah Reach Kram/NS-RKM-1296/36	1996	0	None	Overall objective to prevent, reduce and control pollution to protect public health and upgrade environmental quality.	https://faolex.fao.org/docs/pdf/cam19300.pdf

Indonesia	Enhanced Nationally Determined Contribution	2022	0	None	Enhance coastal zone and ocean pollution control, including marine litter and plastic debris.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15012_N_2022_Enhanced_Nationally_Determined_Contribution.pdf
Indonesia	National Plastic Waste Reduction Strategic Actions for Indonesia	2020	6	None *(only outlines the problems associated with microplastic pollution in the background section).*	Aims to reduce the amount of plastic waste by 30 % and the amount of mismanaged plastic waste by up to 70 % by 2025.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15011_N_2020_National_Plastic_Waste_Reduction.pdf
Indonesia	Ministry of Environment and Forestry Decree No. P.75/2019 on Roadmap to Waste Reduction by Producers	2019	0	None	Aims to prohibit the use of plastic bags, and disposable eating and drinking equipment, including spoons, forks and straws, effective January 1, 2030. Outlines 3R activities to reduce, reuse and recycle plastic waste.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/112021_N_2019_The_minister_of_environment.pdf
Indonesia	Indonesia's Plan of Action on Marine Plastic Debris 2017-2025	2017	1	None *(only notes that microplastics are toxic to a wide range of fish and other marine organisms).*	Aims to reduce marine plastic debris by 70 % in 2025, through awareness raising activities, waste plastics managements from land to the coastal area, marine plastic debris management and capacity building.	https://maritim.go.id/konten/unggahan/2018/03/NAP_Marine_Plastic_Debris_Indonesia_Summary.pdf
Indonesia	First Nationally Determined Contribution of Republic of Indonesia	2016	O	None	Enhance management capacity of urban wastewater, reduce landfill waste by promoting the 3Rs approach, and transform waste and garbage into energy production.	https://faolex.fao.org/docs/pdf/ins186421.pdf
Indonesia	Ministry of Trade Regulation No. 31/2016 on Non-Hazardous Waste Import	2016	0	None	Stipulates that it is permissible to import remains, waste and scrap of plastic as long as it does not come from landfill activity, it is not contaminated or mixed with other waste that is regulated.	https://jdih.kemendag.go.id/backendx/image/regulasi/22200711_Permendag_No._31_tahun_2016.pdf
Indonesia	Ministry of Public Works Regulation No. 3/2013 on Implementation of Solid Waste Infrastructure and Facilities	2013	0	None	Ensure effective waste manage infrastructure and facilities, improve coverage of waste handling services, and reconsider waste as resource, to improve public health and environmental quality and protect water resources, land, and air from pollution.	https://faolex.fao.org/docs/pdf/ins137639.pdf
Indonesia	No. 32/2009 Law on Environmental Protection and Management	2009	0	None	Stipulates that is prohibited to dispose waste into the environment.	http://greenaccess.law.osaka-u.ac.jp/wp-content/uploads/2019/03/Law-No.32-of-

						2009-on-The-Management-and-Protection-of-the-Environment.pdf
Indonesia	Waste Management Act No. 18	2008	0	None	Prohibits the import of waste to Indonesia, disposal of waste in improper manner and not in provided areas, causing pollution and/or environmental damage, open dumping at final processing site, and/or burning waste not according to technical requirements. Tasks of the government in waste management focus on public awareness, technology, infrastructure, coordination and efforts to reduce, handle, and utilize waste.	https://www.vertic.org/media/National%20Legislation/Indonesia/ID_Waste_Management_Act_2008.pdf
Laos	The 9th Five-Year National Socio-Economic Development Plan (2021-2025)	2021	0	None	Strengthen capacity to address the problem of pollution caused by the use of plastics.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15058_N_2021_9th_Five-Year_National.pdf
Laos	National Green Growth Strategy of the Lao PDR till 2030	2018	0	None	Reduce average production of garbage or wastes per person from 237 Kg/person/year in 2015 to 210kg by 2025 and 180kg by 2030. Increase the percentage of garbage or wastes which are reused or disposed through proper methods and sites from 50% in 2015 to 65 % in 2025 and 80% in 2030.	https://faolex.fao.org/docs/pdf/LAO210618.pdf
Laos	National Pollution Control Strategy to 2025 with Vision to 2030 (NPCSAP)	2017	0	None	Establish recycling plants for materials like plastics through a Public Private Partnership approach.	https://www.gms-eoc.org/uploads/resources/922/attachment/Laos-Pollution-Strategy-Plan-2018-2025-draft.pdf
Laos	Natural Resources and Environment Strategy, 10 Years 2016-2025	2015	0	None	Reduce water and air pollution by 30%, protect water quantity and quality in 10 river basins, reduce waste generation in municipal areas across the country by 30%, ensure 50% of household in six priority provinces and along the national road implement proper waste separation practices, ensure that main roads and public areas in municipalities and the important tourist areas have efficient waste collection system.	https://faolex.fao.org/docs/pdf/lao170969.pdf

