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# Biofouling colonization on cubic artificial reefs in Pantai Damas, Trenggalek, Indonesia

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**ABSTRACT**

Biofouling or biological fouling is the term used for colonization of hard surfaces from substrate include artificial by living organisms in the column of water. The mechanism of biofouling succession on a substrate starts biochemical condition, bacteria colonization, unicellular algae colonization, and attach of invertebrate larvae or propagule. Poor live coral coverage due to natural and anthropogenic influence becomes the main reason to deploy concrete cubic artificial reef in Pantai Damas area. Two years later the monitoring project was conducted to examine fouling assemblages in artificial reefs. The result showed ten macrofouling organisms' life from these waters are recorded in which barnacle is one of the successful species colonized at the artificial reef surface. The dominance of barnacle occupying of artificial reef suggested a strong correlation between substratum properties such as surface roughness, wide surface area, type of substratum, and organic composition.

***Key words :*** *Pantai Damas, Community structure, Biofouling, Competition, Macro fouling*

## Introduction

In the first-time artificial reefs (ARs) used for increasing fisheries production but now the function has been enlarged to manage erosion in the coastal area, protect marine habitat, rehabilitee hard coral, and study on ecology (Baine, 2001; Ito, 2011). Two types of ARs unplanned and designed structure, both common use for experiment community development in the nature condition (Perkol-Finkel and Benayahu, 2005). The second type of ARs usually creating carefully to create planned habitat and meet integrating work between engineer and ecologist. Besides, built planned ARs should meet 3 principles, safety, usefulness (Seaman and Jensen, 2000). Nowadays, planned artificial reefs for rehabilitation, conservation, and restoration of coral reef increased over the year. For instance, ARs use to rehabilitee nude reef flat area in Maldives (Clark and Edwards, 1994), increasing life coral cover in Mafia Island, Tanzania (Lindahl, 2003), and enrich sandy bottom of coral reef in northern Gulf of Eilat (Oren and Benayahu, 1997).

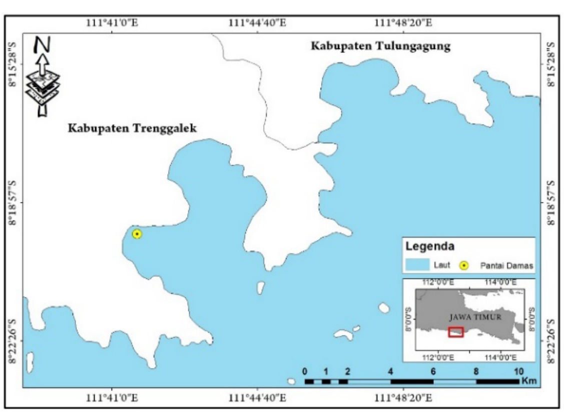
The similar purpose for protecting coastal from abrasion and enhance coral reef growth, in 2017 local community supported by scientist deployed 25 cubic concrete ARs in Pantai Damas water. This location situated only 7 km from Nusantara fisheries port which the largest fisheries port in this area. Pantai Damas has two tropical ecosystems i.e mangrove and coral reef. Recently coral reef in this area in poor condition, natural and anthropogenic disturbances are suggested to become the main cause of this damage. Unconsolidated substrate and high suspended sediment in the water in this area can be secured using ARs. The artificial structure attracts much biofouling created interspecific competition between them.

The colonization of ARs by micro and macro fouler has been studied well and resulting in the many theories on the succession of the biofouling community. The recent theory stated that primary fouling community succession divided into four stages, micro fouling, the stage of fast- and slow-growing macrofoulers, and the climax (Railkin, 2003). Microfouling organisms generally consist of bacteria and fungi (biofilms) and diatoms (periphyton). While macrofouling generally comes from algae and invertebrate larvae. Periphyton is a microorganism that lives attached to a substrate that is submerged in water (Nurfadillah *et al*., 2019). This study aimed to examine the type of macro fouling and its density in the surface of ARs after deployed in 2017.

## Material and Methods

### Study site

The study was carried out in Pantai Damas were still part of Prigi Bay, Trenggalek regency (Fig. 1). The survey was conducted in March 2020. The research station was determined by the presence of artificial coral reefs located in the cross-zone of Pantai Damas, Trenggalek (Fig. 2).




