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# ANALYSIS OF SEDIMENT TEXTURE AND ORGANIC CARBON CONTENT ON MACROZOOBENTHOS ABUNDANCE IN THE MANGROVE AREA OF KARANGTALUN NORTH CILACAP

## Analisis Tekstur Sedimen dan Kandungan Karbon Organik Terhadap Kelimpahan Makrozoobentos di Kawasan Mangrove Karangtalun Cilacap Utara

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**ABSTRACT**

Mangrove forests have an important role in reducing the impact of global warming as a place to absorb carbon dioxide ($CO_2$) from the atmosphere which is mostly stored in sediment. Mangroves are a good habitat for aquatic biota such as macrozoobenthos. Macrozoobenthos are organisms that inhabit the bottom of sea waters and also exist in stable sediments. The aim of this research is to determine sediment texture, sediment organic carbon content, macrozoobenthos abundance and the relationship between sediment type and macrozoobenthos abundance. The method used in sampling was purposive sampling with a total of 3 stations. Sediment samples were taken using a core sampler at depths of 0-10 cm, 10-20 cm and 20-30 cm, while macrozoobenthos samples were taken using the hand sorting method. Organic carbon content was analyzed using the Loss on Ignition (LOI) method. The research results showed that the macrozoobenthos community structure at all stations produced low diversity and dominance indices and high uniformity indices. The type of sediment texture in the research area shows an average value of the sediment fraction of 4.43% sand, 71.11% dust and 24.45% clay. The highest organic carbon content was found at stations near brackish water areas with an average of 12.06%, while stations near factory areas had the lowest content at 5.89%. There is a strong relationship between the type of sediment texture and the abundance of macrozoobenthos in the Karangtalun mangrove area, North Cilacap.

Keywords: Abundance, Macrozoobenthos, Organic Carbon, Sediment Texture

**ABSTRAK**

Hutan mangrove mempunyai peran penting dalam mengurangin dampak pemanasan global sebagai tempat penyerapan karbondioksida ($CO_2$) dari atmosfer yang banyak tersimpan di sedimen. Mangrove menjadi habitat yang baik bagi biota perairan seperti makrozoobentos.

Makrozoobentos adalah organisme yang mendiami dasar perairan laut dan juga berada di dalam sedimen yang stabil. Tujuan dari penelitian ini yaitu untuk mengetahui tekstur sedimen, kandungan karbon organik sedimen, kelimpahan makrozoobentos dan hubungan tipe sedimen terhadap kelimpahan makrozoobentos. Metode yang digunakan dalam pengambilan sampel yaitu menggunakan *purposive sampling* dengan total 3 stasiun. Pengambilan sampel sedimen menggunakan *core sampler* pada kedalaman 0-10 cm, 10-20 cm, dan 20-30 cm, sedangkan pengambilan sampel makrozoobentos menggunakan metode *hand sorting*. Kandungan karbon organik dianalisis menggunakan metode *Loss on Ignition* (LOI). Hasil penelitian diperoleh struktur komunitas makrozoobenthos pada semua stasiun menghasilkan indeks keanekaragaman dan dominansi rendah serta indeks keseragaman tinggi. Tipe tekstur sedimen di kawasan penelitian menunjukkan nilai rata rata fraksi sedimen pasir 4,43%, debu 71,11%dan liat 24,45%. Kandungan karbon organik tertinggi ditemukan di stasiun dekat kawasan perairan payau dengan rata-rata 12,06%, sementara stasiun dekat kawasan pabrik memiliki kandungan terendah sebesar 5,89%. Terdapat hubungan yang kuat antara tipe tekstur sedimen dengan kelimpahan makrozoobentos di Kawasan mangrove Karangtalun, Cilacap Utara.

