Identification of inorganic waste at mangrove ecosystem, Gampong Jawa, Banda Aceh

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Abstract. The plastic pollution entering the ocean has been a global concern. However, the research about the mangrove ecosystem poses the plastic waste in Aceh Province is limited. This study aims to investigate the inorganic waste based on type and its abundance in mangrove area at Gampong Jawa, Banda Aceh. Transect was installed along 6m x 100m at three stations. The total waste collected was 134 items with the most abundance was plastic (126 items). The most common type found at the three stations was plastic bags. Rubber and glass were also observed trapped in Gampong Jawa’s mangrove area. The high level of debris abundance at station 1 was suspected because station 1 has the highest mangrove density so that allows the debris trapped at the mangrove roots. Stations 2 and 3 have less debris abundance because the low density of mangroves.

1. Introduction
Plastic has been used as daily usage products entirely such household, leisure, sports, agriculture, electrical and electronic, automotive, packaging, building and construction, and others. The reason of wide application of plastic is its characteristic as a lightweight, inexpensive, strong, durable, and corrosion-resistant material [1]. Since the commercially manufactured plastic was begun in the 1930s and 1940s [2], the average of plastic production has been increasing 10 million tonnes (MT) annually. The plastic production reached 322 MT, 335 MT, 348 MT and 359 MT in 2015, 2016, 2017 and 2018, respectively [3-5].

The management of plastic waste is considered as a global concern. The accumulation of marine debris in the ocean related to population density of coastal community and their activities, other marine activities such as aquaculture, shipping, and fishing, and waste management [6, 7]. The mismanaged plastic waste is triggering land-based plastic entering the ocean. According to mismanaged plastic waste estimation by Jambeck et al. [2], about 10.1% of Indonesian plastic waste was not managed well. Those mismanaged land-based plastic waste is entering the ocean by beaching, coastal front, river run-off, and intertidal tides [8]. The horizontal movement of plastic waste was affected by its density and wind force while the vertical direction was transported by Ekman Transport factor [7, 8]. The calculation of plastic waste entering the ocean by river run-off is 1.15-2.41% [9].
In Indonesia, the study of plastic pollution in ocean and its transportation have not numerously published yet except in Java Island [6]. The source of land-based waste release into ocean from nine rivers in The Greater Jakarta is plastic [10]. Other studies of floating marine pollutant in Aceh Province indicate that plastic has the higher percentage than other pollutant, flowing on the river stream toward ocean [11, 12].

In the coastal intertidal zone, mangrove area is perfect traps for marine pollutant because of its unique roots system [13]. The existence of pollutant, such as plastic, affected the mangrove roots and seedling. The waste trapped in mangrove area has killed the roots and reduce the density of mangrove seedling [14, 15]. One of mangrove ecosystem area in Aceh Province is located in Gampong Jawa Village. It is a rehabilitation mangrove area after a huge tsunami wave hit Aceh Province in 2004 and destroyed the mangrove ecosystem along the coastline. Furthermore, there is no study about the marine pollutant in this area reported. Therefore, this study was conducted to identify inorganic waste based on type and abundance observed in the mangrove area of Gampong Jawa, Banda Aceh.

2. Material and Methods

2.1. Time and location
This study has been carried out in May 2019 at the mangrove forest area of Gampong Jawa, Banda Aceh, Aceh Province, Indonesia. The samples were collected from three stations as shown in Figure 1. Each station was considered because of its distance from the beach and river stream to predict the direction of inorganic waste.

2.2. Procedures
The method used in this study followed the visual technique by installing 6m x 100m transect at 3 stations of sampling area as shown in Figure [16]. The collected samples were put into trash bags then separated based on the type and abundance. The supplied form data was used to categorize the observed data into plastic, metal, glass, rubber, and clothing/fiber [17]. The abundance of waste found was calculated by following formula: \( C = \frac{n}{wl} \), where \( C \) = abundance of waste (item/m²); \( n \) = number of collected waste (item); \( w \) = width of transect (m); \( l \) = length of transect (m). Since this study was the first work about inorganic waste entering ocean through the mangrove area, the effect of tide was not included in this study.

In order to obtain a description of relationship between trapped waste numbers and the mangrove area, the data of mangrove density and type of mangrove roots were also observed. A transect of 10m x 10m was put at each station to figure out the density of mangrove trees. The calculation was done by
using the formula below: $D = \frac{n}{A}$, where $D$ is the mangrove density (individu/m$^2$); $n$ is the number of mangrove trees; $A$ is the area of transect (m$^2$).

