Eco. Env. & Cons. 26 (June Suppl. Issue) : 2020; pp. (S57-S63)

ISSN 0971–765X

Assessment of water quality in mangrove restoration area based on plankton diversity index in Pangandaran, Southern Coast of West Java, Indonesia

Tri Dewi Kusumaningrum Pribadi*, Archie Sultan Eka Buana, Muhammad Agung Triyudha, Raden Wandha Humaira and Nenci Hariyadi

Department of Biology, Universitas Padjadjaran. Jl. Raya Bandung Sumedang Km. 21 Jatinangor, Sumedang 45363, Jawa Barat, Indonesia

(Received 27 January 2020; Accepted 15 March 2020)

ABSTRACT

Plankton belongs to one of biotic factors, which plays a vital role in their primary productivity as well as water quality indication in aquatic ecosystems such as mangrove areas. A suitable water quality gives significant contribution to biodiversity in a way that they maintain its conservation function. A study of plankton community was conducted based on the analyses of species diversity, dominance, and evenness in mangrove restoration areas of Batukaras and Bulaksetra to assess their reproductive performance as indicator of the water quality in the southern coast of West Java province, Indonesia. This observation was done at 54 spots of two study sites during wet / rainy season in order to assess the primary productivity and plankton community, including its periphyton. The result showed that plankton diversity in Batukaras had higher performance in most of Ecological Indices including the primary productivity performance, as compared to the one in Bulaksetra. The phytoplankton dominated on both study sites was Bacillariophyceae, while zooplankton was dominated by Crustacean. Primary productivity results showed that Batukaras happened to be in euthropic level, while Bulaksetra in mesothrophic one. In general, the results indicate that the areas in both study sites were moderately polluted.

Key words : *Diversity, Mangrove, Water quality, Plankton*

Introduction

Mangrove is one of significant contributors to the existence of marine biodiversity in Indonesia, thus it becomes the main subject of the ecosystem development in Indonesia (Murdiyarso *et al.*, 2015). About 3 million-hectare mangrove forest lies 95.000 km along the Indonesian coastal line, representing 23% of the total mangrove area in the world (Giri *et al.*, 2011). In tropical areas like Indonesia, mangrove contributes ecosystem contributions, such as providing shelters for other organisms living inside, breakwater against ocean waves, carbon stock, nutrient cycle, as far as fishery production for humans (CIFOR, 2012). Those significant roles will disappear whenever disruption emerges such as tsunami.

In the southern coast of West Java, Indonesia, there is mangrove area located in Batukaras and Bulaksetra, in the district of Pangandaran, where both locations serve as restoration area. Both areas along with their ± 28 km coastal line have been devastated by tsunami in 2006 (Pranata *et al.*, 2018). Restoration programme was done in 2013 to recover the local environment including mangrove area (Putra *et al.*, 2015). This condition became interesting for observing the aquatic part of the ecosystem service, in particular its constituent community structure.

In many ways, coastal area rely on its ecosystem for their lives including marine organisms, leading to the requirement of intact and healthy environment in order to flourish. A healthy mangrove ecosystem can be assessed by observing the mangrove plants and its surrounding aquatic ecosystem. This is due to the high presence of plankton as its primary productivity to the next trophic level, which is also affected by water quality (Halidah, 2016). In mangrove ecosystems, plankton plays an important role as the food source to support other living organisms within the food web. Most of the animals living in the sea start their lives as planktonic form, either as eggs or larvae. They spread all over water column until they can reach the spot where lights are able to pass through for photosynthesis (Bismark and Sawitri, 2010), including patch to mangrove root like periphyton.

Periphyton is part of trophic level, which plays a vital role in mangrove ecosystem, either directly as a food source or indirectly through food web for higher trophic level (Nasria *et al.,* 2016; Salwiyah and Nadia, 2013). Apart from being the source of natural feed for other aquatic organisms, the existence of periphyton indicates water prosperity. This ability is attributed to the fast response of periphyton to environmental alteration (Purwani *et al.,* 2014).

