Guidelines for

Community-led Marine Litter Survey in Mangroves

Indonesia

JANUS

Regional Knowledge Centre
for Marine Plastic Debris

ERIA
Economic Research Institute
for ASEAN and East Asia

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INTRODUCTION

The purpose of the guidelines

1. INTRODUCTION

1.1. Background

Mangrove forests are unique ecosystems that thrive in the interface between land and sea.[1] The Indonesia-sponsored UNEA-4 resolution, "Sustainable management for the global health of mangroves", acknowledges mangroves as an important but fragile ecosystem with invaluable biological diversity. Mangrove forests have several crucial functions, including serving as natural filtering systems that can control various forms of pollution, acting as carbon sinks and reservoirs, reducing adverse impacts of climate change, and providing protection from natural disasters such as tropical storms, hurricanes, tsunamis, and coastal erosion. The resolution also encourages UN member states and relevant stakeholders to strengthen and formulate policies to prevent waste disposal into mangrove ecosystems and minimize human-induced pollution.[2]

Litter in the environment can negatively affect society, the economy, and living and non-living environment. For example, beach litter destroys landscapes, diminishing their value as tourist resources. Drifting litter threatens safe ship navigation, while sea floor litter disrupts fishing activities. There are also concerns about the impact of litter on the animals that inhabit these environments, such as those that may accidentally ingest or become entangled in the litter.

Recently, ever worsening plastic pollution in the ocean is threatening the sound ecosystem of mangrove forests. Through the "Pilot Project of Floating and Drifted Marine Plastics in Mangroves", which is an ERIA project being implemented in Indonesia from 2023-2025 with a focus on understanding and solving the litter problem in mangroves, it was confirmed that not only coastal beaches, but also mangrove forests are exposed to drifted marine plastic debris. Plastic debris entangled in small mangrove trees can inhibit their growth and negatively impact the preservation of mangrove forests for future generations. There are concerns not only about the health of the mangrove trees, but also how it could reduce the habitats available to faunal groups[3] and affect local communities that benefit from the ecosystem, both environmentally and financially. For these reasons, it is necessary to take measures to reduce marine litter, including plastics, within the mangrove forests and to contribute to the conservation and restoration of mangroves.

In Indonesia, macro- and meso-debris surveys on beaches have been conducted nationwide, but marine litter surveys on mangroves are still limited. In order to identify the appropriate measures to protect mangrove forests against marine drifted debris, it is becoming more important than ever to conduct in-depth studies to understand the reality on the ground.

Mangroves have the ability to trap marine litter due to their intertwining roots. In addition, many mangroves are located at estuaries, directly exposing them to debris carried by rivers. Consequently, the influence of land-based litter on mangroves is prominent. As a result, the composition of marine litter in mangroves can differ from that of the beach.

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[1] UNEP website. "Mangrove Forest", https://www.unep.org/topics/ocean-seas-and-coasts/blue-ecosystems/mangrove-forests (accessed on 7 Sep 2024)
[2] UNEP/EA.4/L.13. https://leap.unep.org/sites/default/files/unea-resolutions/Sustainable%2520Manage.pdf (accessed on 7 Sep 2024)
[3] Kantharajan, G et al., 2018. Plastics: a menace to the mangrove ecosystems of megacity Mumbai, India. ISME/GLOMIS Electronic Journal 16 (1), 1–5.

For countries with large mangrove areas, understanding the composition of beach litter alone may not provide a comprehensive understanding of the overall marine litter situation in the country. It is necessary to take into account the composition of marine litter specifically in the mangroves as it provides a scientific basis for prioritizing measures and evaluating their effectiveness to reduce marine litter because the composition indicates the type of litter commonly found in mangroves and helps to estimate the source of the litter. Furthermore, it also raises the public awareness and interest of local communities and leads to the promotion of mangrove clean-up and conservation.

1.2. Purpose of the Guidelines

The expected outputs of the "Pilot Project of Floating and Drifted Marine Plastics in Mangroves" are mainly twofold:

(1) Develop Guidelines for Community-led Marine Litter Survey in Mangroves in Indonesia

(2) Develop Guidelines for Community-led Marine Litter Clean-up Activities in Mangroves in Indonesia

This report is the first output listed above, aiming to illuminate the types and amount of (plastic) litter commonly observed in mangroves in each of the pilot project sites selected in Indonesia.

It is to be noted that the survey methodologies suggested here are, by design, not expected to meet the most rigorous international standards, nor to employ any high-tech equipment. Instead, the guidelines are intended to make community-led surveys accessible and easy, without the involvement of specialized staff or tools to ensure that the survey is conducted nationwide and to promote countermeasures according to the actual situation of marine litter in each region.

Once the plastic waste commonly found in the given mangrove areas is identified using the methodologies suggested in the guidelines, this information will in turn be useful for the following:

- To better prepare community-led clean-up activities, based on the types and amount of plastic waste to be expected in the area.

- To develop educational and awareness raising campaigns/materials to reduce the plastic waste leakages at the source, focusing on the top items identified by the survey.

- To engage in advance with recyclers and waste management facilities, to ensure proper management of the waste collected after the clean-up campaign.

- To evaluate periodically, the evolution of the marine litter situation within the same mangrove areas over time.

The project's objective is to propose a sustainable community-led clean-up campaign, based on data-driven understanding of marine litter in the mangrove areas in Indonesia. Although this project was conducted in Indonesia, it is however hoped that the lessons learned from this project can also provide useful insights to other ASEAN countries where mangrove conservation against plastic debris is becoming increasingly important.

1.3. Definition and Terminology

The definition of marine litter or marine debris in the guidelines is "any persistent, manufactured, or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment".[4] Marine debris can be grouped into several categories based on their size. The target size of marine debris for the survey described in these guidelines is plastic debris that is 2.5 cm or longer, also known as macro debris.

1.4. Guideline Development

Globally, there are few surveys on marine debris conducted in mangroves, despite their importance as a shoreline habitat.[5]

Although debris survey methods in mangrove areas are scarce, several guidelines for beach litter surveys do exist as follows, and were used as a reference to develop the guidelines.

- – the Marine Litter Monitoring Guidelines of Indonesia's Ministry of Environment (Kementerian Lingkungan Hidup or in short KLH)[6]
- – the Japanese guidelines for beach litter composition monitoring[7]

To gather the necessary information for creating the guidelines, actual surveys of drifted litter in mangroves in Indonesia were conducted. (See Annex 1 for the general overview of the survey.)

