TRAIN THE TRAINER

Guidebook on Marine Plastic Waste for Educators

ASEAN-Japan Eco-School Program

2022

ASEAN-JAPAN CENTRE

About the ASEAN-Japan Centre

The ASEAN Promotion Centre on Trade, Investment and Tourism (ASEAN-Japan Centre) is an intergovernmental organization established by the ASEAN Member States and Japan in 1981. It has been promoting exports from the ASEAN Member States to Japan while revitalizing investment, tourism as well as people-to-people exchanges between the ASEAN Member States and Japan through seminars, workshops, capacity building programs, research and policy analysis, cross-cultural events, publication and information services, among others.

About the ASEAN-Japan Eco-School Program

At the request of the governments of ASEAN and Japan, the ASEAN-Japan Centre (AJC) launched a project with a special focus on the marine plastic waste problem, which was taken up as a priority issue in multilateral frameworks, such as the G20 and the Japan-ASEAN Summit.

In 2020, AJC launched the "Future Leaders' Declaration on ASEAN-Japan Cooperation for International Marine Plastic Waste"[1] by the 22 students from Japan and ASEAN.

In 2021, the "ASEAN-Hiroshima Eco-School for Marine Plastic Waste Education" was conducted as a pilot programme consisting of online classes taught by the "Future Leaders[2]" from ASEAN and Japan, with the aim of implementing the recommendations in Clause 18 (Education and awareness) and Clause 24 (Youth Engagement) of the Declaration.

In 2022, AJC aims to expand the reach of the previous projects and develop trainers who can educate their peers on marine plastic waste, through an online course called "Train the Trainer." This program is intended for individuals in public and private sectors, especially the education sector, and create an informal pool of educators, who will promote awareness and knowledge on the issue of marine plastic waste in ASEAN and Japan.

[1] https://www.asean.or.jp/ja/wp-content/uploads/sites/2/Declaration-full_Intl-format-20210304-Final-signed.pdf

[2] Refers to the 22 students from the 10 ASEAN member states and Japan who drafted the "Future Leaders' Declaration on ASEAN-Japan Cooperation for International Marine Plastic Waste" in March 2021.

Acknowledgements

The *Train the Trainer Guidebook* is part of the ASEAN-Japan Ecoschool Program on Marine Plastic Waste by the ASEAN-Japan Centre. It succeeds the "Future Leaders' Declaration on ASEAN-Japan Cooperation for International Marine Plastic Waste" and the "ASEAN-Hiroshima Eco-School" projects, both of which were launched in Fiscal Year (FY) 2020-2021.

The guidebook was developed by the following Future Leaders from ASEAN member states and Japan.

Country	Full name	University/Company	Specialization
Malaysia	MOHD FAUZEE, Yasmin Nabilah	Nara Institute of Science and Technology (PhD)	Applied Stress Molecular Microbiology
Lao PDR	CHANTHAVONG, Souphaphone	The University of Tokyo Graduate School (MSc)	Socio-Cultural Environmental Studies
Cambodia	POEUNG, Srey Pich	The University of Tokyo Graduate School (MSc)	Environment System
Philippines	BARTOCILLO, Aye Mee	Silliman University (*Balik* Scientist)	Natural History Science
Indonesia	NURLATIFAH	Kumamoto University Graduate School (PhD)	Environmental Chemistry and Toxicology
Indonesia	SANTOSO, Shelvy	NiX Co., Ltd. (Hydrological Engineer)	Environment and Civil Engineering
Myanmar	TUN, Thant Zin	Kumamoto University Graduate School (PhD)	Environmental Chemistry and Toxicology
Japan	MASUDA, Haruna	Kyoto University Graduate School of Environment	Environmental management

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Introduction

Marine plastic waste is a global environmental issue that threatens the future of our oceans and of humanity. In 2015, the global production of plastics reached 322 million metric tons, out of which 4.8-12.7 million metric tons are discharged into the ocean "as macroscopic litter and microplastic particles" (Jambeck et al., 2015; Worm et al., 2017). The presence of marine litter and debris impacts not only marine life, but also our socio-economic and cultural systems. Research suggests that it has the potential to reduce production of commercial fisheries, contaminate the food chain, human consumption of microplastics through contaminated organisms, endanger marine life, and shift the ecology of marine life, among others (Beaumont et al., 2019). This reflects that marine plastic waste has significant economic and social costs.

The problem of marine plastic waste has become a pressing global problem that has garnered the attention of governments and international organizations, especially in the ASEAN region and Japan. In response to the growing need to address this problem, the ASEAN-Japan Centre has developed the "Train the Trainers", which is a short training course designed for individuals in the government, private sector, and education sector. It is developed to raise future educators of marine plastic waste and promote awareness and behavioral change in their own communities. This Guidebook serves as the textbook companion to the training course and provides the essential and latest information on the issue of marine plastic waste and initiatives in ASEAN and Japan.

Objectives

The goal of the *Train the Trainer Guidebook* is to offer educators the basic knowledge needed to understand the issue of plastic pollution and its impact to the environment, particularly in the context of ASEAN and Japan, and develop the skills to educate their students and peers. We hope it will assist educators in relaying the knowledge to the students in the way you see appropriate.

How to use the guidebook

The guidebook is intended to provide background information on marine plastic waste which would be useful for the trainers'/learners' reference for their future teaching sessions.

The guidebook is divided into 3 main chapters:

1. What is Plastic
2. Plastic Pollution in ASEAN, Japan, and the World
3. Innovative Solutions and Alternatives to Plastic

In addition to providing discussion about the topics, suggested activities for each topic are provided in the Appendix section to make the lesson more interactive. These activities correspond to the knowledge and information learned from each topic and aids in its practical application.

These **suggested activities** can be included or excluded in the trainers' own teaching plan as you deem necessary.

Chapter Overview

"By 2050, there will be more plastic in the sea than fish", this estimation is reported by environmentalist Ellen MacArthur in the World Economic Forum 2016. Plastic is a common material found in many of our everyday objects, and its improper disposal has been associated with increased risk to human and marine life. As seen in Figure 1, plastic used in everyday activities often end up in the environment, blocking waterways and eventually reaching the oceans because of improper disposal. The problem of plastic and its impact in the environment has started various discourses on its utility and finding alternatives to plastic.

Figure 1. Plastic importance and the impact on the environment

Plastic has become a convenience in our lives due to its certain characteristics. Even though people have been using it a lot, many remain unfamiliar with the origin and end destination of this material and its implications for the environment and our futures.

In this guidebook, the learner is introduced to the life cycle of plastic and the different means of its proper disposal, the problem of marine plastic waste and its impact on the environment, and alternative products to plastic and innovative technologies that offer new ways to combat the plastic problem. At the end of each chapter, the learner is expected to achieve the following:

- Chapter 1: What is plastic?
  - Objective: to be equipped with general knowledge about plastic, its origin, and its advantages and disadvantages.
- Chapter 2: Plastic pollution in the world
  - Objective: to be familiar with global plastic production, circular economy, and the impact of plastic waste on the environment particularly in marine life.
- Chapter 3: Innovative solutions and alternatives to plastic
  - Objective: to develop ideas on how to be a part of the solution, the region's ongoing actions and vital intervention through plastic circular economy.

Chapter 1:

What is Plastic?

Chapter 1: What is Plastic?

1.1. Plastic characteristics

Different types of plastic are used in packaging products. It is important to teach students about the different types and characteristics of plastic that are commonly used in daily life. To stimulate your class discussion, you can begin with a question, "What are the characteristics of plastic?"

Table 1. Characteristics of plastic

Cheap	**Attractive finishing (colored)**	**Poor electrical conductor**
Easy to shape	Good transparency	(Some) Resistant to chemical reaction
Light in weight	Do not rust	
Water resistant	Not easily burn	

- **Appearance:** Plastics can be transparent or colored. They can also be shaped into different shapes and size based on their intended use.
- **Tensile strength:** The materials used in plastic manufacturing determine the tensile strength or toughness of plastics. Plastics typically have lower tensile strength or toughness than metals like steel (Li, Wang, et al., 2020).
- **Lightweight:** Plastics are lighter than metals, making them easier to transport or move.
- **Unreactive to chemicals:** Compared to natural polymers like cotton, wool, and so on, plastics are unaffected by acids and alkaline.
- **Thermal conductivity:** Plastics have a limited heat conductivity, as a result, they melt when they come into contact with heat (Sekar et al., 2021).
- **Electrical conductivity:** Plastics are good insulators and poor current conductors. This characteristic makes it a suitable material in the manufacturing of switches, bulb holders, and the outer covering of cables, among other things (Sekar et al., 2021).

As we learn about plastic characteristics, we now realize the reason behind their incorporation into our daily lives. This raises a new question about how manufacturers create plastic objects with distinct characteristics. What kind of additional chemicals do they add during the process to make some plastic objects like the plastic chair stronger but some others, like PET bottles, easier to crumple?

The following section discusses the production of plastics.

1.2. Process of making plastic

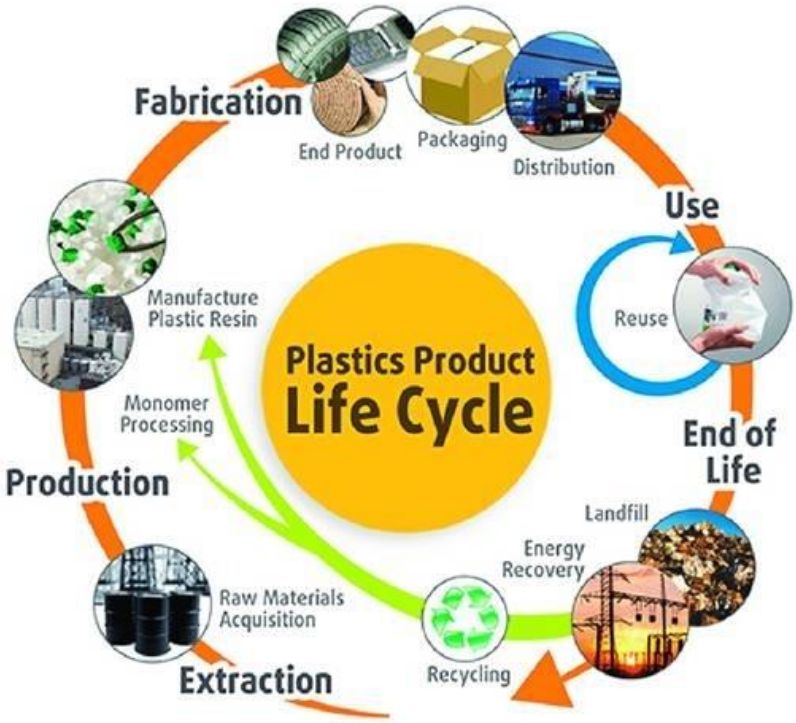
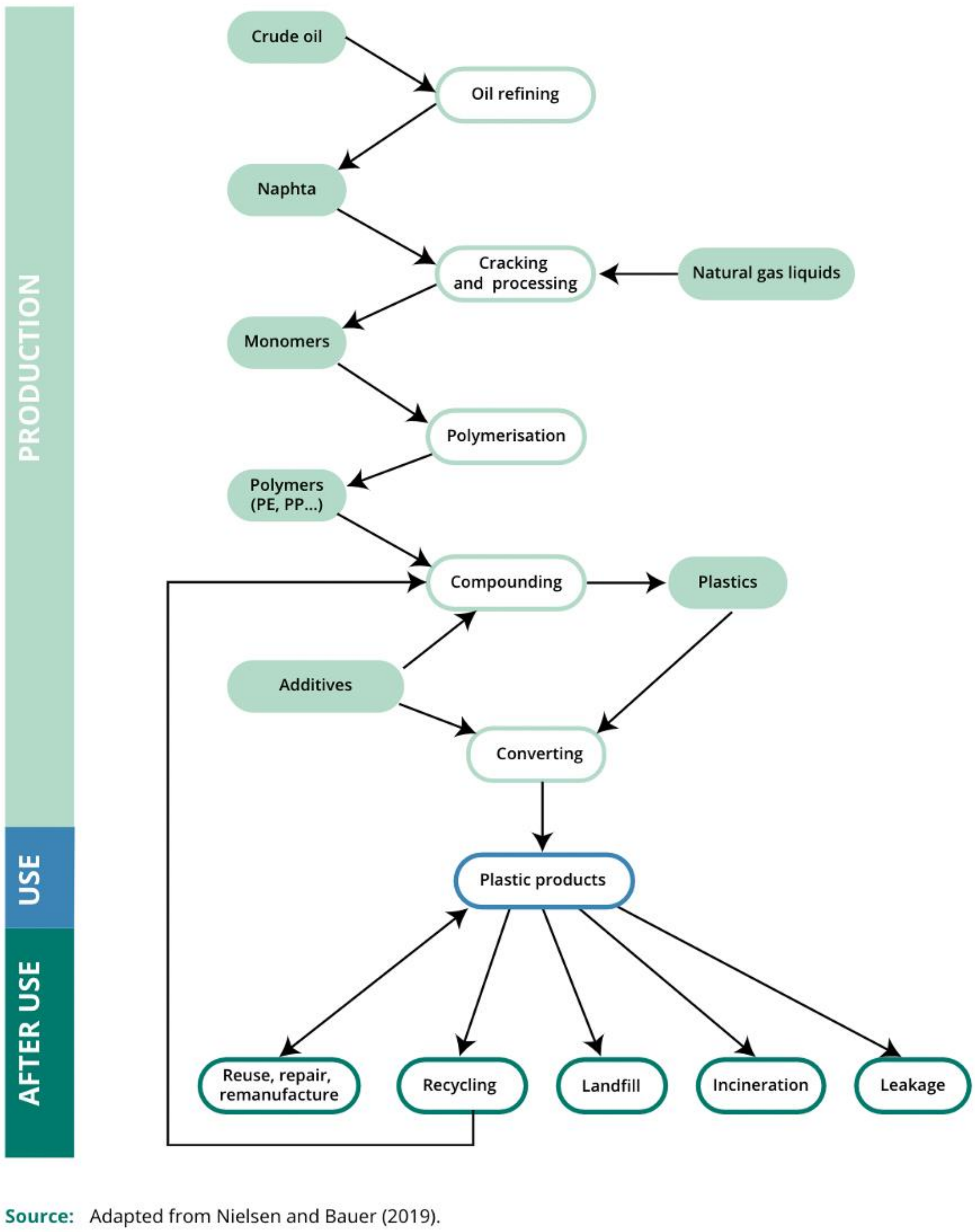


Figure 2. Life cycle of plastic

*Source: (*2019 Asia Manufacturing Summit: Creating a Circular Economy for Plastic*, n.d.; Hahladakis et al., 2018)*

Plastic is primarily made from fossil fuels, such as petroleum. This means that it is **extracted** through mining before going through a lengthy **production** process to convert it into plastic resin. This resin is then **fabricated or modified** to give it the desired properties before being molded into the intended end product, such as a plastic bottle. This plastic object is then **packed** and **distributed** to us, the consumers. As it reaches us and **serves its purpose,** plastic is discarded and **thrown away.**

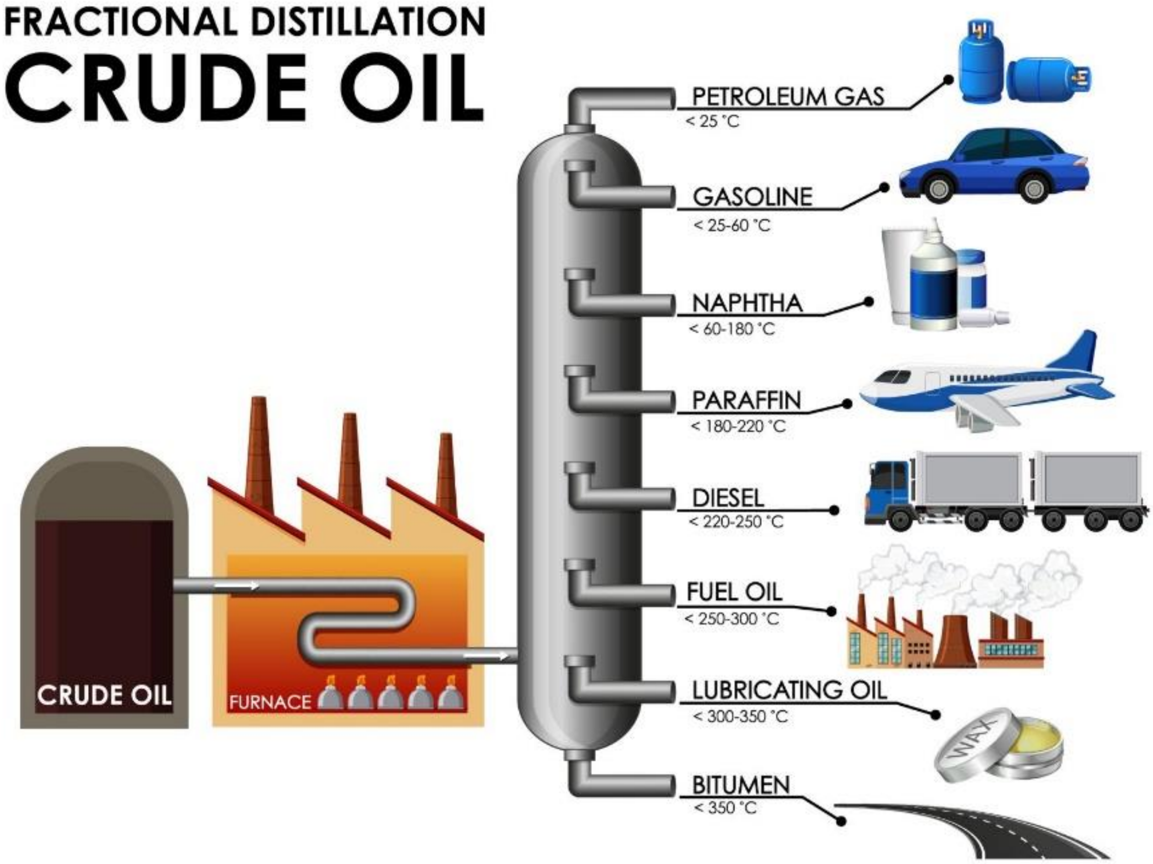
Figure 3. The value chain for plastics



Source: (European Environment Agency, n.d.)