Laos	Ministerial instructions on pollution control	2015	0	None	Projects or activities that contribute to air, water or soil pollution may be subject to Environmental Impact Assessments (EIA). Project owners and entrepreneurs have the responsibility to use appropriate technology in manufacturing processes and ensure proper treatment to reduce pollution.	https://faolex.fao.org/docs/pdf/lao162894.pdf
Laos	Environmental Protection Law	2012	0	None	Disposal of general wastes shall be separated for different purposes such as recycle, reuse, reprocess as new products, and it is prohibited to burn, burry, dispose and demolish wastes, release and discharge waste water into canals, rivers, natural water sources or any sites without treatment based on the technical standards.	https://faolex.fao.org/docs/pdf/lao151747.pdf
Malaysia	The Twelfth Malaysia Plan, 2021-2025	2021	0	None	Enhance efforts to reduce single-use plastics, support a circular economy in the waste sector, extend the Extended producer responsibility (EPR) approach also to plastic waste, and review regulations on import and export of waste.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/14003_N_2021_Twelfth_Malaysia_Plan.pdf
Malaysia	Malaysia Plastics Sustainability Roadmap 2021 - 2030	2021	5	None *(only outlines the problems of microplastics and notes that "Malaysia is looking forward to technologies where plastics do not degrade into microplastics and harm the people and planet")*	Introduce a voluntary Extended Producer Responsibility scheme from 2023 to 2025, and a mandatory EPR scheme in 2026. By 2030: Phase out problematic Single-Use Plastic products, ensure that 100 % of plastic packaging are recycled, ensure that plastic products include a minimum of 15% recycled content, and increase collected-for-recycling rate to 76%.	https://faolex.fao.org/docs/pdf/mal220769E.pdf
Malaysia	National Marine Litter Policy and Action Plan (NMLPAP) 2021 - 2030	2021	30	By 2023: Enhance research on microplastics and promote public awareness on the impacts of microplastics. By 2024: Establish 'Plastic-Free Islands' where microbeads-based products are prohibited. By 2026: Explore safety standards for	Address marine litter pollution in Malaysia through policy adoption and implementation, deployment of technologies, innovation and capacity building, improvement of monitoring and data collection on marine litter, communication, education and public awareness, by adopting a whole-of-nation and multi-stakeholder approach.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/4500_N_2021_National_Marine_Litter.pdf