Kata Kunci: Kelimpahan, Makrozoobentos, Karbon Organik, Tekstur Sedimen

## INTRODUCTION

Indonesia has the largest mangrove ecosystem in the world, with an area of around 3,489,140.68 hectares spread along 95,181 km of coastline. Mangrove forests, also known as mangrove forests, grow on the coast and have unique characteristics and high biodiversity potential. Mangroves play an important role both ecologically and economically. Ecologically, mangroves function as coastal protection from wind, waves, storms, and as mud retainers. Economically, mangroves are used for various needs, such as firewood, building materials, medicines, paper, bark, charcoal, and food and beverage ingredients from their fruit (Khoiriah, 2020).

The Mangrove Forest in Karangtalun, known as the Payau Mangrove Forest, has been managed since 1978 and is now a 10-hectare city forest. Its location is directly adjacent to the residents' rice fields which are only separated by embankments (Hastuti et al., 2023). The Cilacap Mangrove Brackish Forest Ecosystem is a habitat for various mangrove biota, such as mudskippers, Uca crabs, pistol shrimp, birds, and various types of macrobenthos (Effendi, 2017). Macrobenthos are organisms that live on the bottom of the waters, which can be divided into two groups based on their position: infauna, which live in the sediment by digging holes, and epifauna, which live attached to or crawling on the surface of the sediment (Desmawati et al., 2020).

Sediment is one of the main ecological factors that influences the structure of the macrobenthos community. The abundance of macrobenthos is closely related to the type of substrate, where the size of the substrate particles is the main factor that influences the adaptation and distribution of these organisms (Susiana, 2011). This study aims to identify the type of sediment texture, the abundance of macrobenthos, and the relationship between sediment texture and the abundance of macrobenthos in the Karangtalun mangrove area, Cilacap.

## METHODS

### Time and Place

The study was conducted in December 2023 in the Karangtalun mangrove area, Cilacap. There are 3 stations as data sources shown in Figure 1.

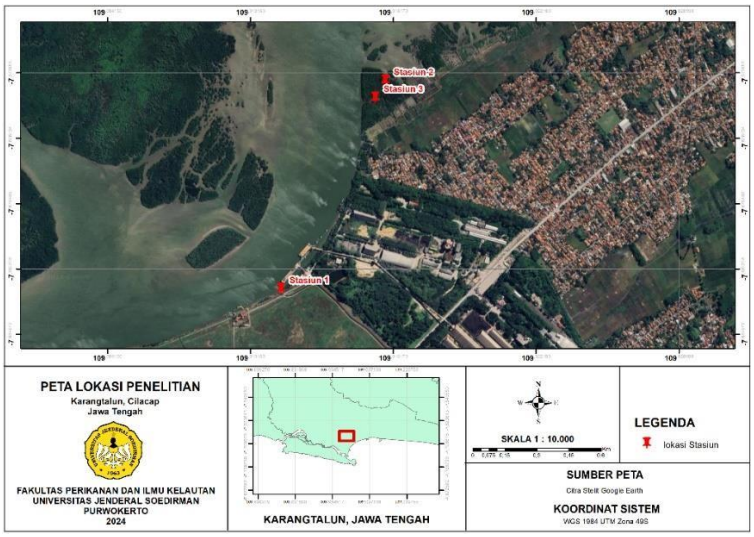


Figure 1. Research Location Map

**Tools and Materials**

The tools used during the research in the field are; ziplock plastic, core sampler, label paper, WQC (Water Quality Checker), stationery, camera, 1m x 1m transect, hand refractometer, cool box, laptop. The materials used in the research are macrozoobenthos samples, sediment samples and alcohol.

**Research Procedures**

The research stages consist of determining the data collection station, sediment sampling carried out using a 50 cm core sampler at a depth of approximately 10 cm at each station. The sediment samples taken are located on the edge near the estuary of the mangrove area. Sediment sampling of 1 kg with 1 repetition at each station. Furthermore, macrozoobenthos sampling is done by hand which will then be washed clean using water to clean the attached substrate.

