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Impact of Anthropogenic Macro Debris on Coastal Water Quality in Sangiang Island, Banten

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ABSTRACT

Sangiang Island, with its rich coastal ecosystem, faces a serious problem with marine debris, particularly plastic, which is polluting beaches and seawater quality. This debris, the result of human activities and industrial marine debris, threatens the environment and the health of marine life. This study is important to identify the type and number of marine debris in Sangiang Island and its impact on coastal ecosystems. This study used quantitative methods to measure and analyze the composition of anthropogenic macro-debris and water quality at Sangiang Island Beach. Trash and water samples were taken from several strategic points, using a purposive sampling technique to select samples based on relevance. The results showed that the composition of anthropogenic macro marine litter in Sangiang Island, such as plastic, plastic foam, and rubber, was closely related to water quality. Plastic debris dominated, affecting the pH, salinity, and DO of seawater. An increase in litter concentration was associated with a decrease in water quality, showing the direct impact of litter on pollution of the marine environment. The conclusion of this study is that plastic litter dominates the coast of Sangiang Island and negatively affects water quality, such as decreasing pH and salinity.

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1. INTRODUCTION

Marine plastic debris is a key environmental issue at the global and national levels and has become a major threat to marine and coastal biodiversity. It is regarded as one of the most significant problems for the marine environment and has been viewed as threat to health of both ocean and human. Marine debris is usually defined as any persistent, manufactured or processed solid material discarded, disposed of, or abandoned within the marine and coastal environment. According to recent studies, approximately 12,7 million tons of plastic entered the world's oceans in 2010 (Jambeck et al., 2015). This marine debris is mostly generated by countries with the largest populations and fastest growing economies like China and Indonesia. Indonesia has many small islands, and they are more vulnerable to marine debris (Savage, et al. 2024).

Sangiang Island is one of the small islands in the Sunda Strait. This island is included in Banten Province and is designated as a Natural Tourism Park based on Forestry Ministerial Decree No.55/Kpts-II/1993 with an area of 528.15 Ha (Lestariningsih, et al., 2022). As an island with a long coastline, Sangiang Island has the potential for coastal and marine ecosystems that are rich in biodiversity. Its location, which is almost in the middle of the Sunda Strait, means that this island is in the waters used by ferry boats connecting Java and Sumatra and also international shipping. Apart from that, debris from Java and Sumatra was carried by the current, some of them trapped in Sangiang Island. Marine debris flow off through the Sunda Strait and reach the open Indian Ocean after a few weeks (Iskandar, et.al., 2021).

The existence of marine debris on Sangiang Island has been widely reported in the mass media and research because it has an impact on reducing tourism, turtle nesting and damage to coral reefs (Hidayat, 2022; Munir, 2022; Chelonian, 2023; Yayasan Kehati, 2023). Marine debris can be large, such as mega debris and macro debris, which pose serious risks to the health of living things, especially marine animals such as fish, turtles and birds. They can mistakenly consume debris or become entangled by it, which can cause internal bleeding, ulcers, blockage of respiratory and digestive tracts, and even death for marine life (Kühn & Van Franeker, 2020).

This research aims to determine the composition of marine debris on Sangiang Island and its impact on water conditions on Sangiang Island. The marine debris problem on Sangiang Island is an unresolved problem with the increasing amount of domestic marine debris and industrial marine debris entering the waters, resulting in changes in water quality.

2. METHODS

Location and time of research

This research was held from May - July 2024. This study was held on 2 beaches on Sangiang Island, Banten. Station 1 was on Panjang Beach and Station 2 was on Blok Helipad Beach. The research location can be seen in **Figure 1** and **Table 1**.

