Jurnal Biodjati 5(1):23-32, May 2020

e-ISSN : 2541-4208
p-ISSN : 2548-1606

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

DISTRIBUTION OF PERIPHYTON IN THE UPSTREAM SECTION OF CITARUM RIVER, WEST JAVA, INDONESIA

Isma Noviana[1], Tri Dewi Kusumaningrum Pribadi[2]*, Keukeu Kaniawati Rosada[3]

Received : February 11, 2020
Accepted : April 17, 2020

DOI: 10.15575/biodjati.v5i1.7717

[1,2,3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran
Jl. Raya Bandung Sumedang Km 21, Jatinangor Sumedang, 45361

e-mail:
[1]isma17001@mail.unpad.ac.id
*[2]tridewi.pribadi@unpad.ac.id
[3]keukeu@unpad.ac.id

**Corresponding author*

Abstract. *Periphyton indeed plays an undeniably vital role as primary producers in the food web within aquatic ecosystems such as rivers. The existence of periphyton will affect the populations of the aquatic organisms at higher trophic level, thus it is interesting to be explored, especially in big rivers like Citarum. This study aimed to explore the distribution of periphyton, including its types and abundance at several stations in the upstream part of Citarum River based on the land use in the riverbanks, in the dry season of 2018. Samples were taken at nine stations, namely Gunung Wayang Springs, Outlet Cisanti at the valley of Mount Wayang and the connecting tributaries as follows: Cihejo, Cibuni, Cirasea, Cikaro, Cisangkuy, Cikapundung and Ciwidey. Samples of periphyton were taken from the substrate of stone, wood, plastic and macrophytes at three sampling points of each station. Periphyton samples were then scraped off from the surface of the substrate, where the deposit would then be filtered using plankton net No. 20, preserved with Lugol 1% and subsequently identified. The results showed there were 83 species from 58 genera of both phyto-periphyton and zoo-periphyton, classified as periphyton found on the sites. The total abundance of phyto-periphyton ranged between 2.3 x 104 ind/m^2 and 1.3 x 108 ind/m^2 where the total abundance of zoo-periphyton covered from 4.7 x 102 ind/m^2 to 3.7 x 105 ind/m^2. The highest and the lowest numbers of total abundance of periphyton were shown at stations of Gunung Wayang Spring and Cirasea tributary, respectively.*

Keywords: *Citarum River, periphyton*

Citation
Noviana, I., Pribadi, T. D. K. & Rosada, K. K. (2020). Distribution of Periphyton in the Upstream Section of Citarum River, West Java Indonesia. *Jurnal Biodjati*, 5(1), 23-32.

INTRODUCTION

The upstream section of Citarum River plays an important role as a multi-purpose river in the province of West Java. Citarum River stretches 269 km from highland in the middle of West Java to the northern coast of Java Island, which is still part of the province of West Java. The main water source comes from the springs around Mount Wayang and flows through 8 regions in West Java Province (LIPI, 2017).

Citarum watersheds are dominated by anthropogenic activities such as industrial, settlement and agriculture (Pratiwi, 2018). The upstream part of Citarum changes in its land use, especially due to rapid urbanization, forest conversion and agricultural intensification (Agaton et al., 2016). Citarum River streams its water all the way through 8 regions and the water is mostly used as the main source for drinking, irrigation, fisheries and also industrial needs such as providing electricity for Java and Bali islands.

Based on the Decree of West Java Governor No. 39/2000 and the statement of the Centre for Research and Development of Natural Resources and the Environmental Management Agency (BPLHD) of West Java, it is stated that the water quality of Citarum River is below water quality standard throughout the year, especially during the dry season and hence categorized as a highly polluted river. The high level of pollution in Citarum River has affected the aquatic organisms such as periphyton, whose existence was once relatively settled and now leading to disrupted ecosystem (Utami, 2019).

