Nutrient Concentration and Population of Macrozoobenthos in Ciletuh Bay, Sukabumi District, West Java

Delilla Suhanda¹, Yuniarti MS²,³, Yudi Nurul Ihsan², and Syawaludin A. Harahap²

¹Marine Science Study Program, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Jl. Raya Bandung-Sumedang KM. 21, Jatinangor, West Java, Indonesia.
²Departemen of Marine Sciences, Fisheries and Marine Sciences Faculty, Universitas Padjadjaran, Jl. Raya Bandung-Sumedang KM. 21, Jatinangor, West Java, Indonesia.
³The Center for Conservation and Management of Maritime Areas of the Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Jl. Raya Bandung-Sumedang KM. 21, Jatinangor, West Java, Indonesia.

Corresponding Authors: delillasuhanda@gmail.com

Abstract. Relationship between nutrient concentration and macrozoobenthos can indicate the level of fertility or pollution in the sea waters. The purpose of this research is to obtain nutrient concentrations in pore water, macrozoobenthos community structures, and the relationship between nutrient concentration and macrozoobenthos in pore water Ciletuh Bay. The research are using survey, purposive sampling and descriptive analysis method. The parameters observed in this research are nutrients including ammonia, phosphate, nitrate, nitrite, total N, and Total Organic Carbon (TOC). Analysis of population macrozoobenthos was determined by knowing abundance index and dominance index. From the results of the study, it has been found that two types of macrozoobenthos is Donax sp. and Nassarius sp which lived immersed, and its dominance influenced by sand sediment fraction. The higher concentration ammonia, nitrate, nitrite, phosphate, N-total, and TOC which is 0.028, 0.708, 1.663, 0.075, 3.066 and 1.4 mgL⁻¹. The factor that most influences the presence of macrozoobenthos is the type of sediment and the closest concentration of nutrient is phosphate.

Keywords: Ciletuh Bay, nutrient, population macrozoobenthos, pore water, sediment.
1. Introduction

Ciletuh Bay is part of Ciletuh National Geopark in West Java Province. Geographically, it is located on the southern coast of Pelabuhan Ratu Bay, which is the largest bay on the South Coast of Java Island and directly facing the Indian Ocean. Currently, Ciletuh Bay was recognized by UNESCO in 2015 as a national Geopark in Indonesia and as a part of the Global Geoparks network in April 2018. Ciletuh Bay is a place that empties into Cimarinjung River and Ciwaru River which affect the physical and chemical conditions of Ciletuh Bay.

In addition to several rivers the changed of a physical and chemical condition of Ciletuh Bay generate sediment quality, there are also human activities such as fishing schemes, shrimp farms and uninhabited islands. Composition and concentration of nutrient will greatly affect the survival of an organism. One of the organisms that need nutrients and impacted by sediment and water quality declamation directly in coastal or sea ecosystem is macrozoobenthos (Asep et al., 2018). The existence of macrozoobenthos is the one of the most important organism parts of food chain in water ecosystem as food for demersal fish and some mammals. Macrozoobenthos also can be used as an indicator of the coastal and sea ecosystem (Sahidin and Yusli, 2016; Putro, 2014).

Macrozoobenthos is an organism whose life relatively long-living at the bottom of the water and measuring 3-5 millimeters. Based on its existence, macrozoobenthos can be divided into two category, called macrozoobenthos epifauna and macrozoobenthos infauna. Macrozoobenthos infauna belongs to organisms living in substrate sediment which has the property to make holes and deposit eater tent to fade in the sediment area that contains organic matter in pore water, they modify chemical components in sediment and decompose of nutrient recycling, organic matter and energy transfer to other links within the food (Gaudencio and Cabral, 2007; Norling et al., 2007; Putro, 2014). The presence of makrozoobenthos is strongly influence by biotic and abiotic factors. Factor of biotic component is food for makrozoobenthos and factor abiotic component is affected by physical-chemical water include: temperature, dissolved oxygen (DO), depth, salinity, substrate and content of nitrogen (N) (Allard, 1987; APHA, 2005; Shou et al., 2009).

