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Marine Debris Management in the Parangtritis Beach Tourism Area, Yogyakarta During Covid-19 Pandemic

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ABSTRACT

Parangtritis Beach, Yogyakarta, Indonesia, is one of the most visited tourist destinations for domestic and international tourists. These tourists are required to carry out health protocols by wearing masks during the COVID-19 pandemic. The high number of visits is linear with the generation of waste in tourist areas. Marine debris is defined as any solid material that settles, dumps, or is dumped, dumped, or disposed of in the marine and coastal environment. Efficient management of marine debris is a coordinated strategic approach to dealing with problems and inefficient law enforcement to improve the preservation of the marine environment. This study aimed to analyze the composition, characteristics, and management of marine debris in the Parangtritis Beach area during the COVID-19 pandemic. The amount of waste generated during the pandemic was recorded at 0.9 kg/m^2.day. Sampling is carried out using the line transect method. The composition of waste consists of PET, PE, other plastics, biodegradable organics, and masks, each of which is 17.86%, 32.54%, 6.85%, 37.61% and 5.14%. Due to the COVID-19 pandemic, mask waste has become waste that has a new category, namely infectious. The characteristics of marine debris other than organic biodegradable tend to have a high calorific value so that it is possible to be processed by thermal processes. Thermal gravimetric analysis (TGA) shows that Polyethylene Terephthalate (PET), (Polyethylene) PE, and mask waste can be decomposed at a temperature of 260-550°C. Organic waste has been managed by processing Black Soldier Fly (BSF), while plastic waste can be processed into handicraft products. In contrast, the remaining plastic waste and masks are processed by a thermal process to allow waste to energy.

INTRODUCTION

The Province of the Special Region of Yogyakarta is a tourist destination that provides various tourist attractions ranging from nature, culture, architecture, and historical heritage, and even Yogyakarta has many coastal beaches, with beauty, and uniqueness on each beach (Hudayanti et al. 2020, Wijayanti & Damanik 2019). The strategy and integrated economic development of the coastal area of Yogyakarta is an alternative form of the economic development model in responding to the challenges of carrying out economic development and regional development in an integrated and comprehensive manner through an integrated approach to developing the potential of the southern coast of Yogyakarta. One of the beaches that have the highest visits in Yogyakarta is Parangtritis Beach (Shidiq Darajat & Susilowati 2018). This beach is legendary or is already very famous among tourists or visitors, and this beach is very crowded when the holidays arrive. To prepare for the arrival of hemp tourists, the manager provides several facilities for visitors to use when they come to Parangtritis Beach. Before the pandemic occurred, the volume of waste always increased along with the increasing number of tourism actors and tourists visiting the tourist area of Parangtritis Beach. The generation of waste that is increasing day by day and cannot be transported every day indicates that the less effective management system implemented by the management has resulted in the condition of the Parangtritis beach area becoming dirty and causing environmental disturbances. Garbage does not only come from tourists, but also from several small rivers that flow to Parangtritis Beach, and garbage is carried by the Opak River to the sea and swept away by waves towards the beach.

Some people in the Parangtritis Beach tourist area think that the facilities and infrastructure for waste management in the area are widely available. However, on the one hand, the community also believes that the available facilities and infrastructure do not yet have good quality. So that in fulfilling the function of the facilities or infrastructure is not optimal. One example that was observed was the Temporary Disposal Site (TPS) at the mouth of the Opak River. The existence of the TPS, in the absence of permanent buildings, causes garbage to overflow so that garbage can enter the river which will eventually pollute the river. Concern in the Parangtritis Beach tourist area may have been quite high, but public awareness has not been followed by a good perception of how to properly manage waste (Masjhoer 2017).

