

# SPATIOTEMPORAL ANALYSIS OF MARINE DEBRIS EXISTENCE IN PARANGTRITIS COASTAL AREA, YOGYAKARTA, INDONESIA

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## Abstract

This research is aimed to identify the marine debris types and their distribution based on morphological characteristic of the coastal area. It was conducted between Pantai Depok and Pantai Parangtritis, Yogyakarta. Specifically, the morphological identification was carried out to characterize the morphology of the location under study and its relation to the distribution of existing marine debris. This research used survey method, accompanied by systematic sampling techniques. Perpendicular line transects created in 100 meters intervals, accompanied by a 1x1 meter grid for marine debris identification. Descriptive qualitative analysis was done to explain the spatial temporal aspect of marine debris existence. The results of the study were presented in a cross-section morphological description, analysis table, and a map showing the distribution of marine debris along with a description of the type of debris and its density. The results showed that the distribution of marine debris was spatially clustered on the west side, especially on the coast of Depok. This fact reveals that the distribution of marine debris will indirectly follow the coastal morphology, i.e. the amount of debris will increase if it approaches the river mouth. Temporally, the highest amount of marine debris was obtained in March and the lowest was obtained in July. Degradable marine debris is dominated by wood, while non-degradable is dominated by plastics and straws. The greatest amount of marine debris occurred during the west season, which indicates that the supply of debris coming from the Opak River, located in the western part of the study area.

**Keywords:** marine debris, morphological characterization, spatial temporal analysis

## Abstrak

Penelitian ini ditujukan untuk mengidentifikasi sampah laut dan distribusinya, berdasarkan karakteristik morfologi di wilayah pesisir. Lokasi penelitian terletak di antara Pantai Depok dan Pantai Parangtritis, Yogyakarta. Identifikasi morfologi dilakukan untuk melakukan karakterisasi morfologi pada lokasi studi, serta keterkaitannya dengan distribusi sampah laut eksisting. Penelitian ini menggunakan metode survey lapangan disertai dengan teknik sampling sistematis. Transek tegak lurus garis pantai dibuat dengan interval 100 meter, disertai dengan kuadran 1x1 meter untuk identifikasi sampah laut pada lokasi tersebut. Analisis deskriptif kualitatif dilakukan untuk menjelaskan aspek spasio-temporal keberadaan sampah laut. Hasil penelitian disajikan melalui deskripsi morfologi *cross-section*, tabel analisis, peta distribusi sampah laut beserta keterangan jenis sampah dan kelimpahannya. Hasil penelitian menunjukkan bahwa sampah laut secara spasial terdistribusi mengelompok pada sisi barat, khususnya di pesisir Pantai Depok. Fakta ini menunjukkan bahwa sebaran sampah laut secara tidak langsung akan mengikuti morfologi pantai, yaitu jumlah sampah akan bertambah jika mendekati muara sungai. Secara temporal, jumlah sampah laut tertinggi diperoleh pada Bulan Maret dan terendah pada Bulan Juli. Sampah laut yang terdegradasi didominasi oleh kayu, sedangkan sampah *non-degradable* didominasi oleh plastik dan sedotan. Jumlah sampah laut terbesar terjadi pada musim barat, yang mengindikasikan adanya masukan sampah yang berasal dari aliran Sungai Opak, yang terletak di bagian barat wilayah studi.