Plastic can either be "synthetic" or "biobased." Synthetic plastics are derived from crude oil, natural gas, or coal (Baheti, n.d.). At the beginning, crude oil is pumped up from the ground and sea in a long pipe and sent to an oil refinery to separate the heavy crude oil into groups of lighter components called fractions. Then, crude oil fractions such as naphtha and natural gas liquids are cracked to produce small molecules called monomers. Through a polymerization process, the monomers are linked together to form larger molecules called polymers. The polymers are then mixed with various chemical additives that give the plastic its desired properties through a process called compounding. After compounding, the plastic material is used by a converter to produce the final plastic products, such as bottles, water pipes, and interior panels for cars (European Environment Agency, n.d.). Figure 4 shows the extraction of plastic from crude oil.

Figure 4. Process of making plastic



Source: (Baheti, n.d.)

Plastics are made from petroleum or crude oil that is derived from following steps (Baheti, n.d.):

1. Extraction of crude oil
   - Heavy crude oil consists of thousands of compounds and needs to be separated before being processed into different petroleum products.
2. Refining step
   - When crude oil is heated in a furnace, the oil gets delivered to the distillation unit before getting separated into lighter components called fractions. One of the fractions called "naptha" is the important component for making plastic.
   - Naptha is further heated at different boiling points to form monomer gases like ethylene, propylene, and butylene, which are the raw materials for making plastics.
3. Polymerization and processing
   - The gases (monomers) are converted into plastic polymers by adding a **catalyst**. The plastic polymers could be molded in the form of powder, pellets, or granules.

- The plastic polymers are further processed into different types of plastics with different desired properties (soft/hard, stretchy/rigid, transparent/colored, etc.) by adding the additives.
- These help to improve performance (i.e., during the molding step), functionality, and age of plastic.

On the other hand, biobased plastics come from renewable products such as carbohydrates, starch, vegetable fats and oils, bacteria, and other biological substances (Baheti, n.d.). It can either be made by extracting sugar from plants like corn and sugarcane to convert it into polylactic acids (PLAs), or it can be made from polyhydroxyalkanoates (PHAs) engineered by microorganisms. PLA plastic is commonly used in food packaging, while PHA is often used in medical devices like sutures and cardiovascular patches (Gibbens, n.d.).

Did you know? Box 1: Plastic additives

Previously, we learned that manufacturers add a mix of chemicals and additives to the polymer during processing to make plastic products with a set of desired characteristics. Plasticizers, colorants, reinforcements, and stabilizers are among the additives. Below we describe the additives and their importance in detail.

Table 2. Types of plastic additives

Source: (Hahladakis et al., 2018)

Category of Additives	Examples	Importance
Functional additives	stabilizers, antistatic agents, flame retardants, plasticizers, lubricants, slip agents, curing agents, foaming agents, biocides, etc.	• **Plasticizer**: improves the flexibility, durability and stretchability • **Antioxidant**: extends a product's life • **Heat stabilizer:** prevents thermal degradation of polymers when exposed to elevated temperatures • **Slip agent:** enables better mould release, and gives anti-sticking properties
Colorants	pigments, soluble azocolorants, etc.	• Improve appearance of products
Fillers	mica, talc, kaolin, clay, calcium carbonate, barium sulphate	• Improve stability • Improve molding step • Increase heat-deflection and reduce thermal expansion.
Reinforcement	glass fibres, carbon fibres	• Enhance the mechanical properties of a plastic • Scratch resistance

Even though additives have many advantages, they also change the structure of plastic polymers. This then gives rise to different types of plastic called thermoplastic and thermosetting plastic (further described in 1.3).

1.3. Types of plastics

Not all plastics are the same, and they can be categorized as either thermoplastics or thermosetting plastics (Millet et al., 2018). The table below provides examples of different types of plastic.

Table 3. Types of plastic

Types	Explanation	Examples
Thermoplastics	• A type of plastic that melts when heated and hardens when cooled; • Reversible; can be repeatedly reheated, reshaped, and hardened; • Mechanically recyclable.	Plastic bottles, films, cups, and fibers
Thermosetting plastic	• A type of plastic that undergoes a chemical change when treated; • Irreversible; cannot be re-molten and reformed after they have been heated and formed.	Electronic chips, dental fillings and the lenses of glasses

Thermoplastics account for nearly 80% of total plastic demand as most of them are used in plastic packaging. Even so, this group alone could further be divided into different types of thermoplastic material. They differ from one another during the processing where different additives are used. Below are seven different types of thermoplastics (*The 7 Different Types of Plastic*, n.d.).

Figure 5. Seven types of thermoplastics

The recyclability of the plastic is varied (Parashar & Hait, 2021). High Density Polyethylene (HDPE), Polyethylene Terephthalate (PET), and Polycarbonate (PC) are examples of widely recycled materials, whereas Polypropylene (PP) and Polyvinyl chloride (PVC) are frequently not recycled, and Low Density Polyethylene (LDPE) and Polystyrene (PS) are rarely recycled. Plastic is perceived as a polluter and worsens the environmental situation. Despite this, it has emerged as a convenient material to protect the public and medical practitioners especially during the pandemic, and the production has been increased to meet the demand in the health care sector (World Economic Forum, 2020).

1.3.1. *Plastic waste sorting and management*

Take a look around you and you might see plastic incorporated into almost everything, but have you ever wondered why none of them can be recycled together? For example, the most common recyclable plastic is PET bottle, but rarely do we see recycle containers for other types of plastic in 1.3.

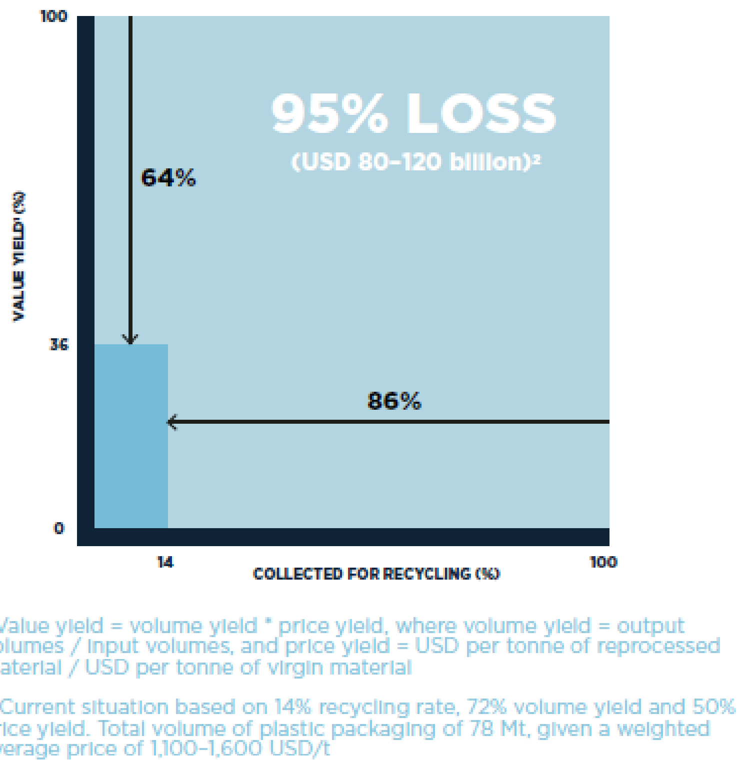


Figure 6. Plastic packaging value and its economic loss

Source: (Hestin et al., 2015; Industry Agenda, 2016)

There are several reasons that makes plastic waste sorting challenging. First, different types of thermoplastic have different melting points. For example, PET (235-260°C), HDPE (120-190°C), LDPE (105-115°C), and PP (150-160°C) (Rajendran Royan et al., 2021). Secondly, a mix of hard and thin or filmy plastic could increase the risk of machine clogging. Furthermore, there is also the challenge to educate or discipline every individual to segregate plastic properly, meaning that each household needs multiple baskets just to throw different types of plastic away. Still, if they have different baskets but there is no proper guideline on how to differentiate plastic in each object, this could lead to confusion and demotivate the public to sort them individually.

Even if the plastic is recycled, it will lose its value over time. Annually, USD 80-120 billion, or 95% of plastic packaging value is lost to the economy after a single use. When additional value losses in sorting and reprocessing are considered, only 5% of material value is retained and recycled for future use. This recycled plastic is used to make lower value applications that are not recyclable after use (Industry Agenda, 2016).

1.4. The role of plastic in socio-economic production and consumption

As discussed in 1.2 and 1.3, plastics have different properties to suit their ends in different economic sectors. Thirty-six (36%) percent of plastic is used in the packaging industry, where its prevalence can be seen in our daily lives. For example, when we go to a bazaar, a night market, or even to a restaurant to have takeout food, the food will be packed in a plastic container and further put into a plastic bag for you to carry it home. The figure below shows the distribution of plastic demand in 2018 (Geyer et al., 2017b; Plastics Europe, 2019):

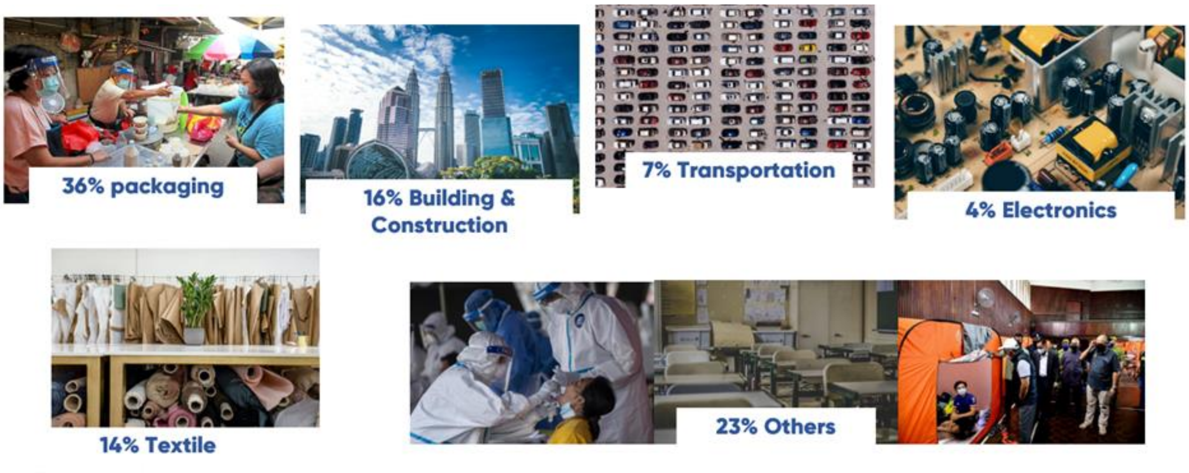


Figure 7. Distribution of plastic demand in 2018

Sixteen (16%) percent of plastic is used in the building and construction industry. Plastic is utilized as seals, profiles in windows and doors, walls, pipes, sanitary fillings, cables, switches, panels, floor coverings, and insulation.

Seven (7%) percent of plastic globally is used in transportation: in cars, aircraft, rockets, and satellites. One-third (1/3) of car components are plastic; the car body, seating, dashboards and lighting part contain plastic components. As we discussed in 1.2, plastic is lightweight and is suitable in reducing the weight of vehicle, which can limit fuel consumption.

Four (4%) percent of plastic is used to make electronic goods as it is a poor electrical conductor. Here, plastic is widely used as an insulator for the outer parts of electrical goods or devices. Because it is a flexible material, it could easily be molded into smaller components or fasteners or make the device have attractive curves.

Fourteen (14%) percent of plastic is used in textile industries to make clothing, footwear and household items like bedding sheets, curtains, and many more.

Lastly, 23% is used for other purposes like daily goods:

- Toothbrushes, hairbrushes, combs, washing sponges, storage containers, and furniture.
- Stationery such as plastic rulers, toys, skates, tiffin boxes, and pencils

In recent years, the whole world was hit by a pandemic and the region also experienced multiple of natural disasters. This also increased the amount of plastic used in the world. Now, let us see in detail in Box 2 the prevalence of plastic usage during that time.

Did you know? Box 2: Plastic and COVID-19

Besides all of the sectors mentioned in 1.4, recently, the world has witnessed the sudden rise of plastic usage in the healthcare sector. The characteristics of plastic make them a preferred material during the COVID-19 pandemic. In Southeast Asia alone, around 11 million people have been infected with the COVID-19 virus. The rising number of cases and virus testing significantly increase the amount of plastic medical waste and packaging resulting from reliance on online shopping during lockdown and takeaway services. This is portrayed in the process below:

Individual

- Mask
- Protective gear
- Plastic shield/ goggles
- Disposable items (gloves)
- RTK-antigen kit
- *Online shopping (packaging)*
- Hand sanitizer

Sampling

- Test tube for viral sampling
- Swab stick
- Packaging for transport

Medical Laboratory, Hospital, Clinics

- Test tube
- RT-PCR tube
- Viral loading tips
- Syringe for vaccine
- Hazardous waste plastic bag

Quarantine center/ shops

- Plastic cover or partition
- Plastic sheets
- Plastic packaging
- Food packaging

WHO anticipates a monthly demand of 89 million facial masks, 76 million gloves, 30 million gowns, and 1.6 million goggles, as well as 2.9 million hand sanitizers among health workers (WHO, 2020). In addition, they estimate a 40% increase in the supply chain of various medical safety products worldwide (World Economic Forum, 2020). According to the Thailand Environment Institute, plastic waste has increased from 1500 to 6300 tons per day, which is 4x greater than the usual. Similarly, the Compound Annual Growth Rate (CAGR) for Personal Protective Gear (PPE) production is expected to increase by around 20% between 2020 and 2025 (Thailand Environment Institute (TEI), 2020).

Due to this, many single-use plastic (SUP) legislations have been repealed (Parashar & Hait, 2021). Countries like the US, the UK, Canada, and Portugal have temporarily revoked the ban of SUP (Klemeš et al., 2020). Thailand is also experiencing 30% increase in SUP production despite the ban since early January 2020 (Parashar & Hait, 2021; Thailand Environment Institute (TEI), 2020).

The pandemic has lost billions of dollars in multi-sectors. The majority of improperly disposed protective gear could survive in the environment for centuries. The cities are expected to bear a higher cost of plastic clean-up every year. Each piece of litter removed from the streets and roadside costs 30 cents (Mccarthy, n.d.; *Plastic Bag Clean Up Costs*, 2022). In addition, virus particles can survive on the gears for up to a week, and the risk of contracting the virus is high for the garbage collectors and even for the public (Grey, n.d.).

Personal protective equipment or PPE are commonly made of plastic and are effective in giving protection against the virus for medical and healthcare professionals and frontliners as they have a higher exposure to COVID-19 patients due to the nature of their work. According to the World Health Organization (WHO), it is recommended to wash and sanitize hands rather than use plastic gloves as viruses are prone to sticking to them, thus increasing the rate of spread (Mccarthy, n.d.). In addition to that, extra packaging on food or grocery items is deemed unnecessary as coronaviruses cannot multiply in food items as they need a live host, either animal or human, to multiply. Thus, the public should be educated with such information whether the items they use are effective methods of prevention or not. The generation of plastic, especially during pandemics, is staggering and better medical waste management as well as serious interventions from multiple sectors are needed to reduce plastic waste from polluting the environment.

Figure 8. *Plastic waste from medical equipment during the pandemic*

Did you know? Box 3: Plastics and natural disasters

Aside from the coronavirus outbreak, the ASEAN countries are also dealing with a number of natural disasters, which are expected to worsen because of the climate crisis. According to the World Risk Index 2021, Brunei, Cambodia, and the Philippines are classified in the "very high risk" category of natural disasters in Asia, while Indonesia, Malaysia, and Vietnam are at "high risk" (Erwida Maulia P Prem Kumar, n.d.). In 2021 alone, the countries were hit by:

Natural disaster risk in Asia

Levels: Very high 10.72-47.73 | High 7.67-10.71 | Medium 5.55-7.66 | Low 3.26-5.54 | Very low 0.3-3.25

Rank	Country	Index	Rank	Country	Index
6	Brunei	22.77	79	Myanmar	7.25
8	Philippines	21.39	85	Pakistan	6.80
9	Papua New Guinea	20.90	90	India	6.65
13	Bangladesh	16.23	92	Thailand	6.52
15	Cambodia	15.80	95	China	5.87
16	Timor-Leste	15.75	122	Nepal	4.66
38	Indonesia	10.67	123	Australia	4.54
43	Vietnam	10.27	126	Laos	4.46
46	Japan	9.66	145	Bhutan	3.25
63	Afghanistan	8.18	148	South Korea	3.13
71	Malaysia	7.73	153	Mongolia	2.98
75	Sri Lanka	7.55	167	Singapore	2.50

Index covers 181 countries — *Source: WorldRiskIndex 2021*

- Several tropical storms or typhoons have displaced hundreds of thousands of people, such as Typhoon Ondoy and Haiyan in the Philippines;
- Flash floods in several states, including Kuala Lumpur and Selangor, have become more frequent in recent years, and
- Volcanic eruption that sends hot cloud avalanches and earthquakes in East Nusa Tenggara in Indonesia.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Referring to the photo on the left, the recurring floods and blocked drainages are caused by improper garbage disposal in drainage systems. The water stagnated at several points due to the huge amount of plastic waste. Researchers estimate a single flooding event contributes 0.5% to the total floating plastic in the world's oceans (Dengler, n.d.).

Even so, plastics are a vital material in extreme weather events and are widely-used in emergency and relief materials (*Plastics Protects during Extreme Weather Events and Natural Disasters*, 2022) for rehabilitation, for example:

- plastic coverings for cars during floods
- rescuing gear; floats, life-jackets, rain-coats, etc.
- plastic gloves, masks, and personal care products and other protective and cleaning equipment
- tents, plastic sheets, etc.
- bandages, ice packs, and flashlights included in the emergency kit.
- food packaging

1. water bottles; access to potable water is incredibly important and the bottles are used in rescue efforts and to sustain people in sheltered areas.

1.5. Disadvantages of plastic use

It has been discussed in 1.3 that plastic consists of many types and is designed to last a long time. As much as it may be advantageous, it also poses a serious threat to the environment because it could thrive for centuries. Below is the lifespan of the common plastic products (WWF, n.d.) compared with the average lifespan of humans and animals in the world (Morelle, n.d.; Pester, n.d.).