Environmental infrastructure facilities are closely related to environmental aesthetics in tourist attractions. Various environmental problems can occur due to the low availability of environmental instructors. One of the problems that are currently often encountered is marine debris management in the Parangtritis Beach area. Marine debris can cause several environmental impacts such as socio-economic issues for the community and the sustainability of marine organisms' ecosystems. It was noted that more than 800 species of marine and coastal organisms were affected by waste pollution due to ingestion and entanglement of marine debris (Secretariat of the Convention on Biological Diversity (SCBD) 2016). Marine debris can be a severe problem in coastal areas and small islands of Indonesia, marine organisms' habitats, and ecosystems (Purba et al. 2019). Based on the results of research from Jambeck et al. (2015), Indonesia is ranked 2nd as the largest producer of plastic waste in the world.

The movement of garbage in the sea knows no boundaries, so marine debris can also end up and accumulate in conservation areas. The marine conservation area is an area designated as a marine resource conservation area. Yogyakarta Coastal Area is an area that is rich in Conservation Areas. One of the closest to Parangtritis Beach is the Baros Mangrove Conservation Area, which has initially been clean and well-maintained, now it is dirty due to a lot of marine debris. This condition will be even more concerning with the COVID-19 pandemic. Conservationists have warned that the coronavirus pandemic could trigger a spike in marine debris. The large quantities of personal protective equipment such as masks and gloves were found to be new potential for environmental impacts in coastal areas in Indonesia. Recently, research in Indonesia has also found contamination of personal protective equipment in coastal areas such as Jakarta (Cordova et al. 2021) and Bali (Suryawan et al. 2021). This does not rule out the possibility of changes in pollution composition due to the COVID-19 pandemic at Parangtritis Beach, Yogyakarta. This study aims to analyze the composition, characteristics, and management of marine debris in the Parangtritis Beach area during the COVID-19 pandemic.

MATERIALS AND METHODS

Marine Debris Generation and Composition

The time of collection of waste generation and composition of waste is carried out on Friday, March 12, 2021. Sampling is carried out using the line transect method. The requirement for the location to be used as a research site is to have a beach length of 100 m. Subsequently, the transects were divided into five transect installation areas with a distance of 20 m between transects. A total of 10 transects measuring 5×5 m were made with the transects positioned at the highest tide and lowest low tide. The 5×5m transects are further divided into sub-transects measuring 1×1 m. It is further divided into 25 sub-transects within the transect area, and then five sub-transects are randomly selected on each transect to be used as sampling areas. The five locations of the station research sub transect can be seen in Fig. 1. Parangtritis beach location coordinates are 8°1′18.5″ S, 110°19′16.6″ E.

The calculation of waste generation and composition refers to SNI 19-3964-1994 waste for each sub-transect. The composition of waste in the sampling area is divided into five types of waste: PET, PE, other plastics, biodegradable organics, and masks (Table 1). Waste from each source, whose weight and volume have been measured, is sorted

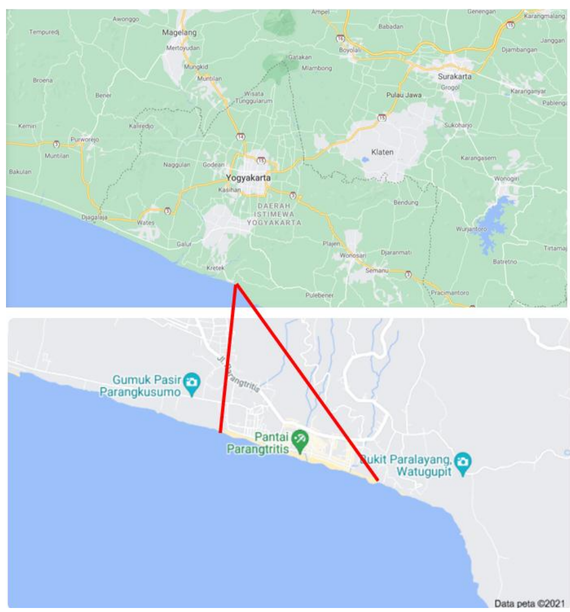

Fig. 1: Research location in Parangtritis beach, Yogyakarta (Google Map 2021).

based on five types of waste. Then each type of waste is measured by weight. Each collected waste is measured in weight (kg) so that later each waste will have a weight/weight (w/w) composition.