**Kata kunci:** sampah laut, karakterisasi morfologi, analisis spasio-temporal

## INTRODUCTION

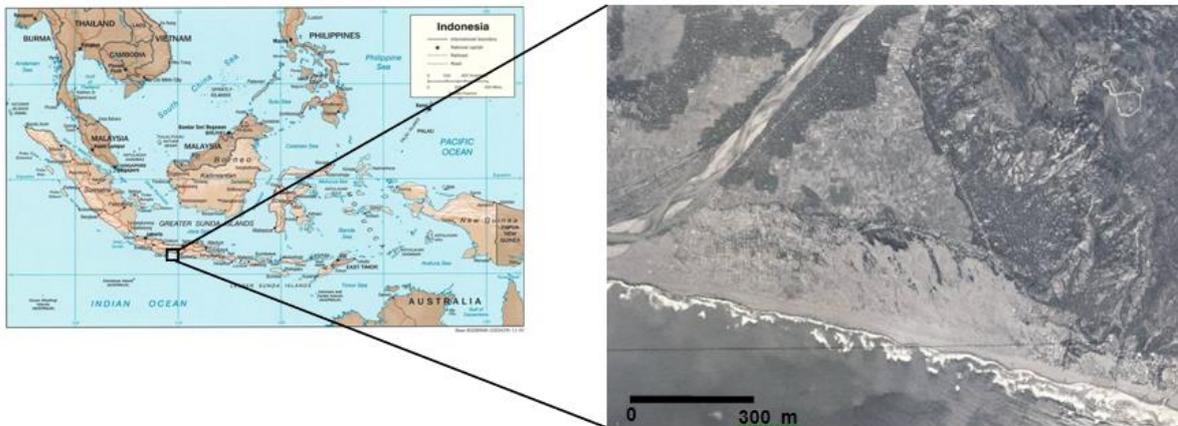
Coastal area is a transitional area between land and sea bounded by the coast on the mainland and the wave breaking zone at sea. Beaches and coasts are part of coastal areas that are affected directly or indirectly by the marine process. The influence of the marine process can transport material coming from the sea to the coast. These materials can be either organic or inorganic material, which can be referred to as marine debris.

Marine debris is all material processed or processed that is intentionally, unintentionally, not directly disposed of or left in the marine ecosystem [1]. Marine debris can originate from human activities directly or indirectly to the sea through river flow, and or movement of ocean currents. The influence of human activities directly, such as garbage disposal on the beach and / or coast by tourism activities. Disposal of marine debris indirectly originates from human activities at sea while on a voyage,

intentionally or unintentionally disposing of trash at sea, so that it will be carried back to shore by the influence of waves and ocean currents.

The morphological characteristics of the beach and coast are influenced by wave activity and ocean currents. Sloping beaches and beaches are likely to be able to receive more material from the sea. Coastal and coastal morphology can be used to identify possible locations of accumulated marine debris on the coast.

The Parangtritis area, covering Parangtritis Beach to Depok Beach, is one of the well-known tourist destinations in Yogyakarta (Figure 1). Marine debris that is periodically blown over in this area requires good management. Identification of coastal and coastal morphology is the first step to determine the potential location of the distribution of marine debris, so that further steps can be determined for its management.



**Figure 1.** The region of Parangtritis Beach and Depok Beach

In the study of geomorphology, known four aspects are studied, includes morphology, morphogenesis, morphochronology, and morphoarrangement [2].

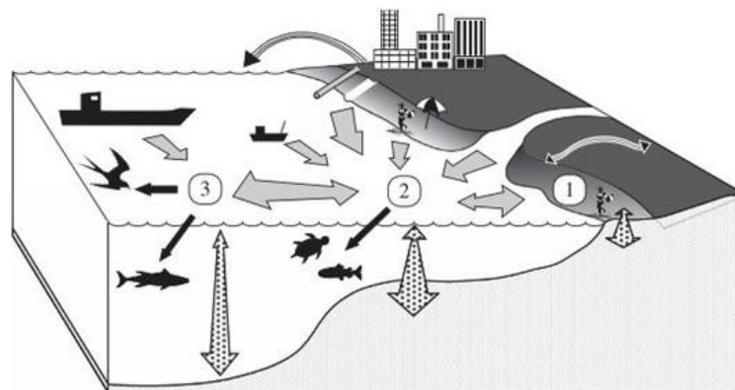
Geomorphological aspects can be distinguished into four categories based on their application in environmental management [3], i.e. static geomorphology, dynamic geomorphology, genetic geomorphology, and environmental geomorphology. Ecological problems that

occur in an area are widely studied in aspects of environmental geomorphology.