Figure 9. Lifespan of plastic compared with human and animal lifespan

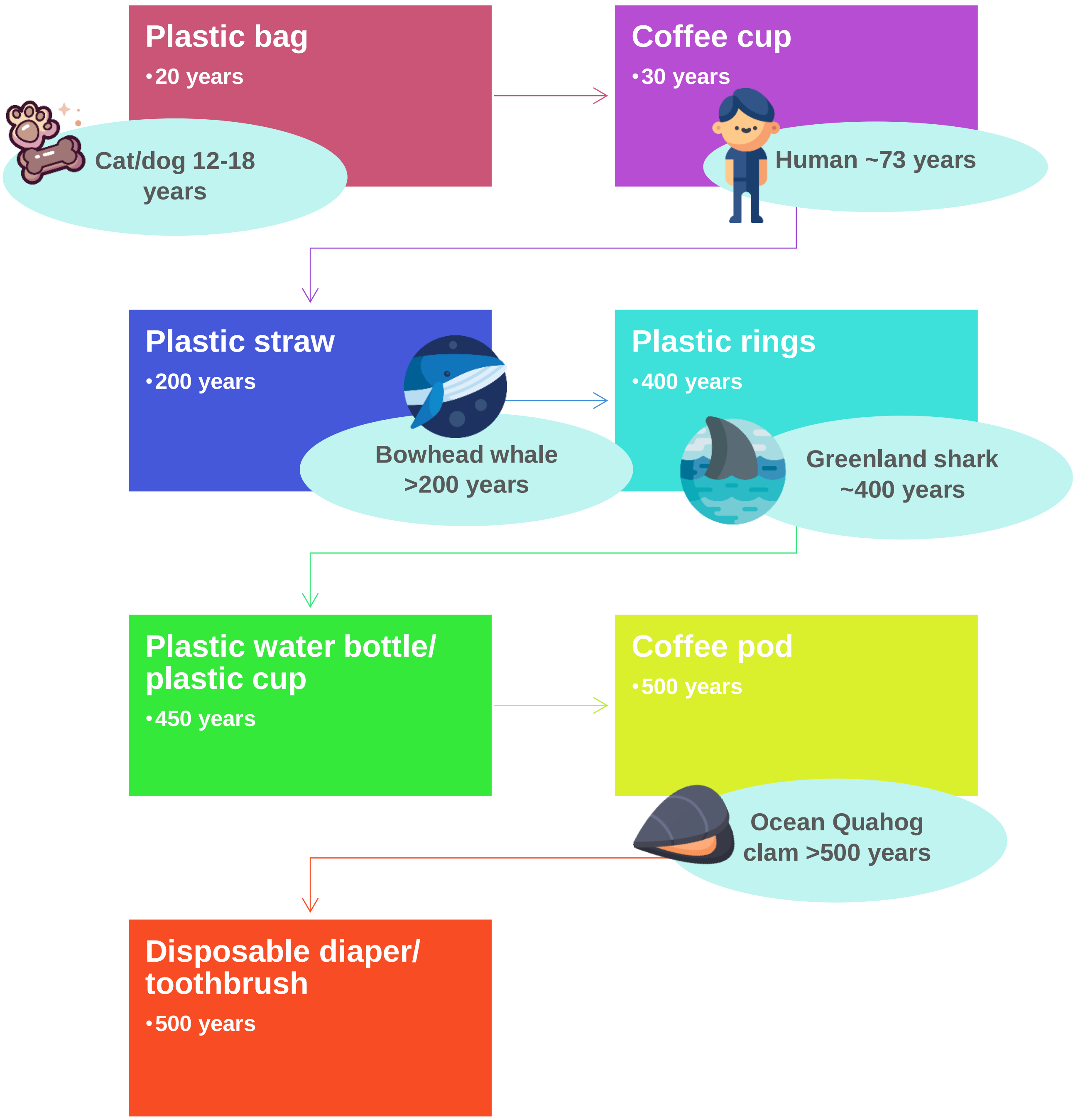

Figure source: (Freepik, n.d.)

If properly disposed of, plastic will be **recycled** mechanically or chemically, bringing the plastic material back to life as monomers or polymers for reproduction or recovery. However, if they are not recycled, they will end up in **landfills or open dumpsites**.

Marine plastic pollution has emerged as a significant environmental issue, drawing attention to the issue of plastic consumption and improper disposal. There are many problems involved in each phase of the plastic lifecycle. For example, most of the problems on plastic pollution exist in the end-of-life phase of the plastic lifecycle, such as plastic waste dumped on land and in the sea, non-bio degradation, and presence of microplastics, among others. There are also new developments in the economic strategies, policies, and new technologies that are being introduced to address the plastic problem. In Chapter 3, we will look at current solutions, such as the circular economy, campaigns and activities to combat plastic pollution, as well as innovations in the field of science and technology that can help improve the situation and provide alternatives to plastics.

Chapter 2:
Plastic pollution in the world

Chapter 2: Plastic pollution in the world

2.1. Global plastic production

From 1950, when industrial-scale manufacture began, until 2015, the global production of plastics has accumulated to 8.3 billion tonnes (Lebreton et al., 2018), with an estimated 6.3 billion tonnes of trash. Only around 9% of this waste has been recycled, 12% incinerated, and the remaining 79% ended up in landfills or in the natural environment, including the oceans (Eriksen et al., 2014). According to a study by Jambeck et al. (Jambeck et al., 2015), around 8 million tonnes of plastic leak into the ocean annually and this is equivalent to the dumping of one garbage truck's worth into the ocean per minute (Jambeck et al., 2015). This shows the great need and potential to increase plastic recycling, which can also reduce the amount of plastics reaching the oceans.

In our daily lives, plastics can be found in almost everything from grocery store bags and flatware to water bottles and meal wrapping. However, excessive plastic consumption and poor waste management are becoming critical problems. When plastic garbage is dumped rather than collected or disposed of in landfills that meet the minimum standards, the wind and storm water drainage systems may carry it, causing landfills to overflow (Ortiz-Colón et al., 2016), rivers to become congested (Geyer et al., 2017a), and ultimately contribute to ocean pollution (Jambeck et al., 2015). Mismanagement of plastic waste affects many different nations and regions of the world. This has a negative impact on industries, such as tourism, shipping, and fisheries, especially on low- and middle-income nations.

2.2. Plastic waste in Southeast Asia and Japan

Southeast Asia has become a major source of plastic pollution as a result of its rapid urbanization (UNCRD, 2019). Plastic products and packaging are widely used in consumable products due to their convenience and variety. Local waste management infrastructure, on the other hand, has not kept up, resulting in massive amounts of improperly handled waste. Furthermore, during the COVID-19 pandemic, the increased use of masks, sanitizing bottles, and delivery packaging exacerbated the problem (Jain, 2020).

According to a series of landmark studies by UNSECAP (UNESCAP, 2020) and the World Bank (The World Bank Group, 2020, 2021a, 2021b), when single-use plastic is discarded rather than recovered and recycled, more than 75% of the material value of recyclable plastic is lost. In Thailand, Philippines, and Malaysia, this loss amounts to around US$6 billion per year. Furthermore, with only 18 to 28% of recyclable plastic recovered and recycled in these countries, the majority of plastic packaging waste not only pollutes the environment by littering beaches and roadsides, but its economic value is also lost (Greenpeace Southeast Asia, 2019).

The ASEAN region is also struggling to manage its own waste. According to a UNEP (2017a) report on waste management in ASEAN countries, waste generation is increasing. Municipal solid waste in ASEAN members' countries is made up of 10-18% plastic. Box 4 below shows the municipal waste generation per day in ASEAN countries.

Did you know? Box 4: Amount of Waste Generation and Composition of Municipal Solid Waste (MSW) in ASEAN countries and Japan

No.	Countries	Waste Generation		Source
		MSW generation per capita (kg/day)	Million tonnes/ year	
1	Brunei	1.4	210,480	(AIT-UNEP Regional Resource Center for Asia and the Pacific (RRC.AP), n.d.; ASEAN, 2009, 2021; Greenpeace Southeast Asia, 2019; UNEP, 2017a)
2	Cambodia	0.55	1,089,429	
3	Indonesia	0.70	64,000,000	
4	Lao PDR	0.69	77,380	
5	Malaysia	1.17	12,840,000	
6	Myanmar	0.53	841,508	
7	Philippines	0.69	14,660,000	
8	Singapore	3.763	7,514,500	
9	Thailand	1.05	26,770,000	
10	Vietnam	0.84	22,020,000	
11	Japan	0.91	41,700,000	(Japan Ministry of the Environment, n.d.)

2.3. Plastic usage in the ASEAN region

The figures below show examples of the most used plastic objects in our daily lives, such as water bottles, food wrapping, beverage cups, toothbrushes, clothes, food utensils, etc. The consumption of plastics is oftentimes associated with social norms, such as the "*tingi*" or sachet culture in the Philippines, where products are repackaged in smaller quantities or sachets for selling in pieces. These photos show the pervasiveness of plastics in various countries in ASEAN.

Figure 10. "Tingi" culture (Sachet culture) in the Philippines.

Source: (Benosa, n.d.; Filipino Shopping Habits, the “Tingi” Culture and Plastic Pollution*, n.d.; Panay News, n.d.; Patton, n.d.; Zulueta, 2019)*

Figure 11. Slave to sachet. “Tingi Culture”

Source: (Lema, n.d.)

Referring to Figures 9, 10 and 11, plastic packaging, such as sachets, is an example of single-use-plastic (SUP) that is used once and then discarded. This type of SUP accounts for the greatest proportion of plastic packaging for personal care products (shampoo, soap, and cosmetics).

Figure 11 shows how plastic is widely used in Japan to preserve appearance, and protect the item in pristine condition. Even though it is convenient, the impact of excessive plastic usage is detrimental in the long term.

Figure 12. Excessive plastic packaging in Japan

Figure 13. Single-use plastic in Malaysia

Figures 12, 13, and 14 show how plastic packaging is widely used in Malaysia and Cambodia. In a night market or food festival, hawkers will pack the food in a plastic container and further put it in another plastic bag to carry it home. Once it serves its purpose, the plastic can either be recycled or thrown away. During a pandemic, in the stores, staff wrap vegetables and fruits in plastic to avoid cross-contamination with viruses, which is an uncommon sight before a pandemic starts. However, such a method of prevention has been reported as ineffective; this has been discussed in Plastic and COVID-19 (p. 21).

Figure 14. Plastics used in businesses in Cambodia

Source: (Quicksand, 2015; Switch Asia, n.d.)

Figure 15. Other usage of plastic bags in daily life as protection (gloves, shoes, rain cover, fly swatter, etc.) and storage (packaging, containers, pots, etc.) in Cambodia

Source: (Quicksand, 2015; Switch Asia, n.d.)

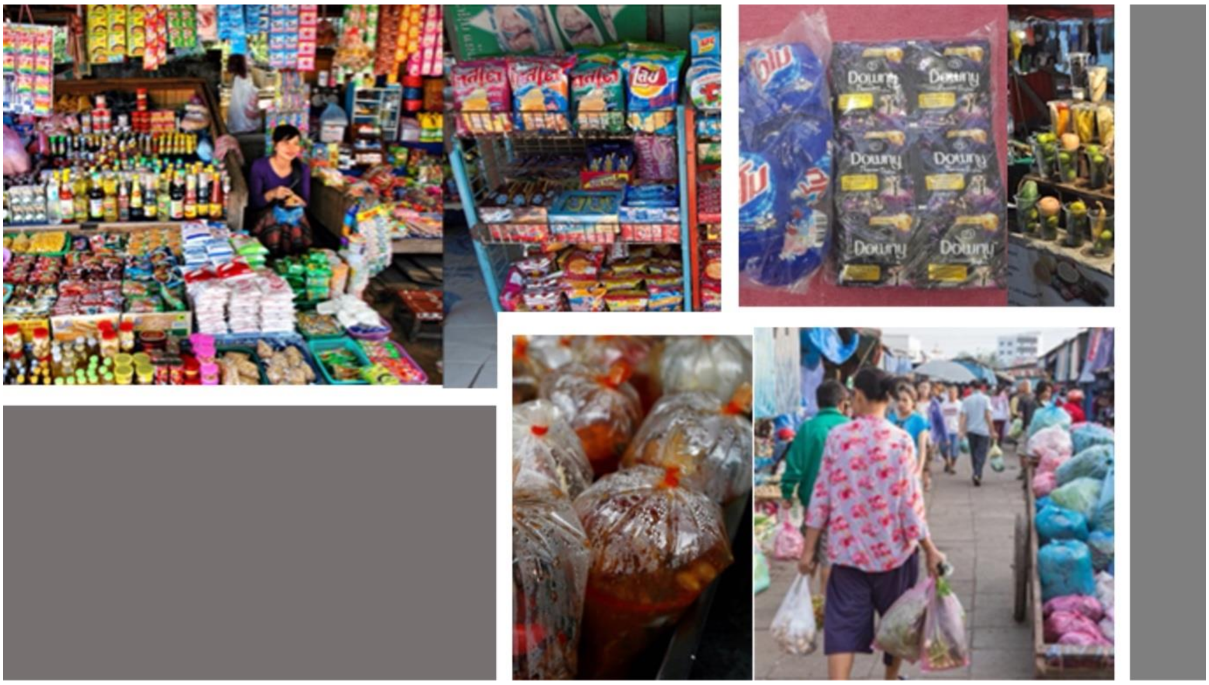

Figure 16. Plastic in daily goods in Thailand and Lao PDR; Photos taken by Souphaphone Chanthavong.

Source: (Beach, n.d.; Magnus Bengtsson, 2022; "Plastic Piles up in Thailand as Virus Fight Sidelines Pollution Battle," n.d.)

Figure 17. The Milk tea craze in the Philippines using single-use plastic straws and cups

Source: (Cup Community, n.d.; Take Out Plastic Double for 16oz and 22 Oz Cups for Milk Tea Shop*, n.d.)*

Figures 15 and 16 show how plastic is a common material used in the packaging of products in the food and beverage sector. The remaining figures below show other sources of plastic waste generated through the use of PPEs, disposable eating utensils and plastic packaging commonly used in food and online deliveries which increased during the COVID-19 pandemic.

Figure 18. Plastic waste through PPEs in Indonesia

Figure 19. Plastic cutleries

Figure 20. Plastic packaging from online shops

2.4. Waste management

It is reported that at least 14 million tons of plastic end up in our oceans each year. This is due to many countries that lack or have inadequate facilities to properly dispose of and recycle plastics, such as sanitary landfills, incineration facilities, recycling capacity and proper management and waste disposal (IUCN, n.d.). Even if the plastics end up in the landfill, they can still have a negative impact on humans and the environment. Plastic degrades into tiny particles that contaminate the soil and can be ingested by animals (Jacobsen, n.d.). According to a German study, terrestrial microplastic pollution is now greater than ocean microplastic pollution. In any case, the plastic pollution in our terrestrial and marine ecosystems can be harmful to humans and animals (*Plastic Planet: How Tiny Plastic Particles Are Polluting Our Soil*, n.d.). Furthermore, the surge in single-use plastic and personal protective equipment during the COVID-19 crisis has put additional strain on countries working to combat marine plastic debris. Because of urbanization and an expanding consumer class, the volume of solid waste and marine debris in Southeast Asia is increasing (*ASEAN Member States Adopt Regional Action Plan to Tackle Plastic Pollution*, n.d.). Table 5 (below) details how each ASEAN member countries and Japan handle solid waste (Jain, 2017; Loh, n.d.).

The most well-known type of waste treatment in Southeast Asian countries is open dumping. However, this technique causes a slew of issues in the surrounding environment, including but not limited to groundwater pollution, which can eventually harm the community.

Table 4. Municipal Solid Waste (MSW) management in ASEAN countries and Japan

Country	Source segregation	Technology		Technology Gap					Sources
		Collection rate (Urban)	Recycling Rate	Treatment/Disposal					
				Composing	Incineration	Sanitary landfill	Open Dump	Open Burning	
Brunei	<50%	90%	15%			✓	✓		(UNEP, 2017a)
Cambodia	<50%	80%	<50%	✓		✓	✓	✓	(AIT-UNEP Regional Resource Center for Asia and the Pacific (RRC.AP), n.d.)
Indonesia	<50%	56%-75%	<50%	✓	✓	✓	✓	✓	(ASEAN, 2009)
Lao PDR	<50%	40%-70%	<50%	✓		✓	✓	✓	
Malaysia	<50%	>70%	50%-60% (Metal, paper, plastic) Others (<50%)		✓	✓	✓		(The World Bank Group, 2021a)
Myanmar	50%		70% (Plastic, paper, metal)		✓	✓	✓		(AIT-UNEP Regional Resource Center for Asia and the Pacific (RRC.AP), n.d.)
Philippines	50%-70%	40%-90%	20%-33% (Paper) 30% - 70% (Aluminium) 20% - 58% (Other Metals)	✓		✓	✓		(The World Bank Group, 2021b)

			23% - 42% (Plastic) 28% - 60% (Glass)						
Singapore	70%	>90%	50% - 60% (Paper, Horticulture) >90% (Fe, Used Slag) >80% (Scrap Tire) >80% (Wood) >50% (Others) Overall (60%)		✓	✓	✓		(ASEAN, 2009)
Thailand	<50%	>80%	>90% (Metal) 50% - 60% (Paper, Construction)	✓	✓	✓	✓		(ASEAN, 2009; Funatsu, 2019; The World Bank Group, 2020)
Vietnam	<50%	80%-82%	>90% (Metal) >70% (Plastic, E-waste) 50% (Paper)	✓			✓		(ASEAN, 2009; UNEP, 2017a)
Japan	>90%	>90%	84%						(Japan Ministry of the Environment, n.d.; Liang et al., 2021)

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2.5. Sources of plastic waste in the oceans

Plastics enter the environment through a number of different channels, such as improper disposal, direct dumping, leakage from waste infrastructure or industry, sewage discharge, wind and surface runoff, and natural disasters such as floods, storms, or landslides (Lechthaler et al., 2020; van Emmerik & Schwarz, 2020). Additionally, land-based plastic that is discharged into the ocean from rivers and coasts compound the land-based discharges from upstream riverine (Roebroek et al., 2021; Schwarz et al., 2019). As a result, river systems are crucial in the movement of land-based plastic waste into oceans (Jambeck et al., 2015).

2.5.1. From land to river

Approximately 80% of ocean plastics come from pollution and inadequate land-based disposal practices (Pew Charitable Trusts, 2020). A major portion of ocean plastic comes from improper disposal of old fishing nets, ropes, and lines. It is important to note that only about 5% of the total plastic debris poured into the oceans are seen as plastic trash floating on the surface. The remaining 95 % is submerged underwater, with a sizeable amount accumulating on the seafloor (European Investment Bank, 2021).

Plastic pollution is an emerging environmental risk due to its negative impact on the health of the ecosystem and human livelihood. Plastics, for instance, can harm animal and vegetation species, damage vessels and hydraulic infrastructures, and increase urban flood risk due to clogging (van Emmerik et al., 2022).