Marine Debris Characteristics

Characteristic tests were carried out in the form of chemical tests consisting of proximate analysis, namely water content, volatile content, fixed carbon, and ash content, as well as analysis of the calorific value of each raw material. A test of the characteristics of raw materials is carried out to determine the potential of each raw material.

Waste Management Analysis

Marine debris management was analyzed based on a literature review, both from existing conditions and from the literature review. In addition, from the results of characteristic testing, the most suitable processing for each component of marine debris. The management of mask waste is also adjusted to the applicable regulations in Indonesia.

RESULTS AND DISCUSSION

The Amount of Marine Debris Before the Covid-19 Pandemic

The volume of waste generated per day by residents and tourists is 1,547 liters per day at Parangtritis Beach. The volume of waste on holidays or national holidays is 7,364 liters per day. The waste management system in the Parangtritis Beach tourist area that has The waste management system in the Parangtritis Beach tourist area that has been carried out so far is considered not effective and efficient enough, it can be seen from the total waste generation has not been transported in one day to the final disposal. been implemented so far are storage, collection, transportation of waste, and final disposal (Masjhoer 2017). At the beginning of 2021 during the New Year's holiday, the amount of waste in the Parangtritis beach area reached 35 tons. This is because tourist objects that blend with nature or outdoors are in demand by tourists during the current Covid-19 pandemic. People who have been at home for a long time due to activity restrictions require refreshing. In addition, the difference in the categorization of waste after Covid is dominated by mask wastes from tourists.

Marine Debris Generation and Composition

Fig. 2 shows the generation for each transect location for sampling waste generation. The highest waste generation was found at location 5 with a value of 1.4 $kg.m^{-2}.day$. L1 to L5 indicates the sampling location. Furthermore, the transect is divided into five transect installation areas with a distance between transects of 20 m. Then five sub-transects were randomly selected on each transect to be used as sampling areas. The average marine debris generation is 0.9 $kg.m^{-2}.day^{-1}$. The composition of the waste found along the coastline is primarily plastic, and only 32.54% (w/w) is included in biodegradable organic waste (Fig. 3). Another

Table 1: Examples of waste included in the composition of marine debris in Yogyakarta.

Component	Example
PET	Bottle Plastic
PE	Plastic Bags, Plastic Wrap, Plastic Packaging Waste, PE Rope
Other Plastic	Pipes, Windowsills, Toys, Automotive Components.
Biodegradable Organic Waste	Food, Leaf
Mask	N95 and Medical Masks

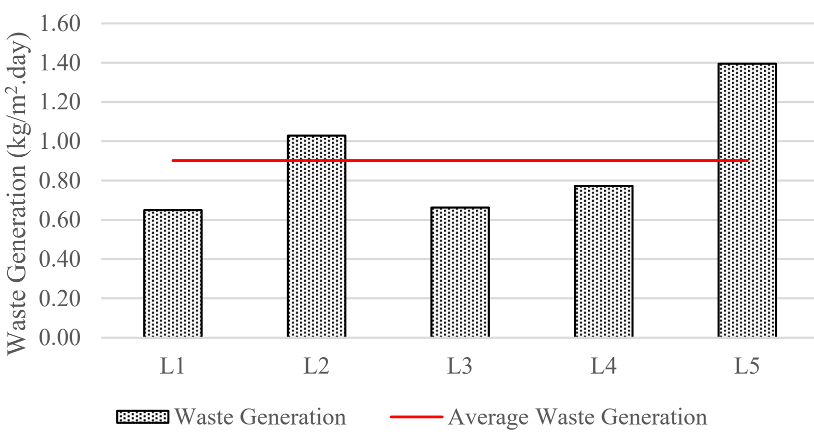

Fig. 2: The generation of marine debris during the COVID-19 pandemic at Parangtritis Beach, Yogyakarta.

finding regarding waste composition by counting pieces of waste at Parangkritis Beach is dominated by degradable waste such as wood, coconut shells, leaves, flower flakes (Mardiatno & Wiratama 2021). A new type of waste that will be a challenge during a pandemic is personal protective equipment, especially masks. It can be seen that the average mask waste is 5.14% (w/w).