In pore water, nutrient can changes influence organism that living in sediment. Pore water comes from surface of the sediment or water column which carries a concentration of acidity and nutrients. Pore water is layers of sediment are filled with water or air (Yuniarti et al.,
Community structure in each organism has its own role. Ecological dominance is a species that plays a major role in controlling energy flows and the environment.

Approachement to determine water condition would be conducted with two methods, using biota response to environmental pressure, describe the environment condition and water quality. Biological method could determining and describes waters condition in long-term rather than use physical-chemical methods. Due to biological method would analyze biota response in pressure water (Junshum et al., 2008). This review paper was prepared as part of a nutrient concentration and population of macrozoobenthos which is in pore water in Ciletuh Bay, District of Sukabumi West Java. Based on foregoing, it should be examined nutrient concentration in pore water by looking at the impact to macrozoobenthos community structures in Ciletuh Bay.

2. Materials and methods

2.1. Study Area and Laboratory Analysis

The study area, in Ciletuh Bay, was conducted at five station in the monts of May to September. Five station are located around coastal of Ciletuh Bay, were selected as the sampling station. Area sampling of each station was be recorded by using a model 60csx Garmin Global Positioning System (GPS), the selection of sampling station was determined after considering characteristic and factors each station. Sampling was conducted on May 27, 2018. Three replicate samples macrozoobenthos and water quality were taken at each sampling station. Macrozoobenthos samples were sieved a surber mesh (40 cm x 20 cm), macrozoobenthos trapped on the sieves were fixed in 5% formalin. Sediment samples were taken by using piston core then putted sediment into zipper plastic. Pore water were taken by piston core then for sieved the water using Millipore sieve and putted into dark polythene bottle and collected in icebox to be brought to the laboratory. Water quality parameters (physical and chemical parameters) such as temperature, salinity, dissolved oxygen, pH, visibility and depth the sampling station were collected and measured in-situ at proper depth. A measurement temperature was recorded by using alcohol standard thermometer, salinity by using a refractometer Atago 2483 Master-S28M, dissolved oxygen by using DO meter Lutron DO-5510, pH by using PH meter Lutron PH-201, brightness by using a secchi disk and depth of waters with aid of scale rope, meanwhile the rest of the parameters was analyzed in laboratory.
Samples macrozoobenthos, sediment and sea water observed in laboratory. Macrozoobenthos identified by using magnifier (Lozarralde and Pittaluga, 2010) identifying macrozoobenthos morphologically to genus level was conducted by using standard macrozoobenthos identification books (Bunjamin, 2005; Agus et al., 2008). Sediment particle size (sand, mud and clay) were analyzed using the wet sieving method. The water nutrient samples to analyze the nitrates, nitrites, ammonia, phosphate, Total Organic Carbon, and Total Nitrogen with the aid of the spectrophotometer (Asep et al., 2018).

2.2. Field Sampling
This research was conducted in the months of May to September and were taken samples on May 27, 2018 which included of determining the research station, taking samples, processing sediment and water samples, identifying macrozoobenthos and analyzing seawater samples. Based on determination of characteristic, station 1 located at Kunti’s Island at coordinate 7,186861°S, 106.431861°E; station 2 located at the shrimp farming at coordinate 7,189389°S, 106.443500°E; station 3 located at Mandra’s Island at coordinate 7,182806°S, 106,448667°E; station 4 located at Ciwaru River which will flow toward the Estuary Ciletuh Bay at coordinate 7,182845°S, 106,457651°E; station 5 located at Cimarinjung River which will flow toward the Estuary Ciletuh Bay at coordinate 7,171157°S, 106,464503°E. The scope of the research can be seen in Figure 1.