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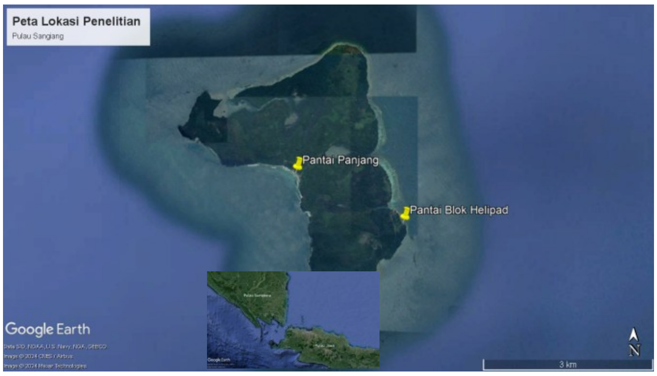

Figure 1. Research Location

Table 1. Research site and coordinate

Station	Name	Coordinate
1	Panjang Beach	5°57'29"S 105°50'54"E
2	Blok Helipad Beach	5°57'58"S 105°51'56"E

Data analysis

Marine debris was collected in labelled plastic bags that were washed with clean water and dried in the sun. Dried macro marine debris was sorted based on categories from NOAA (2024) and then weighed. The classification of marine debris is based on its size characteristics, namely the macro marine debris category. Data related to field conditions and sample results after identification were entered into a standard table format. The results of the marine debris data summary were analysed based on the weight of marine debris in each plot and each transect line. After being grouped, the calculation of marine debris weight and marine debris weight per type based on each transect was calculated based on Prajanti (2020). The weight of marine debris per square meter (M) is the total weight of marine debris per transect box area. The marine debris weight value in units (g/m2) is calculated by the formula:

$$Garbage\ weight\ (\frac{g}{m^2}) = \frac{\text{Total garbage weight (g)}}{\text{Length (m) x width (m)}}$$

Based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 27 of 2021 concerning the Environmental Quality Index regarding guidelines for determining water quality status, the calculation of the pollution index (IP) uses the following formula

$$IPj = \sqrt{\frac{(\frac{Ci}{Lij})^2 M + (\frac{Ci}{Lij})^2 R}{2}}$$

IPj = Pollution index for designation j
Ci = Parameter test results
Lij = Parameter concentration according to quality standards
(Ci/Lij) M = Maximum Ci/Lij value
(Ci/Lij) R = Average Ci/Lij value

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- If the value of $\frac{Ci}{Lij} \leq 1$ then use the measurement results
- If the value of $\frac{Ci}{Lij} > 1$, then find a new $\frac{Ci}{Lij}$
- Ci/Lij new + 1 + 5 log (Ci/Lij old)

for DO:

$$Ci_{new} = \frac{C_{Maximum} - C_{Measurement}}{C_{Maximum} - Lij}$$

If the value of Lij has a range.

- If Ci < average Lij then:
  $(\frac{Ci}{Lij})$ new = $\frac{Ci - Lij_{average}}{Lij_{Minimum} - Lij_{average}}$
- If Ci > average Lij then:
  $(\frac{Ci}{Lij})$ new = $\frac{Ci - Lij_{average}}{Lij_{Maximum} - Lij_{average}}$

In this Pollution Index, water quality status is classified based on the Pollution Index (IP) value. The quality status classification is as follows:

- Good condition, with IP rating (0 < IP < 1.0)
- Light polluted, with IP value (1 < IP < 5)
- Moderately polluted, with IP value (5 < IP < 10)
- Heavily polluted, with IP value (10 > IP)

Descriptive data analysis was conducted to provide a comprehensive picture of the composition of anthropogenic macro marine debris in the Sangiang Island Beach area and its impact on water quality.

3. RESULTS

Marine Debris in Station 1

The results of research at Station 1 based on the data presented in **Table 2**, it is known that plastic marine debris dominates in plot 1 with a total weight of 2,690 kg and in all plots at station 1 with a total weight of 4,785 kg. Plastic foam marine debris dominates in plot 1 with a total weight of 0,515 kg with the total number of plots in station 1 with a total weight of 1,005 kg. Rubber marine debris was most abundant in plot 1 with a total weight of 2,030 kg with the total number of plots in station 1 with a total weight of 4,130 kg. Although not as much as the other types, glass marine debris was also found in station 1 with a total weight of 0,070 kg.