				microplastics. By 2027: Incorporate marine litter (incl. microplastics) in education and activities in schools. By 2028: Ban the most common or damaging types of plastic marine litter such, as microbeads.		
Malaysia	Roadmap Towards Zero Single-Use Plastics 2018-2030	2018	0	None	Achieving zero single-use plastics by 2030 by drafting and revising legal framework, introducing a pollution charge on single-use plastic bags by 2022, adding a federal pollution levy on plastic manufacturers, and launching a Circular Economy Roadmap (CER) for plastics by 2020.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/5006_N_2008_Roadmap_Towards_Zero.pdf
Malaysia	The Customs (Prohibition of Imports) Order 2017	2017	0	None	Waste, paring and scrap of plastics should not be imported into Malaysia except with an Import License.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/13093_N_2017_Customs_Prohibition_of_imports.pdf
Malaysia	The Customs (Prohibition of Imports) Order 2012	2012	0	None	Same as above	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/13122_N_2012_Customs_Prohibition_imports.pdf
Malaysia	Malaysia Solid Waste and Public Cleansing Management Act No. 672 of 2007	2007	0	None	Prohibits unauthorized disposal, treatment, etc., of controlled solid waste.	https://tcclaw.com.my/wp-content/uploads/2020/12/Solid-Waste-and-Public-Cleansing-Management-Act-2007.pdf
Myanmar	National Environmental Policy of Myanmar, 2019	2019	0	None	Pollution and waste is to be avoided and minimized at the source, and enterprises will be encouraged to adopt clean production principles and best practices.	https://www.undp.org/myanmar/publications/national-environmental-policy-myanmar
Myanmar	National Waste Management Strategy and Master Plan for Myanmar (2018-2030)	2018	1	None *(but mentions that microplastic pollution in soils, sediments and freshwater could have*	Achieve a zero waste, circular and sustainable society by 2030 through improving the quality and coverage of waste collection services, eliminating open burning and uncontrolled disposal of waste, reducing waste through the 3Rs, supporting a circular economy of waste, ensuring sustainable	https://wedocs.unep.org/bitstream/handle/20.500.11822/33128/NWMSMP.pdf?sequence=1&isAllowed=y

				long-term negative effects on ecosystems)	financing mechanisms for waste management, ensuring the compliance, monitoring, enforcement and recognition of regulatory frameworks, and awareness raising. By 2030, 100% of all citizens will have access to sound waste collection services.	
Myanmar	Environmental impact assessment procedure	2015	0	None	Stipulates that projects that may have an environmental impact, such as emission of pollution or waste, are subject to an Environmental Impact Assessment (EIA).	https://www.myanmar-responsiblebusiness.org/pdf/resources/EIA-Procedures_en.pdf
Myanmar	Environmental Conservation Rules, 2014	2014	0	None	Nobody shall carry out any activity which can damage the ecosystem and the natural environment, except for the permission of the Ministry for the interests of the people.	https://myanmartradeportal.gov.mm/uploads/legals/2019/3/EC%20Rules_Eng%20version.pdf
Myanmar	Environmental Conservation Law, 2012	2012	0	None	Prohibits the import, export, production, storage, transport or trade of environmentally damaging materials that are prohibited by Ministry without permission.	https://myanmartradeportal.gov.mm/kcfinder/upload/files/The%20Environmental%20Conservation%20Law(Eng).pdf
Philippines	Philippine Action Plan for Sustainable Consumption and Production (PAP4SCP)	2023	0	None	Adopt green technologies and circular economy solutions. By 2023: research and develop alternatives to single-use plastics to support a phase-out, and by 2030: scale-up business models for waste minimization and technology that utilize recycled plastics.	https://neda.gov.ph/wp-content/uploads/2023/01/Philippine-Action-Plan-for-Sustainable-Consumption-and-Production.pdf
Philippines	Extended Producer Responsibility Act of 2022	2022	0	None	Institutionalized the extended producer responsibility (EPR) mechanism, where large enterprises generating plastic packaging waste are required to establish or phase in EPR programs for plastic packaging, to recover or offset their plastic packaging footprint. Micro, small, and medium enterprises are encouraged to voluntarily practice EPR. The scheme includes tax incentives and sanctioning mechanisms. Target for the annual recovery of plastic products: 80% by 2029.	https://legacy.senate.gov.ph/republic_acts/ra%2011898.pdf
Philippines	Single-Use Plastic Products Regulation Act HB9147	2021	0	None	Non-compostable single-use plastic products will be phased out within one to four years. The production, import, sale, distribution, provision, or use of these	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/14005_N_2021_Single-