Figure 1. Map of Research Location
2.3. Data Processing

2.3.1. Abundance Index
Abundance index for each samples mathematically can be described as follows (Brower et al., 1990):

$$DMZ = \frac{n_1}{A}$$

2.3.2. Dominance Index
Species Dominance ($C$) of each samples was determined by the Simpson Index of Dominance (Brower et al., 1990).

$$D = \frac{\sum n_i (n_i - 1)}{N (N - 1)}$$

$$C = 1 - D$$

3. Results and Discussion

3.1. Water Quality Parameters
The results of water quality in every sample was conducted by measuring the parameters of water quality in-situ. The results of measurements of water quality parameters observed for each station are presented in table 1.

| Station | Salinity (%o) | Temperature (°C) | pH | DO (mgL$^{-1}$) | Brightness (%) | Depth (cm) |
|---------|---------------|------------------|----|----------------|----------------|------------|
| 1       | 15            | 28               | 7.34 | 9.5             | 41             | 100        |
| 2       | 26            | 29               | 7.13 | 8.7             | 62.5           | 80         |
| 3       | 33            | 29               | 7.1  | 8.3             | 37.5           | 40         |
| 4       | 31            | 29               | 7.13 | 7.7             | 87.5           | 40         |
| 5       | 34            | 30               | 7.07 | 8.7             | 20.83          | 120        |

As viewed from table 1, it is known that some parameters for measuring water quality. Salinity in Ciletuh bay ranges from 15 – 34 at station 1 shows that the waters is classified as brackish (Widi et al., 2007). The temperature is a parameter that reality affects distribution, abundance and mortality of macrozoobenthos. Based on the temperature value obtained during the observation shows that is strongly influenced by the intensity of sunlight of each station. Variation of temperature value can influenced by nature processes such as
biochemistry, through microorganism that can produce a heat and microbiology (Wenno, 1981). Moreover according to Officer (1976) expressed that temperature condition in sea water can be effected by atmosphere condition, weather and intensity of sunlight entering the waters. Temperature effect toward the metabolism of aquatic organisms so that needs dissolved oxygen increase (Nybakken, 1988).

Dissolved oxygen is needed by organisms that live in water (Evans, 1985). The dissolved oxygen conditions at each station are good because the dissolved oxygen level is not less than 2 mgL\(^{-1}\) which is sufficient value for Gastropods and Bivalves. According to Bambang and Heron (2009) study of current patterns in Pelabuhan Ratu, adjacent to Ciletuh Bay, the pattern of current movements in the region is strongly influenced by tides. When the highest tide occurs, the water will move into the bay with maximum speed. The potential of Hydrogen is one of chemical parameter which is quite important for monitoring the stability of the waters. The organism of aquatic has certain limitations with pH values that are varies depending on sea water temperature, dissolve oxygen concentration and there are anions and cations (Pescod, 1978). Generally, pH in sea water range between 4 -9 (Marojahan, 2009) at each station shows a normal number and is suitable for marine biota to live in these waters.

The brightness level of a waters can indicated of the number of suspended particles or normal weather can give a hint in these waters has a low brightness (Baigo et al., 2018). Based on field observations, in Ciletuh Bay has the level of brightness range between 20,83 – 87,5 % at range depth between 40 – 120 meters. The lowest level of brightness is at station 5 due to by influence of the Cimarinjung River flow. The river flow carries dissolved sediment particles, organic and inorganic materials through run off flow from the land which affects the brightness in station 5, so that the level of turbidity of the waters is high (Baigo et al., 2018; Harpasis, 2004).

3.2. Grain Size
The Analysis of sediment samples carried out by the sieving method using a Sieve shaker were obtained by the percentage and type of sediment texture at each station in Ciletuh Bay, District of Sukabumi which was processed using KUMMOD SEL software. The result of the analysis sediment samples Ciletuh Bay showed two fractions sediments in the area are gravel and sand have different weight percentages at each point and take period.
Table 2. Types of sediments

| Station | Sediment Fraction | Sediment Type       |
|---------|-------------------|---------------------|
|         | Gravel    | Sand                |
| 1       | 18.6      | 81.4                | Gravel Sand         |
| 2       | 0         | 100                 | Sand                |
| 3       | 4.1       | 95.9                | Sand with little Gravel |
| 4       | 0.2       | 99.8                | Sand with little Gravel |
| 5       | 0.4       | 99.6                | Sand with little Gravel |

