THE USE OF TROPHIC DIATOM INDEX TO DETERMINE WATER QUALITY IN THE UPSTREAM OF CILEUNGSI RIVER, WEST JAVA

Nuralim Pasisingi[1], Niken TM Pratiwi[2], and Majariana Krisanti[2]
[1)] Student in Aquatic Resources Management, Bogor Agricultural University
[2)] Lecturers in Aquatic Resources Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University
Received February 25-2014; Received in revised form June 03-2014; Accepted June 05-2014
Email: pasisinginuralim@gmail.com

ABSTRACT

Human activities in the watershed in the upstream of Cileungsi river have tendency to bring high organic materials to the river which determines the aquatic condition of the river. The decreased water quality is event because of the organic materials in the upstream of Cileungsi river would bring negative impacts towards water condition in the downstream. This study was conducted in determining the water quality in the upstream of Cileungsi river, using Trophic Diatom Index (TDI). The sampling was taken in four different sites in the river and sub-river of the upstream of the river. The sampling of ephilitic diatom organisms were taken by scraping the surface of substrate rocks using brush then soaked the materials into a sampling bottle which hasbun containing destile water. Diatom density was measured using census method according to standard of APHA 2012. The TDI score ranged from 48.25 to 60.47, indicating that the water quality of upstream of Cileungsi river is classified from good until poor condition.

KEYWORDS: Bioindicator, Cileungsi River Indonesia, Trophic Diatom Index, Water Quality

INTRODUCTION

The land conversion has made the forest become the farming land and housing. This is one of the factors in the changing of water condition in the upstream through the sedimentation and nutrient fertilization (Rahayu *et al.,* 2009). Human activities in the watershed in the upstream of Cileungsi river are farming and housing (Pasisingi *et al*., 2014). Those activities have tendency to bring high organic materials to the river which determines the aquatic condition of the river. The decreased water quality because of the organic materials in the upstream of Cileungsi river would bring negative impacts towards water condition in the downstream. Therefore, there is a need to measure the aquatic condition of the upstream of Cileungsi river.

The physical, chemical, and biological approaches have been widely used for a long time in determining the quality of aquatic condition. Junshum *et al.* (2008) stated that the biological approach is better than others since the responses of organism can show what happened to the circumstance condition for certain period of time while other approaches can only show the temporary condition.

One type of biota that has been used mostly for bioindicator in the river is the microalgae class (Dutta *et al.*, 2010; Li *et al.,* 2010; Soltani *et al.,* 2012). The group microalgae that can be used in determining the water condition is diatom (Kwandrans, 1998; Wu & Kow, 2002). Diatom is an autotroph organism which responds directly to the organic materials that come into the river either from the water or from outside water. Consequently, diatom becomes one of biological indicators which is used as the sign of the alteration of water quality. One index which uses diatom organism as the indicator of pollution of organic materials is called as TDI. This index is relatively simple and easy to be applied (Kelly & Whitton 1995). This index also has been used in the study of rivers in some tropical countries (Bellinger *et al.,* 2006).

A total and complete management needs to be designed to keep the continuation of ecological function of a river. Pasisingi *et al.* (2014) stated that the organic material parameter of water quality in the upstream of Cileungsi river was over than water quality standard from Government Regulation No. 82/2001 on water quality management and control over water pollution. One of the first ways to design the continued management of Cileungsi river is by determining the water quality. Hence, this study aimed at investigating or determining the water quality in the upstream of Cileungsi river using Trophic Diatom Index.

MATERIALS AND METHODS

This research was conducted in the upstream of Cileungsi river where the sampling was done for three times; from September 2013 until November 2013. The sampling was obtained from four different sites which are located in the river and stream in the upstream of Cileungsi river (Fig. 1) based on the land use. In each site, the sampling of diatom organism

Corresponding author:
Aquatic Resources Management, Bogor Agricultural University
Jl. Lingkar Akademik, Campus IPB Darmaga, Bogor 16680

