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Community structure and species diversity of Diatom in area between Telaga Warna and Telaga Pengilon, Indonesia

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Abstract

The diatom flora of the shallow lakes in border among Telaga Pengilon and Telaga Warna is poorly known. This study focuses on the composition of diatom assemblage in order to know the diversity and dominancy pattern for paleolimnological study. Total 103 taxa was observed, dominated by Eunotia formica 12,27%, Eunotia tropica 9,9%, Pinnularia gibba 4,3% and Frustulia saxonica 4,9%. Based on dominant species Eunotia formica occurring among the epiphyton and found in standing or slow-flowing dystrophic to oligotrophic waters with specific pH 5.6-7,4. But, in the top soil dominated by Eunotia bilunaris var. linearis about 14,50% and it was commonly found in acidic, flowing or standing waters with pH 2.8-3.5. The lowest diversity index represent at 102cm indicated that there is no diatom recorded, it caused by volcanic activity because Dieng area surronded by mountain area also has 31 eruptive history. The results of this research mention that in the border area has influence from both lakes so the pH fluctuated. Overall, diatom assemblages were similar to those Warna and Pengilon.

Keywords: Diatom, biostratigraphy, Warna, Pengilon.

Introduction

The vegetation and environmental history around Dieng were largely unknown until the end of 19th century with research about creater lakes in Dieng from Van Bergen[1]. Basically, Dieng is second highest plateau in the world after Nepal at about 2094 meter above sea level[1-4]. Dieng has unique characteristic with many freshwater ecosystems around that area such as lakes, creater (hydrothermal), valley, water spring and Vulcan complex[5]. The presence of fresh water is really important for irrigation source because Dieng plateau is a rich agricultural area for potatoes, cabbages, tomatoes and other vegetables[2]. Pengilon and Warna lake were located in Dieng, Furthermore, these habitats are characterized by specific ecological conditions, which enable the development of characteristic diatomic microflora that is specialized for pH fluctuations. The pH of Warna was fluctuated depends on seasonal variations about 2.2-5.35 and during the dry season, the pH reached 1. Another, Pengilon lake has pH about 2.52-7.9[6-8]. Research about lake really important because lake sediments provide primary archives containing important information about past environment.

Diatom well known as Bacillariophyta characterized by a silica impregnated cell wall called frustule and the most common benthic primary producers that abundant in all aquatic habitat, the ornamentation from diatom's cell wall makes it easy for identification[8-10]. Diatom consider to be useful indicator of environmental change both in neo and paleolimnological study because the silica preserved in the sediment and diatoms are extremely sensitive to many environmental variables, including light, pH, moisture, temperature, velocity, oxygen, salinity, and inorganic nutrients (carbon, phosphorus, nitrogen, silica, metal), organic carbon and organic nitrogen[11-13]. The aim of this study is to enhance our understanding of diatom assemblages in border between Pengilon and Warna.

Materials and methods

The study of the area is located on the Dieng Central Java in the border of Pengilon and Warna Lake with coordinate S07^{o}12.904" E109^{o}54.894" about 2088 meter above sea level. Stratigraphy sediment collection was obtained only from border area in Pengilon Lake, the three different location was selected for physical measurement, water quality was also checked with multiple water checker. Temperature, pH, conductivity were recorded, stratigraphy sediment was collected with corer from 50-160cm length.

In the laboratory, digestion methods using Soeprobowati et al[7] modified from Battarbee[14] the sample was either cleansed using acid digestion. Each sample was sliced and weighed about 1 gr, then digest with 50ml HCl 10% heat on a hotplate about 90^{0}C in a fume cupboard until all organic material has been oxidized about 2 hours. Wait for 24 hours then removed acid and washed in 50ml distilled water these process repeat for several times. After repeated rinse, add the sample with 50ml H_2O_2 10% and heat again for 2 hours long, decant off supernatant and repeat washing process at least four times in order to clean diatom frustules and removed $CaCO_3$[7-9,14,15].