Marine debris is an economic and ecological problem, along with the increasing amount of waste in the sea [4]. Marine debris is all the results of the production or processing of solid waste originating from various sources [5]. Increasing the amount of marine debris has a bad impact on marine ecosystems. The presence of marine debris can threaten the physical, biological, and chemical damage to the marine ecosystem [6].

Marine debris sources that can be found on the beach can be categorized into two types of sources, namely land-based waste sources and marine waste sources [5]. Sources of rubbish from land in the form of rubbish from land that crashed or flowed into the nearest water flow through rain. Waste can come from domestic activities, industry,

tourism, and solid waste disposal. The source of rubbish from the sea is rubbish originating from human activities in the ocean using ships, such as fishing nets, fishing hooks, and ropes. An illustration of the source of waste originating from land to sea and its movement [7] can be seen in Figure 2.



**Figure 2.** Source of marine debris and its movement in the ocean (1. Tourism; 2. Industry activities and disposal of landfill; 3. Shipping activities)

Several sources of marine debris which can be found on the beach, namely: tourism, shipping activities, industrial activities, and landfill waste disposal [1]. Garbage on the beach can also come from tourists and people who are on the beach who throw garbage in the beach environment. The priority allocation of beach cleaning activities can be done by calculating the amount of abundance of marine debris found on the beach [8]. Ocean currents are a very wide movement of water throughout the ocean that affects the movement of material on the surface of the water. The movement of ocean currents is influenced by the strength and direction of the wind. Knowledge of the direction of ocean currents is useful for determining the direction of shipping for ships [9]. The movement of currents also influences the direction of movement of material such as rubbish which is at sea level and stranded on the beach. Sea currents can be one of the instructions to find out the accumulation of marine debris on the beach. Tides are changes in sea level that are affected by the moon's gravitational force at certain cycles [9]. Conditions at the highest tide on the beach allow to carry marine debris

material from the ocean to the beach. The garbage will be left on the beach after the sea water has receded. The general objective of this research is to identify the marine debris types and their distribution based on morphological characteristic of the coastal area in the area of Depok Beach to Parangtritis Beach. The specific objectives of this study are: (i) morphological characterization of the coastal and coastal locations of the study; (ii) identification of typology of marine debris at the study site, and (iii) analysis of distribution of marine debris based on coastal and coastal morphological characteristics.

## METHOD

The tools used in this study include a digital camera, a set of data processing computers, a field parameter measurement tool (compass, measuring stick, distance meter, clinometer), a 1×1 meter sample grid and a checklist. The materials for the study include 1: 25,000 *Rupabumi* Indonesia Map, high resolution imagery maps (created from Google Earth imagery), and wind and wave

forecast maps from BMKG (February until July, 2019).

### Data collection

The data used in this study include primary data and secondary data. Primary data obtained from the results of field observations. Primary data include beach and coastal morphology (topography and morphometry), debris type and debris abundance, and field photographs. The secondary data obtained from the results of previous studies and data available at the relevant agencies or institutions. Secondary data collected included wave height, temporal wind speed and direction (BMKG) data and the tourism data of the area under study. This research uses a systematic sampling technique. Samples are collected using a grid on each transect that is 100 meters away (see Figure 3). At each transect, topographical identification and morphological parameters were collected, namely the width of the beach and coast, relief, slope, and grain size. The debris parameters are collected in each grid, including the type, amount and abundance of debris.