To reduce and prevent the spread of COVID-19, one of the health protocols that must be carried out while traveling is the use of masks. Disposable masks can be one of the media for the spread of COVID-19; they must be appropriately managed. The Ministry of Environment & Forestry, Indonesia, issued Circular Letter Number SE.2/MENLHK/PSLB3/PLB.3/3/2020 concerning Management of Infectious Waste and Household Waste from Handling Corona Virus Disease (COVID-19), including guidelines for managing single masks wear. In general, disposable face masks used during the pandemic are made of non-renewable petroleum-based polymers that are not biodegradable, are harmful to the environment, and cause health problems (Dharmaraj et al. 2021). Medical mask waste and N95 masks are usually made of polypropylene (Jain et al. 2020). Mask in COVID-19 pandemic is categorized as infectious waste. If the Government has provided a special dropbox for masks in public spaces, the public can dispose of the disposable masks in the particular mask bins that have been provided. The lack of storage facilities can also cause tourists to throw masks carelessly. Fig. 3 shows the condition of mask waste that is thrown carelessly at the Parangkritits Beach location. After determining sample points and transects for Marine Debris Monitoring, we then proceed with waste identification as shown in Fig. 3. The process of identification and categorization of waste types by looking at the categories of types of waste generated during the pandemic, namely the process of sorting waste by type.

Characteristics of Marine Debris

Proximate analysis is a test that includes testing water content, ash content, and volatile materials. Waste samples measured proximate and calorific values were free from water and sand contamination. The highest water content test results were found in biodegradable organic waste, namely 67.43%. Meanwhile, the lowest plastic waste is 0-2.34%. Plastic is a polymer that has unique and extraordinary properties. The nature of plastic tends not to absorb water. When plastic is degraded in a distilled water environment with seawater, sodium chloride (NaCl) in seawater will stick to the plastic surface (Safaat, 2020). PET, PE, masks, and other plastic wastes tend to have a higher calorific value than biodegradable organic waste. The calorific value for mask waste has a value of 21.14 $MJ.kg^{-1}$. Meanwhile, PET and PE plastic waste has a higher heating value - 34.6 $MJ.kg^{-1}$ and 35.06 $MJ.kg^{-1}$, respectively. Overall, plastic from marine debris has considerable potential if it is dry, where the calorific value can reach 44 $MJ.kg^{-1}$ (Pietrelli et al. 2017). During the COVID-19 pandemic, plastic waste (including surgical masks) produced during the pandemic had a high calorific value than other ordinary fuels (Dharmaraj et al. 2021). PE waste and masks are waste made of polypropylene material. So, the characteristics are the same where the water is absent. The absence of water tends to provide a high calorific value (Jain et al. 2020).

The density of waste data is needed to plan waste management systems, such as storage, transportation, and disposal. The density of waste from each type of waste shows varying results. According to Tchobanoglous & Vigil (1993), plastic waste usually has a density of 64 $kg.m^{-3}$ (Tchobanoglous & Vigil, 1993). This is quite different from our findings in coastal areas where the density of plastic waste is more significant, namely between 119.68-288.1 $kg.m^{-3}$; it is estimated that the plastic waste mixes with sand and seawater,