Water quality can also be assessed by applying physico-chemical and biological parameters. Biological parameters used in the assessment were the amount and species found in the location (Sivaranjani *et al.,* 2015). Another method to know the water quality is by assessing its ecological indices, which appeared to be more reliable and suitable as compared to other methods in general (Liu *et al.,* 2019).

This study is aimed to investigate the water quality in terms of prosperity indicator in mangrove ecosystem as restoration area after tsunami during wet /rainy season, through plankton community structure and ecological indices, including periphyton.

Materials and Methods

Study sites

Samples were taken from two different sites of mangrove restoration area in the southern coast of Pangandaran, West Java, Indonesia, in March 2019. The two study sites are Batukaras (7° 45′ 0.23"S; 108° 30′ 8.29"E) and Bulaksetra (7° 3′ 46.15"S; 108° 40′ 30.9"E) (Fig. 1).

Methods

Plankton sampling

Samples of plankton were taken using purposive sampling method following the grouping of mangrove species. Water samples were taken and used as much as 30 litres from each spot, and filtered out using plankton net No.25. The filtered water samples were then stored in a 30 mL sample bottle after they were added lugol 1%. Periphyton samples were collected by cutting the lower part of the mangrove root since they always stayed submerged most of the time, ± 15 cm long, added lugol 1% and then stored in a dark closed vessel prior to the next procedure. Immediately upon the root cutting, the

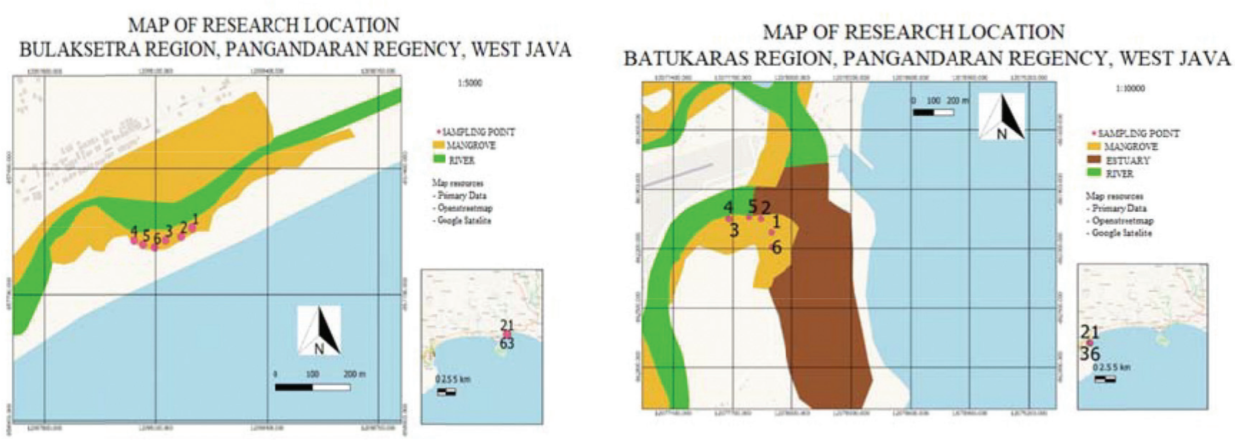

Fig. 1. Study site of Batukaras (A); Study site of Bulaksetra (B).

cut root was then cleaned by a soft brush where the brush stroke would then be stored in a bottle sample prior to the analysis. There were different mangrove species in both the study sites. Mangrove species in Bulaksetra were *Rhizopora mucronata*, *Sonneratia alba*, and *Nypa fructicans*. While the ones in Batukaras were *Rhizopora mucronata*, *Sonneratia alba*, and *Avicennia alba*. Primary productivity samples were taken and measured using the procedures from Likens (1975) on the same sites where plankton were taken from both the study sites.

