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# Strategy on marine debris reduction in Indonesia: a review and recommendation

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**Abstract.** In 2018, the Indonesian government started a program: National Action Plan on Marine Debris, with the target to reduce 70% of marine plastic debris by 2025. Based on local research's result in 2018, there was an estimated 0,27 to 0,59 million tons (MT) of marine plastic debris on local seas. Thus, the target of 70% debris reduction would be at 0.35 MT per year, or the reduction of 29.500 Tons of debris per month. That is a huge number to deal with, considering there are only 4 years left to 2025. To achieve the program, a roadmap was developed, parallel to other supporting programs as well the regulations, a national task force TKN PSL also established to run the programs. But an intriguing question remains: how to improve the achievement of this challenging target in a limited time? This study aimed to figure out the progress of existing waste reduction programs and contribute the way to improve the program. The method is a combination of literature review to collect data, a comparative and analytical work and finally the development of concept and action plans to formulate recommendation. We concluded that to improve the achievement of the target, proper strategy and program are needed to accelerate and boost the progress of marine debris reduction programs. To strengthen the waste reduction effort, the use of technology needs to be strongly emphasized. The program is best to be imply directly on sites, using various integrated methods to reduce more marine debris. More units of waste processing TPS 3R or "Reuse, Reduce, Recycle" are in urgency to obtained. The units will be located along the water body areas covering upstream to downstream, inland as well on-water. For the on-water site works, a concept of the green technology-based system integrated with small-sized floating TPS 3R barge, called STAMSAL P2K, is recommended to be implemented in the action plans.

**Keywords:** marine plastic debris, strategy for waste reduction, TPST 3R waste processing units, integrated green technology-based system, STAMSAL P2K

## 1. Introduction

In 2018, Indonesian Government declared the National Action Plan to Marine Debris Reduction, to 70% by 2025 [1]. To dirige the program, a roadmap was developed, parallel to other supporting programs as well the regulations, a national task force TKN PSL also established to run the programs, waste processing units TPS 3R were constructed. But there are some problems that occurred, that slowing the



run of the Action Plan down. Those are lack of human resources, factors of local culture, lack of waste processing units, and lack of data such as the precise amount and spreading locations of the debris. Meanwhile, Indonesia has vast ocean territory, as well their regional diversity richness. Those are comprehensive actual condition that have become factors that slowing the run of the Action Plan's implication down. This paper is written in 2021, while there is little progress on the running program, specifically on target achievement. There are less than 4 years left to 2025, the end of the action plan program. How to improve the achievement of the targeted program?

Meanwhile, Jakarta is the capital city of the country as the city with the largest area, the densest population, the largest industrial, trade and service facilities and activities in the country. This condition makes Jakarta the largest producer of waste, both household wastes, as well as industrial waste, B3 toxic waste and so on. Greater Jakarta is crossed by 13 rivers, the largest and most important is the Ciliwung River, which divides the city into 2 parts. Some of the 13 rivers merge inland and empties their debris into the U-shaped Jakarta Bay water. The eastern and southern parts of Jakarta are bordered by Bekasi Regency, Province of West Java. While in the west bordering with Tangerang Regency, Province of Banten. The two neighboring provinces also have a large population, high anthropogenic facilities, and activities, and have also rivers that empty their debris into Jakarta Bay. Those conditions posed Jakarta Bay as a giant junkyard.

In the northern part of Jakarta Bay, lies the Thousand Islands as a Regency of DKI Jakarta Province, located 45 km (28 miles) from mainland Jakarta. About 11 inhabited islands of the 105 islands in the Thousands Island. Jakarta Bay covers an area of about 514 km<sup>2</sup>, with its shallow water area an average depth of 15 meters. This study is aimed to figure out the progress of existing waste reduction programs and contribute the way to improve the program. All those natural and anthropogenic aspects of Jakarta city have created problems that occurred in Jakarta greater area, that indicates that this area is the biggest waste producer in the country. Thus, Jakarta Bay is the biggest waste concentration area, these facts become the considering cause to choose Jakarta city and its surround as main study location. At the eastern part of country, Bali Island is also a world barometer for tourist destination. But this highlight economic locomotive is frapped by marine debris problem invading its waters, sea sediment, corals, as well the coastal zone.

## **2. Tools and Methods**

### *2.1. Location Determination*

The main research location is located in the Jakarta coastal bay and the Thousand Island coastal waters, within the limits of coordinate 5.15° - 6.1° south latitudes and 106.4° - 107° west longitudes. The Ciliwung Watershed which trans provincial region is also considered, see figures 3 and 7. Some other areas are also taken into a discussion for a comparative reason, such as: Kuta Beach, Denpasar City and Nusa Penida coastal waters, Bali Province.

### *2.2. Data Collection*

Data collection from the observations, documentations, interviews, reference study, from papers, newspaper, internet sources, reports, etc. In addition, this research was performed during 2019-2020 at Pusriskel KP KKP.

### *2.3. Data processed*

The obtained data was compiled and analyzed, the graph was developed using Microsoft Words and Excels tabulation, spatial maps were plotted using QGIS software (open source), design and modelling was drafted as additional work, with programming Sketchup software (open source), adopting from the data source [16], and was saved in the new NetCDF form.

## 2.4. Analysis

The analysis was performed qualitatively descriptive. Its analysis involving a comparative and synthetic work, and finally constructing a conceptual model and the action plan recommendation [19, 20].

## 3. Results and Discussions

### 3.1. Overall review

The first thing to review in this study is: marine debris number. In 2015, Jambect et al. published a paper showing Indonesia's 2<sup>nd</sup> position in the world's countries in the highest number of marine debris, with the amount of 1,29 Million Tons/ MT [2]. Is this number has been validated? Our investigation shows that there are several related researches and studies from 2015 until present. Our study focused on local researches. There was estimated about 0.29 to 0.59 million tons (MT) of marine plastic debris on the local sea [3], based on [4] researches on Jakarta estuaries area, and the support of the observation data from 18 stations around the country. This number excludes debris in the water column and sea bottom. [5] KLHK/ Ministry of Environment and Forestry mentioned that in 2018, the number of marine debris in Indonesia was around 0,6 MT or 615.674,64 tons. In 2019, the number of marine debris was reduced to 566.074,94 tons or 0,56 MT, keep decreasing to 521.275,06 tons in 2020. So, there are 2 data showing that the total number of marine debris in Indonesian waters are around 0,5 – 0,6 MT, with their research took place during 2018 – 2020. Those numbers are half of Jambect et al. total marine debris data which is 1,29 MT, and also Jambect's research took place in 2015. The comparison ratio is 2:1 for local research's data, which shows total marine debris in Indonesian waters is around 0,5 – 0,6 MT. This study refers on this data: 0.6 million tons (MT) of marine plastic debris on the local sea [2] excluding debris in the water column and sea bottom. Thus, the target 70% debris reduction would be at 0.35 MT, or the reduction of 29.500 Tons of debris per month, equal to 1.000 tons per day. Figure 1 shows the comparison of marine debris number.