					plastic products will be prohibited after these periods.	Use_Plastic_Products_Regulation_Act_HB9147.pdf
Philippines	National Plan of Action for the Prevention, Reduction and Management of Marine Litter	2021	15	a) Establish a national program on monitoring and assessment of marine litter and micro-plastics, b) Coordinate with international bodies on marine litter and microplastics, and c) Carry out a national baseline assessment on waste leakage and accumulation of litter in the marine environment incl. microplastics.	Develop and implement an Extended Stakeholder Responsibility (ESR) system, mainstream circular economy (CE) and sustainable consumption and production (SCP) initiatives, enhance recovery and recycling coverage and markets, prevent leakage from collected or disposed waste, reduce maritime sources of marine litter and manage litter that is already existing in the riverine and marine environments, etc.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/13011_N_2021_National_Plan_of_Action_for_the_Prevention_Reduction_and_Management_of_Marine_Litter.pdf
Philippines	FDA Circular No. 2019-004	2019	0	None	Imposes a ban on Bisphenol A (BPA) in infant feeding bottles and sippy cups as child care article products.	https://faolex.fao.org/docs/pdf/phi210323.pdf
Philippines	Philippine Development Plan (PDP) 2017-2022	2017	0	None	Encourages proper waste management and awareness raising about environmental issues.	https://pdp.neda.gov.ph/wp-content/uploads/2021/02/Pre-publication-copy-Updated-PDP-2017-2022.pdf
Philippines	Chapter 10 of DENR Administrative Order (DAO) No. 2013-22: Revised Procedures and Standards for the Management of Hazardous Wastes	2013	0	None	Stipulates that imports of unsorted and heterogeneous plastic materials are not allowed.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/13102_N_2013_Chapter_10_DENR.pdf
Philippines	National Solid Waste Management Framework (NSWMF) for 2012-2016	2012	0	None	Aims to improve solid waste management practices in the country, through waste segregation at the source and recycling and proper disposal methods.	https://nswmc.emb.gov.ph/wp-content/uploads/2016/07/NSWM-Strategy-2012-2016.pdf
Philippines	Total Plastic Bag Ban Act of 2011	2011	0	None	Prohibits groceries, supermarkets, public markets, restaurants, fast food chains, department stores, retail stores and other similar establishments from using non-biodegradable plastic bags.	https://legacy.senate.gov.ph/lisdata/110779429!.pdf

Philippines	Environmental Awareness and Education Act of 2008 or RA 9512	2008	0	None	Integrate environmental education in its school curricula at all levels, incl. waste minimization, segregation, recycling and composting.	https://www.officialgazette.gov.ph/2008/12/12/republic-act-no-9512/
Philippines	Integrated Coastal Management (ICM) Policy, Executive Order No. 533	2006	0	None	Integrated Coastal Management (ICM) programmes should include Integrated waste management, including, sewage and solid, hazardous, toxic and other wastes by major sources.	https://www.officialgazette.gov.ph/2006/06/06/executive-order-no-533-s-2006/
Philippines	Philippine Clean Water Act of 2004 (RA 9275)	2004	0	None	The Act emphasizes proper wastewater treatment for industrial, commercial, and household discharges. Industries and businesses covered by the Act are also required to implement pollution control measures.	https://lawphil.net/statutes/repacts/ra2004/ra_9275_2004.html
Philippines	Implementing Rules and Regulations of the Philippine Ecological Solid Waste	2001	0	None	Set guidelines for waste avoidance and volume reduction through source reduction, composting, recycling, and other eco-friendly practices. Ensure proper segregation, collection, transport, treatment, and disposal of solid waste without incineration.	https://www.globalplasticlaws.org/wp-content/uploads/2023/10/DAO-2001-34.pdf
Philippines	Philippine Ecological Solid Waste Management Act of 2000 (Republic Act (RA) 9003)	2000	0	None	Aims to formulate and implement a National Solid Waste Management Framework that will include a recycling program for plastics.	https://emb.gov.ph/wp-content/uploads/2015/09/RA-9003.pdf
Philippines	The Marine Pollution Decree of 1976, Presidential Decree (PD) 979	1976	0	None	Aims to prevent and control pollution of the seas. Prohibits the dumping of wastes and other matter that could harm human health and marine life.	https://faolex.fao.org/docs/pdf/phi19097.pdf
Singapore	National Action Strategy Addressing Marine Litter in Singapore	2022	22	Confirms Singapore's commitment to tackling marine litter, including microplastics, through water treatment technologies and waterway clean-up measures.	Focus on addressing land- and sea- based sources of litter, adopting a circular economy approach, research and development, outreach, stakeholder engagement and international collaboration.	https://www.mse.gov.sg/images/nasml/nasml.pdf
Singapore	Singapore Green Plan 2030	2021	0	None	Work towards our vision of becoming a Zero Waste Nation powered by a circular economy, with "Reduce, Reuse and Recycle" as a norm for citizens	https://www.greenplan.gov.sg/