Table 2. Weight of Marine debris by Type at Station 1

Station 1	Marine debris Weight by Type (kg)				Total Garbage Weight (kg)
	Plastic	Plastic Foam	Rubber	Glass	
Plot 1	2,690	0,515	2,030		5,235
Plot 2	1,633	0,420	1,985	0,070	4,110
Plot 3	0,460	0,070	0,115		0,645
Total	4,785	1,005	4,130	0,070	9,990

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The results of research at Station 1, the plot that dominates the most marine debris is in plot 1 with a total weight of 5,235 kg, second is in plot 2 with a total weight of 4,110 kg, and last is in plot 3 with a total weight of 0,645 kg. The overall weight at Station 1 was 9,990 kg.

Marine Debris in Station 2

The results of research at Station 2 based on the data presented in **Table 3**, it is known that plastic marine debris dominates in plot 2 with a total weight of 1,270 kg and in all plots at station 2 with a total weight of 3,230 kg. Foam plastic marine debris dominated plot 2 with a total weight of 0,590 kg with the total number of plots in station 1 with a total weight of 1,555 kg. Rubber marine debris was most abundant in plot 2 with a total weight of 4,115 kg with the total number of plots in station 2 with a total weight of 7,755 kg. Meanwhile, glass marine debris was not found at station 2. Like in Dodola Island Beach, Morotai the most marine debris found was plastic bottle and glass (Idrus, *et al*., 2023).

Table 3. Weight of Marine debris by Type at Station 2

Station 2	Marine debris Weight by Type (kg)				Total Garbage Weight (kg)
	Plastic	Plastic Foam	Rubber	Glass	
Plot 1	0.985	0.590	3.060	-	4.635
Plot 2	1.270	0.580	4.115	-	5.965
Plot 3	0.975	0.385	0.580	-	1.940
Total	**3.230**	**1.555**	**7.755**	**-**	**12.540**

Water Quality

Table 4. Water Quality Measurement Results

No.	Parameters	Station	
		1	2
1	pH	7,2	6
2	DO	6,3	6
3	Temp.	28	27
4	Salinity	5	4

Discussion

Comparison Of Marine debris Weight Per Station

The results showed that the overall macro-sized marine debris types at both stations in the study site consisted of three major groups: plastic, plastic foam, and rubber. Station 2 had a higher total weight of litter than St. 1, with a difference of 2.550 kg (St. 2: 12.540 kg, Station 1: 9.990 kg). The plot with the highest weight of marine debris was Plot 2 at St. 2 (5.965 kg), while at St. 1, Plot 1 had the highest weight of marine debris (5.235 kg).

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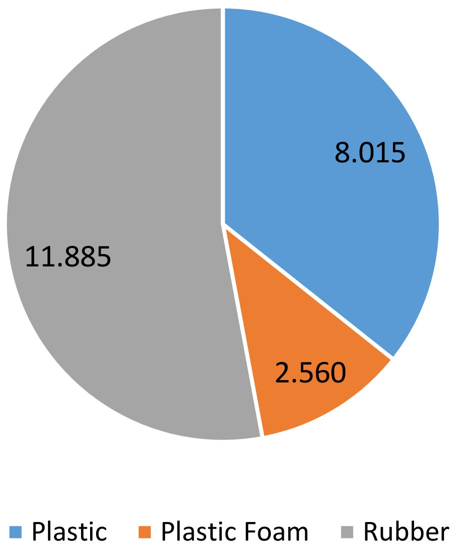

Figure 2. Macro Debris Category Comparison

Impact of Marine Debris on Water Quality in Sangiang Island

The results of pH measurements at 2 stations are 7,2 and 6 (**Figure 3**). Based on Government Regulation of the Republic of Indonesia Number 22 of 2021 in Appendix 8, the pH value at 2 stations is not in the range of pH quality standards of 7-8,5. Variations in the pH value of waters are caused by perimer phytoplankton and the availability of nutrients in marine waters (Megawati *et al*., 2014).