After some desktop review followed by field visits, Balikpapan in East Kalimantan Province and Deli Serdang in North Sumatra Province were selected as the survey locations based on the following criteria:

1. **Existence of a proper waste disposal system**
   Reason: Even if litter is collected, it may be released back into the environment if there is no proper waste management system in place.

2. **Confirmation of large amount of litter**
   Reason: Overall larger sample quantities allow for generally more reliable data on marine litter composition, and they help in assessing the impact of litter on the environment.

3. **Presence of mangrove**
   Reason: The objective of the survey described in the guidelines is to understand the actual situation of marine litter in the mangroves.

4. **Cooperation from the local community**

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[4] UNEP. (1995). Global Programme of Action for the Protection of the Marine Environment from L-based Activities, United Nations Environment Programme, Nairobi.

[5] GESAMP (2019). Guidelines or the monitoring and assessment of plastic litter and microplastics in the ocean (Kershaw P.J., Turra A. and Galgani F. editors), (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 99, p130.

[6] Edisi Kedua, Pedoman Pemantauan Sampah Laut: Sampah Pantai, Sampah Mengapung, dan Sampah Dasar Laut. © Direktorat Pengendalian Pencemaran dan Kerusakan Pesisir dan Laut –

[7] https://www.env.go.jp/content/900543326.pdf (language: Japanese)

Reason: Local support is necessary to obtain their collaboration and avoid concerns from residents during the survey. Obtaining local knowledge also makes it easier to understand appropriate survey locations and tidal patterns, and to identify the types of litter found in any given area. In addition, there is a possibility that conducting the survey based on the guidelines in the long term through collaboration with the local community will contribute to understanding changes in the characteristics of marine debris in mangroves.
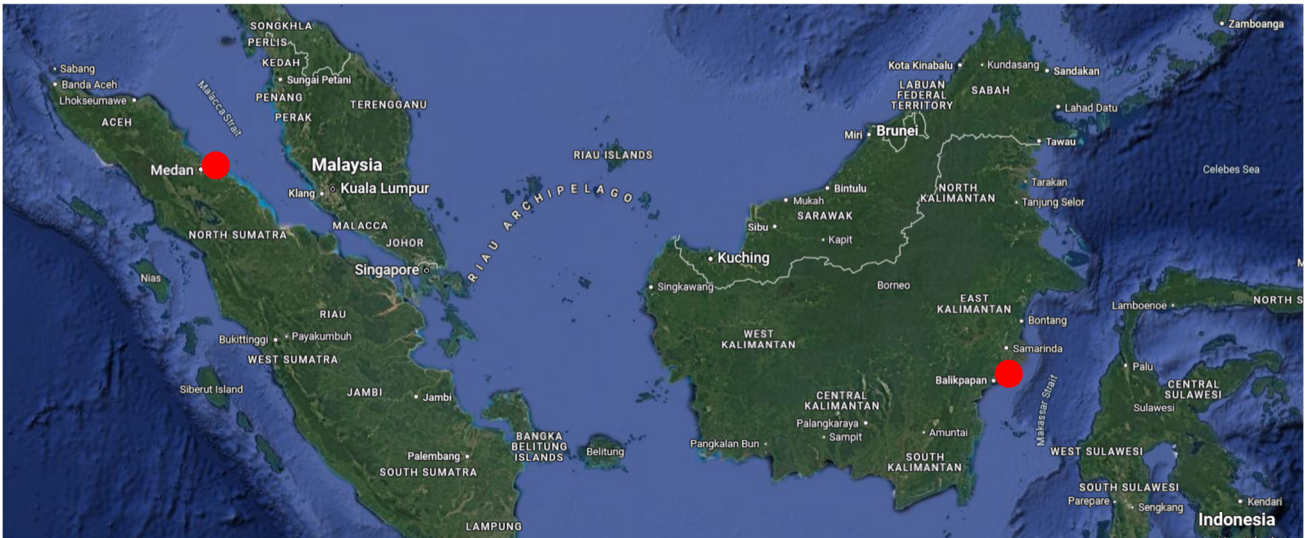
Imagery ©2024 TerraMetrics, Map data ©2024 Google

Figure 1. Survey locations (left red circle: Deli Serdang, right red circle: Balikpapan)

1.5. Scope of the Guidelines

1.5.1. Survey field

The guidelines propose to select survey sites that are accessible by foot without special safety considerations, prioritizing the practicality of the survey activities. Although other survey methods for marine litter in mangroves exist (e.g., using a vessel), to ensure feasibility, the present guidelines suggest a survey method that is both low-cost and accessible, requiring minimal technical skills to implement. In other words, the contents of the guidelines are intended for surveying marine litter on the ground, not for survey fields such as the water surface, water column, or water bottom.

1.5.2. Targeted audiences

The target audiences of these guidelines include:

- Local government and policymakers for their actions against marine litter including plastic pollution
- Academic institutions for their relevant research
- Citizen scientists concerned about national and local environment
- NGOs and other environmental organizations

1.6. Structure of the Guidelines

The guidelines are divided into 5 chapters, as outlined in Table 1. The guidelines start with 1. INTRODUCTION, which provides the background and purpose of the guidelines, the types of surveys covered, and definitions and terminology. The users of the guidelines are invited to read 2. SURVEY PLAN AND PREPARATION, 3. SURVEY IMPLEMENTATION, and 4. SURVEY RESULT ASSESSMENT in this numerical order, and proceed with the survey based on the recommendations and other information.

Each chapter is structured to align with the chronological order of the survey. For instance, the selection of the survey region and location is described in Chapter 2, which is the planning stage of the survey. In contrast, the selection of the survey area (i.e., where the survey lots are set) is explained in Chapter 3, which is the implementing stage of the survey, since it depends on the litter drift conditions on the day of the survey.

As for the description of the number, volume, and weight of litter, how to measure them is described in Chapter 3, while the organization and analysis of this data are covered in Chapter 4, which is the assessment stage, since these activities take place after the survey is completed.

Chapter 5 summarizes the guidelines, enabling readers to quickly grasp the key points of them.

As additional resources, Annex 1 provides the general overview of the survey in the pilot project, and Annex 2 provides pictures of each type of litter listed in the classification table. These images can assist readers in associating the item names in the table with the actual litter found in the environment.