**Abbr**. **Pulau Jawa**: *Jawa Island;* **Pantai Damas**: *Damas beach;* **Teluk Prigi**: *Prigi bay.*

**Fig. 1.** The research location is indicated by a yellow point in Damas coastal waters.

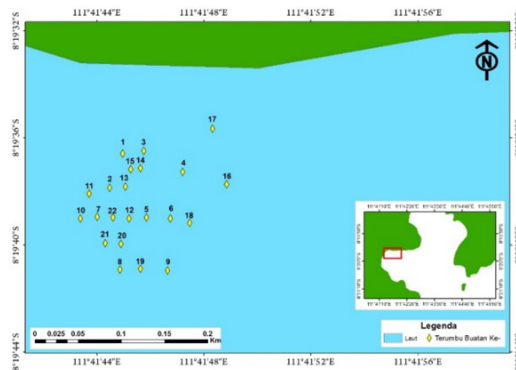



**Fig. 2.** The research station is marked with a yellow rectangular shape and numbered in Pantai Damas.

### Assessment Macrofouling Assemblages

Macrofouling data collection technique is carried out on artificial reefs that are cube-shaped and have 6 sides, but the observation process can only be done by observing 5 sides because 1 side attaches to the substrate (Fig. 3). Each side consists of an outer surface and an inner column. Biofouling data is obtained by visual observation by diver and image capture using an underwater camera Olympus TG-6. Observations are only focused on macro-organisms that can be seen with the naked eye.

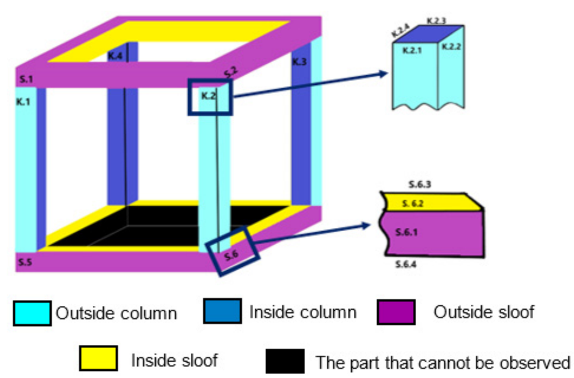



**Fig. 3.** Schematic illustrations artificial reefs (cubic ARs) and its section that deployed in Pantai Damas waters.

Every organism that is attached and can be seen with visible eyes that are alive or dead will be recorded and photographed. Taking photos must use macro mode to produce a clear enough photo. After being photographed and recorded the organisms will be verified (Lindberg and Seaman, 2011).

### Morphology Identification

There are the most common types of biofouling in marine i.e. anthozoa, hydroids, tunicate, algae, mollusks, decapods, crustaceans, and bryozoa. These organisms are very common to be found in various findings around the world (Sahu *et al.*, 2011). The types of biofouling can be seen in Fig. 4.


**Fig. 4.** Types of Biofouling; (A) algae fouling: green algae, brown algae and red algae; (B) animal fouling: barnacle, tubeworm, spirorbis, encrusting bryzoans, bryzoans, hydroids, sponges, ascidians, and tunicates (Bressy and Lejars, 2014).

### Data Analysis

The number and composition of macrofouling organisms are calculated as the number of individuals divided by the total number of individuals multiplied by 100%. The density of macrofouling of organisms can be calculated by the number of colonies divided by the surface area ($m^2$) while for the index of the diversity of macrofouling organisms using the Shannon-wiener diversity index formula.

## Results and Discussion

### Macrofouling organisms

A total of 8 types macro fouling was found during observation in 22 artificial reef media such as tubeworm, barnacle, hermit crab, bryozoan, green algae, tunicate, hydroid, brown algae, sponge, and red algae. The distribution of the number of organisms obtained on artificial reef media is presented in Fig. 6.