There are various reasons for improper discharge of plastics, including:

- **Illegal plastic littering**: There is a poor or lack in waste collection services, especially in informal settlements not served by formal garbage collection services (UNEP, 2020).
- **Illegal and substandard waste dumping and disposal:** The absence of well-located, well-designed operated landfills and dumpsites encourages illegal and poor waste dumping and disposal, which result in covert trash dumping. During storms or floods, dumpsites near rivers or the ocean may discharge waste (Schwarz et al., 2019; van Emmerik & Schwarz, 2020). Some communities without garbage disposal sites simply dump accumulated waste into waterways.
- **Surface run-off water**: During rainy seasons, plastics and other waste from streets and open spaces are transferred to storm drains and canals, where their concentration limits hydraulic capacity. Storms and heavy rains can cause flooding until the flow is high enough to transport collected plastics and waste to rivers, lakes, or seas (Al-Zawaidah et al., 2021; Gasperi et al., 2014). Finally, natural, and environmental elements, such as wind cause plastic fragmentation and dispersion.

2.5.2. Deep sea

It is estimated that 19-23 Mt of plastic waste generated in 2016 entered the aquatic ecosystem with 0.8-2.7 Mt of it is emitted from rivers to the ocean (Meijer et al., 2021). This number is predicted to increase significantly to 90 Mt/year in 2030 if there is no change in plastic waste treatments (Borrelle et al., 2020). Unfortunately, only 0.1%-1.25% of plastic waste entering the ocean was found floating and concentrated in ocean gyres, implying that the remaining 99% might be sinking to the deeper layer of the ocean (Ritchie & Roser, 2018).

These floating plastics travel across a great distance through the sea current. It is hypothesized that the Kuroshio current (flowing eastward between 140^o-180^oE) in southern part of Japan transports plastic wastes from Southern East Asia to the North Pacific Ocean. The density of plastic found at around 150 km offshore of Japan is higher (~1×10^5 pieces/km^2) than those found near the coast (~1×10^4 pieces/km^2) (Yamashita & Tanimura, 2007). A number of studies have found plastic debris in the deeper layers of the ocean [Peng et al., 2019; Amon et al., 2020]. Plastic debris is even found at a depth deeper than >7,000 m (Figure 4) (Chiba et al., 2018) with a high occurrence of single-used plastic (Figure 5) (Nurlatifah et al., 2021). Figure 20 shows the amount of non-plastic, single use plastic and other types of plastic debris in the ocean.

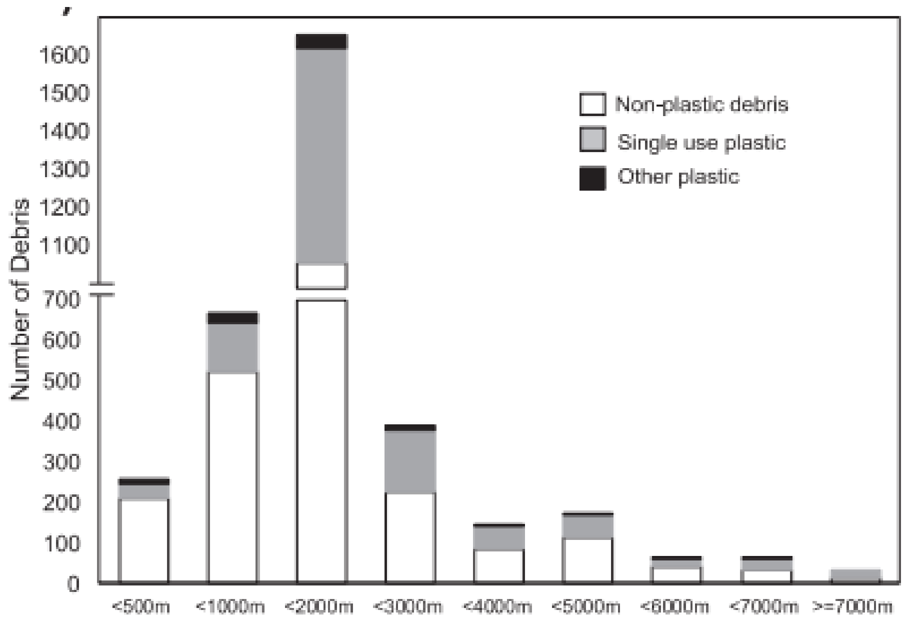


Figure 21. Characteristics of debris found in ocean by its depth (Chiba et al., 2018)

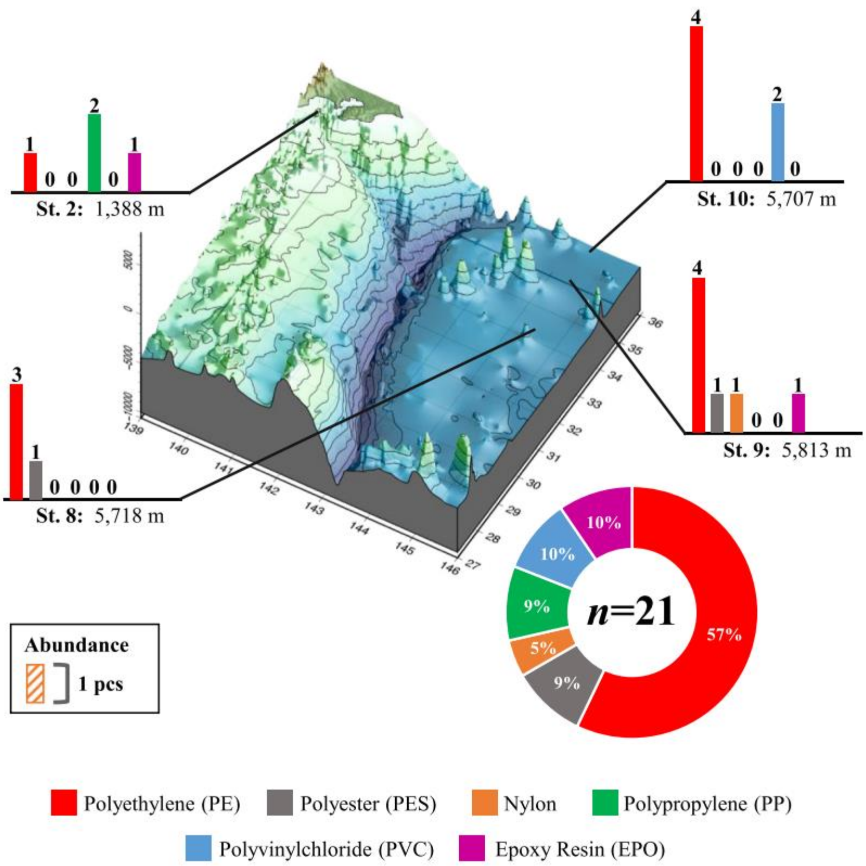


Figure 22. Plastic debris found under KERG recirculation area (Hu et al., 2022)

The nearer a location is to a highly populated area, the higher the abundance of plastic debris found, especially for deep seafloor, submarine canyons, and trenches. Nakajima (2021) reported that there are at least 4,561 items/km^2 of plastic debris found under the Kuroshio current area (covering for 1,420,000 km^2) (Nakajima et al., 2021). It is also estimated that those plastics found in the Kuroshio current area hold enormous burdens of toxic plastic additives (>2.2 tonnes), such as plasticizer of bis(2-ethylhexyl)phthalate/DEHP (230 kg), diethyl phthalate/DEP (160 kg), dibutyl phthalate/DBP (720 kg), antioxidant of butylated hydroxytoluene/BHT (570 kg), and dye mixtures of trichlorobenzenes/TCBs (2,560 kg) (Nurlatifa et al., 2021). Based on the ANNEX XVII TO REACH regulation, concentration of DEHP, DBP, BBP, and DiBP as substances or mixtures are restricted to not greater than 0.1% by weight in toys and childcare products (ECHA, 2019).

2.6. Marine plastic waste and microplastics

The extensive production and usage of plastics has caused massive disposal in the environment. It was already reported that, according to the estimation of marine plastic debris, over 250 million tonnes would be accumulated in the ocean by 2025 (Jambeck et al., 2015). This plastic waste can be fragmented into debris smaller than 5 mm, termed as microplastics (MPs). These kinds of microplastics are so-called secondary microplastics (Fig.22 and 23) (Hu et al., 2022). Plastic pellets, cosmetic exfoliants, and opacifiers are examples of primary microplastics (Mitrano & Wohlleben, 2020). Microplastics are formed from the large amount of fragmentation of large pieces of plastics due to the effects of abrasion, UV radiation, hydrolysis and biodegradation (Mitrano & Wohlleben, 2020). At the same time, proper plastic waste collection is required to further reduce microplastic pollution, and the collected plastics can be recycled or upcycled towards a circular economy. Figure 22 shows the multiple sources of microplastic in the environment.

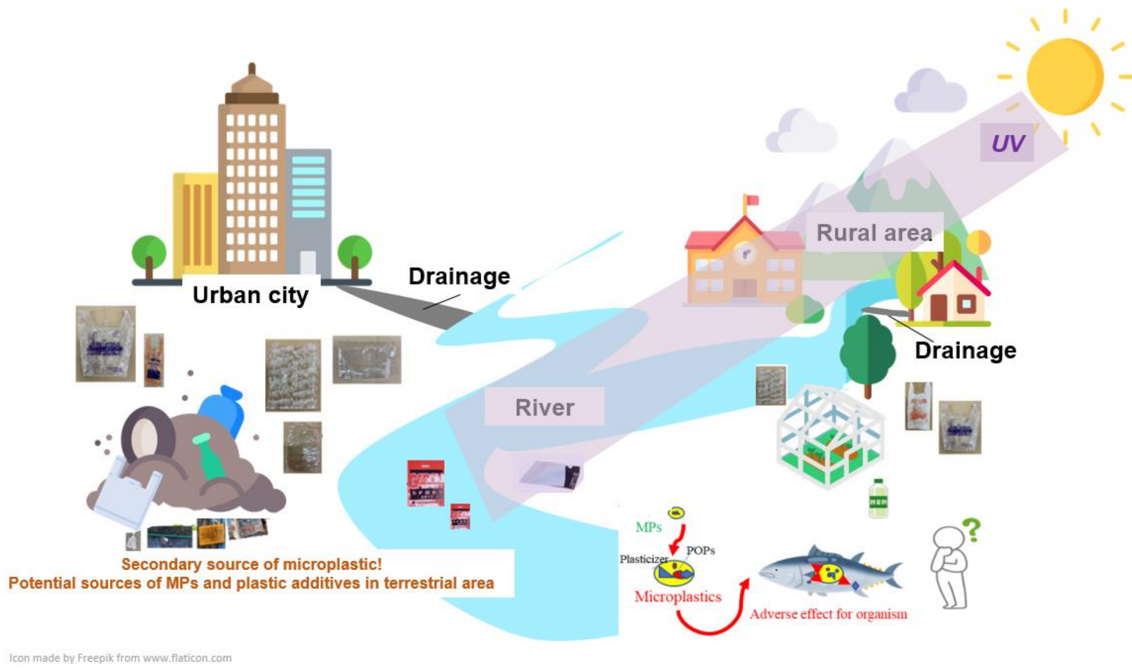
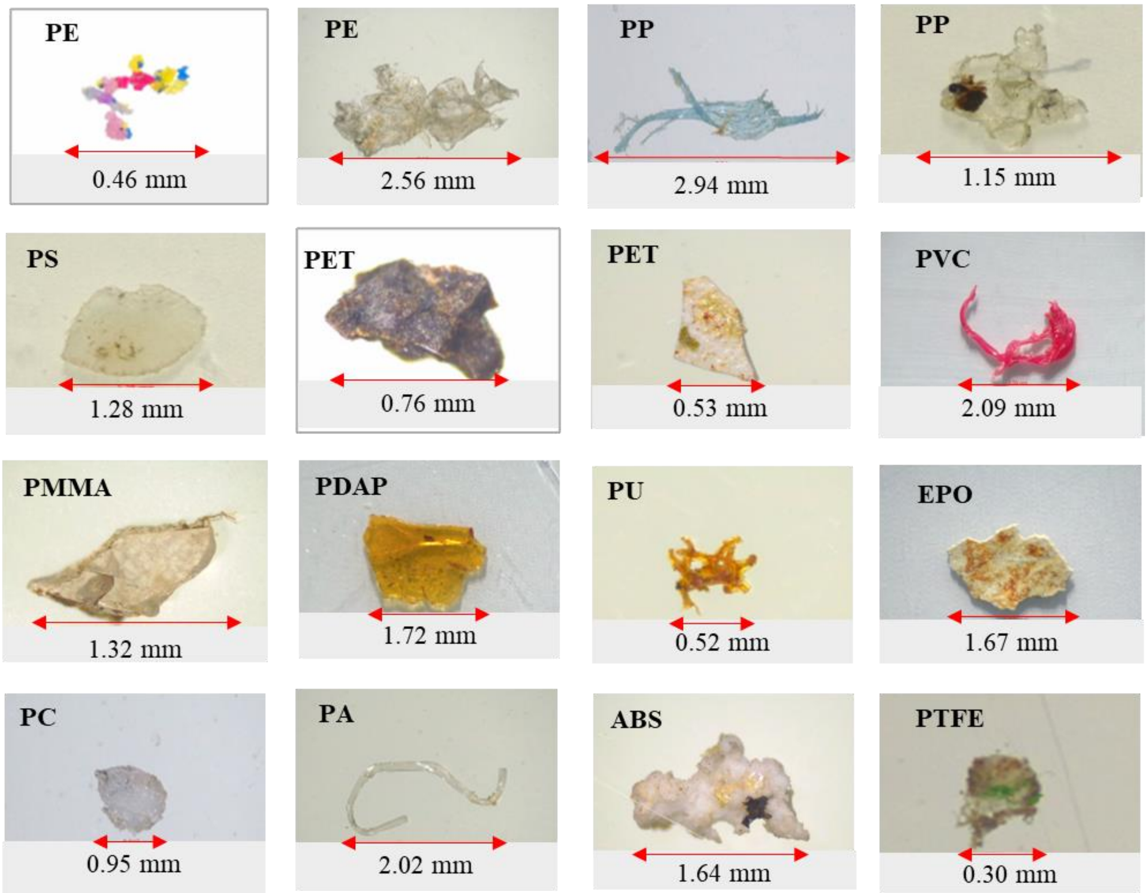


Figure 23. Secondary microplastics derived from macroplastics while improper disposal of plastic wastes (Hu et al., 2022, and illustration by authors)

Microplastics were also found in food and drinks such as milk, table salt, tap/bottled water, seafood, beer, honey, sugar, and pet food (Hantoro et al., 2019; Kosuth et al., 2018; Kutralam-Muniasamy et al., 2020; Liebezeit & Liebezeit, 2013; J. Zhang et al., 2019; Q. Zhang et al., 2020).



PE: Polyethylene, PP: Polypropylene, PS: Polystyrene, PET: Polyethylene terephthalate, PVC: Polyvinyl chloride, PMMA: Polymethyl methacrylate, PDAP: Polydiallyl phthalate, PU: Polyurethane, EPO: Epoxy resin, PC: Polycarbonate, PA: Polyamide, ABS: Acrylonitrile butadiene styrene, PTFE: Polytetrafluoroethylene

Figure 24. Secondary microplastics derived from plastic wastes (Kumamoto University)

Figure 23 shows that plastic waste can be fragmented into smaller pieces called microplastics. This figure shows different types of microplastic found in dumping site soils from six Asian countries: Cambodia, India, Indonesia, Laos, the Philippines, and Vietnam. Microplastics cannot be seen by the naked eye because their sizes are very small. Therefore, they can be easily diffused into the ambient environment and some lighter microplastics can move far from their original location via wind, water flow, and various mechanisms. This is based on the plastic polymer density as each polymer has a specific density. For example, polyethylene (PE) density is 0.91 to 0.96. Meanwhile, PE microplastics are found in ubiquitous places.

2.7. Distribution of microplastics in the environment

Among various environmental systems, the sea is the first place where microplastics are reported in most research. Every year, there are over eight million tonnes of plastic entering the oceans (Jambeck et al., 2015) and over 60% of the floating debris in the oceans was plastic in 2015 (Gewert et al., 2015). Based on previous research data, polyethylene (PE) accounts for the largest proportion (23%) of the total plastics in abundance, followed by polyester, polyamide and acrylic (PP&A) fiber (20%), polypropylene (PP) (13%), and polystyrene (PS) (4%) in the marine environment (Y. Qi et al., 2020). microplastics with lower density than sea water (1.02 g/cm3) float on the sea surface, and the corresponding concentration decreases through the water column, whereas only denser microplastics are enriched with depth (Y. Qi et al., 2020). According to Isobe, there is no change in the amount of plastic entering in oceans, but microplastic concentration will increase significantly in the Pacific Ocean (Fig.24) (Isobe et al., 2015). The assessment of microplastic occurrence has been extended from the marine environment to the terrestrial environment in recent years. Microplastics have been detected in rivers, lakes, estuaries, groundwater, tap water, wastewater and even bottled water across Asian, Europe, Australia and North America, and the concentrations ranged from 1x 10-2 to 108 particles/m3 (Y. Qi et al., 2020). For rivers connecting to the ocean, microplastics would eventually end in the estuaries or marine environments. Every year, rivers alone can bring about 0.47-2.75 million tons of plastic waste to the sea (Mani et al., 2019).