Table 1. Guideline chapter outlines

Chapter	Contents
1. INTRODUCTION	− Background, purpose, scope, and structure of the guidelines − Definition and terminology
2. SURVEY PLAN AND PREPARATION	− How to select the survey location, timing − What to do to prepare (required procedures, ensuring proper waste management) − What and where to procure for the survey − How to collaborate with local communities
3. SURVEY IMPLEMENTATION	− How to survey in a step-by-step approach − Points to consider at each step of the survey − How to classify collected litter
4. SURVEY RESULT ASSESSMENT	− How to organize data (creating rankings of marine litter composition, marine litter density) − How to harmonize other data such as beach litter survey results for data comparison
5. CONCLUSION	− Summary of the guidelines − Usefulness of the guidelines − Characteristics of the guidelines

Chapter 2

SURVEY PLAN AND PREPARATION

How to select survey locations and timing

2. SURVEY PLAN AND PREPARATION

2.1. Survey Location

The following are the list of criteria for selecting survey locations:

☐ Areas with mangrove forests, while preferably avoiding high-density mangrove areas in order to conduct surveys without damaging existing trees;
☐ Areas where municipal solid waste accumulation has been regularly observed;
☐ Sites where the health and safety of the surveyors are ensured (e.g., avoid sites where untreated sewage is directly discharged, etc.);
☐ Areas that surveyors can access by foot (e.g. avoid extremely muddy areas);
☐ Areas where cars can access relatively closer to the site (adjacent to a road).

Figure 2. Examples of suitable survey locations (left: Pantai Hutan Mangrove Pendopo in Balikpapan, right: Serambi Deli beach in Deli Serdang)

2.2. Survey Timing

2.2.1. Survey season

It is important to determine the survey season, taking into account ocean currents, seasonal winds, beach orientation, beach clean-up schedule and frequency, and other factors that affect the amount of litter. If it was simply about the number of debris observed, it is desirable to conduct the survey during the season when large amounts of marine debris are drifting in the mangroves, such as when the seasonal wind blows toward the coast, in order to obtain a large sample amount (i.e., drifting litter). However, it is advisable to postpone the survey right after a storm, primarily because the composition of the litter may be significantly different from normal conditions, in addition to ensuring the safety of the surveyors.

Figure 3. Survey in August in Balikpapan, East Kalimantan

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It is advisable to consider existing research[8] cases that take these factors into account when deciding on the survey season.

2.2.2. Survey frequency

The survey frequency is determined based on the survey purpose. Although human resource and budget constraints may limit the frequency of surveys, it is desirable to continue to conduct surveys as often as possible to understand changes over time. In order to continuously observe the change over time, it is recommended to conduct a survey at a regular interval, such as once a year, during similar conditions to make a more valid comparison.

2.2.3. Survey time

Once the approximate survey date(s) is determined, the following points should be considered in deciding the survey timing:

–   Conducting the survey when the tide is low, to ensure easy accessibility within the mangroves and the safety of surveyors;

Surveying at high tide should be avoided

Figure 4. The difference between low tide and high tide in the same area in Deli Serdang

–   Marine litter collection must be completed in one day to avoid the possibility of new debris drifting into the survey area. Therefore, marine litter collection should be completed by the next high tide, to allow comparative analysis;

–   It is advisable to start the survey early in the morning taking into account that it becomes difficult to visually measure each litter once the sun goes down;

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[8] Noir P. Purba et al., 2021. Marine debris pathway across Indonesian boundary seas. Journal of Ecological Engineering 2021, 22(3), 82–98

–   It is also recommended to avoid the time during the day when the temperature is extremely high (generally from noon to 2-3 o'clock in the afternoon) to avoid the risk of heatstroke posed to the surveyors. Litter collection, which is relatively hard work, should be done in the morning (6AM to 12PM);

–   Avoid surveying during or right after heavy rain, as collected marine litter will weigh more with water, hindering accurate data comparison across sites and over time, in addition to the risk posed to the surveyors.

Better to avoid rainy days

Figure 5. Images of a rainy day

2.3.   Required Procedures

To obtain community support and collaboration, the following preparatory steps were deemed vital before the on-site survey itself was planned:

☐   It is recommended that the community leaders are given a preliminary briefing regarding the upcoming survey;

☐   It is important to check with local authorities for any legal procedures to be filed beforehand;

☐   Ensure the collected waste from the survey is treated adequately, applying the do-no-harm principles.

Figure 6. Consulting with local authorities

2.4.   Waste Treatment

Collected marine litter from the survey must be treated adequately, to ensure that the survey itself will not have any negative impacts on the environment.

Local waste treatment/disposal systems vary from region to region. In general, the way collected waste is officially handled can be categorized into three scenarios:

1. Delivery to a nearby landfill (licensed and unlicensed)
2. Delivery to a waste bank (waste banks segregate recyclable/valuable waste and sell them to the recycling facilities in bulk)
3. Direct delivery to recycling facilities

Figure 7. Waste treatment facilities (left: landfill, center: waste bank, right: recycling facility)

Delivery to a landfill is simpler as it does not require segregation and cleaning, but from a circular economy perspective, Options 2 and 3 are preferable. Since recycling facilities are generally limited in number compared to the waste bank, bringing the collected marine litter to a nearby waste bank (Option 2) is more practical. However, this option is also not without challenge. To be accepted by the waste bank, recyclable waste has to be relatively clean and dry, while mangrove waste tends to be muddy and/or wet. From the limited survey experience in Balikpapan in East Kalimantan Province and Deli Serdang in North Sumatra Province, the project team found that in reality, most of the waste would have to be carried to the nearby landfill. This points to the fact that for similar survey or waste collection in Indonesia, although Options 2 and 3 are preferable, Option 1 (landfill) should be anticipated to be the most realistic course of action.

To prevent collected waste from leaking back into the environment, it is advisable to check local waste treatment/disposal facilities on site. If it is not possible to transfer the collected litter to the landfill, waste bank, or recycling facilities on the same day after the survey, they should be stored in a secure and dry place to prevent them from getting wet or leaking back into the environment.
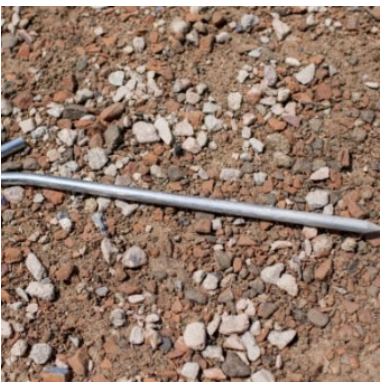
Figure 8. Checking waste treatment/disposal facilities on site

2.5. Procurement and Preparation of Survey Materials and Equipment

The lists of survey materials and the local shops where they were purchased are shown in Table 2 and Table 3.