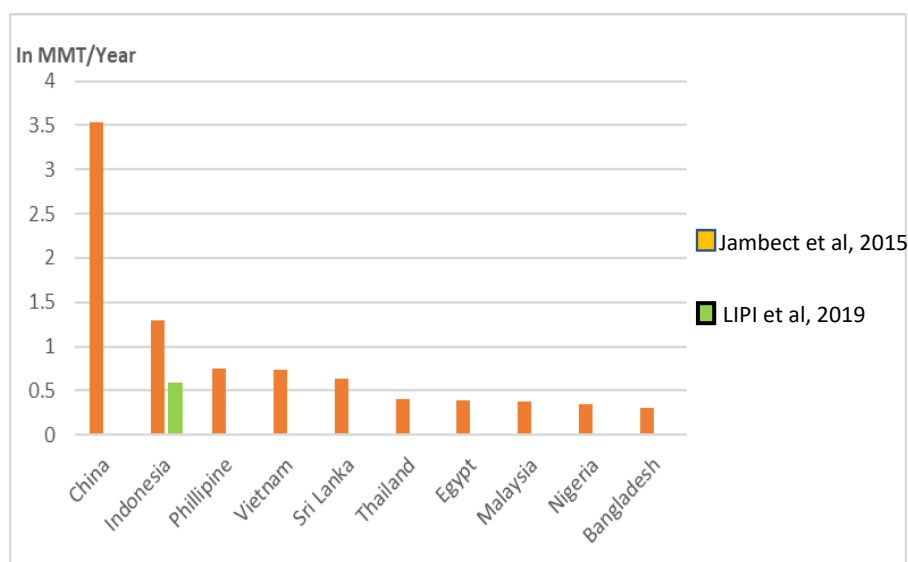


Figure 1. Marine plastic debris Indonesia, was the second biggest number in the world in 1,29 MT [2], but [3-5] released that the marine debris number in Indonesia is around 0.57 – 0,6 MT.

In the other area, Kuta Beach and also Nusa Penida waters are the most famous tourist destination in Bali. Kuta Beach that represents northern touristic spotlight at Denpasar, capital of Bali Province, experiencing a burden of 8-10 tons of marine debris covering Kuta Beach's area in a day, and more than 26% of debris is plastics [6]. The debris source is believed to be transported from the other places and

fragmented into smaller pieces [7]. Same condition is on Legian Beach, neighbor of Kuta Beach, Badung Regency Beach and many other areas in Bali as well. In southern part of Bali, Nusa Penida island's waters is suffering from devastating debris invasion in their water column and its coral reefs area as well (figure 2B).

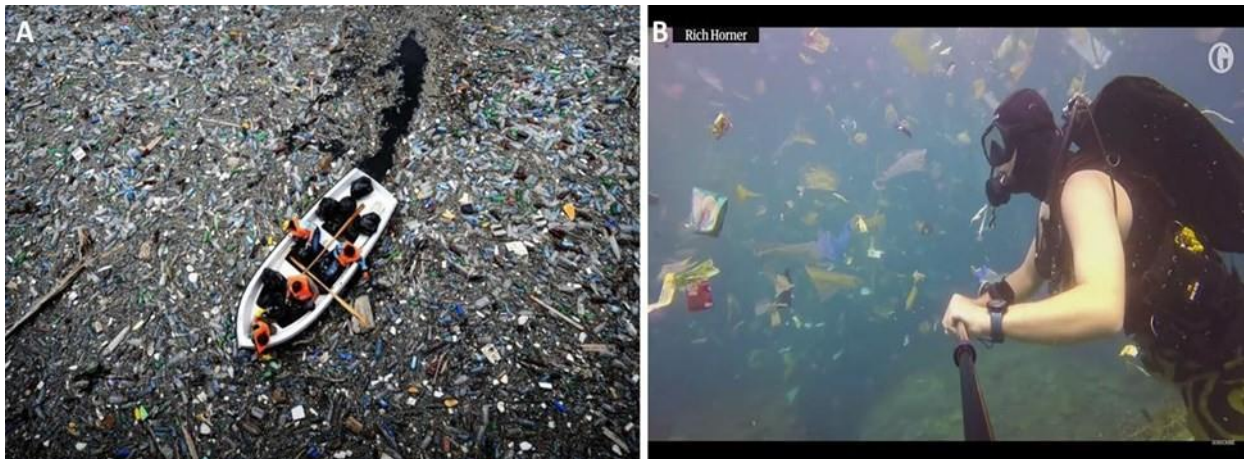


Figure 2. [A] Waste problem in Jakarta as the state's capital city, and [B] in Bali Island Nusa Penida Coastal Waters, as the highlight of state's tourist business. Pictures are taken from [8].

### 3.2 The Existing Programs.

This study took a note that Jakarta city area, is a representative of the highest number of marine debris in the country. Jakarta Bay's water is also a barometer in the national program combatting marine debris. Now, what to review is the existing marine debris reduction programs. There are running regulations as well programs, that are implemented in Indonesian cities that located from upstream to downstream/estuary, but in small number. These existing programs or waste reduction units are localized: they are centralized at Jakarta City and its surrounding areas. As the barometer of waste and marine debris problem discussion in Indonesia, Jakarta city has its well-running municipal waste management.

The Government of Jakarta has achieved a significant result in reducing marine debris. Local research stated that the number of marine debris coming from 7 major rivers flowing on Jakarta's territory, is less than the those coming from a single river, flowing on Tangerang, Banten Province, at the western part of Jakarta. The same condition does exist at eastern Jakarta's neighbor: Bekasi Regency, West Java Province [4]. Even though the number of daily wastes produced in Jakarta is 8.000 tons, it is much higher than those from Bekasi City which is around 1.700 tons per day [9].

What programs are conducted in Jakarta City to reduce marine debris number? And how is their progress? In general, there are several programs that basically implied in waste management: programs in social- economy such as the education, socialization about the urgency of marine debris management for public, and other implicative programs in waste management started from source area of waste in city area, program in dumping stage and programs on water. The water waste management programs are taking place on the water bodies of the riverine zone to the downstream zone or the estuaries. In this study, it is emphasized on the implicative waste reduction part. Those are: waste reduction processing sites, waste reduction structures, small waste processing units, and waste reducer structures.

#### 3.2.1 The Waste Processing Center

There is a best practice future program plan to upgrade and develop the waste reduction system: it is the Intermediate Treatment Facilities or ITF that have been planned to be built in 4 Jakarta's municipals [10]. Each of the ITF is planned to have the capacity to process waste around 2.000 tons

per day. This means: 4 ITF would handle 8000 tons of Jakarta's daily waste the next day. Further, there are public and expert's insights to process the waste to create 30 megawatts of electricity from each ITF, or it is called waste/garbage power plant. These ITF plans are prepared to replace Bantar Gebang prime Landfill that is predicted to become full of waste before 2025. This plan is a brilliant breakthrough, a part of the Jakarta Smart City program. But the final decision is still waiting for a series of meeting between Jakarta Province's authority with legislative [11].

### *3.2.2 TPS 3R processing units*

The waste processing TPS 3R units with Reuse – Reduce – Recycling principle, is an important program in handling marine debris from the source area. The 3R principle is a proper choice rather than the only waste reduction because commonly in waste reduction the only choice for the action is to burn the waste. This option surely impacting the environment with the ashes, smokes, Dioxin hazardous nanoparticles, etc. On contrary, 3R processing separates wastes into biomass and plastics, which could be reused or recycled, having interesting economic value. This cycle is called a circular economy. 3R municipal waste management program is implied in Indonesian cities but only a small number. The Indonesian government has spent up to \$1 billion a year on cleaning up its rivers and seas [13]. Yet, there is no region having such as marine debris processing unit, directly in the downstream zone and in the open sea. For example, neighboring city of Jakarta: Bogor City had 27 units of TPS 3R and could reduce the daily waste number to 16% [12]. In 2019 Jakarta there were only 4 units of TPS 3R in 4 communes in Jakarta City [13]. Yet, there were 263 other communes in Jakarta that haven't equipped with the 3R facilities. The fact is that 3R facilities are proven able to reduce waste by around 1,39 Million Tons per year [14].