					and businesses. 2026 targets: Reduce the amount of waste to landfill per capita per day by 20%. 2030 targets: Reduce the amount of waste to landfill per capita per day by 30%.	
Singapore	Singapore Prevention of Pollution of the Sea Act 1990 (Revised in 2021)	2021	0	None	Prohibits the discharge of waste, incl. plastics, from ships. Violations are subject to a fine not exceeding $20,000 or to imprisonment for a term not exceeding 6 months or to both.	https://sso.agc.gov.sg/Act/PPSA1990#pr1-
Singapore	Singapore Resource Sustainability Act (as of July 2020)	2020	0	None	Calls for the submission of 3R plans: Producers must submit a plan to reduce, re-use or recycle packaging in Singapore (whether or not the packaging is imported or used by the producer). Introduces a producer responsibility scheme and stipulates that applications for a license to operate a producer responsibility scheme must be made to the Agency.	https://www.mse.gov.sg/resource-room/category/2020-07-30-resource-sustainability-act/
Singapore	Singapore National Environment Agency Act 2002 (Revised in 2020)	2020	0	None	Established the National Environment Agency, which has the power to do anything related to waste minimisation, waste recycling, waste collection and disposal.	https://sso.agc.gov.sg/Act/NEAA2002?ValidDate=20211231%3FValidDate
Singapore	Singapore Environmental Protection and Management Act 1999 (Revised in 2020)	2020	0	None	Regulates broader environmental issues such as air and water quality, waste management, and resource conservation.	https://sso.agc.gov.sg/Act/EPMA1999/Uncommenced/20221201?DocDate=20220531&ValidDt=20230301&Timeline=On#pr1-
Singapore	Singapore Environmental Public Health Act 1987 (Revised in 2020)	2020	0	None	Prohibits disposal of waste in public places (does not mention plastics).	https://sso.agc.gov.sg/Act/EPHA1987?ValidDate=20221101
Singapore	Singapore Sewerage and Drainage Act 1999 (Revised in 2020)	2020	0	None	The Act regulates the discharge of sewage into the sea through public sewerage systems, and provides guidelines for sewerage and drainage works.	https://sso.agc.gov.sg/Act/SDA1999/Historical/20220401?DocDate=20230918&ValidDate=20220401?ValidDate=20220401
Singapore	The Hazardous Waste (Control of Import, Export or Transit) Act (HWA) 1997 (Revised in 2020)	2020	0	None	The act stipulates that the import and export of waste, including plastic waste types as listed in the annex, requires special consideration.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/13105_N_2020_the_hazardous_waste.pdf
Singapore	Zero Waste Masterplan Singapore	2019	0	None	Vision: to become a Zero Waste Nation. By 2030: Reduce the amount of waste (per capita) sent to	https://www.towardszerowaste.gov.sg/files/zero-waste-masterplan.pdf

					landfill by 30%, and achieve a 70% overall recycling rate.	
Singapore	Singapore Packaging Agreement (first launched 2007, updated in 2017)	2017	0	None	Reduce packaging waste arising from consumer products, incl. plastics, raise community awareness on packaging waste minimisation; and introduce supply chain initiatives to foster the sustainable use of resources in packaging.	https://www.nea.gov.sg/docs/default-source/our-services/nea_singapore-packaging-agreement-booklet-2017.pdf
Singapore	The Prevention of Pollution of the Sea (Garbage) Regulations 2001	2001	0	None	Stipulates that the disposal of any plastics, including but not limited to synthetic ropes, synthetic fishing nets, plastic garbage bags and incinerator ash from plastic products which may contain toxic or heavy metal residues, from a ship is prohibited.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/1052_N_2005_Prevention_of_Pollution.pdf
Thailand	Marine Fisheries Management Plan of Thailand 2020-2022	2020	0	None	Reduce the use of plastic bag in commercial fishing vessels to reduce marine debris.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15090_N_2020_Marine_Fisheries_Management_Plan.pdf
Thailand	Roadmap on Plastic Waste Management plan 2018-2030	2019	NA	Phase I: in 2019, ban the use of plastic microbeads.	Phase I: in 2019, ban the use of cap seal, OXO-degradable plastics and microbeads. Phase II: in 2022, ban foam food containers, plastic straws, plastic bags thicker than 36 micron and plastic cup thicker less than 100 microns. And phase III: by 2027, 100 % of plastic waste will be reusable/recycled	http://pcd.go.th/Info_serv/File/Plastic%20Roadmap.pdf
Thailand	Enhancement and Conservation of National Environmental Quality Act (No. 2) B.E. 2561 (2018)	2018	0	None	Stipulates that projects without environmental impact assessments (EIA) approval may face penalties, to ensure that development projects evaluate their potential environmental effects.	https://eiadev.onep.go.th/UploadFile/12350125650315.pdf
Thailand	Public Private Partnership for Sustainable Plastic and Waste Management (PPP Plastics)	2018	3	None *(only mentions the adverse effects of microplastics on the environment, marine ecosystems and the human body)*	Two key goals: 1) Reducing and eliminating the use of target plastics, and 2) Reuse the targeted plastic waste 100% by 2027.	https://www.tei.or.th/file/library/2021-Brochure_PPP-Plastics-ENG_60.pdf