Earlier research on plankton in the upstream part of Citarum River has been conducted at different sampling locations, which taken from water samples, resulting in 31 genera of plankton that consist of 22 genera of phytoplankton and 9 genus of zooplankton (Putra et al., 2012). The research on the presence of periphyton was intended to determine the types and abundance of periphyton in order to provide information about the condition of waters in the upstream section of Citarum River, with different sampling stations in comparison to earlier research by Putra et al. (2012). This also based on the reason that periphyton, especially phytoplankton, is a resource base supporting production at higher trophic levels in the aquatic ecosystem (Cloern et al., 2014) and its community structure is an expression of the environmental health or biological integrity of a particular water body (Ekwu & Sikoki, 2006).

The study took place at nine stations on the upstream part of Citarum River comprising of springs, outlets, and tributaries, which the periphyton as part of the plankton that become the main subject. The results of this study are required for the consultancy on the basin of Citarum River in order for the authorities to determine suitable recovery measures for the watersheds' health, particularly the Citarum itself.

MATERIALS AND METHODS

Sampling Sites and Time

This study was conducted in the upstream of Citarum River using purposive sampling method based on the input of the water from tributaries of Citarum River (Figure 1 & Table 1). The research was conducted from September – October 2018.

In once sampling series, the periphytons were taken from substrates such as stone, wood, trash, and macrohydrophytes along the sampling stations. Periphyton substrates were then put into portion in accordance with the size of the area of the substrate and separated using a soft brush. The substrate which has been separated from periphyton would then be rinsed with distilled water, followed by filtering the water using a plankton net No. 20. The area measurement of periphyton was using milimeter blocks, which be matched to the surface area of substrate. The abundance of periphyton was calculated after observation under a microscope with magnification 100, counting the individuals of periphyton in water samples using Sedgewick Rafter Counting Cell (SRC). The periphyton identified referring to the book by Prescott (1980), and calculated using formulae from Eaton et al. (1995). Ecological indices comprised Diversity Index (H '), Evenness Index (E) and Simpson's Diversity Index (D) (Table 2).

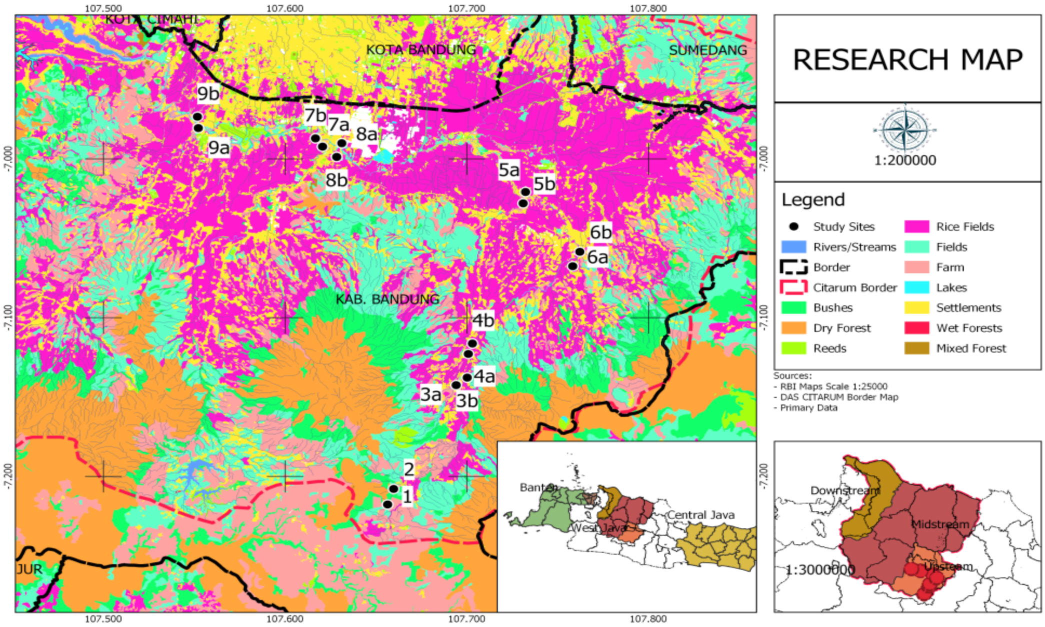

Figure 1. Stations of periphyton sampling in the upstream part of Citarum River, where periphyton samples from tributaries were taken from two different points (before and after the tributary water entered and got mixed with Citarum River);