In big scale structure, 2 Dams is an ongoing development by Ministry of Public Works at the upstream zone Bogor Regency [15]. These Dams are dry Dam, would be functioned during rainy season, as a part of the flood prevention program. The Dams have a significant role in waste reduction in the upstream zone that are designed to reduce the debit flow of Ciliwung water, then it is parallel to reduce the waste number.

### *3.2.3 Waste reducer facility*

The local waste treatment is only emphasized on dumping. On the other side, the rate of inland waste reduction is below the rate of waste production. Worst, there is no region having such a waste processing unit that focuses on marine debris, specifically in the downstream zone and the open sea. Parallel programs to reduce waste are regulations, organization strengthening, human resource education as well socialization. As a result: there is still an abundance of inland waste today, and this condition is identic as well to the number of marine debris quantity. Some part of the inland waste would be transported along with river flow to the open sea. The other fact, around 59% of Jakarta's marine debris coming from rivers into Jakarta Bay is plastics [4], with plastic use per capita 17 kilograms [16]. Figure 3 shows various types of waste reducer facility.

Waste screener? There is a good progress, a collaborative work between PU/Ministry of Public Works, KLHK/ Ministry of Environment and Forestry with the authority of Jakarta Province to build more waste screener structure units. The location is along the upstream zone Bogor Regency and Bogor Municipal, as well at downstream zone Jakarta city area. This program is basically part of Jakarta Flood Management. Figure 3 shows various types of waste screener constructed in Jakarta city. Meanwhile, Waste Bank is significant in the economic sector. In September 2018, the Waste Bank could earn 1,48 billion rupiah. A central Waste Bank in West Jakarta could earn 4,5 billion rupiah per year [17].

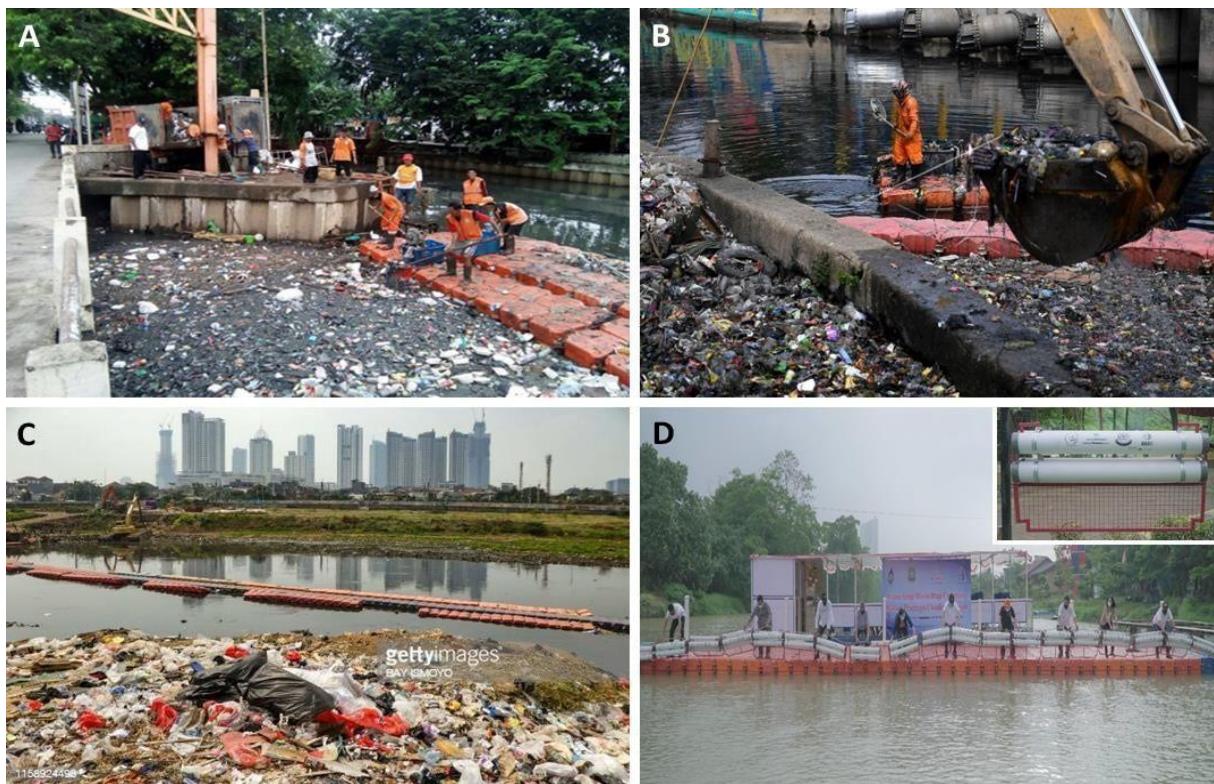


Figure 3. Types of Waste Trap used for inland zone or the upstream zone water bodies to downstream zone: [A] Trash Blocker, [B] Trash Screener, [C] Trash Boom Net, [D] Trash Trapper [9]. Pictures taken from [8].

The current waste production in Jakarta Greater Area in 2021 is 8000 tons per day [18], which is close to the amount of New York's waste production daily [19], and this number keeps increasing. Meanwhile, the speed of waste that has been handled is below the waste production works. Bantar Gebang is the central landfill for Jakarta's waste dumping. It is estimated that this location would be over capacity before 2025 [13]. Therefore, there will be an abundance of unhandled waste, which some of them will transport to the river then flow to downstream, and finally entering the open sea of Jakarta Bay. This chain of waste is yet unbreakable, and worst: its scale is growing up, parallel to the raise of demographic bonuses. If we don't act immediately, by 2025 this problem would have been too late to handle, and the waste could become a time bomb or a disaster, both for the environment or and for the living things on the planet.

The good news is the roadmap of a Clean-from-Waste Indonesia by 2025 has been established [20], aiming to reduce 30 percent of the economic waste and divert waste before it goes to landfills [21]. The programs that have been implemented previously are the 2020 Zero-Waste Indonesia [22], concerning the regulation of payment charge for plastic bags, as well as the Integrated Waste Management Facility for Reduce-Reuse-Recycle (TPS 3R). Parallel to the programs, representative of the Indonesian government has collaborated with the Global Plastic Action Partnership (GPAP) to develop a roadmap of resolutions, namely reducing overpackaging, inventing recyclable plastic or substitute materials, and increasing recycling as well as increasing the rates of waste collection [23]. Banjarmasin city, Province of South Borneo had commenced the construction of the green landfill [24]. Meanwhile, Jakarta city, Province of DKI Jakarta has commenced the reduction of overpacking by implementing

local regulation to charge plastic bags since 2019 [25].

### *3.3 Recommendation: The Strategies for the Action Plan*

This study has summarized several strategies to fortify the existing waste or marine debris reduction programs. First, the current waste program and regulation is comprised of two main activities: (1) waste management; and (2) waste reduction. Waste management includes collecting, transporting, dumping, regulation, socialization, education. Waste reduction involves restrictions on waste generation, waste reduction, recycling, and reuse of potential waste. Then, the first proper strategy is prior to strengthening the waste reduction part, emphasized on technological use. Secondly, the direct program should be implied on sites, in various methods to reduce more marine debris possible.