Data analyses

Analyses of plankton had been conducted comprising the formula from Shannon-Wiener Diversity Index (Odum, 1971), Evenness Index of Magurran (1988), and Simpson's Diversity Index (Odum, 1971). The categories of environmental status followed Wilha (1975), Odum (1971), Krebs (1972) for Diversity Index, Simpson's Diversity Index, and Evenness Index, respectively.

Results and Discussion

From the water samples, the plankton from Batukaras site showed slightly higher level of species richness in comparison to the one from Bulaksetra (Fig. 2). On Batukaras site, 35 species of phytoplankton and 9 species of zooplankton were found in the species of plankton from the water samples, while periphyton was present in 29 species of phytoplankton and 2 species of zooplankton. The result of species richness in plankton on Bulaksetra site showed 18 species of phytoplankton and 9 species of zooplankton. Both study sites were dominated by Bacillariophyceae, though followed by Coscinodyscophyceae in Batukaras, and Pyramimonadophyceae in Bulaksetra. The presence of Crustacea dominated on both sites.

The most existing species found in Batukaras and Bulaksetra were phytoplankton *Coscinodiscus* sp. (1218 ind/m^3), and *Halosphaera* sp. (1771 ind/m^3), respectively. Most present species of zooplankton in Batukaras was *Acartya* sp. (805 ind/m^3) and *Nauplii* sp. (737 ind/m^3) in Bulaksetra.

In the group of periphyton, the result showed similar trend both on phytoplankton and zooplankton in Batukaras in comparison to the one in Bulaksetra. The species richness of both phytoplankton and zooplankton was found higher in Batukaras. There were 17 species of phytoplankton and 5 species of zooplankton found in Batukaras. As for phytoplankton, Bacillariophyceae was predominantly present in Batukaras, while the site in Bulaksetra was dominated by Tubulinea. In terms of Zooplankton, both sites were dominated by Cilliata. In the group of periphyton, most present phytoplankton in Batukaras and Bulaksetra were *Nitzschia* sp. (7420 ind/cm^2 and 7 ind/cm^2, respectively), while zooplankton in Batukaras was *Dileptus* sp. (53 ind/cm^2) and *Chaos corulinense* (442 ind/cm^2) in Bulaksetra. The most present periphyton found on both sites was Bacillariophyceae, which is considered as pioneer species in periphyton due to its high range of adaptive ability to various environmental conditions.

Bacillariophyceae was the most commonly found class in both study sites, either from plankton or periphyton (Fig. 3). This presumably due to high adaptibility of this class to environmental stress rateher than other classes, thus dominated well in numbers or species (Suwartimah *et al.*, 2011). This result meet with the research of Lobo *et al.*, (2010), which showed domination of epiphytic diatom

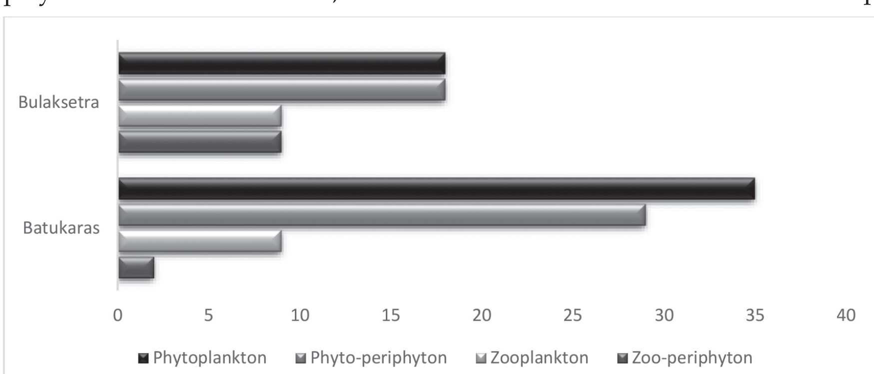

Fig. 2. Total of phytoplankton and zooplankton including periphyton number of species richness between in Batukaras and Bulaksetra during sampling period.