**Data Analysis**

A. Sediment texture analysis

According to Buchanan (1971), the obtained basic substrate samples were analyzed for soil texture using the sieving, pipetting, and texture separation methods into three main fractions: sand, silt, and clay. The weight percentage of each sediment fraction was calculated by applying the equation:

$$\text{Weight Percentage} = \frac{\text{weight of fraction i}}{\text{weight of total fraction}} \text{ atau } \frac{berat\ fraksi\ i}{} \times 100\%$$

B. Macrozoobenthos

1) Abundance of Macrozoobenthos

The abundance of macrozoobenthos is calculated based on the number of individuals per unit area (ind/m²) using the Shannon-Wiener formula as explained by Odum (1993), namely:

$$K = \frac{Xi}{Ni}$$

Description:

K : Species abundance index (individual/$m^2$)

Xi : Number of filtered macrozoobenthos (ind) Ni : Area of species plot ($m^2$)

2) Diversity Index

The diversity index is calculated using the Shannon-Wiener formula, as explained by Odum (1993), namely:

$$H' = -\sum_{i=1}^{s}(\text{pi}) \ln (\text{pi})$$

Description:
H : Species diversity index
Pi : ni/N (proportion of species i)
Ni : Number of individuals of species i
N : Total number of individuals

3) Evenness Index

The evenness index is calculated using the Evenness Index formula as explained by Odum (1993), namely:

$$E = \frac{\text{H}'}{\ln S}$$

Description:
E : Species uniformity index
H' : Species diversity index
S : Number of organism species

4) Dominance Index

The dominance index is calculated using the Dominance of Simpson formula, as explained by Odum (1993), namely:

$$C = \sum_{i=1}^{n}\left[\frac{ni}{N}\right]^2$$

Description:
C : Dominance index
Ni : Number of individuals of each type
N : Total number of individuals

C. Relationship between Sediment Texture and Macrobenthos Abundance

The analysis of the relationship between sediment type and macrobenthos abundance was carried out through linear regression. Based on Chusna et al. (2017), linear regression involves two variables, namely the percentage of dominant substrate types (Y) and macrobenthos abundance (X). This analysis aims to measure the extent to which variable Y affects variable X. The linear equation used in this analysis has the following form:

Y = a + bX

Description:
Y = dependent variable
X = independent variable
a = intercept
b = regression coefficient

D. Calculation of Sediment Organic Carbon

Calculation of dry ash content (loss on ignition) is done using equation (1):

%BO = ((Wo-Wt)/(Wo x 100)) ..... (1)

Description:
%BO = Percentage of organic sediment material lost in the combustion process
Wo = Dry weight before combustion (grams)
Wt = Final weight after combustion (grams)

Conversion of the percentage of organic material to the percentage of carbon is done using equation (2):

%C = (0,580) x %BO… ..... (2)

Description:
%C = Carbon content of organic sediment material
%BO = Percentage of organic sediment material (ashing)
0.580 = Constant to convert % organic material to % organic C

## RESULT

### Sediment Texture in the Karangtalun Mangrove Area

Based on the analysis of sediment fractions carried out in laboratory tests, the sediment texture type at each station has a percentage value of sand, dust and clay content which can be seen in Table 1.

Table 1. Results of Sediment Texture Analysis in the Mangrove Area

| Station | Sediment Fraction | | | Texture Type |
|---|---|---|---|---|
| | Sand (%) | Dust (%) | Clay (%) | |
| I | 3.86 | 68.70 | 27.44 | Dusty Clay Loam |
| II | 3.58 | 72.87 | 23.55 | Dusty Clay |
| III | 2.86 | 71.77 | 25.37 | Dusty Clay |
| Average | 3.43 | 71.11 | 25.45 | |

### Macrozoobenthos

Based on the calculation of the abundance of macrozoobenthos, the abundance of individuals and relative abundance in each genus can be seen in Table 2.