Third, to support the marine debris reduction program, it is needed collaboration and good coordination amongst stakeholders. Forth, it is best to work on both land-based waste and water-based waste spatially. The fifth prior action is to improve the waste management program both on the land-based waste zone as well on water-based waste zone: by strengthening the municipal waste reduction program. The construction of more waste processing TPS 3R units is urging to derive, to multiply the rate of waste reduction, with 3R Reuse – Reduce - Recycle. Plus, it is better to establish the 3R units located alongside the water body as well on the water bodies. The establishment of more TPS 3R units aside from the estuary area is also important.

The use of emerging technology is also a leverage success key in this work. Instead, it is important to plan precisely the capacity of each unit by spatially synchronizing them to the quantity of waste in each area so the program could be operated efficiently in cost and effective. In this study, the waste specifically the marine debris reduction model and action plan is divided spatially into inland waste as a waste source and on water waste handling. The scope is the area of the water body: rivers from the upstream zone, along with and aside from the river's body to downstream zone: the estuaries and the open sea. The existing waste reduction actions and programs used were direct trappings, collecting, and digging marine debris on the spot such as in the riverine area as well as coastal and mangrove areas [26].

#### *3.3.1 Waste Reduction Structures*

The effective program is aimed to accelerate the multiplication of the waste processing TPS 3R units and establish them in each commune, inland to the coastal zone. The 3R facility could reduce the waste number, for example in Bogor City: around 16% of the total daily city's waste number [18]. The units are recommended to be established along the riverside to the estuary zone, combined with net and trash boom on the river. At the inland zone, the debris reduction works could be done in a parallel way to the flood mitigation programs (figure 4).

There are 3 big Dam structures along Ciliwung body: from the upstream there is Katulampa Dam at Bogor City, next: Ratu Jaya Dam at Depok City, and Manggarai Dam at Jakarta City that functioned to block and control the abundance of water run-off coming from the upstream and middle stream zone [15]. The analysis of this study is the river flow takes an important role in land-based waste transportation. On the other part, sea current and wind took place in debris distributions and debris concentrations around the world's waters and the coastal zone as well. From that, the combatting marine debris program on water must collaborate with any flood mitigation programs, which is taking place at the inland upstream area to a downstream coastal area, as well it must include current and meteorology data to locate the marine debris concentration spots on the sea surface.



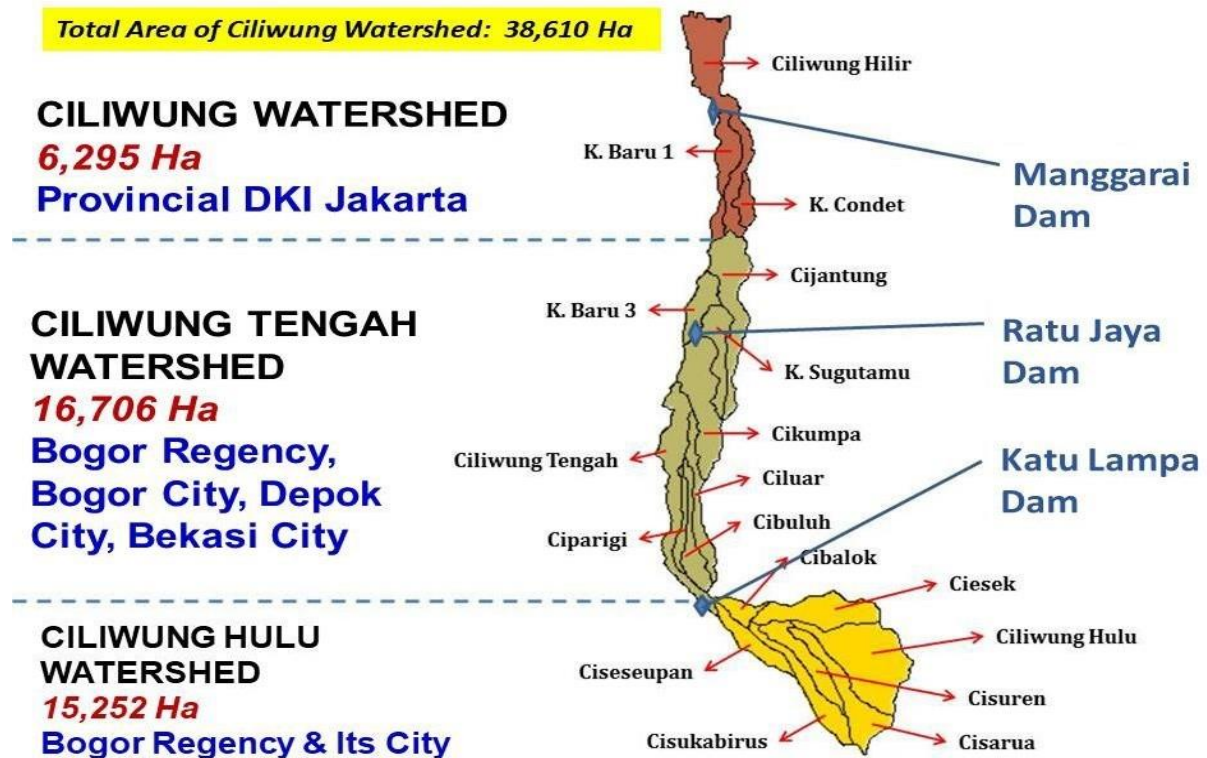


Figure 4. The segmentation of the river's water body from the upstream zones to downstream zone (Adopted from Flood Segmentation Map by Dinas LHK of Jakarta Province).

The recommended programs: for all 3 segments which is the upstream zone, middle stream zone and downstream zone, it is best to build more structures alongside the water body, such as more Dams, and waste traps, waste screeners, waste sluicers, trash boom net, waste blockers, permanently (Figure 4). This formation is aimed to reduce marine debris in the water body, at the earlier stage at the upstream zone, by trapping them as much as possible along the river body, before the debris reaching the downstream zone: the estuary, and then entering seawater. For the estuary, it is needed the combination of trash net boom and TPS 3R units established aside from the water body. This combination would also be effective to implied on the sea surface, to reduce marine debris directly on its spots. Except, the TPS 3R unit that is implied on the seawater, should be established on board, on a floating boat

### 3.3.2 The technology used for the on-water waste zone: A Sustainable Based

The importance of technologies for waste reduction was announced in AHEG-4 meeting in 2020 [27], held by UNEP Global Partnership on Marine Litter. Some of the technology used are data collection on the trajectory of plastic waste from source to sea (e.g., via earth observation), cleansing of waste and marine plastic litter in coastal areas and dumpsites, and prevention of future waste. The solution to the problem recommended in this study is cleaning up the waste and marine plastic debris using technology. The concept is an on-site direct operational based on integrated green technology, as part of the environmental dimension of the principle of Sustainability. However, this technology concept is not a single way. To ensure the success of this concept, it needs to be combined in parallel with other dimension of sustainability: the social dimension as well as the economic dimension.