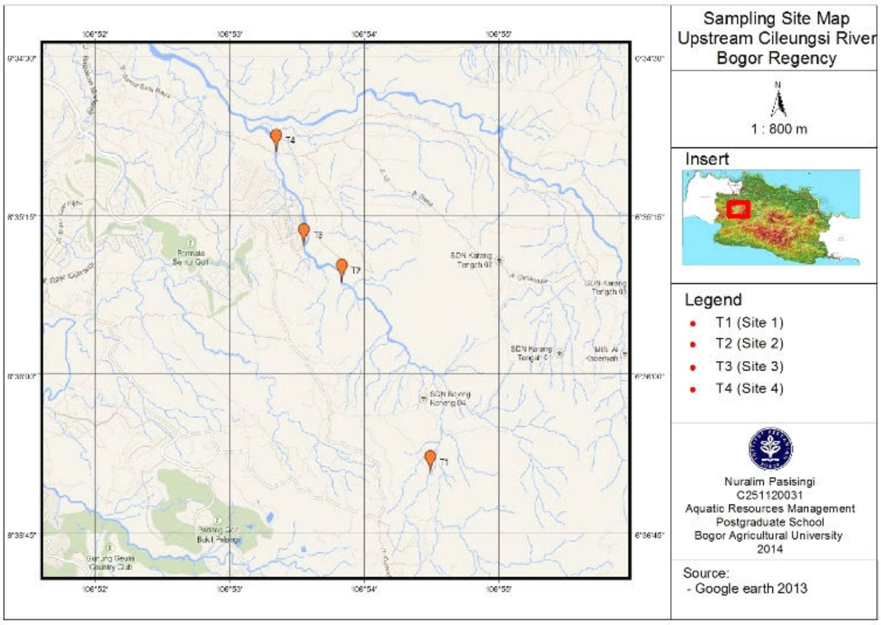

Figure 1. Sampling site used in the research. The distance of each station (1 to 2, 2 to 3, 3 to 4) respectively is 3.34 km, 0.86 km, and 1.39 km.

was taken in three sub sites. Purposively, the sampling at 3 until 5 rocks was taken in each sub site.

Ephilitic diatom sampling was obtained from substrate of rocks which are immersed on the river water but they are still exposed by the sun rays. The sampling of diatom organism was obtained by scraping the surface of substrate rocks using brush. The result of the scraping was placed into a sampling bottle of 10 ml volume containing destile water. The sampling was preserved with Lugol solution 1%.

The identification of diatom taxa is based on the book of plankton identification by Davis (1955); Presscot (1970); Belcher & Erika (1978); and Mizuno (1979) with an aid of trinokuler Zeiss Primo Star. Diatom density was measured by using census method based on the standard of APHA 2012 (Rice *et al.,* 2012).

The ephilitic diatom density was counted in order to find out the abundance of every particular diatom species which is found during the observation process. The TDI score was filled out with the indication of sample proportion which contained taxa that tolerant to the organic materials pollution (Kelly & Whitton 1995). TDI was counted according to 86 taxa (Lavoie *et al.,* 2009). It was formulated as:

$$TDI = (WMSx25) - 25 \quad \text{..1)}$$

$$WMS = \frac{\sum_{j=1}^{n} a_j s_j v_j}{\sum_{j=1}^{n} a_j v_j} \quad \text{..2)}$$

where, a_j = abundance or proportion of valves of species j in samples; s_j = pollution sensitivity (1-5) of species j; and v_j = indicator value (1-3). The list of sensitivities and indicator values for each taxon included in the TDI is given by Kelly (1998).

TDI score was expressed by WMS (*weighted mean sensitivity*) score which ranged from 0 – 100 (Kelly, 1998) with the ecological water status category in the following:

TDI < 35	: high
35 < TDI < 50	: good
50 < TDI < 60	: moderate
60 < TDI < 75	: poor
75 < TDI > 100	: bad

Cluster analysis by using Bray-Curtis similarity index (Brower *et al.,* 1990) was carried out to determine the classification of sampling site which is displayed on a dendrogram using Minitab 15.

RESULTS AND DISCUSSION

RESULTS

There are about 88 species of diatom recorded during the study (Appendix 1). The 21 dominant species which were found in each site are *Synedra capitata, Pleurosigma angulatum, Nitzschia clausii, Navicula laterostriata, Hantzschia amphioxys, Frustulia saxonica, Cymbella affinis, Stauroneis laurenburgiana, Plagiogramma pulchellum, Nitzschia acicularis, Navicula falaisiensis, Grammatophora serpentina, Fragilaria capucina, Cocconeis plancetula, Stauroneis absaroka, Pinnularia pervulissima, Navicula plancetula, Navicula cuspidata, Gomphonema apicatum, Eunotia brasiliensis, Achnanthes* sp. (Fig. 2). Based on the result *Navicula* and *Nitzschia* are the most dominant species in almost sites. It indicates that both of these genus are pollution tolerant species, so they can live in varies water condition.