3. Result and Discussion

3.1. Type of Inorganic waste

The categories of inorganic waste found at the three research stations are plastic, rubber, glass, and others. Plastics were observed as the most abundance waste in Gampong Jawa’s mangrove ecosystem. Its number is rocketing than other categories. The number of plastic waste collected at the sampling area is 126 items while the least abundance is 2 items for glass and other categories (Figure 1). Unlike other categories, the plastics waste was occurred at all stations noted 118 items, 6 items, and 2 items for station 1, station 2, and station 3, respectively. In addition, the variety of waste form was also identified from plastic type. It was identified plastic bags, food packaging, cups, caps or lids, straws, fishing line, toiletries, bottle, and cigarette lighter (Table 1). The most abundance and various form of plastic category encouraged that plastic has been widely used in daily life but not managed well [2, 18, 19]. The buoyancy plastic is easily moved by river stream from land entering the ocean [8–10, 20]. The least various forms of inorganic waste trapped in mangrove ecosystem of Gampong Jawa are rubber and glass.

![Figure 2. The Inorganic waste abundance at Gampong Jawa’s mangrove ecosystem](image)

At all stations, station 1 had the highest number of the total collected inorganic waste. It was counted 124 items inorganic waste presented at station 1. Station 2 had 8 items of inorganic waste and 2 items was taken at station 3. The station 1 location is close to the community settlement. The fishing activities also located there. The community and fishing activities can result in the accumulation of anthropogenic waste, such as plastic. It has been reported that river and beach are had greater accumulation of inorganic waste [21]. The less density of inorganic waste in station 2 and station 3 suggested that those waste was trapped and preserved at station 1 because of the unique of mangrove roots system.

3.2. Relationship waste abundance and mangrove density

The density of mangrove trees at Gampong Jawa’s mangrove ecosystem was investigated to figure out the existence of inorganic waste in different mangrove density sites. According to the Figure 3, mangrove trees at station 1 are growing well and denser than other station. The mangrove density at station 1 was 0.14 ind/m$^2$. It was slight different with the density at station 3 which was 0.09 ind/m$^2$. The least mangrove trees grew at the rehabilitation mangrove ecosystem of Gampong Jawa was station 2. There is no mangrove trees were observed in this station but mangrove seeds. The mangrove species found at station 1 and 3 were *Avicennia alba*, *Rhizopora apiculata*, and *Rhizopora mucronata*. The
highest abundance of inorganic waste at station 1 (0.197 item/m²) was observed as well as the highest density of mangrove trees. It has been reported that mangrove ecosystem is a perfect trap for inorganic waste [13]. Besides, the area that has been grown by *Avicennia alba* and *Rhizopora mucronata* will accumulate the land-based inorganic waste [22].

**Table 1.** The numbers of inorganic waste form

| Type         | Form                               | Station 1 | Station 2 | Station 3 |
|--------------|------------------------------------|-----------|-----------|-----------|
| Plastic      | Plastic bag                        | 24        | 6         | 2         |
|              | Plastic sack                       | 5         |           |           |
|              | Food packaging                     | 15        |           |           |
|              | Cups                               | 14        |           |           |
|              | Bottle caps                        | 3         |           |           |
|              | Straws                             | 6         |           |           |
|              | Ropes                              | 7         |           |           |
|              | Tooth brush                        | 2         |           |           |
|              | Plastic bottle                     | 1         |           |           |
|              | Cigarette lighter                  | 1         |           |           |
|              | Foamed plastic (styrofoam)         | 34        |           |           |
| Rubber       | Footwear                           | 2         | 2         |           |
| Glass        | Glass bottle                       | 2         |           |           |
| Others       | Nappies                            | 2         |           |           |

**Figure 3.** (a) The mangrove density, and (b) The total inorganic waste abundance in Gampong Jawa’s mangrove ecosystem.

**4. Conclusion**

Plastic category was observed as the most abundance inorganic waste at Gampong Jawa’s mangrove ecosystem. Station 1 as the closest station to the community settlement accumulated much more inorganic waste than other stations. The number of inorganic waste concentrated at station 1 was 124 items. It suggested that the source of inorganic waste was land-based waste or anthropogenic waste. Therefore, the higher density of mangrove trees at station 1 has been a perfect trap for accumulating the inorganic waste. The number of plastic waste collected at the location was 126 items (94%) which consists of various forms. The form of plastic waste picked at the area were plastic bags, food packaging, cups, caps or lids, straws, fishing line, toiletries, bottle, and cigarette lighter.
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