Table 2. Abundance of Individuals and Relative Abundance of Macrozoobenthos

| Genus | Number of Individuals | Station 1 | | Station 2 | | Station 3 | |
|---|---|---|---|---|---|---|---|
| | | KI (ind/m$^2$) | KR (%) | KI (ind/m$^2$) | KR (%) | KI (ind/m$^2$) | KR (%) |
| *Chicoreus* | 3 | 3 | 4.22 | - | - | - | - |
| *Cerithidea* | 47 | 20 | 28.16 | 11 | 15.44 | 16 | 22.53 |
| *Tubuca* | 5 | 5 | 7.04 | - | - | - | - |
| *Littoraria* | 5 | - | - | 2 | 2.81 | 3 | 4.22 |
| *Nerita* | 8 | - | - | 8 | 11.26 | - | - |
| *Semiricinula* | 3 | - | - | - | - | 3 | 4.22 |
| **Total** | 71 | 28 | 36 | 21 | 29 | 22 | 30 |

Note: KI: Individual Abundance; KR: Relative Abundance; (-): None

Table 3. Structure of Macrozoobenthos Community in Mangrove Ecosystem

| Community Structure | | | | | | |
|---|---|---|---|---|---|---|
| Station | H’ | Category | E | Category | D | Category |
| 1 | 0.907 | Low | 0.654 | Medium | 0.538 | Low |
| 2 | 0.930 | Low | 0.846 | High | 0.428 | Low |
| 3 | 0.774 | Low | 0.705 | High | 0.566 | Low |

Note: H’: Diversity; E: Uniformity; D: Dominance

### Organic Carbon Content of Sediment in the Karangtalun Mangrove Area, North Cilacap

Based on the results of the analysis and calculation of the organic carbon content in the sediment, the values obtained can be seen in Table 4.

Table 4. Results of Analysis of Organic Carbon Content of Sediment in the Karangtalun Mangrove Forest Area, North Cilacap

| Depth | Station 1 | Station 2 | Station 3 | Average |
|---|---|---|---|---|
| 0-10 cm | 6.12% | 11.56% | 13.06% | 10.24% |
| 10-20 cm | 5.82% | 11.49% | 12.06% | 9.79% |
| 20-30 cm | 5.74% | 10.44% | 11.07% | 9.08% |
| Average | 5.89% | 11.16% | 12.06% | |

**Water Quality of Karangtalun Mangrove Area**

Measurements of water quality parameters carried out in situ can be seen in Table 5.

Table 5. Results of Water Quality Measurements of the Karangtalun Mangrove Area

| Parameter | Station 1 | Station 2 | Station 3 | Quality Standards |
|---|---|---|---|---|
| Temperature (°C) | 30.3 | 25 | 34.6 | 28-32* |
| Salinity (ppt) | 28 | 27 | 27 | 33-34* |
| pH | 7.13 | 4.69 | 7.99 | 7-8,5* |
| DO (mg/L) | 4 | 3 | 4 | >5* |

*: Decree of the Minister of State for the Environment No. 51 of 2004

**Relationship between Sediment Type and Macrobenthos Abundance**

The relationship between sediment type and macrobenthos abundance in the Karangtalun Cilacap mangrove area can be seen in the graph below:

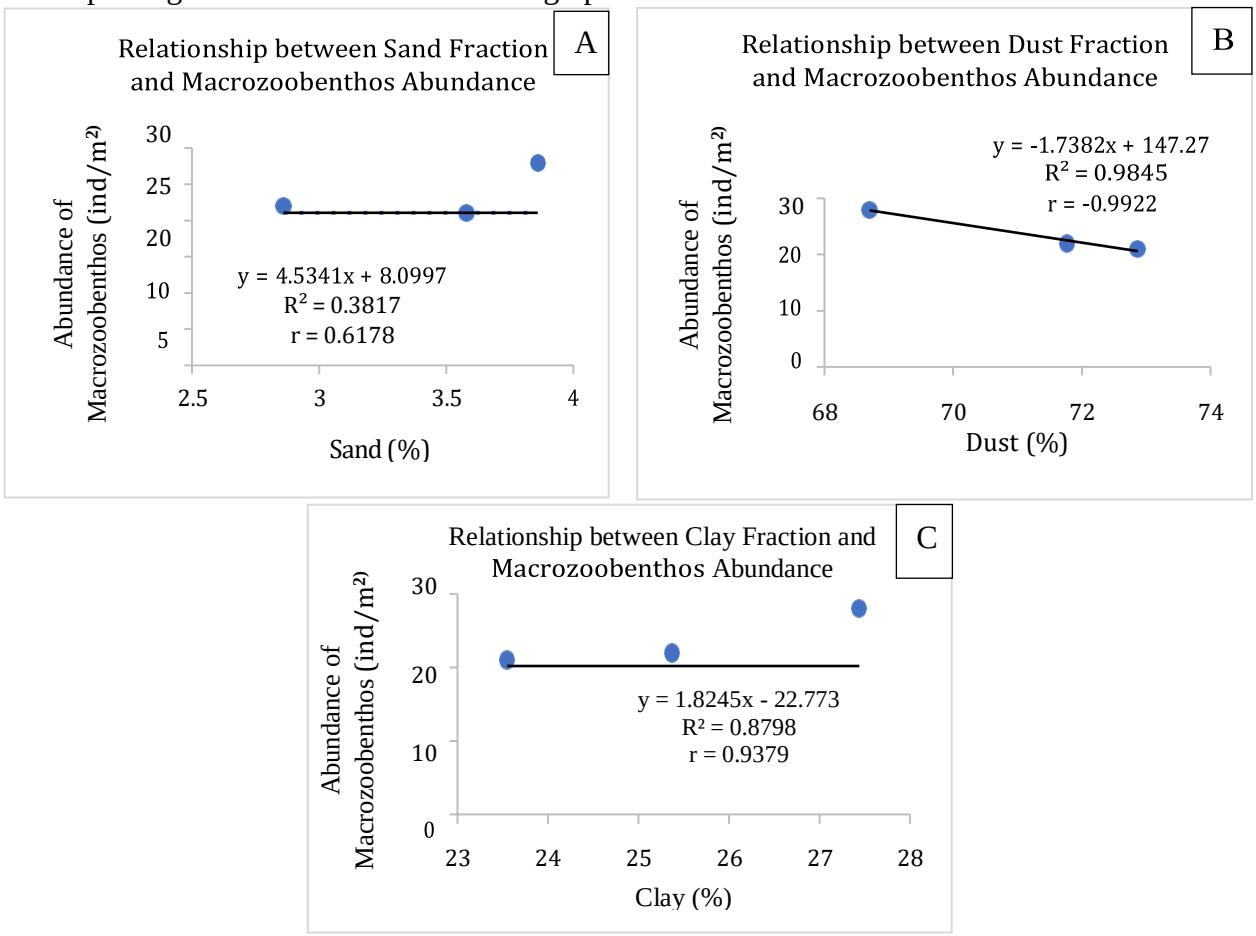


Figure 2. Graph of the Relationship between Sediment Fractions and Macrobenthos Abundance: (A) Sand, (B) Dust, and (C) Clay

**The Relationship Between Sedimentary Organic Carbon and Macrobenthos Abundance**

The relationship between sedimentary carbon and macrobenthos abundance in the Karangtalun Cilacap Mangrove Area can be seen in the graph below:

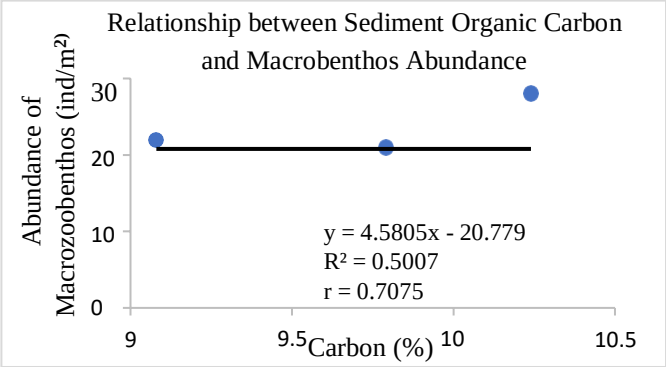


Figure 3. Graph of the Relationship between Sediment Organic Carbon and Macrobenthos Abundance