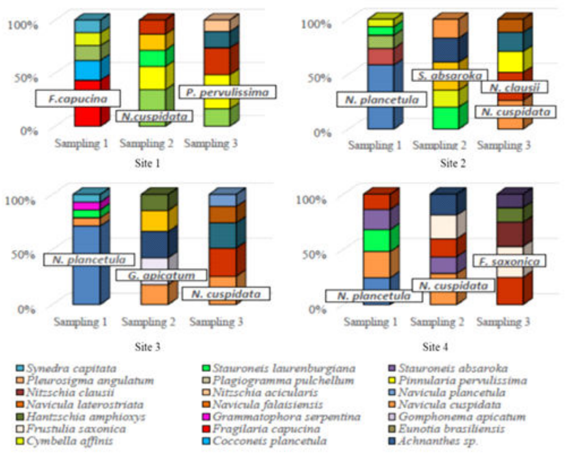

Figure 2. Dendrogram clustering diatom taxa density based on sampling sites.

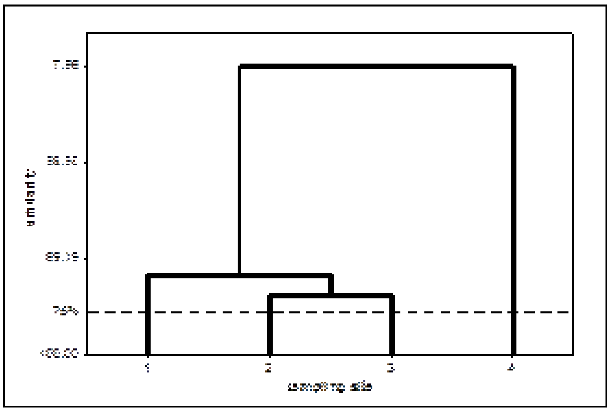

Figure 3. Trophic Diatom Index at 4 sampling sites.

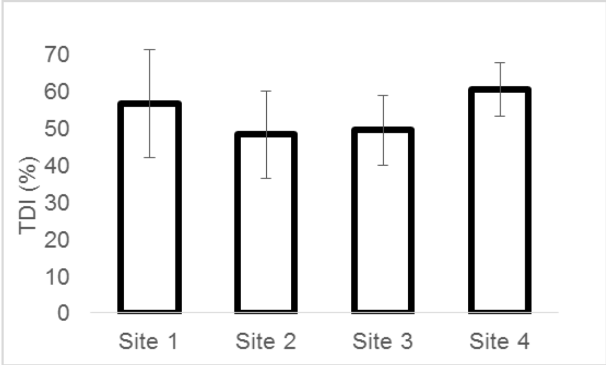

Figure 4. Trophic Diatom Index at 4 sampling site.

The result of cluster analysis towards the average abundance of ephilitic diatom shows that on the similarity level 75%, each site 1, 2, 3, and 4 form a group as shown in Figure 3. This grouping was caused by input materials from different watershed-land use.

From calculation, TDI score in each site is in average around 48.25 – 60.47 (Fig. 4). The average of TDI site 1 is 54.55, site 2 is 48.25, site 3 is 49.43, and site 4 is 60.47. The highest value of TDI is shown by site 4. The lowest value of TDI is shown by site 2. According to ecological status by Kelly (1998), the site 1 is on moderate ecological status, site 2 and 3 are on good status and site 4 is in poor condition.

DISCUSSION

The pennales diatom dominated the result of the observation. It occurred happened because the diatom species which observed in the study were ephilitic diatoms which live on the substrate rocks. The flowing water was characterized by the existence of bacillariophyceae the pennales diatoms which show the community of benthic (Weitzel, 1979). Generally, pennales diatoms live in the bottom of water but the centrales diatoms are planktonic in nature since they live floating on the water column. Diatom from pennales class tends to dominate the water with stream as benthic algae. This related to the form of its cell that can move against the stream and its membrane can stick and move on the substrate (Basmi, 1999; Sze, 1993). From the observed pennales diatom, the result shows that *Navicula* and *Nitzschia* dominated the water since most of diatoms from both genera are tolerant to the pollution of organic materials (Kelly, 1998).