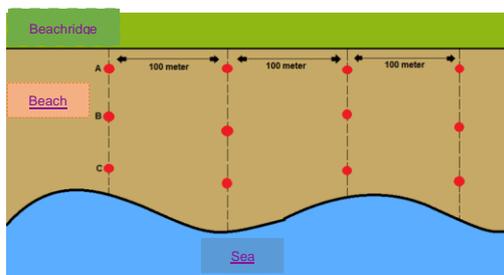


Figure 3. Transect design

### Data analysis

There are three stages of analysis carried out in this research. First, coastal and coastal morphological analysis is carried out to identify the morphological characteristics of each transect. This analysis is done by making a cross section from the coastline to the coastline, then a morphological comparison between transects has been made. Second, typology analysis of marine debris and its distribution, which includes parameters of

type, amount and abundance. The types of debris are divided into degradable and non-degradable debris. The amount of debris is calculated manually in a 1x1 meter grid, with the smallest size of debris being 1 cm. Data on the amount of debris is also used to determine the parameters of the abundance of debris in each grid. Third, the analysis of the distribution of marine debris based on the morphological characteristics of the beach and coast. This analysis is carried out by making a description of the topographical cross section combined with information on the parameters of marine debris at each cross section. The results of this analysis will be used to determine the relationship between the characteristics of coastal areas with the possibility of distribution of marine debris.

### Research output and visualization

The results of the study are a cross-section morphological description, analysis table, and maps of the distribution of marine debris along with a description of the type of debris and its abundance.

## RESULT AND DISCUSSION

### Morphology of the coastal area

In general, the coastal area in Parangtritis is a beach and sand dunes complex located in the north part after the beach. It is composed mainly by sand materials with varied grain size. Shoreline configuration is relatively straight and the beach slope is varied. The eastern part is generally flat and the western part is more undulating. The research areas include Depok beach area, Pelangi beach, Cemoro Sewu beach, Parangkusumo beach, and Parangtritis beach. Based on morphological characteristics, all of these beaches have similar properties, except for the beach steepness. By considering beach steepness and location, the research area can be differentiated into four groups, i.e. beach nearby river mouth (Depok), beach with low steepness (Pelangi and Cemoro Sewu), moderate steepness beach associated with

sand dune (Parangkusumo), and flat beach (Parangtritis).

Depok Beach is located adjacent to the Opak River, followed by Pelangi Beach in the east. Depok Beach has a length of approximately 2.5 km and Pelangi Beach has a length of approximately 1 km. Pelangi Beach is also one of the beach locations which is a turtle conservation point. Cemoro Sewu Beach is situated in the east of Pelangi beach, bordering the sand dune area in the norther side. This beach has around 1.2 km length. The next beach is Parangkusumo, which has around 1 km beach length, followed by Parangtritis Beach in the east. Parangtritis beach has approximately 1.2 km

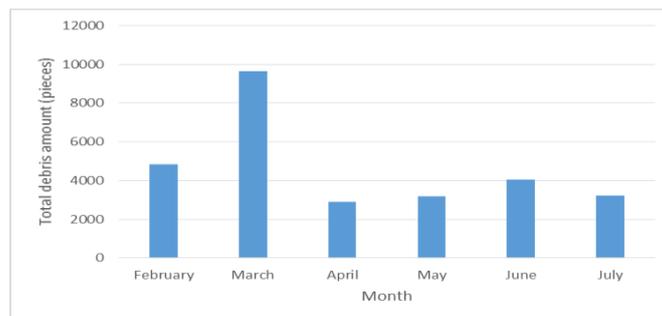
length and it is bordered by the Baturagung hills in the east. Both Parangtritis and Parangkusumo are crowded beaches compared to the other beaches, since they are often visited by many tourists.

### Marine debris types and temporal distribution

Marine debris is classified into two general types, i.e. degradable debris and non-degradable debris. Marine debris types in the research area can be seen in Table 1 and the temporal distribution of total marine debris amount is shown in Figure 4.