Table 2. The list of survey materials and equipment

Materials and equipment to delimit the survey area	
PP rope (30m) x 5 rolls	50m roll meter
Peg (bamboo poles or other materials can be used instead)	Hammer (for pegging)
Square ruler (to enclose the survey area within a 10-meter square)	Scissors (to cut ropes)

Materials and equipment to collect marine litter	

Woven sandbags for waste |

Gloves |
|

Saw or knife
(To cut only the exposed portion of the partially buried waste. Scissors can be used for thin and soft materials.) |

Permanent marker
(To write the survey lot number on each woven sandbag) |
| **Materials and equipment to sort marine litter** | |
|

Sorting containers
(Approximately 30 or more. The capacity of each container should be measured in advance and written on the container.) |

Blue tarp
(To spread collected waste to make sorting easier) |

Materials and equipment to measure marine litter	

Tally counter
(To count a large number of waste without error) |

Digital scale
(The yellow round tool is a horizontal leveler, which helps to measure weights accurately.) |
|

Container for measuring the volume of waste (Can also be used as a sorting container) |

Digital fishing scale
(To measure a large weight of items) |
| Materials and equipment to record the survey result | |
|

Stationery |
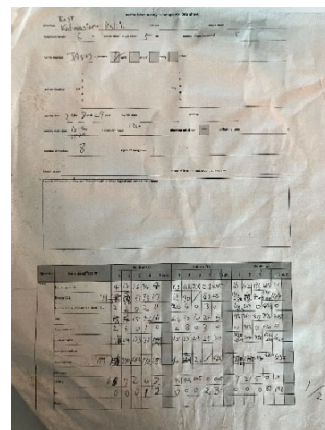
Data sheet |

 White board (Waterproof is better for when it rains)	 **Digital camera**
 Handy GPS (To record the accurate position of survey location)	 **Compass**
Other materials and equipment	
 Trolley bag (Convenient for carrying survey equipment)	 **First-aid kit**
 Insect repellent (Waterproof is better for when it rains)	 **Bags**
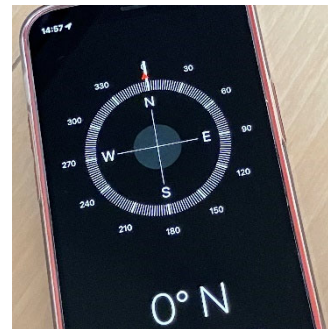
Table 3. Examples of stores that sell survey materials and equipment

Shops in Balikpapan	Survey materials and equipment
	- PP rope (30m) x 5 rolls - Hammer for pegging - 50m roll meter - Sorting containers (approximately 30) - Plastic bags for waste - Gloves
	- Digital scale
	- Litter collection bags - 20 handles for dustpans (as an alternative to pegs, bamboo poles are also considered an option)
	- Blue tarp (left shop) - Tally counter (right shop)
	- Insect repellent

2.6. Survey Organization and Role Assignment

2.6.1. Required team for the survey

The team members and their respective roles required in the survey are listed in Table 4.

Table 4. The main roles required in the survey

Role	Task
Coordinator	Survey planning and preparation, coordination with collaborators etc.
Survey director	Giving instructions to surveyors, recording the survey data etc.
Safety manager	Anticipating survey hazards and ensuring safety
Survey director assistant	Setting and recording the survey compartment
Collector	Picking up the marine litter drifted in mangrove forests
Litter sorter	Sorting collected marine litter based on litter item list
Measurers	Measuring mass, volume, and the number of collected marine litter
Waste treatment operator	Transportation, recycling, and/or disposal of collected marine litter

2.6.2. Arrangements with local organizations

Potential partners for the survey are listed in Table 5.

Table 5. Potential partners

Potential partners	Roles
Local government environmental agency	– The purpose of this activity is consistent with the environmental policy of the local government – To share survey data for use in environmental policy – To explain that coordination is necessary to comply with laws and regulations and to avoid problems with the community – To properly dispose of collected waste
University	– To exchange knowledge with each other – To be able to take advantage of experience in beach litter survey
Waste bank	– To receive trash of value
Fishermen's group	– To contribute to the reduction of marine litter in the fishing area
Mangrove-based tourism facility management organization	– To contribute to the reduction of marine litter in the facility
Clean-up activity group	– To collaborate with existing activities to promote future activities
Student group	– To collaborate with existing activities to promote future activities

2.6.3. Number of survey team members

The number of people needed for a survey depends on the amount of litter, the density of mangroves and litter, the substrate of the survey area etc. Examples of the number of people along with the amount of litter collected are listed in Table 6. Since one person can have multiple roles in Table 4, a minimum of about seven members are needed to carry out the operation effectively. (See Table 7.)

Table 6 shows the relationship between the number of surveyors and the amount of litter collected in the two project sites. The difference in the number of surveyors in the two sites was due to the amount

of litter and availability of people who are willing to do volunteer work. Upon reflection, having more people in the survey was beneficial because it enabled the team to easily collect a large number of litter and reach more people for capacity building and raising awareness.

Table 6. Relationship between number of surveyors and the amount of litter collected

Survey site	Number of team members	Amount of litter collected
Pantai Hutan Mangrove Pendopo in Balikpapan	8 to 9 people	Number: 1809 pcs, Volume: 414 L, Weight: 22245 g, Litter density: approx. 14 pcs per m^2
Serambi Deli beach in Deli Serdang	19 people	Number: 613 pcs, Volume: 253 L, Weight: 31788 g, Litter density: approx. 5 pcs per m^2

Note: Each survey area is 125 m^2 (5 box of 5m x 5m)

Table 7. An idea of the minimum number of people needed to complete the survey

Role	Number of people needed to complete the survey
Coordinator	1
Survey director	
Safety manager	2 - 3
Survey director assistant	
Measurers	
Collector	3 - 4
Litter sorter	
Waste treatment operator	

Chapter 3

SURVEY IMPLEMENTATION

How to conduct the survey

3. SURVEY IMPLEMENTATION

3.1. Survey Flow

In short, the survey flow can be summarized in five steps as shown below.

Figure 9. Survey flow

3.2. Survey Method

Given the lack of mangrove litter survey guidelines, the survey method was developed referring to the other guidelines for monitoring beach litter.[6,7]

The specific survey procedures and considerations for each survey step are shown in Table 8.

Table 8. Specific survey processes and considerations

Step	Task	Points to consider
1	 Kick off meeting	− Explain the time schedule of the day to complete the survey. − Conduct safety check before starting the survey e.g., checking the physical condition of each person, distributing insect repellent, confirming food and drinks for the team distributing gloves etc. − Explain the role assignment.