Figure 6 showed the highest number of organisms was barnacle with 6114 individuals and the lowest is the tubeworm with the number of 10 individuals from all ARs. Barnacle's larvae are positive phototaxis and can find a new substrate for them to grow. Barnacle uses the antenna to receive chemical cues from biofilm in a substrate and guide them to

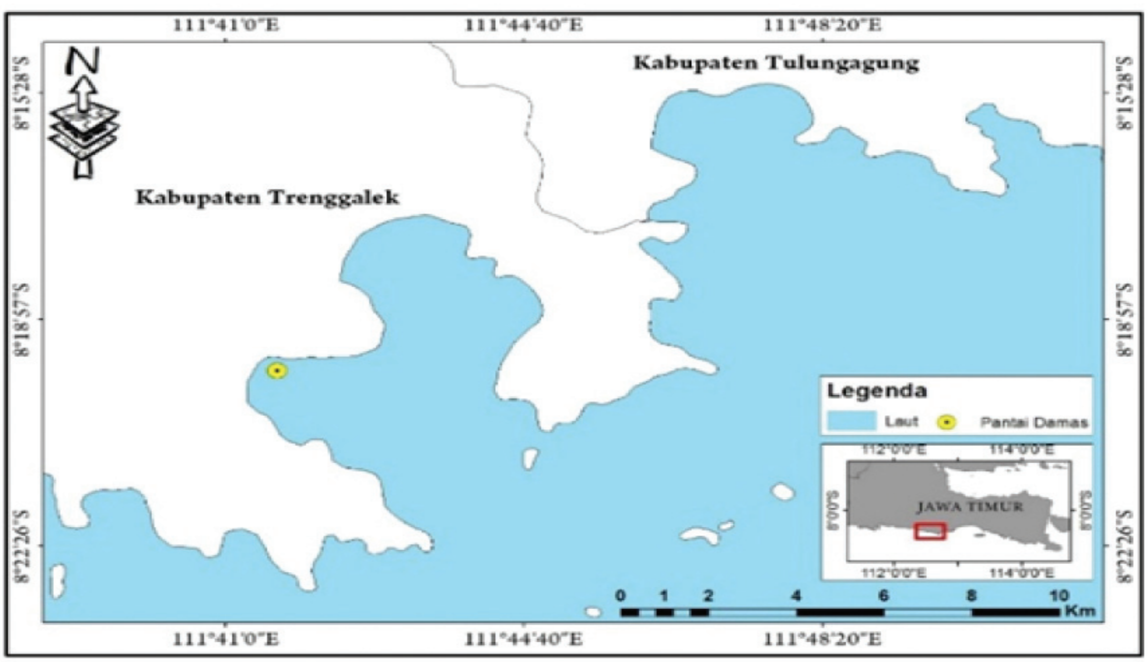



**Fig. 5.** Macrofouling varieties have been identified during this study. A: Tubeworm; B: Barnacle; C: Hermit crab; D: Bryzoan; E: Green algae; F: Ascidians; G: Hydroids; H: Brown algae; I: Sponge; and J: Red algae.

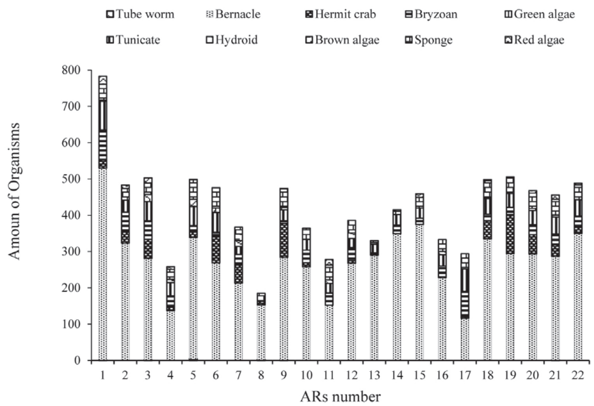



**Fig. 6.** Structure of macrofouling organisms in all ARs at Pantai Damas

emerge on the substrate (Rajitha *et al.*, 2020). Invertebrates such as shellfish and barnacles have a strong adhesive and are not easily dissolved in various types of substrates. The organisms can excrete chemicals such as protein. Barnacle releases mucus fluid during attachment so that it gains habitat. Barnacles and shells contain 99% protein, making it resistant to enzymatic and chemical degradation at water temperatures (Khandeparker and Anil, 2007).