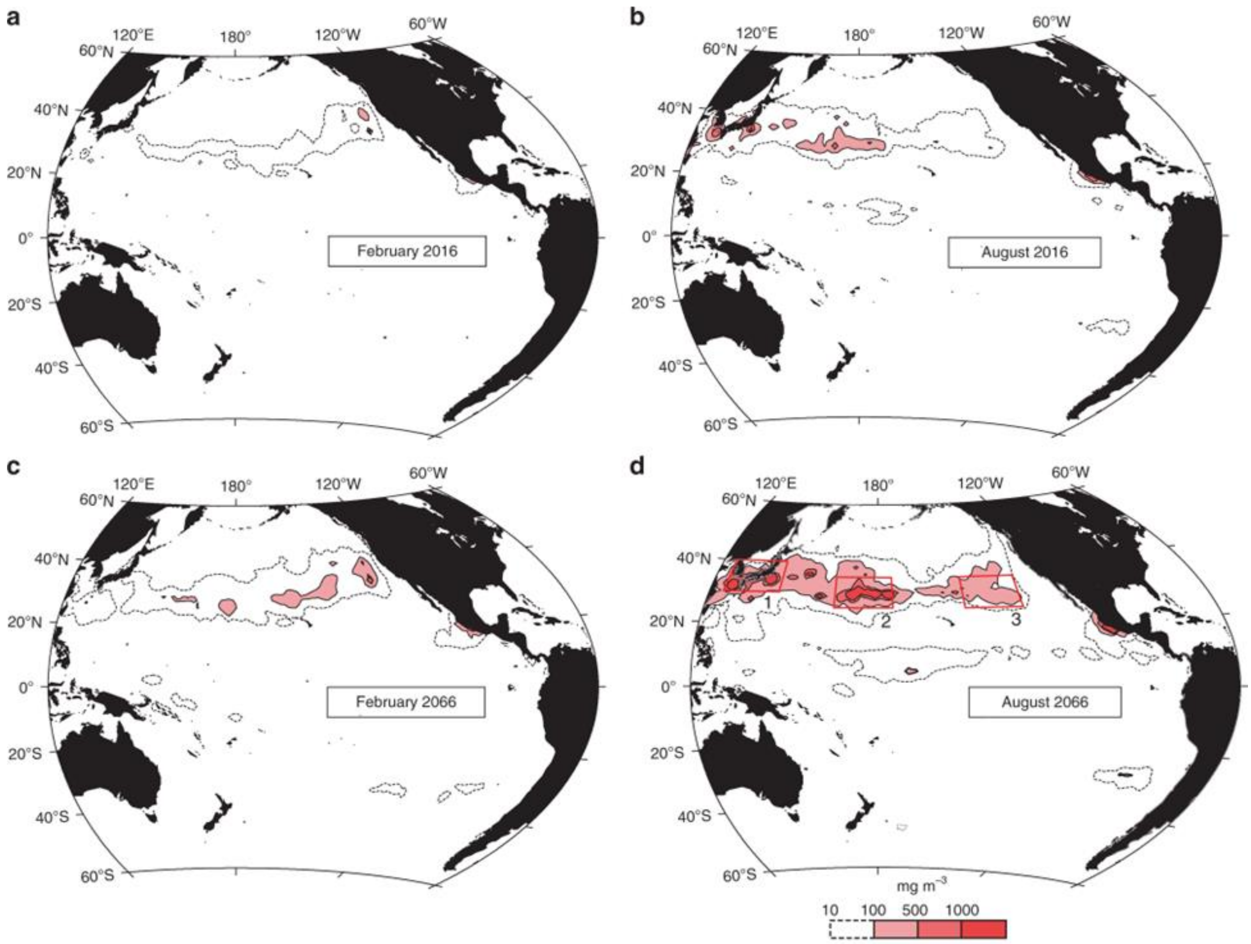


Figure 25. Estimation of MPs abundance in 2066 (Isobe 2019)

The deposition of atmospheric microplastic in terrestrial environments can be caused by the use of plastic mulching in agricultural fields, irrigation with wastewater, flooding with lake water, fragmentation of larger plastics, general littering, road runoff, and air-borne microplastics from surface deposits (Bi et al., 2020; Bläsing & Amelung, 2018; Rillig, 2012). The increased amount of microplastics in solid environment can cause impacts on soil structure, fertility and nutrient transfer, microbial activity, soil animals and plants, which have been comprehensively discussed in several reviews (Guo et al., 2020; Li, Song, et al., 2020; R. Qi et al., 2020; Wang et al., 2019; Xu et al., 2020).

The physical impacts of microplastics on marine organisms and the corresponding factors that influence bioavailability have been well documented (Wright et al., 2013). Vertebrates suffer from a series of impacts, including internal and/or external abrasions and ulcers and blockages of the digestive tract, which can result in satiation, starvation and physical deterioration, giving rise to reduced reproductive fitness, drowning, diminished predator avoidance, impairment of feeding ability and ultimately death (Gregory, 2009; Wright et al., 2013).

Microplastics can act as a medium or vector to adsorb, accumulate, and transfer contaminants such as persistent organic pollutants (POPs), toxic metals, endocrine disrupting chemicals (EDCs), antibiotics, and harmful pathogen species (Auta et al., 2017; Cole et al., 2019). Moreover, plastics contain plasticizers, fillers, and flame retardants, which account for 34%, 28%, and 13% of all additives produced between 2000 and 2014. Other additives are antioxidants (6%), heat stabilizers (5%), impact modifiers (5%), etc (Geyer et al., 2017b). When microplastics sink to sediments where a plethora of metals reside (e.g. Al, Cu, Ag, Zn, Pb, Fe, and Mn), they will act as an adsorbent toward metal ions in the aquatic environment. As a result, if they are ingested or decomposed, these toxic components will be released into organisms or water bodies and then transferred to the food chain, posing threats to human health. The detrimental effects of these hazardous pollutants can be cancer, endocrinopathy, child development issue, birth defects, and immune system problem (Cole et al., 2019).

2.8. Impacts to different industries

Our ocean, particularly in the East Asian region, is made up of six large shared marine ecosystems: The Yellow Sea, East China Sea, South China Sea, Gulf of Thailand, Sulu-Sulawesi Seas, and Indonesian Sea. Its coastline stretches from Japan, China, the DPRK, and RO Korea down through Southeast Asia, from Thailand to the Philippines and Malaysia, and across Indonesia to Timor-Leste (Bernad & Thia-Eng, 2015; Environmental Management for the Seas of East Asia; et al., n.d.).

According to the Organisation for Economic Cooperation and Development (OECD), the ocean contributes approximately US$1.5 trillion to the global economy each year, with this figure expected to more than double by 2030 (Jolly, 2016). East Asia is considered the most abundant and diverse marine ecosystem, comprising 1/3 of all coral reefs and mangroves in the world. It is home to diverse coral reef fish, mollusks, mangroves, and seagrass species, which bring

US$23,100-USS270,000 annual economic benefit per square kilometer of healthy coral reef in Southeast Asia (Asian Development Bank (ADB), 2014; The World Bank Group, n.d.).

With the leading global seafood exporting countries, China, Thailand, and Vietnam, the region contributes 83 percent of the world's aquaculture products and over 32 million tons of annual fish catch (Lymer et al., n.d.). Other marine industries, such as ports and shipping (among top shipping economies; China, Singapore, Port Klang, Malaysia, etc), fishing, and coastal tourism, account for 15 to 20% of the GDP in some East Asian countries (Tropical Coasts, 2009).

The Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) in its 2018 report identified the following nine (9) key industries of the Blue Economy (Environmental Management for the Seas of East Asia; et al., n.d.):

- Fisheries and Aquaculture
- Ports, Shipping and Marine
- Transport
- Tourism, Resorts and Coastal
- Development
- Oil and Gas
- Coastal Manufacturing
- Seabed Mining
- Renewable Energy
- Marine Biotechnology
- Marine Technology and Environmental Services

The health of the marine ecosystem has a strong influence on marine economic growth. Besides climate change, marine plastic pollution alone causes an annual economic loss of around 6 to 9 billion US dollars, impacting multiple maritime capitals. A report by the Asia-Pacific Economic Cooperation (APEC) estimates that the cost of marine plastic pollution to the above-mentioned industries was USD 1.3 billion in the region (UNEP, 2014). It was also reported that the clean-up movement could reach up to USD 695 million per year in relatively low marine plastic leakage area (European Commission, n.d.).

2.9. Marine economy and status of marine plastic litter in ASEAN countries

It was reported that Southeast Asian countries has become the destination for illegal plastic dumping since China, the world's largest importer, announced the ban in 2017 (BBC News, n.d.). In addition to that, poor plastic waste management in countries contributes to the problem despite some improvements in recycling rates in some countries. Since then, significant steps have been taken to combat this issue, ranging from returning the illegally imported plastic waste to the country of origin to domestic enforcement. However, the severity of the situation has yet to be improved.

The table below lists the top plastic litter found during coastal clean-ups in the world.

Table 5. Ocean Conservancy International Coastal Clean-up 2020 Report

1	Food Wrappers (candy, chips, etc.)	4771602
2	Cigarette Butts	4211962
3	Plastic Beverage Bottles	1885833
4	Plastic Bottle Caps	1500523
5	Straws, Stirrers	942992
6	Plastic Cups, Plates	754969
7	Plastic Grocery Bags	740290
8	Plastic Take Out/Away Containers	678312
9	Other Plastic Bags	611100
10	Plastic Lids	605778

Source: Lewis 2020

2.9.1. *Malaysia*

The Marine Park Malaysia recorded 77% of coral species in the world in Malaysian waters and the estimated value of this marine ecosystem ranges between RM 39.6 million and RM 3.6 billion a year. This rich ecosystem brings values to the economy and the social needs of the population. In 2015, it was reported that the ocean economy to the country's GDP was valued 23% and displayed in the table below (Sea Circular, 2019);

Table 6. Malaysia ocean economy to the country's GDP

Marine Industry	Annual value	Note
Fisheries	RM 12.7 billion (US$2.1 billion)	
Aquaculture production	US$829 million	
Coastal and marine tourism	RM 283 million (US$155.3 million)	Average visitors; 630,000 per year. Employment; 131112
Ports and shipping	US$226.7	

Source: Sea Circular 2019

The destruction of marine ecosystems, where marine plastic debris is one of the biggest contributors, has been alarming. Malaysia ranks 8th amongst the countries with the most mismanaged plastic waste in the world. There is an annual leakage of 0.14 to 0.37 million tonnes of plastic waste into the oceans from Malaysia. Oceans and beaches in the country are threatened by mismanaged solid waste, including plastic waste. The table below lists the plastic waste items collected during the International Coastal Clean-up effort in Malaysia (Ministry of Science and Technology of Malaysia, n.d.; Sea Circular, 2019).

Table 7. International coastal clean-up efforts and marine litter items (number) found in Malaysia

Country / location						People	KG	KM of coast	Total items collected
Malaysia						12,817	36,895.48	1,463.15	546,614
Cigarette butts	Food wrappers (candy etc.)	Straws stirrers	Plastic forks Knives spoons	Plastic beverage bottles	Plastic bottle caps	Plastic grocery bags	Other plastic bags	Plastic lids	Plastic cups plates
148,691	139,958	21,715	81,841	47,004	9,132	12,111	2,759	15,915	6,836

Source: Reef Check Malaysia and Trash Hero Malaysia – combined data for International Coastal Clean-up Day and World Clean-Up day 2019 (Ocean Conservancy, 2019)

2.9.2. *Thailand*

Thailand's petrochemical sector is the largest in the Southeast Asian region and the 16th largest in the world. Thailand is grappling with an increase in garbage generation, mainly plastic waste. Despite recent improvements in waste management in Thailand (Master Plan of Solid Trash Management 2016–2021), residual and plastic waste remain key challenges that could have negative consequences, including considerable contributions to marine debris. To systematically address the plastic waste challenge, Thailand's government released the Roadmap for Plastic Waste Management 2018–2030 in April 2019. In addition, it announced the development of a National Action Plan on Marine Plastic Debris to prevent and mitigate plastic waste issues, in line with SDG 14: Zero Waste by 2030 (OECD, n.d.).

In 2018, Thailand produced 11.8 million tonnes of downstream petrochemical products, including plastic resins. Thailand's plastics industry contributed 1,100 billion baht (USD 36.9 billion) to the national economy in 2018, representing 6.71% of Thailand's GDP (International Bank for Reconstruction and Development/The World Bank, n.d.). In addition, Thailand produced 2 million tonnes of plastic pollution, of which 0.5 million tonnes were recyclable plastic (primarily plastic bottles), 1.2 million tonnes were plastic bags, and 0.3 million tonnes were other plastic garbage (e.g., boxes, trays, bottles, lids) (The World Bank Group, 2020). A quarter of plastic waste is recycled, with the remaining 75% sent to landfills.

Figure 26. Plastic waste consumption in Thailand, 2018

Source: (Thai-German Cooperation, n.d.)

2.9.3. Lao PDR

Lao's People Democratic Republic (Lao PDR) is a landlocked country in Southeast Asia. Where the Mekong River plays an important role in supporting population life and the country's economy, plastic waste management is especially critical since land-based leakage into the Mekong River's waterways is an essential channel for plastic waste entering the South China Sea. The changes in consumption and production patterns are posing new issues for Lao PDR, resulting in increased amounts of trash and a more complex waste stream.

In 2016, Lao PDR's municipal solid waste (MSW) was estimated at 364,000 tonnes, with a projection of reaching 522,000 tonnes in 2030 and 748,000 tonnes in 2050 (Magnus Bengtsson, 2022). Based on these estimations, Lao PDR appears to be one of the smallest generators of MSW among the ASEAN+3 member states (UNEP, 2017b). Of the 500 tonnes of solid waste generated daily in Vientiane, the capital and largest city of Lao PDR, plastics made up 6.1% (Climate and Clean Air Coalition (CCAC), 2016).

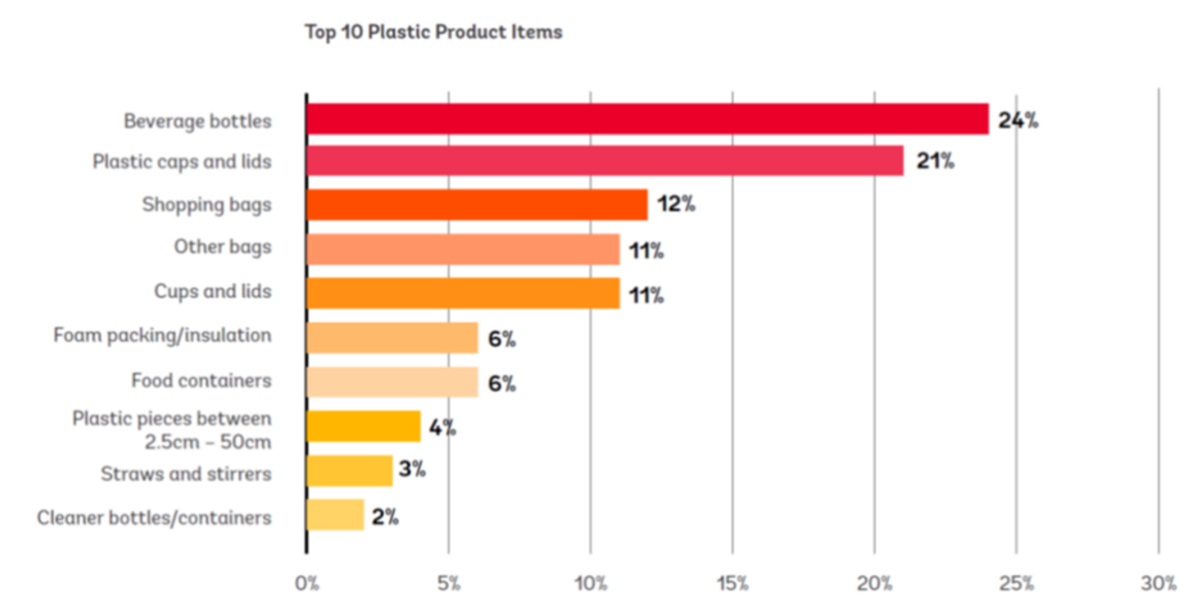


Figure 27. The list of most used plastic in Lao PDR

Source: World Bank. 2021. Supporting Lao PDR in Development of a Plastic Action Plan—Plastic Diagnostics (Kaysone Vongthavilay Klaus Sattler, n.d.)

2.9.4. Philippines

The Philippines, using around 60 billion plastic sachets a year, is one of the world's worst offenders of marine plastic pollution. The plastic used for packaging is the major contributor to marine litter and plastic pollution. The inefficient collection of garbage by local governments also leads to harmful plastic leakage to the wastewater and drainage systems especially in informal settlement areas where waste is not adequately collected. Wastes that clog the waterways contribute to the frequent flooding in Metro Manila and have a negative impact on revenue-generating nature-based tourism and the fishing industry. The ballooning plastic pollution in the Philippines is a product of economic growth that leads to increased production, consumption, and waste. The Philippines aims to promote 60% recovery and recycling of plastic by 2030 and offers opportunities for the private sector for technology transfer and assimilation in plastic waste management (Sea Circular, n.d.).

Chapter 3:

Innovative solutions and alternatives to plastics

Chapter 3: Innovative solutions and alternatives to plastics

Plastic, as mentioned in Chapter 1 is a synthetic product that hardly decomposes in the environment. It could take years to break down and it can exist into a smaller form called microplastic, that travels up to our food chain and contaminates our water. As it could release toxic chemicals removing them is necessary to prevent long-term impacts on the environment.

3.1. Plastic circular economy

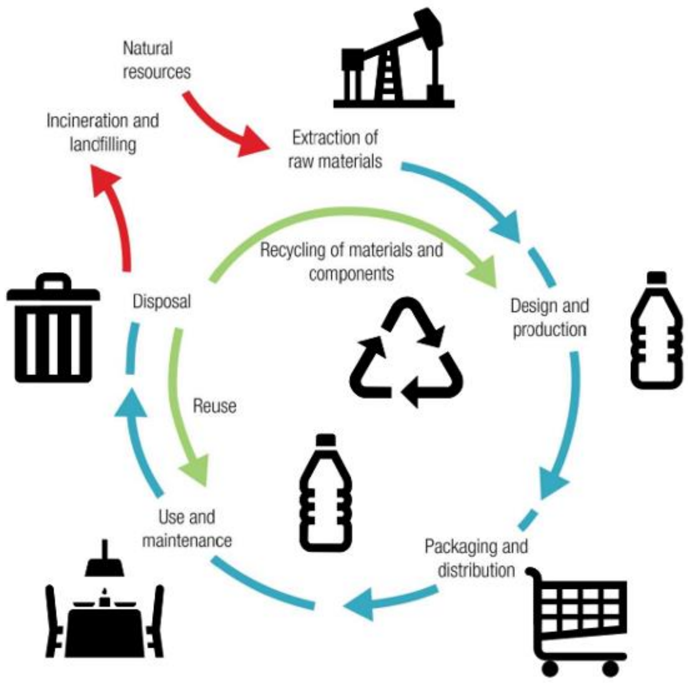


Figure 28. Life Cycle Initiative

Source: (Life Cycle Initiative, n.d.)

In a conventional linear economy, after plastic goes through extraction and interacts with natural resources such as crude oil and natural gas, it is processed and developed into various plastic products and used for different purposes. After consumption, it is either recycled or ends up as waste. However, most of the plastic products are disposed in landfills causing many major environmental issues, including plastic pollution that harms the ecosystem (Alhazmi et al., 2021).