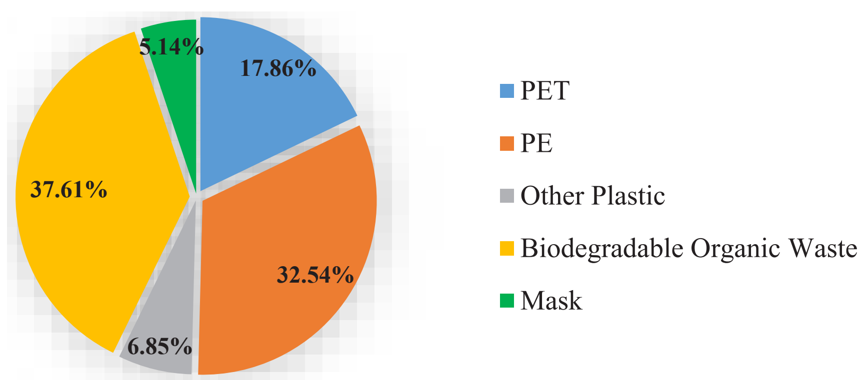

Fig. 3: The composition of marine debris during the COVID-19 pandemic at Parangtritis Beach, Yogyakarta.

the density increases. Sticky sand in plastic waste tends to be challenging to clean.

Marine Debris Management

The urban waste management policy issued by the Ministry of Public Works and Public Housing in Indonesia is in accordance with SNI 3242:2008. Marine debris waste management operational engineering diagram can be seen in Fig. 5. Waste management is integral and integrated into a chain with a continuous sequence, namely: storage/container, collection, transfer, transportation, and disposal/processing.

Sorting and recycling activities are carried out as much as possible from the collection to the final disposal of the waste. As previously discussed, the waste management operational system includes a waste processing and processing subsystem, which needs to be developed in stages by considering processing that relies on reuse, either directly, as raw materials or as an energy source. Removal of waste into the ground accompanied by backfilling is known as landfill. A sanitary landfill is a landfilling method whose application pays attention to environmental sanitation aspects.

Thermal Gravimetric Analysis (TGA)

The decomposition temperature test was carried out by thermogravimetry (Fig. 6). The PET, PE, and mask waste undergo one-stage decomposition, namely in the temperature range of 260-550 °C. This temperature is quite good because it is not too high for the pyrolysis process. The ther-

Fig. 4: Existing condition of mask waste management at Prarangtritis Beach, Yogyakarta during the COVID-19 pandemic.

mal process in PE waste starts at a temperature of 371.51°C. Considerable polymer intermolecular bonds are broken due to increased temperature and are also assisted by radicals resulting from breaking intermolecular bonds (Wati et al. 2018). Sorum et al. state that the thermal degradation of PE occurs at 350-500°C, which is related to the degradation of the released hydrocarbons and becomes volatile (Sørum et al. 2001). In contrast to PE waste, the amount of PET waste residue tends to be higher at 12.95%. The thermal degradation process of PET follows ester link random scission, which results in the formation of oligomers (Lecomte & Liggat 2006). The initial degradation of PET may be due to some volatile impurities such as diethylene glycol (Dimitrov et al. 2013). Overall, the degradation process can cause the thermal degradation properties of plastic waste in coastal areas by seawater and UV radiation (Iñiguez et al. 2018). The mask waste appears to have a different graphic than PET and PE. Garbage masks change at a temperature of 350-490°C. This value is similar to the study of Jung et al. (2021), which showed the primary degradation of the mask was at a temperature of around 330°C and ended up at 495 °C (Jung et al. 2021). Combustion of the mask with N_2 gas by pyrolysis allows the existence of inorganic compounds of Fe primarily and small amounts of Zn, Ti, Ca, and Mn (Jung et al. 2021).

Marine Debris Management

In the results of interviews with 50 Parangtritis Beach tourists who are aware of and dispose of in their place only 16 visitors (32%), 22% or 46% throw garbage in careless places and ditches (Sujatmiko 2009). For this reason, the effort to solve the waste management problem that the Bantul Regency Government has carried out is to encourage community participation in solving environmental problems is to apply a waste bank. The solution offered to solve environmental problems in Gumuk Pasir (Parangtritis Beach) is creating

Table 2: Characteristics of marine debris for each component.