The cleaned valves were mounted onto slides with Naphrax and observed at 1000x magnification, to assess relative representation of all algae group 400 individual from each sample were counted, the identification process mainly using Gell et.al.[9], Sonneman et al.[16], Taylor et al.[11], Krammer and Bertalot[17-19]. The Shannon Winner, Species Richness and Dominance Index, Bryan Curtis correlation were calculated to measures community structure and performed using PAST, A nonparametric test, for eample Kruskal Wallis as used to analysis of variance between each sample and Mann Whitney was used to compre means of Species richness, Shannon, dominancy. Based on Jongman *et al.*[20] and Bere[21] assuming that normality rarely happened in the nature for environmental study and nonparametric test help to avoid the distortion.

Results and discussion

The values of physical variables measured in the site location during the study period are shown in Table-1. The pH slightly down near Warna site, it caused by the influence from Telaga Warna that has pH around 3 [1]. Soeprobowati T.R.[6] reported that pH in Warna slightly down and fluctuated depend on seasonal variation. pH in Telaga Pengilon varied about 6.8-7, the mean value of pH showed slightly alkaline. However, the difference in pH among the three sites described below was not statiscally significant.

Table-1: Physical characteristic of Pengilon Lake.

	Site 1	Site 2	Site 3
Coordinate	S 07^{0}12.903" E 109^{0} 54.934"	S 07^{0}12.973" E 109^{0} 54.040"	S 07^{0}12.904" E 109^{0} 54.894"
Elevation	2086 asl	2077 asl	2088 asl
pH	6.7	7.9	7
Conductivity	70	120	120
Turbidity	30	50	50
Temperature (celcius)	19,8	20,2	21,5