Based on the results of the sediment texture analysis at Ciletuh Bay, District of Sukabumi, the percentage value of the gravel fraction from station 1 to station 5 is quite far, 0.2 - 18.6%. The percentage of sand fraction is 81.4 - 100%. Based on these data it can be seen that the percentage of sand fraction is the largest sediment fraction when compared with gravel, clay and mud, so the result it can be seen that the type of sediment texture in Ciletuh Bay is sand dominance. The gravel fractions have a range of grain sizes from 2.0 to 10.00 with the type of grit particles (Fine gravel). The sediment substrate which is dominated by the sand fraction can be seen based on the research location in the coastal area of Ciletuh Bay. According to Hutabarat (1984) stated that sediments transported from land to sea by rivers in the ocean, the bigger grain sized tend to sink faster and settle.

3.3. Makrozoobenthos
The results of sampling and identification were obtained, there are Nassarius sp. and Donax sp. which dominate the waters of Ciletuh Bay. Ciletuh Bay as a whole scale, there are two species of macrozoobenthos and its dominanced by the species Donax sp. Station 1 is dominance by macrozoobenthos Nassarius sp. with 2 individuals while Donax sp. are not found at station 1. However, stations 2 to 5 are dominated by Donax sp. and there are no other species of macrozoobenthos at the station. At station 4 the number of species of Donax sp. was very abundant, reaching 45 individuals. This is due to its habit which cannot move actively and settles down somewhere (Hilda, 2011). These two types of individuals are Gastropods and Bivalves that are capable of extreme salinity.
Table 3. Structure community of Macrozoobenthos

| Station | Species     | Abundance Index (ind/m³) | Dominance Index |
|---------|-------------|--------------------------|-----------------|
| 1       | Nassarius sp. | 250                      | 1               |
| 2       | Donax sp.    | 2250                     | 1               |
| 3       | Donax sp.    | 3125                     | 1               |
| 4       | Donax sp.    | 5625                     | 1               |
| 5       | Donax sp.    | 750                      | 1               |

These shells live immersed in sand or sometimes in gravel. According to Yunitawati, et al. (2012), the main factor that greatly influenced the community structure of macrozoobenthos was coarse substrate. If the substrate changes, the macrozoobenthos structure will also change. This is evidenced by the abundance of macrozoobenthos types of Donax sp. at each station that has a substrate or type of sediment dominated by a sand fraction.

3.4. Nutrient Concentration
Nutrient conditions will be greatly influenced by the natural processes of a waters or even the process of entry of nutrients that can affect nutrients. Nutrient concentration will greatly affect
the nutrients needed by macrozoobenthos as nutrients for life

**Figure 2. Nutrients in Water Pore**

The amount of deposited organic contents can be influenced by sediment texture. The finer the texture of the sediment substrate in the water, more deposition of organic matter will be (Harpasis, 2004). The concentration of Ammonium (NH$_4^+$) compounds in the waters of Ciletuh Bay at each station ranges from 0.0099 - 0.028 mgL$^{-1}$ (Figure 2). Ammonia comes from organic nitrogen elements which are processed by heterotrophic organisms, namely organisms that need nutrients. In addition, ammonia comes from human activities such as domestic waste and industrial waste. Concentration ammonia in Ciletuh Bay very influenced by decomposition process component organic with some bacteria organism. The concentration of Nitrate (NO$_3^-$) compounds in the waters of Ciletuh Bay at each station ranges from 0.327 - 0.708 mgL$^{-1}$ (Figure 2). Nitrate is the main form of nitrogen in the waters and is the main nutrient for plant growth and algae. Nitrates are stable and very soluble in water (Bahari, 2006). Nitrate in Ciletuh Bay have the highest concentration at station 1, at station 1 have a ecosystem of coral reef and algae that influence by decomposition proses with bacteria ammonification and condition oceanography at station 1. The highest concentration of nitrite concentration is at station 2 which is equal to 1.663 mgL$^{-1}$. In station 2 there is shrimp culture, that dumps its waste into the water, component cultivated liquid waste was dominated by nitrite, total nitrogen, and phosphate (Mat Fahrur et al., 2016). The highest total N-concentration is found at station 2, this can be caused by the activity of shrimp ponds at Station 2. Shrimp ponds greatly affect the nitrogen cycle in the waters and total nitrogen in seawater was combined by ammonia, nitrite and nitrate concentration. The highest concentration of total nitrogen was compound by nitrite.

