MEKONG RIVER COMMISSION
MRC
FOR SUSTAINABLE DEVELOPMENT

# THE STATUS AND TRENDS OF RIVERINE PLASTIC POLLUTION IN THE LOWER MEKONG RIVER BASIN

*The MRC is funded by contributions from its Member Countries and Development Partners, including Australia, the European Union, Finland, Flanders/Belgium, France, Germany, Japan, Luxembourg, the Netherlands, New Zealand, Sweden, Switzerland, and the United States of America.*

Mekong River Commission

# The Status and Trends of Riverine Plastic Pollution in the Lower Mekong River Basin

December 2022

**Copyright © Mekong River Commission, 2022**
First published (2022)

Some rights reserved.

This work is a product of the Mekong River Commission (MRC) Secretariat. While all efforts have been made to present accurate information, the MRC does not guarantee the accuracy of the data included in this work. The boundaries, colours, denomination and other information shown on any map in this work do not imply any judgement on the part of the MRC concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Nothing herein shall constitute or be considered to be a limitation upon or waiver of the privileges and immunities of the MRC, all of which are specifically reserved.

This publication may be reproduced, in whole or in part and in any form, for educational or non-profit purposes without special permission from the copyright holder provided that the MRC is acknowledged as the source and that notification is sent to the MRC. The MRC Secretariat would appreciate receiving a copy of any publication that uses this publication as a source. This publication cannot be used for sale or for any other commercial purpose whatsoever without permission in writing from the MRC Secretariat.

**Title:** The status and trends of riverine plastic pollution in the Lower Mekong River Basin

DOI: 10.52107/mrc.aqrsb2

**Keywords:** riverine plastic/plastic pollution/Mekong River

**For bibliographic purposes, this volume may be cited as:**
Mekong River Commission. (2022). *The status and trends of riverine plastic pollution in the Lower Mekong River Basin*. Vientiane: MRC Secretariat. 10.52107/mrc.aqrsb2

Information on MRC publications and digital products can be found at
http://www.mrcmekong.org/publications/

All queries on rights and licenses should be addressed to:
Mekong River Commission
Documentation and Learning Centre
184 Fa Ngoum Road, Unit 18, Ban Sithane Neua, Sikhottabong District, Vientiane 01000, Lao PDR
Telephone: +856-21 263 263 | E-mail: mrcs@mrcmekong.org | www.mrcmekong.org

## Citation

Mekong River Commission. (2022). *The status and trends of riverine plastic pollution in the Lower Mekong River Basin*. Vientiane: MRC Secretariat. 10.52107/mrc.aqrsb2

## Authors

***Management***

Mr Socheat Hak, Director of Environmental Management Division, MRC Secretariat

***Technical Experts***

Mr Satoshi Sasakura, Riverine Plastic Management and Monitoring Expert, IDEA Consultants, Inc.; Dr Kongmeng Ly, Water Quality Officer, Environmental Management Division, MRC Secretariat; Dr Prayooth Yaowakhan, Ecosystem and Wetland Specialist, Environmental Management Division, MRC Secretariat; Dr So Nam, Chief Environment Officer, Environmental Management Division, MRC Secretariat.

***National contributors***

National Mekong Committee Secretariats of Cambodia, Lao PDR, Thailand and Viet Nam; Mr Roath Sith, Cambodia's National Riverine Plastic Management and Monitoring Expert, Ministry of the Environment; Dr Vatthanamixay Chansomphou, Lao PDR's National Riverine Plastic Management and Monitoring Expert, Faculty of Environmental Sciences, National University of Lao PDR; Dr Akeapot Srifa, Thailand's National Riverine Plastic Management and Monitoring Expert, Department of Biology, Mahasarakham University; and Dr Diep Dinh Phong, Viet Nam's National Riverine Plastic Management and Monitoring Expert, Southern Institute of Ecology.

# Contents

# Figures

# Tables

# Acronyms and Abbreviations

| | |
|---|---|
| **3Rs** | Reduce, Reuse, Recycle |
| **ASEAN** | Association of Southeast Asian Nations |
| **COBSEA** | Coordinating Body on the Seas of East Asia |
| **CR** | Contribution rank |
| **DMCR** | Department of Marine and Coastal Resources (Thailand) |
| **DONRE** | Department of Natural Resources and Environment (Viet Nam) |
| **DRS** | Deposit Refund Scheme |
| **EGAT** | Electricity Generating Authority of Thailand |
| **EPR** | Extended producer responsibility |
| **FADM** | Fishery Abundance and Diversity Monitoring |
| **FTIR** | Fourier transform infrared spectroscopy |
| **GDP** | Gross domestic product |
| **GIC** | Geoinformatics Center of Thailand |
| **GISTDA** | Geo-Informatics and Space Technology Development Agency of Thailand |
| **HDPE** | High-density polyethylene |
| **IMO** | International Maritime Organization |
| **IUCN** | International Union for Conservation of Nature |
| **JICA** | Japan International Cooperation Agency |
| **Lao PDR** | Lao People's Democratic Republic |
| **LAO** | Local administrative organization of Thailand |
| **LDPE** | Low-density polyethylene |
| **LMB** | Lower Mekong Basin |
| **LNMC** | Lao National Mekong Committee |
| **MARD** | Ministry of Agriculture and Rural Development of Viet Nam |
| **MARPOL** | International Convention for the Prevention of Pollution from Ships |
| **MC** | Member Country |
| **MCD** | Center for Marine Life Conservation and Community Development of Viet Nam |
| **MOIC** | Ministry of Industry and Commerce (Lao PDR) |

| | |
|---|---|
| **MORE** | Ministry of Natural Resources and Environment |
| **MPWT** | Ministry of Public Works and Transport (Lao PDR) |
| **MRC** | Mekong River Commission |
| **MRCS** | Mekong River Commission Secretariat |
| **MSW** | Municipal solid waste |
| **NGO** | Non-governmental organization |
| **NUOL** | National University of Lao PDR |
| **PCD** | Pollution Control Department of Thailand |
| **PDIES** | Procedures for Data and Information Exchange and Sharing |
| **PET** | Polyethylene terephthalate |
| **PP** | Polypropylene |
| **PS** | Polystyrene |
| **PVC** | Polyvinyl Chloride |
| **PWQ** | Procedures for Water Quality |
| **RDF** | Refuse-derived fuel |
| **RUPP** | Royal University of Phnom Penh |
| **SEM** | Scanning electron microscope |
| **SUP** | Single-use plastic |
| **SWM** | Solid waste management |
| **TGWQ** | Technical Guidelines on the Implementation of the Procedures for Water Quality |
| **UNEP** | United Nations Environment Programme |
| **VCOMS** | Vientiane City Office for Management and Service |
| **VNMC** | Viet Nam National Mekong Committee |
| **WQMN** | The Water Quality Monitoring Network |
| **WWF** | World Wide Fund for Nature |

# Executive Summary

## Introduction

This report explains the status and trends of plastic waste pollution in the Lower Mekong River Basin (LMB) from the perspectives of plastic pollution itself, and also the frameworks and capacity of each Member Country to address the issues of plastic pollution. Each chapter consists of the explanation of the situation, being followed by challenges to be overcome by the cooperative efforts in the region.

## Key findings

### 1. Background

The problems of riverine plastic debris are highly extensive, exceeding the region of SWM, circular economy and Reduce Reuse Recycle (3R) policies. Therefore, combatting riverine plastic debris requires comprehensive approaches including multi-sectoral cooperation and oceanographical knowledge.

### 2. How Mekong River Commission Member Countries are handling plastic today

Due to a variety of functions and cheap production price of plastic, its production is increasing worldwide, including in some Member Countries (MCs) such as Thailand and Viet Nam. However, when plastic leaks into the environment, it poses serious dangers to the environment to a very wide area almost permanently because it cannot be naturally degraded. Although countries in the LMB produce a relatively less amount of waste in the Association of Southeast Asian Nations (ASEAN), development can cause steep increase in the amount. Furthermore, open dumpsite which is one of the major ways of treating waste in the LMB can also cause the leakage of debris into the environment.

### 3. Policy and institutional frameworks

At regional and international levels, Regional Action Plan on Marine Litter 2019 of Coordinating Body on the Seas of East Asia (COBSEA, 2019) may be most specific framework including the concrete plan for establishing monitoring mechanism. There are several international conventions that covers prevention of marine pollution from ships, discharge of harmful substances, open dumping, or completely prohibiting the disposal of plastic in all forms. However, the number of countries in the LMB that have ratified these conventions has not yet increased, and many exclude landlocked countries such as Lao PDR.

As per national political framework, it seems that none of four MCs have specific policy framework for monitoring of plastic debris or monitoring of riverine debris. In national institutional frameworks, there appears to be a lack of clear allocation of work and responsibility between the institutions on the riverine debris.

## 4. Capacity of riverine plastic debris monitoring

The lack of research equipment is striking within the MCs. Some facilities in Thailand and Viet Nam apply the Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy techniques, which are needed to identify the plastic material. In addition, available equipment is limited to a stereo dissecting microscope in Cambodia, and a water sampler in Lao PDR.

## 5. Current trends and status of plastic pollution in the LMB

### 5.1 Riverine monitoring activities and results in the LMB

Within the MCs, there were several monitoring activities addressing riverine plastic pollution. However, these activities were largely outside the LMB. In the LMB, the only known monitoring of riverine plastic debris pollution was only carried out by the United Nations Environment Programme (UNEP) under its Promotion of action against marine plastic litter in Asia and the Pacific project (the CounterMEASURE II Project). Under the CounterMEASURE II Project, UNEP conducted surveys on plastic waste pollution status in the LMB from four perspectives: riverine macroplastics, riverine microplastics, plastic leakage hotspots, and plastic accumulation hotspots. While the survey results from these perspectives have provided initial understanding of the status of plastic waste pollution under each perspective, the survey methods largely varied for each perspective, making a detailed comparison impossible. For collecting scientific knowledge on plastic pollution to be reflected in policymaking, the standardization of survey methods and regular monitoring are indispensable.

### 5.2 Riverine monitoring results outside the LMB

Outside the LMB in MCs, monitoring is being conducted of marine debris both macroplastics and microplastics. Sharing the resources such as human resource and equipment, as well as knowledge and experience will surely accelerate the efficient monitoring of riverine plastic pollution in the LMB.

### 5.3 Clean-up and collection activities in the LMB

There are no regular clean-up activities that specifically focus on the LMB region.

### 5.4 Solid waste management at 12 ports in four MCs

Out of the 12 ports surveyed, 11 had an accumulation of waste including plastic debris. The ratio of plastic waste in accumulated debris was above 70% in 7 ports out of 11, while the ratio of plastic in debris flowing from upstream reached 50% in only 1 port, with rest of them being 10% to 30%. The spatial accumulation of bags and bottles were most common items reported. Similarly in the accumulated debris, bottle accounted for the largest part in 8 ports, and bags account for the largest in 4 ports among the reported items. And together they compose more than 50% in 8 locations.

**6. Fishery activities and the impacts of plastic pollution on living organisms**

Among 19 species observed by the fishers that were entangled or that ingested plastic, 6 species contribute to more than 1% of the fish catch in the LMB. Also, one of the affected species is classified as 'vulnerable' in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species.

Other effects on the species in MCs and other Asian countries were found through a desktop survey. The effects can be both physical and chemical, such as entanglement in macroplastics and ingestion of microplastics, or accumulation of harmful chemical substances transferred through the ingestion of plastic.

## Recommendations

The basin-wide status and trends of riverine plastic pollution were assessed and information and knowledge were gathered to inform decision-making towards effective and efficient management of riverine plastic pollution in the LMB. The following are recommendations on addressing the identified gaps and challenges in developing a monitoring system for riverine plastic pollution in each MC:

- Conducting riverine debris monitoring rigidly following the protocol by the MRC, and sharing the experience as well as data. This will enable the data compilation for scientific research and active involvement of stakeholders.
- Collaboration between the government, academia and institutes is required to conduct riverine debris monitoring, to maximize the outcome with the limited resources.
- Providing capacity building for development of, definition and classification of riverine debris, sampling methodology, sample analysis and monitoring protocol. A monitoring programme should include both macroplastics and microplastics in a cost-effective manner.
- Identifying government authorities or research institutions suitable for conducting and maintaining monitoring activities in cooperation with related organization.
- Establishing a collaborative mechanism among MCs for riverine debris monitoring activities to fill the gaps in availability of necessary equipment such as FT-IR (e.g. sending the samples after pre-treatment for analysis from a country where FT-IR is not available).
- Establishing and enforcing policies and regulations on waste littering, 3R, riverine plastic waste management including clear responsibility of national government, local government, private sector and community.
- Regular collection of riverine debris and appropriate treatment of collected debris.
- Raising public awareness regarding impacts of plastic waste on environment and water resources.
- An integrated monitoring system that consolidates the monitoring activities and results of each organization.

Through the recommended items above, results of riverine debris can be evaluated, and Material Flow Analysis and Inventory Analysis of plastic can be facilitated. These will also contribute to evaluating the effectiveness of the measure.

# Background

The Mekong River Commission (MRC) was established by the 1995 Agreement on Co-operation for the Sustainable Development of the Mekong River Basin, between the governments of Cambodia, Lao PDR (Lao People's Democratic Republic), Thailand and Viet Nam (MRC, 1995). The role of the MRC is to coordinate and promote cooperation in all fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin with the MRC Secretariat (MRCS) serves the operational arm of the MRC (MRC, 1995). It provides technical and administrative services to the Joint Committee and the Council to achieve the MRC's mission. The Environmental Management Division (ED) is responsible for environment monitoring, assessment, planning and management to support basin planning management and development for sustainable development of the Mekong River.

The Mekong River Basin is one of the largest and most biodiverse river basins in the world, spreading over more than 795,000 $km^2$ and extending over 5,000 km through six different countries and providing a home to more than 70 million people alone in its lower reaches (MRC, 2019). However, the Mekong River is also one of the 10 major contributors to marine plastic pollution. Collectively these major contributors discharge about 95% of the plastic strangling the world's oceans (Schmidt et al., 2017).

In 2019 the United Nations Environmental Assembly agreed on measures aiming at curtailing global plastic pollution and leakage into the world's oceans with the commitment of 180 countries including the MCs (UNEP, 2020e). The main aim is to reduce the use of single-use plastic products. However, it is known that this will not be enough to effectively address the magnitude of plastic waste that pollutes our freshwater ways and our oceans.

The MRC has six core functions including assessments and analysis, monitoring of environmental status and trends and the implementation of MRC procedures. Among the five MRC procedures are the Procedures for Water Quality (PWQ) and the Procedures for Data and Information Exchange and Sharing (PDIES). One of the key objectives of the MRC core function for monitoring is the continuous assessment and identification of basin changes of 5 different disciplines: (i) Hydrology and Hydraulics; (ii) Sediment and Discharge; (iii) Water Quality; (iv) Aquatic Ecology; and (v) Fisheries. The MRC has long experience with environment and fisheries monitoring according to the key disciplines. The MRC water quality monitoring activity dates back to 1985 with the establishment of the Water Quality Monitoring Network (WQMN) in Lao PDR, Thailand and Viet Nam, with Cambodia joining the network in 1993 (MRC, 2018). Presently, its activities spread across 48 sites throughout the Lower Mekong Basin (LMB) with 17 sites located on the Mekong mainstream and 5 sites on the Bassac River. The MRC Fisheries monitoring began in 1995, and consists of three categories to date: Fish Abundance and Diversity Monitoring (FADM), Fish Larvae Drift Monitoring, and *Bagnet* (Dai) fishery monitoring. Today, FADM, which was set up in 2007, takes place throughout the basin in 38 sites and will soon be based to a larger extent on recommendations from the Joint Environmental Monitoring (JEM) Programme for the

Mekong mainstream hydropower projects. These procedures and monitoring activities lay the groundwork for this assignment.

The MRC and United Nations Environment Programme (UNEP) signed a Memorandum of Understanding (MoU) to work on water quality monitoring, including on plastic waste leakage into the Mekong River system. Under this partnership in 2019, the MRC supported the first phase of the UNEP project on the Promotion of Countermeasures Against Marine Plastic Litter in Southeast Asia (CounterMEASURE) including regional workshops, capacity mapping for plastic pollution in the Mekong basin and support to the pilot projects in the four MRC MCs – Cambodia, Lao PDR, Thailand, and Viet Nam (UNEP, 2020e).

Building on the initial efforts under the first phase of the CounterMEASURE, the MRC and UNEP agreed on further cooperation in 2020 including the identification of sources of plastic waste leakage, and the development of a standardized/harmonized methodology for plastic debris assessment and monitoring in the Mekong River. The final objective is to collect up-to-date data and information on transboundary plastic waste pollution status and trends, and to make that information available for policy decision-making.

To this end, the MRC implemented two key activities for 2020 including the review of the status and trends of plastic waste pollution and management in Lower Mekong Countries and the development of a concept note for a long-term and cost-effective assessment and monitoring methodology of plastic waste in the Mekong River.

With the continuous partnership with UNEP and based on the outcomes of the activities carried out to date, the MRC is examining the status of plastic pollution and how to analyse it specifically by:

- analysing the scope and impact of plastic and microplastic pollution in the Mekong River fauna with a focus on migratory freshwater fish species as reported on the review of the status and trends of plastic waste management in the LMB; and
- including a biological monitoring protocol in the concept note on methodological and tool for a long-term and cost-effective assessment and monitoring of plastic debris pollution in the Lower Mekong River.

## 1.1. Problems of riverine debris

The problems of riverine plastic debris pollution are highly extensive and complex, as shown in Figure 1.1. When discussing riverine plastic debris pollution, the focus tends to be on SWM, circular economy or 3R (Reduce, Reuse and Recycle) principle. However, the actual problem of riverine plastic debris pollution is much broader, lying in the very existence of riverine plastic debris. The three main specific problems of riverine plastic debris pollution are as follows (Figure 1.1):

1. Leakages from various sources need to be tackled in different fields such as manufacturing, SWM, fishing and tourism. This cannot be improved without

multisectoral approach from cooperation among governmental bodies, private sector, and research institutions.
2. Difficulties in collecting debris once it flows into the water. Also, its transboundary movements through river flow and current makes the responsibility of management unclear.
3. Understanding and monitoring of their occurrence and flowing paths requires oceanographical approach.

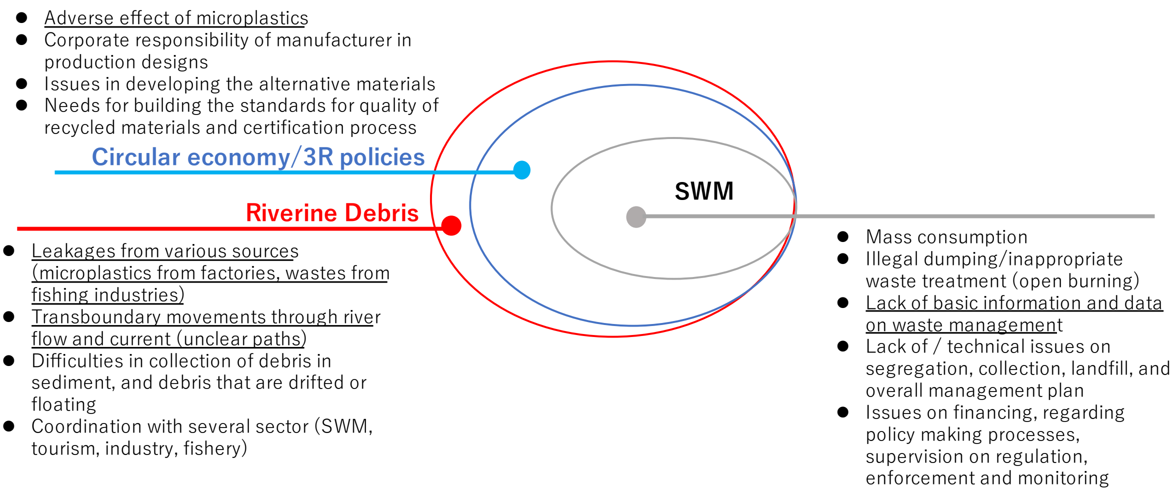



**Figure 1.1.** An outline of the problems of riverine debris and its relevant fields

Still, several research have been carried out for the deeper understanding of its behaviour. The amount of plastic waste, one of the key components of riverine debris, is estimated to be 275 million tonnes per year globally. Among that, 8 million tonnes (2.9%) are estimated to enter the ocean (Our World in Data, 2019).

Mekong River is estimated to be the 10th largest river contributing to the marine plastic occurrence in the world (Schmidt et al., 2017). They calculated the amount of plastic debris discharged from each river using data from various studies, with the aim of integrating as much data as possible. The research team divided the riverine plastic debris into two categories: microplastics smaller than 5 mm in diameter, and macroplastics larger than that. The calculation was made using two models: model 1 using all the acquired data, and model 2 using only the data from a dataset that contains information on both microplastics and macroplastics. The results are shown in Table 1.1, in which calculated microplastics loads showed a significant difference between model 1 (third column from the right) and model 2 (second column from the right), that is, nearly 10 times higher in some areas. In contrast, the results for macroplastics were the same for both models (rightmost column).

Since this study integrates secondary data from various survey methods combined, it is difficult to say which model to fully trust. However, this fluctuation increasingly underscores the importance of collecting primary data to confirm the actual pollution situation. Since river networks can facilitate the transport of plastic debris over long distances into the sea (Schmidt et al., 2017), it is necessary to take urgent action to stop further pollution. The top 10 rivers shown in Table 1.1 are transporting about 88–95% of the global plastic debris load into the world's oceans (Schmidt et al., 2017).

**Table 1.1.** Top 10 rivers transporting marine plastic debris

| Rank | Name of the river | Microplastic load Model 1 [tonnes y-1] | Microplastic load Model 2 [tonnes y-1] | Macroplastic load [tonnes y-1] |
|---|---|---|---|---|
| 1 | Chang Jiang (Yangtze River) | 85,440 | 1,469,481 | 69,282 |
| 2 | Indus | 12,378 | 164,332 | 11,977 |
| 3 | Huang Hec (Yellow River) | 9,678 | 124,249 | 9,561 |
| 4 | Hai He | 7,434 | 91,858 | 7,515 |
| 5 | Nile | 6,919 | 84,792 | 7,043 |
| 6 | Meghna, Bramaputra, Ganges | 6,039 | 72,845 | 6,230 |
| 7 | Zhujiang (Pearl River) | 4,577 | 52,958 | 4,823 |
| 8 | Amur | 3,429 | 38,267 | 3,708 |
| 9 | Niger | 3,185 | 35,196 | 3,469 |
| 10 | Mekong | 3,044 | 33,431 | 3,330 |
| **Total** | | **142,123** | **2,167,409** | **126,938** |

*Source:* Schmidt et al. (2017)

Another study by Haberstroh et al. (2021) estimated that around 74,095 ton/year of plastic were released from Phnom Penh into the Mekong River during the wet season. This accounts for 3.4% to 52% of microplastic load estimation by (Schmidt et al., 2017)

Yet, Meijer et al. (2021) estimated that more than 1000 rivers account for 80% of global annual emissions, which range between 0.8 million and 2.7 million tonnes per year, with small urban rivers among the most polluting. These varying results emphasizes the importance of monitoring riverine debris for specifically identifying the emission source of debris.

**Main results and key challenges**

- 8 million tonnes of plastic waste are estimated to enter the ocean annually (Jambeck et al., 2015).
- Top 10 rivers contributing to the marine plastic occurrence are said to be transporting 88–95% of the global load into the sea (Schmidt et al., 2017). In the Mekong River which ranks 10$^{th}$, the annual flux of riverine plastic is estimated to be 142,123 tonnes/year to 2,167, 409 tonnes/year for microplastics, and 126,938 tonnes/year for macroplastics (Schmidt et al., 2017). The total amount of microplastics and macroplastics is 269,061 tonnes/year to 2,294,347 tonnes/year, respectively, or 3.4% to 29%, respectively, of the 8 million tonnes of annual flux into the ocean (Jambeck et al., 2015).
- The problems of riverine debris are highly extensive, exceeding the region of circular economy and 3R policies. Therefore, combatting riverine plastic debris requires comprehensive approaches including multi-sectoral cooperation and oceanographical knowledge.

# 2. How Member Countries are handling plastic in our lives, and in the environment

Plastic is one of the key components of debris in the water. In fact, it is said that plastic makes up 80% of all marine debris from surface waters to deep-sea sediments (IUCN, 2021). The features of plastic, which is why they are so widely used in our daily lives today, are very much why they pose a crucial impact on the environment (Figure 2.1).

To begin with, its low cost of production has made the widespread consumption available regardless of income. However, due to its convenience and inexpensive product price, it is frequently disposed of in mass consumption. Also, due to its light weight, it can travel a very long distance once disposed of. In addition, due to its durable structure, it remains in the environment almost indefinitely without being decomposed, becoming fine particles (microplastics).

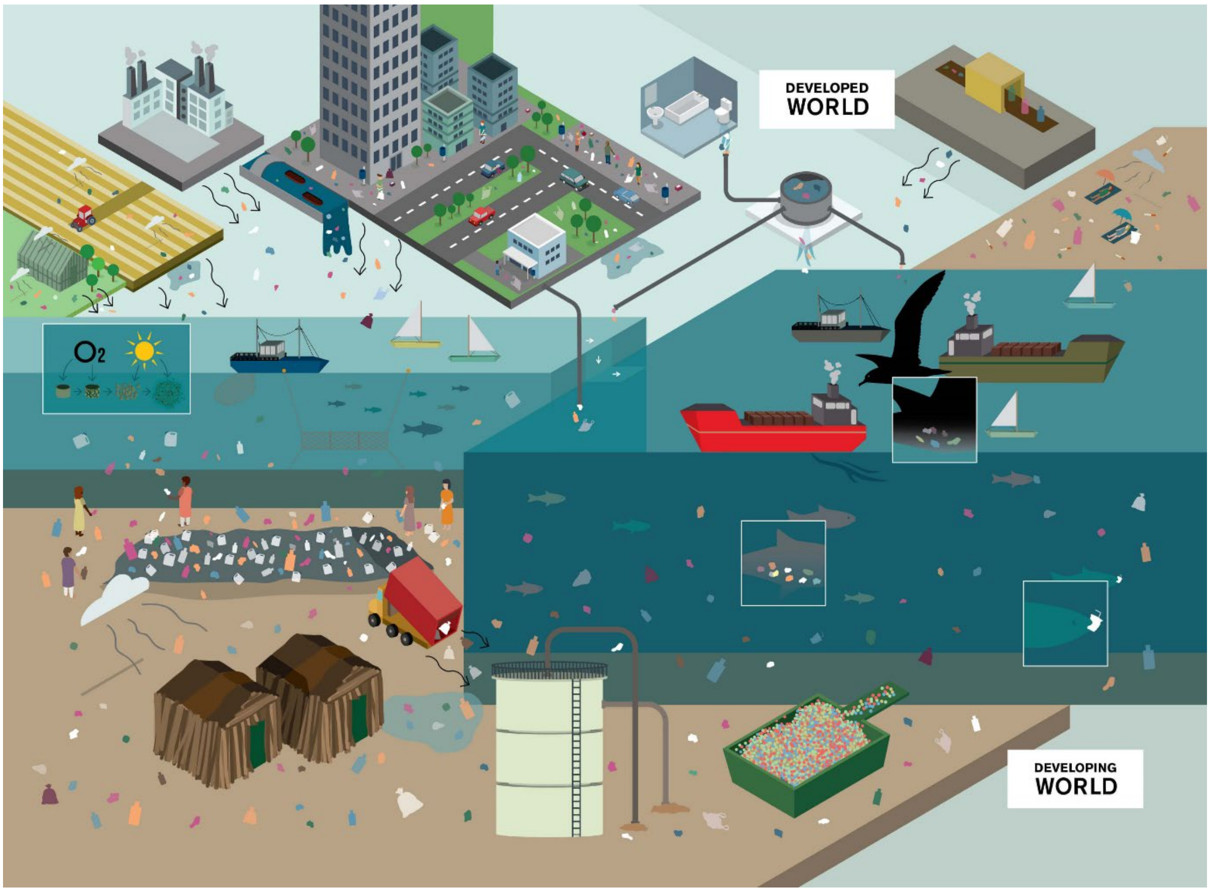



**Figure 2.1.** Production, use, and fate of plastic in the environment

*Source:* ISWA Marine Task Force (2017)

Despite these known environmental effects, plastic today has gained remarkable popularity throughout the world. Looking at the trend of global plastic production, the total amount has been steadily increasing (Figure 2.2). This trend is also notable in MCs. Figure 2.3 shows the growing amount of plastic production in Thailand and Viet Nam, as well as their proportion of worldwide production. Thailand has been producing increasing amounts of plastic with a constant share at around 2.5%, and Viet Nam has increased sharply in just one decade. In Cambodia and Lao PDR, there are no official data on plastic production.

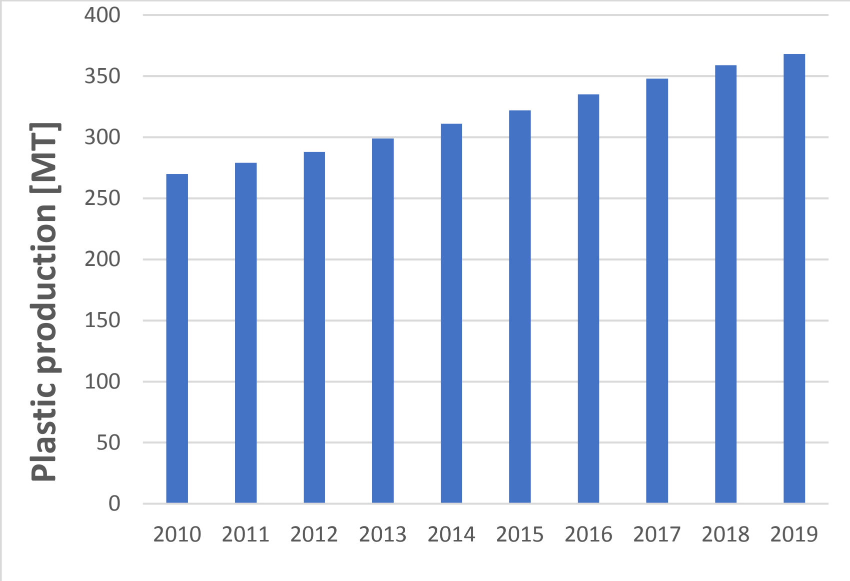



**Figure 2.2.** Amounts of global plastic production

*Source:* Statista (2022)

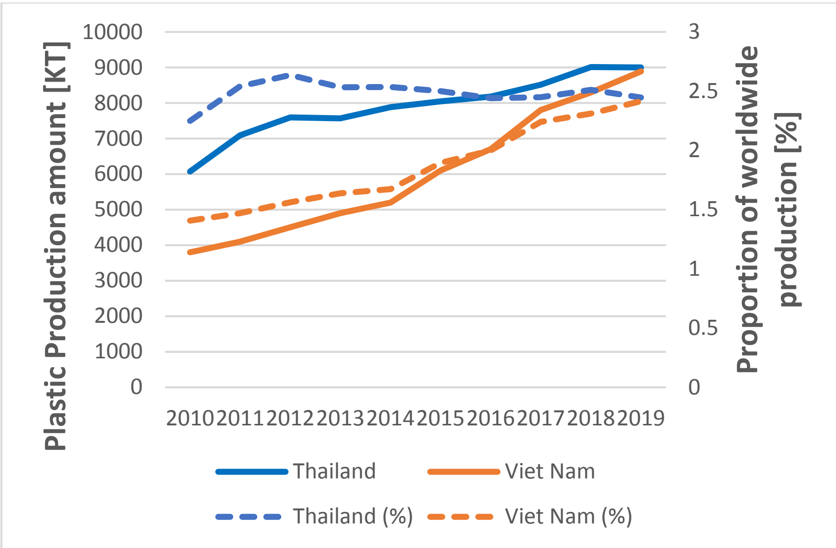



**Figure 2.3.** The amount of plastic production in Thailand and Viet Nam, and their proportion of global production

*Source:* FPT Securities, 2019; Petroleum Institute of Thailand (n.d.)

Figure 2.4 provides detail on plastic resin pellets production in Thailand, showing that production of each kind of pellet is increasing almost constantly. Polypropylene (PP) accounts for more than 30% of Thailand's annual production and was the most produced pellet for six consecutive years from 2012 to 2017 (Figure 2.4). This is due to its wide use for the production of wrappers, bottles, bottle caps, utensils such as cups and straws. The second most produced is high-density polyethylene (HDPE), at around 19% in the 2012–2017 period, which is mainly used for the production of bags, wrappers, bottle caps, or fishing gear (Malakul et al., 2019). Polyvinyl chloride (PVC) ranked third in 2012, but its production was surpassed by the LLDPE in recent years.

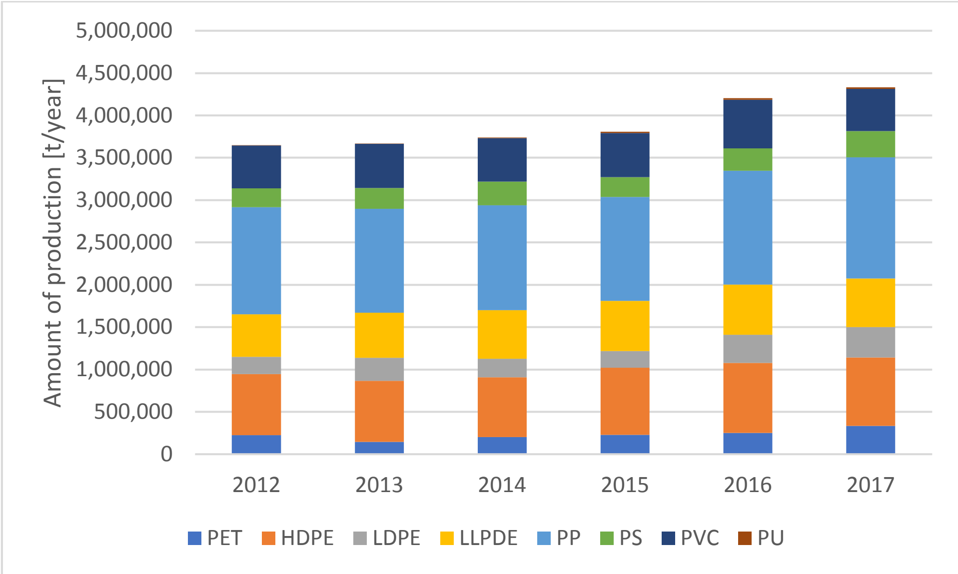



**Figure 2.4.** Production of resin pellets in Thailand, 2012–2017

*Source:* Malakul et al. (2019)

Note: PET= polyethylene terephtalate; HDPE= high-density polyethylene; LDPE= low-density polyethylene; LLDPE= linear low density polyethylene, PP=polypropylene; PS= Polystyrene (or styrofoam); PVC= Polyvinyl Chloride;PU= Polyurethane

The use of resin pellets such as polyethylene terephthalate, HDPE, low-density polyethylene (LDPE), LLDPE, PP, PS, PVC, and PU for the production of plastic goods in Thailand was studied by Malakul et al. (2019), revealing that more than 20% of these pellets were used for the production of daily domestic plastic goods, including plastic bags, wrappers and containers (Figure 2.5).

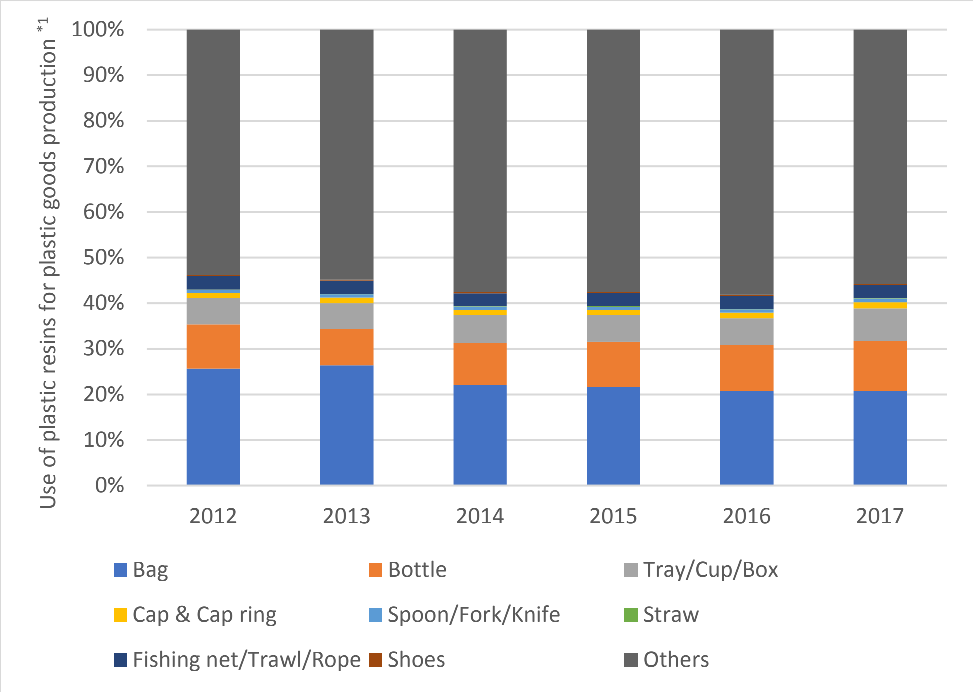



**Figure 2.5.** Proportion of plastic goods production

*Note*: Considering only the production of plastic resins for use in 8 targeted plastic products listed in the legacy.

*Source:* Malakul et al. (2019)

## Overwhelming plastic waste – throughout the world

The growing amount of plastic production follows the growing amount of plastic waste generation. Between 2016 and 2050, the global amount of waste is estimated to increase by 1.7 times (Figure 2.6) (World Bank, 2018b). By multiplying the ratio of plastic waste to the overall amount of waste by 0.12 (World Bank, 2018b), the amount of plastic waste is estimated to grow from 240 MT/year to 410 MT/year, assuming that this ratio remains the same (Figure 2.6). The previous World Bank (2012) indicated that the ratio of plastic waste would increase, which further threatens a number of countries to drown in the overwhelming plastic waste. From 2012 to 2015, the category 'low-income countries' in which Lao PDR and Viet Nam are placed, experiences a growth from 8% to 9%, and 'lower-middle-income countries" in which Thailand is placed, experienced a growth from 12% to 13% (World Bank, 2020).