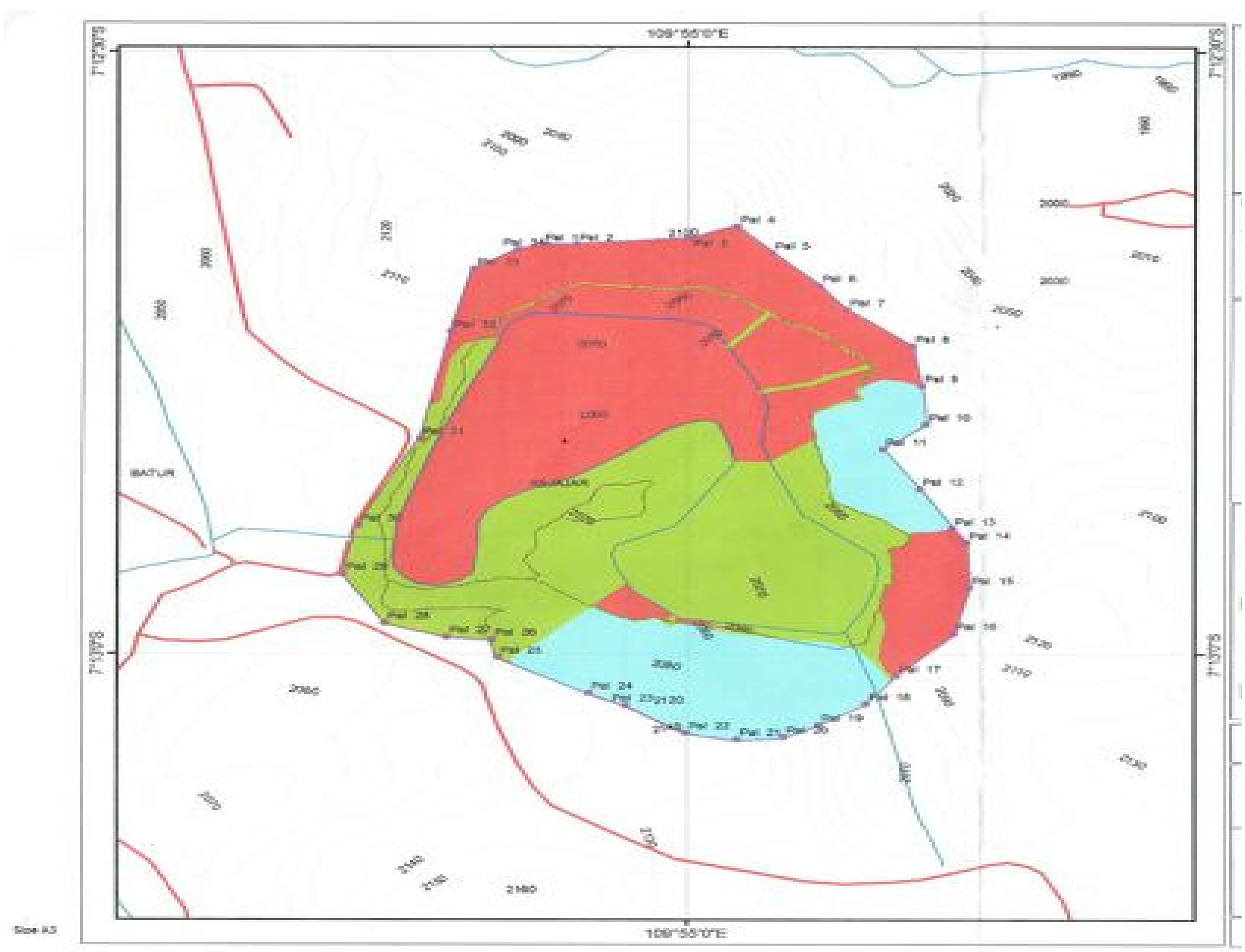

Figure-1: Map of study area[22].

A total 103 diatom species belonging to 25 genera that are distributed among the genus Achanthes, Achantidium, Brachysira, Chamaepinullaria, Cocconeis, Cymbopleura, Denticula, Diploneis, Encyonema, Eunotia, Fragillaria, Frustulia, Gomphonema, Hantzschia, Luticula, Navicula, Neidium, Nitzschia, Peronia, Pinnularia, Rhopallodia, Sellaphora dan Stauroneis. Of the 103 species were observed (Table-2) only 10 species were consider as the dominant (>2% abundance). Eunotia highly dominant with 53,2% abundance, the percent abundance of Pinnularia about 16%. Five genera contribute about 81,7% total abundance, these were Eunotia with 53,2%, Frustulia 6%, Navicula 2,4%, Nitzhia 4,1% and Pinnularia bout 16%. Every site was dominated by one to five species with relative abundance >10%. The most common abundant species was *Eunotia formica* (Ehrenberg) about 12,2%. Other common taxa included in assemblages composition such as *Eunotia tropica* (Husdtedt), *Pinnularia gibba* (Ehrenberg), *Frustulia saxonica* (Rabenhorst), *Eunotia bilunaris var. linearis* (Ehrenberg), *Pinnularia hemipteriformis* (Krammer), *Pinnularia viridiformis* (Nitzsch).

Four diversity indices used were Dominance, Shannon Wiener, Simpson, Evenness to find out the interrelationship among the site (Table-2). Simpson index is used to access the dominance, Based on Shannon Winner index reported that all of stratigraphy site has high diversity index (0.06-3.8) and Dominant index about (0.02-0.5) also Evaneses index about (0.2-1).

Shannon diversity and evenness (relative species abundance) presented small variation between all samples. The value of evenness around 0 indicated that only one species is dominance. Eunotia formed up 80% of the total organism, the abundance of this species with a resulting decrease Shannon index. We can see from our results that the diversity and evenness in this site from the 80cm are much higher than another site about 3.8 (Figure-2). This site has 87 taxa as a greater number of species present, the individuals in the community are distributed more equitably among these species. Site 80 was different among each site, the species richness, diversity were higher compared with another, the site was charactherized by *Eunotia tropica*.

The lowest diversity is shown in site 102cm with 0.69. The lowest Eveness is site 60 about 0.28. This site has several species tolerant. Different levels of disturbance have different effects on diversity, both of sides are dominated with Eunotia but in the site 102-110cm only 6 taxa that represent there are fewer than another site, no diatom recorded in this zone only broken frustule. According to the Evenness's index the value range from 0.2-1, it indicated that species are not evenly distributed. The species compotition changed about 0.6312 based on Whittaker beta diversity. Beta diversity was used to analysis diversity species along environmental gradient[23].