Component	Water Content	Volatile Matter	Fix Carbon	Ash Content	Caloric Value (MJ/kg)
PET	2.34%	95.20%	1.35%	1.11%	34.60
PE	0.00%	99.30%	0.66%	0.04%	35.06
Other Plastic	1.19%	94.20%	2.67%	1.94%	30.34
Biodegradable Organic Waste	67.43%	29.20%	1.89%	1.48%	9.17
Mask	0.00%	100.00%	0.00%	0.00%	21.13

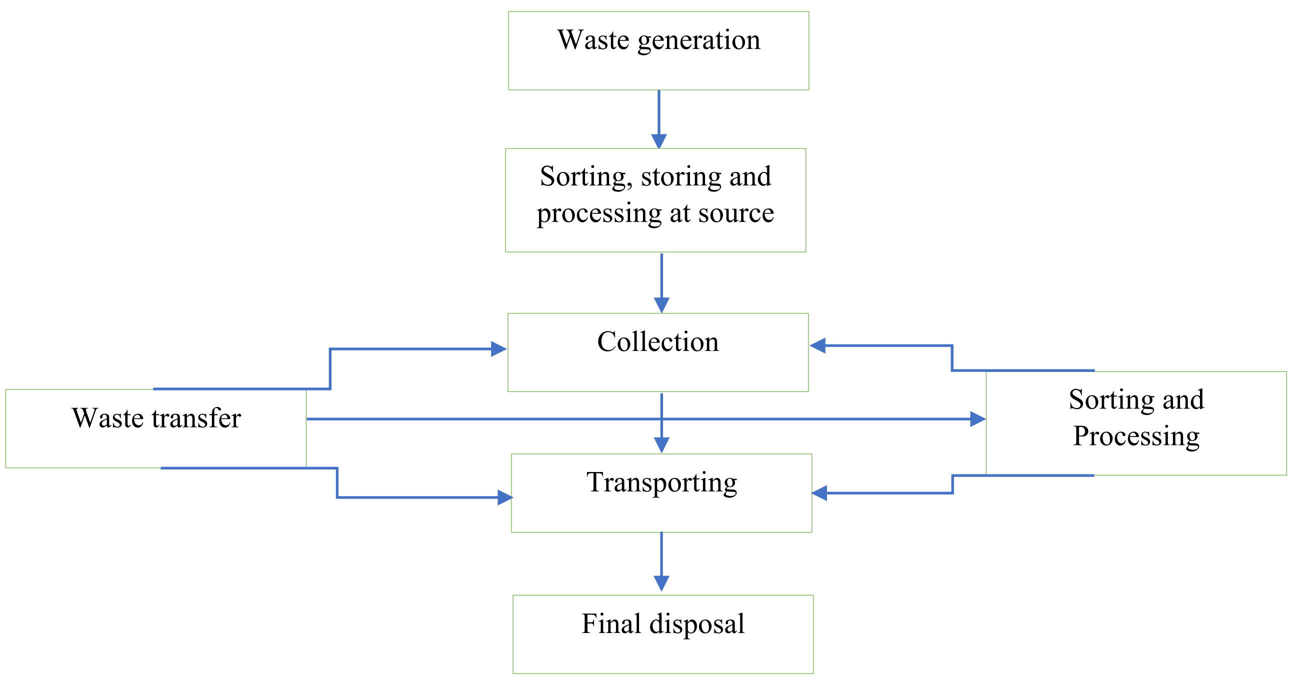

Fig. 5: Waste management operational engineering diagram.

the G-Fly Garbage Bank, which has a solopreneur concept by utilizing Black Soldier Fly larvae (Lisnawati et al. 2019). The utilization of BSF larvae was fed to marine fish as a substitute for traditional feed. The fish growth response was maximal when 25% or fewer BSF larvae were replaced with traditional feed (Cummins et al. 2017). Processing with futuristic BSF can support the basis of waste into biodiesel (Raksasat et al. 2021).