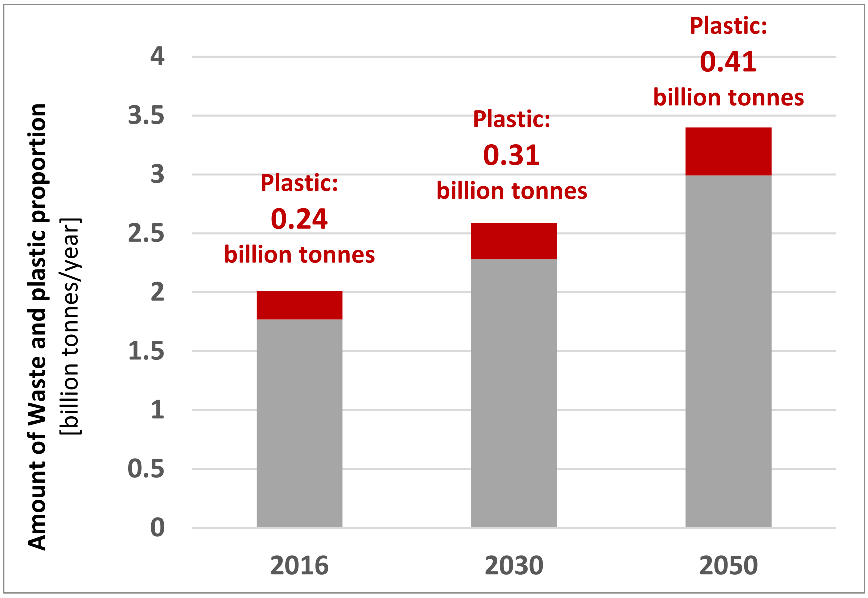



**Figure 2.6.** Estimated amount of worldwide waste generation and plastic waste generation

*Source:* World Bank (2018b)

### Plastic waste in Member Countries

Table 2.1 shows the current situation of MCs regarding waste generation and management**.** Several items are not available, and several countries have no data for overall country. In particular, data on the source segregation rate are not available for four MCs. Among the four MCs, plastic in the waste stream of Thailand (17.62%) is the highest, followed by Cambodia (15%), Lao PDR (12%), and Viet Nam (10%). The collection rate in urban areas of Cambodia and Viet Nam is higher than the others, while Lao PDR has a relatively low rate of 40%, even in Vientiane. It is hoped that the waste management capacity will be improved mainly in major cities, followed by expansion to rural areas. Collected waste would be intermediate treatment, resource recycling, or final disposal. The recycling rate and source segregation rate are high in Thailand compared to other MCs, which may be contributing factors to the low disposal rate compared to other countries. The reduction in the amount of waste disposed will reduce the amount of leakage from the disposal site.

Jambeck et al. (2015) states that the rate of mismanaged waste is 89.0% for Cambodia, 75.4% for Thailand (75.4%), and 87.9% for Viet Nam. Their report defined mismanaged waste as either littered or inadequately disposed of. Inadequately disposed waste is not formally managed and includes disposal in dumps or open, uncontrolled landfills, where it is not fully contained. Mismanaged waste could eventually enter the ocean via inland waterways, wastewater outflows, and transport by wind or tides (Jambeck et al., 2015). Mismanaged general waste rate on Lao PDR was not estimated by Jambeck et al. (2015); however, Schmidt et al. (2017) estimated mismanaged general waste rate (84.2%). Estimation of littering rate is difficult to synthesize because they are typically designed to evaluate counts of particular items which limits comparison between studies (Jambeck et al., 2015).

Jambeck et al. (2015) estimated percentage of waste littered using the only available national estimate of litter mass, which reported 4.17 million MT of litter generated in the United States in 2008, equivalent to approximately 2% of national waste generation. They estimated 2% of the mass of total waste generated is littered for each country.

For acquiring the data of source segregation rate and littering rate, it is required not only to monitor regarding segregation and littering but also to formulate the reporting system of its monitoring. There are many types of landfills including open dumping, which will cause waste leakage. Figure 2.7 is the comparison of plastic waste generation in MCs in 2010. We can see the distinctly large amount of plastic waste in Thailand and Viet Nam.

**Table 2.1.** Summary of waste management situation on each MC

| Country | Waste generation volume (ton/year) | Waste generation rate (kg/person/day) | Plastic in waste stream (%) | Source segregation rate (%) | General waste collection rate (%) | Landfill rate (%) | Recycling rate (%) | Mismanaged rate (%) |
|---|---|---|---|---|---|---|---|---|
| Cambodia | 1,150,939 (2016) | 0.2 (2016)[a] | 15[b] | 4.3 [c] | 80 (urban) [d] | 41 [e] | 11 [e] | 89.0 [f] |
| Lao PDR | 374,810 (2016) | 0.15 (2016)[a] | 12 [b] | No data | 40 (Vientiane) [g] | No data | 7.8 (Vientiane)[g] | 84.2 [h] |
| Thailand | 27,188,499 (2016) | 1.08 (2016)[a] | 17.62 [b] | 34 [i] | 58 [d] | 33 [i] | 36 [i] | 75.4 [f] |
| Viet Nam | 11,278,784 (2016) | 0.33 (2016) [a] | 10 [b] | No data | 85–90 (urban) [j]<br>40–55 (rural) [j] | 56 [j] | 8–12 (urban) [k] | 87.9 [f] |

*Source:* a. World Bank (2018b); b. UNEP (2017b); c. Sethy (2017); d. UNEP (2017a); e. UNEP (2020a), f. Jambeck et al. (2015); g. JICA (2021), h. Schmidt et al. (2017); i. Pollution Control Department (PCD of Thailand (2021); j. UNEP (2020d); k. Nguyen (2017).

*Note:** Waste generation volume is calculated by multiplying the total population by the waste generation rate World Bank (2020).

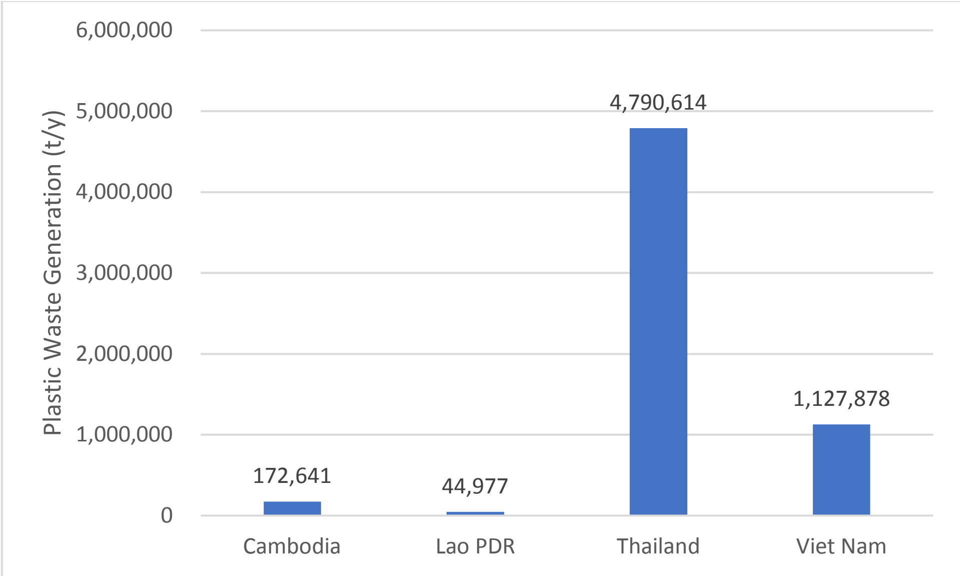



**Figure 2.7.** Plastic waste generation in 2016 in four MRC Member Countries

*Source:* Data are calculated by multiplying waste generation volume (ton/year) with proportion of plastic in waste stream in Table 2.1.

In the Association of Southeast Asian Nations (ASEAN) region, the waste generation rate of low- or middle-income countries is lower than that of more developed countries (e.g. the waste generation rate of Singapore is 3.72.) (World Bank, 2018b). Still, it is questionable that it will remain the same for coming decades. The amount of waste per capita has a close correlation with GDP, which is solidly increasing in MCs. Also, rapid urbanization, industrialization and strong economic growth are likely to cause a sharp increase in the amount of waste in these developing countries (UNEP, 2017b).

Figure 2.8 and Figure 2.9 an overview of the development of the MCs, their gross domestic product (GDP) and growth rate from 1995 to 2019. The GDP continues to grow in all of the MCs, especially in Thailand and Viet Nam. Over the same period, Thailand's GDP increased from USD 169.3 to USD 543.5 billion, i.e. 2.21%, and Viet Nam's GDP increased from USD20.7 billion to USD 261.9 billion, i.e. 11.63%. Other MCs also show steady growth. Even though the GDP growth rates in Cambodia and Lao PDR were lower than in Thailand and Viet Nam (Figure 2.8), in Cambodia GDP increased by over 4.00% from 1995 to 2019 (World Bank, 2020). Similarly, in Lao PDR, GDP increased by over 4.65% (World Bank, 2020) (Figure 2.9). While this growth can considerably improve the lives of people in these countries, it can also cause a much larger amount of waste, as stated above.

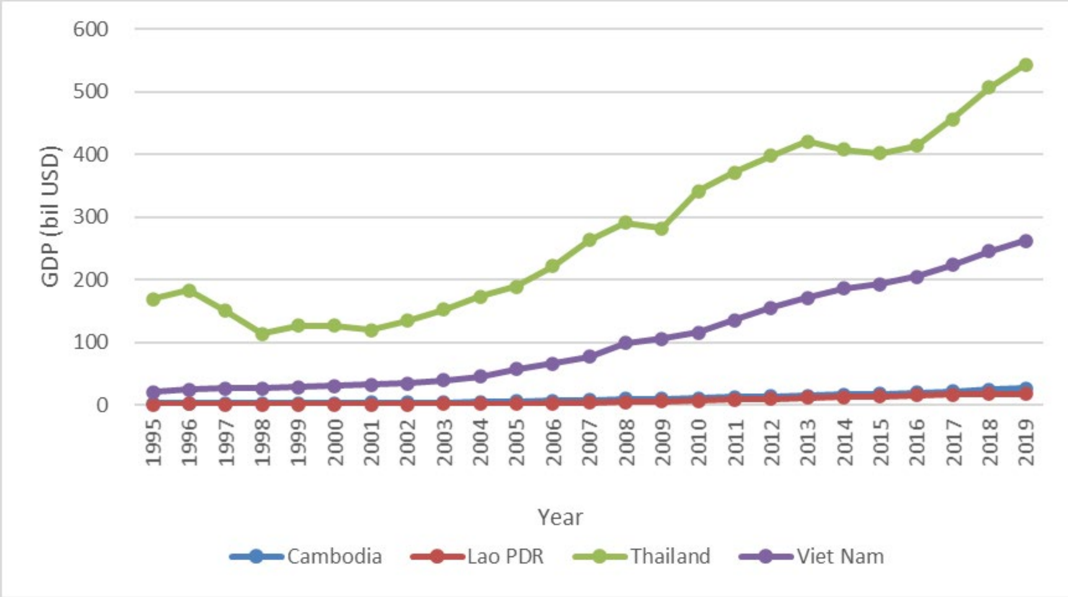



**Figure 2.8.** GDP of each Member Country in the LMB, 1995–2019

*Source:* World Bank (2020)

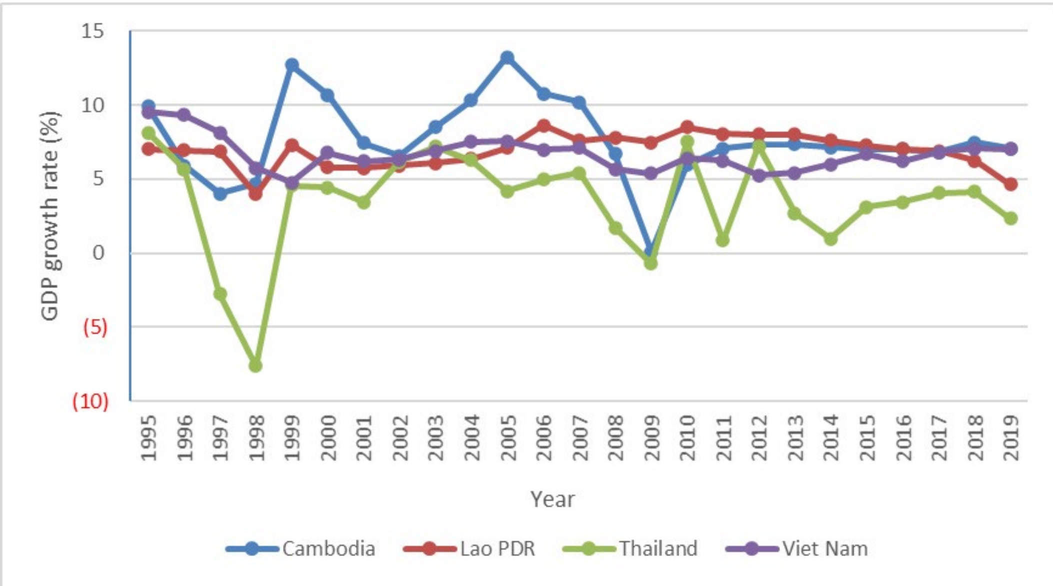



**Figure 2.9.** Percentile change of GDP in each Member Country, 1995–2019

*Source:* World Bank (2020)

A survey carried out at Chulalongkorn University on waste generated in nine coastal areas of Thailand captured the details of plastic waste, such as the composition in the landfill and the incineration, system. The survey consisted of interviews with the relevant agencies, such as municipalities and the Pollution Control Department (Malakul et al., 2019). The Figure 2.10. The highest amount of plastic waste consisted in wrappers (43%), followed by bags (41%) and utensils (9%), which together totalled 93% of the overall composition. These three items have the same problem; i.e. their low selling price for recycling. Also, food stains of these items often increase the cost of washing, which demotivates recyclers from buying them (Malakul et al., 2019). In contrast, due to its high recycling demands [64% of all recycling plastic (Figure 2.11)], only about 2% of plastic bottles find their way into the waste stream.

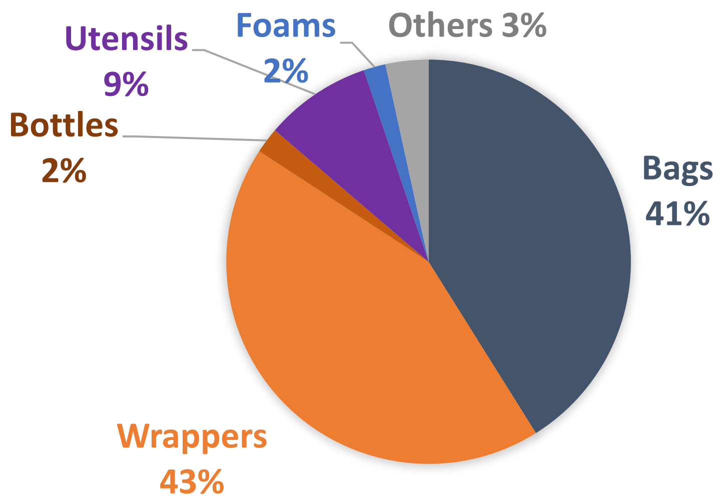



**Figure 2.10.** Composition of plastic waste in the waste management system in Thailand

*Source:* Malakul et al. ( 2019)

Figure 2.11 shows the types of plastic waste handled by the recycling companies of the same surveyed area, which shows a remarkably large proportion of bottles, at 64%.

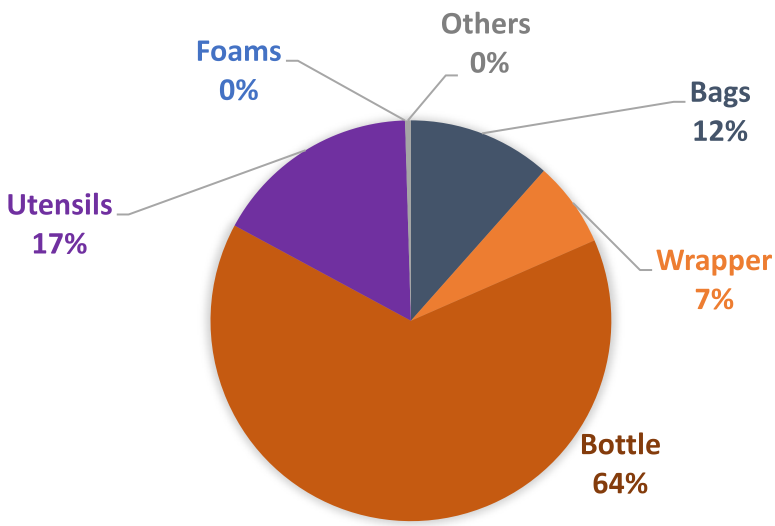



**Figure 2.11.** Composition of plastic waste handled by recycling companies in Thailand

*Source:* Malakul et al. (2019)

### Plastic waste in the Lower Mekong River Basin

The LMB consists of the Northern Highlands, the Khorat Plateau, the Tonle Sap Basin, and the Mekong Delta. It covers Cambodia, Lao PDR, Thailand, and Viet Nam. The economies of the LMB countries have experienced a period of rapid growth and transformation over recent decades, which has also benefited these riverine communities. However, millions of people in the LMB still live without basic amenities, such as clean drinking water and electricity (MRC, 2016; MRC, 2021a).

Some demographical and geographical information of LMB is available in Table 2.2. There are approximately 65 million people living within the LMB (MRC, 2021a). The population of Thailand and Viet Nam together account for 70%, over two-thirds of the population in the LMB; Cambodia, 20%, and Lao PDR, 10% (MRC, 2011). There is a large variation in population distribution throughout the LMB. The large, sparsely populated mountainous areas of the LMB in Lao PDR have the lowest population densities, at 30 persons per $km^2$. Cambodia's population density is nearly triple that of Lao PDR, and Thailand's is a little higher than that of Cambodia; the Vietnamese portion of the Basin has the highest population density (MRC, 2016).

**Table 2.2.** Population and population density in the LMB

| Country | Population in the LMB (million) (2015) | Share of LMB population (%) | Share of national population (%) | Land area within basin ($km^2$) | Share of total country land area (%) | Population density (pax/$km^2$) |
|---|---|---|---|---|---|---|
| Cambodia | 13.4[1] | 22[1] | 86[1] | 156,435[1] | 89[2] | 86 |
| Lao PDR | 6.2[1] | 10[1] | 91[1] | 206,620[1] | 90[2] | 30 |
| Thailand | 25.4[1] | 39[1] | 37[1] | 203,060[1] | 40[2] | 125 |
| Viet Nam | 19.8[1] | 31[1] | 22[1] | 66,773[1] | 22[2] | 297 |
| Total | 65.0[1] | 100[1] | - | 632,888[1] | - | 103 |

Sources: 1. MRC (2016), 2. Calculated by land area within the Basin and land area data from the World Bank (2020).

From this information combined with the per capita waste generation (Table 2.1), the amount of mismanaged plastic waste specifically generated in the LMB region was calculated (Figure 2.12). It did not show as significant a difference as the amount of plastic waste in Cambodia and Lao PDR because the share of the national population is high and mismanaged general waste rate is also high (Figure 2.7); nevertheless, it is too large an amount considering the lack of basic infrastructure in the LMB, which will be further discussed in Chapter 4 – Monitoring capacity of riverine plastic debris.

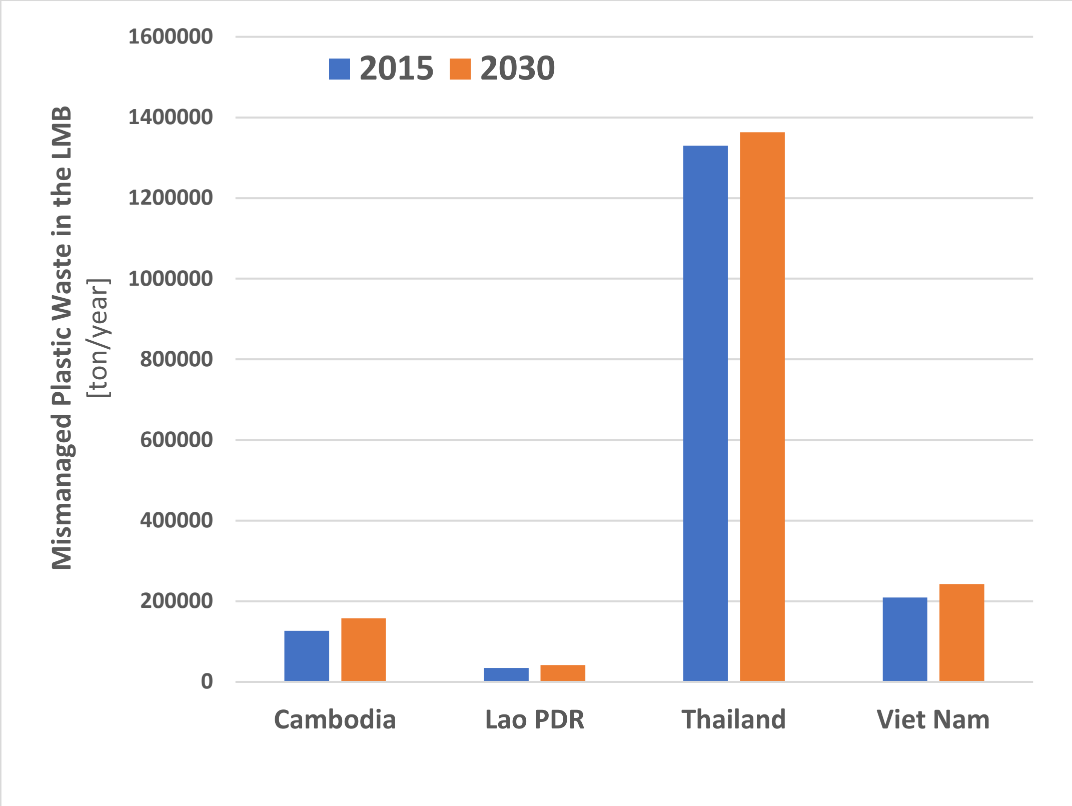



**Figure 2.12.** Estimated amount of mismanaged plastic waste in the LMB from each Member Country

*Sources*: Jambeck et al. (2015), MRC (2016), Schmidt et al. (2017), World Bank (2018b; 2020)

The populations in four MCs have all been growing steadily and are projected to continue to grow (Figure 2.13). The total population of MCs is estimated to be approximately 202 million in 2030, which is 1.34 times larger than that of 1995 (World Bank, 2020). Assuming that the waste generation rate is the same, the current and future amount of waste produced in the LMB can be calculated by multiplying the population by per capita waste generation. This amounts to a total of 172 kilotonnes/day in 2015, and 187 kilo tonnes/day in 2030. The status of plastic waste pollution in the LMB are discussed in detail in Chapter 5.

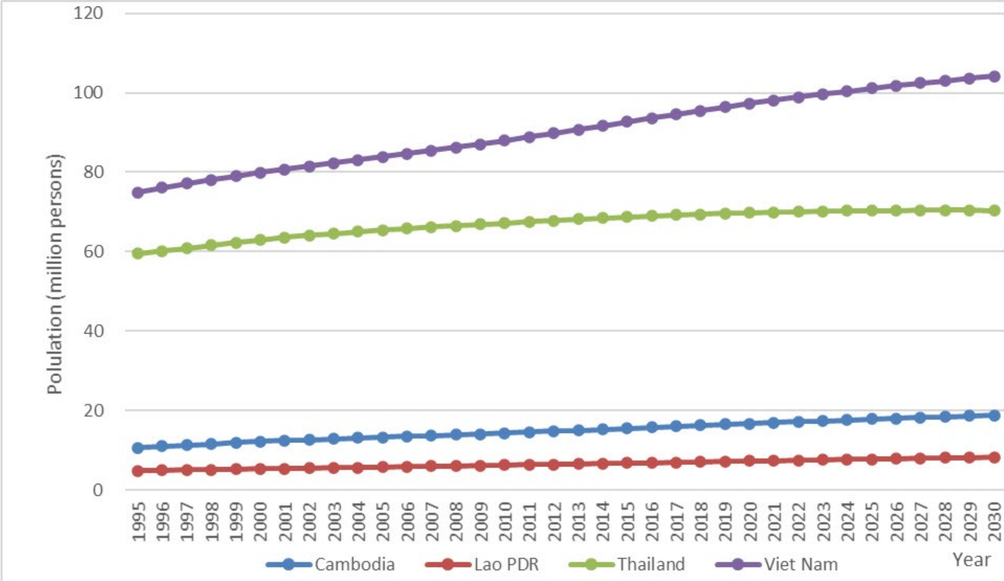



**Figure 2.13.** Estimated and projected population in MCs, 1995–2030

*Source:* World Bank (2020)

Global management of solid waste is highly dependent on countries' level of incomes (Figure 2.14). According to the World Bank (2018a), high-income countries generally utilize a wide-ranging methods for SWM with a large proportion of solid waste ends up in landfills (39%), while only a small proportion (2%) is disposed at open dump sites. Similarly, high-income countries also recycle a high proportion (29%) of their recyclable waste, which include plastic waste (World Bank, 2018a). In contrast, low- and lower-middle income countries tend to rely on open dump sites as the main method for SWM; around 93% and 66% of solid waste are sent to open dump sites, respectively. Although recycling has been identified as one of the SWM methods used by these countries, it makes up only about 3.5% and 6%, respectively, at low- and lower-middle-income countries (Figure 2.14) (World Bank, 2018a).

Among the MCs, Cambodia, Lao PDR, and Viet Nam are classified as lower-middle income countries by the World Bank (2018a), where open dumping accounts for 66% of the disposal method. In contrast, Thailand is classified as one of the middle-upper-income countries (World Bank, 2018a) where open dumping still accounts for 30% (Figure 2.14).

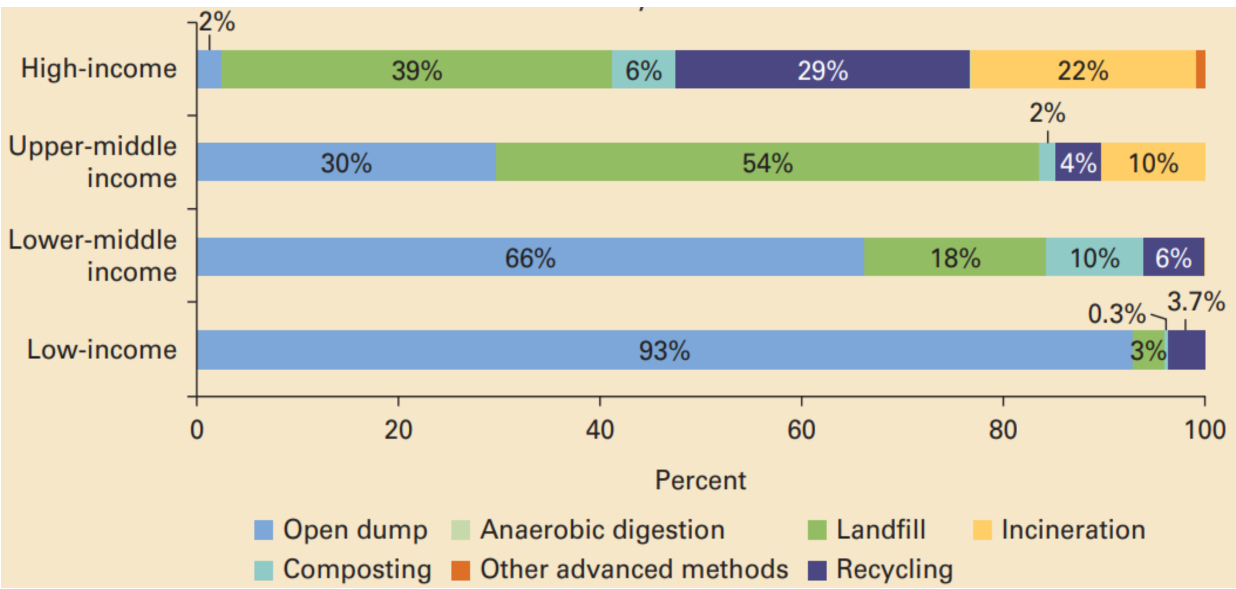



**Figure 2.14.** Countries' waste disposal methods, by income level

*Source:* World Bank (2018a)

The plastic waste flow, as shown in Figure 2.15 to Figure 2.18, provides an overall pictures of the movement of waste in different sectors and how the MCs are addressing the plastic waste issues. The diagrams respectively show the waste flow in Phnom Penh (Cambodia), Vientiane (Lao PDR), Thailand and Viet Nam. These figures show the estimated amount of unmanaged waste or uncollected waste that can eventually leak into the environment. However, an actual understanding of leakage behaviour requires filling the gap in the definition of terms.

In contrast, the study by Jambeck et al. (2015) defines "mismanaged waste" as material that is either littered or inadequately disposed, i.e. not formally managed, including disposal in dumps or open, uncontrolled landfills or final disposal sites such as open dumping. Hence, what is understood as 'collected' or 'landfilled' in the existing waste flow diagrams may be "mismanaged waste" in the interpretation of Jambeck et al. (2015). Therefore, a precise comparison of diagrams and existing research data on plastic debris emission still requires the consideration of plastic debris emission from various areas including open dumping sites. Although analysing the plastic waste flow is useful to determine the amount of waste flowing at different stages of treatment, the CounterMEASURE II Project's conceptual framework states that plastic leakage can occur in any phase of waste flow, such as production and consumption, retailing and waste management services (UNEP, 2020b).

Plastic leakages from each value chain are triggered by specific causes, including accidental loss (degradation of buoys, loss of nets), unintentional loss (unintentional littering), and unmanaged and mismanaged waste. Some plastic leakage finds its way directly nto the waterways (or indirectly via drainage systems), and some are formed at the inland accumulation sites, such as illegal dumpsites or littering spots, where waste is dispersed due to human action or topographic features. The accumulation sites have the highest potential for being a source of plastic leakage, where accumulated wastes at these sites can leak into the waterway and dispersed by environmental factors (i.e. strong winds, heavy rains and flooding) and by human factors (e.g. intentional dumping into the waterway) (UNEP, 2020e).

For the complete treatment of plastic waste, leaving no mismanaged waste behind, a systematic monitoring through explicit policy frameworks is vital; i.e. prevention, collection, and treatment of waste leakage both in the water and on land through appropriate waste management should be strictly supervised at the national level. This report discusses frameworks that serve as guideposts, capacity required in monitoring implementation, and results of monitoring activities for the further development of harmonized monitoring system.

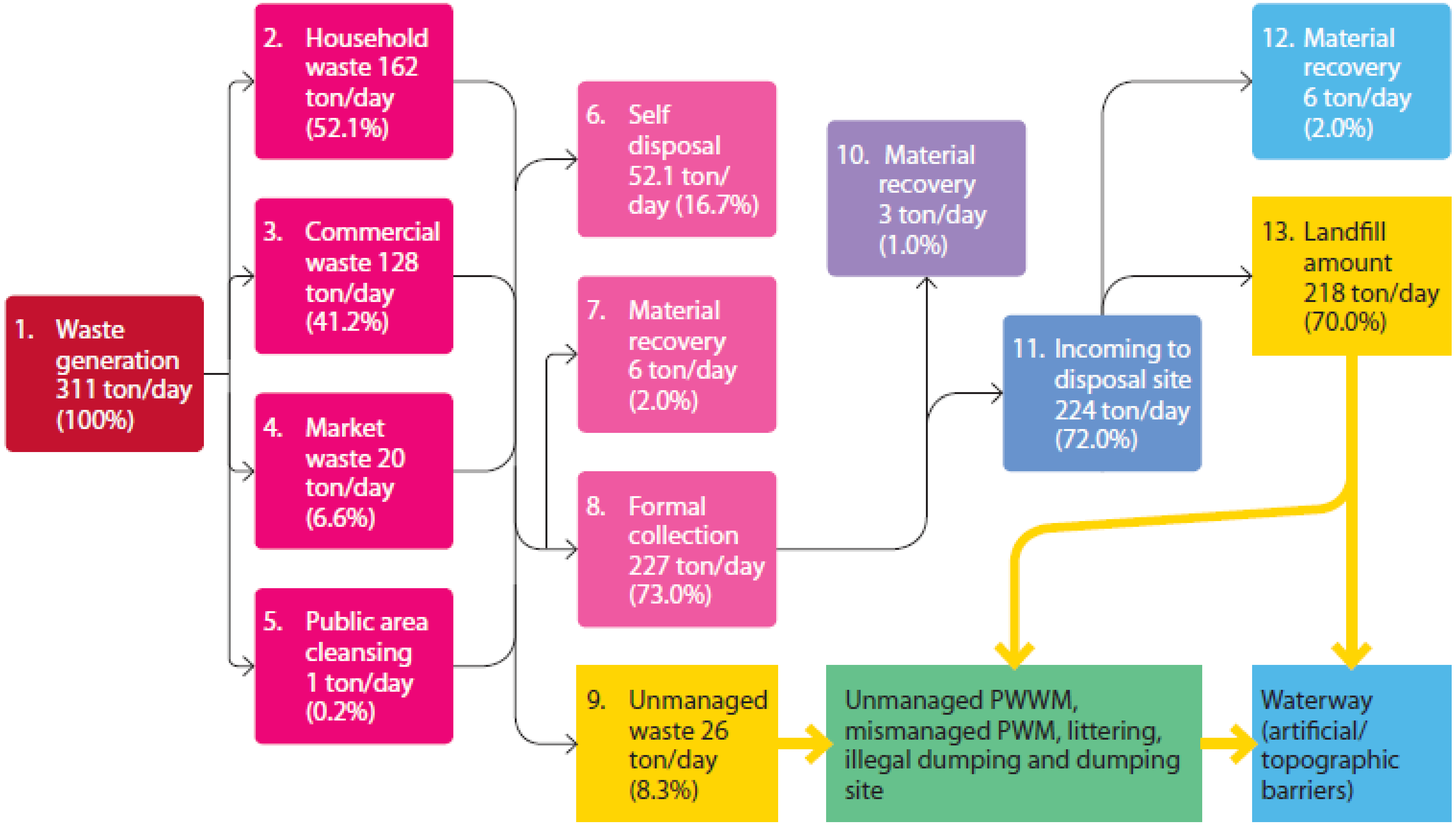



**Figure 2.15.** Plastic waste flow in Phnom Penh (Cambodia) (UNEP, 2020c)

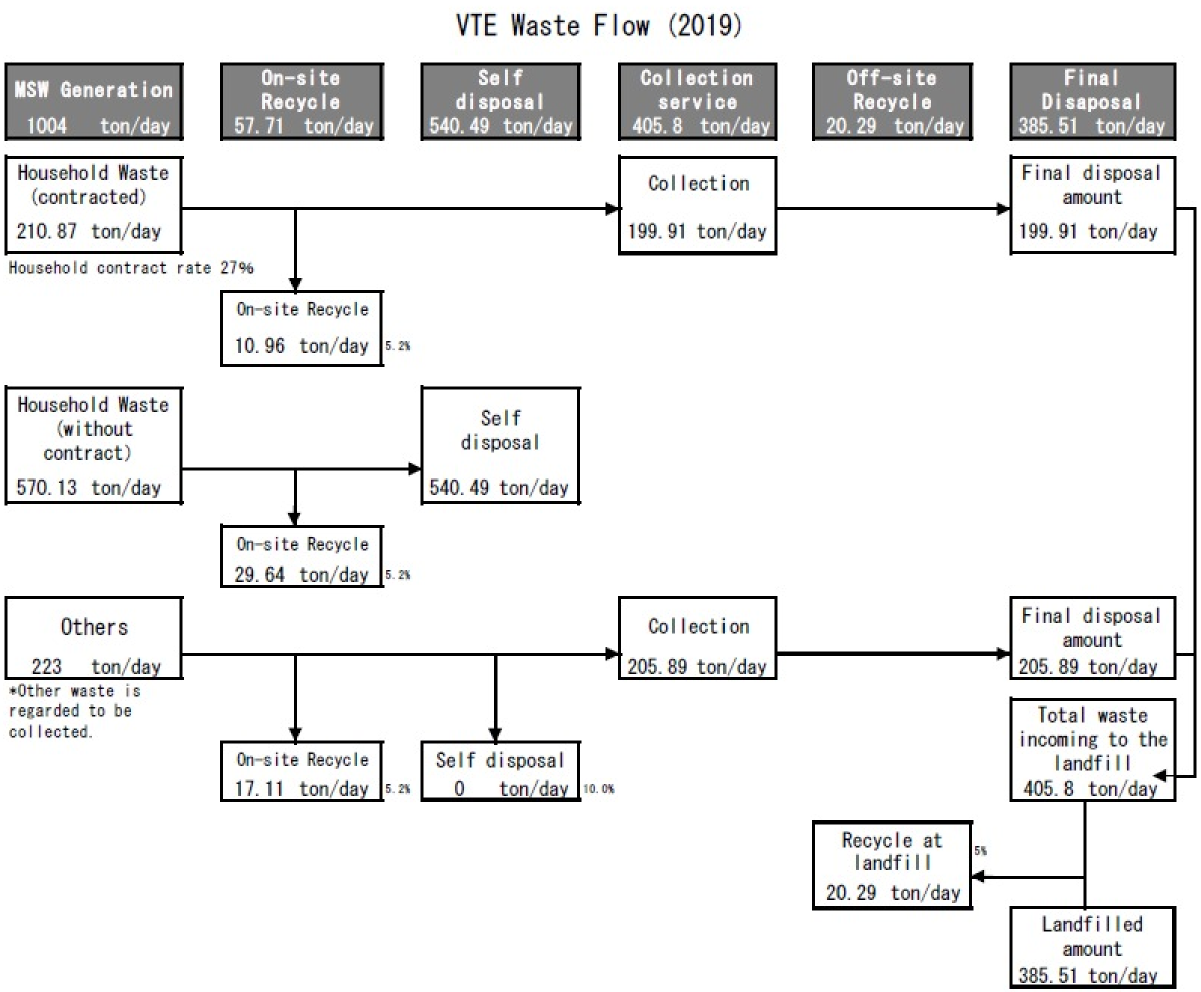



**Figure 2.16.** Plastic waste flow in Vientiane

*Source:* JICA (2021)