Table 1. Description of periphyton sampling locations

Location	Sampling Point (Coordinates)	Anthropogenic activities
Gunung Wayang	Springs (1) (107°39'23.06"E 7°13'3.79"S)	Spring of Gunung Wayang Several fish ponds Tea plantations
Outlet Cisanti	Outlet Cisanti (2) (107°39'34.97"E 7°12'28.49"S)	Situ Cisanti Touristic area in point of 0 Km
Cihejo	Cihejo tributary (3a) (107°41'53.44"E 7°8'26.04"S) Cihejo + Citarum (3b) (107°41'53.99"E 7°8'24.77"S)	Agriculture
Cibuni	Cibuni tributary (4a) (107°42'7.69"E 7°7'16.28"S) Cibuni + Citarum (4b) (107°42'8.62"E 7°7'14.36"S)	Domestic rock mining and irrigation
Cirasea	Cirasea tributary (5a) (107°43'51.98"E 7°1'30.08"S) Cirasea + Citarum (5b) (107°43'48.29"E 7°1'27.24"S)	Sand dredging Domestic brick factory Textile factory
Cikaro	Cikaro tributary (6a) (107°45'37.77"E 7°3'48.58"S) Cikaro + Citarum (6b) (107°45'36.45"E 7°3'44.69"S)	Sand washing
Cisangkuy	Cisangkuy tributary (7a) (107°37'27.96"E 6°59'22.53"S) Cisangkuy + Citarum (7b) (107°37'26.58"E 6°59'19.00"S)	Settlement
Cikapundung	Cikapundung tributary (8a) (107°37'52.23"E 6°59'24.42"S) Cikapundung + Citarum (8b) (107°37'44.64"E 6°59'29.18"S)	Textile factory Public market Local gold mining
Ciwidey	Ciwidey tributary (9a) (107°33'7.96"E 6°58'50.03"S) Ciwidey + Citarum (9b) (107°33'1.80"E 6°58'38.12"S)	Sand dredging

Jurnal Biodjati 5(1):23-32, May 2020

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

Table 2. Ecological indices used in the analysis of periphyton (Wilhm & Dorris 1968; Odum 1996; Berger & Parker, 1970)

Index	Formula	Criteria
Shannon-wiener Diversity Index (H ')	$H' = -\sum\left[\left(\frac{ni}{N}\right) ln\left(\frac{ni}{N}\right)\right]$	H '<1 ; low diversity 1 <H '<3 ; moderate biodiversity H '> 3 ; high diversity
Evenness Index (evenness)	$E = \frac{H'}{\ln s}$	E = 1 ; high evenness
Simpson's Diversity Index (D)	$D = 1 - \sum\left(\frac{ni}{N}\right)^2$	D = 1; low dominance

RESULTS AND DISCUSSION

The periphyton found in all stations comprised 58 genera with all their 83 species (Table 3). These 83 species were classified into 80 species of phyto-periphyton and 3 species of zoo-periphyton.

The species of periphyton was mostly present in Cikaro station while the highest number of phyto-periphyton was found in stations of Cikaro and Cikapundung, where zoo-periphyton on the other hand was mostly encountered in Cihejo and Cikaro (Figure 2).