Based on Kruskal-Wallis analysis the result is no significant difference between each site with (p>0.05) it caused by each site have same dominant species, based our result *Eunotia formica* and *Eunotia tropica* were the dominant species (Figure-2). Mann Whitney pairwise comparison of species was significantly high (Kruskal-Wallis, p>0,05) on every site (Table-3). No significant difference between site was observed. However, broken frustule from 6 species found in site 102cm, and these value significantly low than another site, indicated that the diatom assemblages had disturbance factor from environment. These site totally difference with another site based on diatom abundance. Further analysis was needed to investigate the difference each site.

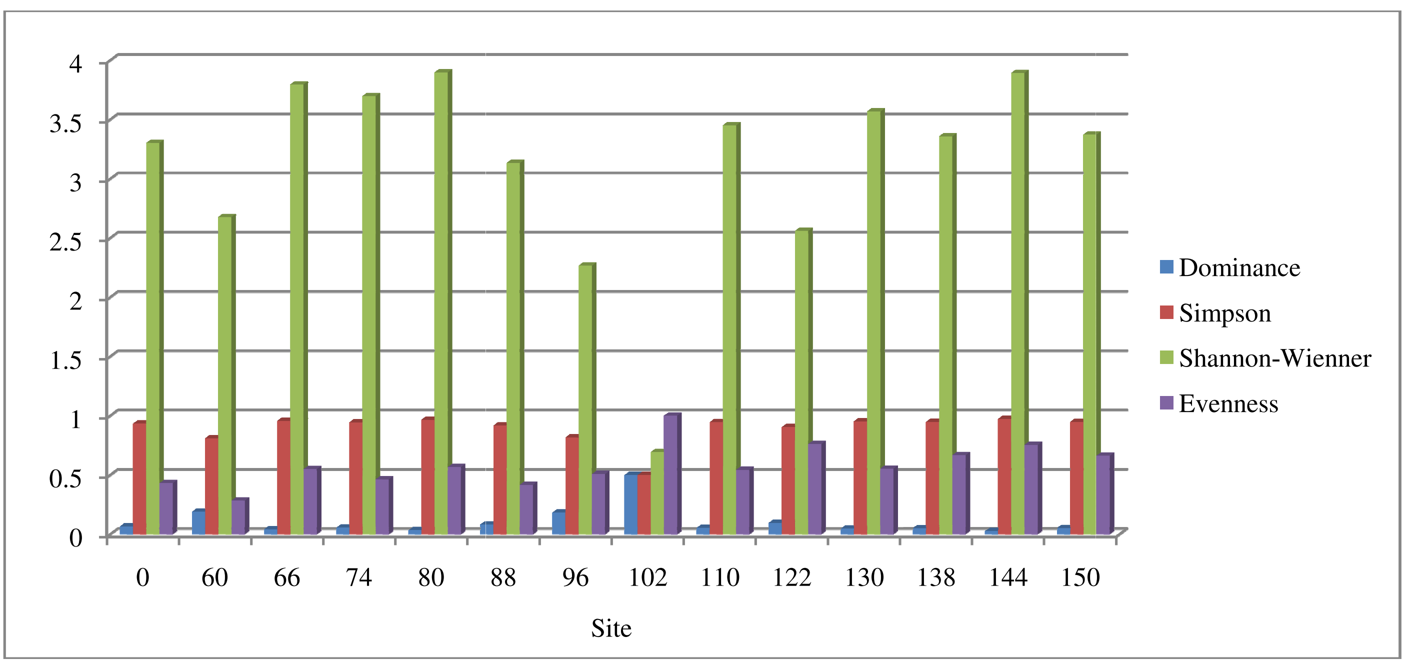

Figure-2: Diversity Index.

Telaga Warna and Telaga Pengilon was similar based on dominance species, both of lakes were dominated with Eunotia and Pinnularia species, even though the charactheristic between the lakes are different. Telaga Warna extremely acidic lake with ph around 3 and rich of sulfure, Telaga Pengilon actually alkali lake with clear water. Soeprobowati *et al.*[6] reported 8 species Eunotia and 6 species Pinnularia, from these research Telaga Pengilon was dominated Eunotia with 28 taxa followed by Pinnularia 17 taxa. Eunotia is a large genus that comprises around 200 species, Eunotia has biggest world-wide distribution area, many species are restricted to tropical areas[24,25].