Circular economy refers to the economic system that seeks to reduce material use, redesign materials to be less resource intensive, and recaptures waste as a resource for production (USEPA, n.d.). In circular economy, plastic products are designed to be reusable, recyclable or compostable, so that they do not end up as waste in the environment. The idea is to retain the value and utility of products within the economy, for example, by eliminating excessive plastic packaging, choosing reusable products over single-use plastic products, as well as recycling plastic waste for other materials and products, in order to close up the circle of material flow of the plastics (EEA, 2020).

Dealing with plastic waste is critical as there are still many problems in solid waste management, especially in developing countries. Waste segregation at source is an important key to drawing an effective recovery of plastic back into the economy. However, many countries in ASEAN are still struggling with solid waste management, with neither proper waste segregation nor recycling systems. Despite the existence of social policies by government, individuals are encouraged to act proactively against contributing to plastic pollution in the environment by switching to eco-friendly lifestyles, practicing 3Rs in their daily life as well as separating recyclable waste, etc.

Figure 29. Ways to reduce plastic

Source: (UNDP Cambodia, n.d.)

In Cambodia, solid waste management is a major problem, especially in the capital city of Phnom Penh, due to the increase of urban population and economic growth. The waste is not segregated and ends up in landfills and illegal dumpsites, causing pollution to the environment and serious health problems. Moreover, concerning the capacity and lifespan of the landfill as well as the environmental impacts of the disposed solid waste, in November 2021, Phnom Penh Capital Hall called for waste segregation at source for households in Phnom Penh to separate their waste into biodegradable and non-biodegradable waste (Phnom Penh Capital Hall, 2021). Moreover, the 5R campaign – Refuse, Reduce, Reuse, Recycle, Remind – is conducted to raise awareness among the public to reduce plastic pollution (Ministry of Environment (MoE) & National Council for Sustainable Development (NCSD), 2021). The Ministry of Environment also introduced circular economy for waste recycling, promoting attention to local plastic waste recycling potentials, such as recycling businesses and producing plastic-based handicrafts (Ministry of Environment (MoE) & National Council for Sustainable Development (NCSD), 2021).

Supplementary articles: For additional readings on this topic, you may wish to check the suggested links below.

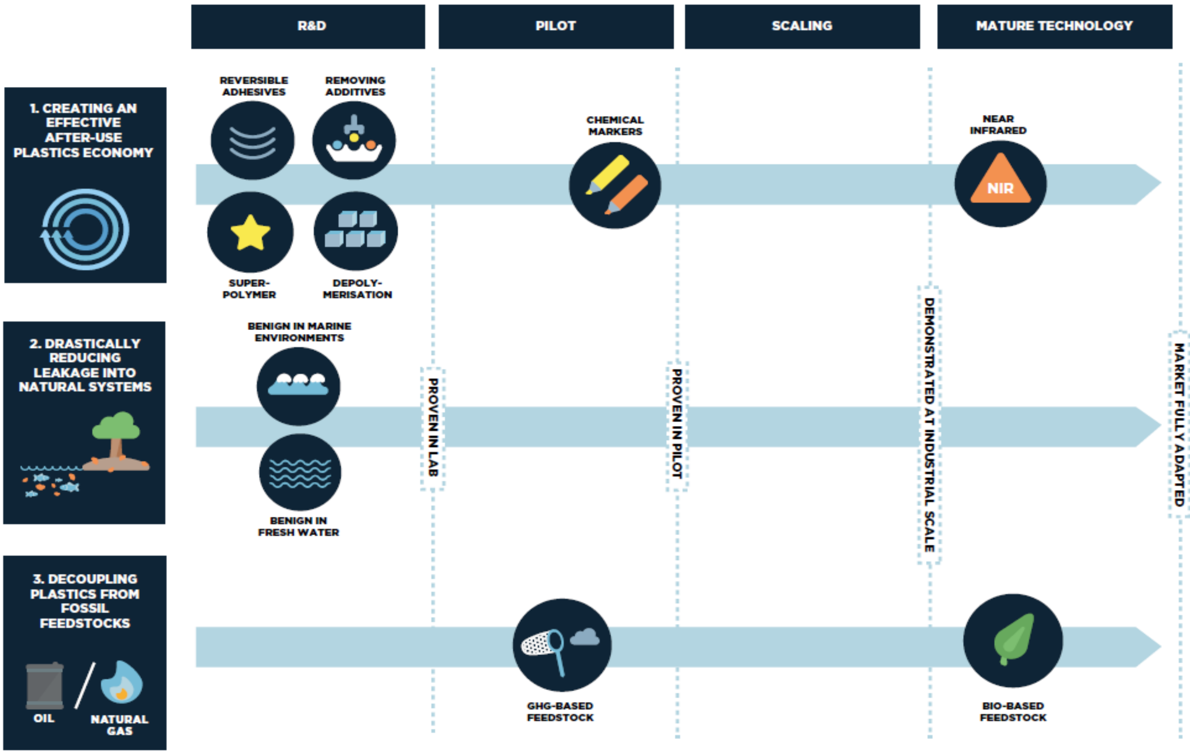
Plastic circular economy: https://youtu.be/xmTQA-RNygQ

General idea on circular economy: https://ellenmacarthurfoundation.org

3.2. New Plastic Economy

Aside from that, the world needs an aggressive approach to achieve a systemic shift towards the "New Plastic Economy," where the current improvements are guided by coordinated global collaboration among industries, governmental agencies, and NGOs. This guideline should be equitable to the complexity of the problem, and the aim is to use existing plastic as an integral resource to drive a plastic circular economy. In the figure below, experts in each process can come together to drive the development or innovation for a New Plastic Economy (Industry Agenda, 2016; Project MainStream et al., n.d.) through the following innovations:

- bio-benign materials and plastic alternatives that are made from renewable resources and biodegradable
- the development of materials designed to facilitate multilayer reprocessing, such as the use of reversible adhesives based on biomimicry principles
- the search for a 'superpolymer' with the functionality of today's polymers and with superior recyclability
- chemical marking technologies
- chemical recycling technologies



INNOVATION	DESCRIPTION	CURRENT STATE
Removing additives	Separating additives from recovered polymers to increase recyclate purity	Lab stage: Some technologies exist but with limited application
Reversible adhesives	Recycling multi-material packaging by designing 'reversible' adhesives that allow for triggered separation of different material layers	Conceptual stage: Innovation needed to develop cost-competitive adhesive
Super-polymer	Finding a super-polymer that combines functionality and cost with superior after-use properties	Conceptual stage: Innovation needed to develop cost-competitive polymer with desired functional and after-use properties
Depolymerisation	Recycling plastics to monomer feedstock (building blocks) for virgin-quality polymers	Lab stage: Proven technically possible for polyolefins Limited adoption: Large-scale adoption of depolymerisation for PET hindered by processing costs
Chemical markers	Sorting plastics by using dye, ink or other additive markers detectable by automated sorting technology	Pilot stage: Food-grade markers available but unproven under commercial operating conditions
Near infrared	Sorting plastics by using automated optical sorting technology to distinguish polymer types	Fragmented adoption: Large-scale adoption limited by capex demands
Benign in marine environments	Design plastics that are less harmful to marine environments in case of leakage	Lab stage: First grades of marine degradable plastics (one avenue towards benign materials) already certified as marine degradable — impact of large-scale adoption to be proven
Benign in fresh water	Design plastics that are less harmful to freshwater environments in case of leakage	Lab stage: Marine degradable plastics theoretically freshwater degradable. One certified product — impact of large-scale adoption to be proven
GHG-based	Sourcing plastics from carbon in greenhouse gases released by industrial or waste management processes	Pilot stage: CO_2-based proven cost competitive in pilots; methane-based being scaled up to commercial volumes
Bio-based	Sourcing plastics from carbon in biomass	Limited adoption: Large-scale adoption hindered by limited economies of scale and sophistication of global supply chains

Figure 30. Examples of Promising Enabling Technologies for the New Plastics Economy and Their Level of Maturity

Source: (Industry Agenda, 2016; Project MainStream et al., n.d.)

3.3. Individual and community action

In recent years, awareness about marine plastic waste or plastic pollution in general has increased among the public. There are many individual or community based actions available to mitigate the problem in their hometown. Below are some of the examples:

Did you know? Box 5: Hiroshima Jogakuin High School, Japan

A student, Ms. Kawanishi, from Hiroshima Jogakuin High School in Hiroshima, Japan participated in one of the classes of the ASEAN-Hiroshima Eco School Program. Ms Kawanishi was inspired by the lesson and created this picture book to highlight the issue.

Figure 31. Picture book by Ms. Maoka Kawanishi (student)

Box 6: Beach cleaning activities (photo by authors)

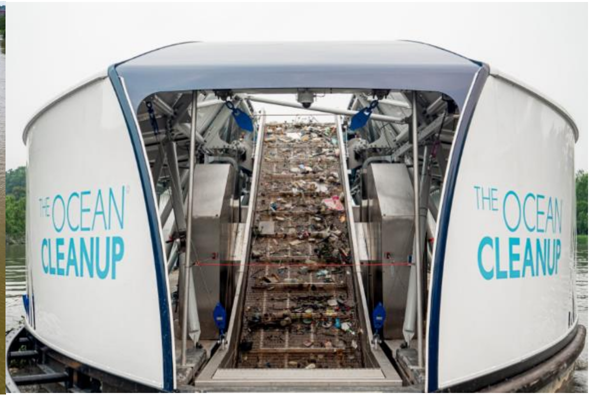
On the left is the picture taken from MY Clean Beach program, which is an initiative by the Malaysian government to clean beaches and coasts around Malaysia. So far they have recruited around 786 volunteers and collect around 5000kg of trash (My Clean Beach, 2022).

3.4. Scientific and technological innovations on plastic waste management and disposal

The advancements in science and technology have offered a variety of solutions to tackle the issue, from preventing plastic from entering rivers to developing new materials or product to replace plastic. This section will give an overview of what has been done in the region.

3.4.1. "Floating" robots

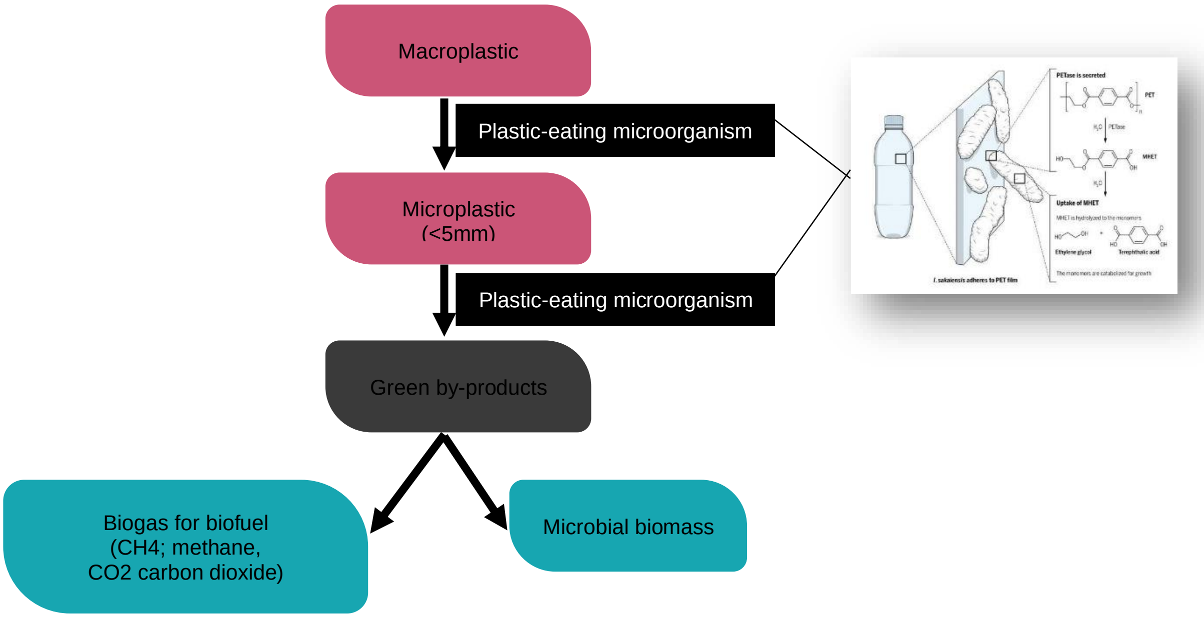
Scientists and engineers have come up with a river clean-up robot called "The Interceptor". This machine runs on solar power and is installed in polluted rivers in Indonesia, Malaysia, and Vietnam (The Ocean Cleanup, n.d.).



3.4.2. Plastic-degrading microorganisms

Scientists have discovered many plastic-degrading organisms like bacteria (Gunther, n.d.) and fungi that can eat plastic and convert it into safer by-products. These by-products could be used as biofuel to generate electricity, while the biomass can be used as fertilizer.

Figure 32. Process of degarding plastics by microorganisms (Ottoni 2018)



3.4.3 Plastic-recycling technology

The following discussion identifies existing plastic recycling technologies used in specific countries.

Expanded Polystyrene (EPS) recycling (Japan, others)

EPS is widely used and discarded in the wholesale fish and seafood markets around the world. The size of EPS that takes up space and the hygiene issues that arise as a result of improperly discarded EPS necessitate an urgent system for recycling and insertion into the economy as a raw material. The progress of industrial equipment capable of converting EPS into ingots provides an opportunity to reuse the material (Pana-Chemical & ERIA, n.d.).

3.4.4. Minimizing plastics

Biohybrid resin from palm stearin (Malaysia)

This innovation eliminates the use of plasticizers or reactive modifiers used in biohybrid polymer blends. This material is made from palm stearin biohybrid with HDPE suitable for making plastic packaging or products like industrial bins, cutleries, trays, and clothes hanger (ERIA & GAIA Greentech, n.d.).

Biostarch resin (Vietnam)

This innovation is made from 40% starch and 60% virgin PP plastic and can be applied to make cutlery, non-woven bendable straws, and coating film. It can be degraded in 168 days (bio-degradation rate is 91.6 percent), which is higher than the minimum requirement (at least 60 percent in two years). When 1 kg of product is used, it reduces CO^2 by 5.2 kg. When compared to plastic recycling activities, this has a significant impact on climate change (ERIA & Biostarch, n.d.).

3.4.5. Plastic as building material

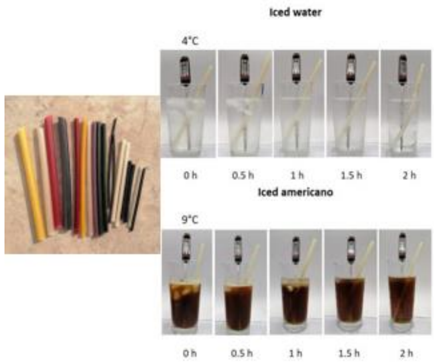
Bricks made from plastic sachets (Indonesia)

Plastic sachet waste is collected and processed inside a machine to form bricks with high pressure power until up to 250 kg/cm2. This product is suitable fit for pedestrian lanes, parking lots, and gardens. They adopt a green layering technology to reduce microplastic pollution. Since June 2022, they have received 17,500kg of plastic waste and generated 10,000kg of processed products (ERIA & Rebricks, n.d.).

3.4.6. Plastic alternatives

Alternative Straws (Vietnam, Malaysia)

Grass straw is made 100% from Vietnamese Lepironia plant, which grows in the Mekong Delta region. The grass stem, which is long and hollow is suitable for creating drinking straws. No chemicals, dyes and plastic derivatives are added to the product to make it safe for humans and the environment ("19-Year-Old Agricultural University Student Launches a Grass Straw Brand," n.d.; "Lepironia Grass Straws in Vietnam: The Ultimate Sourcing Guide," n.d.; ERIA & Eco Friendly Viet Nam JSC, n.d.).



Moreover, there is also an alternative straw made from broken rice flour and tapioca starch, whose dissolvability in cold water is around 2 hours and in hot water is around 1.5 hours. The straw comes in different colors, and is made from 100% natural and plant-based (ERIA & RiceStraws, n.d.).

Biodegradable and Compostable Food Packaging (Thailand, Malaysia)

Compostable food packaging is made from natural virgin 'left-over' materials from agricultural waste that is usually burned. Examples of this are rice husk, corn husk, sugarcane bagasse, bamboo, water hyacinth and palm. They are non-toxic and completely compostable, microwaveable, oven-safe and cold-resistant (ERIA et al., n.d.).

3.5. The "myth" of biodegradable plastic

Since the early 1920s, research in the field of polymeric materials has been done in search of a solution to tackle the growing concern of plastic pollution in the environment (Ainali et al., 2022). Bioplastics were then introduced to the market as an innovative solution to this problem. There are at least two common names for these eco-friendly plastics, bioplastic and biodegradable, which can be quite confusing. Bioplastics are plastics that are bio-based (made from renewable materials), both bioplastics and biodegradable have properties similar to conventional plastics but offer additional benefits such as reduced carbon footprint, improved functionality, or additional waste management options such as organic recycling (Plastics Europe, 2021). Thus, basically all biodegradable plastics are bioplastics. However, bioplastics are not only limited to biodegradable plastics but also any plastic made from renewable materials (not degradable) which produce less carbon footprint to the environment.