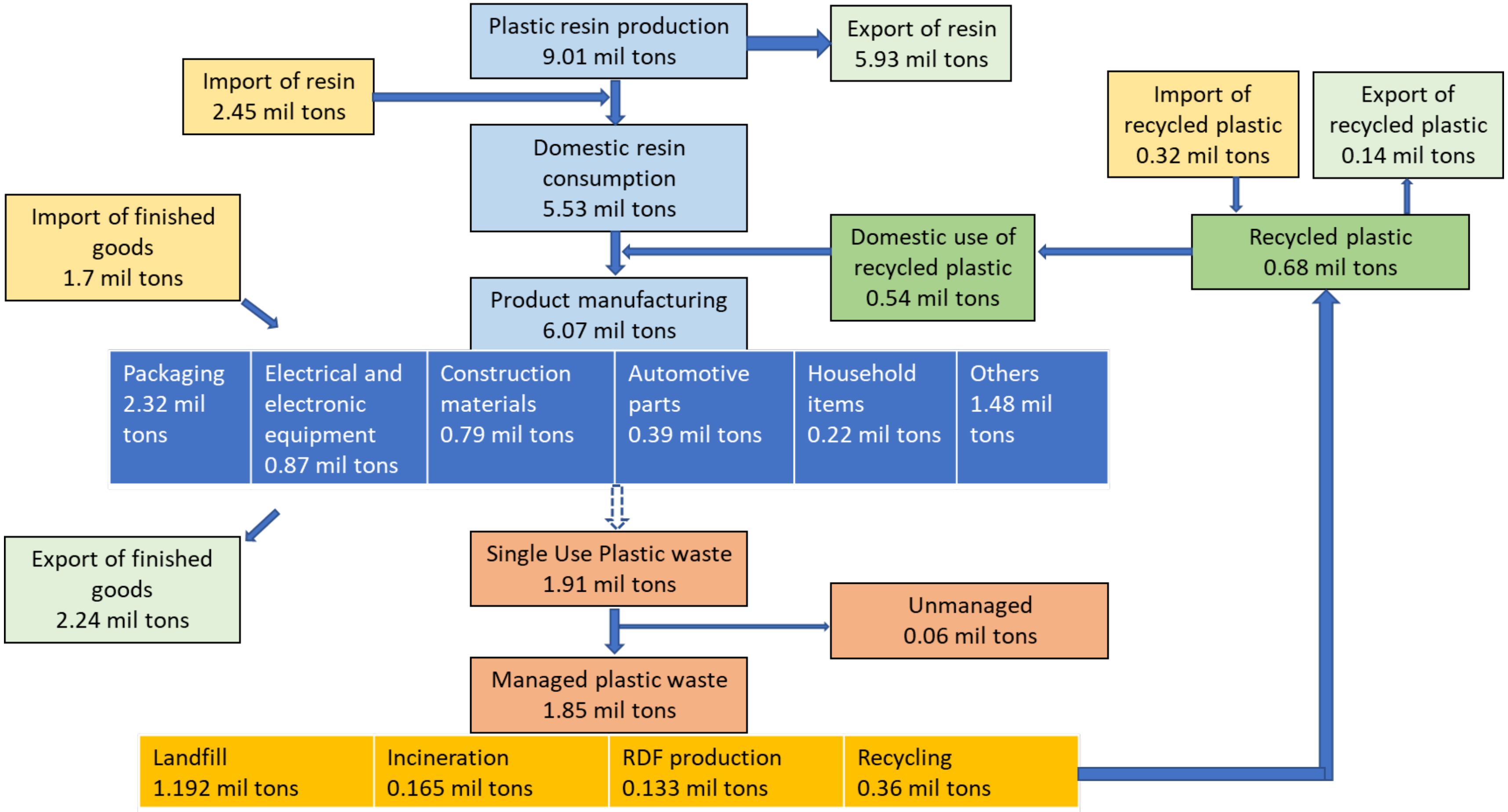



**Figure 2.17.** Plastic waste flow in Thailand

*Source:* PCD of Thailand (2019)

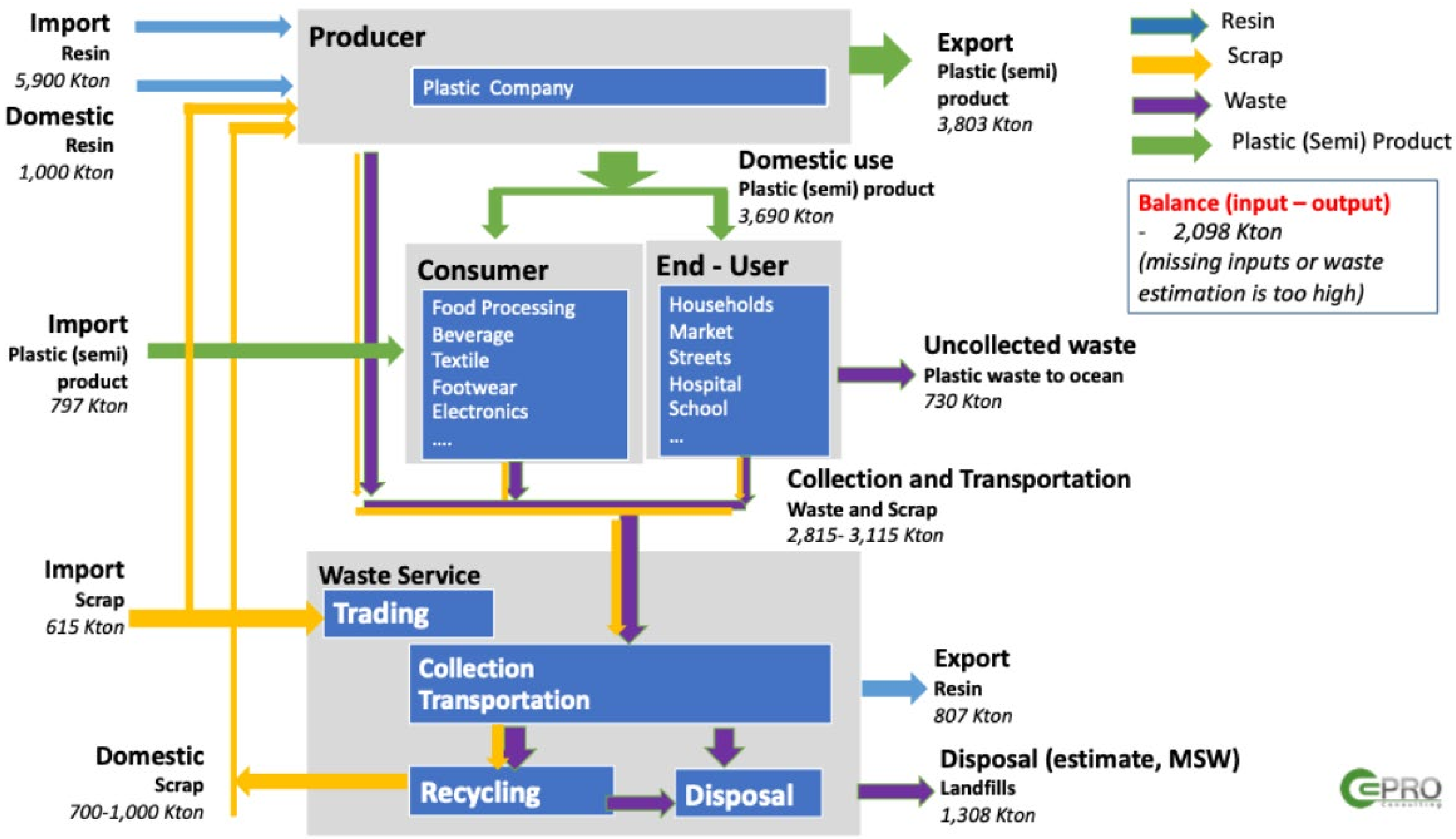



**Figure 2.18.** Plastic waste flow in Viet Nam

*Source:* VCCI (2019)

**Main results and key challenges**

- Despite its convenience, plastic pose serious dangers to the environment in a very wide area, almost permanently.
- Production of plastic is increasing worldwide and also in some MCs such as Thailand and Viet Nam (Figure 2.3).
- Countries in the LMB produce a considerably lower amount of waste than developed areas in the ASEAN region, but development can cause a steep increase in the amount of waste (UNEP, 2017b).
- The amount of plastic waste is estimated to significantly increase at every step of development (World Bank, 2012).
- The actual amount of plastic waste was very large in Thailand and Viet Nam. Furthermore, mismanaged rate of general waste in MCs are all above 75%, emphasizing the increased need for the appropriate waste management. Also, poor waste collection service and uncontrolled disposal sites remain challenges in MCs.

# 3. Policy and institutional frameworks for plastic waste management in the LMB

## 3.1. Regional frameworks

Marine debris has been recognized as one of the key environmental issues at the global level. A recent study estimates that between 4.8 and 12.7 million tonnes of plastic were discharged into the ocean in 2010. In addition, five ASEAN countries are included in the 10 top-ranked countries and account for 28% of the land-originated debris with the potential to be discharged into the sea in the world (Jambeck et al., 2015). For the LMB, this rank included Thailand and Viet Nam. Several research studies reported that the mismanaged waste is transported to the sea, and the resultant marine debris has negative impacts on the ecosystem and several industries, such as tourism and fisheries. Votier et al. (2011) raise an alert that the items used by birds for nest construction are typically ropes, straps, and fishing line, which pose an entanglement threat to adults and chicks. Young et al. (2009) found a dead Laysan albatross chick with plastic in its stomach. Nets, pots and traps can continue to attract and entangle or capture biota, both target and non-target species, a phenomenon referred to as ‘ghost fishing’. Thus, there should be a land-to-sea integrated approach to issues regarding marine debris. The impact of plastic pollution to the living organisms is discussed in Chapter 6.

Against this background, nations in the ASEAN Region have worked together in various events, publishing regional frameworks that clarify the activities to be carried out in the region (Table 3.1). For example, ASEAN Conference on Reducing Marine Debris in ASEAN Region held in Thailand in November 2017 recommended considering an integrated land-to-sea policy approach by developing and implementing a regional action plan on marine debris in the ASEAN Region. In order to enhance concrete action in this region, the Bangkok Declaration on Combating Marine Debris in the ASEAN Region and the ASEAN Framework of Action on Marine Debris were adopted at the ASEAN Summit in June 2019. Particularly, the ASEAN Framework of Action on Marine Debris provided for the design of the Regional Action Plan (RAP), which was launched in May 2021. This aimed to enhance coordination at the regional and international levels in order to achieve sustainable management of coastal and marine environments by responding to marine plastic pollution. Similarly, the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Seas Region (the ‘East Asian Seas Action Plan’) was approved by the Coordinating Body on the Seas of East Asia (COBSEA) in 1981. The Plan addresses the impacts and sources of the marine pollution. COBSEA is one of the regional seas conventions and action plans initiated by UNEP. Its nine participating countries are Cambodia, Thailand, Viet Nam, People’s Republic of China, Indonesia, Republic of Korea, Malaysia, the Philippines, and Singapore. Its regional action plan, COBSEA Regional Action Plan on Marine Litter 2019 (COBSEA, 2019), is in line with the ASEAN Framework of Action (ASEAN, 2019a;2021), but focuses much more on monitoring the implementation of the national action plans regarding marine litter and its removal, and establishes a science-to-policy body specifically on marine litter (ASEAN, 2020a; 2020b).

Among all the listed regional frameworks, the COBSEA Regional Action Plan on Marine Litter 2019 and the ASEAN Regional Action Plan on Combating Marine Debris seem to be the most specific framework, with its concrete action plans for monitoring. Emphasizing the importance of data compilation and analysis, the framework plans to establish a Marine Litter Monitoring Expert Group to develop a motoring programme, as well as regional guidance and training. Although Lao PDR is not the member of this community, it is hoped that the MCs can cooperate in developing the monitoring system for marine debris. A summary of published regional frameworks covering the LMB region is shown in Table 3.1.

**Table 3.1.** Regional frameworks that cover the LMB

| Name of regional framework | Purpose and overview |
|---|---|
| Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (Mekong River Commission, 1995) | - The Governments of the Kingdom of Cambodia, The Lao People's Democratic Republic, The Kingdom of Thailand, and The Socialist Republic of Viet Nam all wish to continue to cooperate in a constructive and mutually beneficial manner for the sustainable development, utilization, conservation and management of the Mekong River Basin water and related resources.<br>- Artificial Intelligence (AI) though the Mekong Agreement does not specifically mention plastic debris pollution; rather, it contains articles relating to the protection and conservation of the water quality and ecosystems of the Mekong River. |
| Bangkok Declaration on Combating Marine Debris in ASEAN Region (ASEAN, 2019b) | - The Declaration was made during the 34th ASEAN Summit in Bangkok, Thailand on 22 June 2019.<br>- The Declaration emphasizes the ASEAN Community Vision 2025, particularly the ASEAN Socio-Cultural Community (ASCC) Blueprint 2025 on Conservation and Sustainable Management of Biodiversity and Natural Resources, which reaffirmed the commitment of strategic measures to “promote cooperation for the protection, restoration and sustainable use of coastal and marine environments, respond and deal with the risk of pollution and threats to marine ecosystem and coastal environment, in particular in respect of ecologically sensitive areas”.<br>- The Declaration states that the actions should be strengthened at the national and inter-sectoral levels between ASEAN sectoral bodies; however, these statements only point to general courses of action, such as encouraging an integrated land-to-sea approach. |
| ASEAN Framework of Action on Marine Debris (ASEAN, 2019a) | - ASEAN Member States including Cambodia, Lao PDR, Thailand and Viet Nam welcomed this framework at the Special ASEAN Ministerial Meeting on Marine Debris on 5 March 2019 in Bangkok, Thailand.<br>- Comprises four priority areas:<br>• Policy Support and Planning<br>• Research, Innovation, and Capacity Building<br>• Public Awareness, Education, and Outreach<br>• Private Sector Engagement.<br>- Each priority area consists of actions and suggested activities for further collaboration among ASEAN countries and its partners in combating marine debris.<br>- The Frameworks provides for the drafting of regional action plans on combating marine debris in the ASEAN Region.<br>- Suggested activities include the standardization of methods for the measurement and monitoring of marine debris, as well as the provision of training on monitoring and management of marine debris.<br>- Suggested activities also include cooperation and the sharing of data and information to corporate on combating marine debris. |

| Name of regional framework | Purpose and overview |
|---|---|
| ASEAN Regional Action Plan on Combating Marine Debris (ASEAN, 2021) | - Launched in May 2021 by the ASEAN Secretariat, aiming to enhance coordination at the regional and international levels for achieving the sustainable management of coastal and marine environments by addressing marine plastic pollution.<br>- Plans include developing a guidebook for common methodologies for the assessment and monitoring of marine litter.<br>- Plans also include conducting a regional study on microplastics.<br>- The ASEAN Working Group on Coastal and Marine Environment (AWGCME) will be in charge of overall management and coordinating with the relevant sectoral bodies. |
| COBSEA Regional Action Plan on Marine Litter (COBSEA, 2019) | - COBSEA aims to ensure the sustainable development and protection of the marine environment and coastal areas of the East Asian Seas. The Strategic Directions 2018–2022 and the COBSEA Regional Action Plan on Marine Litter (RAP MALI) provide regional frameworks for cooperation and identify regional priorities to guide action.<br>- Overseeing the implementation of the East Asian Seas Action Plan, adopted in April 1981 and revised in 1994. The Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Seas Region (the 'East Asian Seas Action Plan') aims at protecting the marine and coastal environment in the region for the health and well-being of present and future generations.<br>- In the LMB, Cambodia, Thailand, and Viet Nam participate in COBSEA.<br>- It was introduced at the 24th Intergovernmental Meeting of the Coordinating Body on the Seas of East Asia (COBSEA) at Bali, Indonesia, on 19–20 June 2019.<br>- The Framework supports COBSEA participating countries (Cambodia, People's Republic of China, Indonesia, Republic of Korea, Malaysia, the Philippines, Thailand, Singapore, and Viet Nam) in delivering target 14.1 of Sustainable Development Goal (SDG) 14 to prevent and significantly reduce marine pollution of all kinds.<br>- Its goals and objectives include improving the monitoring and assessment of marine litter and its impacts using a science-based approach. Indicating the lack of adequate science-based monitoring and assessment programmes, it sets out to:<br>• establish a Marine Litter Monitoring Expert Group under the COBSEA;<br>• prepare regional guidance on the development of monitoring programmes;<br>• conduct regional training for monitoring;<br>• develop national monitoring programmes based on respective national policies and circumstances;<br>• prepare regional report on marine litter and microplastics;<br>• explore the development of a regional marine litter and microplastics monitoring metadatabase and portal. |

## 3.2. International conventions

There are specific international conventions related to the prevention of marine pollution with a view to save the environment, some of which MCs have ratified. The International Convention for the Prevention of Pollution from Ships (MARPOL) is one of a number of international conventions for the prevention of marine pollution. It is also the main international convention covering the prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted on 2

November 1973 at International Maritime Organization (IMO). The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976–1977. Since the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention. Annex 3, 'Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form', identifies substances that are harmful to the marine environment. These include marine pollutants included in the International Maritime Dangerous Goods Code (IMDG Code) and those that meet the criteria stated in the Convention. Annex V, 'Prevention of Pollution by Garbage from Ships', covers the different types of garbage, and specifies the distances from land and how they may be disposed of. The most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastic.

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention) is one of the first global conventions to protect the marine environment from human activities, and has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent sea pollution by prohibiting the dumping of wastes and other matter. In 1996, the "London Protocol" was agreed on to further modernize the Convention, and eventually, replace it. Under the Protocol, all dumping is prohibited, except for acceptable wastes.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (The Basel Convention) regulates the transboundary movement of hazardous wastes and other wastes to ensure that such trade operates in accordance with environmentally sound management principles. The 2019 amendments clarify the range of plastic wastes presumed to be hazardous and therefore subject to the Prior Informed Consent procedure. This seems satisfactory for the prevention of pollution in the water; nevertheless, all of them exclusively focus on marine pollution, excluding landlocked countries such as Lao PDR. Also, the number of countries that have ratified these multilateral treaties in the LMB has not increased, as shown in Table 3.2.

**Table 3.2.** Ratification status of multilateral treaties on the prevention of marine pollution

| **State** | **Ratification status of multilateral treaty (as of 12 July 2020)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | ***IMO Convention 48***[*1] | **MARPOL 73/78**[*2] | **MARPOL 73/78 (Annex III)**[*3] | **MARPOL 73/78 (Annex V)**[*4] | **London Convention 72**[*5] | **London Convention Protocol 96**[*6] | **Basel Convention**[*7] |
| Cambodia | x | x | x | x | | | x |
| Lao PDR | | | | | | | x |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Thailand | x | x | | | | | x |
| Viet Nam | x | x | x | x | | | x |

*Legend:*
x: Convention/Protocol/Annex ratified, Leg=Legislation enacted
*Note*:
*1 International Maritime Organization (IMO) Convention
*2 International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MORPOL 73/78)
*3 Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
*4 Annex V Prevention of Pollution by Garbage from Ships
*5 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention: LC).
*6 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (London Protocol: LP)
*7 The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (The Basel Convention).

## 3.3. National policy frameworks

Policy frameworks on plastic waste management and monitoring of each MC in the LMB are shown in this chapter. Each country has published the plans or the laws regulating the use of plastic towards the appropriate management of plastic waste/debris in the near future. Nevertheless, when analysing their content, it is clear that stricter and more specific laws in are needed in order to control the plastic waste/debris at the national level. Even some current action plans may need some revision, since it places too much emphasis on awareness raising or lacks essential parts to cover riverine plastic pollution.

None of the MCs has policy framework for monitoring plastic waste nor for monitoring riverine debris. To fully understand the up-to-date situation of waste such as volume, composition, and litter accumulation, it is necessary to build a concrete system for monitoring of waste built and supervised with policy frameworks. Table 3.3 summarizes the national policy frameworks in MCs, and the following sections discuss the detailed information in each country.

**Table 3.3.** Summary of national policy frameworks regarding waste/debris monitoring in Member Countries

| **Country** | **Basic environment** | Solid waste management | Reduce Reuse Recycle (3R), Extended producer responsibility (EPR) | **Marine debris (MD) Action Plan** | **MD-related (e.g. collection and monitoring)** |
|---|---|---|---|---|---|
| Cambodia | Law | Law, Strategy | Strategy | | |
| Lao PDR | Law, Strategy | Law | Action Plan | | |
| Thailand | Law | Law | Action Plan, Roadmap | Plastic Action Plan | |
| Viet Nam | Law | Law | Action Plan | Action Plan | |

### 3.3.1. Cambodia

**Sub-Decree No. 36 ANK.BK. of 27 April 1999 on Solid Waste Management** was ratified with the goal of protecting the health of the nation’s citizens and its environment by governing the “collection, storage, transportation, recycling, and disposal of municipal wastes”.

**Sub-Decree No. 113 on ANK.BK. of 27 September 2015 on litter and SWM in urban-town** delegates solid waste management to local governments, requiring them to handle waste collection, final disposal, clean-up of recreation areas, the dissemination of public awareness, and enforcement.

**Sub-Decree No. 168 ANK.BK. of 10 October 2017 on the Management of Plastic Bags**, promotes the reduction of the import, production, distribution, and use of plastic bags in order to enhance public health, environment, and landscaping. Its Decree also includes provisions to manage and reduce single-use plastic (SUP), reduce and management plastic imports, and address micro-plastic pollution.

**Cambodia's Law on Fisheries,** which is currently under review, will include provisions on inland aquaculture and mariculture management, water quality and discharge of waste matter.

As an action plan, **the Policy on Litter and SWM in urban-town, 2020–2030** includes the medium- and long-term strategies and outlines the further formulation of legal frameworks for sound waste management including of plastic. It mandates local government to take measures for a sound waste management, and calls on the private sector to invest in waste management including landfill operations.

### 3.3.2. Lao PDR

There is a national strategy and municipality strategies for waste management and environmental pollution in Lao PDR. Although they cover aspects of plastic waste and plastic pollution, there is no specific policy framework for plastic waste. However, the Ministry of Natural Resources and Environment (MONRE) of Lao PDR recognizes land-to-sea of marine debris, and it is interested in updating its National Pollution Control Strategy and Action Plan (NPCSAP) to address freshwater plastic debris rather than marine debris, as an inland country (ASEAN, 2020a).

**The National Pollution Control Strategy by 2025 with a Vision to 2030 (NPCSAP)**: Pursuant to the Revised Law on Environmental Protection 2012 and subsequent decrees, regulations, and instructions, the Pollution Control Department (PCD) of MONRE is responsible for preparing a National Pollution Control Strategy by 2025 with a Vision to 2030 (NPCSAP). This strategy and long-term vision to 2030 will guide the country's environmental pollution prevention and control work during the period of promoting the country's industrialization and modernization.

**The Sustainable Solid Waste Management Strategy and Action Plan for Vientiane Capital 2020–2030**: The long-term targets for sustainable SWM for Vientiane Capital have been developed to contribute to achieving the National Green Growth Strategy (NGGS) of the Lao PDR by 2030 and the Sustainable Development Goals (SDGs). The Action Plan presents the indicative long-term targets that are aligned with associated goals specified in the NGGS and the SDGs.

### 3.3.3. Thailand

**Thailand's Roadmap on Plastic Waste Management 2018–2030** and the Action Plan on Plastic Waste Management 2018–2022 (PCD of Thailand, 2019) are the most direct policies concerning plastic waste. They were introduced by the PCD, MONRE. Under the Roadmap, there are two main targets to be achieved by 2030, whose details are as follows:

- **Target 1**. **Phase I**: Elimination of cap seal, oxo-plastic and microbead from use within 2019.

  **Phase II**: Elimination of plastic bags with a thickness of less than 36 microns, food-containing foam, single-use plastic cups and plastic straws from use by 2022.
- **Target 2**. Recover and utilization of 100% of target plastic waste by 2027.

It should be noted that implementation of this policy is mostly based on awareness raising and cooperation. There is no penalty or fine enforced if the targets are not met. In addition, most of the targets in the Action Plan are not quantifiable.

**Action Plan on Plastic Waste Management 2018–2022**: Targets of this action plan are to: (i) stop using styrofoam food containers, plastic straws, single-use plastic (SUP) bags of a thickness <36 micron, and SUP cups of a thickness <100 micron; and (ii) recycle 50% of targeted plastic wastes to apply the circular economy concept. However, there is no regulation regarding the banning of SUPs.

There are also two policy frameworks for importing of plastic waste:

- **The Export and Import of Goods Act, B.E. 2522 (1979)**: A Ministerial Notification concerning the control of import of plastic waste authorizes the Department of Industrial Works to grant or reject import licences for the recycling of plastic waste.
- **The Notification of the Ministry of Commerce on the import of goods into the Kingdom of Thailand (No.112) B.E. 2539 (1996)**. This states that plastic waste, plastic chips, and unusable plastic products require approval prior to import into the country. Import permits shall be granted upon approval of the Ministry of Industry is received.

**The Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992)** states that sample collection and analysis methods shall be studied before new parameters for water quality standards are proposed. Considering that as of October 2020, the water quality parameters do not include the concentration of garbage or plastic waste in water, further research may be required to introduce these standards for riverine debris monitoring.

Extended producer responsibility (EPR), which has proven successful in many countries in Europe and the Republic of Korea, has not gained political attention in Thailand. The pay-as you-throw (volume-based waste management fee) scheme, packaging taxes, and the deposit refund scheme (DRS) principles are also effective in reducing waste and increasing the recycling rate. For EPR, packaging taxes and the volume-based waste management fee may require a new regulation, while DRS can be implemented by private companies, without a new law, if they are willing to do so. If the EPR law is in place, DRS can be one of mechanisms to support compliance.

### 3.3.4. Viet Nam

There are laws and regulations in Viet Nam on plastic pollution. In particular, Viet Nam has a policy framework on SUP bags such as establishing tax, eco-friendly plastic bags. In addition, the amendments to the Environment Law, which came into effect in 2020, proposes new content on SWM and plastic pollution, including: plastic pollution management, segregation of solid waste at sources, and collection fees for different types of wastes. Although Viet Nam has approved the National Action Plan on Marine Plastic Debris Management by 2030, it has yet to issue the action plan for plastic waste from municipal solid waste (MSW).

**Decision 1746/ QD-TTg of 4 December 2019, on the National Action Plan for the Management of Marine Plastic Litter by 2030,** with provisions on the following key issues:

1. Education and behavioural change pertaining to plastic and marine plastic.
2. Collection, classification, storage, transfer and processing of plastic waste from coastal and ocean-based activities.
3. Control of plastic litter at source.
4. International cooperation, scientific research, and the application, development and transfer of marine plastic litter processing technologies.
5. Consistent and effective investigation, survey, review, research, and formulation of mechanisms for marine plastic litter management.

**Decision No. 491/QD-TTg of 07 May 2018**, national strategy on integrated management of solid wastes up to 2025, with a vision toward 2050: 85% of MSW will be recycled, reused, and recovered for use as an energy source, or to produce organic fertilizer (by 2020), and 90% of MSW will be recycled, reused, and recovered for use as an energy source or to produce organic fertilizer, by 2025.

**Law No. 57/2010/QH12, 15 November 2010, Environmental Protection Tax,** establishes taxable commodity groups, which include plastic bags. Moreover, **Decree No. 67/2011/ND-CP** giving details and guiding the implementation of a number of Articles of the Law on Environmental Protection Tax (i.e. taxable plastic bags specified in Article 3, clause 4 of the aforementioned Law).

**The Prime Minister's Decision No. 06/2018/QDTTg of 12 July 2018** regulates the functions, tasks, powers, and organizational structure of the Viet Nam Administration of Sea and Islands under the MONRE. With China's restriction on the import of scrap plastic, waste import in Viet Nam has increased significantly (0.25 million tonnes of plastic imported in 2016 and 0.27 million tonnes in just the first half of 2018).

**Decree No. 38/2015/ND-CP, 24 April 2015, on the management of waste and discarded materials** requires sorting of plastic waste in domestic solid waste and industrial solid waste for recycling; this waste must be managed from generation and collection, to transportation and handling.

**Decision No. 582/QD-TTg of 11 April 2013 of the Prime Minister approving the project on improving the environmental pollution control for the use of non-biodegradable plastic bags by 2020**: This policy aimed to: (i) reduce plastic bag consumption by 40% in supermarkets and shopping malls and by 20% consumption in the markets; and (ii) collect and recycle domestic plastic bags by 25% in 2015 compared to 2010. By 2020, the corresponding rates were set at 65%, 50% and 50%, respectively, compared to 2010.

**Circular No. 07/2012/BTNMT of 4 July 2012, providing the criteria, order of and procedures for recognition of environment-friendly plastic bags:** By March 2017, 34 different kinds of plastic bags from 30 companies were approved as eco-friendly bags; Decision No. 582/QD-TTg of 2013 to approve the project on enhancing the control of environmental pollution due to the use of non-biodegradable plastic bags by 2020.

## 3.4. National institutional frameworks

This section shows the roles and actions of various institutions involved in reducing plastic pollution in MCs. In addition to governmental authorities, this includes the public and private sectors, multinational development agencies, international non-governmental organizations (NGOs), and community-based and civil society organizations. Institutional arrangements involve inter- and intra-agency coordination. Also, there is usually cooperation between multiple governmental authorities at the central/national and local government levels in these countries. Nonetheless, detailed information of institutional frameworks in each country suggests a lack of a clear allocation of work and responsibility between the institutions. For the smooth operation of waste management, would be of great value to establish responsibilities. Table 3.4 summarizes the national institutional frameworks in MCs, and the following sections discuss the detailed information in each country.

**Table 3.4.** Summary of National Institutional Frameworks regarding waste/debris monitoring in MCs

| Country | Environment | SWM | Marine debris | Riverine debris |
|---|---|---|---|---|
| Cambodia | Ministry of Environment (MOE) | Department. of Solid Waste Management (SWM) (MOE), Provincial administrations/ Phnom Penh administration, MOI | Department of Pollution Control (MOE) | n/a |
| Lao PDR | Ministry of Natural Resources and Environment (MONRE) | Pollution Control Department (PCD) (MONRE), MOPWH | | Department of Water Resources (DWR) |
| Thailand | MONRE | PCD (MONRE), DEQP (MONRE), Ministry of Public Health, DLA (MOI), LAOs | Department of Marine and Coastal Resources (DMCR) MONRE, Marine Dept. | PCD (MONRE), DMCR (MONRE), Fishery Department (MOAC) |

| | | | | |
|---|---|---|---|---|
| | | | (Ministry of Transport), Port Authority of Thailand (Ministry of Transport), Fishery Dept. (MOAC) | |
| Viet Nam | MONRE | Vietnam Environment Administration (MONRE), Ministry of Construction, Ministry of Health, Ministry of Planning and Investment, District People's Committees | Administration of Sea and Islands (MONRE), Directorate of Fisheries (MARD) | Provincial People's Committee (PPC), Department of Agriculture and Rural Development, Vietnam Inland Waterways Administration (VIWA) (Ministry of Transport). |

### 3.4.1. Cambodia

**Table 3.5.** Summary of the roles of organizations engaged in waste management in Cambodia

| Sector | Organization | Roles |
|---|---|---|
| Government | Ministry of the Environment (MOE) | - Establishes guidelines on solid waste management (SWM) including disposal, collection, transport, storage, recycling, minimizing and dumping; monitoring of solid waste management (SWM) plans. |
| | Ministry of the Environment (Provincial Departments) | - Provides technical advice to the municipality<br>- Collaborates in planning and implementing laws, legal instruments, and promoting citizen education<br>- Approves landfill selection and use |
| | Provincial administrations / Phnom Penh administration | - Implements waste management policies, delivers waste management services; the municipalities have been encouraged to take over more of the role from the provinces.<br>- Prepares action plans and budgets, and establishment of waste collection fees |
| | Ministry of Commerce | - Grants permits for the export of household waste |
| | Ministry of the Interior | - Supports the Ministry of the Environment in coordinating with other ministries. |
| | Ministry of the Interior (Provincial Administration) | - Approves landfill selection and use. |
| | Ministry of the Interior (Municipality) | - Is responsible for overall management of urban garbage and solid waste in their territory.<br>- Can collect service fees for waste management.<br>- Must provide enough bins and services in public places.<br>- Approves recycling activities or other uses of waste. |
| | Ministry of Economics and Finance (MoEF) | - Establishes waste collection fees. |
| | Ministry of Public Works and Transport | - Implements various international donor projects relating to solid waste management- |
| | Ministry of Agriculture, Forestry and Fisheries | - Includes a number of fisheries-focused research bodies that may support marine litter monitoring, |

| Sector | Organization | Roles |
|---|---|---|
| | | such as the Inland Fisheries Research Division and the Marine Fisheries Research Division. |
| | Ministry of Water Resources and Meteorology (MOWRAM) | - Supports national and transboundary data collection and monitoring efforts in the Mekong River Delta.<br>- Acts as the key body in monitoring the status of plastic pollution in the Mekong River Delta in Cambodia (with support from the Mekong River Commission). |
| | MOI,<br>Capital and Provincial Department of Environment,<br>Municipal and District Administrations | - Is responsible for SWM in addition to the MOE- |
| | Ministry of Tourism (MoT) | - Is responsible for public education and identifying indicators on the aesthetic reasons for controlling the use of plastic bags |
| Academia/ research institutes | Royal University of Phnom Penh (RUPP) | - Conducts research for the JICA and SEA CIRCULA project (United Nations Environment Programme) related to plastic leakages into the sewage system and marine environment. |
| | MOE Lab, MOWRAM | - Carries out public water quality control (e.g. open sources, end of pipes) |
| Non-governmental organizations (NGO) | Cambodia Educational Waste Management Organization (COMPED) | - Cooperates with the local authorities in addressing the waste crisis, saving the environment, and reducing greenhouse gas emissions by reducing the amount of organic waste dumped into dump sites through the promotion of the compost approach<br>- Has a composting facility at Battambang Plastic Products, which recycles plastic bags |
| International | United Nations Envelopment Programme (UNEP) | - Leads an intergovernmental agency that also carried out work on COBSEA (SEA circular) and the complementary CounterMEASURE project |
| | United Nations Development Programme (UNDP) | - Supports the MOE in developing regulations related to the sound waste management of plastic |
| | FFI | - Is an in-country technical partner for COBSEA's SEA circular project and a leading NGO focusing on monitoring and data collection for biodiversity conservation, including of plastic in Cambodia. |

### 3.4.2. Lao PDR

Several stakeholders are currently involved in addressing waste issues: the MONRE, the Ministry of Public Works and Transport (MPWT), the Ministry of Industry and Commerce (MOIC), the Ministry of Public Health, and the Ministry of Agriculture and Forestry. Several international organizations raise awareness on plastic waste, assess plastic waste littering in the rivers, and support the Lao Government in establishing policies to reduce plastic waste. A summary of the roles of the organizations engaged in waste management in Lao PDR are provided in Table 3.6.

**Table 3.6.** Summary of roles of organizations engaged in waste management in Lao PDR

| Sector | Organization | Roles |
|---|---|---|
| Government | Ministry of Natural Resources and Environment (MONRE) | - Develops and implements regulation, strategies, policies and guidelines.<br>- Develops a National Plastic Management Action Plan. |
| | Pollution Control Department (PCD) (MONRE) | - Formulates policies, guidelines, programmes, regulations and standards. |
| | Ministry of Public Works and Transport (MPWT) | - Is responsible for issues related to solid waste management. |
| | Lao National Mekong Committee (LNMC) and Department of Water Resources (DWR) | - Is responsible for coordinating with the Mekong River Commission (MRC) and supervising the plan and management of river basins in Lao PDR. |
| | MOIC | - Issues permits for businesses producing plastic and recycles waste such as manufacturers who produce, use, import, and export plastic, plastic recycling factories, and waste recovery centres. |
| Academia/ research institute | National University of Lao PDR (NUOL) | - Is the most important national university in the country;<br>- Has a faculty of Environmental Sciences has been recently involved in the monitoring of marine plastic litter.<br>- Has a laboratory for handling and testing the quality of recycled plastic and conducting research on microplastics. |
| Private sector | Several hydropower projects | - Cleans up sediment and wastes on dams. |
| NGO | - Green Vientiane<br>- Various civil society organizations | - Raises awareness on waste and waste management. |
| International | - MRC<br>- World Bank<br>- United Nations Development Programme (UNDP) | - Currently works on raising awareness on plastic waste, assesses plastic waste littering into the rivers; and supporting the Lao Government in establishing policies to reduce plastic waste. |

### 3.4.3. Thailand

There are several ministries involved directly and indirectly in waste management. The three main ministries directly responsible for MSW are MONRE, the Ministry of Public Health, and the Ministry of Interiors. Both the Ministry of Public Health and the Ministry of Interior directly delegate duties to local administrations to manage solid waste, while MONRE develops policies and technical guidelines, monitors and reports on environmental data, and serves as a coordinating body for inter-ministerial committees. There have been increasing efforts in cooperation among public and private organizations and communities, domestically and internationally, to tackle marine and riverine plastic debris. The roles of relevant organizations are shown in Table 3.7.

**Table 3.7.** Summary of roles of organizations engaged in waste management in Thailand

| Sector | Organization | Roles |
|---|---|---|
| Government | Pollution Control Department, MONRE | - Develops national solid waste and plastic waste plans.<br>- Produces national report on the state of pollution.<br>- Monitors and reports on environmental data. |

| Sector | Organization | Roles |
|---|---|---|
| | | - Serves as a coordinating body for inter-ministerial committees. |
| | Regional Environment Office, MONRE | - Monitors municipal solid waste (MSW) disposal facilities.<br>- Collects MSW data.<br>- Monitors water quality. |
| | Department of Marine and Coastal Resources (DMCR), MONRE | - Conducts research studies.<br>- Develops policies and measures.<br>- Provides floating garbage traps and other support to local administrations in river mouth areas. |
| | Department of Health, Ministry of Public Health | - Oversees and facilitates the implementation of the Public Health Act. |
| | Department of Local Administration (DLA), Ministry of Interiors | - Collects MSW data.<br>- Develops policy on MSW management for local administration organizations (LAOs) to implement. |
| | Department of Industrial Works (DIW), Ministry of Industry | - Issues permits and ensures the leak-free operation of plastic recycling factories.<br>- Controls the import/export of hazardous waste and plastic waste. |
| | Fishery Department, Ministry of Agriculture and Cooperatives | - Enforces the Royal Ordinance on Fisheries to prohibit illegal waste discharge into waters. |
| | Marine Department, Ministry of Transport | - Enforces the Navigation in the Thai Waters Act, which prohibits illegal waste discharge into water. |
| | LAOs | - Manages SWM generated in areas under its jurisdiction.<br>- Sanctions violators who dump garbage into national water bodies.<br>- Cleans up garbage at riverbanks and in canals or rivers in the area or jurisdiction. |
| | Electricity Generating Authority of Thailand (EGAT) | - Draft reports on hydrology and telemetry of its 11 dams.<br>- Installs nets upstream of penstocks to capture riverine debris that does not cause problems. Most debris are biomass such as tree branches and water hyacinth.<br>- Invents and operates air spiral barriers (patented by EGAT) to prevent riverine debris from entering the water cooling system of the gas-fired power plant in Bangkok. |
| Academia/ research institute | Chulalongkorn, Kasetsart, Mahidol, Thammasart University, Prince of Songkla University, etc. | - Conducts research studies on waste and plastic waste. |
| Private sector | IRPC, PTT GC, Siam Cement Group of Thailand (SCG) Chemicals, DOW | - Raises awareness on plastic littering.<br>- Provides plastic collection bins.<br>- Develops and produces biodegradable plastic. |
| | Coca-Cola, Unilever, P&G, Thai Bev, etc. | - Raises awareness on plastic littering.<br>- Provides plastic collection bins.<br>- Redesigns packaging to reduce plastic use.<br>- Organizes clean-up activities. |
| | Siam Piwat, etc. | - No longer provides free plastic bags.<br>- Allows polymer and product manufacturers to place plastic waste collection bins near supermarket zones.<br>- Allows customers to refuse single-use plastic (SUP). |
| | TPI, Insee EcoCycle, SCI Eco, Eastern Energy Plus, etc. | - Uses refuse-derived fuels (RDF) made from plastic waste as alternative fuels. |
| | Suez, Starboard, etc. | - Reutilizes plastic waste as raw materials. |

| Sector | Organization | Roles |
|---|---|---|
| Non-governmental organizations (NGOs) | Thailand Environment Institute (TEI), Sustainable Consumption and Production (SCP) Network | - Conducts a research project on Support Development of Thailand's National Action Plan on Marine Plastic Debris, commissioned by World Bank Group. It aims to identify gaps between existing plans and marine plastic pollution. |
| | Trash Hero | - Organizes regular clean-ups on beaches, rivers, and canals around Thailand. |
| International | UNEP | - Initiates the SEA Circular together with the COBSEA to inspire market-based solutions and encourage enabling policies to prevent marine plastic pollution. |
| | International Union for Conservation of Nature (IUCN) | - Produces national guidance for plastic pollution hotspotting and shaping action.<br>- Conduct studies on marine litter.<br>- Cooperates with other organizations to implement projects to reduce marine litter. |
| | Government of Japan | - Supports UNEP in the CounterMEASURE project. |
| | Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) | - Provides technical support to Thai government agencies on the circular economy and the Rethinking Plastic project. |
| | World Wide Fund for Nature (WWF) | - Conducts plastic waste management projects in coastal cities.<br>- Develop an extended producer responsibility (EPR) proposal for Thailand.<br>- Raise funds to support project implementation related to marine plastic. |

### 3.4.4. Viet Nam

Many institutions are involved in reducing plastic pollution in Viet Nam, including the public and private sectors, multinational development agencies, international NGOs, and community-based/civil society organizations. SWM falls under the jurisdiction of several governmental bodies at the national, provincial, and municipal levels; however, there is no unified or standardized system of waste collection. Institutional arrangements involve inter- and intra- agency coordination and the support of multiple government institutions at the central/national and local government levels (Rab et al., 2015). The National Action Plan stipulates that MONRE will lead in the collaboration to periodically develop and operate environmental monitoring networks and programmes. To date, no monitoring and assessment programmes for plastic pollution have been approved. Among the related organizations, the Center for Marine Life Conservation and Community Development (MCD) plays a crucial role in reducing marine debris. A summary of the roles of organizations engaged in waste management in Viet Nam is provided in Table 3.8.