The different characteristics of watershed in each site has caused this event. There is a farming land around site 1 and not many housing found there. Likewise in site 2, the land usage is for farming. In site 3, there are rice fields and farm land as well as people's housing. In site 4, there are many houses and human activity.

Based on biological calculation using TDI, the condition in the upstream of Cileungsi river needs to be managed and become the main concern. Therefore, an integrated management and a monitoring of the water condition in Cileungsi river need to be carried out. The quality of water in Cileungsi river might decrease, and likewise for the ecological function that might be disturbed if the right management is not applied immediately. The riparian buffer systems need to be designed along the riverbanks of Cileungsi to intercept surface runoff and subsurface flow. The riparian buffers would control non-point source pollution by removing nutrients. Riparian areas slow the flow of water, helping to ensure that sediments settle out before they reach the water course.

CONCLUSION

- The TDI score in the upstream of Cileungsi river ranged from 48.25 to 60.47, indicating that the water quality is classified from good until poor condition. According to ecological, the site 1 is on moderate ecological status, site 2 and 3 are on good status and site 4 is in poor condition.
- The highest TDI score is shown by site 4 compared to site 1, 2, and 3 since the location is located in around housing area which has a great potential to contribute organic materials from household activities.

ACKNOWLEDGEMENT

This research was budgeted by individual funding. I would like to thank to the head and staffs of Laboratorium Biologi Mikro 1, Manajemen Sumberdaya Perairan FPIK IPB who help us to analyze material samples.

REFERENCES

Basmi, J. 1999 (in Indonesian). *Planktonology: plankton as water quality bioindicator.* Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor.

Belcher, H. & S. Erika. 1978. *A beginner's Guide to Freahwater Algae*. Institute of Terrestrial Ecology. London (GB).

Bellinger, B.J., C. Cocquyt. & C. M. O'Reilly. 2006. Benthic diatoms as indicators of eutrophication in tropical streams. *Hydrobiologia*. 573: 75–87.

Brower, J.E., J. H. Zar & C. N. Von Ende. 1990. *Field and Laboratory methods for General Ecology, 3rd edition*. Wm.C. Brown Co. Publisher. Dubuquelowa.

Davis, C.C. 1955. The Marine and Freshwater Plankton. *Michigan State University Press*. Michigan (US).

Dutta, S. A., S. Kumari & A. Smita. 2010. Toxicokinetics and bioaccumulation of copper and lead in *Chironomus* sp. (diptera: chironomidae) at different temperature under laboratory condition. *The Bioscan.* 2: 313-321.

Junshum, P., S. Choonluchanon & A. Traichaiyaporn. 2008. Biological indices for classification of water quality around Mae Moh power plant, Thailand. *Maejo International Journal of Science and Technology.* 2(01): 24-36.

Kelly, M.G. 1998. Use of the trophic diatom index to eutrophication in rivers monitor. *Waf. Res*. 32(1): 236-242.

Kelly, M.G. & B. A. Whitton. 1995. The Trophic Diatom Index: a new index for monitoring eutrophication in rivers. *Journal of Applied Phycology.* 7: 433-444.

Kwandrans, J., P. Eloranta, B. Kawecka & K. Wujtan. 1998. Use of benthic diatom communities to evaluate water quality in rivers of Poland. *Journal of Applied Phycology.* 10: 193-201.

Lavoie, I., P.B. Hamilton, Y.K. Wang, P.J. Dillon, & S. Campeau. 2009. A comparison of stream bioassessment in Québec (Canada) using six European and North American diatom-based indices. *Nova Hedwigia Beiheft* 135: 37–56.

Li, L., B. Zheng, L. & Liu. 2010. Biomonitoring and bioindicators used for river ecosystems: definitions, approaches and trends. *Procedia Environmental Sciences.* 2: 1510–1524.

Mizuno, T. 1979. *Illustrations of the Freshwater Plankton of Japan*. Hoikusha Publishing Co Ltd. Osaka (JP).

Pasisingi, N., N.T.P.Pratiwi, & M. Krisanti. 2014 (in Indonesian). The water quality of upstream of

Cileungsi River based on physico-chemistry condition. *Depik*. 3(1): 56-64.

Prescott, G.W. 1970. H*ow to Know The Freshwater Algae*. Wm. C. Brown Company Publishers. Montana (US).