Eunotia formica most dominant in all samples except in the top sediment. Other common species were *Eunotia monodon var. tropica, Eunotia zygodon, Frustulia saxonica, Eunotia sulcata, Pinnularia gibba, Pinnularia viridiformis, Pinnularia viridis* with percent abundance ≥2% were distributed frequently. Mostly dominance species in each stratigraphy is *Eunotia formica*, the characteristic of *Eunotia formica* are valves lunate dorsiventral and symmetrical to the transapical axis. Apices are weakly capitate, with acutely rounded to cuneate ends. The main characteristic is the central valves bigger than apical with a more or less pronounced it. Ecology reference occurring among the epiphyton and found in standing or slow-flowing dystrophic to oligotrophic waters with specific pH 5.6-7,4[11].

The most frequently ditom species had a generally widespread distribution. The layer relatively less diversity and species richness were characterized by 102. On the another hands, every site relatively similar with diversity around 3. But the composition of diatom abundance slightly different between upper layer and bottom layer. The upper layer was domiinated by *Eunotia bilunaris var.linearis* (Figure-3). Basically, *Eunotia bilunaris* is acid species with pH 2,8-3,5. The result indicated that the water around telaga warna and Pengilon mixtured during rainy season, the sampling site actually located in the area between Telaga Warna and Pengilon. Dieng has average rainfall quite higher around 3,217.5mm/year, wet months start from September to March.

Kihara *et al*[26] reported that there were 11 taxa Eunotia species in the Yakumogahara Moor in the Mountain Range Japan. Another year Kirara *et al*[27] reported that Eunotia species Yakumogahara Moor increased became 19 taxa, but Eunotia proportion has lower than previous research in the high Moor of Honshu. Puusep et al.[28] reported that Eunotia was dominant in the Lake Ķūzi, Vidzeme Heights (Central Latvia) around the lakes 5300-2500 cal. BP and its facilitated acidification process of the soil sediment. Hobbs et al[29] reported that in the Beowulf Spring, Yellowstone America is dominated by Eunotia. Eunotia rea/lly abundance in Indonesia because large genus that comprises around 200 species and more than 100 Eunotia were found in a tropical area. Eunotia well distributed around the world because their ability to tolerate with environmental condition such us large pH range about 2,9-8[30-32].

Table-2: Mann Whitney pair wise comparison of species site.

	0	60	66	74	80	88	96	102	110	122	130	138	144	150
0		0,67	0,89	0,89	0,67	0,67	0,67	0,89	0,89	0,89	0,67	0,89	0,67	0,89
60	0,67		0,67	0,67	0,67	0,89	0,89	0,89	0,67	0,89	0,67	0,67	0,67	0,67
66	0,89	0,67		0,89	0,89	0,67	0,67	0,67	0,89	0,67	0,89	0,89	0,89	0,89
74	0,89	0,67	0,89		0,89	0,67	0,67	0,89	0,89	0,89	0,89	0,89	0,89	0,89
80	0,67	0,67	0,89	0,89		0,67	0,47	0,67	0,89	0,67	0,89	0,89	0,89	0,89
88	0,67	0,89	0,67	0,67	0,67		0,89	0,89	0,67	0,89	0,67	0,67	0,67	0,67
96	0,67	0,89	0,67	0,67	0,47	0,89		0,89	0,67	0,67	0,67	0,67	0,67	0,67
102	0,89	0,89	0,67	0,89	0,67	0,89	0,89		0,89	0,89	0,89	0,89	0,47	0,67
110	0,89	0,67	0,89	0,89	0,89	0,67	0,67	0,89		0,67	0,89	0,89	0,89	0,89
122	0,89	0,89	0,67	0,89	0,67	0,89	0,67	0,89	0,67		0,67	0,67	0,67	0,67
130	0,67	0,67	0,89	0,89	0,89	0,67	0,67	0,89	0,89	0,67		0,89	0,89	0,89
138	0,89	0,67	0,89	0,89	0,89	0,67	0,67	0,89	0,89	0,67	0,89		0,89	0,89
144	0,67	0,67	0,89	0,89	0,89	0,67	0,67	0,47	0,89	0,67	0,89	0,89		0,89
150	0,89	0,67	0,89	0,89	0,89	0,67	0,67	0,67	0,89	0,67	0,89	0,89	0,89	