**Table 3.8.** Summary of roles of organizations engaged in waste management in Viet Nam

| Sector | Organization | Roles |
|---|---|---|
| Government | Ministry of Natural Resources and Environment (MONRE) | - Develops and issues regulations, technical guidelines, standards, policies, and systems for solid waste management. |

| | | |
|---|---|---|
| | | - Supports research and technical development related to waste management.<br>- Develops projects related to waste management-<br>- Approves environmental impact assessment reports. |
| | Vietnam Environment Administration under the MONRE | - Is responsible for planning, formulating strategies, legislation, and policy nationally and provincially.<br>- Covers guidelines and environmental standards for MSW, industrial and hazardous waste and emerging waste streams, including plastic. |
| | Administration of Sea and Islands under the MONRE | - Is responsible for the preparation of the national action plan for the management of marine plastic litter<br>- Conducts surveys, monitoring, analysis, inspection, research and supervision of marine plastic waste and control of environmental pollution as well as organizes investigations, evaluation, and management of marine plastic litter. |
| | Ministry of Construction | - Is responsible for municipal solid wastes.<br>- Develops policy and legislation.<br>- Develops and instructs on the implementation of the solid waste treatment investment programme.<br>- Develops, appraises, instructs, and monitors the implementation of solid waste management (SWM) interprovincial planning.<br>- Instructs and monitors the development and management of construction planning of SWM facilities.<br>- Appraises the SWM planning of state-run cities.<br>- Organizes investment promotion activities and instruct on the implementation of investments in inter-provincial SWM facilities. |

| | | |
|---|---|---|
| | Ministry of Health | - Develops guiding documents, regulations, and standards on plastic waste management for the health sector.<br>- Assesses the impacts of solid waste on human health and inspects and supervises hospital waste treatment. |
| | Directorate of Fisheries under Ministry of Agriculture and Rural Development (MARD) | - Develops guiding documents, regulations, and standards on plastic waste management for the fishery and aquaculture sectors.<br>- Assesses the impacts of solid waste on fisheries and aquaculture. |
| | Provincial People's Committee (PPC)/Department of Agriculture and Rural Development Management | - Is responsible for river management.<br>- Is responsible for the management of irrigation, agriculture and water resources. |
| | Vietnam Inland Waterways Administration (VIWA) under Ministry of Transport | - Is responsible for the management and environmental protection in inland waterway navigation activities, including the management of plastic pollution.<br>- Oversees and coordinates with the MONRE in guiding and organizing the implementation of the management of and environmental protection in inland waterways.<br>- Examines and promotes the implementation of the law on environmental protection in inland waterway navigation.<br>- Prepares plans on environmental protection in inland waterway navigation activities.<br>- Organizes training and disseminates the law on environmental protection among cadres, civil servants, public employees, and staff members of management units in charge of inland waterway navigation;<br>- Carries out studies on the pilot application of, and expands the model of environmental protection and treatment of environmental pollution at |

| | | |
|---|---|---|
| | | establishments engaged in inland waterway navigation activities. |
| | Ministry of Planning and Investment | - Is responsible for municipal solid waste, industrial solid waste, and hazardous waste. |
| | District People's Committees | - Are responsible for environmental issues in their provinces including urging and directing the implementation of regulations and decentralized programmes in solid waste management. |
| Academia/research institute | Ho Chi Minh City University of Technology | - Conducts macroplastic and microplastic surveys |
| The private sector | Hydropower plants such as Yali Hydropower Company, Se San Hydropower Development Company, *Dong Nai Hydropower Company* (under Vietnam Electricity, EVN)<br><br>Buon Don Hydropower Company | - N/A |
| | Urban Environment Company (URENCO)/City Environment Company (CITENCO) | - Is responsible for collecting solid wastes in the cities and on rivers/canals. |
| | Vietnam Plastics Association | - Supports funding for research.<br>- Conducts awareness campaigns in collaboration with other parties. |
| NGO | Centre for Marine Life Conservation and Community Development (MCD) | - Operates in the field of marine environmental protection and sustainable development of 19 coastal areas of Viet Nam.<br>- Promotes efficiency in marine debris management, especially the reduction of plastic debris in the ocean, as one of its priority contents in the 2018–2023 period.<br>- Has had a long and effective cooperation with the Vietnam Administration of Sea and Islands.<br>- Has made active contributions to the drafting of the National Action Plan for Ocean Plastic Waste Management up to 2030. |
| | WWF, IUCN, Greenhub, MCD | - Conduct awareness raising campaigns on solid waste in collaboration with other parties (NGOs, non-profit organizations, international organizations). |

| | | |
|---|---|---|
| | | - Conduct surveys on solid waste treatment and management.<br>- Propose incentives on solid waste management.<br>- Create forums/networks of the related parties. |
| International | Japan International Cooperation Agency (JICA), United States Agency for International Development (USAID), United Nations Development Programme (UNDP) | - Support funding for surveys on, and treatment, and management of solid waste. |

**Main results and key challenges**

- Among all the regional frameworks listed, COBSEA Regional Action Plan on Marine Litter 2019 (RAP MALI). RAP MALI 2019 (COBSEA, 2019) may be the most specific framework, with its concrete action plan for building a marine debris monitoring system. Although Lao PDR is not the member of COBSEA, it is hoped that the MCs will be able to cooperate in developing a riverine debris monitoring system in the LMB.
- There are several international conventions aiming to prevent and control marine pollution from ships, the discharge of harmful substances, open dumping, or to completely prohibit the disposal of plastic in all forms. This may be satisfactory for the prevention of pollution in the water; however, it excludes landlocked countries such as Lao PDR. Also, the number of countries that have ratified these multilateral treaties in the LMB has not increased.
- None of the MCs have a specific policy framework for monitoring plastic debris or riverine debris. To fully understand the current situation of waste in terms of volume, composition and littering accumulation, it is necessary to build a concrete and effective system for monitoring of waste/plastic debris.
- The available information of national institutional frameworks lacks a clear allocation of tasks and responsibilities among the institutions on the riverine debris due to the transboundary movements, which underlines the increased importance of clarifying the path of riverine debris movements.

# 4. Capacity of riverine plastic debris monitoring

To solve the plastic pollution issue, it is crucial to accurately monitor the current situation of waste and to compare the data over time. This requires human resources and equipment for this monitoring, but governmental agencies, universities, and institutes at the early stage of research often lack these resources. However, some universities such as Chulalongkorn University and Kasetsart University in Thailand have the proper equipment for monitoring. To maximize the outcome with the limited resources, collaboration between government and academia or institutes is required in conducting riverine debris monitoring. Table 4.1, Table 4.2, Table 4.3, and Table 4.4 provide information on the capacity of riverine debris monitoring, i.e. the organizations, laboratories, human resources, equipment of each MC.

In conducting a survey on plastic debris in rivers or in the ocean, various equipment is required from sampling to analyse. Plankton nets such as zooplankton nets are used in sampling microplastics. FTIR and Raman spectroscopes are used to identify the plastic material. A stereo dissecting microscope can be used to sort microplastic debris, which enables a more accurate analysis.

## 4.1. Cambodia

Since no riverine debris monitoring activities have been carried out to date, Cambodia needs to build the capacities of relevant institutions such as MOE, Ministry of Water Resources and Meteorology (MOWRAM), Ministry of Agriculture, Forestry and Fisheries, MPWT, local authorities, etc. in order to perform riverine debris monitoring in the future. Currently, the Fishery Administration under the Ministry of Agriculture, Forestry and Fishery, is working on Ecological Health Monitoring and Larvae Drift Monitoring in Cambodia; in the Fishery Administration, it is important that the laboratory has the capacity for conducting plastic monitoring.

**Table 4.1.** Capacity of riverine debris monitoring activities in Cambodia

| Organization | Items | Description |
|---|---|---|
| Fishery Administration, Ministry of Agriculture | Source and amount of budget | - N/A |
| | Human resources | - N/A |
| | Sampler | - Zoo plankton net with 20µm mesh size<br>- D-frame net with 30 cm x 20 cm with mesh size of 475µm<br>- Bongo net with 1-m diameter and a 1-mm mesh size, a flow meter |
| | Analytical equipment | - A stereo dissecting microscope with a 2x–4x objective lens and a 10x eyepiece |

## 4.2. Lao PDR

The staff in the laboratory of the National University of Lao are able to conduct microplastic and microplastic sampling, although there is no analytical equipment. The Government lacks the capacity to sample, monitor, and analyse riverine plastic debris.

**Table 4.2.** Capacity of riverine debris monitoring activities in Lao PDR

| Organization | Items | Description |
|---|---|---|
| The laboratory of the Faculty of Environmental Sciences of the National University of Lao PDR | Source and amount of budget | - N/A |
| | Human resources | - 6 staff members are trained in riverine macroplastic sampling.<br>- 2 staff members are trained for riverine microplastic sampling. |
| | Sampler | - Five water samplers |
| | Analytical equipment | - N/A |

## 4.3. Thailand

The Department of Marine and Coastal Resources (DMCR) has a sampler for microplastics and analytical equipment such as FTIR. However, FTIR is only used at Phuket Marine Biological Center. DMCR also has two boats and booms installed in the rivers in the coastal areas for capturing riverine and marine debris. Government agencies lack equipment for analysing and monitoring plastic pollution. Chulalongkorn University and Kasetsart University have analytical equipment. Collaboration between the Government and universities is required to conduct plastic debris monitoring.

**Table 4.3.** Capacity of riverine debris monitoring activities in Thailand

| Organization | | Description |
|---|---|---|
| Marine and Coastal Resources Research and Development Centres (7 locations) in the Department of Marine and Coastal Resources (DMCR) | Source and amount of budget | Fiscal budgets from central government |
| | Human resources | - Around 20 employees each at the Eastern Gulf of Thailand Center, the Eastern Upper Gulf of Thailand Center, the Upper Gulf of Thailand Center, The Lower Andaman Center.<br>- About 30–40 employees each at the Central Gulf of Thailand Center and the Lower Gulf of Thailand Center.<br>- More than 60 employees at the Phuket Marine Biological Center. |
| | Sampler | - Plankton nets |
| | Analytical equipment | - Microscope<br>- FTIR (only at Phuket Marine Biological Center)<br>- Other details are not available |
| Laboratory in Marine Science Department, Faculty of Science, Chulalongkorn University | Source and amount of budget | - University budget and project-based grants |
| | Human resources | - 18 faculty members and 4 research assistants |
| | Sampler | - 0.33 mm and 4.75 mm meshes<br>- Other details are not available |
| | Analytical equipment | - Microscope at ×40 magnification<br>- FTIR is available<br>- Raman spectroscope is available<br>- Other details are not available |
| Laboratory in Material | Source and amount of budget | - University budget and project-based grants |
| | Human resources | - N/A |

| Organization | | | Description |
|---|---|---|---|
| Engineering Department, Faculty of Engineering, Kasetsart University | Sampler | - | Details are not available |
| | Analytical equipment | - | FTIR is available |
| | | - | Raman spectroscope is available |
| | | - | Other details are not available |
| Mahidol University – Frontier Research Facility (MU–FRF) | Source and amount of budget | - | N/A |
| | Human resources | - | 11 scientists to support researchers. |
| | Sampler | - | N/A |
| | Analytical equipment | - | FTIR, micro FTIR, Raman and stereomicroscopes are available. |

## 4.4. Viet Nam

MONRE and the Department of Natural Resources and Environment (DONRE) lack sampler and analytical equipment for plastic monitoring. An environmental laboratory in Ho Chi Minh City University of Technology had two trained staff members for marine debris monitoring, and sampler and analytical equipment for microplastic monitoring. The aquatic ecology laboratory in the Southern Institute of Ecology and the ecological toxicology laboratory in the Institute for Environment and Resources have trained staff for marine debris monitoring and microplastic analysis.

**Table 4.4.** Capacity of riverine debris monitoring activities in Viet Nam

| Organization | | | Description |
|---|---|---|---|
| - Center for environmental monitoring (CEM) of MONRE:<br>- Centre for Environmental and Natural Resources Monitoring or the Center for Environmental Monitoring and Analysis (CEMA) of the Department of Natural Resources and Environment (DONRE) | Source and amount of budget | - | N/A |
| | Human resources | - | N/A |
| | Sampler | - | Beta water sampler |
| | | - | Van Veen grab sampler |
| | Analytical equipment | - | N/A |
| Environmental lab in Ho Chi Minh City University of Technology/*Centre Asiatique De Recherche Sur L'eau* (CARE, Asian Water Research Center) | Source and amount of budget | - | N/A |
| | Human resources | - | Around 15 (CARE centre) |
| | | - | Around 2 (trained staff members for marine debris monitoring) |
| | Sampler | - | Beta water sampler |
| | | - | Plankton/fish-egg net (e.g. manta net, neuston net): mesh size 300 um |
| | Analytical equipment | - | FTIR, scanning electron microscope (SEM) |
| Aquatic Ecology Lab in Southern Institute of | Source and amount of budget | - | N/A |
| | Human resources | - | Around 35 |

| Organization | | Description |
|---|---|---|
| Ecology (SIE)/ Department of Aquatic Ecology | | - 2 trained staff members for marine debris monitoring |
| | Sampler | - Beta water sampler<br>- Van Veen grab sampler<br>- Fishing sampling net: various mesh sizes<br>- Manta net, size 100 um |
| | Analytical equipment | - FTIR, SEM |
| Ecological Toxicology Laboratory in the Institute for Environment and Resources (IER) | Source and amount of budget | - N/A |
| | Human resources | - Around 200<br>- Around 2 (trained staff members for marine debris monitoring) |
| | Sampler | - Beta water sampler<br>- Van Veen grab sampler |
| | Analytical equipment | - FTIR, SEM |
| Environmental lab in Department of land resources, Can Tho University | Source and amount of budget | - N/A |
| | Human resources | - N/A |
| | Sampler | - Beta water sampler<br>- Van Veen grab sampler |
| | Analytical equipment | - N/A |

**Main results and key challenges**

- Not only governmental agencies but also universities or institutes work on research on plastic pollution. However, since most of them are at an early stage of research on plastic pollution, they lack human resources with riverine debris monitoring skills and monitoring equipment.
- A concrete system for cooperation to supplement the lack of resources is required. For example, some facilities in Thailand and Viet Nam own FTIR and Raman spectroscopes, which are required for identifying plastic material. In addition, available equipment is limited to a stereo dissecting microscope in Cambodia, and a water sampler in Lao PDR. As emphasized in the ASEAN Framework of Action on Marine Debris (Table 3.1), regional collaboration between the Government and academia and institutes is required to conduct riverine debris monitoring in order to maximize outcomes with limited resources.

# 5. Current trends and the status of plastic pollution in the LMB

There were several monitoring activities addressing riverine plastic debris outside the LMB. However, in the LMB, the monitoring of riverine plastic debris was only covered by UNEP's CounterMEASURE II Project, which aims to determine the origins and pathways of plastic waste in major rivers in Asia and provide governments with bespoke policy recommendations to help mitigate plastic pollution. Even though the collected information allows to make a general comparison of plastic debris pollution status in the LMB area, there is no standardized method for data collection, which makes it impossible to obtain an accurate analysis, and the number of NGO activities exceed those of MC's governmental bodies.

In addition to reflecting the results of CounterMEASURE II Project in policy formulation, the shared experiences can be utilized for standardizing the method of riverine debris data collection and expanding the monitoring activities throughout the LMB region for future actions to address riverine plastic debris in the Mekong River.

This Chapter is divided into three sections describing the general trend of plastic debris pollution in the LMB: ("***5.1 Riverine monitoring activities and results in the LMB***"), the Introduction of Riverine debris monitoring activities that do not directly address LMB but can be utilized for enhancing the monitoring activities in the LMB ("***5.2 Riverine monitoring results outside the LMB"***), and Riverine debris cleaning activities in the LMB that can be accelerated along with the monitoring of collected debris ("***5.3 Clean-up and collection activities in the LMB***").

## 5.1. Riverine monitoring activities and results in the LMB

In the LMB, five survey areas were chosen along the Mekong River in the CounterMEASURE II Project, as shown in Figure 5.1.

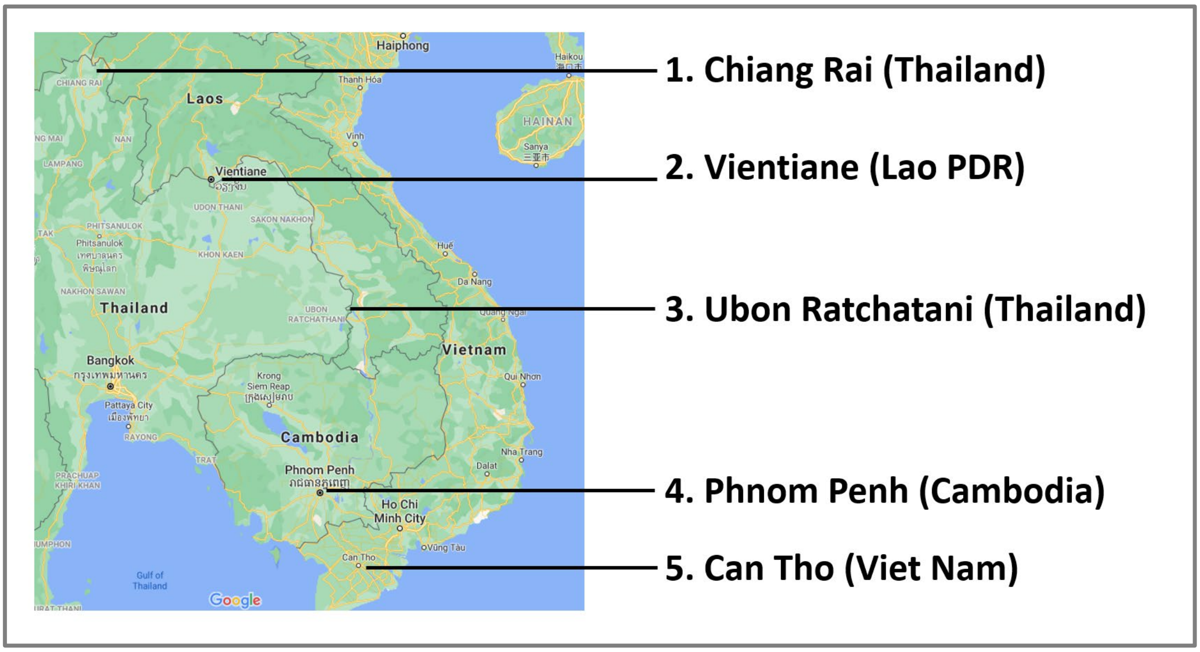



**Figure 5.1.** Five survey areas of CounterMEASURE II Project

*Source:* UNEP (2020e)

Then, four target categories of plastic pollution were investigated in each survey area, namely, riverine macroplastic, riverine microplastic, plastic leakage hotspot, and plastic accumulation hotspot (Figure 5.2) Plastic pollution challenges have traditionally focused on macroplastics and their management. However, the focus of recent research has been on understanding of the sources, fate, sink and transport, and generation mechanisms of microplastics (UNEP, 2020b). Two types of riverine plastic debris were collected and analysed: 'microplastics', whose diameter is smaller than 5 mm, and 'macroplastics', whose diameter is larger than 5 mm (Figure 5.2). Also, two types of plastic waste hotspots located near the Mekong River were investigated mainly by visual inspection. Specifically, 'plastic leakage hotspots' are the piles of waste formed by activities such as illegal dumping or unsanitary landfills, and these locations can be the main source of plastic waste leakage from land into the water. 'Plastic accumulation hotspots' are mostly artificial barriers where riverine plastic debris is most likely to become entangled and accumulate. Figure 5.2 provides a summary and photos of each target category. These four target categories in each survey area are not necessarily investigated by a unique organization or cannot be conducted. Riverine macroplastic, plastic leakage hotspots, and plastic accumulation hotspots are surveyed mainly by national universities, and riverine microplastic is sampled and analysed by Pirika (2020).

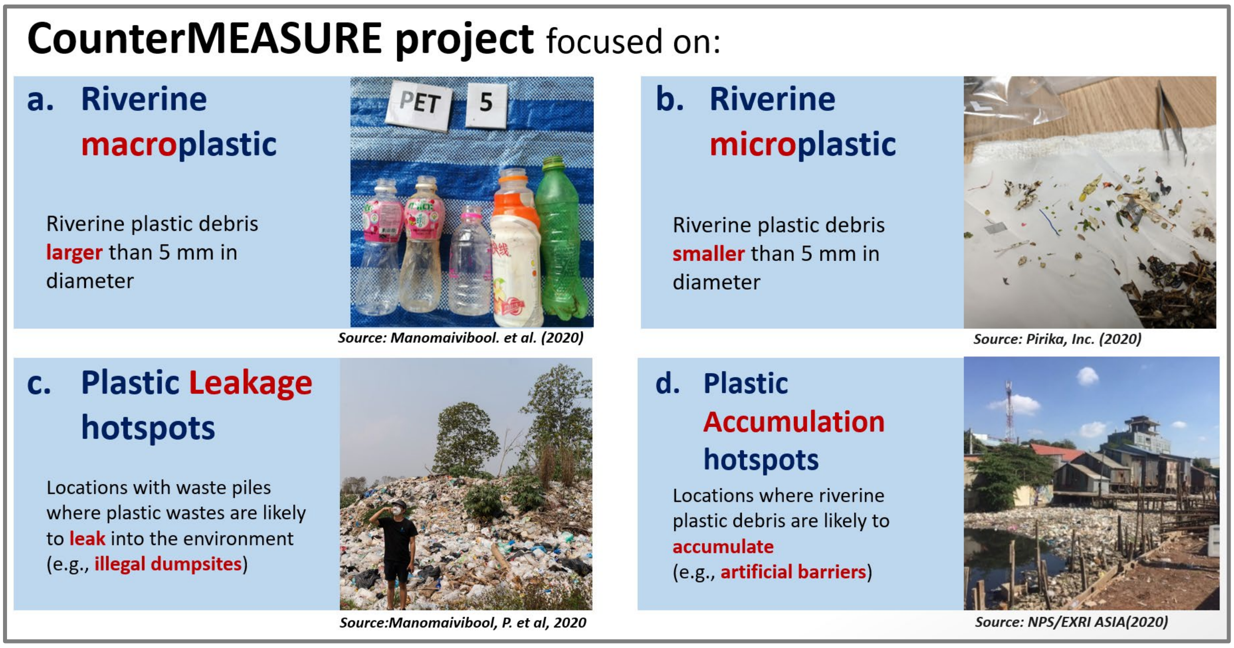



**Figure 5.2.** Four target categories of the CounterMEASURE II Project (UNEP, 2020e)

Table 5.1 briefly explains the polymers addressed in the CounterMEASURE II Project. Each material has a different structure, density and use, leading to diverse behaviour both on land and in the water.

**Table 5.1**. Plastic polymers addressed in the CounterMEASURE II project

| Polymer | Abbreviation | Density ($g/cm^3$) | | Main application |
|---|---|---|---|---|
| | | Min. | Max. | |
| Polypropylene | PP | 0.9 | 0.91 | Food containers, utensils, packaging |
| Low-density polyethylene | LDPE | 0.91 | 0.94 | Packaging |
| High-density polyethylene | HDPE | 0.94 | 0.97 | Bags, bottles, buckets, pipes |
| Polyethylene terephthalate | PET | 1.37 | 1.45 | Bottles |
| Polystyrene | PS | 1.01 | 1.04 | Food foam containers |
| Polyvinyl chloride | PVC | 1.16 | 1.58 | Pipes, hoses, building and construction |

*Sources:* Malakul et al. (2019); UNEP (2020e)

Due to tis lack of surveyed data and significant difference in the units and methodology of collected data, it was impossible to perform a precise data comparison. Nevertheless, by combining the existing data and modifying some units, it was possible to obtain a general comparison.

Figure 5.3 shows the material and quantity of macroplastics and microplastics in the riverine plastic debris collected by in CounterMEASURE II Project from upstream to downstream of the Mekong River. The left side of the figure shows the results of macroplastics, and the right side shows the results of microplastics. The pie charts show the percentage of the different materials of the collected plastic debris, and the numbers on the grey arrows show how much debris was flowing in the river.

Regarding macroplastics, the concentration varied from place to place, as shown on the grey arrow in the left of Figure 5.3. Also, in looking at the pie charts presented in the left side of Figure 5.3, PE was the most popular material at the three surveyed points. And from the pie charts presented in the left side of Figure 5.4, the plastic wrapper was the most popular product, which highlights the importance of the alternative packaging materials. Regarding microplastics, the concentration increased as it flowed down the stream, as shown on the grey arrow in the right of Figure 5.3. At all the points surveyed, PP was the most popular material, as shown in the five pie charts listed in the right of Figure 5.3. This may have resulted from its lowest density among all the plastics, which enables it to be carried for a long distance. High-density PET was not seen at any points because it may sink in the water and does not appear in the surface water.

The lower part of the Figure 5.3 compares the flux of macroplastics at Can Tho, located in the most downstream of the five sites surveyed, with the flux of riverine debris in the Mekong River predicted (Schmidt et al., 2017). In the CounterMEASURE II Project, the flux was 2.14–12.4% of the predicted value (Schmidt et al., 2017).

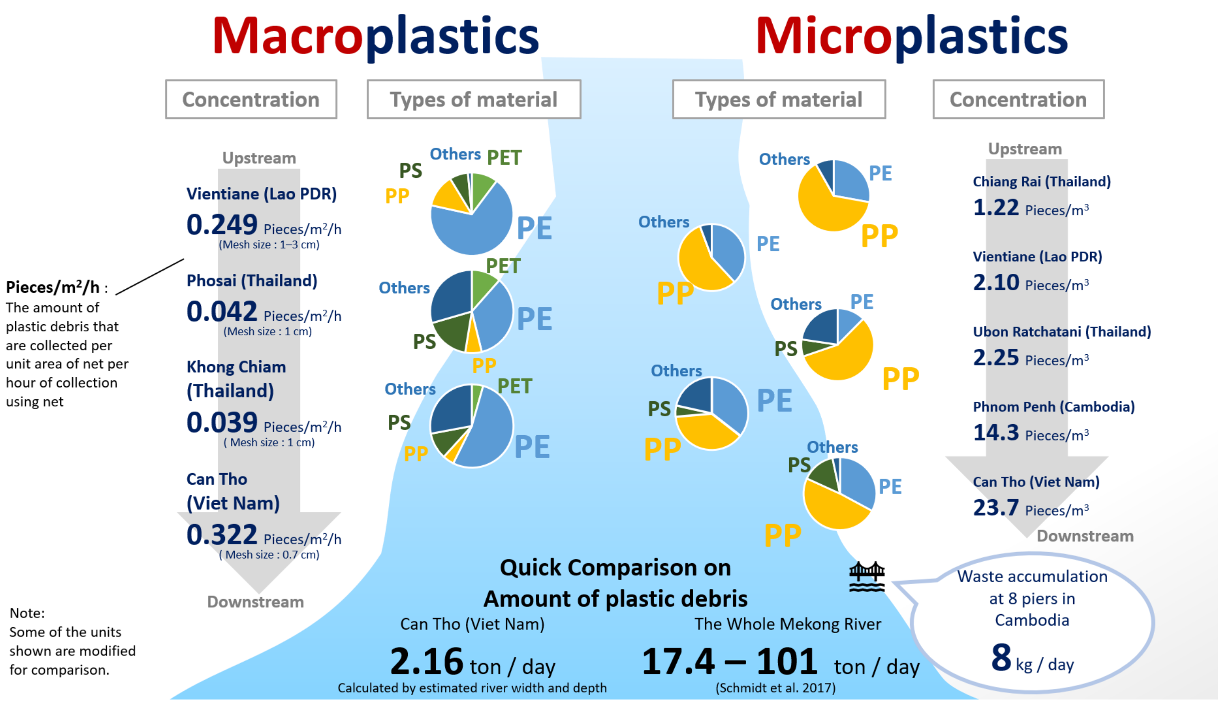



**Figure 5.3.** A summary of macro and microplastic types and compositions as surveyed by the CounterMEASURE II Project in the LMB

*Source:* UNEP (2020e)

Figure 5.4 compares the riverine macroplastic debris that flow in the river, and accumulated plastic waste that is stuck at artificial barriers. Wrappers were dominant in riverine macroplastic debris in all surveyed points, whereas the composition of debris accumulated at artificial barriers varied greatly in all locations with no commonality observed, emphasizing the need for the individual treatment at each location. The right side shows the total amount of waste pile and the total number of sites identified as illegal dumpsites and artificial barriers.

Several locations contained vast amounts of waste, thus calling for urgent treatment. More detailed information is provided in the subsequent chapters for each site.

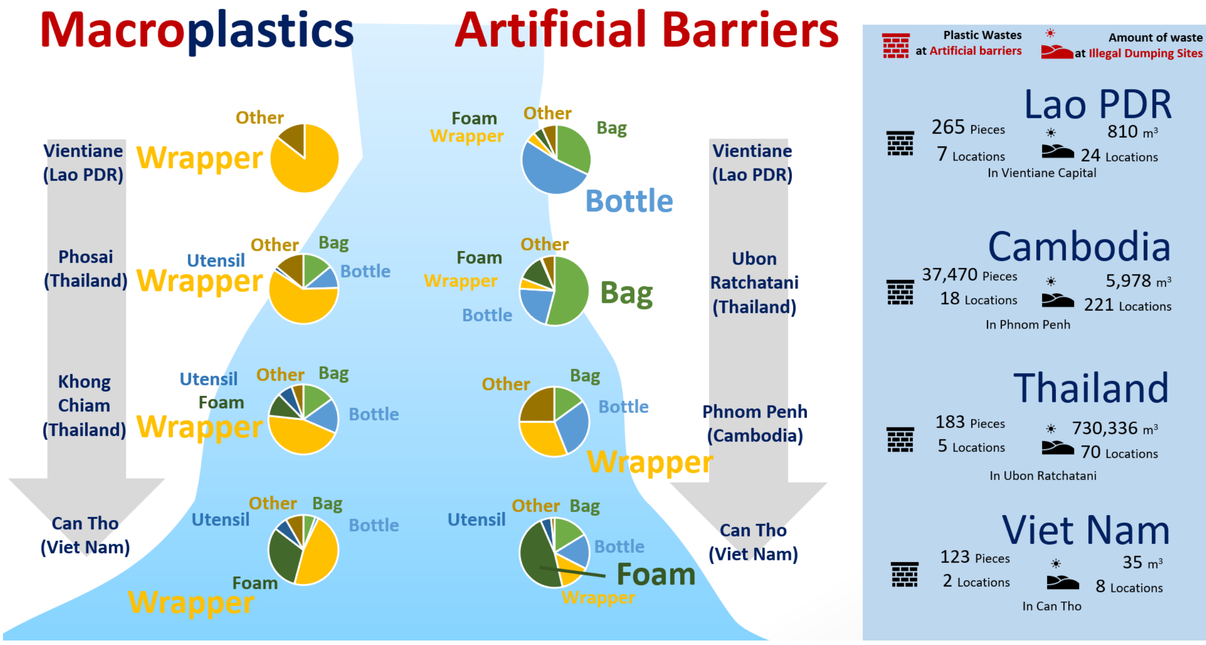



**Figure 5.4.** A summary of macroplastic collected at artificial barriers in the LMB by the CounterMEASURE II Project

*Source:* UNEP (2020e)

The following chapters describe the detailed results together with the comments from survey teams in each survey conducted at the five sites presented above. The quick profile table (Table 5.2) attached in each paragraph provide the general methodology on how each survey was conducted, such as debris collection methods and debris classification methods (see the referenced documents for the detailed information).

**Table 5.2**.Project profiles at a glance

| | |
|---|---|
| **Location** | Location where sampling was conducted |
| **Duration** | Time duration of sampling conducted |
| **Samples dried?** | Whether or not samples were dried after collection before weighing |
| **Classification type** | The characteristic by which the samples were classified (weight, material, use, quantity, etc.) |
| **Collection method** | Method used for sampling |

### 5.1.1 Area 1/5: Chiang Rai (Thailand)

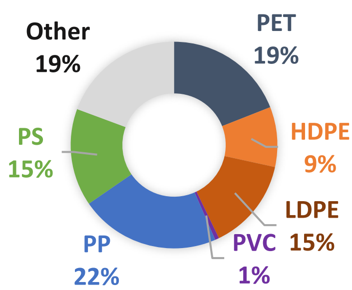
#### a. Riverine macroplastics

| | |
|---|---|
| **Location** | Chiang Saen Port |
| **Duration** | twice/day, 7 days in March 2020 |
| **Samples dried?** | No |
| **Classification type** | Material, quantity, weight |
| **Collection method** | Net installation |

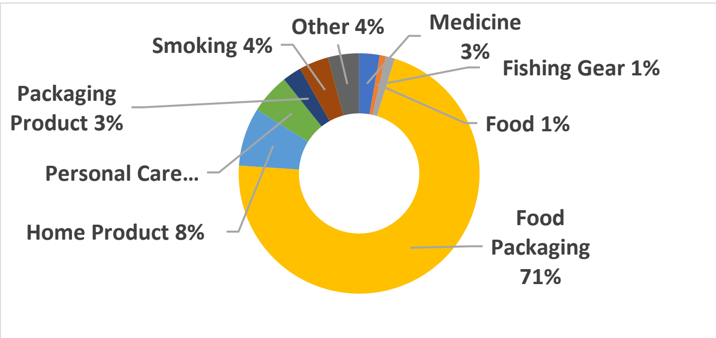
Manomaivibool (2020) conducted macroplastic sampling at the Chiang Saen port, collecting more than 1,500 pieces, **or 51 kg** of riverine plastic debris, by installing a net at the Chiang Saen Port in the Mekong River (**Figure 5.5**a). The detailed classifications of collected debris are shown in **Figure 5.5**b and Figure 5.5c. However, the survey team explained that the results might not represent the **normalcy of** the area and most likely underestimated the amount of plastic waste found in Mekong; therefore, the team recommended carrying out the survey again for greater accuracy. Also, the flows of waste might not be well-illustrated due to the extended drought experienced in the region since most of the macroplastics are likely collected from nearby activities. The survey team recommended that standardizing the methods of site selection, equipment setting and documentation would be of **great** benefit **to** the region.

| Area | Amount of collected debris in 7 days |
|---|---|
| Chiang Saen Port | 1587 pieces / 51810 g |

(a)




(b)




(c)

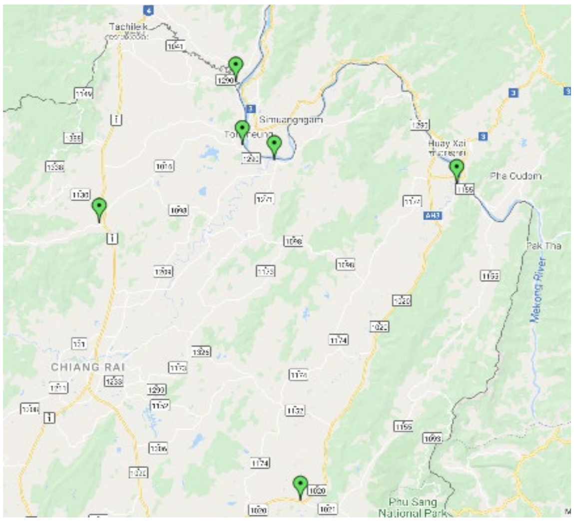
**Figure 5.5.** Riverine macroplastic sampling in Thailand with (a) summary of sampling activities, (b) debris classification by plastic types, and (c) debris classified by uses

*Source:* Manomaivibool (2020)

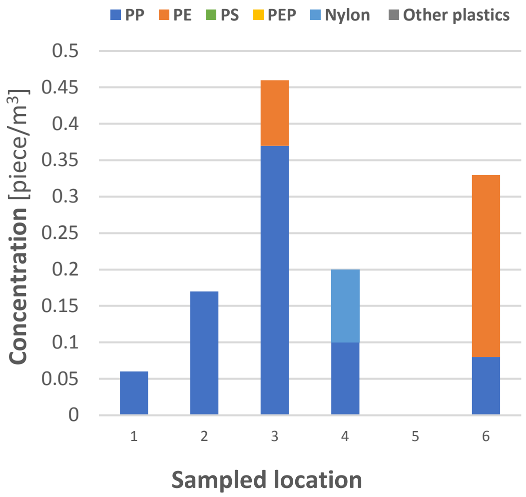
## b. Riverine microplastic

| | |
|---|---|
| **Location** | Chiang Rai |
| **Duration** | January – March 2020 |
| **Samples dried?** | Not described |
| **Classification type** | Material, quantity |
| **Collection method** | Albatross Mark V lite |

Chiang Rai, located **in the most** upstream section of 5 surveyed areas, had the smallest average microplastic concentration **(Pirika, 2020)**. Microplastic concentration was mostly composed of PP, with **the nylon** and PE appearing in several locations. The highest concentration recorded was 0.46 $m^3$**,** and the lowest was under **the detectable** limit **(Figure 5.6b).**




(a)




(b)

**Figure 5.6.** Riverine microplastic monitoring showing (a) sampling location and (b) concentration of microplastics

*Source:* Pirika (2020)

## c. Plastic leakage hotspots (illegal dumpsites)

| | |
|---|---|
| **Location** | Chiang Rai |
| **Duration** | February – March 2020 |
| **Samples dried?** | No |
| **Classification type** | – |
| **Collection method** | GIC mobile app |

**Manomaivibool (2020)** visited four dumpsites in Chiang **Rai to conduct an analysis** from a list of 213 dumpsites provided by the Department of Local Administration and the Pollution Control Department (Figure 5.7). Moreover, the study reported that illegal dumpsites and littering spots have never been officially recorded in Thailand.