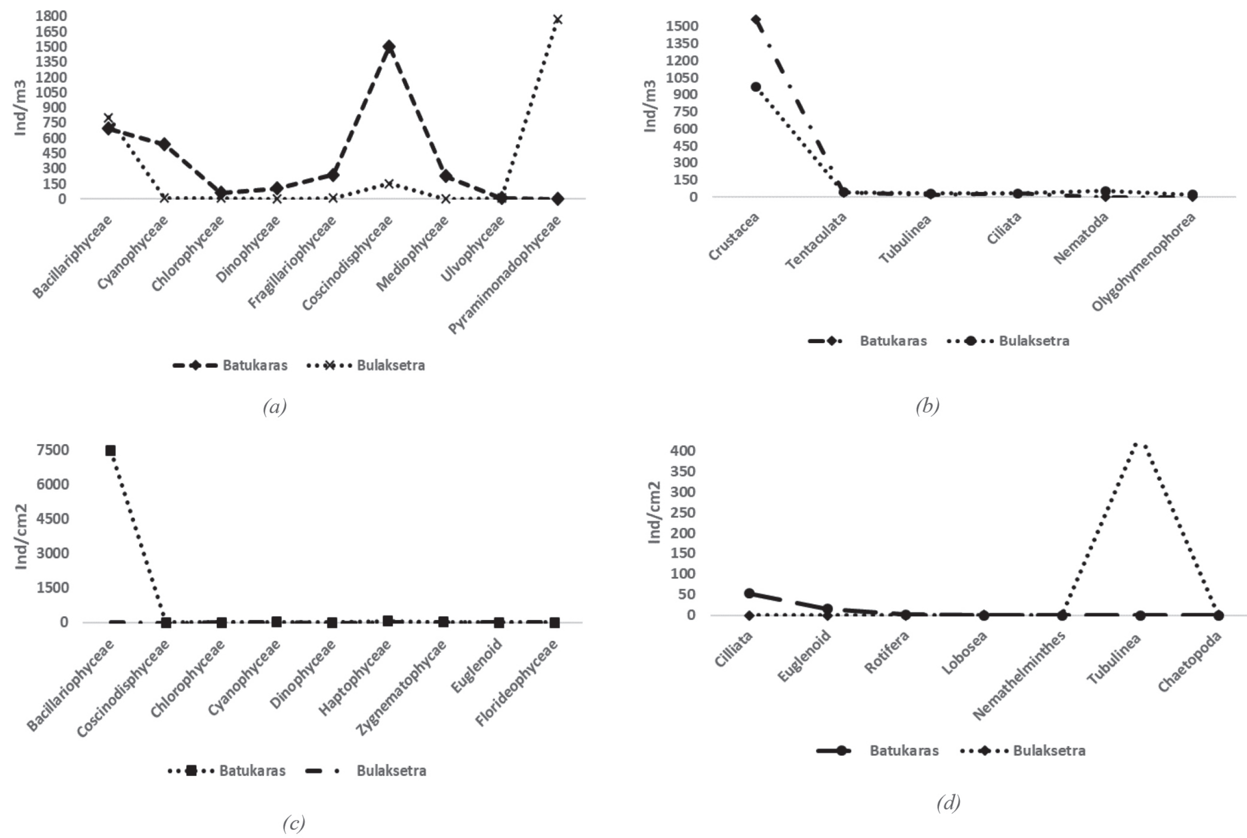

Fig. 3. Total abundance of (a) Phytoplankton, (b) zooplankton, (c) Phyto-periphyton, (d) Zoo-periphyton during sampling period.

from *Nitszchia* and *Navicula* genus in many rivers in South Brazil region. *Nitszchia* is one of the diatoms which can live in freshwater conditions and have a high level of salinity tolerance (Hogan, 2008), and this presumed to be the cause of dominance of this genus in both study sites, which is still influenced by coastal characteristic with slightly different salinity.

Crustaceans and Protoza were zooplankton groups that are most commonly found at both stations during the sampling period. This was similar with the research of Widyarini *et al.*, (2017), which presumed that Crustacea and Protozoa have the ability to live against a deteriorating environment, such as utilizing organic material as food and having faster reproductive stage compared to other classes.