The pH of the water at Station 1 recorded at 7,2 is within the optimal range according to Government Regulation of the Republic of Indonesia Number 22 of 2021 in Appendix 8, which stipulates that the ideal pH of water for various purposes is in the range of 7 to 8,5. This pH value indicates that the water at Station 1 falls into the neutral to slightly alkaline category, which is in accordance with the water quality standards expected by the regulation.

The pH of the water at Station 2 recorded at 6 indicates a more acidic condition compared to the optimal standard set out in Government Regulation of the Republic of Indonesia Number 22 of 2021 in Appendix 8, which states that the ideal water pH is in the range of 7 to 8,5. This lower pH condition indicates the possibility of contamination or changes in water quality that require serious attention, especially related to the presence of marine debris.

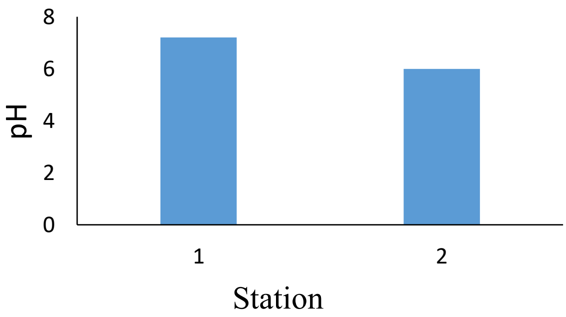

Figure 3. pH Analysis Result

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DO measurement results (**Figure 4**), namely station 1 (6,3 mg/L) and station 2 (6 mg/L). The research results from the measurement of the DO parameter did not vary much, namely the range of 6 – 6,3 mg/l. Based on the Government Regulation of the Republic of Indonesia Number 22 of 2021 in Appendix 8 for the life of marine biota with a DO value of >5 mg/L and marine tourism >5 mg/L, DO at Sangiang Island Beach is still classified as meeting tourism requirements. The presence of trash can potentially affect this quality. The degradation of organic marine debris, for example, can consume dissolved oxygen in the decomposition process, which in turn can reduce future DO levels if not properly managed.

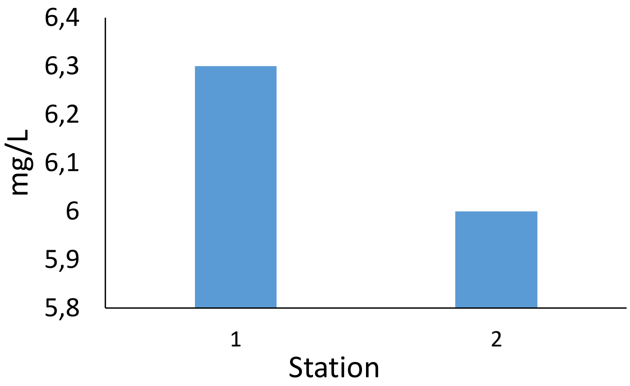

Figure 4. DO Analysis Result

The measurement results obtained from the analysis of each station (**Figure 5**), namely station 1 (28 °C) and station 2 (27 °C). Based on the water quality standards in Government Regulation of the Republic of Indonesia Number 22 of 2021 in Appendix 8, in general, measurements for marine biota are around 28-30 °C. These conditions indicate that the water quality of Sangiang Island can still tolerate the temperature of the beach. This condition shows that the water temperature quality of Sangiang Island beach can still be tolerated by aquatic biota. The results showed that the sea temperature at Sangiang Island Beach was in a relatively good range, namely 28 °C at station 1 and 27 °C at station 2. These figures are in accordance with the temperature range set by the Government Regulation of the Republic of Indonesia Number 22 of 2021 in Appendix 8 which recommends sea water temperatures between 28 to 30°C.