## DISCUSSION

The sediment texture in the Karangtalun mangrove area, Cilacap consists of sand, dust, and clay, which are one of the factors that influence the distribution of macrozoobenthos. Dust texture dominates at the three observation stations, with a percentage of 68.70% at station 1, 72.87% at station 2, and 71.77% at station 3. Based on the results of the sediment fraction percentage, the substrate type in this mangrove area is classified as clay that tends to be dusty clay and clayey clay. Differences in sediment fractions between stations are caused by variations in geographical conditions at each observation location. According to Nybakken (1992), sediment texture or basic substrate is one of the main ecological factors that influence the abundance and distribution of macrozoobenthos. The basic substrate functions as a place for macrozoobenthos to attach, crawl, or walk. In addition, the substrate supports the availability of nutrients, acts as a habitat, and is part of the macrozoobenthos life cycle, while the organic matter in it is the main food source for these organisms.

Research in the Karangtalun mangrove area, Cilacap showed the presence of six genera of macrobenthos divided into two classes. The gastropod class consists of five genera, namely Littoraria, Chicorius, Cerithidea, Nerita, and Semiricinula, while the crustacean class is represented by one genus, namely Tubuca. The abundance of gastropods varies at each observation station, with the highest value found at station 1 at 28 ind/m², followed by station 3 at 22 ind/m², and the lowest at station 2 at 21 ind/m². The results of the observations showed variations in individual abundance and relative abundance at all stations. The gastropod class is the macrobenthos group with the highest number and abundance value. This is due to the strong adaptability of gastropods to environmental changes, supported by the presence of hard shells and their more active and free nature, so that they have a better chance of survival compared to other classes (Ulfah et al., 2012). In addition, research by Anggraeni et al. (2016) showed that gastropods have a high level of tolerance to variations in substrate conditions and environmental changes, allowing them to dominate macrobenthic communities in several coastal ecosystems. A study by Hall et al. (2013) also revealed that gastropods, with the ability to move freely on hard substrates, can utilize various food sources more effectively, which contributes to their higher abundance compared to other groups.

The diversity index values at all stations were in the low category, namely between 0.774–0.930. This low diversity is likely due to ecosystem imbalance due to environmental pressure, which causes only certain species to survive. According to Mustofa et al. (2023), human activities in waters such as tourism, waste disposal, and opening of ponds around the

mangrove area greatly affect the diversity index. The macrobenthic uniformity index in the mangrove area at Station 1 was recorded at 0.654 (moderate category), Station 2 reached 0.846 (high category), and Station 3 was 0.705 (moderate category). The dominance index value ranges from 0.428 to 0.566, which is low. A dominance index value approaching 0 indicates the absence of dominant species in a body of water, which means that each individual at the observation station has an equal opportunity to utilize the resources in the body of water. The lower diversity index compared to the uniformity index is caused by the dominance of several macrobenthic species that are very abundant, while other species are few in the area.

This is due to the environmental conditions in the Karangtalun mangrove area which are more stable and homogeneous, which support the growth and survival of these dominant species (Kamil, 2024). Based on the results of the study, the water temperature in the mangrove area at each station ranges from 25-34.6oC. The salinity measured at the research location ranges from 22-28ppt. The pH value obtained at each station ranges from 4.69-7.99 where macrobenthic species generally require a pH between 6.5-8.5 for survival and reproduction. The results of measurements of dissolved oxygen (DO) concentration at the three stations ranged from 3-4 mg/L (Susanti, 2021).

The relationship between sand fraction and abundance of macrozoobenthos in the Karangtalun mangrove area, Cilacap, forms a linear equation Y = 4.5341x + 8.0997, which indicates a positive relationship between sand sediment and abundance of macrozoobenthos in the area. An increase in the amount of sand sediment will cause an increase in the abundance of gastropods. The correlation value r = 0.6178 indicates a strong relationship between the two variables. The greater the percentage of sand fraction in the sediment, the higher the abundance of macrozoobenthos in an area. The $R^2$ value of 0.3817 indicates that 38.17% of macrozoobenthos abundance is influenced by the sand fraction, while 61.83% is influenced by the fraction and other factors. Puspasari et al. (2012) stated that sand substrates make it easier for gastropods to move, even though the nutrient content is low. The abundance and distribution of gastropods are influenced by environmental factors, food availability, predation, and competition.

