

Identifying the characteristics of visible (macro) litter in the Mangrove Park Berbas Pantai Area, Bontang City, East Kalimantan Province

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ABSTRACT

Ecotourism areas are locations where human activities are prevalent in the surrounding environment, including settlements, trade, and other activities that contribute to the community's economic, social, and cultural development. However, these activities can also pose a potential threat to environmental quality if not properly managed. A study conducted at the Mangrove Berbas Pantai area, Bontang City, aimed to identify the types, quantity, and abundance of visible (macro) waste. Sampling was carried out using purposive sampling methods. A 100 m x 20 m transect line was placed parallel to the mangrove ecotourism trail, considering areas that visually contained significant amounts of waste. This transect was divided into five lanes, each containing sub-transects measuring 5 m x 5 m as the sampling areas. Visible (macro) waste identified at the research location includes plastic, rubber, metal, glass, and wood. The composition of waste by weight shows that glass waste has the highest percentage by weight (59.2%), even though it is not the most abundant in number. Polynomial analysis indicates a low influence (21%) between waste type composition and waste weight, while the correlation is 46%.

INTRODUCTION

Indonesia is the largest archipelagic state in the world and possesses a highly strategic geographical position. The officially recorded number of islands in Indonesia reaches 16,056. This figure was established during the *United Nations Conferences on the Standardization of Geographical Names (UNCSSGN)* and the *United Nations Group of Experts on Geographical Names (UNGEGN)*, held on 7–18 August 2017 in New York, United States. Indonesia has a coastline extending approximately 99,093 km, with a land area of around 2.012 million km² and marine waters covering approximately 5.8 million km² (75.7%), of which 2.7 million km² are included within the Exclusive Economic Zone (EEZ).

Ecotourism is a form of environmentally oriented tourism that emphasizes aspects of environmental conservation, socio-cultural and economic empowerment of local communities, as well as educational and learning values. Ecotourism emerged as a response to the negative impacts caused by conventional tourism activities. These negative impacts have been highlighted not only by environmental experts, but also by cultural observers, community leaders, and tourism business practitioners themselves. Such impacts include environmental degradation, uncontrolled influences on local culture, the declining role of local communities, and increasing business competition that threatens the environmental, cultural, and economic sustainability of local societies (Yuniati, 2018).

One of the cities in Indonesia that possesses a mangrove ecosystem area is Bontang. As a coastal city, Bontang has extensive mangrove forest coverage distributed along its coastline. Mangrove Park Berbas Pantai, as one of the educational mangrove tourism destinations, has considerable potential. Established in 2009, the area continues to develop to the present day. In managing ecotourism areas, in addition to maintaining the ecosystem, regular monitoring of waste accumulation is also essential, particularly because mangrove root systems provide favorable conditions for the accumulation of coastal debris (Toar et al., 2021).

Based on the study conducted by Toar et al. (2021) regarding the factors influencing ecotourism development in Mangrove Edu Park, Berbas Pantai Village, Bontang City, from the perspective of stakeholder preferences, the research only described the general condition of the Mangrove Park Berbas Pantai area and did not specifically monitor the types of waste found within the site. Therefore, it is necessary to identify the quantity and types of marine debris present in the Mangrove Park Berbas Pantai (MPBP) area through sampling conducted along the tourism track area.

METHODOLOGY

Time and Location of the Study

This study was conducted from January to February 2023 within the recreational zone along the bridge area of Mangrove Park Berbas Pantai in Bontang, East Kalimantan (Figure 1). Waste abundance data were analyzed statistically using SPSS software with the Kruskal–Wallis test. The research stages included a literature review, field data collection, sample analysis, and preparation of the research report.