Mangroves in both study sites have an important

Table 1. Ecological Index of Mangrove water ecosystem of Batukaras and Bulaksetra sites during sampling period.

Index	Biota	Batukaras	Bulaksetra	Categories
H’	Plankton	2.77	1.96	> 3 clean water 1-3 moderately polluted
	Periphyton	0.99	0.22	< 1 heavily polluted (Wilha, 1975)
C	Plankton	0.11	0.25	>0.8 lightly polluted 0.6-0.8 moderately polluted
	Periphyton	0.67	0.93	<0.6 heavily polluted (Odum, 1971)
E	Plankton	0.73	0.59	0 < E ≤ 0.5 = community depressed 0.5 < E ≤ 0.75 = community unstable
	Periphyton	0.06	0.32	0.75 < E ≤ 1 = community stable (Krebs, 1972)

role for water fertility. Characteristic of *Rhizophora* itself has a high level of abundance be cause of slighty rough root texture that making it easier for other organism to stick on it (Fig. 4). The differences in periphyton attachment susbstrate is one of the factors of presence or composition of the periphyton itself. Other results showed that the differences of mangrove roots type have the differences in environmental conditions too, so that it can influence living organisms in it including periphyton (Kabir *et al.*, 2014).

Primary productivity in Batukaras and Bulaksetra took place in the range of 296,53-464,38 mgC/m^2 and 15,012-51,64 mgC/m^2, respectively. The Dissolved Oxygen of Batukaras and Bulaksetra were 7,22 mg/L and 4,28 mg/L, respectively. The Ecological Indices on both sites showed that Batukaras had better results in most indices (Table 1).

Based on Shannon-Wiener Diversity Index, the value of diversity index of plankton including periphyton on both sites can be classified in the category of middle level, with slightly higher value in Batukaras. In Simpson's Diversity Index, Bulaksetra showed the dominance of *Chaos corulinense.* This might indicate that Batukaras has a more stable condition in comparison to Bulaksetra. The results were even strengthened by the evenness index showing the depressed level on Bulaksetra site. This condition tells us that most of the time, an aquatic ecosystem with a high level of diversity and low dominance will have low productivity yet stable condition (Dash, 2009).

Results also showed that Bacillariophyceae was dominant on both sites. This is presumably due to the high adaptive ability of this class in order to adjust to the environmental conditions (Suwartimah *et al.,* 2011). The genera of *Nitszchia* and *Navicula* were also highly dominant on both sites. This result is in line with Lobo *et al.,* (2010), showing diatom from genera *Nitszchia* and *Navicula* found in rivers in the southern part of Brazil, which also has tropical climate.

In general, species richness and abundance of zooplankton were dominated by Crustacea on both sites. The result meets the previous research that in the ecological point of view, Copepod from Crustacean can truly dominate 50% to 85% of the number of zooplankton in the sea and therefore leading to their undeniably vital role in the food web (Nybakken, 1992). Besides crustacea, protozoa was also highly present on both study sites, which is presumably due to its high adaptability, short reproductive cycles, and the ability to form cyst in bad condition (Suwignyo *et al.*, 2005).

In the present study, low Evenness index, especially on periphyton, found on both sides. This presumably due to domination of phytoperiphyton species *Nitszchia* sp. in both sites. In the present study, low evenness index on both sides, especially on periphyton caused by domination of species *Nitszchia* sp. in both sites. This is inline with Andriani *et al.* (2017) research that the result obtained the dominance spesies which occupies Pabean Bay is from *Nitszchia* sp. and *Pleurosigma* sp. which become main food source for fish. Both genus included in diatom groups and found to be easily attached on different subtrates, even hydrophytes. This genus also have adaptability in changes of hydroperiod in wetland area (Novelo and Tavera,