There were 21 species of periphyton found on all substrates (Table 3). These species were cosmopolitan that they can actually live in various substrates, while others found only in specific substrates. There were four species of periphyton found only in the trash (macroplastic from domestic activities), five species found only in macrohydrophytes and 10 species found only on the stone surface, 18 species found only on wood (Table 3). This finding showed that wood was the most liked substrate to be inhabited by periphyton among others. This result also in line with Signor et al. (2015), which reported that wood, was the most liked substrate for periphyton, and this presumably due to the use of substrate for the production of organisms as a source of food.

Table 3. Number of species in each periphyton genus in the Citarum's Upstream

Genus	Species	Substrates			
		Stone	Wood	Macrohydrophytes	Trash
Arcella	*Arcella vulgaris*	√	√	√	√
Criconema	*Criconema* sp.	√			
Achnanthes	*Achnanthes lanceolata*	√	√	√	√
Amphipleura	*Amphipleura* sp.		√		
Amphora	*Amphora* sp.	√			√
Anomoeneis	*Anomoeneis* sp.	√	√	√	√
Bacillaria	*Bacillaria paradoxa*		√		
Cocconeis	*Cocconeis duplex*	√	√	√	√
Cyclotella	*Cyclotella meneghiniana*				√
	Cyclotella polymorpha	√			
	Cyclotella sp.	√	√	√	√
Cymatopleura	*Cymatopleura elliptica*		√		√
Cymbella	*Cymbella naviculiformis*	√	√	√	√
	Cymbella sp.	√		√	√

Diatoma	*Diatoma* sp.				√
Diploneis	*Diploneis* sp.		√	√	√
Encyonema	*Encyonema* sp.		√		
Epithemia	*Epithemia adnata*	√		√	
	Epithemia turgida		√	√	√
Fragilaria	*Fragilaria* sp.	√	√	√	√
Gomphonema	*Gomphonema olivaceum*	√	√	√	√
	Gomphonema sp.	√	√		
Gyrosigma	*Gyrosigma* sp.		√		
Melosira	*Melosira granulata*	√	√	√	√
Navicula	*Navicula arvensis*	√			√
	Navicula sp.	√	√	√	√
Nitzschia	*Nitzschia filiformis*		√	√	√
	Nitzschia linearis		√		
	Nitzschia plicatilis		√		
	Nitzschia sp.	√	√	√	√
	Nitzschia vermicularis	√	√	√	√
Pinnularia	*Pinnularia biceps*		√		
	Pinnularia dactylus		√		
	Pinnularia sp.	√			
	Pinnularia viridis	√	√	√	√
Stauroneis	*Stauroneis phoenicenteron*		√	√	√
Stenopterobia	*Stenopterobia* sp.		√		
Surirella	*Surirella* sp.	√	√	√	√
Synedra	*Synedra* sp.	√	√	√	√
Tabellaria	*Tabellaria fenestrata*	√			
Cladophora	*Cladophora* sp.	√	√		
Closteriopsis	*Closteriopsis* sp.	√			
Closterium	*Closterium acutum*		√		
	Closterium pronum	√	√		
	Closterium sp.	√	√	√	√
	Closterium strigosum		√		
Coelastrum	*Coelastrum* sp.	√			
Cosmarium	*Cosmarium ralfsii*	√			
	Cosmarium sp.	√	√		
Crucigenia	*Crucigenia* sp.	√			
	Crusigenia fenestrata				√
Hyalotheca	*Hyalotheca* sp.	√	√		
Oedogonium	*Oedogonium* sp.		√		
Pediastrum	*Pediastrum duplex*	√	√	√	√
	Pediastrum sp.		√		