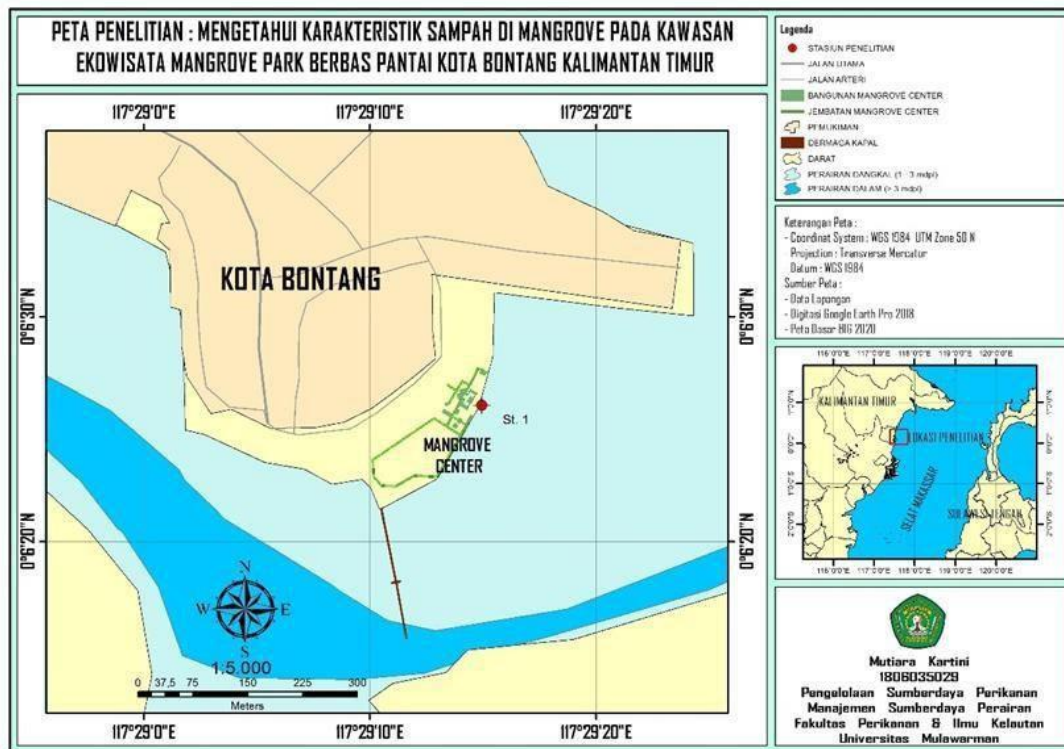


Figure 1. Map of Mangrove Park Berbas Pantai in Bontang, East Kalimantan

Research Procedure

The implementation of this study consisted of several stages, as described below:

Preparation Stage

The preparation stage included gathering information and conducting a literature review related to the general conditions of the study area, preparing the required materials and equipment, and determining the research methods to be applied throughout the study.

Determination of Research Stations

Sampling points were determined based on visual observations along the tourism bridge track, particularly in areas with a high accumulation of visible waste and that were easily accessible for safety considerations. Sampling was conducted within sub-transect areas measuring 5×5 m in each lane along a 100 m transect.

Sampling Method

Samples were collected using a purposive sampling method, in which samples were selected according to the objectives of the study. Transect lines measuring 100 m in length were established parallel to the ecotourism park boundary, with a minimum width of 5 m following the rear boundary of the ecotourism area. The 100 m transect line was divided into five lanes, each spaced 20 m apart, and wooden stakes were used to mark the boundaries. Within each lane, a 5×5 m sub-transect quadrat was established, as illustrated in Figure 2, following the marine debris monitoring guidelines of the Indonesian Ministry of Environment and Forestry (KLHK, 2020).