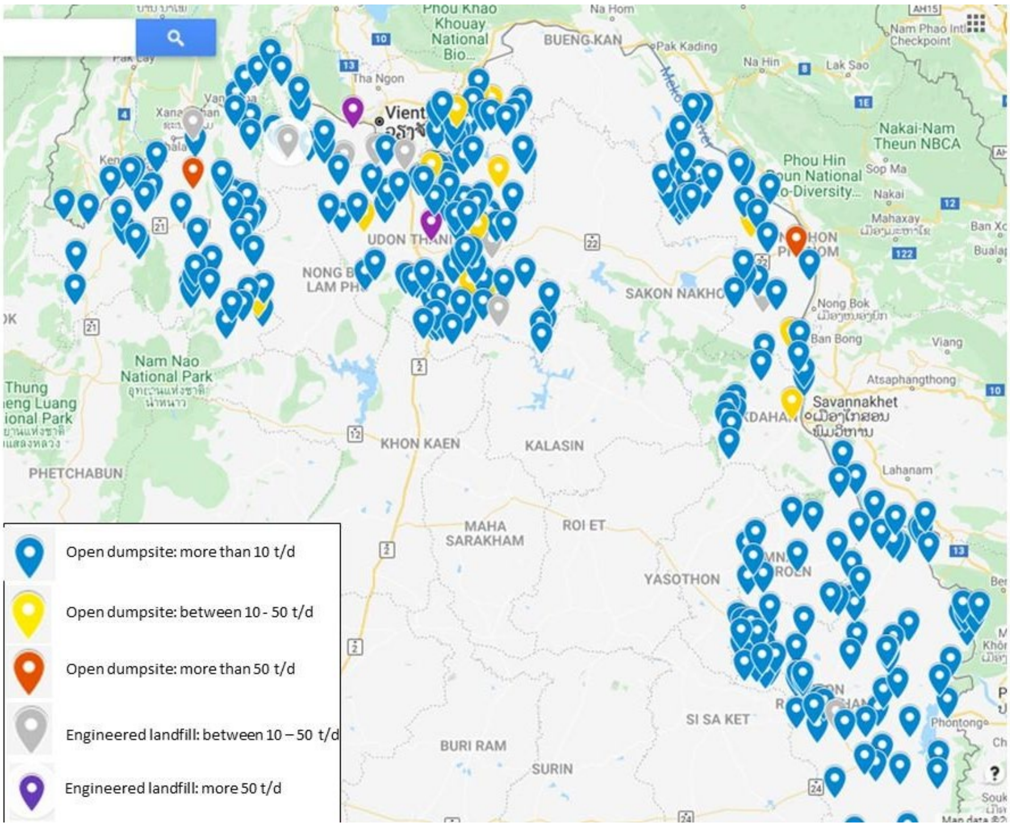


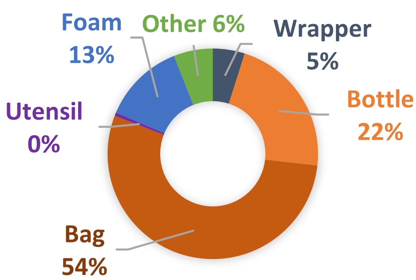

**Figure 5.7.** Leakage hotspot locations

*Source:* Manomaivibool (2020)

**d. Plastic accumulation hotspots (artificial barriers)**

| | |
|---|---|
| **Location** | Chiang Rai |
| **Duration** | February – March 2020 |
| **Samples dried?** | No |
| **Classification type** | - |
| **Collection method** | Visual inspection |

**Manomaivibool (2020)** listed 25 weirs managed by the Royal Irrigation Department and local governments in three districts in Chiang Rai. The field inspection selected five locations of these weirs, and collected data on their location and plastic waste that could be **found** entangled in **the barriers**.




(a)

**Inspected plastic debris accumulation**

**183 pieces / 5 weirs**

(b)

**Figure 5.8.** Plastic accumulation hotspot monitoring results with (a) plastic debris classified by types and (b) total plastic accumulation

*Source:* Manomaivibool (2020)

### 5.1.2 Area 2/5: Vientiane (Lao PDR)

**a. Riverine macroplastics**

| | |
|---|---|
| **Location** | Vientiane |
| **Duration** | • 24 h/day, 7 days in February 2020 (net)<br>• 3 h/day, 7 days in February 2020 (boat) |
| **Samples dried?** | No |
| **Classification type** | Material, Quantity, Weight |
| **Collection method** | • Large net installation (W:40 m, D:2 m)<br>• Small net installation (W:10 m, D:1.5 m, L:3 m)<br>• Boat |

**Chansomphou (2020)** used three collection methods trying to cover entire cross-section of the river at Thinpia Village, namely, installing two kinds of nets and **collection by boat.** Over 4,000 pieces of debris were collected during the survey amounting to over 43 kg (Table 5.3), of which plastic waste accounted for 29%. Among the plastic debris collected, 58% were of **low-density polyethylene (LDPE),** followed by PP at 13% (Figure 5.9b).

As part of his survey, **Chansomphou (2020)** pointed out the following difficulties and challenges:

- Tools and methods of primary data collection are not standardized among the implementing institutes.
- It was difficulty to install the net trap in the Mekong due to strong water currents.
- Although the simple net traps **may be used**, some waste might escape the trap due to strong water currents.

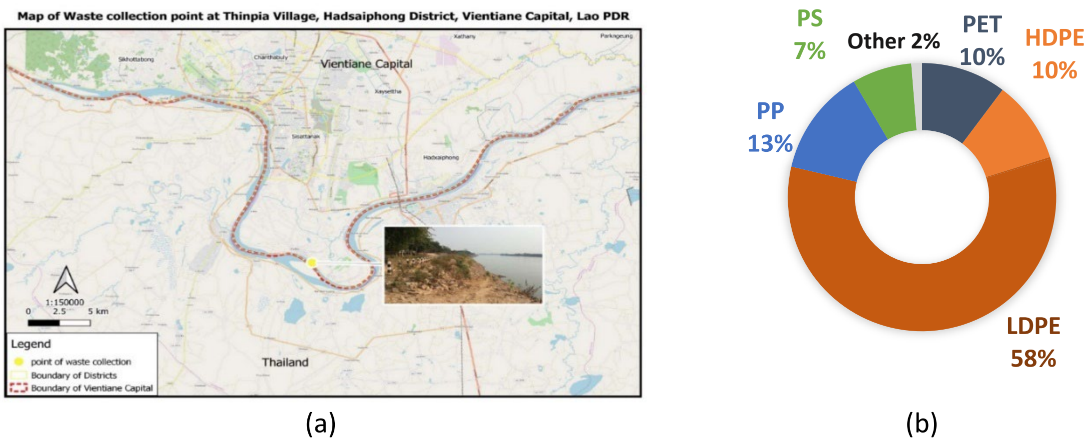



**Figure 5.9.** Riverine macroplastic monitoring showing (a) the location of the sampling and (b) the plastic debris, by type and proportion

*Source*: Chansomphou (2020)

**Table 5.3.** A summary of collected riverine debris by pieces and weight

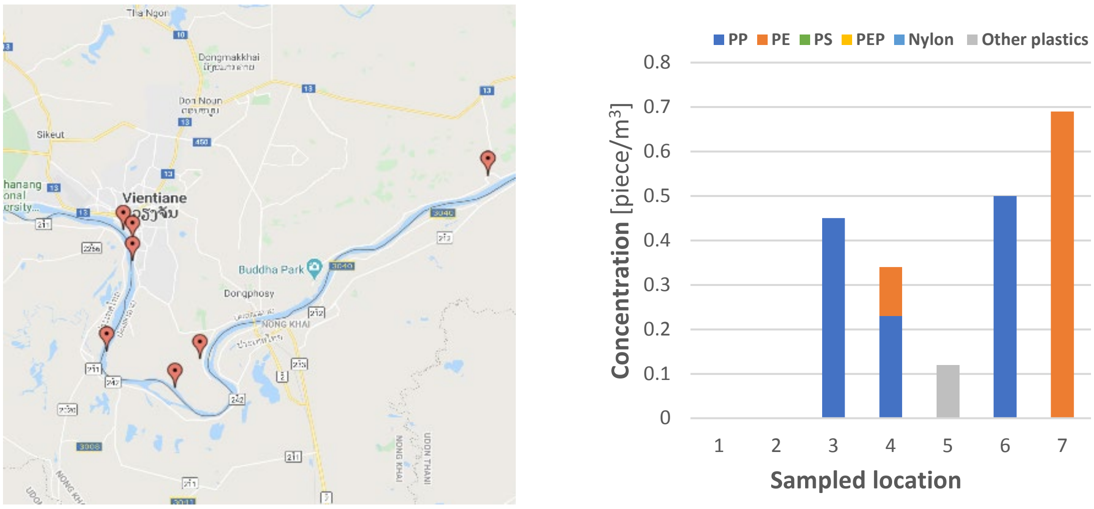
| Method | Summary of debris by item (pieces) | Summary of debris by weight (g) |
|---|---|---|
| Small trap | 918 | 7,971 |
| Large trap | 1,789 | 15,494 |
| Boat collection | 1,351 | 19,720 |
| Total | 4,058 | 43,185 |

*Source*: Chansomphou (2020)

### b. Riverine microplastics

| | |
|---|---|
| **Location** | Vientiane |
| **Duration** | January – March 2020 |
| **Samples dried?** | Not described |
| **Classification type** | Material, quantity |
| **Collection method** | Albatross Mark V lite |

Vientiane, located in the second most upstream of the five surveyed areas, had the second smallest average microplastic concentration (Pirika, 2020). A high ratio of PP was seen in three sampled locations, while one location had a surprisingly large amount of PE. The highest concentration recorded was 0.69 $m^3$, and the lowest was under the detectable limit in two sampled locations (Figure 5.10b).




(a) (b)

**Figure 5.10.** Riverine microplastic monitoring showing (a) the location of the sampling and (b) the plastic debris by types and concentration

*Source*: Pirika (2020)

**c. Plastic leakage hotspots (illegal dumpsites)**

| | |
|---|---|
| **Location** | Vientiane |
| **Duration** | 15–17 March 2020 |
| **Samples dried?** | No |
| **Classification type** | Volume |
| **Collection method** | Measuring dimensions of waste piles |

**Chansomphou (2020)** observed no illegal dumpsites nearby the city cent**re, but approximately 25 sites beyond 15 km (Figure 5.11). These illegal dumpsites are not big; they have small piles of wastes scattered around. From observations and interviews with people living nearby, waste dumped in the sites may be from households; most people who wish to throw away their waste would sneak out and dump waste at night. Some wastes are burned, but many are not.**

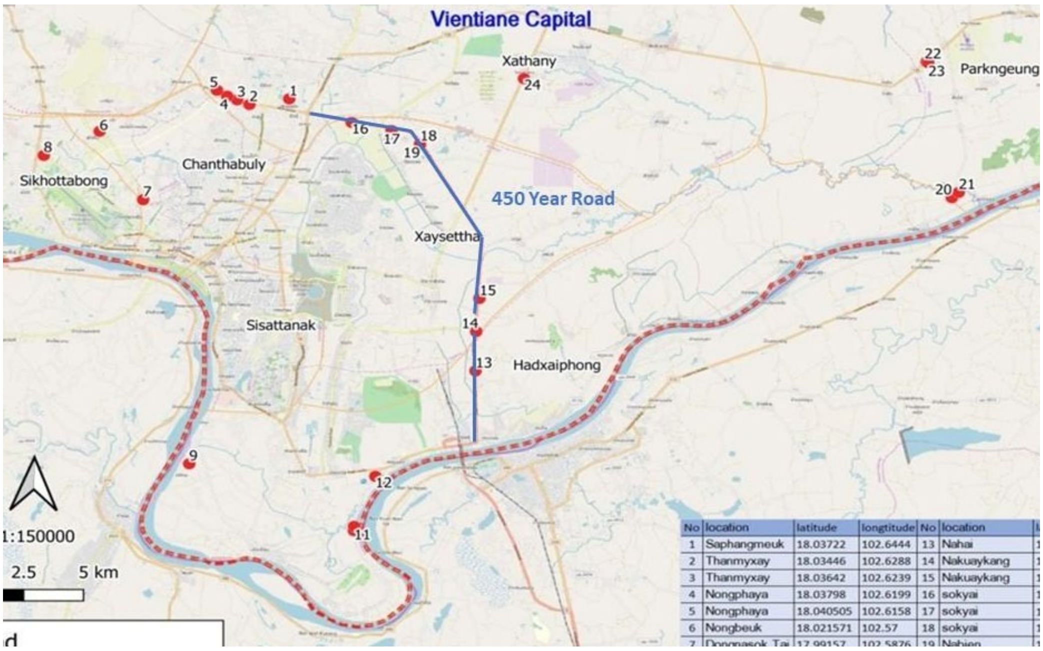



**Figure 5.11.** Plastic leakage hotspots surrounding Vientiane, Lao PDR

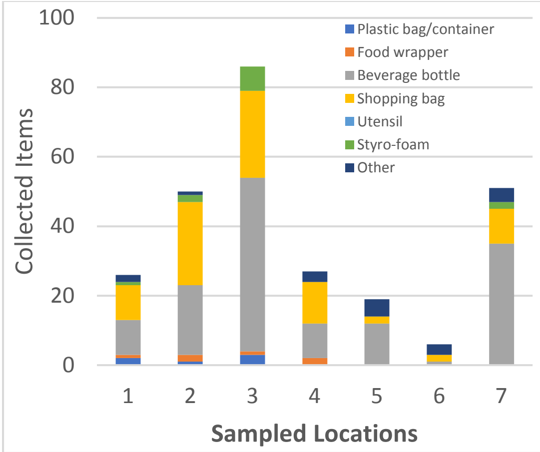
*Source*: Chansomphou (2020)

**d. Plastic accumulation hotspots (artificial barriers)**

| | |
|---|---|
| **Location** | Vientiane |
| **Duration** | 26 February – 16 March 2020 |
| **Samples dried?** | No |
| **Classification type** | Quantity |
| **Collection method** | Not described |

A total 265 pieces of plastic debris was collected from the artificial barriers around Vientiane by **Chansomphou (2020)**. **This plastic debris was classified by quantity and type; a large amount was identified to be beverage bottles (Figure 5.12b). The survey team noted that most wastes are plastic beverage bottles and plastic shopping bags, which are common products and containers** used by local people in their daily consumption.

(a)




(b)

**Figure 5.12.** (a) Plastic accumulation hotspots surrounding Vientiane, Lao PDR, and (b) results of plastic collection at these accumulation hotspots (Chansomphou, 2020)

### 5.1.3 Area 3/5: Ubon Ratchatani (Thailand)

**a. Riverine macroplastics**

| | |
|---|---|
| **Location** | Ubon Ratchatani |
| **Duration** | 7 days for each location in January–February 2020 |
| **Samples dried?** | Yes |
| **Classification type** | Material, quantity |
| **Collection method** | Net (W:7 m, D:1.5 m, L:6 m) from boat |

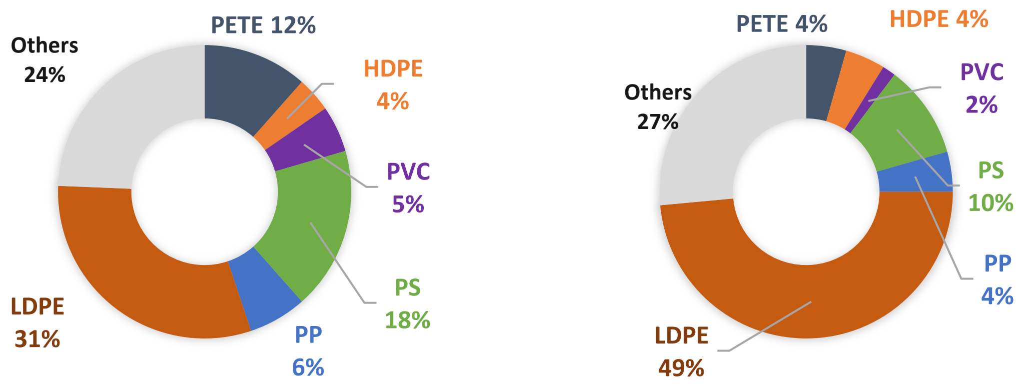
**Limpiteeprakan (2020) targeted two sites in Ubon Rachatani, i.e. Khong Chiam District and Phosai District. In addition to studying the composition of riverine plastic debris, the study team found that some of plastic is old and some very new. Based on the types of plastic, the team assumed that their sources were both from land and water activities.**

**The study pointed out the following difficulties faced in carrying out the study:**

- Nets can be installed only in certain parts of the river such as the shallow part and the place near to the shore.
- In January and February, there is a great deal of freshwater seaweed in the river which get stuck in the net.
- Not many **waste leakages** were collected by the net.


| District | Amount of collected debris in 7 days |
|---|---|
| Khong Chiam | 81 pieces / 1214.2g |
| Phosai | 61 pieces / 443.92g |

(a) (b)




(c) (d)

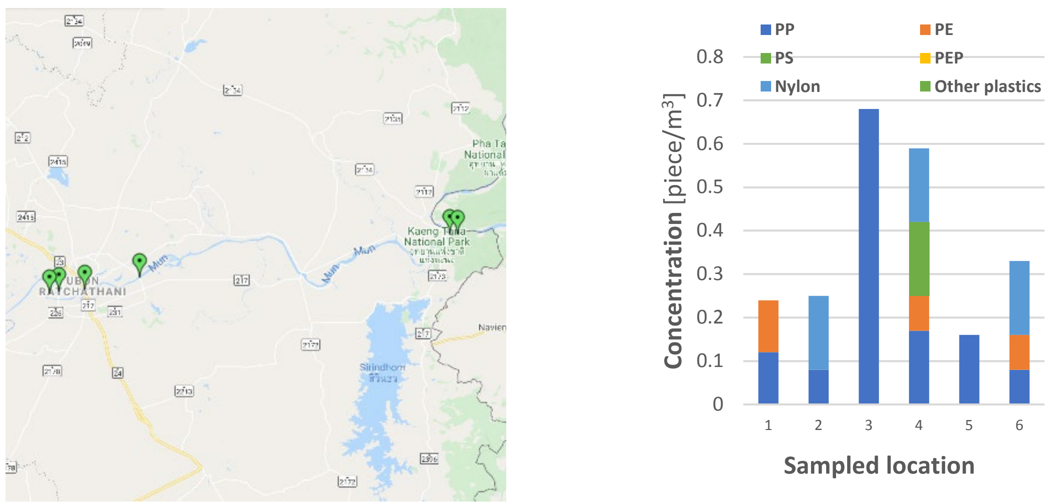
**Figure 5.13.** Riverine Macroplastic Survey at Khong Chiam and Phosai, Ubon Rachatani Province of Thailand showing (a) sampling locations, (b) amounts of plastic debris collected, (c) types and proportion of plastic debris collected at Khong Chiam, and (d) types and proportion of plastic debris collected at Phosai

*Source*: Limpiteeprakan (2020)

## b. Riverine microplastic

| | |
|---|---|
| **Location** | Ubon Ratchatani |
| **Duration** | January – March 2020 |
| **Samples dried?** | Not described |
| **Classification type** | Material, quantity |
| **Collection method** | Albatross Mark V lite |

Ubon Ratchatani, located in the third most upstream of five surveyed areas, had the third smallest average microplastic concentration **(Pirika, 2020)**. PP was seen in all the six sampled locations, with PE, nylon, and PS observed in some locations: the highest concentration recorded was 0.68 $m^3$, and the lowest was 0.16 $m^3$ (Figure 5.14).




(a) (b)

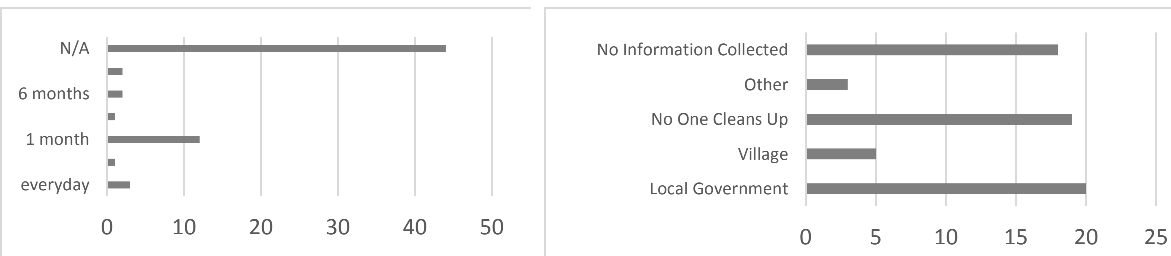
**Figure 5.14.** Riverine microplastic survey in Ubon Ratchatani, Thailand showing (a) the survey locations and (b) microplastic debris classification by quantity and concentration

*Source:* Pirika (2020)

**c. Plastic leakage hotspots (illegal dumpsites)**

| | |
|---|---|
| **Location** | Ubon Ratchatani |
| **Duration** | February–March 2020 |
| **Samples dried?** | No |
| **Classification type** | - |
| **Collection method** | GIC mobile app |

According to **Limpiteeprakan (2020)**, there were 65 illegal dumpsites pointed out in Ubon Ratchatani, of which, 62 were unsanitary disposal sites that belonged to the local municipality, and three were not included in the list provided by the Ministry of Interior; i.e. they were not under any supervision. **The frequency** of **and** bodies **responsible** for the cleaning activities at these sites are shown in Figure 5.15, which further emphasizes the lack of supervision or appropriate management.




(a) (b)

**Figure 5.15.** A summary of (a) plastic leakage hotspots' clean-up frequency and (b) responsible agency

*Source:* Limpiteeprakan (2020)

**d. Plastic accumulation hotspots (artificial barriers)**

**Not conducted**

### 5.1.4 Area 4/5: Phnom Penh (Cambodia)

**a. Riverine microplastic**

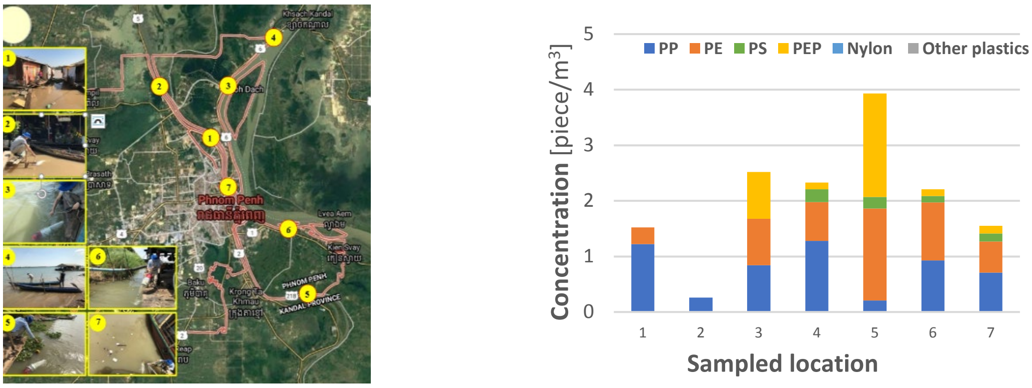
**Not conducted**

**b. Riverine microplastic**

| | |
|---|---|
| **Location** | Phnom Penh |
| **Duration** | January–March 2020 |
| **Samples dried?** | Not described |

| | |
|---|---|
| **Classification type** | Material, quantity |
| **Collection method** | Albatross Mark V lite |

Phnom Penh, located in the second **least upstream** section of the five surveyed areas, had the third smallest average microplastic concentration **(Pirika, 2020)**. PP was seen in all of the six sampled locations, with PE, nylon, PS appearing in some locations. The highest concentration recorded was 0.68 $m^3$, and the lowest was 0.16 $m^3$ (Figure 5.16).




(a) (b)

**Figure 5.16.** The riverine microplastic survey in Phnom Penh showing (a) the survey location and (b) the results of the survey as classified by type and concentration

*Source:* Pirika (2020)

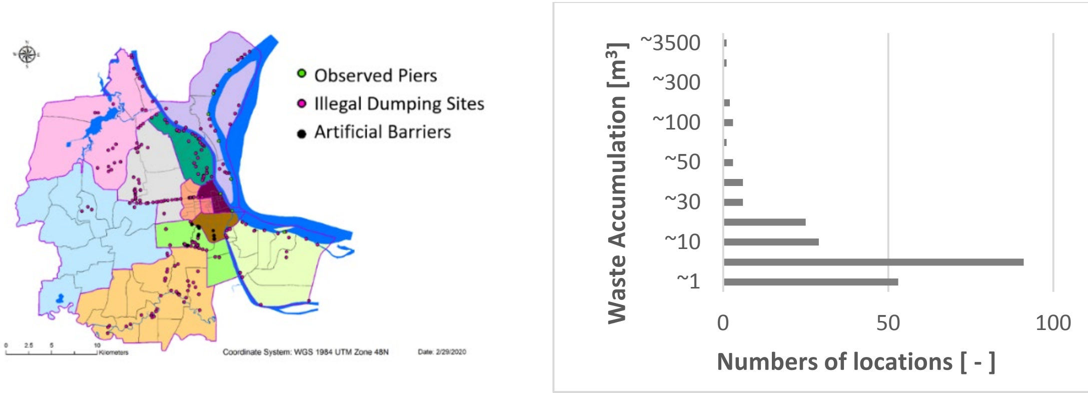
## c. Plastic leakage hotspots (illegal dumpsites)

| | |
|---|---|
| Location | Phnom Penh |
| Duration | 20–23 February 2020 |
| Samples dried? | No |
| Classification type | Volume |
| Collection method | GIC mobile app |

**The study by NPS/EXRI Asia (2020) reported that Phnom Penh has no recycling, transfer station or sanitary landfill, and its only municipal solid waste disposal site (Dangkor Landfill) was not managed properly.**

**The survey team has found 221 illegal dumping sites through a series of visual inspections in Phnom Penh, as shown in the Figure 5.29, as well as piers and artificial barriers with waste accumulation. The study team pointed out that low accessibility to services may have caused the frequent illegal dumping in the sub-urban areas where the waste collection trucks collect the discharged garbage door-to door.**

**The waste volume in each illegal dumping site ranged from 0.08 to 3,500 $m^3$, as shown in Figure 5.28. Although there were some locations with vast amounts of waste, amounts in almost 90% of the locations were below 20 $m^3$ (Figure 5.17).**




**(a)** **(b)**

**Figure 5.17.** (a) Plastic leakage hotspot in Phnom Penh and (b) their plastic waste accumulation

*Source:* NPS/EXRI Asia (2020)

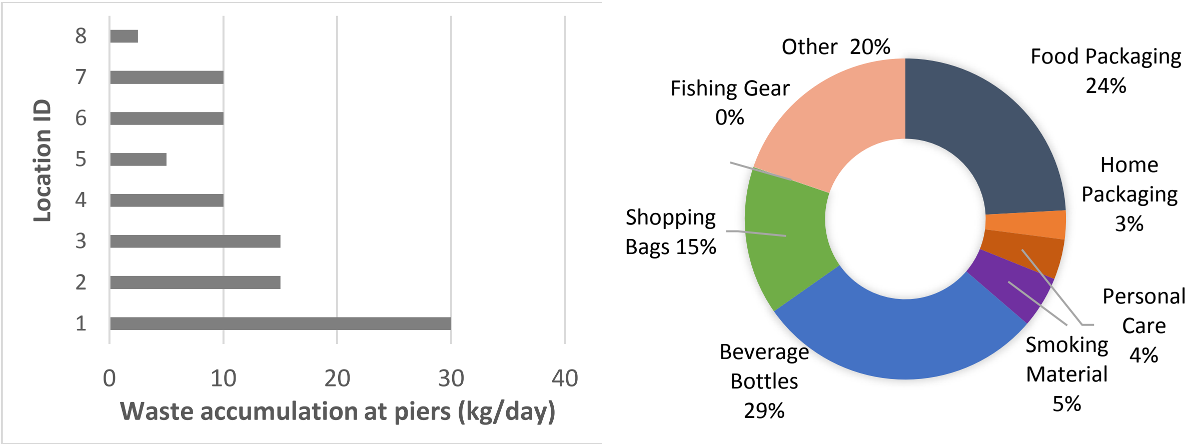
**d. Plastic accumulation hotspots (artificial barriers)**

| | |
|---|---|
| Location | Phnom Penh |
| Duration | 20–23 February 2020 |
| Samples dried? | No |
| Classification by | Quantity |
| Collection method | 20 plastic litter bag method |

**In the survey by NPS/EXRI Asia (2020), accumulations of mismanaged waste were seen at 18 artificial barriers in total, most of which was plastic bags, PET, Styrofoam, plastic bottle.**

**The quantity of accumulated waste along the artificial barriers was estimated at a total of 96,600 litres. Daily waste accumulation at the piers, which was obtained through interviews with pier staff, amounted to 97.5 kg/day in just eight piers (Figure 5.18a).**

**The survey team found four locations filled up by especially large amounts of garbage, where each estimated amount of garbage is 4,000, 10,000, 32,000 and 40,000 litres. Detailed locations are shown in Figure 5.18b.**




(a) (b)

**Figure 5.18.** Survey results of (a) plastic accumulation at piers and (b) the types and proportion of accumulated plastic wastes

*Source*: NPS/EXRI Asia (2020)

### 5.1.5 Area 5/5: Can Tho (Viet Nam)

**a. Riverine microplastic**

| | |
|---|---|
| Location | Can Tho |
| Duration | 8 h/day, 7 days in March–April 2020 |
| Samples dried? | Yes |
| Classification type | Quantity, weight (sum) |
| Collection method | Net installation (W:8 m, L:7 m), ESRI survey 123 |

**Since the data collected were only for the dry season, this does not represent data for the entire year (Minh, 2020). Therefore, obtaining data from the rainy season would be necessary for a more accurate estimation of the amount of littering in Can Tho City in the Mekong Delta, Viet Nam.**

**Furthermore, more durable and sturdy equipment may be needed to collect data in Can Tho City along the Mekong River; however, it may be costly to build this equipment.**

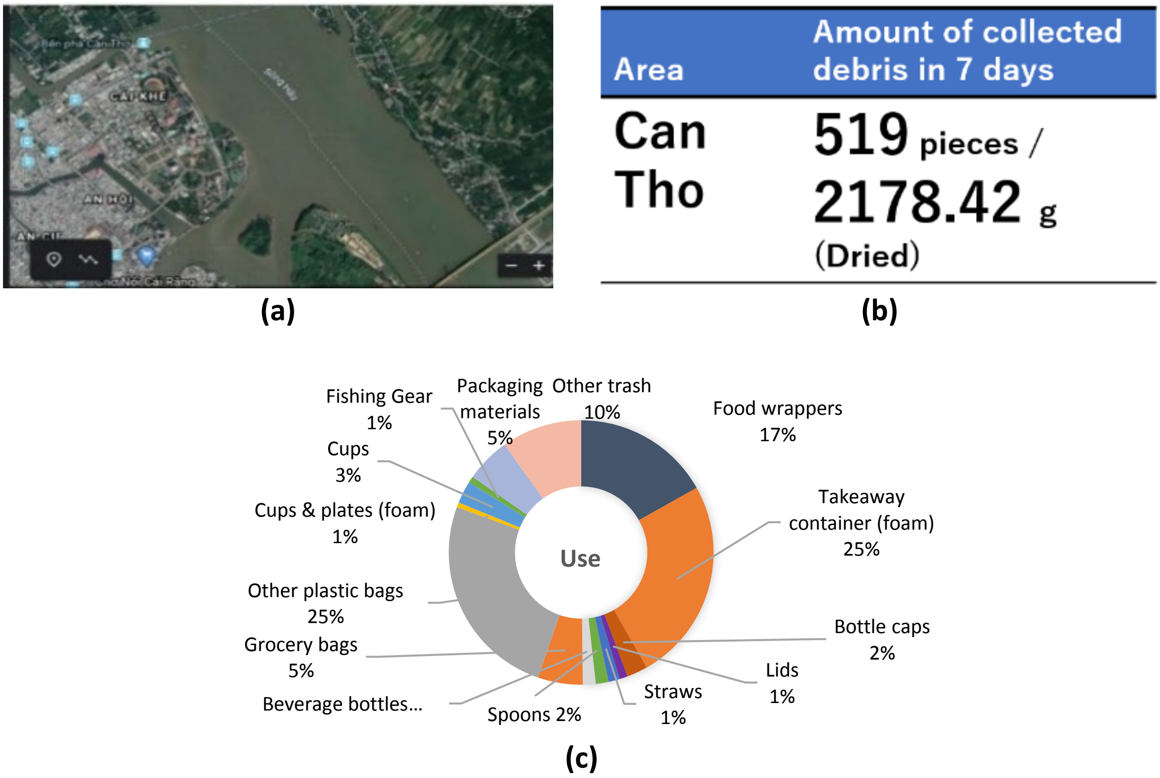


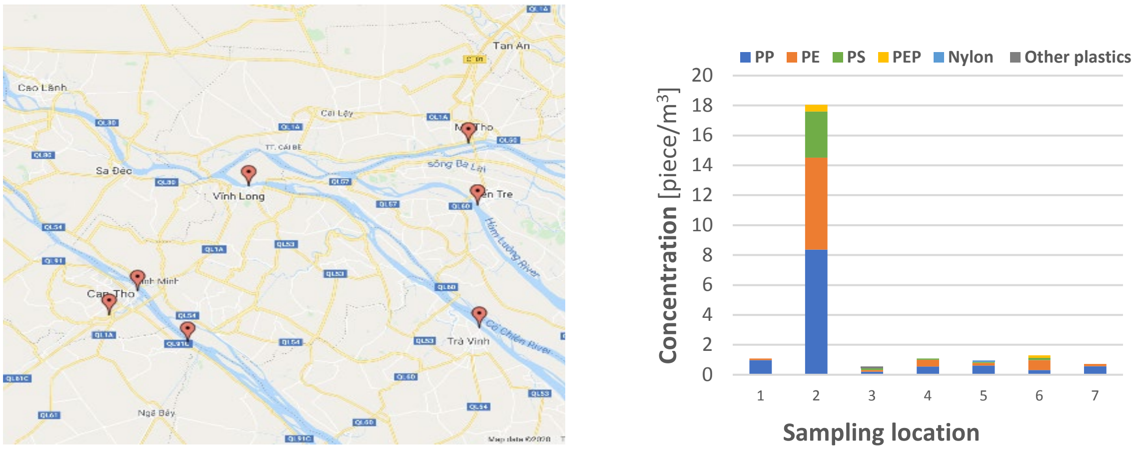

**Figure 5.19.** The Riverine Macroplastic Survey at Can Tho showing (a) the location of the survey, (b) the total amount of plastic debris collected, and (c) the types and proportion of plastic debris collected

*Source:* Minh (2020)

## b. Riverine microplastics

| | |
|---|---|
| **Location** | Can Tho |
| **Duration** | January–March 2020 |
| **Samples dried?** | Not described |
| **Classification type** | Material, quantity |
| **Collection method** | Albatross Mark V lite |

The amount of plastic particles in Can Tho is larger than in all other survey locations, i.e. Phnom Penh, Vientiane, Chiang Rai, and Ubon Ratchathani **(Pirika, 2020)**. Also, components of samples have a wider variety compared with other survey locations. In Table 5.11, it can be observed that location No. 2 has a significantly higher number of samples than at other locations, and therefore, only 60 pieces were analysed to calculate the overall figures.




**(a)** **(b)**

**Figure 5.20.** Riverine microplastic survey (a) locations and (b) their results as classified by concentration and plastic types

*Source:* Pirika (2020)

### c. Plastic leakage hotspots (illegal dumpsites)

| | |
|---|---|
| **Location** | Can Tho |
| **Duration** | Not described |
| **Are samples dried?** | No |
| **Classification type** | Volume |
| **Collection method** | Measuring dimensions |

Results of a survey at illegal dumps in Can Tho City by **Minh (2020)** are presented in **Figure 5.21.** There were eight illegal dumpsites detected during the time of the **survey**. The volume of **wastes** at illegal dumps ranged from 1.65 $m^3$ to 7.70 $m^3$, on average of 4.37 $m^3$. It can be observed that the major dumps were located in the central areas of the city, especially near residential zones such as Hung Phu, Tam Vu.

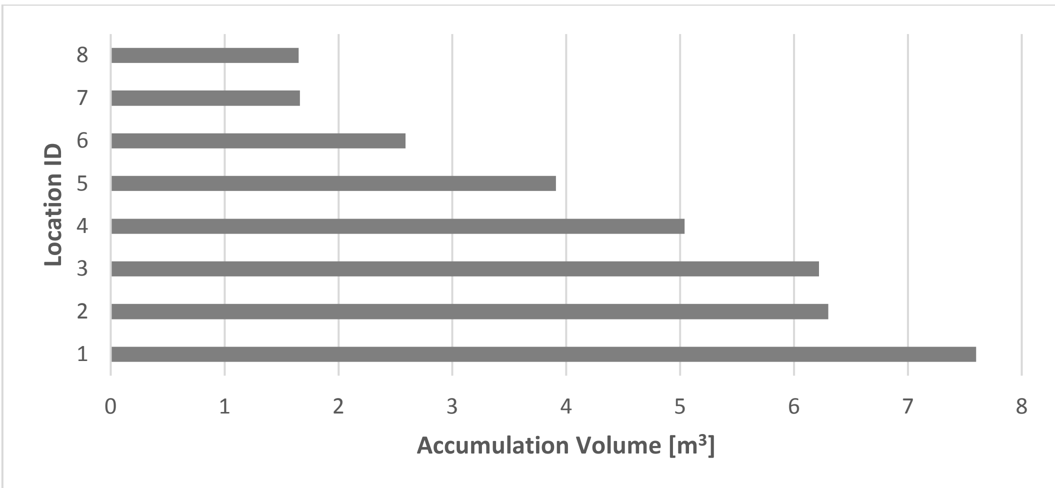



**Figure 5.21.** Volume of plastic waste accumulated at plastic leakage hotspots or illegal dumpsite in Can Tho, Viet Nam

*Source*: Minh (2020)

**d. Plastic accumulation hotspots (artificial barriers)**

| | |
|---|---|
| **Location** | Can Tho |
| **Duration** | Not described |
| **Samples dried?** | No |
| **Classification type** | Quantity, use |
| **Collection method** | Collecting in 20 plastic litter bags |

Survey results of plastic wastes at the Xang Thoi barrier and Xuan Khanh barriers showed **that in both sites, the highest proportion of waste was foam** (Minh, 2020). There were around 1.5 times more pieces collected on the Xuan Khanh barrier than that on the Xang Thoi barrier. At both barriers, foam dominated all plastic wastes collected during the survey, representing 39% and 53% of all plastic collected at Xang Thoi and Xuan Khanh, respectively **(Figure 5.22**a and b). At Xuan Khanh Barrier, grocery bags were be the second most accumulated plastic type, at 17% (**Figure 5.22**b). At Xang Thoi barrier **(Figure 5.22a),** plastic beverage bottles were the second most accumulated plastic type (21%), followed by other plastic bags (19%) and grocery plastic bags (15%). The Xang Thoi barrier is located at the gate of an artificial lake, which is a place of relaxation.. Plastic waste **could originate from** the illegal dumping of waste by **people living nearby**. Also, the Xuan Khanh barrier is located near an open market. Therefore, most plastic wastes could come from commercial activities in the market.