Rahayu, S., R.H. Widodo, N.M. Van, I. Suryadi & B. Verbist. 2009 (in Indonesian). Monitoring *of waters in river watershed. . Bogor, Indonesia*. Southeast Asia Regional Office: World Agroforestry Centre.

Rice, E.W., R.B. Baird, A.D. Eaton & L. S. Clesceri. 2012. APHA (*American Public Health Association*): Standard Method for The Examination of Water and Wastewater 22th ed., AWWA (*American Water Works Association*), and WEF (*Water Environment Federation*). Washington D.C. 20001-3710.

Soltani, N., K. Khodaei, N. Alnajar, A. Shahsavari & A.A. Ashja. 2012. Cyanobacterial community patterns as water quality bioindicators. *Iranian Journal of Fisheries Sciences*. 11(4): 876-891.

Sze, P. 1993. A Biology of the Algae. Editor: Kevin Kane. Wm. C. Brown Communication. Inc. Georgetown University. United States of America.

Weitzel, R. L. 1979. Methods and Measuremants of Perifiton Communities: A review American Society for Testing and Materials. Philadelphia.

Wu, J.T. & L.T. Kow. 2002. Applicability of a generic index for diatom assemblages to monitor pollution in the tropical River Tsanwun, Taiwan. *Journal of Applied Phycology.* 14: 63–69.

Appendix 1. 88 species of diatom recorded during the study

Number	Species	Number	Species
1	*Achnanthes exigue*	45	*Navicula tripunctata*
2	*Achnanthes* sp.	46	*Navicula viridis*
3	*Achnanthidium eutrophilum*	47	*Navicula subminuscula*
4	*Achnanthidium* sp.	48	*Neidium* sp.
5	*Amphora pediculus*	49	*Nitzschia acicularis*
6	*Caloneis bacillum*	50	*Nitzschia amphibia*
7	*Cocconeis pediculus*	51	*Nitzschia clausii*
8	*Cocconeis plancetula*	52	*Nitzschia dissipata*
9	*Coscinodiscus* sp.	53	*Nitzschia distans*
10	*Cymbella affinis*	54	*Nitzschia exilis*
11	*Cymbella ventricosa*	55	*Nitzschia fonticola*
12	*Denticula elegans*	56	*Nitzschia frustulum*
13	*Diatoma monoliformis*	57	*Nitzschia communis*
14	*Diatoma* sp.	58	*Nitzschia incristans*
15	*Diatoma vulgaris*	59	*Nitzschia kutzingiana*
16	*Encyonema minutum*	60	*Nitzschia linearis*
17	*Eunotia arcus*	61	*Nitzschia palea*
18	*Eunotia papilioforma*	62	*Nitzschia sigmoidea*
19	*Fragilaria capucina*	63	*Nitzschia socialis*
20	*Frustulia rhomboides*	64	*Pinnularia appendiculata*
21	*Frustulia saxonica*	65	*Pinnularia pervulissima*
22	*Frustulia vulgaris*	66	*Pinnularia viridis*
23	*Gamphoneis* sp.	67	*Plagiogramma pulchellum*
24	*Gomphonema apicatum*	68	*Planothidium lanceolatum*
25	*Grammatophora serpentina*	69	*Pleurosigma angulatum*
26	*Gyrosigma acuminatum*	70	*Pleurosigma intermedium*
27	*Gyrosigma exlmium*	71	*Pseudotaurosiropsis* sp.
28	*Gyrosigma peisonis*	72	*Staurastrum* sp.
29	*Hantzschia amphioxys*	73	*Stauroneis absaroka*
30	*Hantzschia* sp.	74	*Stauroneis anceps*
31	*Mastogloia braunii*	75	*Stauroneis amphicephala*
32	*Navicula anglica*	76	*Stauroneis ancepsfallax*
33	*Navicula cuspidata*	77	*Stauroneis parvula*
34	*Navicula dicephala*	78	*Stauroneis pseudagrestis*
35	*Navicula elegans*	79	*Stauroneis superkuelbsii*
36	*Navicula falaisiensis*	80	*Stenopterobia intermedia*
37	*Navicula gregaria*	81	*Surirella biseriata*
38	*Navicula laterostriata*	82	*Synedra affinis*
39	*Navicula medisculus*	83	*Synedra capitata*
40	*Navicula nunivakiana*	84	*Synedra formosa*
41	*Navicula plancetula*	85	*Synedra pulchella*
42	*Navicula pseudolanceolata*	86	*Synedra tabulata*