Although the current water temperature at the 2 stations is still within optimal limits, the presence of marine debris can negatively impact the stability of water temperature in the long term. Plastic, rubber and other materials can absorb and store heat, causing micro-temperature variations around the area. In addition, piles of debris in the water can disrupt water circulation and cause localized changes in temperature, which can affect oxygen distribution and the life of marine organisms.

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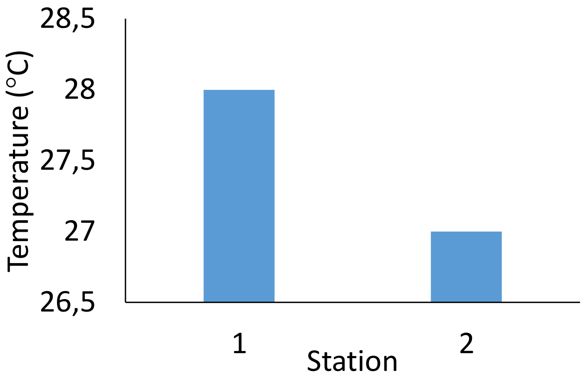

Figure 5. Temperature Analysis Result

The results of the analysis of salinity results (**Figure 6**), namely station 1 (5 ppt) and station 2 (4 ppt). The low salinity at each station is due to the large supply of water entering the Sangiang Island Beach area. The results of water salinity analysis at 2 stations are far below the standards set in Government Regulation of the Republic of Indonesia Number 22 of 2021 in Appendix 8, which recommends a salinity range between 33 to 34 ppt. This low salinity indicates the dilution of seawater, possibly caused by freshwater inflow or other sources that reduce the salt content in these waters.

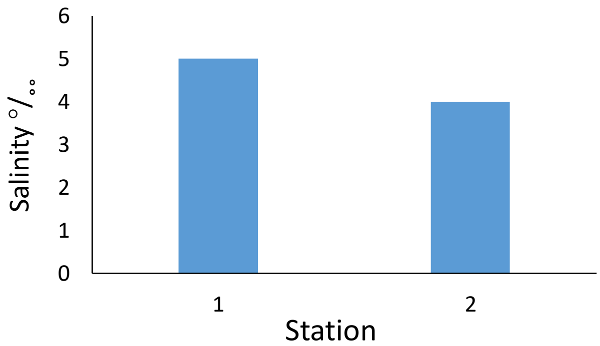

Figure 6. Salinity Analysis Result

Based on measurement and analysis of the water pollution index it can be concluded that Station 1 is in good condition (Table 5), and Station 2 (Table 6) is in light polluted.

Table 5. Water Quality at Station 1

Parameter	Ci	Lij	Lij average	Ci/Lij	Ci new	(Ci/Lij) new
pH	7,2	7-8,5	7,75	0,93		0,93
DO	6,3	>5		1,26	0,40	1,26
Salinity	5	33-34	33,5	0,15		0,15
Temp	28	28-30	29	0,96		0,96
(Ci/Li) Maximum				1,26		
(Ci/Li) Average				0,82		
Pollution Index (IP)				1,12		
Quality standards				0,75		
Water quality status				Light polluted		

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Table 6. Water Quality at Station 2

Parameter	Ci	Lij	Lij average	Ci/Lij	Ci new	(Ci/Lij) new
pH	6	7-8,5	7,75	0,77419	0,5	0,77
DO	6	>5		1,20		1,20
Salinitas	4	33-34	33,5	0,1194		0,12
Suhu	27	28-30	29	0,93103		0,93
(Ci/Li) Maximum				1,20		
(Ci/Li) Average				0,76		
Pollution Index (IP)				1,1		
Quality standards				1,4		
Water quality status				Light polluted		

The composition of anthropogenic marine debris is significantly related to the quality of seawater in the area. Anthropogenic macro-debris, mainly plastics, plastic foam and rubber, not only polluted the beach but also affected water quality parameters such as pH and chemical content. These findings suggest that the higher the concentration of debris on the beach, the worse the measured water quality, indicating a direct impact of the type and amount of debris on seawater pollution.