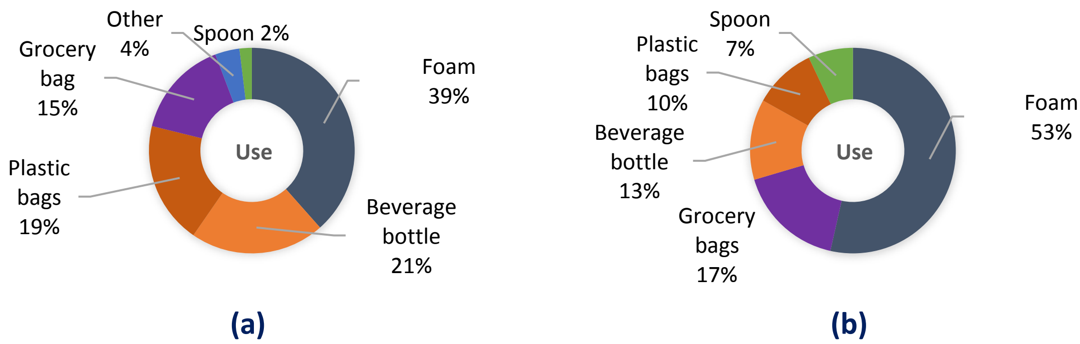



**Figure 5.22.** Type of plastic and their proportion accumulated at (a) Xang Thoi Barrier and (b) Xuan Khanh Barrier

*Source:* Minh (2020)

## 5.2. Riverine monitoring results outside the LMB

Outside of the LMB, there are several reports on marine plastic debris that focus on items collected from the beach, river mouth, estuary, and open se, as shown in **Table 5.4**. Just as in the LMB, there is a very limited number of monitoring activities conducted and reported of riverine plastic debris , and almost all the activities are not carried out regularly. However, sharing resources such as knowledge, equipment, and expertise among the area will surely accelerate the riverine monitoring system in the LMB.

**Table 5.4.** Riverine monitoring results outside of the LMB

| Project name | Organization | Location | Method | Volume: Tonnes | Volume: No. of pieces | Description |
|---|---|---|---|---|---|---|
| **Cambodia** | | | | | | |
| | | | | | | |
| **Lao PDR: N/A** | | | | | | |
| **Thailand** | | | | | | |
| Monitoring of macroplastics in a one-year period from March 2017 to March 2018 | Department of Marine and Coastal Resources (DMCR) | In 5 rivers: Bang Pakong, Chao Phraya, Tha Chin, Mae Klong and Bang Taboon Rivers | Floating oil booms with underwater nets | 2,172 | 98,822,270 (plastic bags) | - The highest volume was captured from Chao Phraya River, with a weight of 1,425 tonnes.<br>- Plastic bags were the most prevalent type of garbage; there were 98,822,270 plastic bags collected from traps over this period. |
| Collected marine debris in 2019 | DMCR | Beaches, coral areas, mangrove areas and river mouths | Collected 185 times | 101.88 | 1,398,329 | The most prevalent type of garbage found was plastic bottles (16%), bags (13%), and plastic packaging (9%). |
| Survey on type and amount of floating garbage entering the Gulf of Thailand and out of Songkla Lake | DMCR | At 5 river mouths and 4 stations at Songkla Lake | Based on the International Coastal Cleanup | 2.879 (kg/day) to the Gulf of Thailand 11.87 (kg/day) out of Songkla Lake | 245,755 (pieces/day) to the Gulf of Thailand 43,970 (pieces/day) collected from Songkla Lake | Garbage comes from recreational activities (90.8%), Fishing and marine transport (6.5%), medical activities (1.7%) and others. |
| Microplastic samples collected twice in 2019 during dry and rainy seasons | DMCR | 21 beaches | FTIR was used at a wavelength of 600–4,000 $cm^{-1}$ | N/A | N/A | - Microplastic density in sand sediment ranged from 19 to 2,102 pieces/$m^2$ in the dry season and 0 to 1,052 pieces/$m^2$ in the rainy season.<br>- Major types of plastic found are PE, PET, PS, and PP. |

| Project name | Organization | Location | Method | Volume | | Description |
|---|---|---|---|---|---|---|
| | | | | Tonnes | No. of pieces | |
| Total 1,235 clean-ups in 2019 | Trash Hero Thailand | From canals, rivers, beaches and open seas | | 280 | N/A | |
| Clean-up collection | The Ocean Conservancy | N/A | - International Coastal Clean-up<br>- Collection by volunteers | 10.4 | 191,916 | The types and amount of garbage found are 31,408 plastic bottles, 10,391 food wrappers, 7,750 plastic bags, 6,316 plastic caps, 5,886 food take-out containers, 5,543 straws, 2,211 plastic cups and plates, 1,433 cigarette butts, 627 cup lids, and 32,030 other items. |
| **Viet Nam** | | | | | | |
| Marine debris survey and clean-up events in June 2016 and January 2017 | N/A | Ha Long Bay | N/A | 1.57 (along 2.2 km of coast line) | N/A | - 220 volunteers and stakeholders participating, including local governments, distinguished guests (US Embassy in Viet Nam, USAID), Ha Long Bay Management Board, the Youth Union, and the mass media;<br>- The most common marine litter items collected during coastal clean-up events were: polystyrene (45.30%), plastic grocery bags (17.78%), plastic beverage bottles (9.40%), rubber sandals and shoes (2.96%), plastic bottle caps (2.03%), and others (22.53%). |
| International coastal clean-up | Coco-Cola, Dow Viet Nam, Amcham Viet Nam and Keep Viet Nam Clean and Green in collaboration with Vung Tau's local committee and Ba Ria – Vung Tau university | Vung Tau City | N/A | 2.398 along 10.3 km of the coast | 17,002 along 10.3 km of the coast | - 869 participants |

| Project name | Organization | Location | Method | Volume | | Description |
|---|---|---|---|---|---|---|
| | | | | Tonnes | No. of pieces | |
| Beach monitoring activities | IUCN in partnership with GreenHub | In 132 transects (11 locations) including Bai Tu Long, Cat Ba, Bach Long Vi, Con Co, Cu Lao Cham, Ly Son, Hon Cau, Nui Chua, Nha Trang, Phu Quoc and Con Dao | N/A | N/A | N/A | - Forty-four debris categories were collected from beaches. Plastic items were the most numerous debris (92% of the total number; 61% in weight): styrofoam (31.37%), fishing nets or ropes (15.49%), containers/foam (8.28%), plastic bags (6.93%) and beverage bottles (3.51%) |
| Study on macro and micro-plastic | (Lahens et al., 2018) | In the Saigon River | Sampling bulk water for anthropogenic fibre analysis and 300-mm mesh size plankton net exposition for fragment analysis | N/A | N/A | - The analysis of floating debris collected daily on the Nhieu Loc Thi Nghe canal by the municipal waste management service shows that the plastic mass percentage was 11% to43%, and the land-based plastic debris entering the river was estimated at 0.96–19.91 g/inhabitant/d, namely 350 g to 7,270 g/inhabitant/yr.<br>- The macroplastics and fragments mainly consisted of polyethylene and polypropylene, while the anthropogenic fibres mainly consisted of polyester. |

*Sources:* (DMCR, 2013; GISTDA, 2019; IUCN, 2020; Lahens et al., 2018; Ocean Conservancy, 2019; Sunwook, 2017; Trash Hero, 2020; UNEP, 2020f)

### 5.3. Clean-up and collection activities in the LMB

Table 5.5 shows the clean-up and collection activities conducted in the LMB. Some of the cleaning activities are included in Sections 5.1 and 5.2 (*Monitoring activities and results in and outside the LMB*), because they include the information of collected debris. In spite of the large number of the plastic waste leakage/accumulation hotspots and the vast amount of unmanaged debris identified by CounterMEASURE II, there are no regular cleaning activities specifically focused on the LMB region.

Since cleaning up debris requires the allocation of human resources and financial resources, an efficient collection system that can minimize the required effort of collection and scientific evidence that supports policymaking are urgently needed.

**Table 5.5.** Summary of riverine plastic debris collection activities in the LMB

| Type of Activity | Method | Organization | Location | Duration | Volume | Composition | Analysis | Disposal | Reporting |
|---|---|---|---|---|---|---|---|---|---|
| **Cambodia** | | | | | | | | | |
| World and National Environment Day | Awareness campaign | MOE, its line departments, relevant ministries, local authority | Random throughout Cambodia | One-day event | No recorded | N/A | No | At dumpsites | No |
| National clean-up day (5 June) | Awareness campaign | MOE, its line departments, relevant ministries, and local authorities | Random throughout Cambodia | One- day event | No recorded | N/A | No | At dumpsites | No |
| Recyclable plastic collection at the referral hospital | Setup collection bins for plastic bottles | Referral hospitals | Mostly surrounding Tonle Sap's provinces | Daily | No recorded | N/A | No | Sale to scavengers/informal waste collector | No |
| **Lao PDR** | | | | | | | | | |
| Regularly clean-up | Manual collection | District Agriculture and Forestry Office (DAFO) | Water gates and irrigation canal | Every 3 months | N/A | Reported | N/A | Disposed at landfill | Not exist |
| **Thailand** | | | | | | | | | |
| Regular clean-up | Automatic screen | Department of Drainage and Sewerage, Bangkok Metropolitan Administrative | 170 out of 300 pump stations | Daily | Recorded | Not recorded | No | At dumpsite | Yes |
| **Viet Nam** | | | | | | | | | |
| Campaign "Clean up the Mekong River" | 2 solar-powered garbage collectors (ships) | Hanwha Group (Republic of Korea) in collaboration with the Viet Nam Environment | In Vinh Long | 2019 | N/A | N/A | N/A | N/A | N/A |

| Type of Activity | Method | Organization | Location | Duration | Volume | Composition | Analysis | Disposal | Reporting |
|---|---|---|---|---|---|---|---|---|---|
| | | Administration and the Global Green Growth Institute (GGGI) of Viet Nam. | | | | | | | |
| Regular collection | The Interceptor with autonomous in 24 hours a day, 7 days a week | The Ocean Clean-up (NGO) | Can Tho City | 2019 | 50,000 kg of trash per day | N/A | N/A | N/A | N/A |

## 5.4. Solid waste management at 12 ports in four Member Countries

As part of this study, a survey was carried out on SWM at ports and piers in MCs. Three ports were selected from each country. The amount of waste generated at each port, the amount of waste that drifted to its shore, and the amount of the waste accumulated at the port were surveyed. Moreover, the method and system of managing both solid waste and accumulated/drifted debris were also surveyed. The map shows the 12 locations selected for the survey, and IDs are given from the most upstream toward the downstream (Figure 5.23).

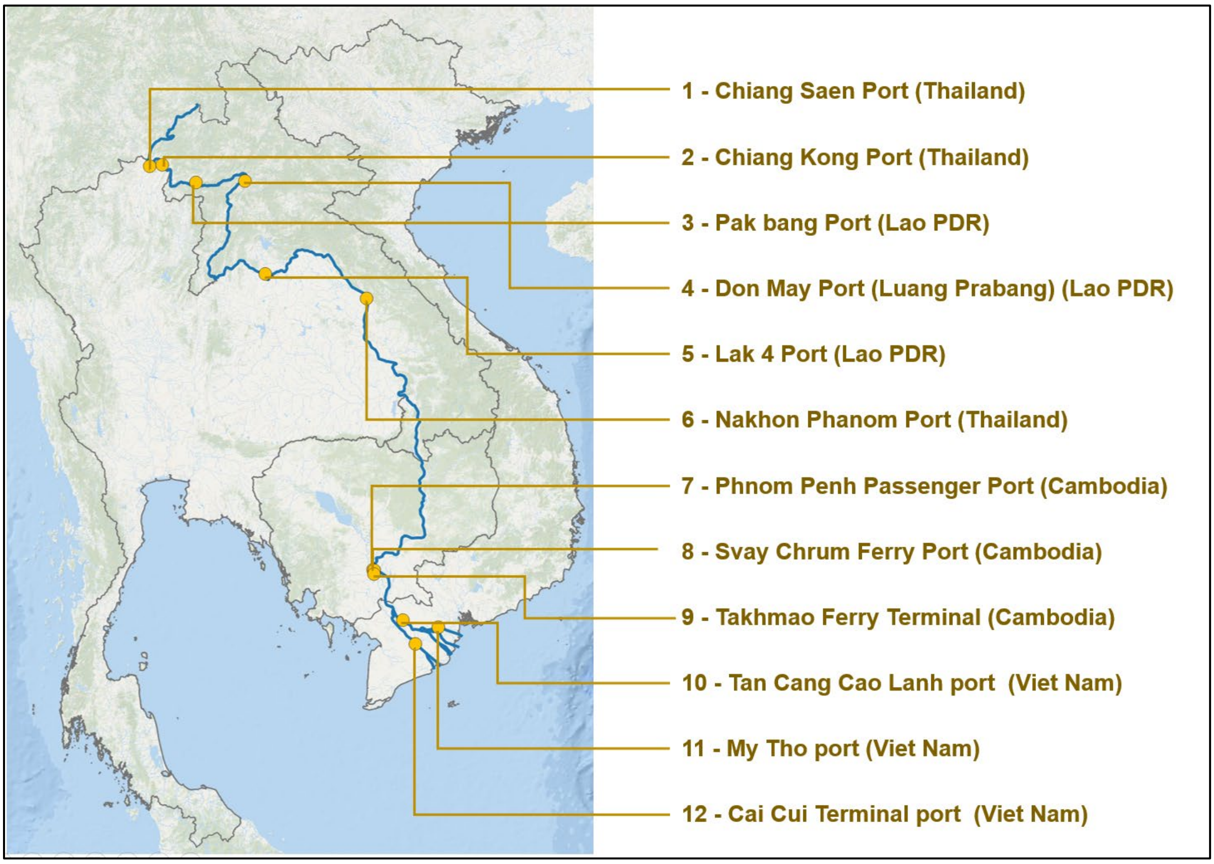



**Figure 5.23.** A map of 12 surveyed ports/piers

Interviewed results were then integrated using the conversion factor to calculate the weight of plastic waste from volume (or the other way around), which is 0.35 t/m$^3$. This value is used in managing industrial waste in Japan (The Japan Industrial Waste Information Center, 2013). In Japan, the category of 'plastic waste' in industrial waste includes waste plastic containers and packaging, styrofoam, urethane foam, polystyrene foam, PVC construction materials, waste tires, plastic bumpers for automobiles, and waste agricultural plastic. The weight of plastic waste per unit volume, on the whole, is 0.35 t/m$^3$. Similarly, in this report, 0.35 t/m$^3$ is used to convert the volume of overall plastic waste into weight given that the recorded volume of plastic waste is the mixture of various kinds of goods. Some of the units are also modified from the daily/weekly amounts into the monthly amount assuming that 1 month equals 4 weeks or 30 days. Three figures below show the amounts of waste generation, riverine debris flowing from the upstream, and current waste accumulation at each port, each of which is defined in this report as follows:

- **Waste generation at port [kg/month]**: The total amount of general/plastic waste that is generated from activities at each port. In the questionnaire (Annex 3), the total amount of waste is indicated in "6.2 *Daily amount of wastes generated* (t/d)" The amount of plastic waste is indicated in "6.2 *Waste composition or type of waste*" (Annex 3).
- **Spatial accumulation from upstream [kg/month]:** The amount of debris that is transported by the river from upstream. The total amount is cited from "7.1 Amount of (total) waste accumulation (per day, week, or year)" (Annex 3). Amount of plastic debris is indicated in "7.2 *Proportion of plastic waste accumulated*" (Annex 3).
- **Accumulated plastic waste at port [kg]:** The amount of waste and debris that currently remain accumulated and uncleaned. It is indicated in "8.2 *Estimate total amount of accumulated wastes*" and "8.3 *Estimate total amount of accumulated plastic wastes*" (Annex 3).

(1) **Waste generation at port [kg/month]**: The amount of waste generation did not depend solely on the purpose of the port. The largest amount occurs at Port 8: Svay Chrum Ferry Port (Cambodia), with an average of 7,920 kg of waste generated per month; however, the ratio of plastic could not be estimated because several organizations are engaged in waste collection and information is not shared among them. The main source of waste is generated from passengers of 11 ferries. Chiang Saen Port in Thailand was found to generate the second most waste with an average of 3,210 kg/month, including 1,350 kg of plastic. The port is mainly used for trade with the main source of waste coming from offices.

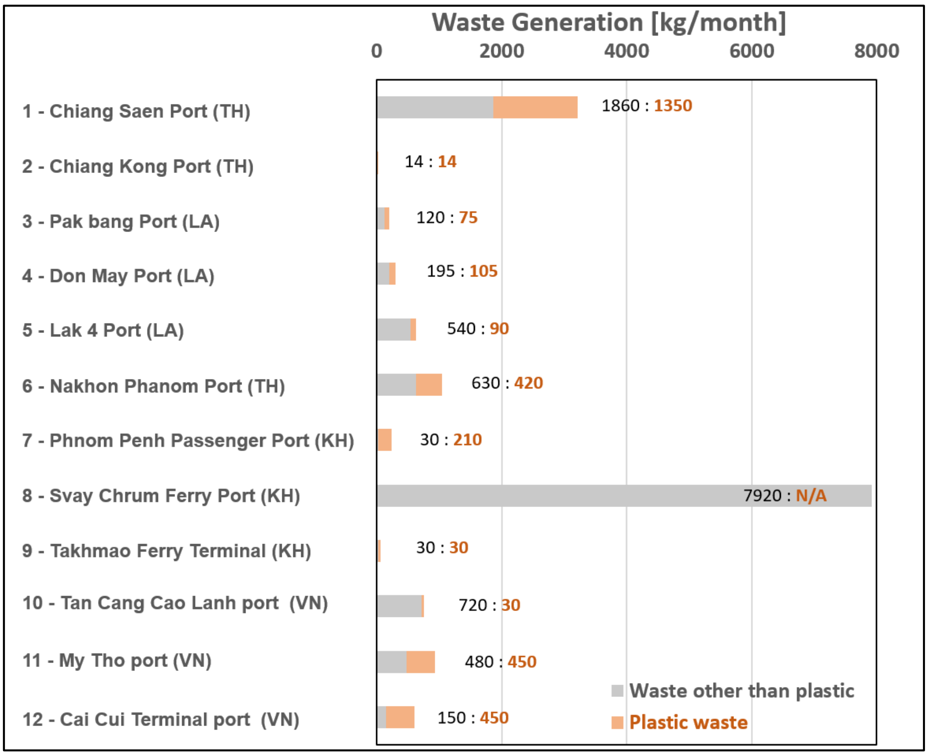


**Figure 5.24.** Generation of plastic and other waste in 12 surveyed ports

(2) **Spatial accumulation of riverine debris [kg/month]:** The monthly amount of debris flowing from upstream did not show an increasing trend towards downstream, showing large difference even within the country in the total debris both plastic and non-plastic. For example, at Port 1: Chiang Saen Port (Thailand), the monthly amount of overall drifted debris is 0 kg since its structure does not allow any debris accumulation, as observed in the interview survey. However, at Port 2: Chiang Kong Port (Thailand) located just down the Port 1, experiences the largest amount of debris accumulation among all the surveyed port, which is 150 kg/month in total, of which 75 kg is plastic. Similarly, Port 9: Takhmao Ferry Terminal (Cambodia) also receives 150 kg/month of riverine debris, of which 45 kg is plastic. Debris is then cleaned regularly in Takhmao Ferry Terminal, while no accumulation is observed the three ports located downstream.

From these observations, there is an obvious difference in the locations where debris gets accumulated similar to the concentration of riverine plastic debris, as mentioned in the previous chapter. The amount of the riverine plastic debris that a port receives in a unit time can be affected by a number of factors such as the structure of port and the frequency of cleaning activity in the upstream.

The ratio of plastic debris to the overall amount was highest in Port 1: Chiang Saen Port. In the other ports where spatial accumulation was observed, the ratio varied from 10% to 30%. The most common plastic item was plastic bags, observed in five ports, followed by bottles, which were observed in four ports.

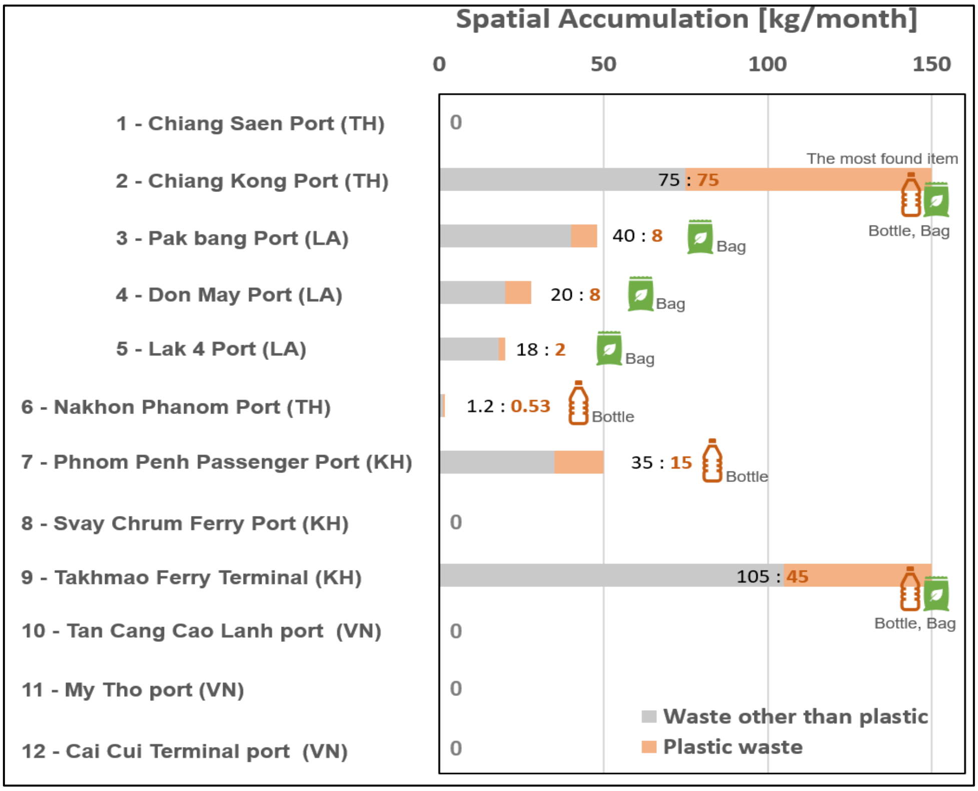



**Figure 5.25.** Spatial accumulation of riverine debris in 12 surveyed ports

| | 1st | 2nd | 3rd |
|---|---|---|---|
| **1** | (Not observed) | | |
| **2** | Bag, Bottle | | |
| **3** | Bag | Bottle | Foam container |
| **4** | Bag | Bottle | Container |
| **5** | Bag | | |
| **6** | Bottle (90%) | Bag (10%) | |
| **7** | Bottle (40%) | Bag, Container (30%) | |
| **8** | (Not observed) | | |
| **9** | Bag, Bottle (40%) | Container (20%) | |
| **10** | (Not observed) | | |
| **11** | (Not observed) | | |
| **12** | (Not observed) | | |

**Figure 5.26.** Popular plastic items that drift to the 12 surveyed ports

(3) **Accumulated plastic waste at ports [kg]:** The overall amount of debris accumulation at each port/piers showed an increase from upstream to downstream, unlike the debris flow. Given that the concentration and destination of riverine debris varies from place to place, it can be suggested that this difference results from the frequency and scale of clean-up activities. For example, three ports in Viet Nam, Tan Cang Cao Lanh Port, My Tho Port, and Cai Cui Port where no clean-up activities are conducted have the largest debris accumulation among 12 ports, which is 840 kg, 910 kg, and 4,900 kg respectively, including both plastic and non-plastic. In contrast, Port 4: Don May Port (Lao PDR) and Port 9: Takhmao Ferry Terminal (Cambodia). with regular clean-up activities 12 times/month and 30 times/month, accumulates relatively small amount of debris (5 kg and 40 kg, respectively), including both plastic and non-plastic, despite the large amount flowing from the upstream.

In the accumulated debris, the ratio of plastic waste to the overall accumulation was above 70% in seven surveyed ports, Port 1: Chiang Saen Port 100%, Port 2: Chiang Kong

Port 100%, Port 6: Nakhon Phanom Port 100%, Port 7: Phnom Penh Passenger Port 100%, Port 10: Tan Cang Cao Lanh port 70%, Port 11: My Tho Port 70%, and Port 12: Cai Cui Port 90%.


**Figure 5.27.** The amount of accumulated debris (plastic and non-plastic) in 12 surveyed ports

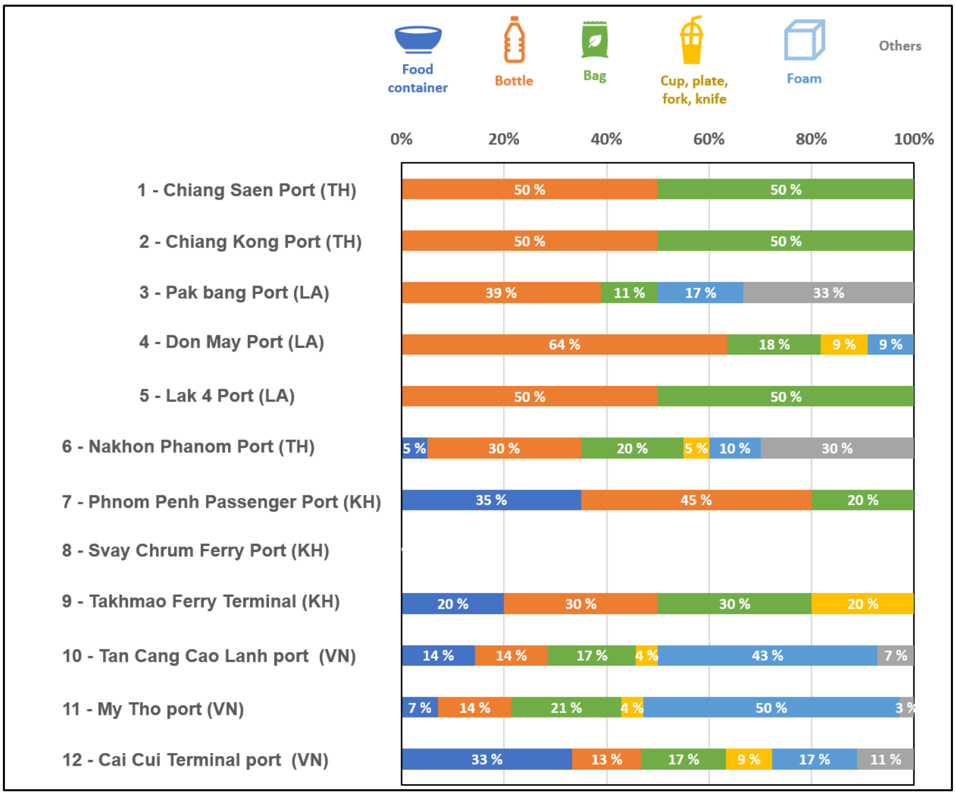



**Figure 5.28.** The composition of accumulated plastic debris

**(4) The relationship between waste generation, spatial accumulation, and accumulated debris:**

There was a significant difference in amount of waste generation, spatial distribution, and debris accumulation among the surveyed locations; however, comparing them provides an interesting perspective. For example, Port 2: Chiang Kong Port (Thailand) generates the smallest amount of waste while receiving the highest amount of riverine debris from upstream; therefore, its monthly accumulation exceeding its solid waste generation. This unbalanced source of waste is also seen at Port 9: Takhmao Ferry Terminal (Cambodia), which is located directly downstream of Phnom Penh City. Because of the transboundary movements of riverine debris, it is highly possible that some locations bear the burden of managing waste from other areas in terms of both financial and human resources. This is but one of the biggest problems of riverine plastic debris; there is an unclear allocation of responsibilities due to the transboundary movements, which underlines the increased importance of clarifying the path of riverine debris movements. While the ratio of plastic waste in accumulated debris was above 70% in 7 out of 11 ports, it was only 50% in 1 port, and ranged between 10% and 30% in the other ports. This suggests that the plastic debris that drifts to the port can remain in the environment longer than other items due to its persistent structure, compared to other items such as organic matter that is decomposed by the microorganisms in the riverbank. Bags and bottles were the most prevalent in spatial accumulation. Similarly, of the accumulated debris, bottles accounted for the largest part in 8 ports, bags accounted for the largest in 4 ports among the reported items, together making up more than 50% in 8 locations.

To appropriately address the riverine plastic debris problems in close cooperation within the four MCs, an agreed concept and framework on managing the drifted debris are necessary. To this end, analysing the path of riverine debris, systematic solid waste management, and role sharing considering the capacity of each country will play a crucial role.

**Note (data modification):**

- Specific gravity of plastic waste = 0.35 tonne/$m^3$
- 1 month = 4 weeks = 30 days
- The values answered in range is modified into the median (e.g. 10 – 20 kg => 15 kg).
- For the unification of data sources, all the numbers are cited from the original questionnaires, not from the national report.

### 5.4.1. Cambodia

**Waste generation**

Wastes are mainly generated from the passengers in tourism and trade, especially Svay Chrum Ferry Port, where nine medium-sized and two large ferries operate every day. It manages 99–165 kg/day of waste, ranking first among the 12 surveyed ports.

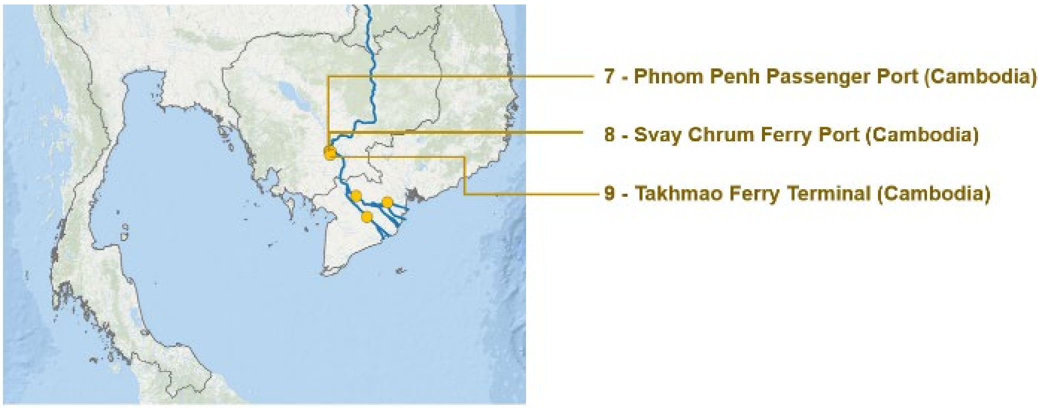



**Figure 5.29.** Map of surveyed ports in Cambodia

### Waste management

The manager of each port is responsible for waste management to keep each boat clean. However, the management follows its own rules and there is a lack of official management plans. Waste is only segregated in the Svay Chrum Ferry Port, only when primarily collecting it right after use.

### Accumulation and clean-up activity

Unlike waste generation, the largest amount of waste flow from upstream was observed at Takhmao Ferry terminal. Despite the large amount drifting to the shore, the waste accumulation at Takhmao Ferry Terminal was as low as the other port in MCs due to regular clean-up activities. Clean-up activities are usually conducted three times a week based on the project "One earth, one ocean", where the Cambodia Educational Waste Management Organization (COMPED) collects and records the drifted waste. As reported by the manager, the total waste collected within six months in 2021 was around 50 tonnes, in which plastic accounted for 15%, and 82.2% of collected waste is sent to land fills.

**Table 5.6**. Profile of three surveyed ports in Cambodia

| Port ID | | 7 | 8 | 9 |
|---|---|---|---|---|
| Name | | Phnom Penh Passenger Port | Svay Chrum Ferry Port | Takhmao Ferry Terminal |
| Management | | Government | Private | Government |
| Main purpose | | Tourism | Tourism | Trade |
| **Waste management** | | | | |
| Main source of waste | | Passenger | Passenger | Passenger |
| System | Designated agency | - | - | - |
| | Management plan | - | - | - |
| | Awareness in personnel | - | - | - |
| Generation | Plastic [kg/month] | 210 | N/A | 30 |
| | Overall [kg/month] | 240 | 3,960 | 60 |
| Routine collection | Overall [kg/month] | 300 | N/A | 30 |
| | Collection Bin | X | X | X |
| | Central Collection | X | X | - |
| | By | Government | Government | Government |
| | Segragation | - | Primarily | - |
| **Accumulation and clean-up activity** | | | | |
| From upstream | Plastic [kg/month] | 15 | - | 45 |
| | Overall [kg/month] | 50 | - | 150 |
| At artificial barrier | Plastic [kg] | 2 | 0 | 10 |
| Collection [time/month] | | 0 | 0 | 12 |

### 5.4.2. Lao PDR

**Waste generation**

Wastes are mainly generated from the port office and ship operations. Passenger cruises are the main source of waste since they carry and dispatch about 200 people per port per day. The waste mainly consists of organic materials such as food waste, green waste (garden and park waste), paper, and cardboard.

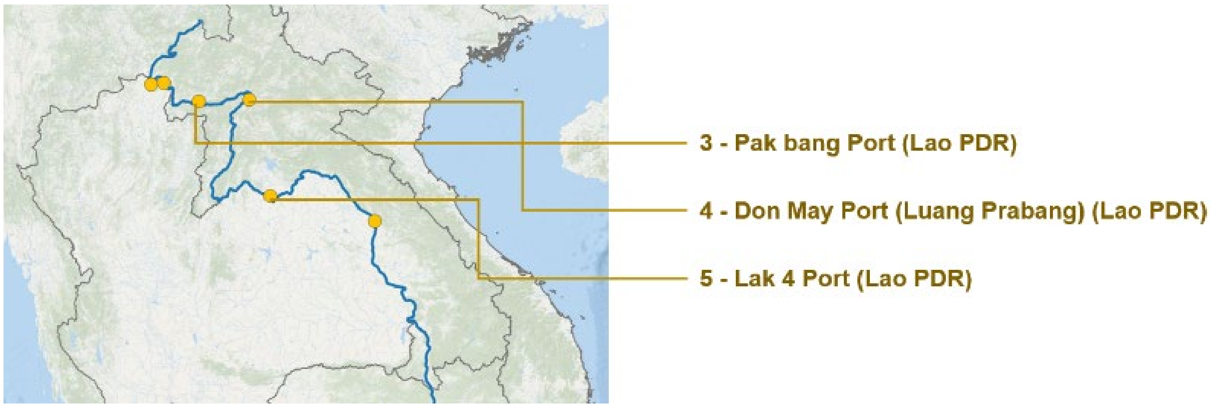



**Figure 5.30.** Map of surveyed ports in Lao PDR

**Waste management**
At all ports, there are baskets/bins for waste collection. There is a central waste collection point for the port at Vientiane but not for the Done Mai port of Luang Prabang. Since waste recycling facilities are not available at the ports, most of the recyclable materials are usually collected informally by the port workers/keepers.

There is scheduled clean-up at each port; at least once a week in Vientiane and twice a week in Don May and Pak Bang. There are also event-based clean-up activities at each port; they are organized according to national events. Moreover, there are also unscheduled clean-ups due to unexpected accumulation of waste along the riverside in the port area, which are carried twice a month in Vientiane, and twice a week in Luang Prabang and Pak Beng.

**Accumulation and clean-up activity**
Waste found at these ports are mostly removed by the port authority using conventional manual removal methods. In Vientiane, all waste is removed and disposed of at the central waste collection point, while in Luang Prabang and Pak Beng, most riverine waste is collected and placed in the temporary designated collection point the day before the waste truck arrives.

**Table 5.7.** Profile of three surveyed ports in Lao PDR

| Port ID | | 3 | 4 | 5 |
|---|---|---|---|---|
| Name | | Pak bang Port | Don May Port (Luang Prabang) | Lak 4 Port |
| Management | | Government | Government | Government |
| Main purpose | | Trade, Tourism | Tourism | Trade, Tourism |
| **Waste management** | | | | |
| Main source of waste | | Tourism | Ship operation | Office |
| System | Designated agency | X | X | X |
| | Management plan | X | X | - |
| | Awareness in personnel | X | X | - |
| Generation | Plastic [kg/month] | 75 | 105 | 90 |
| | Overall [kg/month] | 195 | 300 | 630 |
| Routine collection | Overall [kg/month] | 300 | N/A | 4500 |
| | Collection Bin | X | X | X |
| | Central Collection | X | X | X |
| | By | Government | Government | Government |
| | Segragation | - | Collection | Primarily |
| **Accumulation and clean-up activity** | | | | |
| From upstream | Plastic [kg/month] | 10.5 | 18 | 2 |
| | Overall [kg/month] | 30 | 75 | 20 |
| At artificial barrier | Plastic [kg] | 1 | 27.5 | 4 |
| Collection [time/month] | | 0 | Vary | 30 |

## 5.4.3. Thailand

**Waste generation**

The waste types, quantity, and distributions i the survey ports varied, possibly due to their operation objectives. There may be a high proportion of food and plastic waste in Nakhon Phanom City Port, which hosted a dining boat cruise, while plastic and paper/cardboard wastes dominate in Chiang Saen Commercial Port.

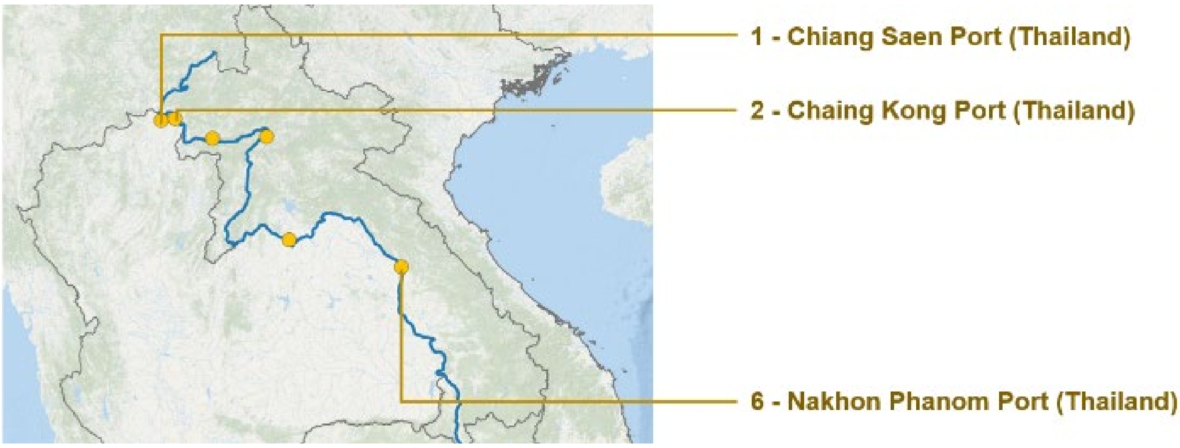



**Figure 5.31.** Map of surveyed ports in Thailand

**Table 5.8.** Profile of three surveyed ports in Thailand

| Port ID | | 1 | 2 | 6 |
|---|---|---|---|---|
| Name | | Chiang Saen Port | Chiang Kong Port | Nakhon Phanom Port |
| Management | | Government | Government | Government |
| Main purpose | | Trade | Trade, Tourism | Tourism |
| **Waste management** | | | | |
| Main source of waste | | Office | Tourism | Ship operation |
| System | Designated agency | X | X | X |
| | Management plan | X | - | - |
| | Awareness in personnel | X | - | - |
| Generation | Plastic [kg/month] | 1350 | 14 | 420 |
| | Overall [kg/month] | 3210 | 28 | 1050 |
| Routine collection | Overall [kg/month] | 6000 | 28 | 630 |
| | Collection Bin | X | X | X |
| | Central Collection | X | - | X |
| | By | Private | Government | Government |
| | Segragation | X | - | Primarily |
| **Accumulation and clean-up activity** | | | | |
| From upstream | Plastic [kg/month] | - | 75 | 0.525 |
| | Overall [kg/month] | - | 150 | 1.75 |
| At artificial barrier | Plastic [kg] | 1 | 0.2 | 1 |
| Collection [time/month] | | 0 | 0 | 0 |

**Waste management**

Waste management in the three surveyed ports in Thailand are moderately to readily available. All three ports are equipped with a collection system employing collection bins. Waste are segregated, and management staff or units are designated and employed in all three surveyed ports. Chiang Saen Commercial Port has a central waste collection site together with a waste management plan, according to their EIA requirements. Its employees are also aware of this waste management plan.