Scenedesmus	*Scenedesmus acuminatus*			√	
	Scenedesmus armatus	√	√	√	
	Scenedesmus obliquus	√	√		√
	Scenedesmus opoliensis		√		
	Scenedesmus parisiensis			√	
	Scenedesmus sp.	√	√	√	√
Sphaerozosma	*Sphaerozosma* sp.				√
Spirogyra	*Spirogyra* sp.	√	√	√	√
Staurastrum	*Staurastrum* sp.		√	√	
Tetraedron	*Tetraedron triangle*		√		
Zygnema	*Zygnema* sp.			√	
Gambusia	*Gambusia affinis*			√	
Tribonema	*Tribonema* sp.		√	√	√
Anabaena	*Anabaena spiroides*				√
Chroococcus	*Chroococcus turgidus*			√	
Microcystis	*Microcystis* sp.	√			
Nodularia	*Nodularia* sp.	√			
Oscillatoria	*Oscillatoria* sp.	√	√	√	√
Plectonema	*Plectonema* sp.		√		
Spirulina	*Spirulina* sp.	√		√	√
Stigonema	*Stigonema* sp.	√	√	√	
Stanieria	*Stanieria* sp.	√	√	√	√
Euglena	*Euglena acus*		√		
	Euglena sp.	√	√		
Phacus	*Phacus* sp.	√	√		√
Trachelomonas	*Trachelomonas* sp.		√	√	√
Peridinium	*Peridinium* sp.		√		
Lemanea	*Lemanea* sp.			√	
58	83	46	57	39	39

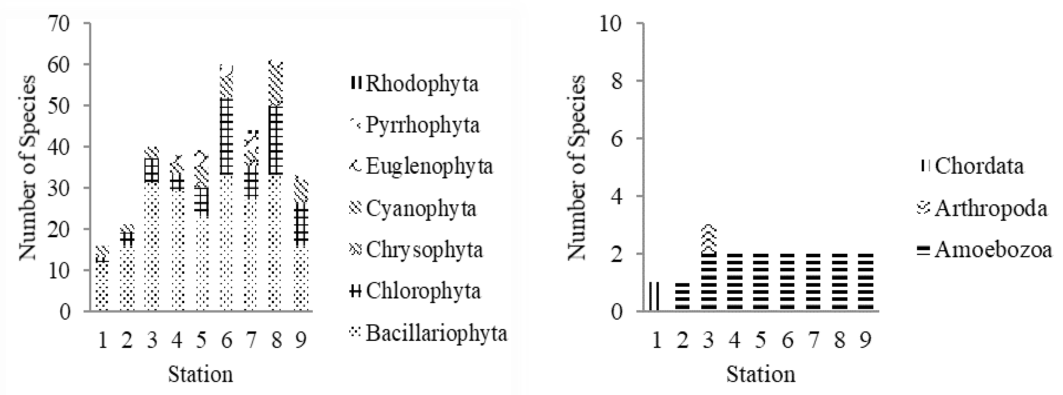

Figure 2. Composition of the number of types of periphyton in each station during sampling period; phyto-periphyton (left) and zoo-periphyton (right).

The abundance of periphyton by species has a value ranging from 2.3 x 103 ind/m^2 to 2.2 x 109 ind/m^2. The highest abundance of periphyton was found in Station 1 (Gunung Wayang Spring), while the lowest was in Station 9 (Ciwidey) (Table 4). This presumably due to the different environmental stress received by both stations, while station 1 is relatively better in water quality in comparison to mixed tributary and the main river (Station 9). In terms of groups, the most abundance one was found in Bacillariophyta, and this result has led us to presume that the area had been in eutrophic condition. Bacillariophyta proved to be the bioindicator of eutrophic conditions in the aquatic ecosystem, including in the river (Woods et al., 2019).

The total abundance of periphyton (Table 4) found during sampling period varied among stations, ranging from 2.3 x 104 ind/m^2 (Station 9) up to 1.3 x 108 ind/m^2 (Station 1) for phyto-periphyton and from 4.7 x 102 ind/m^2 (Station 1) up to 3.7 x 105 ind/m^2 (Station 7) for zoo-periphyton. These results presumably were due to different land utilisations along the riverside, which gave different loading nutrients as a result. Similar results were mentioned in Putra et al. (2012), showing various abundance among stations.