Thailand	Act on the Maintenance of the Cleanliness and Orderliness of the Country, B.E. 2535 (1992)	1992	0	None	Prohibits the disposal of waste, such as plastic bags, in public places or onto the road or waterway.	https://faolex.fao.org/docs/pdf/tha209432.pdf
Viet Nam	Decree No. 08/2022/ND-CP on elaboration of several Articles of the Law on Environmental Protection	2022	4	The production and import of products and goods containing microplastics shall be gradually reduced. After December 31, 2030, the production and import of products and goods containing microplastics shall be terminated.	1) As of January 01, 2026, it is not permitted to produce and import non-biodegradable plastic bags with dimensions less than 50 cm x 50 cm and a wall thickness of less than 50 µm. 2) Producers and importers of single-use plastic products and non-biodegradable plastic packaging shall fulfill the responsibility for recycling and treatment. 3) The production and import of single-use plastic products and non-biodegradable plastic packaging shall be gradually reduced. After December 31, 2030, the production and import of single-use plastic products non-biodegradable plastic packaging shall be terminated. (Exemptions apply to item 1 and 3).	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15034_N_2022_Decree_No_082022.pdf
Viet Nam	Scheme for Environmental Protection in Fishery Sector in the period of 2021 – 2030,	2022	0	None	Control, prevent, monitor, and manage pollution and waste (including plastic litter) from fishery activities.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15027_N_2022_Scheme_for_Environmental_Protection.pdf
Viet Nam	National Strategy for Biodiversity until 2030 and vision to 2050	2022	0	None	Effectively implement solutions to increase control of pollutants, especially plastic wastes, to improve environmental quality around natural heritage sites, sanctuaries, and areas with high biodiversity.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15036_N_2022_National_Strategy_for_Biodiversity.pdf
Viet Nam	National Aquaculture Development Program for the Period of 2021 – 2030	2022	0	None	Reduce the use of plastic materials in aquaculture.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15037_N_2022_National_Aquaculture_Development_Program.pdf
Viet Nam	Decree No. 68/2022/ND-CP on functions, tasks, powers and organizational structure of the Ministry of Natural Resources and Environment	2022	0	None	Assigns responsibility for managing ocean plastic waste to the Ministry of Natural Resources and Environment.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15116_N_2022_Decree_No._68.pdf
Viet Nam	Resolution No. 26/NQ-CP, Master Plan and 5-year plan for	2020	0	None	a) Formulate and launch the national action plan for management of marine plastic litter by 2030.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-