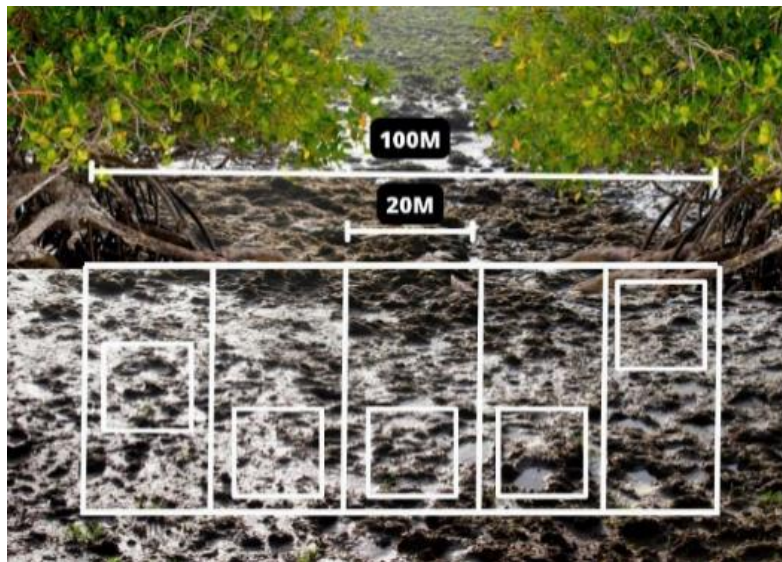


Figure 2. Sampling transect illustration

Subsequently, marine debris within each sub-transect was collected manually using gloves. The collected samples were cleaned and dried from seawater contamination, then placed into labeled sample bags according to the respective station and sampling point. The samples were then identified, counted, and weighed.

Data Analysis

Composition of Waste Types

The composition of waste types was determined by calculating the percentage of both the quantity and weight of each waste type relative to the total quantity and total weight of waste collected within the transect plots. The percentage was calculated using the following formula (Prajanti et al., 2020):

$$\text{Waste Composition (Quantity or Weight) per Type (\%)} = \frac{x}{\sum n \times i} \times 100\%$$

Where:

x = quantity/weight of waste for each type (g)
 $\frac{x}{\sum n \times i}$ = total quantity/weight of all waste types (g)

Regression Analysis

The composition values based on the quantity of each waste type were compared with the composition values based on the weight of each waste type to determine the influence and correlation between the two variables. The analysis was conducted using the regression model with the highest coefficient of determination value obtained from the regression curve. The regression equation used was as follows:

$$Y = ax^2 - bx + c$$

Where:

Y = dependent variable
 a = constant
 b = regression coefficient
 x = independent variable
 c = intercept

RESULT AND DISCUSSION

Identification of Visible (Macro) Litter

Based on the identification results, visible (macro) litter was classified according to its type, as presented in the following Table 1.

Table 1. Waste categories based on identified types

No.	Category	Constituent Materials of Marine Debris Categories
1	Plastic	Plastic cups, plastic bottles, plastic straws, detergent packaging, facial soap packaging, food packaging, plastic bags, raffia ropes, gas lighters, plastic sacks, and others
2	Wood	Processed wood fragments
3	Rubber	Tire fragments, sandals, and sandal straps
4	Glass	Glass bottles and glass fragments
5	Metal	Bottle caps, aluminum packaging, and cans (iron)

A total of 27 macro marine debris items originating from the five transect lanes in Mangrove Park Berbas Pantai were identified, encompassing various types of waste. The distribution of waste types was primarily found in Sub-transect 1, as illustrated in the figure below.

The most frequently encountered macro litter types at the study site were, respectively, plastic, rubber, metal, glass, and wood. Plastic was identified as the dominant type of waste due to its widespread use by tourists and local residents, inadequate waste disposal facilities, and its lightweight properties, which

allow it to be easily transported by water currents. In addition, the morphology of mangrove root systems contributes to the trapping and accumulation of plastic waste. Previous studies by Yuniarti et al. (2023) and Toar et al. (2021) also reported that plastic waste dominates the MPBP area.

According to Jenna Jambeck (2015), increasing plastic consumption among middle-income communities contributes significantly to the accumulation of plastic waste in coastal regions. Furthermore, Zhukov (2017) stated that plastic is the dominant type of marine debris because of its durability and buoyant characteristics.

Composition of Visible (Macro) Litter

The analysis results indicate that the waste type with the highest number of items did not necessarily have the greatest total weight (Table 2). Based on weight percentage, glass constituted the heaviest category of waste, despite being represented by only a few items. Plastic, although the most abundant waste type, ranked second in terms of weight percentage, followed by wood, metal, and rubber.