2	Select survey area	– Select five (5) square shaped areas of 5m x 5m. – Select areas with high marine litter density for the study. (See image on the left.) – Exclude areas where waste is evidently dumped intentionally from the survey area, regardless of the high waste density. (See image below.) – Select the highest waste density areas to establish a standardized methodology and to compare waste composition and volume over time and across different survey sites. So, five areas with the visibly highest litter concentration should be selected. – Remind the team members not to stray away from the group to avoid the risk of getting lost in the forest. – Avoid a high mangrove tree density area as it prevents the operation from being conducted smoothly.

3	Record site information	– Check if any type of litter is collected by local people, as this may bias the composition of marine litter. (See images on the left for locally collected PET bottles and plastic cups.)
		
		– Record the meta data listed below.
		
		   o beach name
		   o beach usage
		   o potential litter sources around survey area
		   o coastal substrate
		   o weather
		   o types of mangroves in the survey site
		   o others (See Figure 10)
		
		– Record site information in advance during a preliminary survey of the survey site.

4	 Set the survey lot (5 m x 5 m)	– Surround the survey area with rope, hammer, peg, roll meter, square ruler etc. – Cut the rope into appropriate lengths (about 30 meters) in advance. – Remind the team members not to damage the roots or branches of the mangroves during the survey. – Attach a ribbon or other highly visible colored item to the equipment to prevent loss of the equipment.
5	 Check the position coordinates	– Obtain latitude and longitude information at each survey lot. – Turn on Handy GPS before the survey, as it may take time to obtain latitude and longitude information. – Verify by comparing latitude and longitude with data from other survey lots on site, as sometimes incorrect information is obtained. – Record the information on the data sheet. (See Figure 10.)
6	 Take photos before collecting litter	– Take a photo with a white board with the survey lot number written on it to avoid confusion after the survey. – Take a photo from an angle where the litter is clearly visible before collecting the litter. – Avoid surveying during rain as it may cause raindrops on the camera lens resulting in blurred images. (See image below.)

7	 Collect litter Cut litter	– Collect artificial litter larger than 2.5 cm. – Separate collection bags by survey lot to compare the composition of marine litter. – Do not dig any buried waste to establish a standardized method. Instead, cut them at the surface level when collecting. (See image on the left.) Digging out the buried waste will consume time, with no tangible merit to the survey results.
8	 Take photos after collecting litter	– Take a photo after the collection is completed from the same angle as the one taken before the waste collection. – Include in the photo, a white board indicating the survey lot number, and the state of the collection (e.g., "after the waste collection"). – Prepare a waterproof board with the necessary information already written on it, if there is a risk of rain during the operation.
9	 Sort collected litter Sort collected litter when raining	– Wash away any mud or sand on the waste before sorting marine litter, especially if the mud or sand significantly affects the mass of the litter. – First, lay out a blue tarp and spread out the collected litter, separated by each survey lot. – Second, sort the waste by material (i.e., plastic, paper, metal, etc.). – Finally, sort in detail based on the classification table. (See Table 9 - Table 12.) – If it is raining, set up a rain shelter and perform the measurement. (See image on the left.)

10	 Quality control	– Double-check the classified litter, as the litter classification may be incorrect. – Quality control performed by an experienced person will increase the accuracy of the classification.
11	 Measure number of pieces of litter	– Count the number of pieces by each classified item. – A tally counter (see image on the left) is useful when counting a large number of items. – There is no use in counting the number of pieces of litter that are easily fragmented (see image below). This can be counted as 1 piece.
12	 Measure weight	– Measure the weight of each classified litter item using a digital scale. – A digital scale with a lower limit of 1 gram or less is preferable, as some collected items can be very lightweight. – It is important to keep the digital scale level (see images below) to accurately measure the weight. – A digital fishing scale (see following images) is useful when measuring heavy and/or big litter.

13	\nMeasure litter volume	– Volume is measured by placing the collected litter in containers of known capacity and measuring without pressure.\n\n– Litter volume is useful in assessing the impact on disposal costs and the landscape.
14	\nRecord the survey result	– Record the number of pieces, volume, and weight of each litter item. (See Figure 12, Figure 13.)\n\n– Check for errors or blanks in the data sheet by comparing the number of pieces, volume, and weight.\n\n– It is recommended to take a photo of the completed data sheet for backup purposes.
15	\nTake photos of each item	– Take photos of each litter with a white board indicating the litter type and survey lot number.\n\n– Taking photos of each litter item is helpful in verifying the contents of the data sheet after the survey.

16	 Tidy up	− Trash on the blue tarp should be collected with a broom and dustpan. − The collected litter is delivered to a waste bank, etc. − While measuring, it is better to put the already measured waste into the trash bags according to the waste bank classification. (See the image in the upper left.) − Wash the used equipment. (See image below.)
17	 Finish	− Check the equipment list to make sure there are no items left behind. − Suggest taking a photo of all the participants to disseminate information about community activities.

3.3. Litter Classification

Litter classification was created considering the following 3 sources:

1. UNEP/IOC guidelines (2009)[9]
2. Dominant litter types at the survey sites of the "Pilot Project of Floating and Drifted Marine Plastics in Mangroves" (ERIA)
3. Classification of the local waste bank

Pictures of each item are shown in Annex 2. Based on this classification, it is possible to customize it for more detailed classification of specific items according to regional circumstances.

To harmonize with the beach litter data in Indonesia, the classification table was designed to allow conversion to the UNEP classification items. (See Table 9 - Table 12.)

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[9] Cheshire et al., (2009). UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter. UNEP Regional Seas Reports and Studies, No. 186; IOC Technical Series No. 83: xii + 120 pp.