Marine debris is a global concern that is supported by the United Nations/UN, written in the Sustainable Development/SDG Goal point 14.1 [27]. In terms of sustainability with 3 pillars: Economic Dimension - Environmental Dimension - Social Dimension. Solving waste problems using only technology, which is identical to the Environmental Dimension, is not enough. This marine debris reduction action in this study's concept is emphasized on the use of technology to reduce more debris. But this concept should be conducted in parallel accommodating programs on social and economic dimension. Presently, the government is seeking the use of proper technologies in reducing marine debris [27]. Many types and models of waste reduction schemes are available, most of them scoped to inland waste management. Fewer programs and products offered the product and model of on water marine debris handling. Despite marine debris is urged to handle, the waste management action in Indonesia is slower than the waste flows.

Best practices in waste management, as well as regulation making, education and socialization in many developed countries to support waste reduction are part of the Social Dimension. The Economic Dimension also takes an important place in any successful waste management program. Managing waste properly requires high costs as well as economic incentives as a locomotive that can run and turn waste from non-existent into an attractive business. This scheme is implemented in the land area in the upstream zone to the downstream zone along the water body. To be more effective, marine debris reduction operations under this concept will be carried out in water bodies, especially in downstream zones such as estuaries, coasts, and ports. This program requires a collaborative, interconnection, multi-stakeholder, and multi-institutional work. The agencies related to waste reduction in Jakarta waters are recommended: those that collaborating in Jakarta Flood Management [28,29]. Those are LHK/Ministry of Forestry and Environment for waste management authorities on land, Ministry of Public Works PU KIMPRASWIL for the structure and infrastructure, Bogor Municipal, Bogor Regency and Depok Municipal, Bekasi Municipal authorize the upstream and middle stream areas, and DKI Jakarta Province is authorizes the downstream zone. New collaborator in marine debris reduction team that is recommended in this study is: The Ministry of Maritime Affairs for handling marine and coastal areas

### *3.3.3 A Green Technology-based Marine Debris Reducer for on-Water Zone*

A concept of floating 3R waste processing unit is created in this study, to fulfill the need of waste reduction action directly on-site on the water body on neritic sea water (figure 5). A small sized semi catamaran barge, non-propeller, NRE (Non Renewable Energy) hybrid energy sourced from wind and solar energy, functioned as a one stop station: marine debris collector, processing 3R has been designed, which named STAMSAL P2K, or The Floating Station for Waste Reduce purposed on Coastal and Small Islands [30].

For the operation, the debris reducer unit is dragged by a small tugboat towards coordinate on the sea surface, then being anchored. Tugboat is also equipped with TNB (Trash Net Boom), to find, siege, and drag debris towards the debris reducer unit to be collected and processed in 3R (Figure 5). Debris that has already been collected is then classified into biomass and plastics. The 3R processing type chosen is pyrolysis, to transform plastic debris become fuel by heat, while biomass debris would be its firewood. Simple, low cost and fast way to reduce marine debris, plus having side impact: economic value from plastic-based fuel. This concept is supporting SDG 14.1 about the clean ocean as well as stimulates the circular economy from reuse and recycle plastic debris.

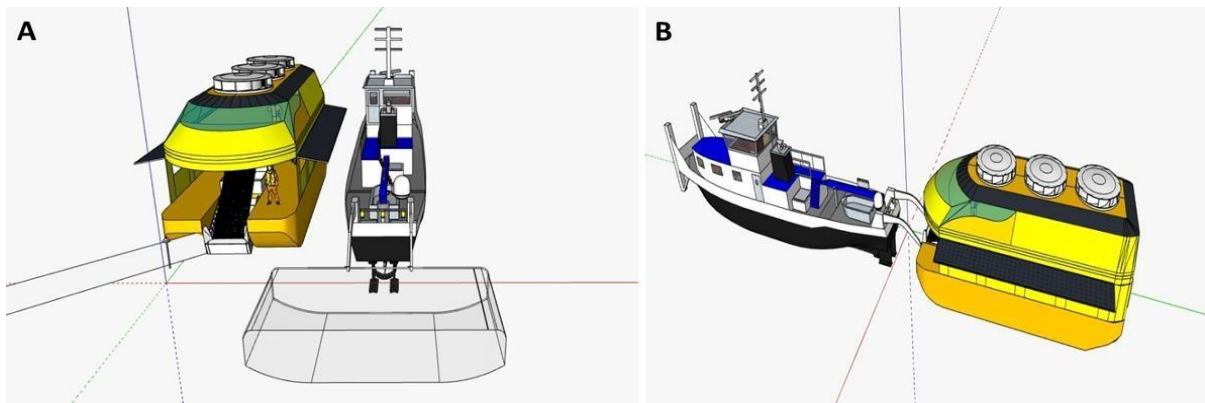


Figure 5. [A] An illustration on left is a set of STAMSAL 3R marine debris reducers with a small tugboat, equipped with Trash & Net Boom/TNB. [B] On the right, mobilization by tugboat [30].

Figure 6 is an illustration of the direct action on reducing marine debris, which is operated directly on the debris spots, on the water. The simulation took place at the estuary zone of Banjir Kanal Timur/BKT or the Eastern Flood Canal of Jakarta. Banjir Kanal Timur is one of 7 major water bodies containing the greatest number of marine debris that emptying debris in Jakarta Bay. Debris colony as illustrated in the figure 6 as the black form is following the river flow, marked with blue arrow shaped, is nearly reaching Jakarta Bay's water. At the edge of the Canal's gate, a unit of STAMSAL is anchored and catching debris with a pair of Trash and Net Booms/TNB. One TNB is directly attached to STAMSAL unit as an arm, and the other one is set up at the other side of the canal.