**Accumulation and clean-up activity**

Waste accumulation from upstream seems to be very light at two ports; moreover, Chiang Saen Commercial Port is not experiencing waste accumulation because of the location. In contrast, Chiang Kong Port has approximately 100–200 kg of upstream waste per month, 50% of which is plastic. The crew of Mekong Paradise Cruise II of Nakhon Phanom City Pier schedule a monthly clean-up for aesthetic reasons by using dip nets to take the accumulated waste out of the river. Wastes are then carried to the municipal bins to be further transported to a landfill. However, Chiang Saen Commercial and Chiang Kong Ports do not have these clean-up programmes for accumulated waste from upstream.

### 5.4.4. Viet Nam

**Waste generation**

In the three ports, the waste comes from port offices and ship operations. Other waste sources are tourists passing by My Thuan port and the storage house, and from equipment maintenance in Tan Cang Cao Lanh and Cai Cui ports.


**Figure 5.32.** Map of surveyed ports in Viet Nam

**Waste management**

Since the amount of waste generated at the ports is small t, the central waste collection point at the port is considered not necessary. Despite Decree No. 38/2015/NĐ-CP on the management of waste and discarded material, the waste segregation is not properly implemented. For example, the recyclable wastes that are not for sale or difficult to segregate such as nylon bags and food containers are generally mixed with food waste in the same container.

The Cai Cui port is the only port with a waste management plan; however, it is not well-disseminated, and only a few managing personnel are aware of it.

**Accumulation and clean-up activity**

Accumulated wastes were observed in only one location, along the wharf for each port.

Although the waste accumulation is visible at the ports, the waste is not managed or controlled by any unit (private company, local government, port personnel and resources). In addition, information on amounts of waste and its composition is still lacking.

**Table 5.9.** Profile of three surveyed ports in Viet Nam

| Port ID | | 10 | 11 | 12 |
|---|---|---|---|---|
| Name | | Tan Cang Cao Lanh port | My Tho port | Cai Cui Terminal port |
| Management | | Private | Private | Private |
| Main purpose | | Trade | Trade | Trade |
| **Waste management** | | | | |
| Main source of waste | | Office | Office | Office |
| System | Designated agency | X | X | X |
| | Management plan | - | - | X |
| | Awareness among personnel | - | - | - |
| Generation | Plastic [kg/month] | 30 | 450 | 450 |
| | Overall [kg/month] | 750 | 930 | 600 |
| Routine Collection | Overall [kg/month] | 750 | 930 | 600 |
| | Collection bin | Land | Land | X |
| | Central collection | - | - | - |
| | By | Private | Private | Private |
| | Segragation | Primarily | Primarily | Primarily |
| **Accumulation and cleanup activity** | | | | |
| From upstream | Plastic [kg/month] | - | - | - |
| | Overall [kg/month] | - | - | - |
| At artificial barrier | Plastic [kg] | 588 | 637 | 4410 |
| Collection [time/month] | | 0 | 0 | 0 |

**Main results and key challenges**

- The CounterMEASURE II studied the composition and weight/volume of riverine debris, both microplastics and macroplastics. Also, it listed in detail of plastic accumulation hotspots such as illegal dumping sites, and plastic leakage hotspots such as artificial barriers,.
- The concentration of macroplastics varied from place to place. At all the points surveyed, PE was the most prevalent material, and plastic wrappers was the most prevalent product, showing the importance of revising the packaging materials.
- The concentration of microplastics increased as it flowed downstream. At all the points surveyed, PP was the most prevalent material since its lowest density among all the plastics enables it to be carried for a long distance. High-density PET was not observed because it sinks in the water and cannot be seen on the surface.
- Plastic waste hotspots, which are Illegal dumping sites and artificial barriers, were found in great quantity with waste accumulation along the riversides and roadsides. There was no similarities in the types of products of plastic waste, thus emphasizing the need for the individual treatment at each location. They are considered the main leakage source to the waterways, and their details often showed a lack of appropriate supervision and cleaning activities.
- Although this information can be used for effective policymaking, there is still room for it to be developed as a tool or a system for plastic pollution monitoring. Specifically, their collection methods (equipment, duration) and reporting methods (units, classification) used for data collection vary significantly, making it impossible to compare the data within areas or over time. For appropriate monitoring, it is essential to establish standardized/harmonized methods for data collection and compilation.
- Although these research results and public services do contribute to tackling the riverine plastic pollution, there needs to be a role-sharing system that maximizes the efforts of each stakeholder. For closer cooperation to effectively manage the riverine plastic debris, governmental organizations of MCs need to establish regular activities in waste monitoring and collection in the LMB.
- Most of the macroplastic debris found were common products in people's daily lives. Therefore, raising awareness of the residents in the region as well as developing the appropriate SWM systems will be key to combating the problem of riverine debris in the Mekong River.
- There was a significant difference in the amounts of both waste generation and waste accumulation in the survey locations, but there was no correlation between them. Due to the transboundary movements of riverine debris, it is highly possible that some locations bear the burden both financially and in human resources of managing wastes from other areas . This is but one of the biggest problems of riverine plastic debris, i.e. unclear monitoring responsibilities due to transboundary movements, which underlines the increased importance of clarifying the path of riverine debris movements.
- To appropriately address the riverine plastic debris issues the concept and framework on managing the drifted debris are needed, wit close cooperation between the four MCs. To this end, analysing the path of riverine debris, systematic solid waste management, and role sharing in consideration of the capacity of each country will play a crucial role.

# 6. Fishery activities and the impacts of plastic pollution on living organisms

The Mekong River system hosts one of the most diverse and prolific freshwater capture fisheries in the world, with the largest fisheries catch occurring in the extensive floodplain in central Cambodia and the Mekong Delta of Viet Nam (MRC, 2021b). The abundant natural resources support life in the LMB. A recent review of MRC monitoring programme data and other studies from multiple sources estimated 1,148 fish species in the Mekong Basin, making the LMB one of the areas with the highest fish biodiversity per square kilometre in the world (MRC, 2021b). Yet, the plastic pollution has various adverse effects on water life. The following chapters explain the fishery activity in the LMB (Chapter 6.1), and its impact on living organisms based on a literature review and interview survey (Chapter 6.2).

## 6.1. Fisheries in the LMB

The overall unit value of capture fisheries in the LMB is derived from first-sale prices of a wide variety of fish species. Based on average first-sale prices in each of the four MCs, the economic value of the 2.3 million tonnes of annual capture fish production was calculated at about USD 11.2 billion, i.e. around 65% of the total value of all types of fisheries production. Of this amount, the economic value from capture fisheries in Thailand is the largest, at USD 6.3 billion, followed by Cambodia, at USD 2.8 billion annually (MRC, 2021b).

For sustainable use of water resources, national and regional organizations have worked closely on monitoring freshwater fauna. The MRC conducts three kinds of monitoring programmes: Fish Abundance and Diversity Monitoring (FADM), Fish Larvae and Juvenile Drift Monitoring (FLDM), and Dai (bag-net) fishery monitoring in Tonle Sap River. Specifically regarding the use of fish, MRC has integrated the monitoring results from various surveys into one report, Integrated Analysis of Data from MRC Fisheries Monitoring Programmes in the Lower Mekong Basin (MRC, 2013), where the contributions of fish species to the total catch weight has been analysed. Table 6.1 shows the species that contribute more than 1% of the total catch on average in the four MCs. Contribution rank (CR) is based on the contributions to the total fish catch weight (average of the four countries).

**Table 6.1.** Species that largely contribute to the catch in the LMB (MRC, 2013)

| Species | Average contribution to total catch [%] | CR [-] | Species | Average contribution to total catch [%] | CR [-] |
|---|---|---|---|---|---|
| *Henicorhynchus siamensis* | 5.9 | 1 | *Macrobrachium* sp. | 1.7 | 20 |
| *Clupeoides borneensis* | 5.7 | 2 | *Pangasius macronema* | 1.7 | 20 |
| *Cosmochilus harmandi* | 4.4 | 3 | *Hemibagrus wyckioides* | 1.5 | 23 |
| *Labeo chrysophekadion* | 4.1 | 4 | *Bagarius yarrelli* | 1.5 | 23 |
| *Cirrhinus lobatus* | 3.4 | 5 | *Paralaubuca riveroi* | 1.5 | 23 |
| *Hemibagrus spilopterus* | 3.3 | 6 | *Helicophagus leptorhynchus* | 1.5 | 23 |
| *Pangasius conchophilus* | 3.3 | 6 | *Mystus mysticetus* | 1.4 | 27 |
| *Hemibagrus nemurus* | 2.7 | 8 | *Puntioplites proctozystron* | 1.2 | 28 |
| *Phalacronotus apogon* | 2.6 | 9 | *Hypsibarbus lagleri* | 1.2 | 28 |
| *Puntioplites falcifer* | 2.5 | 10 | *Macrognathus siamensis* | 1.1 | 30 |
| *Poropuntius malcolmi* | 2.4 | 11 | *Bagarius bagarius* | 1.1 | 30 |
| *Anabas testudineus* | 2.3 | 12 | *Labiobarbus lineatus* | 1.1 | 30 |
| *Helicophagus waandersii* | 2.2 | 13 | *Notopterus* | 1.0 | 33 |
| *Wallago attu* | 2.1 | 14 | *Pangasius djambal* | 1.0 | 33 |
| *Barbonymus gonionotus* | 2.1 | 14 | *Labeo erythropterus* | 1.0 | 33 |
| *Cyprinus carpio* | 2.0 | 16 | *Channa striata* | 1.0 | 33 |
| *Polynemus dubius* | 1.9 | 17 | *Boesemania microlepis* | 1.0 | 33 |
| *Scaphognathops stejnegeri* | 1.8 | 18 | *Phalacronotus bleekeri* | 1.0 | 33 |
| *Nibea soldado* | 1.8 | 18 | *Syncrossus helodes* | 1.0 | 33 |
| *Netuma thalassina* | 1.7 | 20 | | | |

Monitoring of freshwater fauna is also carried out at the national level, both by the Government and in collaboration with the MRC. Other monitoring programmes by each country are listed in Annex 1, "Riverine Environmental Monitoring Activities".

## 6.2. Impact of plastic pollution

Plastic pollution from land can be transferred to the environment, as shown in Figure 6.1, causing biodiversity loss in rivers and ocean, and also coral reef loss in the ocean. For example, a common issue with macroplastic is the entanglement of species, and a common issue with microplastic is ingestion. Despite many reports of direct harm or mortality as a result of plastic entanglement or ingestion across a wide range of aquatic and terrestrial species, there is still little evidence available on the long-term population-level impacts resulting from plastic pollution alone (Horton & Blissett, 2021).

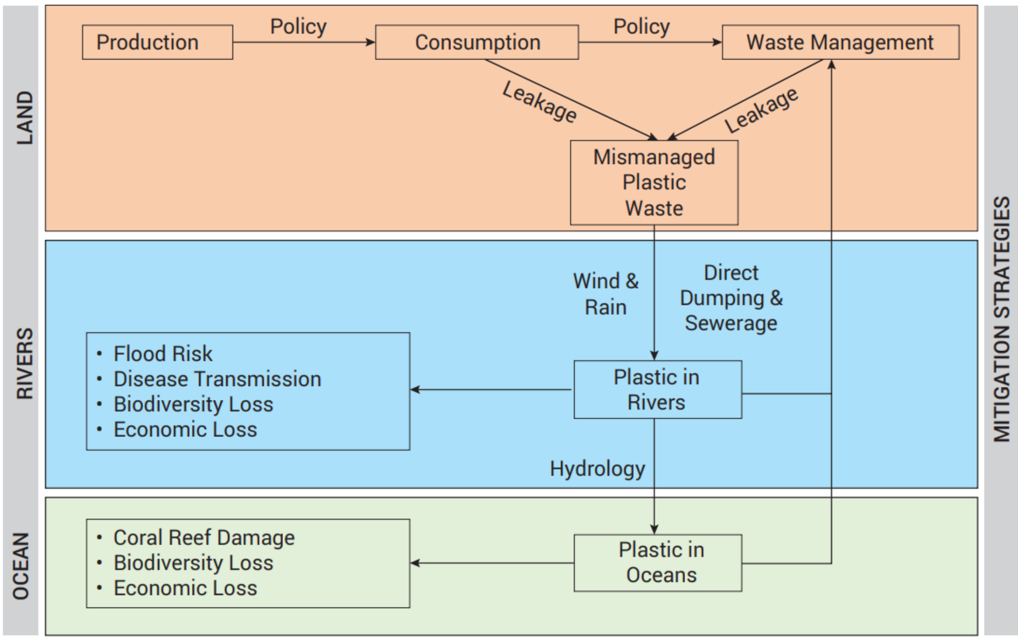



**Figure 6.1.** Conceptual flow of plastic from production to consumption, waste management and leakage into the natural environment (land, rivers and ocean), with possible points of action for policies

*Source:* UNEP (2020b)

### 6.2.1. The literature review

The literature review revealed the adverse effect of plastic debris on living organisms such as entanglement and ingestion of plastic. This plastic can even capture and accumulate hazardous chemical substances, which can then be transferred to living organisms, further leading to Bioconcentration. Although the information below is not limited to the LMB, it will surely help us understand and take the appropriate measures to prevent damage from plastic pollution.

**Macroplastics – Entanglement**

- Globally, Ryan (2018) reviewed literature and information on the internet using various combinations of search terms, bird groups (mainly waterbirds) as well as other terms such as 'plastic', 'balloon', and 'six-pack ring' in 16 languages. He found that the proportion of affected seabirds increased to 25% in 2015, compared to 16% in the prior two decades. He further explored Google Images and other web-based sources, and found that at least 147 seabird species (36%), as well as 69 freshwater birds (10%) and 49 land birds (0.5%) from 53 families were entangled in plastic or other synthetic materials. Fishing gear is responsible for entangling most species (83%) (Ryan, 2018).

**Microplastic – Ingestion**

- In India, Rochman et al. (2017) reported that an experimental study was carried out by feeding a range of environmentally relevant microplastics to the prey species Asian Clam (*Corbicula fluminea*), and subsequently feeding the clams to their natural predator, white sturgeon. It was observed that feeding behaviour was altered in the sturgeon exposed to clams that had ingested microplastics, with exposed sturgeon ingesting more food overall. Asian clams are a key food source for a range of Acipenser species, and therefore, it is a reasonable assumption that other species of sturgeon within the region of interest will also ingest microplastics through their prey and may show similar responses.

- Chi River is a major Mekong tributary in northeastern Thailand that drains into Mekong River in Ubon Ratchathani Province. Kasamesiri and Thaimuangphol (2020) examined eight freshwater fish species from Chi River in Maha Sarakham Province across a wide range of habitats and feeding habits, which included *Labiobarbus siamensis*, *Puntioplites proctozyson*, *Cyclochelichthy repasson*, *Henicorhynchus siamensis*, *Labeo chrysophekadion*, *Mystus bocourti*, *Hemibagrus spilopterus*, and *Laides longibarbis* Out of 107 individuals examined, 78 were found with microplastics in their digestive tracts; i.e. 72.9% of the overall occurrence and 50.0–86.7% occurrence in each species. *Puntioplites proctozysron* had the highest occurrence rate (86.7%). Overall mean abundance of microplastics was at 1.76 ± 0.58 pieces per fish. There was no significant difference in mean abundance among these eight fish species. Almost half (47.5%) of microplastics found in these samples were larger than 0.5 mm, which is the size frequently used in fishing lines or ropes (Kasamesiri & Thaimuangphol, 2020). Fibre-shaped microplastics (86.9%) had highest percentage among other microplastic shapes (5.8% rods, 4.4% pellets, and 2.9% fragments). Blue (56.9%) was the colour with the highest percentage of microplastics followed by red15.3%, black, 10.9%, white, 9.5%, transparent, 5.1% t, and brown, 2.2%). The results showed variations and possible diversity of microplastics that could originate from various sources of plastics pollution.
- In Thailand, a study on the digestive tracts in fish was carried out in 10 stations around the Ubolratana Reservoir, Khon Kaen Province (Kasamesiri et al., 2021). This is one of the major reservoirs on the Chi River Basin, where 14 fish species were examined: Puntioplites proctozysron, Cyclocheilichthys repasson, Parambassis siamensis, Henicorhynchus siamensis, Pristolepis fasciatus, Labiobarbus leptocheilus, Barbobymus goniontus, Rasbora aurotaenia, Clupeichtys aesarnensis, Mystacoleucus marginatus, Osteochilus vittatus, Paralaubuca harmandi, Mystus mysticetus, and Hemibagrus spilopterus. Ten out of the 14 fish species were found with 100% occurrence, with an overall 96.4% occurrence across all fish species (163 out of total 167 individuals). The abundance of microplastic in each fish ranged from 0 to 6 pieces per fish, with an overall mean of 2.92 ± 1.30 pieces per fish. These occurrences and abundances were higher than those of Kasamesiri and Thaimuangphol (2020) in the Chi River, while the characteristics of microplastics (size class, colour, and shape) displayed the same trend as the study. One highlight from the study of Kasamesiri et al. (2021) was that the highest abundance of microplastics (3.79 ± 1.25 pieces per fish) among all sites in the reservoir was found at the station where a major tourist recreation spot is located. In addition, the low-population site in the reservoir was found with the lowest microplastic abundance (2.20 ± 1.24 pieces per fish) This shows that human activities, especially tourism, could be a risk factor in increasing microplastic pollution in aquatic ecosystems.
- A study from Songkla province in the Lower Gulf of Thailand that focused on the

distribution of size classes of plastic debris, including microplastics, which were found in four marine fishes: Panna croaker (Panna microdon), Goatee croaker (Dendrophysa russelli), Sharpnose hammer croaker (Johnius borneensis), and Weber's croaker (Johnius weberi) (Azad et al., 2018). Most plastic debris found in the fish stomach was mesoplastics (5–25 mm, pelagic 68.57% and demersal 71.19%), followed by microplastics (smaller than 5 mm, pelagic 25.72% and demersal, 28.81%) and macroplastics (larger than 25 mm, pelagic 5.71% and demersal, 0%). Demersal and pelagic fish samples showed slightly differences in the percentages of the size plastic debris. These pieces of results showed that size distribution is possible and could be observed in other systems, and differences in fish habitat could also be yielded in size distribution.

- In Viet Nam, studies of microplastic contamination were conducted on Asian green mussels from a brackish water zone in Thanh Hoa province, and wild species of fishes and shrimps from the Long Tau River – the downstream section of the Saigon– Dong Nai River (Le, 2021; Phuong, 2019).
- In Dong Nai River system, Viet Nam, microplastics were found in all tested species, of which 99% were fibre-shaped (Le, 2021). The tested species were wild shrimps and fish (Metapenaeus ensis, Metapenaeus brevicornis, Cynoglossus puncticeps, Family Scianidae, Polynemus melanochir, Pseudapocryptes elongatus, Clupeoides borneensis and Glossogobius sp.). More specifically, the average microplastic fiber concentration varied from 0.33 to 1.41 fibers per gram wet weight of organisms with the lowest and highest concentrations found in Pseudapocryptes elongatus and Metapenaeus brevicornis, respectively. Concentrations of fibres varied from 1.33 to 9.33 fibres per individual. with the lowest and highest concentrations found in Polynemus melanochir and Clupeoides borneensis, respectively.

**Accumulation of chemical substances**

- Yamashita et al. (2011) investigated the short-tailed shearwaters, Puffinus tenuirostris, that were accidentally caught during experimental fishing in the North Pacific Ocean in 2003 and 2005. Although Plastic mass did not correlate with body weight, the ingested plastic mass correlated positively with adipose concentration of lower-chlorinated concentration of polychlorinated biphenyls (PCBs) (Yamashita et al., 2011).

### 6.2.2. The primary data collection through interviews

Interviews of fishers and fish vendors were conducted in four MCs aiming to clarify the plastic pollution status on freshwater fauna. The interviews mainly focused on two points, the incidence of living organisms getting entangled by riverine plastic debris, and the incidence of species found with plastic debris in the digestive system (hereafter referred to as 'ingestion').

The interview results showed the impact of plastic pollution varying from place to place. While no incidences of entanglement or ingestion were reported in Lao PDR, striped catfish, classified as endangered (EN), was found to ingest the styrofoam in Viet Nam. Also, a fish vendor in Chiang Saen, Thailand claimed that she frequently opened up fish stomachs to clean them before selling. In addition to the entanglement and the ingestion, for five years, the fishers in Cambodia have been deal with an amount of plastic debris that exceeds the fish catch.

Nevertheless, the analysis on the effect of plastic debris on the freshwater fauna shows serious gaps. Four countries reported that there was no published report on the effect of plastic pollution on freshwater ecosystems in the LMB nor in specific MCs. Some of the consultants pointed out that most of the research put an emphasis on analysing the marine rather than on freshwater ecosystems. Considering that the Mekong River ecosystem provides food and is home to various species including humans, it is necessary to clarify both the distribution and significance of the risk of plastic pollution.

Table 6.2 shows a summary of the entanglement and ingestion reported in four MCs. The two columns on the left indicates the scientific names and English common names. The right-next column indicates the conservation status in IUCN Red List of Threatened Species, and in CITES. The next four columns to the right indicate whether entanglement or ingestion has been observed in the four MCs. The column on the far right shows the contribution to the total fish catch (average of the four MCs).

From the interview surveys, it emerged that the species under threat of extinction, such as *Bagarius* (Near Threatened: NT), *Wallago attu* (Vulnerable: VU), *Pangasius hypophthalmus* (Endangered: EN) are affected by entanglement or ingestion of plastic debris. Moreover, species that significantly contribute to the fish catch in the Mekong River are also affected by both entanglement and ingestion, hence the lives of species that play a critical role in the environmental hierarchy and in human daily lives are at risk. Also, since the table shows the results from interviews with several fishers from each country, closer scientific observation of the ecosystem may reveal further adverse impacts. For example, the case of frequent ingestion of plastic debris seen in Chiang Saen, Thailand could be taking place anywhere in the basin. In this context, continuously monitoring the impacts of plastic pollution on freshwater fauna and comparing the results by locations and over time will allow to take effective action towards the more sustainable use of freshwater resources.

**Table 6.2.** Impact from plastic pollution on freshwater fauna observed in interviews

| Species | English common name | Conservation status | | Effect from plastic debris<br>E: Entanglement, I: Ingestion | | | | | | | | CR [*1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | KH | | LA | | TH | | VN | | |
| | | IUCN | CITES | E | I | E | I | E | I | E | I | |
| *Bagarius* | Goonch | NT | N/A | | | | | | X | | | 30 |
| *Barbonymus gonionotus* | Common silver carb | LC | N/A | | | | | | X | | | 14 |
| *Channa striata* | Snakehead murrel | LC | N/A | X | | | | | | | | 33 |
| *Cirrhinus siamensis* | Siamese mud carp | LC | N/A | X | | | | | | | | - |
| *Clarias batrachus* | Philippine catfish | LC | N/A | | | | | | | X | | - |
| *Clarias gariepinus* | African sharptooth catfish | LC | N/A | | | | | | | X | | - |
| *Cyclocheilichthys enoplos* | Soldier river barb | LC | N/A | | | | | | | X | | - |

| Species | English common name | Conservation status | | Effect from plastic debris E: Entanglement, I: Ingestion | | | | | | | | CR *1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | KH | | LA | | TH | | VN | | |
| | | IUCN | CITES | E | I | E | I | E | I | E | I | |
| *Cynoglossus microlepis* | Smallscale tonguesole | LC | N/A | | | | | | | X | | - |
| *Datnioides microlepis* | Finescale tigerfish | LC | N/A | | | | | | | X | | - |
| *Glossogobius biocellatus* | Sleepy goby | LC | N/A | X | | | | | | | | - |
| *Hemibagrus nemurus* | Asian redtail catfish/yellow catfish | LC | N/A | X | | | | | | | | 8 |
| *Hemibagrus wyckioides* | Asian redtail catfish | LC | N/A | | | | | | | X | | 23 |
| *Kryptopterus micronema* | | LC | N/A | X | | | | | | | | - |
| *Oxyeleotris marmorata* | Marbled goby | LC | N/A | X | | | | | | | | - |
| *Pangasius hypophthalmus* | Striped catfish | EN | N/A | | | | | | | X | X | - |
| *Pangasius larnaudii* | Spot pangasius | LC | N/A | | | | | | | | X | - |
| *Rasbora borapetensis* | Blackline rasbora | LC | N/A | | | | | | | X | | - |
| *Rasbora hobelmani* | Kottelat rasbora | N/A | N/A | X | | | | | | | | - |
| *Wallago attu* | Wallago | VU | N/A | | | | | | X | | | 14 |

***Notes***: *1 Contribution Rank based on the contributions to the total fish catch weight (average of four countries). Unnumbered species contribute less than 1%. (Modified from MRC, 2013)

*2 IUCN Red List of Threatened Species (International NT: Near Threatened, VU: Vulnerable, EN: Endangered, LC: Least Concern)

*3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (N/A: The specie does not appear on the list).

## Cambodia

Local fishers reported that seven kinds of fish species were found trapped in plastic bags, but ingestion was not reported. Other problem with the plastic debris was the fish-trap often containing plastic waste, such as plastic bottle, plastic bags, and plastic straws. Local fishers claimed that they sometimes caught more plastic than fish, a problem that they had been experiencing for the last five years. There are no data or nor has research been conducted on the effect of plastic pollution on the freshwater ecosystem in the LMB or specifically in Cambodia.

## Lao PDR

In three survey areas, including Vientiane, Luang Prabang, and Pak Beng, neither entanglement nor ingestion of plastic debris was common. Most of the interviewees mentioned that these cases were rarely observed, except for rare cases of small pieces of waste debris, hook, or soap in fish found at the morning market of Luang Prabang. Fishers in Luang Prabang reported that the only impact from waste debris was the entanglement of waste debris in their nets. To date, there has been no study on the impacts of plastic pollution on Mekong migratory species.

**Figure 6.2.** Waste debris entangled in the net

## Thailand

Most of the interviewees in all three areas (Nakhon Phanom, Chiang Saen, and Chiang Kong) found no incidences of plastic entanglement or ingestions by freshwater fish nor waterbirds. No one interviewed had seen any fish nor bird samples that clearly ingested or entangled plastic waste by any means.

However, in Chiang Saen market, there was one incident of plastic ingestion or entanglement reported. A fish vendor in Chiang Saen market reported that she frequently opened up fish stomachs to clean them before selling. She had seen plastic bags in three fish species that were taken from Mekong River: *Bagarius*, *Wallago attu*, and *Barbonymus gonionotus*.

There have been no official reports nor news on incidents of plastic ingestion or entanglement in fish and birds associated with freshwater systems that cause physiological abnormalities or deaths, either in at the national level or regionally in the LMB.

## Viet Nam

The survey results showed that at a fishing area near My Tho port, two fish species were reported to be entangled with plastic bags, including African sharptooth catfish and fine-scaled tigerfish. Fish species entangled with plastic bags near Tan Cang Cao Lanh port are striped catfish, spot pangasius, Philippine catfish, soldier river barb; and near Cai Cui port, Asian redtail catfish, small-scaled tonguesole, blackline rasbora, and Asian redtail catfish. Also, styrofoam was ingested by two species, namely striped catfish and spot pangasius Philippine catfish, near Tan Cang Cao Lanh Port. Of these species, striped catfish is classified as endangered (EN) in the Viet Nam Red Data Book.

During the interview survey on plastic impact on water birds, there was no observed impact on the birds due to entanglement or ingestion. It is likely that macroplastic debris is accumulated mainly in riversides of populated areas and high activities of boat traffic. There areas are not favourable feeding or resting places for water birds, so it is difficult to observe this impact.

As far as it is known, to date, there is no study of impact of plastic pollution on water birds in Viet Nam. However, the food chain may be impacted by plastic pollution through the accumulation of microplastic from fishes and other aquatic species to water birds.

Impacts of plastic pollution on Cetacean: Irrawaddy dolphins (*Orcaella brevirotis*) are distributed along the coast in the Mekong Delta. Two individuals were caught in a fishing net in An Giang Province, one in March 2002 (Bui & Dao, 2002) and one in October 2005 (Beasley et al., 2006). Through the survey on the impacts of plastic on cetaceans, no impact was observed on the dolphins due to entanglement or ingestion.

**Main results and key challenges**

- LMB utilize its abundant freshwater resources for daily consumption and economic activities, therefore carries out the environmental/agricultural monitoring on both national and regional level.
- The interviews conducted in the four MCs targeting fishers and fish vendors showed that the lives of species that play a critical role both on the environmental hierarchy and in human daily lives are at risk of getting entangled by the riverine plastic debris and ingesting plastic debris.
- Although monitoring activities in the LMB involve freshwater fauna, scientific insights on the adverse effects of plastic pollution in the LMB still show a serious gap. Since the results discussed above are from interviewing several fishers in each country, closer scientific observation of the ecosystem may possibly reveal further adverse impacts.
- Continuously monitoring the impacts of plastic pollution on freshwater fauna and comparing the results in different locations and over time will allow to take effective action towards the more sustainable use of the freshwater resources.

# 7. Key challenges and opportunities for riverine plastic pollution management

Key challenges and opportunities for riverine plastic pollution management for MCs as a whole are discussed below.

### a) Key challenges

- There are no or few regular monitoring systems for riverine plastic waste (**Chapter 5**).
- There is no harmonized methodology available for monitoring plastic debris, making the data incomparable over time or location.
- The issue of riverine debris goes beyond the problem of SWM and 3R policies, which therefore requires a cross-sectional cooperation system.
- There is a lack of public awareness on plastic waste impacts on water resources.
- There is no specific regulation for implementing riverine plastic waste monitoring (**Chapter 3**).
- Common weakness in the implementation for SWMI include waste segregation, collection, transportation, treatment, recycling, and disposal (**Chapter 3**).
- It is not clear which organization should be responsible for riverine waste management **(Chapter 3).**
- Investment in SWM is still limited and fails to meet the actual needs due to a lack of financial resources.

### b) Opportunities

- The MRC's Riverine Plastic Monitoring Programme will establish a detailed methodology of monitoring plastic debris in the Mekong River, that will help to obtain more accurate data and on long-term trends. This will enable data comparison over location and time, helping to understand the amount, pathways of occurrence, which will then help determine the effective measures on reducing riverine debris based on scientific data and evaluate the effectiveness of measures. This can be reflected in the policymaking in the relevant countries.
- The data obtained scientifically will also serve as scientific evidence to enhance regional cooperation, as emphasized in the ASEAN Framework of Action on Marine Debris.
- UNEP's CounterMEASURE II Project conducted riverine monitoring in the LMB. Four MCs are able to utilize the data from these riverine monitoring activities (**Chapter 5**).
- There are already water quality monitoring stations and well-established water sampling points. The introduction of appropriate equipment and human resources may enable these monitoring stations to conduct routine riverine plastic debris monitoring.

- The issue of waste management and plastic waste management is gaining attention from various stakeholders from domestic and international parties. Thus, several agencies support MCs in improving waste management. Nevertheless, there is still la ack of coordination and cooperation. (**Chapter 3**).

Key challenges and opportunities for each MC are shown below.

## 7.1. Cambodia

### a) Key challenges

Riverine plastic pollution is a new topic for Cambodia. Hence, to date, Cambodia is facing specific challenges, as follows:

- There is no comprehensive legislation on plastic waste and plastic pollution and monitoring for plastic leakage.
- There is limited knowledge about riverine plastic pollution management such as on the amount of plastic used in manufacturing, the amount of plastic waste generation and plastic waste leakage into the environment and water bodies.
- Institutional capacity is also limited in terms of the monitoring and evaluation of the status of riverine plastic pollution and its adverse effects on human health and the environment, specifically on biodiversity.
- There is no official or science-based information on the current amount, trends and status of plastic pollution.
- There are no activities taking place related to riverine plastic debris collection and monitoring.
- There is limited awareness on plastic wastes handling and disposal, as well as on the adverse impacts of plastic pollution on human health, etc.

### b) Opportunities

- Cambodia's National 3R Strategy for Waste Management in Cambodia (2008) outlines the principles of and actions for reducing, reusing, and recycling solid waste; however, the implementation of measures has been insufficient.
- The legislation and policies of Cambodia outline the leading role in waste management systems. Legislation dictates that responsibilities are highly decentralized, primarily to the provincial level, with the option to further delegate to the municipal, district and commune administration. However, the government actors who are expected to be involved in waste management can be unclear.
- Some environmental campaigns by the Government have been taken place such as clean-up activities. However, there is no record of the amount of wastes including plastic wastes collected during this clean-up event.
- In Phnom Penh, part of the plastic waste from land are collected at sewage pumping stations and transported to dumpsites.

## 7.2. Lao PDR

### a) Key challenges

The key challenges relating to plastic waste management in Lao PDR are as follows:

- There is an increasing amount of plastic waste associated with population growth, economic growth, and changing lifestyles of the Lao people.
- Since most people are not aware of the impacts of plastic and solid waste on the environment, society and health, they do not separate waste at source and still get rid of waste as they always have, by illegal burning and dumping. Many people dispose of waste at illegal dumpsites, some of which are nearby waterways, streams or rivers.
- The waste collection service still does not cover the entire countries, which leads to the improper management of waste by some people (illegal dumpsites and open burning).
- There is a high cost of SWM operations.
- There is poor technical capacity of landfill operations.
- Lao PDR still lacks a clear policy and legislation for 3Rs (i.e. promotion and implementation); therefore, efforts to encourage waste segregation at source and waste-to-resource by international agencies and private sector are undermined.
- There is a low recycling rate of waste and debris.
- The enforcement of regulations and prohibitions is still weak in many areas.

  - Riverine debris monitoring programmes do not officially exist.
  - Lack of awareness of waste impacts on the water resources.
  - No specific regulations and prohibitions on littering waste into water resources.
  - Low capacity and human resource to monitor waste littering into water resources.

### b) Opportunities

Currently, SWM in Lao PDR is mostly collection and disposal, with limited recycling rate. Nevertheless, with proper management, waste in Lao PDR could be reused and utilized as a resource for other production activities. Some opportunities relating to waste management in Lao PDR are as follows:

- Some regulations relating to waste management are already in place; therefore, with the effective enforcement, improper waste disposal activities could be reduced. Nevertheless, the authority must ensure that the appropriate waste collection system is established.
- At present, several international agencies are supporting the Lao Government in raising awareness and improving its waste management system. Nevertheless, there is still a lack of coordination and cooperation.
- Currently, informal waste pickers are very active in the cities and towns due to the presence of junkshops, waste dealers, and recycling factories. Integrating them into more formal waste collection system could help reduce the amount of plastic and solid waste.

- The media can help bring information about the impacts of plastic waste on water resource to the public.
- Many young volunteers from educational institutions are enthusiastic about awareness-raising activities. Involving them in awareness-raising activities could help increase public awareness of waste.
- Line ministries and government agencies are willing to cooperate in riverine plastic debris monitoring.

## 7.3. Thailand

### a) Key challenges

- Despite the policies in place, implementation on the reduction of waste or avoiding its unnecessary use rarely practised. Budgets from both the public and private sectors are mostly allocated to waste segregation and recycling. Consumers are not provided with an economic incentive nor made aware of how to avoid using unnecessary plastic and segregating waste. For those who are aware of the benefits of the waste segregation, personally or environmentally, it is sometimes confusing and inconvenient to properly segregate it due to there being several types of bins and plastic materials or a lack of collection services. From the data available in Thailand, key challenges along the plastic pollution management phases can be summarized as follows:

  - **The production phase**: Without incorporating externalities, costs of plastic packaging are too low for producers to give up using plastic packages or change to alternative materials. Utilizing recycled plastic to produce new products or packaging can be a challenge because it is limited by standards related to health and safety. Some producers have tried to introduce bioplastic or biodegradable plastic to consumers. These plastic materials are intended to be degraded in industrial composting facilities and not for recycling. If mixed with normal plastic, the recycling process will be challenged.
  - **The consumption and discarding phase**: Consumers are becoming more aware of the waste problem and are willing to segregate waste (Vassanadumrongdee, 2017), but greener products are still not widely available and usually more expensive. Refusing plastic, especially SUPs, causes an inconvenience to general consumers. The key challenge is, however, a low segregation rate.
  - **Waste management phase**: As mentioned in Chapter 2, plastic waste may leak from uncollected MSW, illegal recycling processes and improper disposal by open dumps or burning. Lao PDR does not charge a waste management fee to cover the disposal costs, and every household is charged only with a flat-rate garbage collection fee. After leakage to water bodies, clean-up programmes are not routine. The available equipment and technology are not sufficient to handle large volumes of riverine plastic pollution. It is not clear which organizations should be responsible for the clean-up.

- The clean-up of riverine debris is not performed regularly. In some rivers, there is no clean-up activity at all. Garbage floating traps installed in some rivers are not effective because they are installed in just a small area of the river cross-section. Once the garbage is fully trapped, transferring the garbage requires too much time or too many workers.
- For monitoring riverine plastic, the national standards on plastic pollution as one of the parameters in water quality standards has not been developed. It is important to have standardized/harmonized sampling methodology, analysis methods and a monitoring protocol. There is data collection in some areas such as Rayong Province, but the data have not been published. There is no national or local policy on riverine plastic waste monitoring.

### b) Opportunities

- Even though there are numerous challenges, there are opportunities to improve riverine plastic pollution management in Thailand.
- The policy on banning free plastic bags at supermarkets and shopping malls from the beginning of 2020 has changed consumers' behaviour to a certain extent. Efforts in innovation and technology have proven successful in several cases. Artificial Intelligence (AI) will play a more active role in analysing consumer behaviours and supporting waste segregation by machines.
- There are already water quality monitoring stations and well-established water sampling points around Thailand. Human resources who conduct monitoring activities are knowledgeable and skilled, with many years of experience. Sampling tools and analysis equipment are available, although limited. Procuring more essential equipment is not beyond the budget when there is the political will.
- With the policy to merge the Regional Environmental Offices with the Pollution Control Department, it is hoped that the new agency will be equipped with financial and human resources needed to set up new water quality standards on riverine plastic pollution and conduct routine monitoring.