Tube worms were found on artificial reefs number 1,3, 5, 8, 9, and 21. Tube worms were found to have a round shape with thick feathers on the arms. The most common tube worm found in the genus Sabellastarte. The pH value is very influential for the life of the tubeworm to survive and tubeworm larvae can live at a pH of 7.9 but cannot live with a pH below 7.7 (Lane *et al.*, 2013). Tube worm functions as a bioindicator of marine pollution because it has a responsive nature to the enrichment of organic matter (Mucha *et al.*, 2003). The life cycle of a tubeworm is affected by temperature and salinity. Optimal salinity that is suitable for tubeworms ranging from 10 – 30 $^{o}/_{oo}$ and the right temperature for reproduction must exceed 10 - 18 $^{o}$C, but can still be tolerated (Dittmann *et al.*, 2009).

**Composition of macrofouling organisms**

The results of the identification of organisms on artificial reefs were found, namely, ten organisms attached to 8 sides of artificial reefs on the surface of columns and sloof. Organisms found among them are tubeworm, barnacle, hermit crab, bryozoan, green algae, tunicate, hydroid, brown algae, sponge, and red algae. The number of organisms found and the average organisms' artificial reef can be seen in Table 1.

The average number of organisms per artificial reef that has been found on artificial reef media can be seen in Fig. 7.

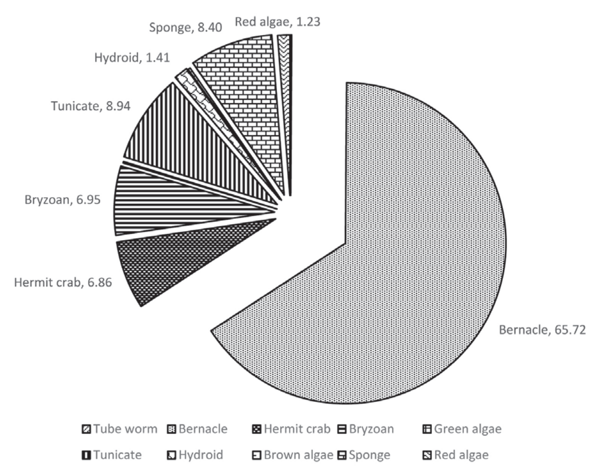



**Fig. 7.** Percentage of organism composition on artificial reefs

**Table 1.** Organisms found on artificial reefs

| No | Phylum | Class | General name | Total | Average (%) |
|---|---|---|---|---|---|
| 1 | Annelida | Polychaeta | Tube worm | 10 | 0.11 |
| 2 | Arthropoda | Cirripedia | Barnacle | 6114 | 65.78 |
| 3 | Arthropoda | Malacostraca | Hermit crab | 638 | 6.86 |
| 4 | Bryzoa | Gymnolaemata | Bryzoa | 647 | 6.96 |
| 5 | Chlorophyta | Chlorophyceae | Green algae | 13 | 0.14 |
| 6 | Chordata | Ascidiacea | Tunicate | 824 | 8.87 |
| 7 | Cnidaria | Hydrozoa | Hydroid | 131 | 1.41 |
| 8 | Phaeophyta | Phaeophyceae | Brwon algae | 22 | 0.24 |
| 9 | Porifera | Demospongiae | Sponge | 781 | 8.40 |
| 10 | Rhodophyta | Rhodophyceae | Red algae | 114 | 1.23 |
| | **Total** | | | **9293** | **100** |

Based on the diagram on the composition of the organisms above Figure 7, it can be seen that the most dominant organisms is barnacle with a percentage of 66.00% and some organisms has a percentage of organisms <1%. Organisms composition that can be found on artificial reefs made from concrete is derived from the phylum Annelida, Arthropoda, Bryozoa, Chlorophyta, Chordata, Cnidaria, Phaeophyta, Porifera and Rhodophyta (Lacoste *et al.*, 2014). Barnacle or barnacle has a large number because of its very wide distribution and can be found in tidal areas, open beaches, and open seas (Pérez-Losada *et al.*, 2008). Barnacle can also store additional water if there has been a significant change in temperature, additional water will be stored in the cavity of the barnacle coat. Barnacle uses its shell to maintain body temperature and so as not to lose water (Wally, 2016).

### Density of macrofouling organisms

The density of macrofouling organisms can be seen in the results graph from the calculation of the average density of each organism that has been found on an artificial reef. The density of organisms has been presented in Fig. 8.