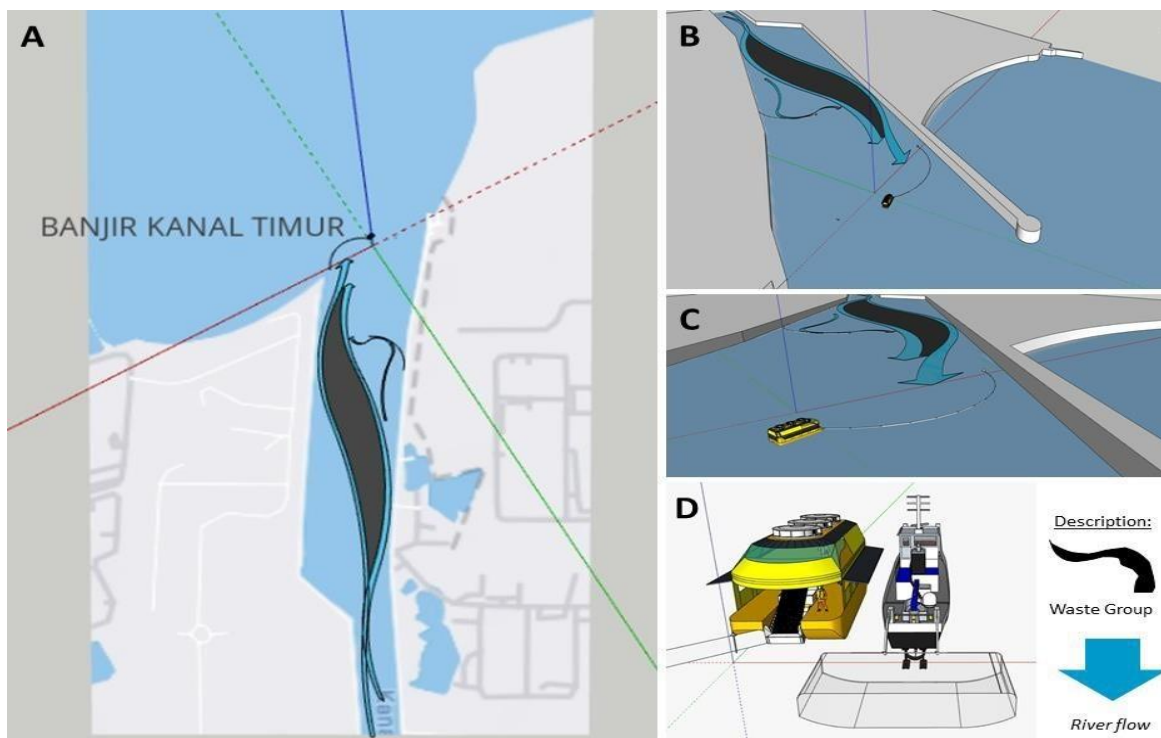


Figure 6. [A - C] An illustration of STAMSAL P2K System's Operational, Simulation on Banjir Kanal Timur/ BKT downstream zone Jakarta city. [D] STAMSAL unit with Trash Net Boom/TNB equipped Tugboat. Pictures are adopted from [30].

For more information, there are dozens of rivers flowing on land and emptying their contents in the waters of Jakarta Bay. 13 rivers flowing in the administration area of Jakarta Province [31], 7 majors

rivers are emptying their debris in Jakarta Bay. Plus, 1 other major river in the Tangerang Regency, Banten Province, at the western part of Jakarta and 1 other river located at the east part of Jakarta in the Bekasi Regency area, West Java Province [32]. The concentration of marine debris collected in Jakarta Bay is highest in the central part, at the bottom of the bay, in Jakarta Province, then continuing to the west coast of Tangerang area, Banten Province [33], as shown in Figure 7. Then, at the north of the Thousand Islands, a group of marine debris was found connected toward the east: the northwest part of Muara Gembong Bay, Bekasi Regency, West Java Province.

In figure 7, the design of the operational scheme of the concept is shown. Based on the debris concentration map in 9 estuaries of Jakarta City, the STAMSAL units were then plotted on those 9 estuaries. The debris occupies the estuaries, port area, jetties alongside the coastal shoreline. These STAMSAL units are excluding spots having debris problems on jetties, fishing ports, passage, and container ports, etc. This means that to handle marine debris problem in Jakarta Bay’s coastal and Thousand Island’s waters, the need of STAMSAL will require a dozen unit to be operated.

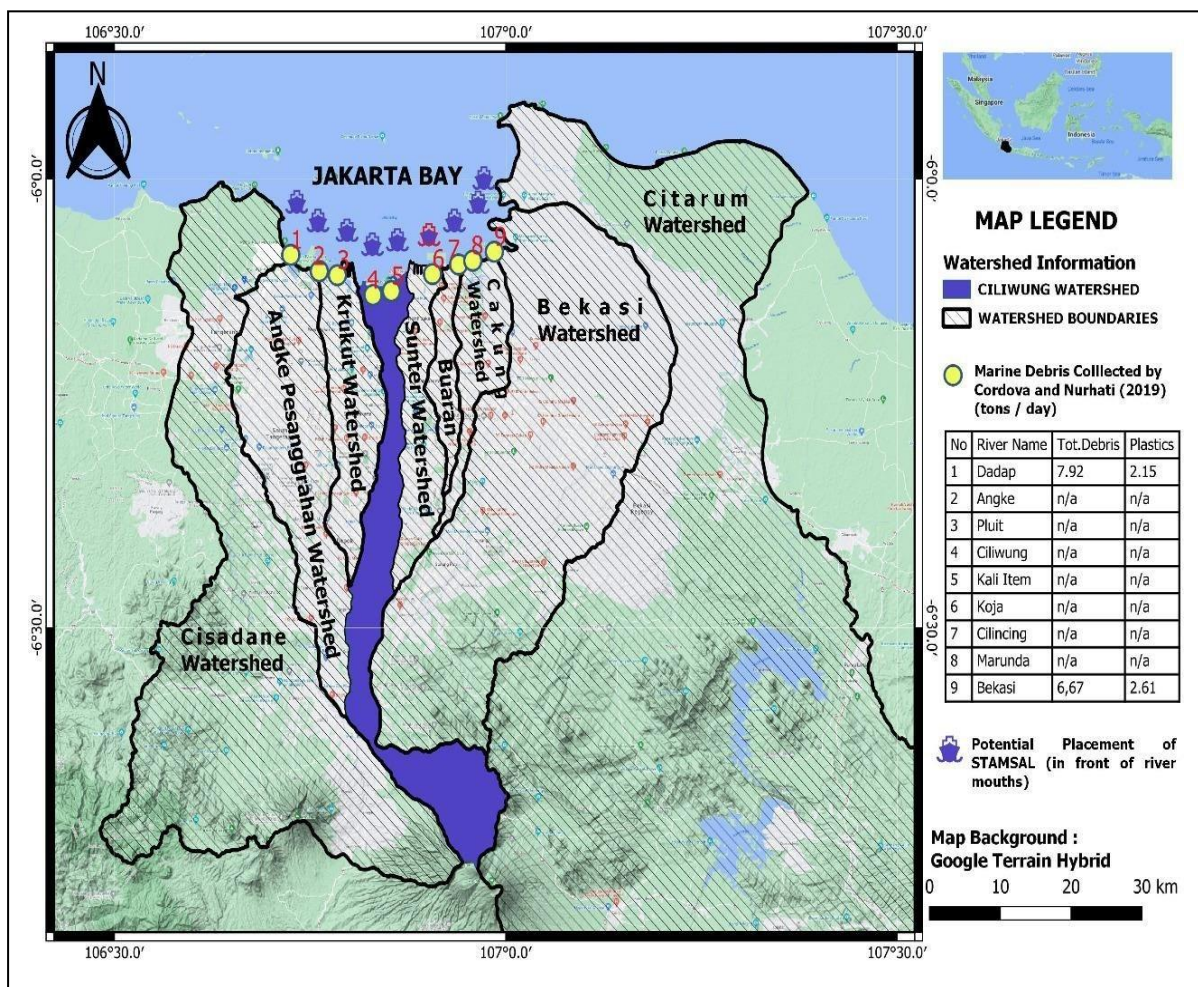


Figure 7. Design of the Green Based-Technology 3R Waste Reducer STAMSAL Units Plotting (ship icon), on 9 estuaries (yellow circles), including prime watershed Ciliwung (dark purple), using STAMSAL P2K, the simulation at Jakarta city’s coastal water, Jakarta Bay Greater area.

To reduce marine debris on islands such Thousands Island, north of Jakarta city, same technology is recommended to implied: floating 3R waste processing unit STAMSAL. Figure 8 shown the illustration

of how the systems work. Floating 3R debris reducer: STAMSAL is anchored between the inhabit islands. A Trash and Net Boom or TNB equipped tugboat would take part as well as collecting plastic debris on the Thousands Island water. Meanwhile, the island's people as well as sailors from many boats or ships passing around could dump their waste to the unit. Trash in the Thousand Islands consists of two types [34], namely household waste and garbage shipped from the sea around the Thousand Islands. There is Bank Sampah or waste bank [35] at Thousand Island that produce compost, doing BSF work to yield maggots, and even pyrolysis. Touristic and ship traffic activities are also resulting waste.