Plastic waste can be processed by recycling, and some types of inorganic waste that are not recycled are sent to waste collectors. Plastic waste can be focused on minimizing efforts. Continue and strengthen plastic restriction policies. According to Kuo & Huang marine debris, management can be done by strengthening plastic restriction policies, promoting marine environmental education, recycling fishing gear, and converting waste into energy (Kuo & Huang 2014). Currently, in Yogyakarta, there is still no policy on the use of single-use plastic. In Indonesia, several local governments have issued policies on using single-use plastic in Indonesia, such as Bali and Jakarta (Suryawan et al. 2021). Plastic waste recycling can be done through crafts such as flowerpots from used PET bottles, key chains, plastic bags, wallets, room decorations, and tablecloths. Waste that is not recycled will be sent to the garbage collector. Plastic waste with quality that cannot be recycled as handicraft products can be processed into refuse-derived fuel (RDF) fuel sources because it has a high calorific value than other waste materials. The mask waste is disposed of in the domestic trash after being crushed and wrapped in a tight plastic bag. In addition, if the Government has provided a dropbox for masks in public spaces, the public can dispose of the disposable masks in the mask bins that have been provided. The result of mask waste is recommended to be treated by thermal means to eliminate infectious properties. The processing that can be applied is also the pyrolysis process, allowing the mask waste to energy.

CONCLUSIONS

The average generation of marine debris based on the transect method is 0.9 kg/m^2.day. Meanwhile, the amount of waste is dominated by plastic types (PE, PET, and others), including masks. The amount of mask waste is 5.14%, which was not found before the pandemic condition. The characteristics of marine debris for PET, PE, other plastics, and masks have a high calorific value, making it possible to use a thermal process. The TGA thermal analysis process shows that PET, PE, and mask waste decomposes at a temperature of 550^{o}C. Meanwhile, the existing biodegradable organic waste management is carried out using BSF, and plastic waste can be recycled into handicraft products. Meanwhile, plastic waste that cannot be recycled and mask waste must be treated with a thermal process.

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Table 3: The density of marine debris for each component.

Component	Density [kg.m^{-3}]
PET	288.1
PE	267.84
Other Plastic	119.68
Biodegradable Organic Waste	317.6
Medical Mask	222.4

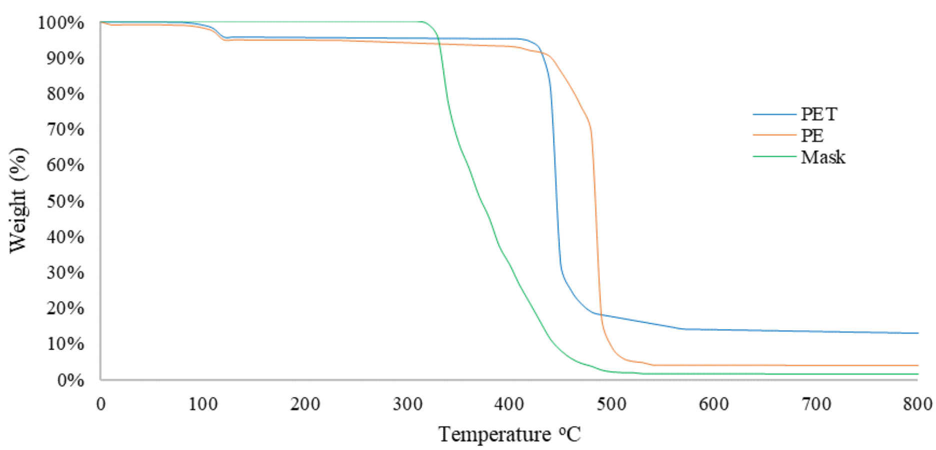

Fig. 6: Thermogravimetric analysis of marine debris for PET, PE, and mask.

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