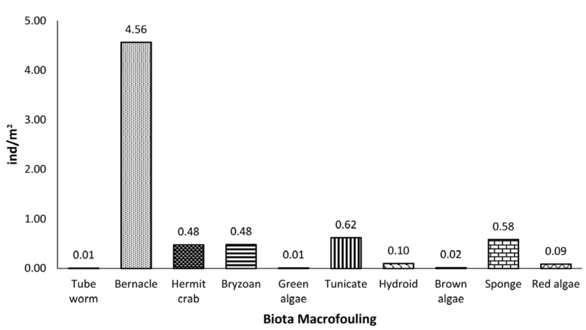



**Fig. 8.** The density of Macro fouling organisms

Based on the organisms density graph Fig. 8, it can be seen that 3 organisms that have the highest value are barnacle 4.77, tunicate 0.65 and sponge 0.61 individual/ m², then organisms which have the lowest value, namely tubeworm and green algae of 0.01 individual/ m². The density of organisms is strongly influenced by the current speed and brightness, the higher the current speed and brightness, the effect is to attach organisms to a substrate (Wellnitz *et al.*, 2019). Intertidal area characteristics such as substrate type, area, and coastal morphology will be a factor for organisms density (Mestdagh *et al.*, 2020).

Barnacle is a type of organisms that lives permanently attached. One type of barnacle has an arthropodine compound which functions to invite barnacles of the same type to stick to even accumulate on the same substrate (Coombes *et al.*, 2017). Rubble and hard substrate will be the location of attachment of aquatic organisms such as sponge and ascidian (Tuhumena *et al.*, 2013). The density of the sponge is increasingly diverse when the water conditions are far from the mainland (Ward-Paige *et al.*, 2005). The density of the sponge will be hampered if local waters have high sedimentation so that it inhibits the development of the sponge (Carbalo, 2006). Ascidian is a basic organism that can be firmly attached to the substrate at the bottom of the water. The diversity of ascidians in a place depends on the availability of temperature, salinity, and hard substrate (Primo and Vázquez, 2009).

### Macrofouling organism diversity index

Organisms diversity index is the diversity of varieties in the attached organisms that is in a form of community, where the value of diversity is related to a little or a large number of varieties found in the community or artificial reef. Macrofouling organisms diversity index can be seen in Fig. 9.

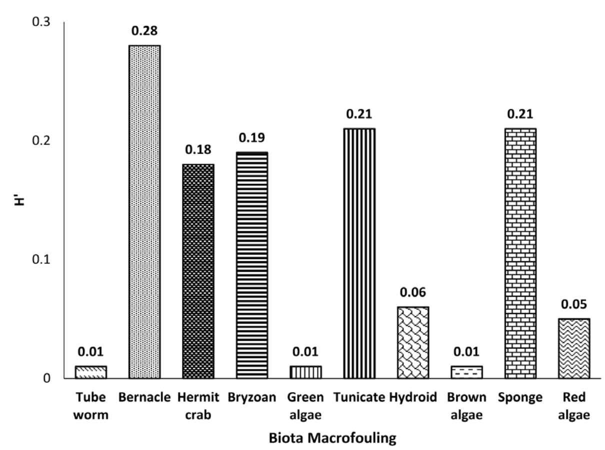



**Fig. 9.** Diversity index of macrofouling organisms

Diversity index (H ‘) is a number that does not have units in the range 0 - 3. The level of diversity is high if the value of H′ is close to 3, it can be said that the waters are in good condition. Conversely, if the value of H ‘close to 0, the level of biodiversity of the organisms is low and water conditions are not good (Insafitri, 2010). Organisms diversity index in Pantai Damas is classified as low due to the total diversity of organisms amounting to 0.79. That is because the value of H ' <2.0. Diversity is synonymous with stability in an ecosystem, if the ecosystem is relatively high then the conditions in that ecosystem can be said to be stable. Then diversity tends to be categorized as moderate if the ecosystem environment is disturbed and the environment is polluted, the diversity of organisms species tends to be low (Nento *et al*., 2013).

## Conclusion

Overall, in this study, we found ten variations found, including the tubeworm, barnacle, hermit crab, bryozoa, green algae, tunicate, hydroid, brown algae, sponge, and red algae. The highest number, composition, density, and diversity are barnacle macrofouling organisms and the lowest is tubeworms.

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