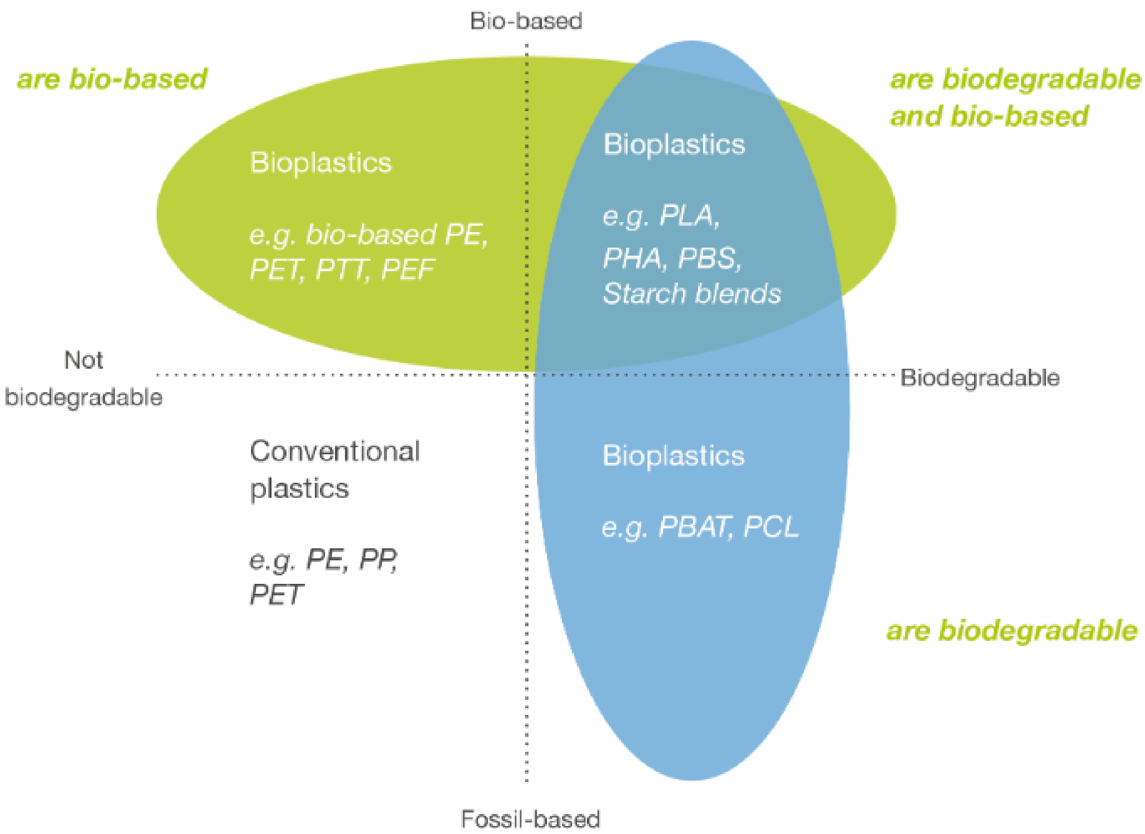


Figure 33. Classification of bioplastics (European Bioplastics)

In 2021, there are 2.42 million tons of bioplastics produced with rigid and flexible packaging dominating the market demand. And it is predicted that the global production capacity for bioplastics will keep increasing to 7.6 million tonnes in 2026 (European Bioplastics, 2022).

There are many types of bioplastic materials, such as polyhydroxyalkanoate (PHA), poly(lactic acid) (PLA), polyhydroxybutyrate (PHB), polyglycolide, polycaprolactone (PCL), poly(butylene adipate-co-terephthalate) (PBAT), poly(butylene succinate) (PBS), and starch-based blends. Among all bioplastic types, PLA is the most well-known substitute for petroleum-based plastics, offering great biocompatibility, strength, thermoplasticity, good processability, UV resistance, and is subjected to naturally degradation when exposed to environmental conditions (Ainali et al., 2022).

The degradation process is sped up in a composting environment (which includes high temperature and moisture, existence of microorganism and enzyme), but this not the case for biodegradable polymers as it slowly degrades in the environment. Studies show that PLA actually needs a long period to be degraded within soil substrate (Zaaba & Jaafar, 2020) and in wastewater treatment plants (WWTPs) since it resists microbial attack (Rom et al., 2017). Furthermore, an investigation of microplastics (MPs) transportation in the Arctic Sea and their variability in the entire sea cores show that <1% of the total isolated particles was PLA MPs (Peeken et al., 2018).

Starch-based materials are also being promoted as readily degraded in the environment. Some commercially available plastic bags are advertised as dissolvable and drinkable plastic bags. Similar to a conventional plastic bag, a bio-based plastic bag is found to contain high concentration of antioxidant. Dissolving plastics actually raise concern as it means releasing more chemical additives to the environment. As the production of bioplastics is growing, a sufficient waste management (European Bioplastics, n.d.) infrastructure is needed to control the release of toxic chemicals. As with conventional plastics, the manner in which bioplastic waste is actually recovered depends on the type of product and bioplastics material used, the inherent quantities and the recovery systems available.

Figure 34. Waste management of bioplastics (European Bioplastics)

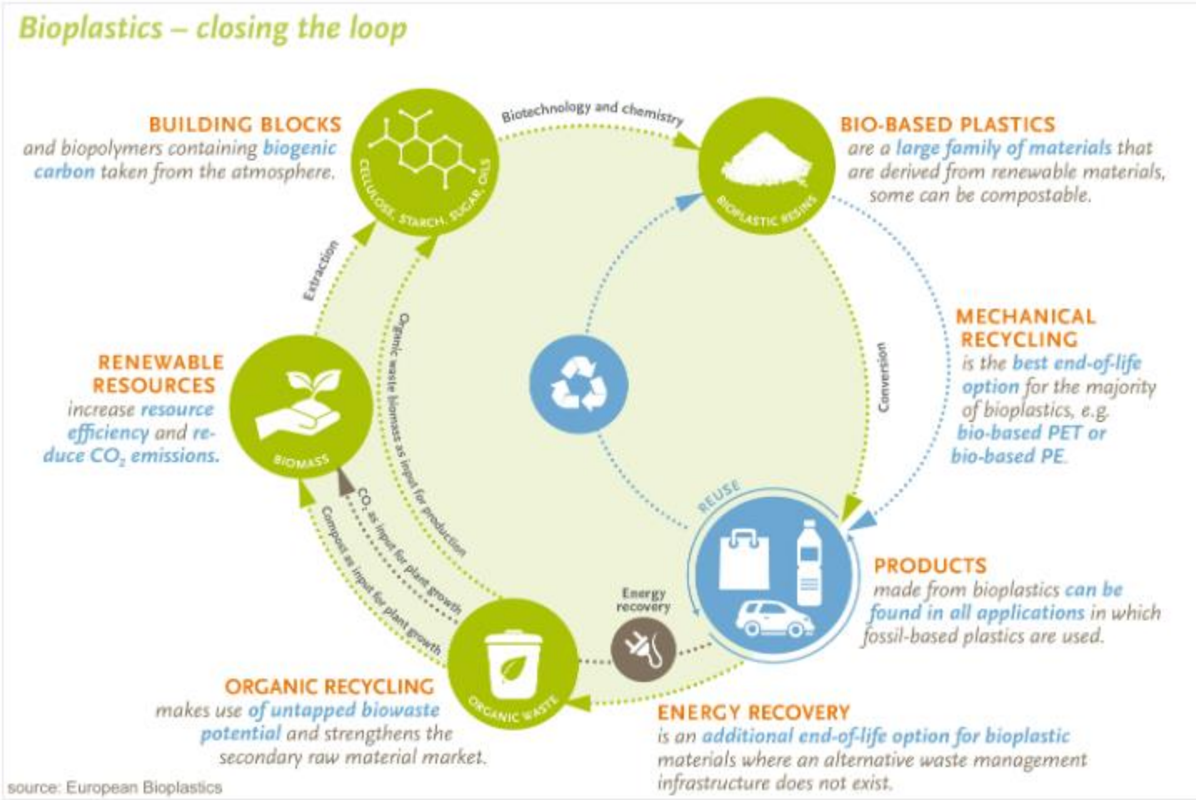


Figure 35. Life cycle of bioplastics

Source: European Bioplastics.

Appendices

Appendix 1: Lesson plan and teaching materials

This section provides you with contents for our lesson plan and teaching materials that can be utilized in conducting your teaching sessions. You can include or exclude some of the activities as needed.

Course outline

1. Introduction
    1. Content: Chapter 1 Plastic in daily life
        - Characteristics of plastic
        - Process of plastic manufacturing
        - Types of plastics
        - Advantages and disadvantages of plastic
2. Development
    1. Content: Chapter 2 Plastic pollution in ASEAN, Japan and the world
        - Global plastic production
        - Plastic usage in Southeast Asia and Japan
        - Waste management
3. Action
    1. Content: Chapter 3: Innovative solutions and alternatives to plastic
        - Plastic circular economy
        - New plastic economy
        - Individual and community efforts
        - Scientific and technological innovations
4. Conclusion
    1. Plastic Footprint (see page 69-70)
    2. Feedback

Standardized teaching materials

1. Elementary school

    Click to download: https://bit.ly/TOTteachingmaterial

2. High school

    Click to download: https://bit.ly/TOTteachingmaterial

3. Frequently asked questions

    Here we provide answers or information to typical questions by the students

    Click to download: https://bit.ly/TOTteachingmaterial

The table below lists the suggested activities and a brief description.

Table 8. List of suggested activities for your teaching session

Activities	***Description***
Standardized teaching materials	*These teaching materials were made by the Fellows based on the feedback and learnings from the ASEAN-Hiroshima Eco-school*

	program lectures. The aim is to make the material accessible for you to explain the issue in a presentation-based setting. It is suitable for use either in physical or online class set-ups. Further instructions on how to use the slide is provided in the beginning of each slide.
Suggested activities per chapter	*These activities are suggested activities made by the Fellows based on the outline of this guidebook. You can use these activities depending on the flexibility of time and the number of students.*
Plastic Footprint	*You need to distribute this sheet to each student, 1 week prior to conducting the activity. Students need to record their plastic usage for 5 days and calculate the total number by the end of the week. After finishing Topic 3, you can ask them to present and then reflect their usage if it is appropriate or not. You then encourage them and discuss how to reduce plastic usage in their daily life.*
Chart of plastic classification	*You can teach the students how to classify plastic using this chart. For detailed instruction, please refer to this section.*
Hands on-activity (1h lesson)	*This is an example of experience-based lesson where the students need to interact with each other to complete the task. This is suitable for elementary and high school students. Further instruction is provided in this section.*
Open source materials	*The activities listed in this section consists of two types of activities:* *1) Additional activity made by Fellows and information book for corporate members.* *2) Additional activities developed and made public by different organizations for educational purpose are collated as reference; they are developed by different organizations for educational purpose.*

Appendix 2: Suggested activities per chapter

Chapter 1: Plastic in Daily Life Activities

Activity 1: Plastic in daily life

Name of activity	***Plastic is it good or bad?***
Learning objectives	*To enhance the knowledge on plastic and its characteristics*
Recommended activity	*Before the class*
Communication style	*"Entakun" – Round table discussion*
Materials	*A round cardboard cutout (1 m in diameter), marker pens*
Venue	*In a class/hall*
Estimated duration	*15 minutes (5minutes/questions)*
Guided method	• *Ask 4-6 students to sit in a circle* • *Ask them to place the round cardboard cutout on top of their knees* • *Pre-recorded instructions (Link below)* *Follow up questions to add on the cardboard:* • *How is plastic used in your daily life?* • *What are the disadvantages of plastics?*
Link	*File name: Entakun* *Click for download: https://bit.ly/TOTteachingmaterial*

Activity 2: Hello Plastic!

Name of activity	***Hello Plastic!***
Learning objectives	*To enhance the knowledge of plastic characteristics and for students to know each other*
Recommended activity	*Before the class*
Communicate style	*Circle facing, 2-3 groups (4-5 students/group)*
Materials	*Notes/paper/post it, pencil/pen*
Venue	*In classroom/hall*
Estimated duration of the activity	*30-40 minutes*
Guided method	*Ask everyone to sit in a circle facing each other* *The teacher gives students the note/paper to write down their names, and list one item of plastic that they used* *Let them introduce themselves by starting to introduce their names together with 1 plastic item they use by singing a song and clapping hands* • ***1st person*** *"Hello plastic Hello plastic"* • *"I am Haruna I use bottle" la la la… Here I am Here I am* • ***2nd person*** *"Hello Phone she used bottle"* • *"I am Yasmin I use bento box" la la la…Here I am Here I am* • ***3rd person*** *"Hello Phone She used bottle"* • *"Hello Yasmin, she used bento box"* • *"I am Fah I use toothbrush" la la la. Here I am Here I am….* *One person will start by saying their name and 1 item of plastic. The next person will repeat what the first person says and then add their own. The next person will then repeat the first two in order and then add their own.* *The song will continue until the last person says each one in order and ends with their own.* *If someone makes a mistake, the person who gets it wrong will be eliminated and the last person to say them all without making a mistake will win the game* *After finishing the round, let students get back to their seats and collect all the plastic items that they used for the next activity.*

Activity 3: Plastic and Me!

Name of activity	***Plastic and me!***
Learning objectives	*To enhance the knowledge of plastic and how plastic is involved in our daily lives*
Recommended activity	*Before the class*
Communicate style	*Round table discussion, 2-3 groups (4-5 students/group)*
Materials	*Notes/paper, pencil/ pen, photos of plastic items*
Venue	*In classroom or wide space*
Estimated duration of the activity	*15-30 minutes*
Guided method	*Ask everyone to sit in a circle facing each other.* *The teacher gives students the note/paper to write down their name, and list one item of plastic that they used.* *Let students collect all the plastics that they used* *Then the teacher prepares a copy photo of each plastic items such as: Plastic bottle, plastic shopping bag, snack packaging, mask, straw, plastic cup, food container, etc. such as the one below:*  *Each student puts the number of their used plastic in the photo. Ask them to summarize, and let them think, why and how they use that amount of plastic? Then select one representative of the group to present the responses and discuss .* *This will help students to realize how plastic is involved in their daily lives.* *After that, the teacher will give a slide presentation or video presentation on where plastics come from. You can follow up by asking how has it become involved in our daily lives? Why do we use it? How does it cause the problems/pollutions in the environment?* *Let students take a break as they may get tired of some activities.* *The next activity will be group discussion on how plastic waste polluted.*

Chapter 2: Plastic Pollution in the World Activities

Activity 1: Oh! Plastic!

Name of activity	***OH! PLASTIC!***
Learning objectives	*To enhance the knowledge of plastic waste pollution problems*
Recommended activity	*During the class*
Communicate style	*Circle facing*
Materials	*Notes, paper, post it, pencil, pen, VDO, PPT*
Venue	*In classroom or wide space*
Estimated duration of the activity	*15-30 minutes*
Guided method	*Ask everyone to sit in a circle facing each other.* *After listening the presentation from the teacher, students are free to ask questions and the teacher will give some useful info to strengthen their understanding.* *Then, let students brainstorm on how they understand about the plastic issues.* *The teacher will* ***prepare some photos*** *to illustrate the animals whose lives are affected by plastic, animals with normal condition, and let them choose the photos that correspond to the topic.* *Ask a representative of the group to share what they feel when they see that photo.* *(E.g. the turtle is eating the straw and it is suffering, the dolphin was covered with plastic bag, it could not breath, etc.)* *This activity will show how the students feel and increase their understanding of the effect of plastic waste on environment.*

Activity 2: Impact of Plastic to Marine Life

Name of activity	***Impact of plastic to marine life***
Learning objectives	*To learn about the various ways in which plastic enters the food chain*
Recommended activity	*During the class*
Communication style	*4-5 students per group*
Materials	*Cardboard, markers/pens, pictures of animals with plastic litter*
Space	*In class/hall*
Estimated duration	*15-30min*
Guided method	*Pre-recorded*
Link	*File name: Food web* *Click for download: https://bit.ly/TOTteachingmaterial*

Chapter 3: Innovative Solutions and Alternatives to Plastic Activities

Activity 1: Bye Bye! Plastic!

Name of activity	***BYE BYE! PLASTIC!***
Learning objectives	*To encourage students to take steps on tackling the plastic issue*
Communicate style	*Circle facing*
Materials	*Notes, paper, post it, pencil, pen*
Space	*In classroom or wide space*
Estimated duration of the activity	*15-30 minutes*
Guided method	*Ask everyone to sit in a circle facing each other.* *The teacher gives another presentation on 3R (Reduce, Reuse, Recycle) (How can students do with the plastic?).* *Students are free to ask and share what they plan to do about plastic from now on.* *Recall the memory of what they have learnt today.* *Ask students on their impressions about this activity, and key take away.* *If the time allows, we can do some garbage collection/pick up around school nearby (if they find any garbage there).* *Sing a song for saying goodbye (just additional)* *Bye Bye Plastic! Bye Bye Plastic!* *Nice to know you! Nice to know you!* *It's time to say goodbye! It's time to say goodbye!* *For our world! For our world!*

Activity 2: River Survey

Name of activity	***River survey***
Learning objectives	*To record plastic transportation in rivers*
Recommended activity	*Outdoor activity class*
Communication style	*Group work + adult/teacher****
Materials	*Smartphone/Tablet (Apps: River survey)*
Space	*Outdoors (River bank)*
Estimated duration	*1 hour*
Guided method	*Using the following apps:* *https://play.google.com/store/apps/details?id=com.theoceancleanup.riversurvey&hl=en&gl=US* *https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/cleanswell/* *Outcome:* - *Contribute to the survey data of the clean-up organization in the app* - *The students could relate theoretical knowledge from the class with real-life problem* - *Inspire them to clean the river and reach-out to the locals about the impact of marine litter*
Link	*File name: River Survey* *Click for download: https://bit.ly/TOTteachingmaterial*

Hands-on activity

Title: Learn about the plastic waste problem in the ocean

Introduction:

This lecture is a hands-on activity on the issue of marine plastic waste developed by fellows of the ASEAN Eco School. The purpose of this lecture is to learn the seriousness of the marine plastic waste problem.

By setting up the venue as the “ocean” and using actual plastic materials as “marine plastic waste”, the students can recognize the waste that is flowing into the sea. They will be asked to actually pick up the waste they find in the “ocean” and sort how they are disposed. For them to understand the various plastic waste disposal methods around the world, the teacher discusses calculates how many students selected each disposal category, and replacing it with the real world values of disposal methods in ASEAN, Japan, and the world. As a result, students will be able to correlate the problems related to the disposal of plastic waste.

