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PROCEEDINGS

16th WORLD LAKE CONFERENCE
BALI - INDONESIA

THE 16TH WORLD LAKE CONFERENCE

"Lake Ecosystem Health and Its Resilience: Diversity and Risks of Extinction"

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Lake Ecosystem Health and Its Resilience: Diversity and Risks of Extinction
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Foreword

Water, along with air, has always been the basic part of human's life. Among the water bodies, lakes are of severe impacted ecosystems despite its importance to the surroundings. Lakes confer numerous functional roles that may include defense over flood, recharge and storage of groundwater, biodiversity hot spot and the social economic services. Unfortunately, the alarming signals of lakes being under stress are underway. Contamination and pollution, sedimentation, wetland habitat degradation, alien species invasion, and other anthropogenic activities may have been the major stressors often associated with lake's deterioration. Since the issues on lake's deterioration have been globally emerged, a collected commitment should be engaged to supporting lake sustainability.

The World Lake Conference comes forward as an international forum serving to bridge communication among multi-sectoral parties towards sustainable management in lakes and basins. The 16th World Lake Conference, held from Nov 7th to 11th 2016 in Bali, Indonesia, invited distinguished keynote speakers around the globe; Prof. Takehiko Fukushima from University of Tsukuba, Prof. David Hamilton from GLEON, Prof. Walter Rast from ILEC Japan, Prof. Soontak Lee from IHP UNESCO, Dr. Fauzan Ali (Director of Research Center for Limnology, Indonesian Institute of Sciences) and Mr. Alue Dohong from Peatland Restoration Agency (Indonesia). It was also delightful that we had Governor Mikazuki from Shiga Prefectural Government (Japan) and Governor Hashimoto from Ibaraki Prefectural Government (Japan) to deliver their speeches.

The conference had also been completed nicely by the release of Bali Declaration. Another significant output of the conference is the publication of proceedings. The total papers reviewed and compiled in these proceedings are 83 which were broken up into several thematic sections. The sections comprise (1) climate change and water crisis (2) lake environment under stress and their restoration challenges (3) lake and lake basin management and policies (4) multiple water use purposes (5) water education, ecotourism, culture (6) database and knowledgebase systems, informatics and monitoring technologies (7) biodiversity and conservation (8) ecotechnology and ecohydrology (9) manmade lakes (10) limnology and limnological science fundamentals. Lastly, we acknowledge the creditable efforts and dedications that editors, reviewers and the proceeding team have been put forward.

July 2017

Prof. Gadis Sri Haryani
Chairperson of Scientific Advisory Board

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DIATOMS, WATER QUALITY OF TOBA LAKE AND ITS MANAGEMENT

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ABSTRACT

Toba Lake is one of the largest lakes in the world: 1,124 km^2 wide, 508 meter-depth; total volume of water 256.2 x 10^9 m3, and 2,486 km^2 of total catchment area. There is Samosir Island in the centre of Toba Lake. Toba Lake has 19 inlets (rivers) but only has 1 outlet i.e. Asahan River. The main functions of Toba Lake are for hydroelectricity power, resource for drinking water, transportation, tourism, irrigation, and fish culture. The town development in Toba Lake side and Samosir Island had induced water quality deterioration. This research was conducted in order to study the diatoms and water quality of Toba Lake, particularly in Parapat and Tomok Harbours and its management. Water samples were taken on August 2014 from 3 sites for diatom and water quality analysis. Identification of diatoms was done using microscope with 1,000X magnification. Based on this research, the main problem of water quality in Toba Lake was heavy metals of copper (Cu) that exceeded Indonesian water quality criteria for all class, a high concentration of total nitrogen (1.085-2.03 mg/L) that was in the state of mesotrophic – hypereutrophic; and a high concentration of total phosphorous (0.37-0.42mg/L), that was in the state of hypertrophic. Based on chlorophyll-a Toba Lake, particularly in the harbor of Parapat and Tomok, as well well near fish culture cage is in the state of hypereutrophic. pH in Toba Lake were in the range of 7-8. There are 31 diatom species found in Toba Lake, the domination of Ctenophora pulchella Kutzing, Gomphonema brasiliense Grunow, Denticula vanheurcki Brun, Navicula aurora Sovereign, Synedra famelica (Kutzing), Fallacia pygmaea (Kützing) Stickle et Mann, *and* Gomphonema brasiliense Grunow *are more indicated pH rather than trophic state.*

Keywords: Toba Lake, diatom, water quality, hyper-eutrophic, *Denticula, Fallacia*

INTRODUCTION

Toba is the largest lake in Indonesia, with the large unique peninsula called Samosir Island in the midle of the lake. Geographycally, Toba Lake located in Bukit Barisan highlands in North Sumatra Province, situated 175 km Southern of Medan City, and parts of 7 regencies. Toba Lake is located in coordinates of 980 31' 2"E – 980 09' 14"E and 20 19' 15"N – 20 54'02"N, and 903 meters above sea level. Geologically, Toba Lake is resulted of volcanic eruption 74,000 years ago and became the largest caldera in the world (Chesner, 2011). Administratively, Toba Lake included 7 regency areas, namely regency of Karo, Simalugun, Dairi, Toba Samosir, Samosir, Humbang Hasundutan, and North Tapanuli.