DISCUSSION

The research findings showed that the anthropogenic macro marine debris in Sangiang Island is dominated by plastic, plastic foam, and rubber. This pattern is consistent with previous studies in Indonesian small islands (e.g., Dodola Island, Morotai) where plastic is a predominant pollutant due to its persistence and widespread use in packaging and daily activities [Idrus et al., 2023]. The dominance of plastic in plot 1 (Station 1) and plot 2 (Station 2) indicates that these locations may serve as main deposition zones due to their geomorphological characteristics and exposure to currents and wind.

Rubber debris, primarily in the form of used footwear (e.g., sandals), was found in significant weight, although in lower quantity. This reflects not only the consumer behavior of visitors and residents but also suggests poor waste management practices either on the island or in nearby land-based sources. The absence of glass in Station 2 may be due to either better collection in that area or different human activity patterns.

The degradation of water quality parameters—such as pH, salinity, and dissolved oxygen (DO)—is closely related to the presence and accumulation of macro-debris. At Station 2, where debris weight is highest, the water pH dropped to 6, falling below the acceptable quality standard of 7.0–8.5 for marine waters [Government Regulation No. 22, 2021]. This decrease may be attributed to the decomposition of organic components within the debris and the release of acidic compounds from rubber and plastic materials [Megawati et al., 2014].

DO levels at both stations remained above the minimum standard (>5 mg/L), but a declining trend from Station 1 (6.3 mg/L) to Station 2 (6.0 mg/L) suggests the potential for oxygen depletion. Organic matter within macro-debris contributes to microbial activity that consumes oxygen, especially in more stagnant or poorly circulated zones. Although the current levels still support marine tourism and biota survival, continuous input of debris could push these systems toward hypoxic conditions.

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Temperature differences between the stations were minimal (28°C vs. 27°C), yet they remain within the optimal range for marine biota. However, as debris continues to accumulate, it can trap heat, reduce circulation, and create microhabitats that differ thermally from surrounding waters, potentially impacting local species' survival and reproduction [Kühn & Van Franeker, 2020].

Salinity in both stations (5 ppt at Station 1 and 4 ppt at Station 2) was significantly below the standard range (33–34 ppt), which raises concern. Such dilution might result from freshwater influx, possibly from rainfall or river runoff, or from physical barriers created by debris altering water exchange with the open sea. Low salinity can affect marine organisms adapted to saline conditions, potentially leading to shifts in species composition.

The presence of high volumes of anthropogenic macro-debris, particularly plastic and rubber, poses threats not only to the physicochemical properties of seawater but also to local marine biodiversity and ecological balance. Sangiang Island, being a designated Natural Tourism Park, is ecologically sensitive and economically valuable. The accumulation of debris threatens coral reefs, turtle nesting grounds, and reduces the aesthetic value critical to eco-tourism [Hidayat, 2022; Lestariningsih et al., 2022].

These findings highlight the urgent need for targeted management interventions such as:

- Community-based coastal cleanup programs,
- Enforcement of waste discharge regulations for passing vessels and visitors,
- Establishment of debris monitoring and early warning systems.

Furthermore, more research is needed to examine the temporal patterns (e.g., seasonal variation in debris inflow) and expand to microplastic assessment, which may provide a more complete understanding of pollution impact at a finer scale.

In Biawak Island, West Java, a study by Purba et al. (2017) reported marine debris weights ranging from 3–26 kg per station, with the highest concentration found in mangrove zones that act as natural debris traps. The dominant materials included ropes, plastics, and styrofoam—similar to what was found in Sangiang. This reinforces the notion that mangrove environments, while ecologically vital, are particularly vulnerable to debris accumulation due to their root structure and position along tidal fronts.