Table 9. Litter classification table (1/4)

Material	Item classification			
	This guideline	UNEP guidelines		
		Code	Litter type	
Plastic	Bottle caps & lids	PL01	Bottle caps & lids	
	Bottles < 2 L	PL02	Bottles < 2 L	
	Bottles, drums, jerrycans & buckets > 2 L	PL03	Bottles, drums, jerrycans & buckets > 2 L	
	Cups	PL06	Food containers (fast food, cups, lunch boxes & similar)	
	Food containers	PL06	Food containers (fast food, cups, lunch boxes & similar)	
	Food packages	PL06	Food containers (fast food, cups, lunch boxes & similar)	
	Detergent packages **Do not classify as food packages**	PL07	Plastic bags (opaque & clear)	
	Shopping bags	PL07	Plastic bags (opaque & clear)	
	Other bags	PL07	Plastic bags (opaque & clear)	

Table 10. Litter classification table (2/4)

Material	Item classification			
	This guideline	UNEP guidelines		
			Code	Litter type
	Cutlery		PL04	Knives, forks, spoons, straws, stirrers, (cutlery)
	Fishing net		PL20	Fishing net
	Rope		PL19	Rope
	String and cord		PL24	Other
	Seedling pot Do not classify as shopping bags		PL24	Other
	Fabric sheet & bag (blue tarp, sand bag etc.)		PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)
	Mica plastic		PL06	Food containers (fast food, cups, lunch boxes & similar)
	Sheet pieces		PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)
	Hard plastic fragment		PL24	Other

Table 11. Litter classification table (3/4)

| Material | Item classification | | |
| | This guideline | UNEP guidelines | |
		Code	Litter type
	Other ( )	-	-
	Other ( )	-	-
	Other ( )	-	-
	Others (plastic)	PL24	Other
Foam plastic	-	FP05	Other (specify)
Rubber	Footwear	RB02	Footwear (flip-flops)
	Others (rubber)	RB08	Other
Glass and Ceramics	Drink bottle	GC02	Bottles & jars
	Others (glass and ceramics)	GC08	Other

Table 12. Litter classification table (4/4)

Material	Item classification		
	This guideline	UNEP guidelines	
		Code	Litter type
Metal	Drink can	ME03	Aluminium drink cans
	Others (metal)	ME10	Other
Paper and Cardboard	Drink containers	PC03	Cups, food trays, food wrappers, cigarette packs, drink containers
	Others (paper and cardboard)	PC05	Other
Fabric	-	CL06	Other cloth (including rags)
Wood	-	WD06	Other
Other	Diaper	OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)
	Other	OT05	Other
Large sized litter (> 1 m)	-	-	-

3.4. Data Sheet

The data sheet is shown in Figure 10 - Figure 13. The data sheet can be downloaded from the following URL: https://bit.ly/ERIAMangroveGuidelines.

Figure 10. Data sheet format (1/4)
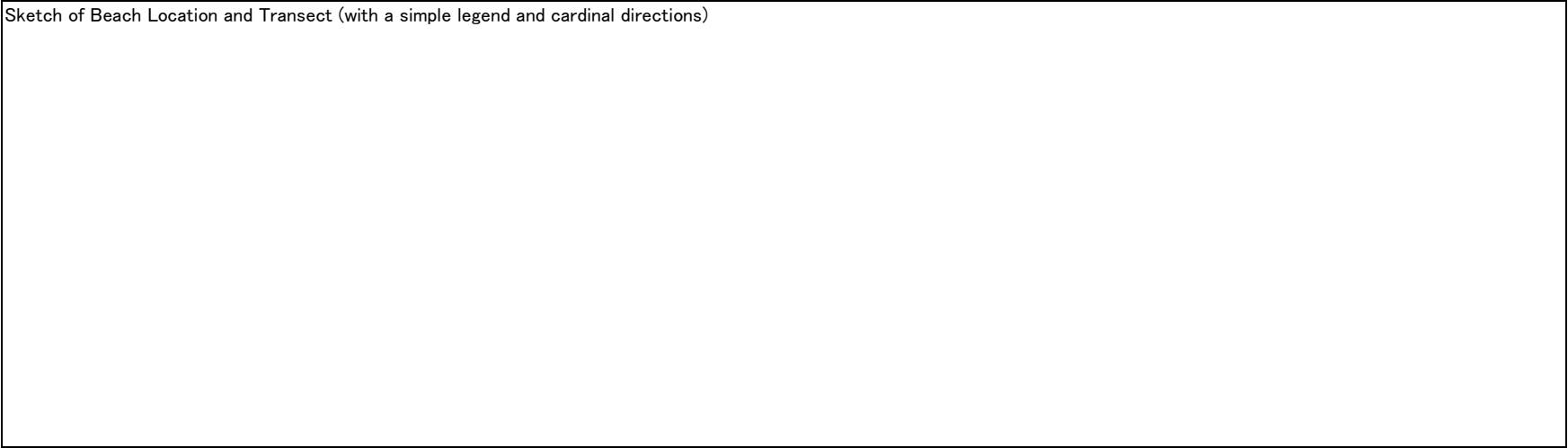
number of workers _____   types of mangroves _____

beach usage _____   potential litter sources around survey area _____

Sketch of Beach Location and Transect (with a simple legend and cardinal directions)

Figure 11. Data sheet format (2/4)

Material	item classification	Number (n)						Volume (L)						Weight (g)					
		1	2	3	4	5	sum	1	2	3	4	5	sum	1	2	3	4	5	sum
Plastic	Bottle caps & lids																		
	Bottles < 2 L																		
	Bottles, drums, jerrycans & buckets > 2 L																		
	Cups																		
	Food containers																		
	Food packages																		
	Detergent packages																		
	Shopping bags																		
	Other bags																		
	Cutlery																		
	Fishing net																		
	Rope																		
	String and cord																		
	Seedling pot																		
	Fabric sheet & bag (blue tarp, sand bag etc.)																		
	Mica plastic																		
	Sheet pieces																		

Figure 12. Data sheet format (3/4)

	Hard plastic fragment																				
	Other ( )																				
	Other ( )																				
	Other ( )																				
	Others (plastic)																				
Foam plastic	–																				
Rubber	Footwear																				
	Others (rubber)																				
Glass and Ceramics	Drink bottle																				
	Others (glass and ceramics)																				
Metal	Drink can																				
	Others (metal)																				
Paper and Cardboard	Drink containers																				
	Others (paper and cardboard)																				
Fabric	–																				
Wood	–																				
Other	Diaper																				
	Others																				
Large sized litter (> 1 m)																					

Figure 13. Data sheet format (4/4)

Chapter 4

SURVEY RESULT ASSESSMENT

Litter commonly found in mangroves

4. SURVEY RESULT ASSESSMENT

4.1. Rankings of Marine Litter Composition (number, weight, volume)

In order to implement effective actions to reduce plastic litter, it is suggested that countermeasures should be taken in accordance with the most frequently found items in the environment. This chapter describes a method to rank litter, with the objective of facilitating the decision-making as to which litter types should be targeted with priority. It is desirable to create rankings not only by numerical quantity of litter, but also by weight or volume to avoid biased evaluation of the actual marine litter situation (e.g., one large net may have more negative impact on the navigation than ten small net pieces). The main uses for each data unit are shown in Table 13.