Station 1 showed the highest abundance of phytoperiphyton, which was presumably due to its type of the station, in this case, springs, with its lower environmental stress in comparison to other stations that have been exposed to anthropogenic activities, such as industrial and agriculture. On the reverse, Station 7 showed the highest value of zoo-periphyton abundance, presumably due to the presence of abundant food sources rather than environmental factors whereas the environmental factors were still in the normal range for the growth support.

Due to the water quality, the lowest value of the abundance of phyto-periphyton was found at Station 9 made it highly unlikely to support the growth and development of phytoperiphyton during the sampling period. Likewise, with zoo-periphyton found in Station 1, which scored the lowest abundance due to its water condition, they were also less supportive of growth and development even in conditions of having abundant food sources.

The ecological indices being observed were biological Diversity Index (H'), Evenness Index (E) and Simpson's Diversity Index (D). These indices show the richness of a community as well as the balance of the amount of each species.

Table 4. Total abundance of phytoperiphyton and zooperiphyton in the upstream section of Citarum River

Stations	Total abundance (x10^4 ind/m^2)	
	Phyto-periphyton	Zoo-periphyton
1	13356.5688	0.0470
2	60.5547	0.0375
3	2552.4631	0.1203
4	46.4868	0.6434
5	5.6744	0.9577
6	754.2240	4.5411
7	29.8482	37.1466
8	2108.7792	2.4244
9	2.2740	10.1032

The results (Table 5) showed that the value of the diversity index of periphyton varies at each station. Station 1 has the lowest value of 0.008 in its diversity index and Station 4 has the highest value 1,651. Overall, the diversity index of Citarum's upstream during the sampling period amounted to 0.618. This overall result proves to be in accordance with Wilhm & Dorris (1968) and Odum (1996) that waters with a diversity index of less than 1 indicate a low species diversity even though Station 4 has a value of more than 1 in its diversity index.

Evenness Index value (E) of all stations being observed ranged from 0.003 to 0.520 (Table 5). In general, the evenness index value in each station showed a value smaller than 0.5 except in Station 4 where its index value was greater than 0.5. Having an evenness index value greater than 0.5 indicates that the individual distribution of species occurred unevenly, whereas the E value lower than 0.5 indicates that the distribution of species was relatively even. Overall, the uneven distribution of periphyton in the upstream section of Citarum River is triggered by the average value 0.187 of the Evenness Index. This result is in line with the dominance index where values in some stations are closer to 0 rather than 1, showing that there were dominant species in some stations, presumably due to high-stress level of abiotic factors, which in the end suppressed the growth of some species and drive growth other species in the reverse.

Apart from that, anthropogenic activities, such as agriculture which use herbicides and agricultural fertilizer can also trigger changes in aquatic organisms (Burford et al., 2012; Dalton et al., 2015), including periphyton communities (Tlili et al., 2012), which can be identified by the water quality and deviating sensitivities of periphyton taxa towards nutrients and other substance in the water column (Briggs & Kilroy, 2000; Rimet, 2012; Zizek et al., 2011).

Table 5. Ecological Indices of periphyton in upstream Citarum River during sampling period

Stations	Index		
	H'	E	D
1	0.008	0.003	0.032
2	0.967	0.313	0.582
3	0.600	0.178	0.345
4	1.651	0.520	0.828
5	0.954	0.283	0.688
6	0.059	0.016	0.199
7	0.625	0.180	0.487
8	0.380	0.102	0.169
9	0.319	0.088	0.295

ACKNOWLEDGEMENTS

This study was supported by the research grants from RISTEKDIKTI for the scheme of Fundamental Research 2019 with contract number 2826/UN6.D/LT/2019. The authors cordially thank Aep Saeppudin from Aquatic Laboratory of Centre for Environment and Sustainability Science – Universitas Padjadjaran for the plankton identification.

REFERENCES

Agaton, M., Setiawan Y. & Effendi H. (2016). Land Use / Land Cover Change Detection in an Urban Watershed: a Case Study of Upper Citarum Watershed, West Java Province, Indonesia. *Procedia Environmental Sciences,* 33, 654–660.