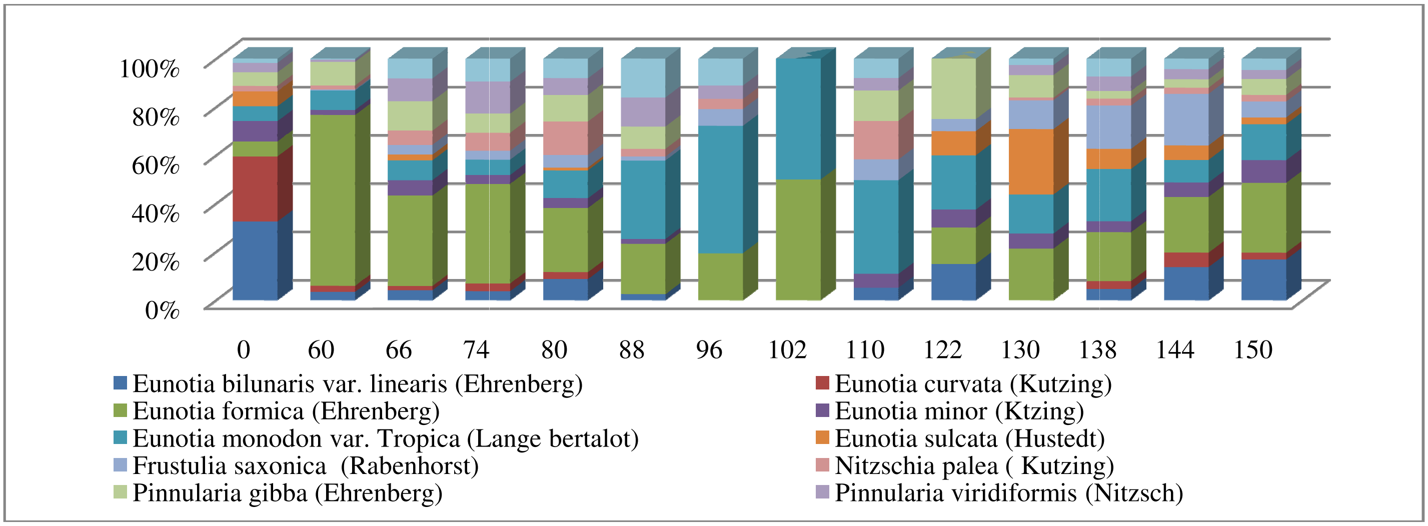

Figure-3: Diatom abundance in Telaga Pengilon.

The most interesting result from this result is Eunotia tropica has highest abundance than Eunotia tropica that was found in Vietnam[29], Previous study from Hudstedt Eunotia tropica was found in Toba lake (Sumatra, Indonesia) and Borneo (Kalimantan, Indonesia). In Java, Eunotia tropica was found in Telaga Warna and Rawa Pening just lower abundance. Morphologhy of Eunotia tropica almost similiar *with Eunotia Eunotia zygodon* but *Eunotia tropica* more longer and widely round apical, while the length of valvae of *Eunotia zygodon* shortheer and narrow in the apical.

Conclusion

The difference about ecology factor between Pengilon Lake and Warna lake has an influence of taxa diatom with tolerant of pH fluctuation. Based on cluster analysis the zonation between topsoil and another stratigraphy show that the habitat its further subdivided spatially (Figure-3). Another analysis shows the dominant species between each stratigraphy similar except topsoil, Based on the domination index the highest value is dominated by Eunotia and Pinnularia.

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References

1. Van Bergen J.M., Alain B., Sri S., Terry S. and Kastiman S. (2000). Creater lakes of Java: Dieng, Kelud, Ijen. Excursion Guidebook. Bali: IAVCEI General Assembly.