Table 2. Quantity and Total Weight of Visible (Macro) Litter by Type

Type of Waste	Quantity (items)	Total Weight by Type (g)
Plastic	16	142.6
Rubber	2	4
Metal	3	133.5
Glass	5	601.2
Wood	1	135
Total	27	1016.3

These findings are consistent with the study conducted by Ayuningtyas (2019), which also reported that glass waste contributed the greatest weight, followed by plastic and metal waste. Walalangi (2012) stated that the highest density and mass of waste are generally derived from inorganic materials, particularly plastic and glass. The primary sources of waste in the MPBP area originate from local community activities, with glass waste mainly consisting of intact beverage bottles and broken glass fragments. Consequently, glass dominated the waste composition based on total weight.

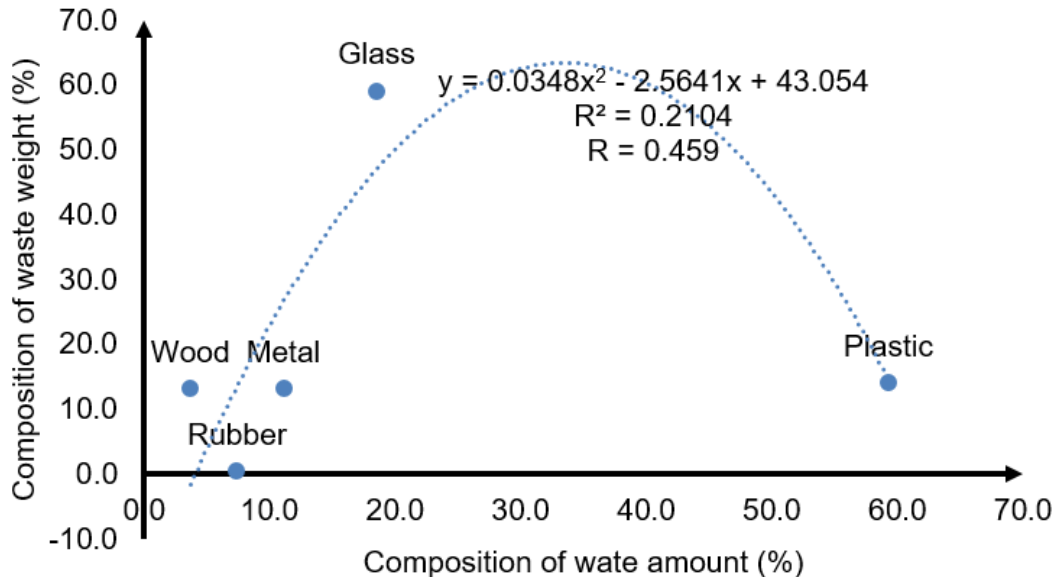


Figure 3. Polynomial Analysis of Visible (Macro) Litter Data at the Study Site

The data analysis comparing the composition of waste quantity by type with the composition of waste weight by type showed that the polynomial regression model explained only approximately 21% of the

variation, with a correlation value of around 46%. These results indicate that the composition of waste weight by type was only slightly influenced by the composition of waste quantity found at the study site. Nevertheless, the relationship between the two variables demonstrated a moderate level of association based on the obtained correlation value.

CONCLUSION

The findings of this study highlight that plastic waste dominates in terms of quantity, while glass waste contributes the greatest proportion by weight within Mangrove Park Berbas Pantai. This dual perspective underscores the complexity of marine debris management, where both the frequency of items and their physical mass must be considered to fully understand environmental impacts. The accumulation of waste in mangrove ecosystems is strongly influenced by the morphology of mangrove roots, which act as natural traps for debris, particularly lightweight plastics.

The regression analysis revealed only a moderate correlation between waste quantity and weight, indicating that item counts alone cannot reliably predict the overall pollution load. This emphasizes the importance of integrating both quantitative and weight-based monitoring approaches in future studies to provide a more comprehensive assessment of marine debris. Such insights are crucial for designing effective waste management strategies that address not only the most abundant materials but also those posing significant risks due to their density and persistence.

From a broader perspective, the study reinforces the need for community involvement, improved waste disposal facilities, and stricter ecotourism management policies to safeguard mangrove ecosystems. By combining ecological monitoring with stakeholder participation, Mangrove Park Berbas Pantai can strengthen its role as an educational ecotourism destination while promoting environmental sustainability. These efforts will not only preserve the ecological integrity of the mangrove forest but also enhance the socio-economic and cultural values associated with ecotourism in Bontang.

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