The concentration of Phosphate compounds (PO$_4^{3-}$) in the waters of Ciletuh Bay at each station ranges 0.056 - 0.075 mgL$^{-1}$ (Figure. 2). The highest phosphate concentration is at station 2 which is in Shrimp Pond. This can be caused by the high phosphate diffusion process from sediment particles. Sediment is also a major place in phosphorus storage in cycles that occur in the ocean.

The carbon content can affect the level of ocean acidification, this impact can affect the supply of dissolved oxygen concentrations needed by marine biota as a process of respiration. The observations of Total Organic Carbon (TOC) concentrations ranged from
0.281 - 1, 4 mgL^{-1}. The highest TOC concentration is found at station 3, this can be caused by the activity of macrozoobenthos at station 3 and decaying vegetation from Mandra Island then settles and accumulates in pore water at station 3.

The correlation between the abundance index and each nutrient measured showed that almost all nutrients were negative. The regression results between abundance and ammonia concentration in pore water have a value of \( r = 0.1815 \), abundance index with nitrate concentration \( r = 0.0358 \), abundance index with nitrite concentration \( r = 0.0005 \), abundance index with phosphate concentration \( r = 0.7215 \), abundance index with N-Total concentration \( r = 0.1066 \), abundance index with TOC concentration \( r = 0.1768 \). Values show that the abundance value with the concentration value of ammonia, nitrate, nitrite, phosphate, N-Total and TOC is directly proportional, this correlation value shows the relationship between abundance index and nutrient concentration that closest nutrient concentration is phosphate. The nutrient concentration in the pore water and water column is interconnected from the activity of marine biota contained in it. If the higher the concentration of nutrient, the more abundance of the ecosystem will be.

Acknowledgement
This Research was totally supported by Universitas Padjadjaran, Indonesia (Project HIU-Hibah Internal Unpad). We thank Riska Zandhi, Fani Wulan Sari, Hazman Hiwari, and Ridlo Setiadeswan for sampling in Ciletuh Bay. Many thanks to reviewers for their comments that greatly improved the quality of the manuscript.

Conclusion
1. All nutrient parameters have relationship with macrozoobenthos, nutrient concentration that closest with abudance macrozoobenthos is phosphate and nutrient concentration that least influential with abundance macrozoobenthos is nitrate.
2. Macrozoobenthos in Ciletuh Bay is Donax sp. and Nassarius sp. in Ciletuh Bay dominated by macrozoobenthos Donax sp.
3. sediment in Ciletuh Bay is dominated by sand fraction.

Citation and References
[1] Allard M, Moreau G. (1987). Effects of experimental acidification on a lotic macroinvertebrate community. Hydrobiologia, 144(1):37-49

[2] Asep S. Zahidah. Heti H. Yusli W. Isdradjad S. Ruhyat P. (2018). Macrzoobenthos as bioindicator of ecological status in Tnajung Pasir Coastal, Tangerang District, Banten Province, Indonesia.

[3] Bahri and Andi Faizal. 2006. Analysis of Concentration Nitrate and Phosphate in Mangrove Sedimens utilized in the District of Mallusetasi, Barru Regency. Case Study of Utilization of Mangrove Ecosystems and Coasts Areas by Bungoro Community, Pangke Regency. Association of Environmental Consevators: Makassar.

[4] Baigo, H. Rosye H.R.T., Suwito,. Hendra K.M., Alianto. (2018). Sea Waters Quality Study and Pollution Index Based on Physics-Chemical Parameters in the Depapre District Waters, Jayapura. Jayapura: Journal Environment Science Volume 16 Issue 1 (2018) : 35 - 43.

[5] Brower, J. Jernold, Z., Von Ende, C. (1990). Field and Laboratory Method for General Ecology. Third Edition. USA: W. M. C. Brown Publishers.