**Table 1.** The amount and types of marine debris

Debris Types	Debris Amount (pieces)					
	February	March	April	May	June	July
Degradable (wood, coconut shells, leaves, flower flakes)	4,254	8,885	2,551	2,739	3,424	2,284
Non-degradable (plastic straws, bottles, plastic bags, etc.)	588	825	341	429	588	883



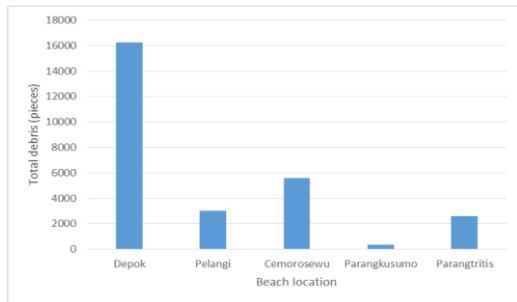
**Figure 4.** Temporal distribution of total marine debris amount

According to the Table 1 and Figure 4, it shows that degradable debris is more dominant than non-degradable debris. The biggest amount of degradable debris is found in March, while the least is found in July. For non-degradable debris, the biggest amount is still can be found in March, but the least amount is found in April.

### Spatial distribution of marine debris and its abundance

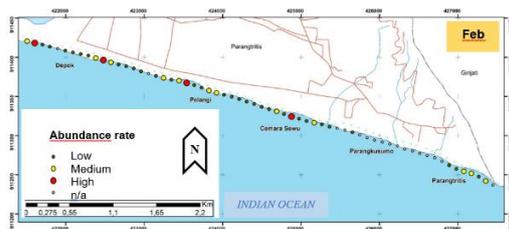
The abundance of marine debris classified into *high*, *medium* and *low* class. There are some transects with no debris appearance during the field observations, so it marked as none (n/a=not available) in the map. The range of debris abundance for each class includes high abundance class 714 - 477 amount/m<sup>2</sup>, medium

abundance class 477 - 239 amount/m<sup>2</sup>, low abundance class 239-2 amount/m<sup>2</sup> and no debris. The class of no debris does not have a range of amounts because the smallest abundance of debris which is counted per transect is 2 amount/m<sup>2</sup>. The spatial distribution of marine debris can be seen in Figure 5.



**Figure 5.** Spatial distribution of total marine debris amount in each beach

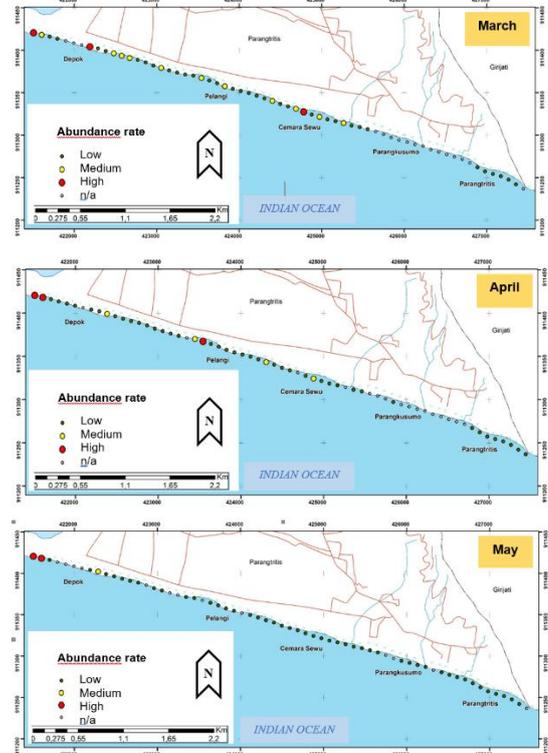
The abundance of marine debris spatially can be seen in the figure 6 to figure 8 as follows. It is represented different season, i.e. February for West season, March-May for transition season and June-July for East season. During the West season (February), high abundance of marine debris can be found from the western part up to Cemoro Sewu beach (middle part of the research area), as shown in Figure 6.