Table 13. Main uses of each data unit

Data unit	Uses of the data
Quantity of litter	– Easy to use for data comparison with other clean-up activities such as International Coastal Clean-up (ICC) – To quantify the workload required for collecting marine litter – To assess the abundance of marine litter
Weight of litter	– From the perspective of assessing navigation hazards then mass may be more appropriate[5] – To develop a solid waste management plan
Volume of litter	– To assess the impact on the landscape – To develop a solid waste management plan

To understand the general characteristics of the survey site, the survey data for each lot is summed to create a ranking.

Table 14. Example of litter composition ranking (Quantity of litter)

Rank	Item classification	Number (pcs)	Ratio (%)
1	Shopping bags_PL	219	35.7
2	Food containers and packages_PL	138	22.5
3	Other bags_PL	65	10.6
4	Mica plastic_PL	29	4.7
5	Seedling pot_PL	28	4.6
6	Fabric_CL	23	3.8
7	Fabric sheet & bag (blue tarp, sandbag etc.)_PL	22	3.6
8	Detergent packages_PL	20	3.3
9	Fishing Net_PL	15	2.4
10	Diaper_OT	10	1.6

Source: Survey* in August 2023 in Pantai Serambi Deli, Deli Serdang, North Sumatra
(* A general overview of the survey conditions in the pilot project is described in Annex 1)

Because there is a risk of misleading the understanding of the current status of the litter by looking at the ranking by number of pieces only, ranking by weight and/or volume should also be created.

Table 15. Example of litter composition ranking (Weight)

Rank	Item classification	Weight (gram)	Ratio (%)
1	Fabric_CL	10,691	33.6
2	Shopping bags_PL	7,027	22.1
3	Fabric sheet & bag (blue tarp, sandbag etc.)_PL	4,428	13.9
4	Diaper_OT	1,957	6.2
5	Fishing net_PL	1,694	5.3
6	Food containers and packages_PL	1,396	4.4
7	Seedling pot_PL	968	3.0
8	Drink bottle_GC	963	3.0
9	Other bags_PL	875	2.8
10	Mica plastic_PL	606	1.9

Source: Survey in August 2023 in Pantai Serambi Deli, Deli Serdang, North Sumatra

Table 16. Example of litter composition ranking (Volume)

Rank	Item classification	Volume (Liter)	Ratio (%)
1	Shopping bags_PL	62.2	24.6
2	Fabric sheet & bag (blue tarp, sandbag etc.)_PL	42.2	16.7
3	Fabric_CL	37.0	14.7
4	Other bags_PL	24.5	9.7
5	Mica plastic_PL	17.4	6.9
6	Food containers and packages_PL	16.7	6.6
7	Seedling pot_PL	14.1	5.6
8	Fishing net_PL	11.4	4.5
9	String and cord_PL	6.8	2.7
10	Diaper_OT	6.4	2.5

Source: Survey in August 2023 in Pantai Serambi Deli, Deli Serdang, North Sumatra

In order to check whether there is any spatial bias in the composition of beach litter, rankings are also created for each survey lot.

Table 17 shows that plastic shopping bags are ubiquitous in all survey lots.

Table 17. Example of litter composition rankings by each compartment (quantity of litter)

Survey lot number	Rank	Item classification	**Number (pcs)**	Ratio (%)
1	1	Shopping bags_PL	26	26.3
	2	Food containers and packages_PL	20	20.2
	3	Seedling pot_PL	10	10.1
2	1	Shopping bags_PL	81	59.1
	2	Fabric sheet & bag (blue tarp, sandbag etc.)_PL	11	8.0
	3	Other bags_PL	7	5.1
3	1	Shopping bags_PL	50	28.2
	2	Food containers and packages_PL	47	26.6
	3	Other bags_PL	34	19.2
4	1	Shopping bags_PL	36	34.6
	2	Food containers and packages_PL	33	31.7
	3	Other bags_PL	10	9.6
5	1	Food containers and packages_PL	32	33.3
	2	Shopping bags_PL	26	27.1
	3	Mica plastic_PL	10	10.4

Source: Survey in August 2023 in Pantai Serambi Deli, Deli Serdang, North Sumatra

4.2. Marine Litter Density

The data on marine litter density in mangroves should not simply be compared with the data on beach litter density, as the method used to select the survey lot was different (i.e., the beach litter survey based on the monitoring guidelines of KLH shows the representative litter density. On the other hand, the marine litter survey in mangroves based on the guidelines shows the maximum litter density). However, in order to raise public awareness regarding the marine litter pollution in mangroves and to encourage clean-up activities etc., it is considered important to show the litter density in mangroves. In addition, organizing the litter density in mangroves is also effective for comparison with the data from mangroves in other areas.

Therefore, the following is an example of litter density calculation.

Table 18. Example of litter density calculation

Survey lot No.	Number of litter (pcs)	Litter weight (g)	Litter volume (L)	Survey area (m^2)
1	182	3030	75.5	25
2	451	3543	70.9	25
3	534	9485	160.4	25
4	222	1059	22.91	25
5	420	5128	84.4	25
Sum	1809	22245	414.11	125
Density	**14.5 pcs/m^2**	**178.0 g/m^2**	**3.3 L/m^2**	

Source: Survey in August 2023 in Pantai Hutan Mangrove Pendopo, Balikpapan, East Kalimantan

4.3. Data Comparison

To compare the composition of beach litter with marine litter in mangroves in Indonesia, the item classification should be converted to the UNEP classification.

The following are examples of marine litter rankings in mangroves Table 9 - Table 12 to convert the litter item categories. The ranking table before classification conversion clearly shows the types of items commonly found in the area. The ranking table after classification conversion makes it easy to compare beach litter data from Indonesia and other countries.

Rank	Item classification (based on the guidelines*)	Number (pcs)	Ratio (%)
1	Shopping bags_PL	219	35.7
2	Food containers and packages_PL	138	22.5
3	Other bags_PL	65	10.6
4	Mica plastic_PL	29	4.7
5	Seedling pot_PL	28	4.6
6	Fabric_CL	23	3.8
7	Fabric sheet & bag (blue tarp, sandbag etc.)_PL	22	3.6
8	Detergent packages_PL	20	3.3
9	Fishing Net_PL	15	2.4
10	Diaper_OT	10	1.6

* Some of the item classification names in this table differ slightly from those in the guidelines because the item classifications were not finalized at the time of the 2023 survey.