## 7.4. Viet Nam

### a) Key challenges

- Increased domestic consumption combined with higher growth of the manufacturing and service sectors has led to increased waste generation in Viet Nam. Due to uncollected waste and the current waste collection, transportation and disposal practices, there is extensive leakage of plastic waste in water and wastewater, ultimately leading to marine litter and plastic pollution (SEA Circular, 2020). Although there has been remarkable progress, SWM still has many shortcomings. Solid waste has not been classified at source; mitigation measures have not been strongly applied; the rate of rural domestic solid waste collection is low and there is no positive change; and recycling is backward, polluting and the main treatment method is still landfilling (Nguyen et al., 2019).

- The legal system and laws on SWM are incomplete and overlapping. The organization and assignment of the responsibility for solid waste are still fragmented and lack consensus, making it difficult for implementation. There are still problems with the implementation of solid waste policies and legal documents. Inspection and law enforcement are still limited, and sanctions on solid waste management are not enough of a deterrent (MONRE, 2015).
- The implementation of approved SWM planning in localities is slow (MONRE, 2017). Investment in SWM is still limited, failing to meet the actual needs due to the lack of financial resources. Socialization is weak due to the lack of appropriate regulations to attract investment resources.
- The problem of selecting optimal solid waste treatment technology is still challenging for managers and scientists and there is no complete technological model of domestic solid waste treatment to address the technical, economic, social, and environmental issues (MONRE, 2015). Viet Nam's solid waste treatment technologies are not modern and are on a small scale. Most imported solid waste treatment technologies are not consistent with the reality of solid waste in Viet Nam because they are not classified at the source.
- In addition, solid waste including plastic waste recycling is still small-scale, ad hoc, and informal in many villages, lacking the management and control of local environmental protection agencies. Most of the recycling facilities are small; the level of technology investment is not high; most of the technologies are outdated; and the machinery and equipment are old, causing environmental pollution. The State does not have clear regulations on the use of technology, and there are no targets and standards for appropriate treatment of equipment and technology (MONRE, 2017).
- Solid waste recycling technologies, including plastic waste, have not been fully documented and evaluated to provide guidance on the selection of recycling technologies in accordance with local waste characteristics. Informal recyclers, with low-grade technology and lack of waste treatment infrastructure dominate in plastic recycling. Therefore, formal recyclers cite difficulty in obtaining a steady supply of high-quality recyclable feedstock due to the opaque market structure, cumbersome local informal networks, and the poor quality and quantity of recyclable feedstock. Households in Viet Nam (the major source of solid waste) do not typically practise sorting-at-source. There is also a significant lack of transparency on manufacturers and consumers of recycled plastic raw materials, especially given that most activity occurs in the informal sector.
- The waste collection in rural areas is limited due to the sparse distribution of pollution and lack of access to collection means. Domestic waste or plastic waste in the rural areas are generally dumped into rivers or canals. Therefore, implementation of plastic control in the rural is more challenging and requires greater efforts.
- Currently, plastic pollution is a controversial issue not only at the global scale, but also in Viet Nam, and there is increasing funding for studies on it. However, studies on the impacts of plastic pollution on the aquatic ecosystem and human health in Viet Nam are at the early stage, which will attract public attention to this issue. Users have the habit of using plastic bags, mainly due

to their convenience when shopping and cost. It is difficult to change habits of using plastic bags in their daily lives. In addition, eco-friendly products are not widely sold, and still need to be recognized as being qualified for licensing standards.

- There is a lack of adequate funding for waste management or recycling infrastructure. Revenue from waste collection and transportation is insufficient to build an integrated waste management system, due in part to low SWM charges to households.
- There is a lack of human resources, especially at the commune level and in rural areas where one officer alone (usually the land administrative officer) is responsible for the waste management and other tasks.

### b) Opportunities

- There could be tighter environmental regulations, with an increasing number of countries targeting higher recycling rates, stricter 3R policies at the household level, circular design guidelines, and the stipulation of minimum recycled plastic content for certain products. Recently, prompt action has been taken to address plastic pollution in Viet Nam, such as an environmental policy and strategy. The MONRE has introduced new articles in the Draft Law on Environmental Protection (amended) to address public concern on SWM and the management hazardous waste. Specifically, the draft provides regulations on the collection, transportation and treatment of domestic solid waste, which is calculated based on generated volume (Article 79, clause 6,). The MONRE will guide the method of collection, transportation, and treatment of domestic solid waste according to the generated volume and type. This will motivate people to reduce the amounts of waste generated because less waste clearly means fewer costs. In line with guidance from the central government, some provinces have set a target to reduce waste. For example, in Dong Nai province, it is expected that in the 2020–2025 period, the rate of landfill will be reduced to 15%; this rate in HCMC is set at 20%.
- The issue is receiving attention from various stakeholders from domestic and international parties, which are attracting more investment and funding in technology development for the waste treatment. In addition, recently, an increasing number of awareness campaigns and studies have been carried out.

# 8. Recommendations

It is essential to assess the basin-wide status and trends of riverine plastic pollution, and gather information and knowledge to inform decision-making towards the effective and efficient management of riverine plastic pollution in the LMB. Recommendations on addressing the identified gaps and challenges, and developing a monitoring system for riverine plastic pollution in each MC are as follows:

- Conduct strict riverine debris monitoring following the protocol by the MRC and share experience and data. This will enable data compilation for scientific research and the active involvement of stakeholders.
- Collaborate with the Government, academia and institutes in order to conduct riverine debris monitoring and to maximize the outcome with the limited resources
- Provide capacity building for the development, definition and classification of riverine debris, sampling methodology, sample analysis and monitoring protocols. The monitoring programme should be cost-effective and include both macroplastics and microplastics.
- Develop and legalize national standards or targets on riverine plastic debris.
- Identify government authorities or research institutions suitable for conducting and maintaining monitoring activities in cooperation with related organizations.
- Establish and enforce policies and regulations on waste littering, 3R, and riverine plastic waste management, clearly identifying the responsibilities of the national government, the local government, the private sector, and the community.
- Regularly collect riverine debris and appropriately treat the collected debris.
- Raise public awareness on the impacts of plastic waste on the environment and water resources.
- Develop an integrated monitoring system that consolidates the monitoring activities and results of each organization.

Through the recommended items above, the results of riverine debris can be evaluated, and a material flow analysis and an inventory analysis of plastic can be facilitated. These will also contribute to evaluating the effectiveness of the measure.

## 8.1. Cambodia

- Establish policies and regulations to address plastic pollution such as on the management and monitoring of plastic waste and riverine plastic debris.
- Formulate an integrated management system for plastic manufacturing, plastic waste generation and plastic leakage to fully understand plastic waste flow through cooperation between the government, the private sector, and academia.
- Develop monitoring and evaluation capacity for plastic pollution, especially for riverine plastic debris of laboratories that belong not only to the Government but also to the universities.
- Improve and enforce SWM at the national and local levels. A proper collection service will contribute to reduce plastic leakage. Also, segregation at source will accelerate its effectiveness.

- Clarify the responsibilities of plastic waste management actors.
- Raise public awareness by implementing regular clean-up campaigns by the government.
- Strengthen the implementation and enforcement of targets stipulated in the national 3R strategy.
- Collect plastic debris from trapping point like a sewage pump station and formulate reporting system regarding collected plastic debris.

### 8.2. Lao PDR

- Establish and promulgate the policies and regulations that support the 3R principle.
- Establish and enforce a regulation on waste littering into water resources.
- Implement a waste reduction scheme using the EU's waste hierarchy.
- Maximize waste-to-resource opportunities by encouraging separation at source.
- Raise awareness on the impacts of plastic waste on environment and water resource.
- Set up a separation scheme at source and distribute waste bins in several public place, especially those near water resources.
- Encourage and set up a separation mechanism at source for households and business entities to ensure that plastic waste is well segregated.
- Increase business opportunities for waste recover/recycling entrepreneurs.
- Undertake regular plastic waste monitoring activities at critical locations.

### 8.3. Thailand

- Provide capacity building for the development, definition and classification of riverine debris, sampling methodology, sample analysis and monitoring protocol. The monitoring programme should include both macro- and microplastics.
- Identify locations that can represent overall water quality in terms of riverine plastic pollution for the monitoring programme.
- Develop and legalize national standards on riverine plastic debris.
- Identify the suitable government authorities or research institutions for conducting continued monitoring activities. Sampling and analysis can be conducted by separate organizations.
- Legalize the new tasks and responsibilities for the selected organizations and establish performance indicators to implement and ensure sufficient fiscal budgets for the newly assigned responsibilities.
- Upgrade monitoring stations and sampling tools and procure more equipment if necessary. For example, an AI-powered camera may be installed at the spot where water overflows to count the number of macroplastic items.

### 8.4. Viet Nam

- Promptly revise the legal regulations on the implementation oft the Government's Resolution on assigning the MONRE as focal point for unified SWM. The Department of Natural Resources and Environment should act as the focal point and unify the SWM in all provinces and cities.

- Strengthen the implementation and enforcement of 3R targets stipulated in the national strategy. Increase the implementation of measures to minimize waste generation and promote sorting at source. Enterprises should be encouraged to apply cleaner production, waste audits, and product life cycle measures. Implement communication programmes to promote sustainable consumption in residential communities.
- Strengthen the management of rural domestic solid waste. Research, develop, and issue separate documents on rural SWM; increase collection and disposal rates. Strengthen the responsibilities of local authorities at all levels in planning, budgeting and organizing the implementation of rural solid waste collection and treatment. In addition, strengthen inter-regional and local coordination in rural solid waste and gradually develop the waste recycling industry.
- Incentivize partnerships between the state waste management company (Urban Environment Company of Viet Nam), waste pickers, junkshops, recyclers and major companies looking to purchase recycled goods.
- Invest in modernizing and integrating the informal recycling sector, not only to increase environmental efficiency (water, energy) of their processes, but also to reduce leakage of residual plastic waste into the environment.
- Conduct further research on the quantification and monitoring of riverine plastic, as well as hotspots. Further improvement of understanding on sources and pathways, as well as the ecological, environmental, and socio-economic impacts within the country could support decision-making in the adoption of adequate management measures. The monitoring may consist of monitoring plastic in surface water and in fishes, or even in bivalves to evaluate the plastic pollution in the aquatic ecosystem. It is expected that the monitoring will contribute to building research capacity of local research institutions.

# 9. References


ASEAN. (2019a). ASEAN framework of action on marine debris.

ASEAN. (2019b). Bangkok declaration on combating marine debris in ASEAN region.

ASEAN. (2020a). Case studies and good practices in addressing marine debris in ASEAN region Booklet 1.

ASEAN. (2020b). Case studies and good practices in addressing marine debris in ASEAN region Booklet 2.

ASEAN. (2021). *ASEAN regional action plan for combating marine debris in the ASEAN Member States (2021–2025)*. Jakarta: ASEAN Secretariat. Retrieved from https://bit.ly/3FxTpYw

Beasley, I., Le, X. S., & Hodgson, A. (2006). Investigating the occurrence of Mekong Irrawady dolphins (Orcaella brevirostris) in Viet Nam. *Journal of Scientific Research, Can Tho University*, 291-300.

Bui, D. C., & Dao, T. H. (2002, 24-26 July 2002). *A review of the results of the studies on marine mamals in Vietnamese waters.* Paper presented at the Unpublished report submitted to the Workshop on the Biology and Conservation of Small Cetaceans and Dugongs of Southeast Asia, Dumaguete City, Philliphines.

Chansomphou, V. (2020). The project on promotion of countermeasures against marine plastic litter in Southeast Asia and India activity report. Vientiane.

COBSEA. (2019). *COBSEA Regional Action Plan on Marine Litter 2019 (RAP MALI)*. Bangkok.

DMCR. (2013). Project on integrated action and participation on marine debris management. Retrieved from https://projects.dmcr.go.th/miniprojects/147/37515

FPT Securities. (2019). Plastic sector report August 2019.

GISTDA. (2019). Geo-Informatics and Space Technology Development Agency, News DMCR installed oil boom like garbage trap. Retrieved from http://coastalradar.gistda.or.th/wp/?page=news-detail&id=12979

Haberstroh, C. J., Arias, M. E., Yin, Z., Sok, T., & Wang, M. C. (2021). Plastic transport in a complex confluence of the Mekong River in Cambodia. *Environmental Research Letters, 16*(9), 095009. doi:10.1088/1748-9326/ac2198

Horton, A. A., & Blissett, I. (2021). *Impacts of plastic pollution on freshwater aquatic, terrestrial and avian migratory species in the Asia and Pacific Region*.

ISWA Marine Task Force. (2017). Prevent marine plastic litter-now! Retrieved from https://bit.ly/3Bguo1o

IUCN. (2020). Conducting a beach debris monitoring programme in the coastal areas of Viet Nam.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., . . . Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science, 347*(6223), 768-771. doi:10.1126/science.1260352

JICA. (2021). Data collection survey on waste management sector in the Lao People's Democratic Republic.

Kasamesiri, P., Meksumpun, C., Meksumpun, S., & Ruengsorn, C. (2021). Assessment on microplastics contamination in freshwater fish: A case study of the Ubolratana Reservoir, Thailand. *International Journal of GEOMATE 20* (77). doi: https://doi.org/10.21660/2020.77.6108

Kasamesiri, P., & Thaimuangphol, W. (2020). Microplastics ingestion by freshwater fish in the Chi River, Thailand. *International Journal of GEOMATE 18* (67), 114-119. DOI: https://doi.org/10.21660/2020.67.9110

Lahens, L., Strady, E., Kieu-Le, T. C., Dris, R., Boukerma, K., Rinnert, E., . . . Tassin, B. (2018). Macroplastic and microplastic contamination assessment of a tropical river (Saigon River, Vietnam) transversed by a developing megacity. *Environ Pollut, 236*, 661-671. doi:10.1016/j.envpol.2018.02.005

Le, K. (2021). First evaluation on microplastics abundance level in several wild aquatic organisms captured in the downstream of the Saigon – Dong Nai River system, Viet Nam. *Vietnam Journal of Science, Technology and Engieerning*.

Limpiteeprakan, P. (2020). Data analysis report Ubon Ratchathani, the Counter MEASURE Project.

Malakul, P., Nithitanakul, M., Charoensang, A., Butdee, K., Moochan, P., Preechawong, J., . . . Phiphattharakul, J. (2019). Report on plastic waste database development project based on material flow analysis concept.

Manomaivibool, P. (2020). Project: Promotion of countermeasures against marine plastic litter in Southeast Asia and India. Activity report: Chiang Rai Province, Thailand.

Meijer, L., van Emmerik, T., van der Ent, R., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. *Science Advances, 7*(18), eaaz5803. doi:10.1126/sciadv.aaz5803

Minh, V. (2020). Promotion of countermeasures against marine plastic litter in Viet Nam.

MRC. (1995). *Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin*. Vientiane: MRC Secretariat. https://doi.org/10.52107/mrc.akivwc

MRC. (2011). *Planning atlas of the Lower Mekong River Basin*. Vientiane: MRC Secretariat. https://bit.ly/3BhniKg

MRC. (2016). *Basin development strategy*. Vientiane: MRC Secretariat. https://mrcmekong.org/assets/Publications/strategies-workprog/MRC-BDP-strategy-complete-final-02.16.pdf

MRC. (2018). *2016 Lower Mekong regional water quality monitoring report*. Vientiane: MRC Secretariat. https://bit.ly/3P6erAE

MRC. (2019). *State of the basin report 2018*. Vientiane: MRC Secretariat. https://doi.org/10.52107/mrc.ajg54f

MRC. (2013). Integrated analysis of data from MRC fisheries monitoring programmes in the Lower Mekong Basin. Vientiane: MRC Secretariat.

MRC. (2021a). People. Retrieved from https://www.mrcmekong.org/about/mekong-basin/people/

MRC. (2021b*). Status and trends of fish abundance and diversity in the Lower Mekong Basin during 2007–2018*. Vientiane: MRC Secretariat.

Nguyen, T. T. (2017). Country chapter state of the 3Rs in Asia and the Pacific.

NPS/EXRI Asia. (2020). Report on quick survey for plastic waste related data and information in Phnom Penh under the project of promotion of countermeasure against marine plastic litter in Southeast Asia and India.

Ocean Conservancy. (2019). International coastal cleanup 2018 report.

Our World in Data. (2019). Mismanaged plastic waste 2019. Retrieved from http://bit.ly/3VOY51s

PCD of Thailand. (2019). Thailand's roadmap on plastic waste management 2018–2030 and action plan on plastic waste management 2018–2022.

PCD of Thailand. (2021). Thailand state of pollution report 2020.

Petroleum Institute of Thailand. (n.d. ). The amount of plastic production in Thailand.

Phuong, N. N. (2019). Contamination of microplastic in bivalve: First evaluation in Viet Nam. *Vietnam Journal of Science, Technology and Engineering 41*, 252–258.

Pirika. (2020). Survey on microplastic Leakage in the Mekong River Basin.

Rab, H. N., Martinez-Vasquez, J., Shah, A. M., Vu, Q. H., Nguyen, M. V., & Monkam, K. F. N. (2015). *Fiscal Decentralization Review in Vietnam: Making the Whole Greater than the Sum the Parts. Vol. 2: Main report (English).*

Rochman, C. M., Parnis, J. M., Browne, M. A., Serrato, S., Reiner, E. J., Robson, M., . . . Teh, S. J. (2017). Direct and indirect effects of different types of microplastics on freshwater prey (Corbicula fluminea) and their predator (Acipenser transmontanus). *PLoS One, 12*(11), e0187664. doi:10.1371/journal.pone.0187664

Ryan, P. G. (2018). Entanglement of birds in plastics and other synthetic materials. *Marine Pollution Bulletin, 135*, 159-164. doi:10.1016/j.marpolbul.2018.06.057

Schmidt, C., Krauth, K., & Wagner, S. (2017). Export of plastic debris by rivers into the sea. *Environmental Science & Technology*, *51*(21), 12246-12253. https://doi.org/10.1021/acs.est.7b02368

Sethy, S. (2017). Country chapter state of the 3Rs in Asia and the Pacific.

Statista. (2022). Global plastic production 1950-2020. Retrieved on 18 January 2022 from https://bit.ly/3uCuPzn

Sunwook, H. (2017). Addressing marine debris for a sustainable marine ecosystem in Ha Long City, Viet Nam. *Marine Litter News, Asia Pacific Civil Forum on Marine Litter*.

The Japan Industrial Waste Information Center. (2013). Aggregation unit and weight conversion factor for each type of industrial waste. Retrieved from https://bit.ly/3h7WBRq

Trash Hero. (2020). Trash hero annual report 2019. Retrieved from https://bit.ly/3FyHRVa

UNEP. (2017a). ASIA waste management outlook.

UNEP. (2017b). Summary report: Waste management in ASEAN countries.

UNEP. (2020a). Monitoring plastics in rivers and lakes.

UNEP. (2020b). Plastic leakage assessment and monitoring in river basin in Asia: A conceptual framework.

UNEP. (2020c). Capacity mapping for monitoring and assessment of plastic pollution in the Lower Mekong. Asian Institute of Technology. https://bit.ly/3VFakho

UNEP. (2020d). SEA circular country profile of VIET NAM.

UNEP. (2020e). Summary of CounterMEASURE project.

UNEP. (2020f). Survey on microplastic leakage in the Mekong River Basin.

Vietnam Chamber of Commerce and Industry (VCCI). (2019). Vietnam materials marketplace.

Votier, S. C., Archibald, K., Morgan, G., & Morgan, L. (2011). The use of plastic debris as nesting material by a colonial seabird and associated entanglement mortality. *Marine Pollution Bulletin*, *62*(1), 168-172. http://doi:10.1016/j.marpolbul.2010.11.009

World Bank. (2012). What a waste: A global review of solid waste management. Washington, DC: World Bank Group. http://hdl.handle.net/10986/17388

World Bank. (2018a). Solid and industrial hazardous waste management assessment: Options and action area to implement the national strategy. Washington, DC: World Bank Group. https://bit.ly/3gWuLY9

World Bank. (2018b). What a waste 2.0: A global snapshot of solid waste management to 2050. Urban Development Series. Washington, DC: World Bank. http://doi:10.1596/978-1-4648-1329-0

World Bank. (2020). The World Bank databank. Retrieved from https://databank.worldbank.org/home.

Yamashita, R., Takada, H., Fukuwaka, M.-a., & Watanuki, Y. (2011). Physical and chemical effects of ingested plastic debris on short-tailed shearwaters, Puffinus tenuirostris, in the North Pacific Ocean. *Marine Pollution Bulletin, 62*(12), 2845-2849. doi: http://doi.org/10.1016/j.marpolbul.2011.10.008

Young, L. C., Vanderlip, C., Duffy, D. C., & Afanasyev, V. (2009). Bringing home the trash: Do colony-based differences in foraging distribution lead to increased plastic ingestion in laysan albatrosses. PLoS ONE *4*(10): e7623. http://doi:10.1371/journal.pone.0007623

# 10. Annexes

## Annex 1 Riverine Environmental Monitoring Activities

Description: Ongoing riverine environmental monitoring programmes including water quality, sediment, fisheries, plankton, and hydrology, etc., in the country (methodology, location, parameters, frequency, organizations, etc.) will be possible activities for developing long-term/cost-effective riverine monitoring since the monitoring will be developed through the alignment with and possible integration into the ongoing monitoring activities. These explanations are described one by one.

### 10.1.1. Cambodia

**Table 1.** Summary of riverine environmental monitoring activities in Cambodia

| Organization | Type of monitoring | Budget | Items |
|---|---|---|---|
| Ministry of Water Resources and Meteorology (MOWRAM) | Water quality, sediment, hydrology | Fiscal year budget and MRC support | |
| Ministry of Agriculture, Forestry and Fisheries, Fisheries Administration | Fisheries, plankton | Fiscal year budget and MRC support | |
| Ministry of Environment (MOE) | Water quality, i.e. BOD, COD, total nitrogen, TSS, | Fiscal year budget | |
| Tonle Sap Authority | Fish monitoring<br>(reports on plastic survey at Tonle Sap) | Fiscal year budget and MRC support | |

### 10.1.2. Lao PDR

**Table 2.** Summary of riverine environmental monitoring activities in Lao PDR

| Organization | Type of monitoring | Budget | Items |
|---|---|---|---|
| Natural Resources and Environmental Research Institute (NRERI), Ministry of Natural Resources and environment (MONRE) | - Water quality | N.A. | - 11 sampling sites in the Mekong River flow through the country such a: Houakhong, LuangPrabang, Vientiane, Savannakhet, Pakse, Ban Hatkham, Ban Hai, HouayMakHioa, Ban Kengdone, Sebangfai and Sedone Bridge.<br>- Monitoring is conducted annually.<br>- The method employed follows the Standard Operating Procedure of Water Quality Monitoring Network (WQMN).<br>- The monitoring parameters include:<br>∗ Basic parameters: Temp, pH, EC, TSS, alkalinity, and DO<br>∗ Major ions: $Na^{+}$, $K^{+}$, $Ca^{+2}$, $Mg^{+2}$, $SO4^{-2}$, $Cl^{-}$ |

| Organization | Type of monitoring | Budget | Items |
|---|---|---|---|
| | | | * Nutrients: $NH4^{+}$, $NO2,3^{-}$, T-N, T-P<br>* Organic matter: COD<br>* Microbiology: BOD (Vientiane station), faecal coliforms<br>- This monitoring is reported annually. |

### 10.1.3. Thailand

**Table 3.** Summary of riverine environmental monitoring activities in Thailand

| Organization | Type of monitoring | Budget | Items |
|---|---|---|---|
| Pollution Control Department | Monitor water quality and report Water Quality Indices (WQIs). | Fiscal budget | - 76 automatic stations every 30 minutes<br>- Manual sampling 4 times a year. |
| Department of Water Resources (DWR) | Report daily on hydrology and telemetry from the Royal Irrigation Department (RID) and rainfall data from the Meteorological Department. | Fiscal budget | - Daily |
| Hydro-Informatics Institute (Public Organization) | • Compile all data from all sources; and<br>• Focus on integrating and analysing hydroinformatics data system, including research and the development of advanced tools and technologies to be applied by other related organizations. | Fiscal budget | - Over 900 stations are deployed and operated 24/7 countrywide, and the data are displayed in Internet GIS format at www.thaiwater.net |
| Royal Irrigation Department | • Water quality (especially salinity);<br>• Sediment – LL, PL, PI, grain density, particle size, metals X-ray fluorescence (XRF). | Fiscal budget and water consumption charge | - Daily report<br>- 25 watersheds stations<br>- 447 water reservoirs |
| Metropolitan Water Authority (MWA) | Monitor salinity | Fiscal budget and tap water fee | - More than 30 monitoring points along Chao Phraya River |
| Electricity Generating Authority of Thailand (EGAT) | Report of hydrology, telemetry of 11 dams | Fiscal budget and electricity fee | - 11 dams owned and operated by EGAT |
| Fishery Department | Project-based data collection on fish diversity, productivity, plankton diversity, etc. | Fiscal budget | - |

### 10.1.4. Viet Nam

**Table 4.** Summary of riverine environmental monitoring activities in Viet Nam

| Organization | Type of monitoring | Budget | Items |
|---|---|---|---|
| The Strategic Master Scheme for Hydro-Meteorological Network | Hydrology | | - 6 key stations; namely, the Tan Chau, My Thuan, Chau Doc, Can Tho, Vam Kenh and Vam Nao stations<br>- Real-time monitoring since 2020 |

| Organization | Type of monitoring | Budget | Items |
| --- | --- | --- | --- |
| (Southern Regional Hydrometeorological Center of the MONRE) | | | |
| The Strategic Master Scheme for Hydro-Meteorological Network (Southern Regional Hydrometeorological Center of MONRE) | Sediment | | Tan Chau and Chau Doc stations 2–3 times/month |
| Provincial Center for Environmental Monitoring under DONRE | Water quality | | - In Mekong Delta, there are 35 monitoring stations<br>- Quarterly basis<br>- Method of sampling and analysis follow national standards, the QCVN, which is mainly based on international methods such as the Standard Methods for the Examination of Water and Wastewater<br>- 15 basic parameters (pH, temperature, EC, TDS, DO, $BOD_5$, COD, TSS, Ammonium, nitrite, nitrate, Cd, Fe, Pb, CN) |
| The Centre of Water Quality and Environment, Southern Institute for Water Resources Planning, Viet Nam | Water quality | Vietnam National Mekong Committee (VNMC) | - 10 stations<br>- Monthly basis<br>- Water sampling, sample preservation, sample transportation and storage, are carried out in accordance with methods listed in the Technical Guidelines for the Procedures for Water Quality (PWQ) and the Technical Guidelines for the Procedures for Water Quality (TGWQ), which have been prepared in accordance with the 21st edition of the Standard Methods for the Examination of Water and Wastewater, or with national standards that comply with the requirements of the method validation of ISO/IEC 17025-2005.<br>- Temperature, pH, electrical conductivity, alkalinity/ acidity, dissolved oxygen (DO), chemical oxygen demand (COD), Total phosphorous (T-P), total nitrogen (T-N), ammonium ($NH_4$-N), total nitrite and nitrate ($NO_{2-3}$-N), faecal coliform, total suspended solid, calcium (Ca), magnesium (Mg), sodium (Na), |

| Organization | Type of monitoring | Budget | Items |
| --- | --- | --- | --- |
| | | | potassium (K), sulphate ($SO_4$), chloride (Cl), BOD5 |
| Southern Institute of Ecology | Four aquatic groups including benthic diatom, zooplankton, littoral invertebrates, and benthic macroinvertebrates | With funding from the VNMC | - Six monitoring activities were implemented: in 2008, 2011, 2013, 2015, 2017, and 2019. |
| Southern Institute of Ecology | | | - Eight sites on last sectionsof Mekong River belonging to Viet Nam territory<br>- Regular monitoring every two years<br>- MRC method, 2010. Biomonitoring Methods for the Lower Mekong Basin |
| Research Institute for Aquaculture II (RIA2) | Fish | | - at 7 locations in the Mekong Delta<br>- Every year<br>- MRC method (2010), Fisheries Programme 2011–2015. Programme Document |

## Annex 2. Status of solid waste treatment/disposal facilities in four Member Countries

**Table 5.** The number of solid waste treatment/disposal facilities in Cambodia

| No. | Treatment/disposal | No. of facilities | Capacity | Handling volume (tonne/year) |
|---|---|---|---|---|
| 1 | Incineration with an air pollution control system | 0 | 0 | 0 |
| 2 | Incineration without an air pollution control system | 35 | N/A | N/A |
| 3 | Sanitary landfill | 0 | 0 | 0 |
| 4 | Controlled landfill with more than 50 t/d of municipal solid waste (MSW) | 3 | N/A | N/A |
| 5 | Open dump | N/A | N/A | N/A |
| 6 | Open burning | N/A | N/A | N/A |
| 7 | Recycling facility | N/A | N/A | N/A |
| 8 | Others (compost, mechanical and biological treatment [MBT], refuse-derived fuel) | N/A | N/A | N/A |

**Table 6.** The number of solid waste treatment/disposal facilities in Lao PDR

| No. | Treatment/disposal | No. of facilities | Capacity | Handling volume (tonne/year) |
|---|---|---|---|---|
| 1 | Incineration with air pollution control system | N/A | N/A | N/A |
| 2 | Incineration without air pollution control system | 2 | 960 kg/day | 350.4 |
| 3 | Sanitary landfill | 1 | 100 ha | 131,400 |
| 4 | Controlled landfill with more than 50 t/d of municipal solid waste (MSW) | N/A | N/A | N/A |
| 5 | Open dump | N/A | N/A | N/A |
| 6 | Open burning | N/A | N/A | N/A |
| 7 | Recycling facility | N/A | N/A | N/A |
| 8 | Others (compost, mechanical and biological treatment [MBT],, refuse-derived fuel) | N/A | N/A | N/A |

**Table 7.** The number of solid waste treatment/disposal facilities in Thailand

| No. | Treatment/disposal | No. of facilities | Capacity | Handling volume (tonne/year) |
|---|---|---|---|---|
| 1 | Incineration with air pollution control system | 11 | N/A | N/A |
| 2 | Incineration without air pollution control system | 72 | N/A | 111,942 |

| No. | Treatment/disposal | No. of facilities | Capacity | Handling volume (tonne/year) |
|---|---|---|---|---|
| 3 | Sanitary landfill | 372 | N/A | N/A |
| 4 | Controlled landfill with more than 50 t/d of municipal solid waste (MSW) | 7 | N/A | 1,581,140 |
| 5 | Open dump | 2,123 | N/A | 3,928,420 |
| 6 | Open burning | 55 | N/A | 51,720 |
| 7 | Recycling facility | N/A | N/A | N/A |
| 8 | Others (compost, mechanical and biological treatment [MBT], refuse-derived fuel) | 26 | N/A | N/A |

**Table 8.** The number of solid waste treatment/disposal facilities in Viet Nam

| No. | Treatment/Disposal | No. of facilities | Capacity | Handling volume (tonne/year) |
|---|---|---|---|---|
| 1 | Incineration with air pollution control system | N/A | N/A | N/A |
| 2 | Incineration without air pollution control system | 50 | N/A | N/A |
| 3 | Sanitary landfill | 660, of which 204 is sanitary landfill | N/A | 7,384,701 |
| 4 | Controlled landfill with more than 50 t/d of MSW | N/A | N/A | N/A |
| 5 | Open dump | NA | N/A | N/A |
| 6 | Open burning | N/A | N/A | N/A |
| 7 | Recycling facility | N/A | N/A | N/A |
| 8 | Others (compost, mechanical and biological treatment [MBT],, refuse-derived fuel) | N/A | N/A | N/A |

## Annex 3. Waste Management Data Collection Survey Template

[**<u>Note to the survey administrator:</u>** Information for Questions 1 to 5 in this template should be obtained by interviewing relevant authorities of the ports/piers. Information for Question 6 should be obtained through visual inspection at the artificial barriers of the ports/piers]

<table>
<tr><th colspan="6">Waste Management Data Collection Sheet at a selected port in Mekong River Basin</th></tr>
<tr><th colspan="3">Item</th><th colspan="3">Result</th></tr>
<tr><td colspan="3">1. Name of the ports/piers</td><td colspan="3"></td></tr>
<tr><td colspan="3">2. Location of the site (with GPS and photo)</td><td colspan="3"></td></tr>
<tr><td colspan="3">3. Name of the interviewee(s)</td><td colspan="3"></td></tr>
<tr><td colspan="3">4. Roles and responsibilities of the interview(s)</td><td colspan="3"></td></tr>
<tr><td colspan="6">5. Basic Information of the site</td></tr>
<tr><td>5.1</td><td>Managing Authorities</td><td>Port Authority, municipality, private or others organizations ( )</td><td colspan="3"></td></tr>
<tr><td>5.2</td><td>Operation Authorities</td><td>Self-employed or under contract, name of the company if under contract</td><td colspan="3"></td></tr>
<tr><td rowspan="5">5.3</td><td rowspan="5">Responsibility/activity</td><td rowspan="5">Rank activities from the main activity to secondary activites, and estimate the volumes associated with each type of activity: e.g. tourism (number of ships and tourists, trade (number of cargo ship and container loading, Others ( )</td><td>Type of activities</td><td>Number of ships (operate /day)</td><td>Number of passenger/cargo containers/volume of goods (per day)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| | | | | |
| 5.4 | Any other information | | | |
| **6. Waste generation and management information** | | | | |
| 6.1 | Waste management and collection practices | Is the waste being collected or is openly disposed of on the street? Request a copy if possible of the waste management plan (if not, please take a photo of the waste management plan) | Main source of waste (e.g. port office, passing by tourist, ship operation) | 1.______________<br>2.______________<br>3.______________ |
| | | | Are there collection systems (bins) for waste generated at the port (on land)? | ☐ Yes ☐ No |
| | | | Are there collection systems (bins, specific disposal point) for waste generated by ships operating at the port? | ☐ Yes ☐ No |
| | | | If waste collection systems exist, are waste separated? | ☐ Yes ☐ No |
| | | | Is there a central waste collection point at the port? | ☐ Yes ☐ No |
| | | | Is a waste management plan available? <u>If the answer is YES, please request a copy (preferably an electronic one if possible)</u> | ☐ Yes ☐ No |
| | | | Are port/piers personnel aware of the existence of a waste management plan? | ☐ Yes ☐ No |
| | | | Are there designated personnel/Is there a department for waste collection and management activities? | ☐ Yes ☐ No |
| 6.2 | Daily amount of wastes generated (t/d) | (Daily amount of wastes generated at the ports). If not recorded, what is the estimated amount? | | |
| 6.2 | Waste composition or type of waste | If known (list all types of waste known and their estimated quantity), for | Type of waste | Estimated daily amount |
| | | | Food waste | |
| | | | Green waste (garden and park waste) | |

| | | | | |
|---|---|---|---|---|
| | | example, food waste, plastic, paper, oil (organic). | Paper and cardboard waste | |
| | | | Wood | |
| | | | Textiles | |
| | | | Nappies (disposable diapers) | |
| | | | Rubber and leather | |
| | | | Plastic waste | |
| | | | Metal | |
| | | | Glass, pottery and china | |
| | | | Face mask | |
| | | | Hydrocarbon waste (e.g. oil) | |
| | | | Electronic waste | |
| | | | Others | |

| | | | Methods | Unit available | Collection frequency | Estimate amount per collection (kg or volume) |
|---|---|---|---|---|---|---|
| 6.3 | Waste collection methods | What methods are used to collect daily generated waste at the port? | Waste collection bins | | | |
| | | | Scheduled routine clean-up | | | |
| | | | Event-based clean-up activities | | | |
| | | | Unscheduled clean-up due to the accumulation of waste | | | |
| | | | Open disposal of waste | | | |
| | | | Burning of waste | | | |

| | | | | |
|---|---|---|---|---|
| 6.4 | Waste separation method at the port (primary collection points or onsite waste sorting facility) | If waste is separated, what kind of materials are separated? (Are there separate bins for general waste and recyclable waste?) | Primary collection points<br>☐ Yes ☐ No | Types of waste separated: |
| | | | Port onsite waste sorting facility<br>☐ Yes ☐ No | Types of waste separated: |

| | | | Waste types | Removal types/ authorities (municipality, private contractor, dumping in river, illegal dump site) | Frequency of collection | Collection fee | Estimate amount per removal |
|---|---|---|---|---|---|---|---|
| 6.5 | How is the waste removed/managed from port? | Municipality, private contractor, dumping in the river, recycling, frequency of clean-up, others. | General waste (landfill) | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Recycle (plastic, metals, etc.) | | | | |
| | | | Oil (organic) | | | | |
| | | | Others | | | | |
| | | | Others | | | | |
| 6.6 | Any other information | Are there any reports on waste management? Take a photo of the accumulation area. | | | | | |
| **7. Management of accumulated waste that is transported by the river from upstream** | | | | | | | |
| 7.1 | Amount of (total) waste accumulation (per day, week, or year) | Estimation, weighing, specify the unit per timeframe (i.e. per day, per week, per year) | | | | | |
| 7.2 | Proportion of plastic waste accumulated | Estimation, weighing, specify the unit per timeframe (i.e. per day, per week, per year) | | | | | |
| 7.3 | Most common type of plastic waste observed | Specify which type is the most commonlyu observed and estimate percentage out of all plastic waste types | | | | | |
| 7.4 | How is accumulated waste in river managed? | Is a private company engaged for clean-up? the local government? port personnel? | | | | | |
| 7.5 | Methods used for waste clean-up | Collected manually, collected by heavy equipment, not collected or just remove to the river | | | | | |
| 7.6 | Frequency of clean-up | How often does the clean-up occur? | | | | | |
| 7.7 | When is the last clean-up | Day/month/year, any photos, others | | | | | |
| **8. Visual observation of accumulated at the barrier of the port** | | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| P8.2 | Estimate the total amount of accumulated wastes | All types of waste should be considered (including plastic, glass, wood, etc.) | | | |
| 8.3 | Estimate the total amount of accumulated plastic wastes | Estimation can be made either in total weight or in proportion | | | |
| 8.4 | How many types of plastic waste can be observe and what are they? | Identify all types of plastic that be seen and list them all | **Type of plastic** | **Estimate weight or percentage** | **Take Photo** |
| | | | Food container | | |
| | | | Plastic bottle | | |
| | | | Plastic bag | | |
| | | | Plastic cup, plate, spoon, knife, fork, etc. | | |
| | | | Styrofoam | | |
| | | | Other: | | |
| | | | Other: | | |
| | | | Other: | | |

Mekong River Commission Secretariat

P. O. Box 6101, 184 Fa Ngoum Road, Unit 18 Ban Sithane Neua,
Sikhottabong District, Vientiane 01000, Lao PDR
Tel: +856 21 263 263. Fax: +856 21 263 264
www.mrcmekong.org

© Mekong River Commission 2022