[6] Bunjamin, D. (1988). Recent and Fossil Indonesian Shells. Conch Books.

[7] Gaud’encio, M.J., Cabral, H.N., (2007). Trophic structure of macrobenthos in the Tagus estuary and adjacent coastal shelf. Hydrobiologia 587, 241–251.

[8] Harpasis, S.S. (2004). Chemical Characteristic and Fertility Pelabuhan Ratu Bay Waters at West and East Monsoon. Journal Waters Sciences and Fisheries of Indonesia Volume 11, Number 2 : 93 – 100.

[9] Hutabarat, S. S.M. Evans. (1984). Introduction Oseanografi. UI-Press. Jakarta

[10] Junshum P, Choonluchanon S, Traichaiyaporn S. (2008). Biological indies for classification of water quality around Mae Moh power plant, Thailand. Mj Intl J Sci Tech 2 (1): 24-36.

[11] Lizarralde Z, Pittaluga S. (2010). Distribution and Temporal Variation of The Benthic Fauna In the Tidal Flat Of the Rio Gallegos Estuary, Patagonia, Argentina. *Thalassas, An International Journal of Marine Sciences* 27:9-20.

[12] Marojahan, S. (2009). Relationship of Chemical, Physics Environmental Factors of Plankton Distribution in East Belitung Waters, Bangka Belitung. Jakarta. LIPI: 31-45
pp.

[13] Mat Fahrur, Makmur Makmur, and Muhammad Chaidir Undu. 2015. Characteristics of Wastewater Culture Shrimp Vaname Superintensive. Forum of Innovation Technology Aquaculture.

[14] Norling, K., Rosenberg, R., Hulth, S., Grémare, A., Bonsdorff, E., (2007). Importance of functional biodiversity and speciesspecific traits of benthic fauna for ecosystem functions in marine sediment. Marine Ecology Progress Series 332, 11–23.

[15] Nybakken, W.J. (1988). Marine Biology. An Ecological Approach. Gramedia, Jakarta: 459

[16] Odum, E.P., (1993). The Basics of Ecology. Third Edition. Yogjakarta: Gadjah mada University Press.

[17] Officer, C.B. (1976). Physical Oceanography of Estuaries and Associated Coastal Waters. John Willey and Sons. New York: 465 pp.

[18] Putro, S. P. (2014). Sampling Method of Macrobenthos Research and its Applications. Graha Ilmu. Yogyakarta. 1–37.

[19] R. Bambang A,M., Heron Surbakti. (2009). Simulation of Two Dimensional Flow Patterns in Pelabuhan Ratu Bay in September, 2004.

[20] Sahidin A, Yusli W. (2016). Spatial distribution of Polychaete at Tangerang coastal water, Banten Province. J Fish Mar 6 (2): 83-94. [Indonesian]

[21] Shannon, C.E., Weaver, W., (1963). *The Mathematical theory of communication*. University of Illinois Press, Urbana, Illinois.

[22] Water Environmental Federation and American Public Health Association (APHA). (2005). Standard methods for the examination of water and wastewater. Washington DC: APHA

[23] Wenno, L.F. 1981. Research report: Nature of Oceanology Shallow Waters Maluku. Maluku Aquatic Marine Resources Research and Development Project (1980 – 1981). LON-LIPI, SPA, Ambon: 185 pp.

[24] Widi A. Adil J. and Muhammad A. Brackish Water Desalination Using Surfactant Modified Zeolite. LIPI Vol.6 Number 1. May 2007.

[25] Yuniarti. Y. N. Ihsan, C. Asdak, Y. Dhahiyat, M. K.A. Kamarudin, M. B. Gasim, A. F. Ireana Yusra and H. Juahir. (2018). Impact Sedimentation To Community Structure
Macrozoobenthos In Segara Anakan Lagoon. Journal of Fundamental and Applied Sciences.

[26] Yunitawati. Sunarto. Zahidah, H. (2012). Relationship between Substrate to Structure Community of Macrozoobenthos at Cantigi River, District of Indramayu. Sumedang: Journal Fisheries and Marine Science Volume 3, Number 3 2012 : 221 – 227.