Rank	Item classification (based on the UNEP classification)	Number (pcs)	Ratio (%)
1	Plastic bags (opaque & clear)_PL07	304	49.6
2	Food containers* (fast food, cups, lunch boxes & similar)_PL06	175	28.5
3	Other_PL24	39	6.4
4	Other cloth (including rags)_CL06	23	3.8
5	Sheeting (tarpaulin or other woven plastic bags, palette wrap)_PL16	22	3.6
6	Fishing net_PL20	15	2.4
7	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)_OT02	10	1.6
8	Bottles & jars_GC02	5	0.8
9	Cardboard boxes & fragments_PC02	4	0.7
10	Knives, forks, spoons, straws, stirrers, (cutlery)_PL04	3	0.5
10	Rubber bands_RB06	3	0.5

* Food containers include food packages

Source: Survey in August 2023 in Pantai Serambi Deli, Deli Serdang, North Sumatra

Figure 14. Survey data conversion (upper table: before conversion, bottom table: after conversion)

5. Conclusion

These guidelines outline methods for planning, preparing, conducting, and assessing the results of surveys on the composition of marine litter within mangroves. The primary goal is to comprehend the actual state of marine litter and promote countermeasures.

Compared to beach litter surveys, conducting surveys within mangroves is inherently more challenging, and there is a general lack of understanding. However, utilizing the guidelines can help reduce the difficulty of such surveys.

The findings from surveys conducted based on the guidelines can answer questions regarding the types of litter prevalent in local mangroves. These findings will provide scientific evidence for policymaking related to marine litter.

Furthermore, the guidelines contribute to raising public awareness and encouraging action regarding mangrove conservation and waste management.

In developing the guidelines, several existing beach litter monitoring guidelines with similar methodologies were referred to. However, there are three notable differences:

- **Simplified Classification**: The greatest challenge in beach litter surveys is the need to classify nearly 100 types of litter. In practice, certain types of litter often dominate the composition. Based on the survey results in Indonesia, the guidelines focus on frequently found litter types across regions and provide a simplified classification table. The table allows for customization based on regional circumstances, acknowledging the variability in litter composition by each region.

- **Focus on Composition Reliability**: The guidelines emphasize methods to understand litter composition accurately. To enhance reliability, they recommend collecting as much litter as possible and selecting survey lots in areas with higher litter density rather than randomly. Additional considerations to avoid bias in litter composition are also outlined.

- **User-Friendly, Visual Approach**: Existing guidelines often rely heavily on pedantic explanations with limited clarity on specific survey procedures. The guidelines organize survey procedures in chronological order and employ visual aids, such as photographs, to make the process comprehensible even for non-experts.

Although the guidelines do not cover methods for surveying litter on the water surface, within the water column, or on the water bottom, they are considered applicable to litter deposited on substrates within mangroves, not only in Indonesia but also in mangrove regions of other countries.

The implementation of surveys based on the guidelines is expected to advance marine litter countermeasures and mangrove conservation initiatives.

Annex 1. General overview of the survey in the pilot project

No.		1	2
Sites	province	East Kalimantan	North Sumatra
	city/prefecture	Balikpapan	Deli Serdang
	district	Teritip	Pantai Labu
	beach name	Pantai Hutan Mangrove Pendopo	Serambi Deli
Area		125 m^2 (5 lots of 5m x 5m)	125 m^2 (5 lots of 5m x 5m)
Timing	date	24/8/2023	30/8/2023
	time	Collection: 9:30 -12:00 Measurement: 13:00-16:20	Collection: 11:00 -12:00 Measurement: 13:40-15:55
	weather	Sunny with intermittent rain	Sunny
	low tide time	1 p.m.	10:30 a.m.
Surveyor		Total 8-9 person JANUS 3+1, administrator of mangroves 1, Waste bank 3-4	Total 19 person JANUS 3+1, N-Sumatra gov. 4, Waste bank 2, Deli Serdang gov. 3, University 6
Clean-up activities		No	Yes (only plastic drink bottle (PET) and plastic drink cup)
Types of mangroves		Rhizophora mucronate (dominant), Rhizophora apiculate, Avicennia marina, Avicennia alba, Avicennia officinalis, Sonneratia alba	Rhizophora mucronata (dominant), Kandelia candel, Avicennia sp. (unidentified), Burguiera sp. (unidentified)
Beach usage		Fishing (commercial, recreation), aquaculture, tourism, mangrove reforestation	Tourism, restaurant, mangrove reforestation
Potential litter sources around survey area		Sea based, land based	From coastal restaurants and homes, and homes in the watershed area of nearby river

The amount of collected marine debris in mangroves	Number: 1809 pcs, Volume: 414 L, Weight: 22245 g Number density: approx. 14 pcs per m^2	Number: 613 pcs, Volume: 253 L, Weight: 31788 g Number density: approx. 5 pcs per m^2
Top litter type	Shopping bags (plastic) Number: 804 pcs (44.4%), Volume: 188 L (45.4%), Weight: 12814 g (57.6%)	Shopping bags (plastic) Number: 219 pcs (35.7 %), Volume: 62 L (24.6 %), Weight*: 7027 g (22.1%) * As for weight, shopping bags rank second.

Figure 1 The location of the survey lots (left: Balikpapan, right: Deli Serdang)

Annex 2. Pictures of each litter item

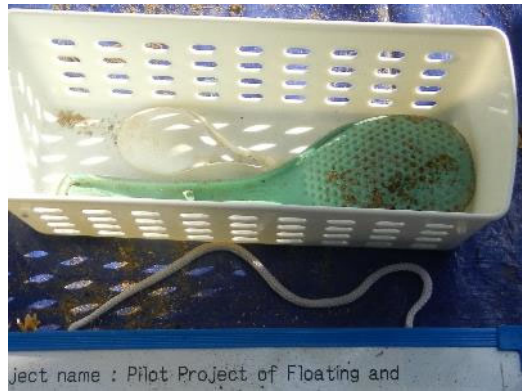| Plastic	
1_Bottle caps & lids	2_Bottles < 2L
3_Bottles, drums, jerrycans & buckets > 2 L	4_Cups
5_Food containers	6_Food packages

7_Detergent packages	8_Shopping bags
9_Other bags	10_Cutlery
11_Fishing net	12_Rope

13_String and cord	14_Seedling pot
15_Fabric sheet & bag (blue tarp, sandbag etc.)	16_Mica plastic
17_Sheet pieces fragment	18_Hard plastic

Foam plastic	
19_Foam plastic	

Rubber	Glass and Ceramics
20_Footwear	21_Drink bottle

Metal	Paper and Cardboard
22_Drink can	23_Drink containers

Fabric	Wood
24_Fabric	25_Wood

Other	
26_Diaper	27_Other