Time: 45min

Suitable grade: Elementary school students

Suitable place: Gym or Large classroom

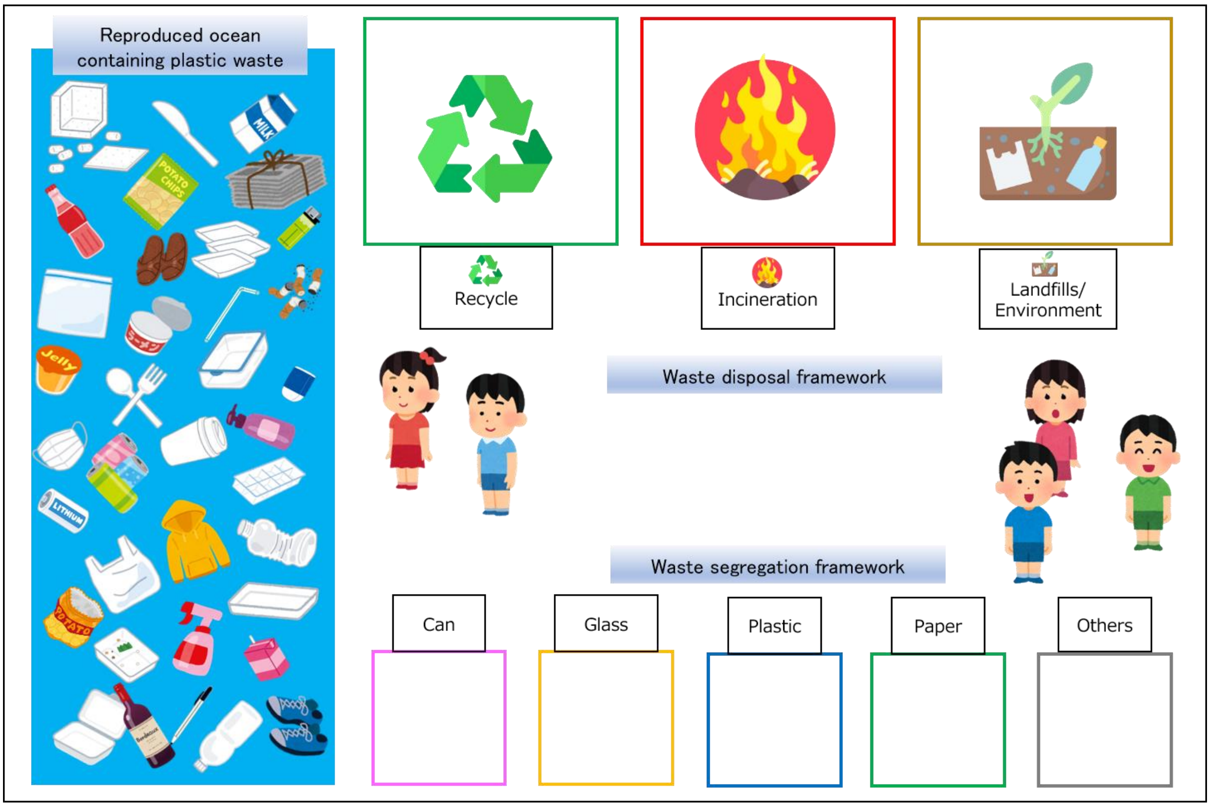
Things to prepare: Blue tarp, tape or string to show the frame, paper describing types of waste and how to dispose of it, dozens of trash

Whole layout:

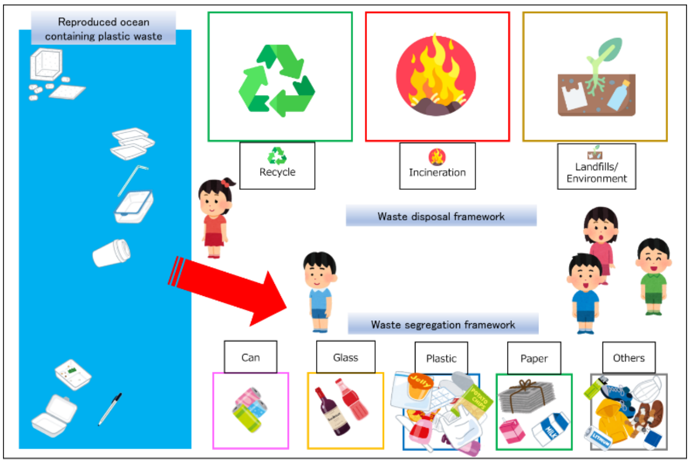
Reproduction of a beach containing plastic waste

Waste segregation framework

Waste disposal framework



Part 1



Students carry waste from the "ocean" to the waste separation framework they think each plastic belongs to. The rule is to have students carry one time one by one, and when students have finished carrying it, carry the next waste. When the students have finished, the teacher picks up each trash and explain the following points.

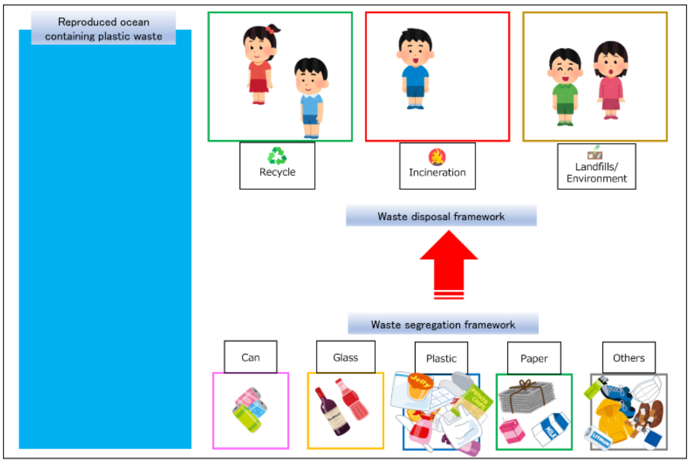
Plastics in everyday life

Mostly single use plastics

What seems to be non-plastic is actually made of plastic: shoes, clothes, erasers, non-woven masks, aluminium cans (coatings on the inside of), etc.

Part 2

Then ask the students. "I want you to imagine yourself as a plastic and think where you might go/end up after being used. If you think you might go to the recycle center, please move to the recycle frame. If you are going to be burned (incinerated), please move to incineration. If you think you will end up in the environment or landfill, please move in that category." After all the students have moved, ask the students how many people there are in each frame. The lecturer announces the percentage of plastic waste disposal in the world. In the world, 9% of plastic waste is recycle. 12% be burned, and 79% end up in landfills and environment.



The lecturer then applies the total number of students to the percentage of the world's waste disposal distribution to calculate the number. Then ask that number of students to move according to the real world value of each disposal frame. If students are 40, it means that 9% out of 40 of students is 3, so 3 students will move to the recycle frame, 12% is around 4.8, so 5 students will move to the incineration frame. All remaining 31 students will move to the landfill and environment.

Through this activity, students realize the actual distribution of plastic waste in the world in reality.

Discussion

Discuss how to tackle the marine plastic waste problem.

The amount of plastic that humans have ever made

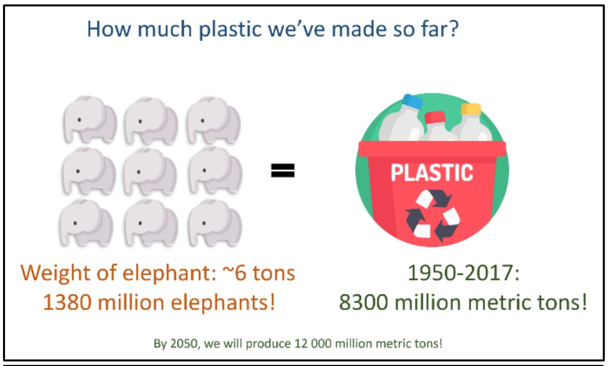
What is microplastic?

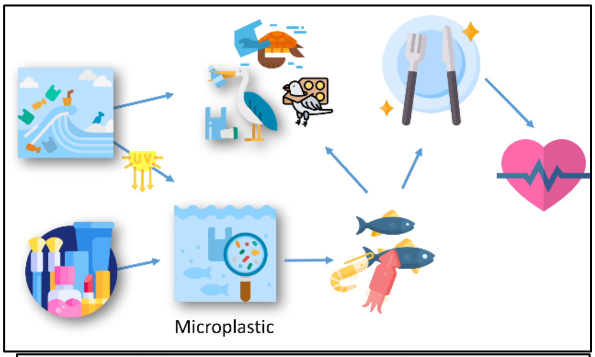
Movement of plastic in the ocean

Importance of the 3Rs

Introduction of plastic alternatives

※Example of Slides for discussion





<u>**Question-and-answer session**</u>

Activities that focus on 3Rs: Reduce, Reuse, Recycle

a) https://www.plt.org/educator-tips/reduce-reuse-recycle-lesson-ideas
b) https://www.teacherplanet.com/content/reduce-reuse-recycle

Plastic Footprint

(Japanese version)

My Plastic Footprint

「私のプラスチックゴミ記録」

以下のプラスチックゴミの種類を基に、1日のプラスチックゴミの数を記録しよう

種類	1日目	2日目	3日目	4日目	5日目	合計
プラスチック袋						
プラスチック包装						
プラスチックボトル						
食品トレイ						
プラスチックフォーク、ナイフ、スプーン						
プラスチックストロー						

種類	1日目	2日目	3日目	4日目	5日目	合計
プラスチックラップ						
プラスチック容器						
缶*						
紙パック飲料*						
マスク						
その他						

*注意: 缶や紙パック飲料は通常プラスチック（PETやエポキシ樹脂など）でコーティングされています。

(English version)

ASEAN-JAPAN CENTRE

ECO SCHOOL Project

My Plastic Footprint

Based on plastic categories below, write the number of plastic garbage you throw within one day!

Plastic Category	Day 1	Day 2	Day 3	Day 4	Day 5	Total
Plastic Bag						
Plastic Package						
Plastic Bottle						
Food Tray						
Plastic Cutlery						
Plastic Straw						

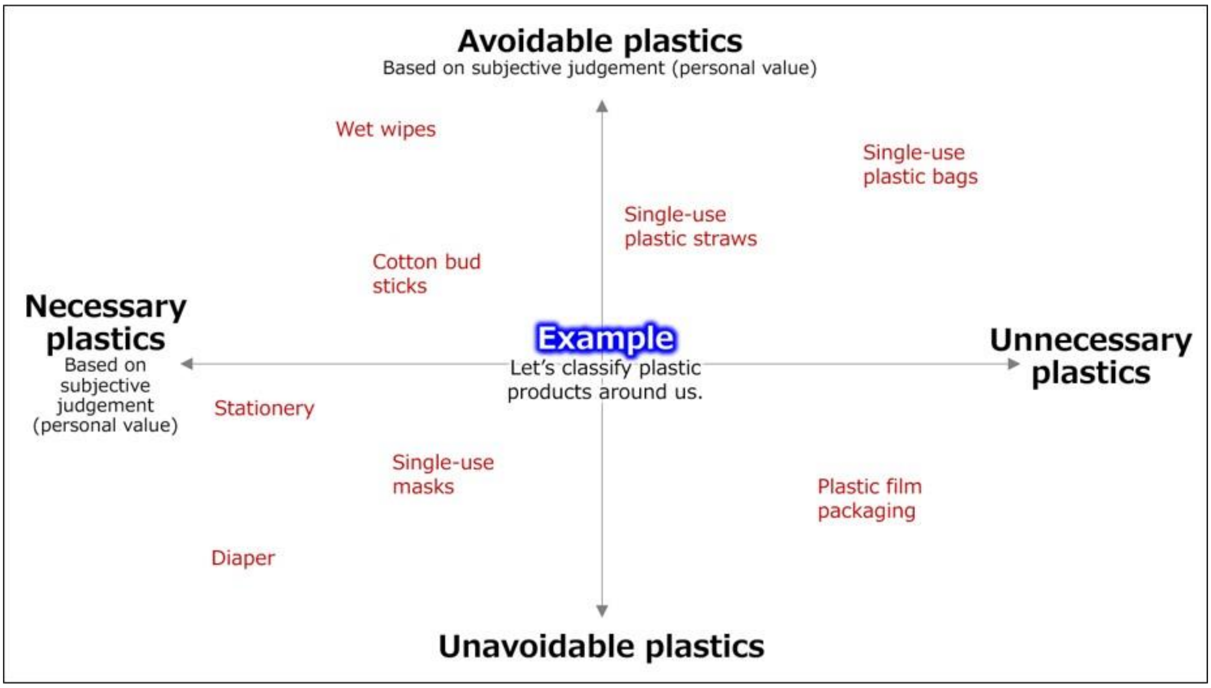
Plastic Category	Day 1	Day 2	Day 3	Day 4	Day 5	Total
Plastic Wrap						
Plastic Cup						
Can*						
Boxed Beverage *						
Mask						
Others						

*Note: Can and Boxed Beverage are usually coated with plastic polymer (i.e. PET or Epoxy resin)

Plastic classification chart

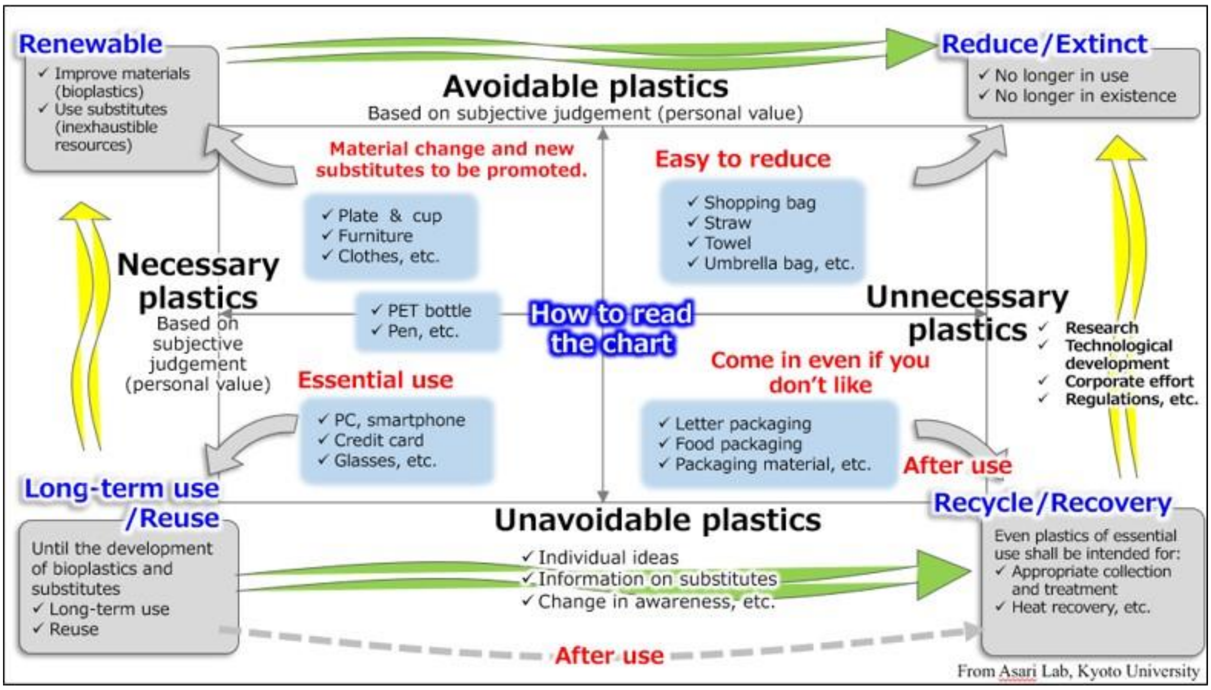
Our lives are filled with a wide variety of plastic products. To tackle plastic pollution, we must rethink in our own lives how do we use plastics. However, we are not very aware of how much we need and how much we can avoid using plastic in each product.

The following four-quadrant diagram makes it possible to visualize an individual's practice on the consumption and avoidance of each plastic product.



Instruction:

Prepare a blank chart. Plot the plastic products according to their usage (avoidable plastic, unavoidable plastic, necessary plastic, unnecessary plastic). Students may plot individually or in groups. As for what plastic products to plot, you can prepare them in advance or enumerate whatever comes to mind. Next, you show how to read the chart.



From the chart, you can visualize the different responses that can be addressed, such as the group that can intensify reduction at an early stage, the group that needs to promote awareness, the group that needs to spread avoidance measures, the group that needs to develop alternatives, and the group that will focus on long-term use and reuse for the time being.

The plastic classification method using this chart can be a tool to visualize awareness of plastic use in daily life and communicate about the efforts to solve plastic problems. It can be used to discuss with stakeholders in government and industry, and individual actions.

Source: Asari et al.,2020,Visualization tool for consumers' consciousness and behavior on plastic products -Proposal and significance of "Plide" Chart, 環境と安全 12 巻 2021 年 1 号

Appendix 3: Open source materials

The activities listed in this section consists of two types.

Type 1: Additional activity made by Fellows and also information book for the office users.

- Suggested activities. Instruction is provided in the link.

Click for download: Train the Trainer Program | ASEAN-JAPAN CENTRE

Type 2: Marine plastic waste-related activities developed by different organizations for the public.

- Curriculum for different grades. Developed by Sea Grant Pennsylvania (Sea Grant Pennsylvania, n.d.)
  This curriculum created for students in grade 3, 4-6 and 7-12. You can find list of activities comprising the objectives, duration, and materials needed.
  https://seagrant.psu.edu/sites/default/files/Lessons%20for%20NIE%202%20and%203%205GyresALLACTIVITIESPlasticPollutionCurriculum.pdf
- Lesson on ocean plastics. Developed using UNESCO's education framework that was adjusted to align with UK National Curriculum.
  This resource offers robust learning experiences that builds knowledge for students aged 5 to 14 years old. The resource also offers information from the perspective of Geography, Science and Design and Technology.
    - Age 5-7 (*Ocean Plastics; X-Curric | Ages 5-7*, n.d.)
      https://encounteredu.com/teacher-resources/ocean-plastics-x-curric-ages-5-7
    - Age 7-11 (*Ocean Plastics; Cross-Curricular | Ages 7-11*, n.d.)
      https://encounteredu.com/teacher-resources/ocean-plastics-x-curric-ages-7-11
    - Age 11-14
        - Geography (*Ocean Plastics - Geography | Ages 11-14*, n.d.)
          https://encounteredu.com/teacher-resources/ocean-plastics-geography-ages-11-14
        - Science (*Ocean Plastics - Science | Ages 11-14*, n.d.)
          https://encounteredu.com/teacher-resources/ocean-plastics-science-ages-11-14
        - Design and technology (*Ocean Plastics - Design and Technology | Ages 11-14*, n.d.)
          https://encounteredu.com/teacher-resources/ocean-plastics-design-and-technology-ages-11-14

- Lesson on plastic pollution by Department of Education Western Australia (Department of Education Government of Western Australia, 2020)
  This link provides detailed information and guided method to perform the activities revolving plastic pollution. This material also includes set of questions to encourage critical thinking among students.
  https://myresources.education.wa.edu.au/docs/default-source/resources/stem-learning-project/year-3/3_plastic_pollution.pdf?sfvrsn=bad1440e_3
- Resources page (*World Ocean Day for Schools*, n.d.)
  This link provides you with activities related to ocean and marine plastic that you can set based on the parameters you set. The parameters are ages, duration, learning area.
  https://worldoceanday.school/resources-2020/

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ASEAN Promotion Centre on Trade, Investment and Tourism
1F, Shin Onarimon Bldg. 6-17-19 Shimbashi, Minato-ku, Tokyo 105-0004 JAPAN
Research and Policy Analysis Cluster

Tel: 03-5402-8004
Fax: 03-5402-8005
Email: info_rpa@asean.or.jp

www.asean.or.jp