Another comparable study in Karimunjawa and Kemujan Islands revealed a strong inverse correlation between debris density and benthic biota density ($r = –0.939$, $R^2 = 0.881$). The research demonstrated that greater debris mass led to reduced biodiversity, particularly among mollusks and crustaceans inhabiting mangrove sediments.

These findings from various small islands in Indonesia suggest that macro-debris does not only affect physical water parameters but may also lead to broader ecological degradation. Integrating these insights, it is critical to expand monitoring efforts and promote stricter waste management policies, especially in tourism-exposed coastal areas like Sangiang Island.

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4. CONCLUSSIONS

Plastic marine debris dominates in both quantity and volume, while rubber marine debris, which is mainly in the form of sandals (rubber), shows a significant weight but relatively low quantity. The results of the analysis show that the quality of seawater in the coastal area of Sangiang Island has decreased, which is not too significant but affects the water quality on Sangiang Island. Water quality parameters such as temperature, dissolved oxygen content, salinity and pH show a decrease that can be attributed to the accumulation of anthropogenic macro marine debris. Contamination from this debris can cause physical, chemical and biological changes in seawater, such as decreased water clarity, decreased salinity, reduced dissolved oxygen, and changes in pH.

5. REFERENCES

Jambeck, Jenna R., Roland Geyer, Chris Wilcox, Theodore R. Siegler, Miriam Perryman, Anthony Andrady, Ramani Narayan, and Kara Lavender Law. "Plastic waste inputs from land into the ocean." *science* 347, no. 6223: 768-771. 2015. https://doi.org/10.1126/science.1260352

Roman, Lauren, Andrew Warmbrunn, T. J. Lawson, Kathryn Willis, Chris Wilcox, and Britta Denise Hardesty. "Comparing marine anthropogenic debris on inhabited mainland beaches, coastal islands, and uninhabited offshore islands: A case study from Queensland and the Coral Sea, Australia." *Marine Pollution Bulletin* 172: 112919. 2021. https://doi.org/10.1016/j.marpolbul.2021.112919

Iskandar, Mochamad Riza, Dewi Surinati, Muhammad Reza Cordova, and Kian Siong. "Pathways of floating marine debris in Jakarta Bay, Indonesia." *Marine Pollution Bulletin* 169: 112511. 2021. https://doi.org/10.1016/j.marpolbul.2021.112511

Hindayani, P., A. Khosihan, and A. R. Pratama. "Can marine debris pollution cause the loss of tourism revenue in Indonesia? An empirical study." In *Promoting Creative Tourism: Current Issues in Tourism Research*, pp. 289-296. Routledge, 2021.

Hoare, V., N. Atchison Balmond, G. C. Hays, R. Jones, H. Koldewey, J-O. Laloë, E. Levy, F. Llewellyn, H. Morrall, and N. Esteban. "Spatial variation of plastic debris on important turtle nesting beaches of the remote Chagos Archipelago, Indian Ocean." *Marine Pollution Bulletin* 181: 113868. 2022. https://doi.org/10.1016/j.marpolbul.2022.113868

Nama, Suman, Ashna Shanmughan, Binaya Bhusan Nayak, Shashi Bhushan, and Karankumar Ramteke. "Impacts of marine debris on coral reef ecosystem: A review for conservation and ecological monitoring of the coral reef ecosystem." *Marine Pollution Bulletin* 189: 114755. 2023. https://doi.org/10.1016/j.marpolbul.2023.114755

NOAA. "NOAA Marine Debris Monitoring and Assessment Project (MDMAP) Marine Debris Item Categorization Guide". Available in https://marinedebris.noaa.gov/protocol/mdmap-marine-debris-item-categorization-guide. 2021

Lippiatt, S.; Opfer, S. and Arthur, C. "Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment". Silver Spring, MD, NOAA Marine Debris Division, 82pp. (NOAA Technical Memorandum NOS-OR&R-46). 2013. http://dx.doi.org/10.25607/OBP-727

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