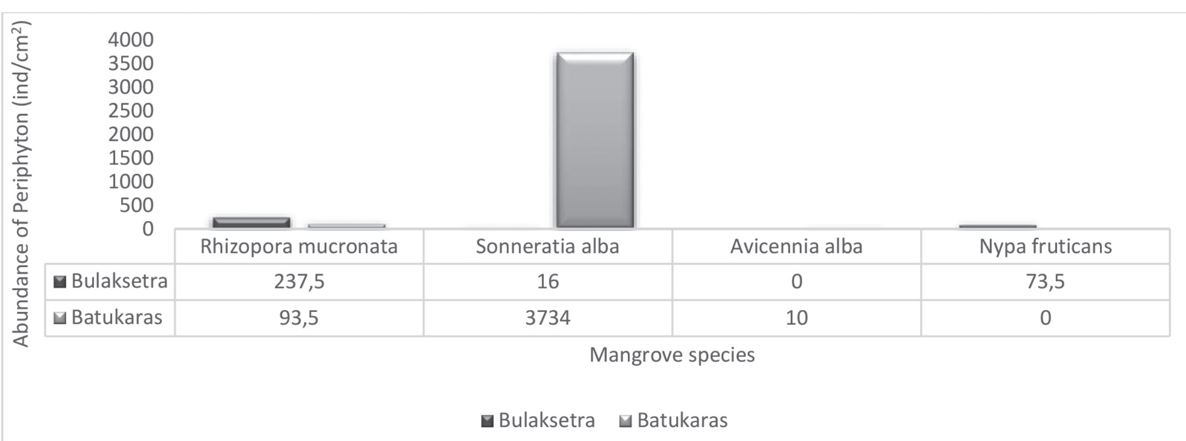

Fig. 4. The presence of periphyton in the substrate of mangrove root during sampling period.

2003; Sahlan, 1982). Phytoplankton dominated on both sites in the present study was *Coscinodiscus* sp., which is meet the result of Rosada *et al*. (2017) in East Coast of Pananjung Pangandaran, West Java, adjescent to study sites. The high level of abundance from genus *Coscinodiscus* influenced the bacterial community in water Column of the Gulf of Gdansk (Ameryk *et al*., 2014).

Species richness and diversity of periphyton can indicate water quality. The higher the diversity and abundance, the more the biomass of periphyton will be as its accumulative product. The accumulative pattern of biomass is triggered by the interaction of physico-chemical and biological factors such as mangrove community growth (Kaufman, 1980). The results of Diversity Index of periphyton showed that the diversity index of Batukaras is higher in comparison to Bulaksetra, from which we can assume that the former has better water quality.

The water prosperity of Batukaras provides the eutrophic characteristics, while the one in Bulaksetra the mesotrophic level. Mangrove in estuary is loaded by organic material from either the river or the sea (Nybakken, 1992). Environmental condition such as salinity, temperature and pH at the time when data is collected is still in good condition which supports plankton development on both sites (Barus, 2004; Effendi, 2003; Goldmann and Horne, 1983; Odum, 1971). This condition is causing the high nutrient level in water column in the estuary, including in mangrove areas, which explains higher primary productivity level in Batukaras compared to the one in Bulaksetra.

Conclusion

This study showed that during sampling period, mangrove water ecosystem of Batukaras had better constituents in terms of water quality compared to the one in Bulaksetra. This was shown by the ecological indices of plankton, which indicated higher value in most of the assessed indices. However, the trophic condition showed different perspective, where Batukaras proved to have higher level of trophic condition in comparison to Bulaksetra.

Acknowledgement

This research has been made possible by involving Student Field Project from the Biology Department of Universitas Padjadjaran, Indonesia, and supported by the research grants from RISTEKDIKTI for the scheme of Fundamental Research 2019 for publication. The authors express their gratitude to Aep Saeppudin from Aquatic Laboratory of Centre for Environment and Sustainability Science - Universitas Padjadjaran for the plankton identification.

References

Aini, S.N., Hartati, R., Nugraha, T. and Nurdianto, F. Komposisi alga perifiton pada akar vegetasi mangrove di Desa Pantai Harapan Jaya and Desa Pantai Mekar, Kabupaten Bekasi. *Jurnal Ikamat*.