Meanwhile, the relationship between the dust sediment fraction and the abundance of macrozoobenthos forms a linear equation Y = -1.7382x + 147.27, which shows a negative relationship between the two. An increase in dust sediment will lead to a decrease in the abundance of macrozoobenthos. The correlation value r = -0.9922 shows a very strong correlation even though the effect is inversely proportional. The higher the percentage of dust fraction in the sediment, the lower the abundance of macrozoobenthos in the area. The $R^2$ value of 0.9845 means that 98.45% of the abundance of macrozoobenthos is influenced by the dust fraction, while 1.55% is influenced by other factors. Other factors that affect the abundance of macrozoobenthos include water quality, organic matter content in the sediment which is a source of nutrients, and habitat changes due to human or natural activities. Puspasari et al. (2012), explained that dust substrates have lower oxygen content than sand. Finer dust tends to settle more slowly, which causes sediment accumulation and affects oxygen circulation in the water, affecting the abundance of macrobenthos because these organisms require oxygen to survive.

The relationship between clay fraction and macrobenthos abundance forms a linear equation Y = 1.8245x - 22.773, which indicates a positive relationship between clay sediment and macrobenthos abundance. The correlation value r = 0.9379 indicates that the relationship between the two variables is very strong. This indicates a significant positive effect between the clay fraction and the abundance of macrobenthos, with a unidirectional relationship between the two variables. The higher the percentage of clay fraction in the sediment, the higher the abundance of macrobenthos in an area. The $R^2$ value of 87.98% indicates that the abundance of macrobenthos is greatly influenced by the clay fraction, while 12.02% is

influenced by other factors. According to Puspasari et al. (2012), clay substrates have the ability to retain water and organic matter longer than other types of substrates, which can increase the availability of nutrients for macrobenthos. In addition, clay also tends to have more organic matter trapped in it, which functions as a food source for macrobenthos. Another study by Anggraeni et al. (2016) also showed that the presence of clay fractions in sediments can affect the presence and abundance of macrobenthos, because of its ability to retain more nutrients and affect the stability of macrobenthos habitats.

Meanwhile, the relationship between organic carbon and the abundance of macrobenthos in the Karangtalun mangrove area, Cilacap, forms a linear equation Y = 4.5805x - 20.779, which shows a positive relationship between organic carbon and the abundance of macrobenthos. An increase in organic carbon levels will cause an increase in the abundance of gastropods. The correlation value r = 0.7075 shows a strong relationship between the two variables. The higher the percentage of organic carbon in the sediment, the greater the abundance of macrobenthos in an area. Research by Hall et al. (2013) showed that organic carbon in sediment plays an important role in supporting the abundance of macrozoobenthos because it is the main source of food and energy for these organisms. Anggraeni et al. (2016) also found that increasing organic carbon content is associated with increasing abundance of macrozoobenthos, because decomposing organic matter provides the energy needed by benthic organisms.

## CONCLUSION

The types of sediment textures found in the Karangtalun mangrove area, Cilacap are sand, dust, and clay with the largest percentage at each station being the dust type with an average value of 71.11%. The number of macrozoobenthos found at the research location consisted of 6 genera included in 2 classes, namely gastropods and crustaceans where there was a strong relationship between the sediment texture types of sand, dust and clay to the abundance of macrozoobenthos in the Karangtalun mangrove area, Cilacap. The organic carbon content of the sediment was obtained at station 1 with a depth interval of 0-30 cm of 6.12%, 5.82%, and 5.74% with an average of 5.89%. At station 2 it was 11.56%, 11.49%, 10.44% with an average of 11.16%. At station 3 it was 13.06%, 12.06%, 11.07% with an average of 12.06%.

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