2. Hadi S., Mulyono A. and Marganingrum D. (2013). Potensi sumberdaya air kawasan dataran tinggi dieng bagi pemanfaatan air irigasi. *Prosiding Pemaparan Hasil Penelitian Puslit Geoteknologi*, 365-371. ISBN: 978-979-8636-20-2.

3. Hermawan P.E. and Setyowati E. (2014). Evaluasi termal ruang luar desa wisata Dieng Wonosobo. *J.PPKM*, 1(2), 115-122.

4. Van Bemmelen R.W. (1949). Geology of Indonesia. vol. 1A, Second Edition, Holland: Martinus Nijhoff-The Hague, 615-616 ISBN:10 9024711711.

5. Rusiah M., Satya M. and Wahyudin A. (2005). Dampak aktivitas pertanian kentang Terhadap kerusakan lingkungan obyek Wisata dataran tinggi dieng**.** *Pelita*, 1(1), 1-9.

6. Soeprobowati T.R., Suedy S.W.A. and Hadiyanto (2016). Diatom and water quality of Telaga Warna Dieng, Java, Indonesia. In IOP Proceding. *Earth and Environmental Sciences,* 55, 1-6. doi:10.1088/1755-1315/55/1/012051.

7. Soeprobowati T.R., Suedy S.W.A., Hadiyanto Ali R.L. and Gell P. (2018). Diatom assemblage in the 24 cm upper sediment associated with human activities in Lake Warna Dieng Plateau Indonesia. *Environmental Technology and Innovation*, 10(1), 314-323.

8. Stavreva Veselinovska S. (2010). Ecology of the diatomic flora in thermo-mineral springs of Katlanovska Banja in the Republic of Macedonia. *Ecologia Balkanika*, 2, 1-6.

9. Gell P., Tibby J., Fluin P., Leahy M., Reid K., Adamson S., Bulpin A., Macgregor P., Wallbrink G., Hancock and Walsh B. (1999). An Illustrated Key To Common Diatom Genera From Southern Australia. Albury, New South Wales: Cooperative Research Center for Freshwater Ecology, 1-63. ISBN 1876144270.

10. Martín G. and María R.F. (2012). Diatoms as Indicators of Water Quality and Ecological Status: Sampling, Analysis and Some Ecological Remarks. *Ecological Water Quality-Water Treatment and Reuse*. China: Intech publisher. ISBN 9535105086.

11. Taylor J.C., Harding W.R. and Archibald C.G.M. (2007). An Illustrated Guide to Some Common Diatom Species from South Africa. Republic of South Africa, 1-225 ISBN 1-77005-484-7.

12. Gasse F.P., Barker P.A., Gell S.C. Fritz and Chalie F. (1997). Diatom inferred salinity in palaeolakes: an indirect Tracer of climate change. *Quat. Sci*., 16(6), 547-563.

13. Nascimento L.R.D., Abdelfettah S., Lezilda C.T. and Ana A.L.A. (2010). Diatom assemblage in a tropical lake of northeastern Brazil. *Brazilian archives of Biology and Technology,* 53(1), 241-248.

14. Batarbee R.W. (1984). Diatom analysis and the acidification of lakes. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 305(1), 451-477.

15. Ruhlan K., Karst T., Paterson A., Eaver R.G., Smol J.P. and Cumming B.F. (1999). Standart sdiment sample preparation methods for siliceous microfossil (Diatom and Chrysophyte Scales and Cysts). Paleoecological Environmental Assessment and Research Laboratory Department of Biology Queen's University.

16. Sonneman J.A. (2000). An illustrated guide to common stream diatom species from temperate Australia. Hurgoona, N.S.W.: Cooperative Research Centre for Freshwater Ecology, 11-168. ISBN 1876144 351.

17. Krammer K. and Lange-Bertalot H. (1991). Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. In: In: ETtl H., Gerloff J., Heynig H., M Ollenhauer D. (Eds): Süsswasserflora Von Mitteleropa Fischer Verlag, Stuttgart. 2/3, 1-576, ISBN 978-3-8274-1987-3.