Ameryk, A., Hahnke, R.L., Gromisz, S., Kownacka, J., Zalewski, M., Szymanek, L. and Harder, J. 2014. Bacterial Community Structure Influenced by *Coscinodiscus* sp. in the Vistula River Plume. *Oceanologia*. 56 : 825-856.

Andriani, A., Damar, A., Rahardjo, MF., Simajuntak, H., Asriansyah, A. and Maulana, R. 2017. Kelimpahan Fitoplankton Dan Perannya Sebagai Sumber Makanan Ikan Di Teluk Pabean, Jawa Barat. *Jurnal Sumberdaya Akuatik Indopasifik.* 1(2): 133-144.

Barus, T.A. 2004. *Penghantar Limnologi Studi Tentang Ekosistem Air Daratan.* Medan: USU Press.

Bishop, J.E. 1973. *Limnology of Small Malaya River Gombak*. the Hague: Dr. W. Junk. V.B. Publisher. 205p

Bismark, M. and Sawitri, R. 2010. Kelimpahan and Keragaman Jenis Plankton di Hutan Mangrove, Pulau Siberut. *Info Hutan.* 7(1) : 77-78. Badan Litbang Kehutanan. Bogor.

CIFOR. 2012. Mangrove Adalah Salah Satu Hutan Terkaya Karbon di Karbon Di Kawasan Tropis. https://www.cifor.org/library/3773/ (accessed 2.17.2019).

Dash, M. C. and Dash, S. P. 2009. *Fundamentals of Ecology (3rd ed.)*. New Delhi: Tata McGraw-Hill Education Private Limited.

Effendi, H. 2003. Telaah kualitas air.Yogyakarta: Kanisius.

Giri, C., Ochieng, E., Tieszen, L. L., Zhu, Z., Singh, A., Loveland, T. and Duke, N. 2011. Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography.* 20(1) : 54-159.

Goldman, R.C. and Horne, A.J. 1983. *Lymnology*. Mc Graw Hill International Book Company. New York

Halidah, 2016. *Lumnitzera littorea* (Jack) Voight, Mangrove Sejati yang Terancam Punah. *Info Teknis EBONI.* 11(2) : 129-137.

Hogan, C.M. 2008. *Makgadikgadi The Megalithic Portal.* Edition. A. Burnham.

Kaufman, J. 1980. Prime Time Nutrition. *Journal Communication*. (30) : 37-47.

Kabir, M., Abolfathi, M., Hajimoradloo, A., Zahedi, S., Kandasamy, K. and Goli, S. 2014. Effect of Mangroves on Distribution, Diversity, and Abundance of Mollusc in Mangrove Ecosystem: A Review. *AACL Bioflux*. 7 (3): 286-293.

Krebs, C.J. 1972. *Ecological Methodology*. Menlo Park, California. Benjamin/Cummings. 694 p.

Likens, G.E. 1975. *Primary Productivity of The Biosphere*. New York: Lieth and Whittaker. Springler-Verlag.

Liu, L., Xing, X., Hu, C. and Wang, H. 2019. O3-BAC-Cl2: a multi-barrier process controlling the regrowth of opportunistic waterborne pathogens in drinking water distribution systems. *J. Environ. Sci. (China)*. 76: 142-153.

Lobo, E.A., Wetzel, C.E., Ector, L., Katoh, K., Sa´ul, B. and Mayama, S. 2010. Response of Epilithic Diatom Communities to Environmental Gradients in Subtropical Temperate Brazilian Rivers. *Limnetica*. 29(2): 323-340.

Magurran, A.E. 1988. *Ecological Diversity and Its Measurement.* USA: Chapman and Hall.

Mudiyarso, D., J. Purbopuspito, J. B. Kauffman, M. W. Warren, S.D. Sasmito, D.C. Donato, S. Manuri, H. Krisnawati, Sartji T. and Kurnianto, S. 2015. The potential of Indonesian Mangrove forests for Global Climate Change Mitigation. *Nature Climate Change.* 5 (12) : 1089-1092.