The best solution is to plan and implement the integrated waste management that combining various methods from collecting, sorting, recycling, reusing, reducing/ incinerating, conversion, and disposal. These programs are important especially for countries with low rates of waste capture and high leakage areas such Southeast Asian [36,37]. Reuse and Recycle are part of circular economy, in this study the economy that started up by plastic processing [38,39], and reduce, means to incinerate marine debris, specifically those non plastic waste that is also a proper and effective method [40]

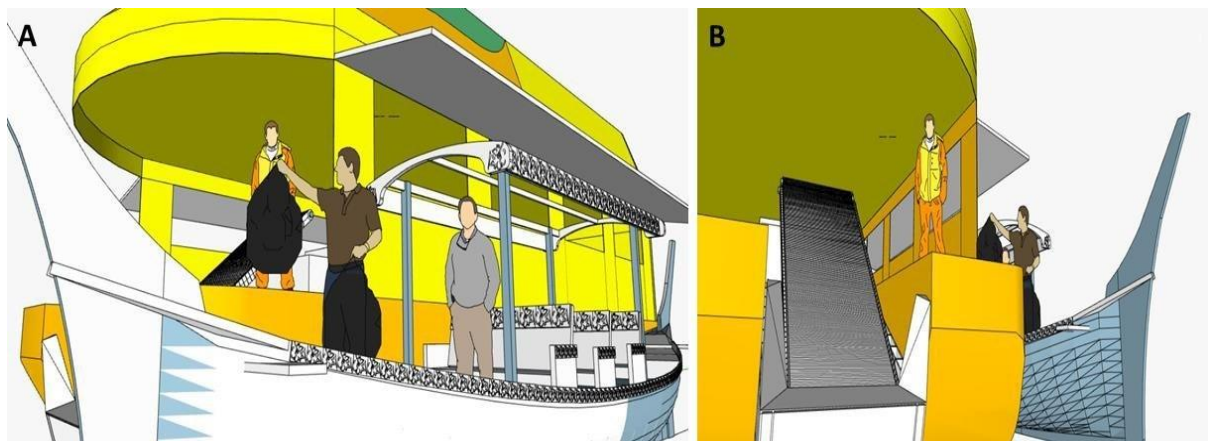


Figure 8. [A] An illustration of floating 3R Marine Debris Reducer unit STAMSAL in the operation, on island's water. [B] The people who live in the small islands sent their waste to Marine Reducer Unit that is anchored around the inhabited islands waters. This scheme is suitable for the program implementation in the Thousand Islands coastal waters r [30].

#### 4. Conclusions

According to data and information collected and processed in this study, there is some version of marine debris amount in Indonesia, 1,29MMT by Jambeck et al in 2015, which posed this country as 2<sup>nd</sup> highest marine debris in the world. Later in 2019, local researcher from LIPI et al at the end of 2019 launched their result that the amount of local marine debris is 0,57MMT. KLHK and KKP stated that in 2019 the marine debris is 0,56 MMT [2]. Therefore, the dominant number of marine debris in Indonesia tends to reach 0,56-0,59MMT per year in 2019. This fact has a consequence which reposed those 2<sup>nd</sup> positions become the 6<sup>th</sup> in the world. Next, the progress of the existing marine debris reduction programs in Indonesia has reached 15,3% from the year 2018 to 2020. There is around 55% left as the target of 70% marine debris reduction in 3 years before 2025.

In the last three years before 2025, there is an average of 18,3% of marine debris to reduce per year. Based on KLHK data, the calculation is as follows; marine debris to reduce in Indonesia waters is around 93.829 tons per year, or equal to 260 tons per day. Jakarta Bay and all cities on the coastal area of the northern Java Islands are the densest marine debris concentration in the region. Therefore, the effort to combat marine debris is most proper to be focused there. The rate of marine debris reduction

is better to increased achieving up to 18% per year, to achieve target of 70% marine debris reduction by 2025.

### Recommendation

There are ways to improve the progress of the existing marine debris reduction programs that is only 3 years left before 2025. What best we could do is to keep doing any marine debris reduction programs and actions possible, collaborative, trans provincial, state – regional scope, multi-stakeholders and implied with the community based social actions, directly on-site, at inland zone, water body zone, and directly on seawater as well as in an integrated and collaborative multi-stakeholder work.

The important part of this work is to accelerate the progress by planning good and comprehensive programs to produce effective and bypassing result, such as use of technology, development of more waste reduction structures such as Dams, waste blockers, waste screeners, waste traps, trash boom nets, addition of 3R facilities in each community and alongside the riverine to the estuary, as well as floating 3R facilities operated on the water that directly collect and process marine debris with 3R principle on the spot. For marine debris that fills the water columns and coral reef areas, different method of cleaning is needed, such as using a team of divers to collect marine plastic debris. For the on-water marine debris handling, such as in the estuary water and coastal water, or in small island water, it is recommended to implement STAMSAL P2K a concept of green based-technology system.

### References

- [1] Purba, N.P., D.I.W. Handyman, T.D. Pribadi, A.D. Syakti, W.S. Pranowo, A. Harvey, Y.N. Ihsan. 2019. Marine debris in Indonesia: A review of research and status. *Marine Pollution Bulletin* 146(2019): 134-144. <https://doi.org/10.1016/j.marpolbul.2019.05.057>.
- [2] Jambeck, J.R. 2015. Plastic waste inputs from land into the ocean. *Climate Change: Impacts, Adaptation, and Vulnerability*, 347, 1655-1732.
- [3] LIPI, Kemenkomarves 2019. TKN PSL meeting. <https://politik.rmol.id/read/2019/12/13/413411/data-terbaru-sampah-laut-indonesia-versi-pemerintah>
- [4] Cordova, M.R. & Nurhati, I.S. 2019. Major sources and monthly variations in the release of land derived marine debris from the Greater Jakarta area, Indonesia. *Scientific Reports* 9(1):18730. DOI:10.1038/s41598-019-55065-2
- [5] Tahar, N 2020. Director of Solid Waste Management, Ministry of Environment and Forestry, Indonesia. <https://tirto.id/klhk-catat-setengah-juta-ton-sampah-plastik-di-lautan-indonesia-ghxy>
- [6] Suryawan, I, W, K., Sarwono, A., Septiariva, I, Y., Chun-Hung, L 2021. Evaluating Marine Debris Trends and The Potential of Incineration in the Context of The Covid-19 Pandemic in Southern Bali, Indonesia. *Scientific Journal of Fisheries and Marine*, Vol 13, No 2 (202). <http://dx.doi.org/10.20473/jipk.v13i2.25164>
- [7] Attamimi, A., Noir P. P., Anggraini, S, R., Harahap, S, A., Husrin, S. 2015. Investigation of Marine Debris in Kuta Beach, Bali. Proceeding, the 1 st Young Scientist International Conference of Water Resources Development and Environmental Protection, Malang, Indonesia, 5-7 June 2015
- [8] PT Waste for change Alam Indonesia [waste4change]. 2020. 'Everything You Need to Know About 2025 Clean-from-Waste Indonesia'. <https://waste4change.com/everything-you-need-to-know-about-clean-from-waste-indonesia-2025/>. [accessed 2021-07-14].
- [9] Nazirwan, 2019. Regional Service for the Environment and Forestry, Bekasi Regency. <https://megapolitan.kompas.com/read/2019/01/17/13304701/sampah-per-hari-capai-1700-ton-kota-bekasi-kekurangan-truk-pengangkut> [accessed 2021-07-13].
- [10] Daryoto, 2020. Head of Jakpro, Jakarta Province. <https://utara.jakarta.go.id/ITF-Sunter-Akan-Kelola-Sampah-Jakarta>