18. Krammer K. and Lange-Bertalot H. (1991). Süsswasserflora von Mitteleuropa. Bacillariophyceae, Teil 3: Centrales, Fragilariaceae, Eunotiaceae. Jena. Gustav Fischer Verlag. 1-576, ISBN: 978-93-83083-77-0.

19. Krammer K and Lange-Bertalot H. (2004). Bacillariophyceae 4. Teil: Achnanthaceae, Kritische Erganzungen zu Navicula (Lineolatae). Gomphonema Gesamtliteraturverzeichnis Teil 1-4 [second revised edition] [With "Ergänzungen und Revisionen" by H. Lange Bertalot]. In: H. Ettl et al., Suesswasserflora von Mitteleuropa. Spektrum Akademischer Verlad Heidelberg, 2(4), 1-468.

20. Jongman R.H.G., Ter braak C.J.F. and Van Tongeren O.F.R. (1987). Data analysis in community and landscape ecology. Den Haag: Pudoc Wageningen. ISBN 90-220-0908-4.

21. Bere T. (2010). Benthic diatom community structure and habitat preferences along an urban pollution gradient in the Monjolinho River, São Carlos, SP, Brazil. *Acta Limnologica Brasiliensia.,* 22(1), 80-92.

22. Balai Konservsi Sumber Daya Alam (2012). Rencana Pengelolaan Jangka Panjang Taman Wisata Alam Telogo Warno Telogo Pengilon Periode 2013 sampai dengan 2022 Provinsi Jawa Tengah (*unpublish report*). Semarang: Kementrian Kehutanan Direktorat Jendral Perlindungan Hutan dan Konservasi Alam.

23. Barton P.S., Cunningham A.S., Manning A.D., Gibb H., Lindenmayer D.B. and Didham R.K. (2013). The spatial scaling of beta diversity. *Global Ecol. Biogeogr*., 22(6), 639-647.

24. Kaars S.D.V., Penny D., Tibby J., Fluin J., Dam R.A.C. and Suparan P. (2000). Late quatenary paleoecology, palynology and paleolimnology of a tropical lowland swamp, Rawa Danau, West Java, Indonesia. *Paleography, Paleoclimatology, Paleoecology,* 171, 185-212.

25. Stefkova E. (2008). Diatom species composition in the sediment core of Plešné Lake (Bohemian Forest, Czech Republic). *Vimprek,* 14(2), 73-84.

26. Kihara Y., Sahashi Y., Arita S. and Ohtsuka T. (2009). Diatoms of Yakamado Moor in Shiga Perfecture, Japan. *Diatom,* 25, 91-105.

27. Kihara Y., Sahashi Y. and Ohtsuka T. (2009). Diatoms of Yakamado Moor in the Hira Mountain Range West Central, Japan. *Diatom,* 23, 83-90.

28. Pussep L. and Kangur M. (2010). Linking diatom community dynamics to changes in terrestrial vegetation: a palaeolimnological case study of Lake Ķū.i, Vidzeme Heights (Central Latvia). *Estonian Journal of Ecology,* 59, 259-280.

29. Hobbs W.O., Wolfe A.P., Inskeep W.P., Amskold L. and Konhauser K.O. (2009). Epipelic Diatom from an extreme acid environment: Beowulf Spring, Yellowstone USA. *Nova Hedwigia,* 135, 71-83.

30. Antoniades D., Hamilton P.B., Douglas M.S.V. and Smol J.P. (2008). Diatoms of North America: The freshwater floras of Prince Petrcik, Ellef Ringnes and northern Ellesmere Islands from the Canadian Arctic Archipelago. *Iconographia Diatomologica,* 17(1)*,* 1-6.

31. Denicola D.M. (2000). A review of diatom found in highly acidic environment. *Hydrobiologia,* 433, 111-122.

32. Koplova K., Nedbalova L., Nyvlt. D., Elster J. and Vijver B.V.D. (2013). Diversity, ecology and biogeography of the freshwater diatom communities from Ulu Peninsula (James Ross Island, NE Antarctic Peninsula). *Polar Biology,* 36(7), 933-948.