Berger, W. H. & Parker, F. L. (1970). Diversity of Planktonic Foraminifera in Deep-sea Sediments. *Science, New Series*, 168(3973), 1345–1347.

Briggs, B. F. J. & Kilroy, C. (2000). *Stream Periphyton Monitoring Manual*. New Zealand: NIWA.

Burford, M. A., Webster, I. T., Revill, A. T., Kenyon, R. A., Whittle, M. & Curwen, G. (2012). Controls on Phytoplankton Productivity in a Wet-Dry Tropical Estuary. *Estuarine Coastal and Shelf Science*., 113, 141 – 151.

Cloern, J. E., Foster, S. Q. & Kleckner, A. E. (2014). Phytoplankton Primary Production in the World's Estuarine-Coastal Ecosystem. *Biogeosciences*, 11, (2477).

Dalton, R. I., Boutin, C. & Pick, F. R. (2015). Determining in situ Periphyton Community Responses to Nutrient and Atrazine Gradients via Pigment Analysis. *Sci. Total Environ*., 515, 70 – 82.

Eaton, A. D., Clesceri, L. S. & Greenberg, A. E. (1995). *APHA (American Public Health Association): Standard Methods for the Examination of Water and Wastewater 19th ed*. Washington D. C: AWWA (American Water Works Association) and WPCF (Water Pollution Control Federation).

Ekwu, A. O. & Sikoki, F. D. (2006). Phytoplankton Diversity in the Cross River Estuary of Nigeria. *J. Appl. Sci. Environ. Manag*., 10, 89 – 95.

Indonesian Institute of Sciences (LIPI). (2017). The Citarum River Basin. Retrieved from http://lipi.go.id/siaranpress/Citarum-Harum-dan-Harapan-Pemulihan-Daerah-Aliran-Sungai/21575.

Odum, E. P. (1996). *Fundamentals of Ecology; 3rd Edition, Translation*. Yogyakarta: Gadjah Mada University Press.

Pratiwi. (2018). Overview of water quality in region Citarum River. *Optimizing environmental and Sustainable Industry Journal*, 1(1).

Prescott, G. W. (1980). *The Fresh Water Algae*. University of Montana: MC Brown Company Publishers.

Putra, A. W., Zahidah & Walim, L. (2012). Community Structure of Plankton in Upper Citarum River in West Java. *Journal of Fisheries and Marine Resources*, 3(4), 313–325.

Rimet, F. (2012). Recent Views on River Pollution and Diatoms. *Hydrobiologia*, 683, 1–24.

Signor, A., Signor, A. A., Boscolo, W. R., Reidel, A., Klein, S. & Feiden, A. (2015). Periphyton Biomass on Artificial Substrates During the Summer and Winter. *Ciencia Rural*, 45(1), 72–78.

Tlili, A., Montuelle, B., Berard, A. & Bouchez, A. (2011). Impact of Chronic and Acute Pesticides on Periphyton Communities. *Sci. Total Environ*., 409, 2102 – 2113.

Utami, A. W. (2019). The Citarum River Water Quality. Jakarta.

Wilhm, J. L. & Dorris, T. C. (1968). Biological Parameters for Water Quality Criteria. *BioScience*, 18, 477 – 481.

Wood, R. J., Mitrovic, S. M., Lim, R. P., Warne, M. S. J., Dunlop, J. & Kefford B. J. (2019). Benthic Diatoms as Indicators of Herbicide Toxicity in Rivers – A New Species at Risk (SPEARherbicides) index. *Ecol. Indicator*., 99. 203 – 213.

Zizek, S., Milacic, R., Kovac, N., Jacimovic, R., Toman, M. J. & Horvat M. (2011). Periphyton as Bioindicator of Mercury Pollution in a Temperate Torrential River Ecosystem. *Chemosphere*, 85, 883–891.