	implementation of Resolution No. 36NQ/TW on strategy for sustainable development of Viet Nam's ocean economy by 2030, with visions towards 2045				b) Encourage formulation of regional and international cooperation frameworks for prevention, control and reduction of marine plastic litter. c) Establish and put into use an international marine plastic litter center in Viet Nam	policies/15091_N_2020_Resolution_Promulgating_Government%27s_Master.pdf
Viet Nam	National Action Plan on Sustainable Consumption and Production (2021-2030)	2020	0	None	By 2030: 100% of supermarkets and commercial centers distribute and use eco-friendly packaging which gradually replaces single-use, non-degradable plastic items. By 2030: 7-10% decrease in resources and materials used for production sectors such as plastics.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15119_N_2020_National_Action_Plan.pdf
Viet Nam	Law No. 72/2020/QH14 on Environmental Protection	2020	1	The Government shall introduce a roadmap for reducing production and import of single-use plastic products, non-biodegradable plastic packaging and products and goods containing microplastics.	Ensure the reduction, reuse, recycling and treatment of plastic waste, prevention and control of ocean plastic waste pollution.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/15069_N_2020_Law_No_722020QH14.pdf
Viet Nam	Directive No. 33/CT-TTg dated August 20, 2020 on regarding strengthening of management, reuse, recyciling, disposal and reduction of plastic waste	2020	4	a) Research and build environmental technical barriers to products and commodities containing microplastics, nanoplastics and plastic bags, b) Research and propose a roadmap to ban the use of microplastics in the production of cosmetics, garments, and fertilizers, etc. and c) Conduct a review and announcement of domestically produced and imported products containing microplastics,	By 2021: Ensure that all shops, markets and supermarkets in urban areas do not use single-use plastics. By 2025: Ensure that the whole country do not use single-use plastics.	https://lawnet.vn/en/vb/Directive-33-CT-TTg-2020-regarding-strengthening-of-management-reduction-of-plastic-waste-73FF8.html

				nanoplastics for consumers' information.		
Viet Nam	National Action Plan for Management of Marine Plastic Litter by 2030	2020	2	Identify solutions to plastic microbeads from wastewater of urban areas and industrial parks, and conduct more research on the pollution risks and impacts of plastic litter, especially plastic microbeads.	Reduce marine plastic litter by 50% by 2025, and by 75% by 2030.	https://www.undp.org/Viet Nam/publications/national-action-plan-management-marine-plastic-litter-2030
Viet Nam	Resolution No. 36NQ/TW on strategy for sustainable development of Viet Nam's ocean economy by 2030, with visions towards 2045	2018	0	None	Aims to prevent, control and dramatically reduce sea pollution, especially from plastic waste, and ensure that 100% of household solid waste is collected and disposed according to environmental standards at coastal provinces and cities.	https://faolex.fao.org/docs/pdf/vie219173.pdf
Viet Nam	Decision No. 491/QD-TTg dated May 07, 2018 approving adjustments to national strategy for general management of solid waste to 2025 with vision towards 2050	2018	0	None	By 2025: Use 100% environmentally friendly plastic bags in trade centers and supermarkets to replace persistent plastic bags. Phase out the import, export and provision of types of persistent plastic bags used in daily life towards 2026 in trade centers and supermarkets. 90% of daily-life solid waste discharged in urban centers must be collected and treated satisfying the environmental protection requirement;	https://lawnet.vn/en/vb/Decision-491-QD-TTg-approving-adjustments-to-national-strategy-for-general-management-solid-waste-5E825.html
Viet Nam	Circular No. 159/2012/TT-BTC - Detailing and Guiding a Number of Articles of the Law on Environmental Protection Tax	2012	0	None	Specifies the types of plastic bags that are subject to an environmental tax.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/3021_N_2012_Law_on_Environmental_Protection_Tax.pdf
Viet Nam	Circular No. 07/2012/TT-BTNMT of July 4, 2012, providing the criteria, order of and procedures for recognition of environment friendly plastic bags	2012	0	None	Stipulates the criteria, order of and procedures for recognition of environment friendly plastic bags permitted for import, production and use in Viet Nam.	https://faolex.fao.org/docs/pdf/vie117977.pdf

Viet Nam	Order No. 14/2010/L-CTN on the promulgation of the Law on Environmental Protection Tax	2010	0	None	Introduced an environmental protection tax rate of 30.000-50.000 VND per kg of taxable plastic bags. This tax is payable by the producers and importers of these products.	https://faolex.fao.org/docs/pdf/vie107002.pdf
Viet Nam	Decision No. 2149/QD-TTg - Approving the National Strategy for Integrated Management of Solid Waste up to 2025, with a Vision to 2050	2009	0	None	Gradually reduce the quantity of plastic bags used in supermarkets and trade centers by 40% (by 2015), 65% (by 2020) and 85% (by 2025) compared to 2010.	https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/2306_N_2009_No_2149_QD-TTg_Approving_the_National.pdf

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