**Figure 6.** Spatiotemporal distribution of marine debris abundance in each beach (west season)

During the transition season (March-May), high abundance of marine debris can be found mainly in Depok beach (accumulated in the western part of the research area), although some high

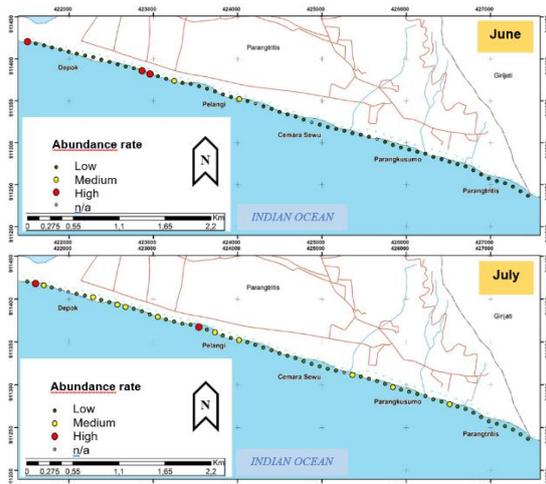
abundance can also be found in the middle part of the research area (Pelangi beach and Cemoro Sewu beach). It can be seen in Figure 7.



**Figure 7.** Spatiotemporal distribution of marine debris abundance in each beach (transition season)

For East season (June-July), high abundance of marine debris is found mainly in the western part (Depok beach and Pelangi beach). It is shown in Figure 8.

Refer to Figure 6 to Figure 8, it can be argued that the spatial arrangement of marine debris abundance is related to the distance from the river mouth and season. The number of debris also depend on the amount of material from the hinterland transported by Opak River. During the rainy season, the number of debris may be higher than in the dry season.



**Figure 8.** Spatiotemporal distribution of marine debris abundance in each beach (East season)

The heavy rains on March caused flooding in several areas in Bantul Regency and surrounding areas. The flow of the flood carried debris material through Opak River and was washed away to the sea. The garbage is then thrown back to the beach so that it becomes marine debris on the surface of the beach. This is consistent with the research [10] that there is an influence of river flow on marine debris abundance. In this case, the influence of tourism activities at the coast to the amount of marine debris can be neglected. Based on the field observation during weekend and the holiday season, the debris amount in the beach did not escalate significantly.

The main factor influencing the amount of marine debris is additional material from Opak River located in the western part of the research area. All materials were transported by the river to the sea and the debris was carried back the shore by the sea current and swash. The distribution of marine debris on the coast is influenced by the movement of currents and sea breezes so that marine debris will be accumulated at a certain location on the beach. Knowledge about the distribution of marine debris is beneficial for cleaning up debris on the beach by giving priority to the location of the beach with the most debris conditions.

The impact of marine debris is detrimental to marine ecology, the

economy, and human health [1]. Marine debris can disrupt marine life such as being bound and even eaten so that it can cause death. Economically, it can cause a decrease in profits for the beach tourism management community due to the deteriorating aesthetic condition of the beach and the expensive expenses for cleaning up trash on the beach.

Human health is also threatened by the presence of marine debris, with the presence of debris like glass and broken wood can hurt humans [1]. Disease can also be caused by garbage with toxic chemical waste that has accumulated in the debris [5][6]. Marine debris can also damage the bottom part of the ship [5]. The presence of marine debris can disrupt the lives of living things, damage fishing rods, and decrease the quality of tourism [11]. Part of coastal areas which are mostly affected by the presence of marine debris is the beach. Thus, regular cleaning is necessary to be conducted in this area when the amount of marine debris increase significantly. On the other side, the coastal area, especially beach and coast, are also widely used for recreation and fisheries, so that it is needed to control the human activities (especially tourism) in order to prevent the addition of marine debris amount in that area.

## CONCLUSION

The combination of marine and river processes affects the amount of marine debris in the beach spatially and temporally. Marine debris is dominated by degradable debris and the highest total debris can be found in March (transition season). High abundance of marine debris is mainly found in the western part, approaching the river mouth. The source of marine debris is predicted coming from the hinterland, because the amount of debris is high at the rainfall event in the upland. For maintaining the beach relatively clean, it is necessary to carry out regular garbage clean-up activities. Human activities such as fishing and tourism activities probably affect the type and amount of debris on the beach, however, they are not occurred in

this case. The amount of debris visitor during holiday or weekend is considerably low.

#### ACKNOWLEDGEMENT

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