- [11] Jansen, A. 2021. <https://metro.tempo.co/read/1435429/kritik-soal-pengolahan-sampah-itf-nasdem-hambur-hamburkan-uang/full&view=ok>
- [12] Arya, B. 2021. Mayor of Bogor City, West Java Province. <https://news.detik.com/berita/d-5400703/pemkot-bogor-berhasil-kurangi-sampah-harian-16-selama-2020>
- [13] Warih, A. 2019. Chief of LHK (Regional Service for the Environment and Forestry) of Jakarta Province. <https://wartakota.tribunnews.com/2019/08/01/jakarta-hanya-punya-empat-tps-3r-idealnya-88-buah>
- [14] Borongan, P. & P. Kashyap. 2018. 'Country Profile Indonesia, Managing Municipal Solid Waste and Packaging Waste' (Bonn: GIZ,2018). [https://www.giz.de/de/downloads/giz2018\\_Indonesia-Country-Profile\\_web.pdf?](https://www.giz.de/de/downloads/giz2018_Indonesia-Country-Profile_web.pdf?) [accessed 2021-07-12].
- [15] Hadimulyono, B 2020. Minister of Public Works, Indonesia. [https://eppid.pu.go.id/page/kilas\\_berita/2098/Pengendalian-Banjir-Jakarta-Bendungan-Ciawidan-Sukamahi-Rampung-2021](https://eppid.pu.go.id/page/kilas_berita/2098/Pengendalian-Banjir-Jakarta-Bendungan-Ciawidan-Sukamahi-Rampung-2021)
- [16] World Bank Group 2018. Indonesia Marine Debris Hotspot. Rapid Assesment Synthesis Report, April 2018. Accessed July 21th 2021.
- [17] Ratnawati, R, V 2019. Director General of Solid Waste, Hazardous Waste and Hazardous Substances Management, Ministry of Environment and Forestry, Indonesia. <https://tirto.id/industri-plastik-dan-ekonomi-sirkular-dmTL>
- [18] LHK (Regional Service for the Environment and Forestry), Jakarta Province.
- [19] New York Municipal, 2021. <https://data.ny.gov>
- [20] World Research Institute Indonesia [WRI]. 2019. <https://wri-indonesia.org/id/our-work/project/indonesia-national-plastic-action-partnership-npap> [accessed 2021-07-07]
- [21] Rogers, C. 2018. 'Indonesia, a Top Plastic Polluter, Mobilizes 20,000 Citizens to Clean Up the Mess', Mongabay, 4 September 2018, <https://news.mongabay.com/2018/09/indonesia-a-top-plastic-polluter-mobilizes-20000-citizens-to-clean-it-up/>. [accessed 2021-07-11].
- [22] World Economy Forum 2020. Radically Reducing Plastic Pollution in Indonesia: A Multi stakeholder Action Plan National Plastic Action Partnership.
- [23] World Economic Forum 2016, Ellen MacArthur Foundation and McKinsey & Company, The New Plastics Economy — Rethinking the future of plastics.
- [24] EKONID, 2019. Promoting sustainable solutions to waste management, The Annual Report. <https://indonesien.ahk.de/en/infocenter/news/news-details/promoting-sustainable-solutions-to-waste-management/>
- [25] Jakarta Province, 2019. Pergub DKI number 142, 2019. Governor of Jakarta's regulation number 124 for the obligatory Use of Eco-Friendly Shopping Bags. [www.jakarta.go.id](http://www.jakarta.go.id)
- [26] Olha K 2018. Solving Marine Pollution: Successful models to reduce wastewater, agricultural runoff, and marine litter. Report, World Bank Group, September 2018.
- [27] UNEP. 2021. Global Partnership on Marine Litter. Available online: <https://www.unenvironment.org/explore-topics/oceans-seas/what-we-do/addressing-land-based-pollution/global-partnership-marine#> [accessed 2021-07-12].
- [28] World Bank Report, 2011. Environment and social management framework. <https://documents1.worldbank.org/curated/en/395151468263089230/pdf/E26580v100EA0P00in0English00P111034.pdf>
- [29] Directorate of Water Resources, Ministry of Public Works Indonesia, 2013. Jakarta Comprehensive Flood Management. Technical Cooperation Report. [https://openjicareport.jica.go.jp/pdf/12127122\\_01.pdf](https://openjicareport.jica.go.jp/pdf/12127122_01.pdf)
- [30] Prabawa, F.Y. & Cahyadi, D. 2021. Design of Floating 3R Marine Debris Reducer STAMSAL P2K. (in preparation to publish).
- [31] Juaini, Y, 2020. Regional office of environmental services Jakarta Province.

- [www.jakarta.go.id](http://www.jakarta.go.id)
- [32] Directorate of Water Resources, Ministry of Public Works Indonesia. [www.sda.pu.go.id](http://www.sda.pu.go.id)
- [33] Jasmin, H.H., N.P. Purba, S.A. Harahap, W.S. Pranowo, M.L. Syamsudin, & I. Faizal. 2019. The Model of Macro Debris Transport Before Reclamation and Existing Condition in Jakarta Bay. *Jurnal Ilmu dan Teknologi Kelautan* 11(1): 131-140. DOI: <http://dx.doi.org/10.29244/jitkt.v11i1.24777>
- [34] Suryono, D.D. 2019. Sampah Plastik di Perairan Pesisir dan Laut: Implikasi kepada Ekosistem Pesisir DKI Jakarta. *J. Riset Jakarta* 12(1): 17-23.
- [35] Kristina, H. J. 2014. Model konseptual untuk mengukur adaptabilitas bank sampah di Indonesia. *J@TI Undip* 9(1): 19-28.
- [36] Ledsham, N 2021. <https://www.sustainability.com/thinking/creating-a-circular-economy-for-plastics/> <http://www.ellenmacarthurfoundation.org/publications>
- [37] World Economic Forum and Ellen MacArthur Foundation 2017. The New Plastics Economy – Catalysing action. <http://www.ellenmacarthurfoundation.org/publications>.
- [38] Hayati, Y., L. Adrianto, M. Krisanti, W.S. Pranowo, F. Kurniawan. 2020. Magnitudes and tourist perception of marine debris on small tourism island: Assessment of Tidung Island, Jakarta, Indonesia. *Marine Pollution Bulletin* 158(2020): 111393. <https://doi.org/10.1016/j.marpolbul.2020.111393>.
- [39] Syakti AD, Bouhroum R, Hidayati NV, Koenawan CJ, Boulkamh A, Sulistyo I, Lebarillier S, Akhlus S, Doumenq P, Wong-Wah-Chung P. 2017 Beach macro-litter monitoring and floating microplastic in a coastal area of Indonesia. *Marine Pollution Bulletin* 122: 217–225. <https://doi.org/10.1016/j.marpolbul.2017.06.046>
- [40] Herdiman, Y 2018. Head of Regional Service for the Environment and Forestry, Thousands Island, Jakarta Province. <https://news.detik.com/berita/d-3923445/ini-cara-pemprov-dki-jakarta-cegah-sampah-masuk-teluk-jakarta>

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