Nasria, R., Salwiyah and Irawati, N. 2016. Perbandingan Kepadatan Dan Keanekaragaman Perifiton Pada Subtrat Buatan Yang Berbeda Di Perairan Air Terjun Tinonggoli (Nanga-Nanga) Kota Kendari Sulawesi Tenggara. *Jurnal Manajemen Sumber Daya Perairan*, 2(1): 71-78.

Novelo, E. and Tavera, R. 2003. *The role of periphyton in the regulation and supply of nutrients in a wetland at El Edén, Quintana Roo. In Lowland Maya Area: Three Millennia at the Human-Wildland Interfase, A. Gómez-Pompa, S. Fedick, M. Allen and O. J. Jimenez (eds.).* Binghamton: The Haworth Press Inc. 217-239 pp.

Nybakken, J. W. 1992. *Biologi Laut Suatu Pendekatan Ekologi* (Diterjemahkan). PT. Gramedia, Jakarta. 36 – 85 hlm.

Odum. 1971. *Fundamental of Ecology* . 3rd ed. W. B Saunders Company. Philadelphia.

Pranata, R., Ardiansyah, F. and Sari, W.F. 2018. Pemetaan Habitat Bentik Intertidal: Informasi Awal Perencanaan Pengelolaan Pesisir Laut Secara Spasial di Bulak Setra dan Batu Karas, Kabupaten Pangandaran. *Semnas Geomatika. 2017*. 105-114 pp.

Purwani, A., Suwono, H. and Prabaningtyas, S. *Analisis komunitas bacillariophyta perifiton sebagai indikator kualitas air di Sungai Brantas Malang, Jawa Timur*. http://jurnalonline.um.ac.id/data/artikel/artikelF424498E5A9785A3B46A489C996C22C9.pdf (diakses pada 3 Mei 2019 pukul 17.00 WIB).

Putra, A., Husrin, S. and Kelvin, J. 2015. Identification of Changes Area of Greenbelt in Pangandaran Regency, West Java Using Landsat. *Jurnal Akuatika.* 6 (1) : 59-67).

Rosada, K.K., Sunardi, T.D.K. and Pribadi S.A. Putri, 2017. Struktur Komunitas Fitoplankton Pada Berbagai Kedalaman Di Pantai Timur Pananjung Pangandaran. *Jurnal Biodjati*. 2 (1) : 30-37.

Sahlan, M. 1982. *Planktonologi.* Semarang: Fakultas Perikanan and Kelautan Universitas Diponegoro, pp. 117.

Salwiyah and Nadia, A.R. 2013. *Kajian Keragaman Jenis and Biologi Reproduksi Ikan Ricefish Endemik Sulawesi Sebagai Upaya Konservasi di Kawasan Air Terjun Tinonggoli dan Wisata Air Terjun Moramo*. Kendari : Universitas Halu Oleo.

Sivaranjani, S., Rakshit, A. and Singh, S. 2015. Water Quality Assessment with Water Quality Indices. *International Journal of Bioresource Science*. 2 (2): 85-94.

Suwartimah, K., Widianingsih, Hartati, and Wulandari, S.Y. 2011. Komposisi Jenis and Kelimpahan Diatom Bentik di Muara Sungai Comal Baru Pemalang. *Jurnal Ilmu Kelautan*. 16(1) : 16-23. Universitas Diponegoro.

Suwignyo, S. Dkk. 2005. Avertebrata Air (Jilid 1). Jakarta: Penebar Swadaya.

Widyarini, H., Pratiwi, N.T. M. and Sulistiono. 2017. Zooplankton Community Structure at Majakerta Estuarya and its Surrounding Waters, Indramayu Regency, West Java Province. *Jurnal Ilmu and Teknologi Kelautan Tropis*. 9 (1) : 91-103.

Wilha, J.F. 1975. *Biological Indicator of Pollution.* London: Blackwell Scientific Publications.