The Toba Lake has a surface area of 1,124 km^2, and maximum depth 508 meters, with the total volume of water around 256.2 x 10^9 m^3, and catchment area 2,486 km^2 (Lukman and Ridwansyah, 2010). Toba Lake have 19 inlet (rivers) enter to Toba Lake, but only has 1 outlet: Asahan River which flows east to the Strait of Malacca. The main function of Toba Lake are sources for drinking water, hydroelectricity power, tourism, transportation, agriculture, and culture (Ministry of Environment of Republic Indonesia, 2011). The development of hydroelectricity dam at the mouth of Asahan River has increased retention time that limit the flushing of nutrients from Toba Lake (Lehmusluoto, 2000). The water retention time of Toba Lake upwards of 81 years with oligomictic water stratiphication (Lukman & Ridwansyah, 2010).

Ecologically, the terrestrial of water catchment area, riparian zone, and eutrophic lake are the main problem on the Toba Lake. The problems of Toba Lake in the water catchment area are illegal logging, illegal mining, and agriculture. The problems in the riparian zone are mining, land occupation become residential, tourism, fascilities and infrastructure, source of domestic and agricultural waste. Meanwhile, eutrophication, floating fish cage, domestic, agricultural, husbandary and business wastes in the waterbody had induced water hyacinth bloom (Ministry of Environment & Forestry of Republic Indonesia, 2016). The significant concerns throughout the watershed is the lack of wastewater management (Lehmusluoto, 2000).

Toba Lake was habitat for some various aquatic organisms, particularly for endemic fish of *Lissochilus sumatranus* and *Labeobarbussoro*, locally known as ikan batak, and *Corbiculatobae* or remis Toba[3]. There were also found other fish, macrobenthic, phytoplankton, zooplankton, and emerge, floating and submerged macrophytes. *Eichornia crassipes, Potamogeton, Myriophyllum, Ceratophyllum, Hydrylla,* and *Chara* had reported found since 1939. It was reported that there were some kind of specific diatoms found in Toba Lake. *Denticula vanheurckii* is one species that found epiphytic in *Potamogeton* sp in 1929 (Hustedt, 1935).

Diatoms are microalgae that dominated almost in all aquatic ecosystem. Their silicious unique of cell wall persist in sediment and able to tell the environmental condition across the time. Diatoms glass walls are usually well preserved in sediments and they are very good bioindicators of water quality changes. Many studies have demonstrated the value of diatoms as a bioindicator of water. Their value in monitoring relates to a range of their characteristics. Being primary producers diatoms play significant roles in the food web. They are distributed worldwide in saline or freshwater, have short life cycles and quick response to environmental change. Some species are sensitive across ecological gradients and they are easily sampled and analysed at low cost (Soeprobowati et al., 2016).

The composition and abundance of planktonic algae have not changed in Toba Lake at least during the last 70-year period, are most responsible for influencing water clarity. There was strong correlation between free floating algae and algal growth rate at the most greatest shoreline development as well as attached algae. In the central portion of the lake, the algal density was low, while the areas nearest to the Parapat tourist area and south shore developments showed an increase of algal production. Community wastes and waste waters had stimulate algal growth. The highest nutrient deposition onto the lake may be found near the areas of greatest development. The nutrient sources from the numerous Toba watersheds is mostly related to the extend of disturbance of soils, particularly pronounced in Samosir (Lehmusluoto, 2000). The town development in Toba Lake side and Samosir Island had induced water quality deterioration. Long term environmental monitoring and research offers opportunity for providing data as a base for the best future planning and regulatory decisions. Based on those background, this research was conducted in order to study the diatoms and water quality of Toba Lake, particularly in Parapat tourist area and Samosir (Tomok) Harbours in comparison with site around traditional net fish culture.

METHODS

Water samples were taken from 3 sites with 3 replications: Parapat Harbour (T1), Tomok Harbour (T2), and nearby fish culture cage (T3, **Figure 1**) for diatom identification and water quality analysis for heavy metals of Pb, Cd, Cu, Cr, Total Nitrogen, Total Phosphorous, SiO_2, and chlorophyll-a. Heavy metals were analyzed using AAS, Total Nitrogen with micro Kjeldahl, Total Phosphorus and silicate using Spectrophotometry method, and chlorophyll-a content using extraction and spectrophotometry method. In T1, epiphytic diatoms were collected from *Potamogeton sp*, epilitic diatoms were collected by brush the stone. In T2, epilitic diatoms were collected from the stone. In T3, only collect water sample to identify planktonic diatoms. Diatoms were collected from *Potamogeton* sp and stone by brush 4 cm^2 the thallus and solute in 50 mL aquadest. Diatoms were identified under microscope with magnification of 1,000. The Shannon Wiener diversity and Evennes indices were calculated.

Shannon Wiener Index (H') (Magguran, 2004).

$$H' = -\sum_{i=1}^{s} (ni/N) \log (ni/N)$$

Note:
H'= Shannon-Wiener Diversity Index
ni = number individual of species -i
N = total indivdual of all species

The H' value indicates the distribution of abundance species among all the species in the community. High values of H' would be representative of more diverse communities.

Eveness Index (J)

$$\mathbf{J = H'/H'max}$$

Note:
J = Eveness index
H’ = Diversity index
H_{max} = ln S
S = number of species encountered

Dominance Index:

$$\mathbf{C = \square\square[n_i/N]}$$

Note:
C = Simpsom dominance index
n_i = number individual of species -i
N = total indivdual of all species

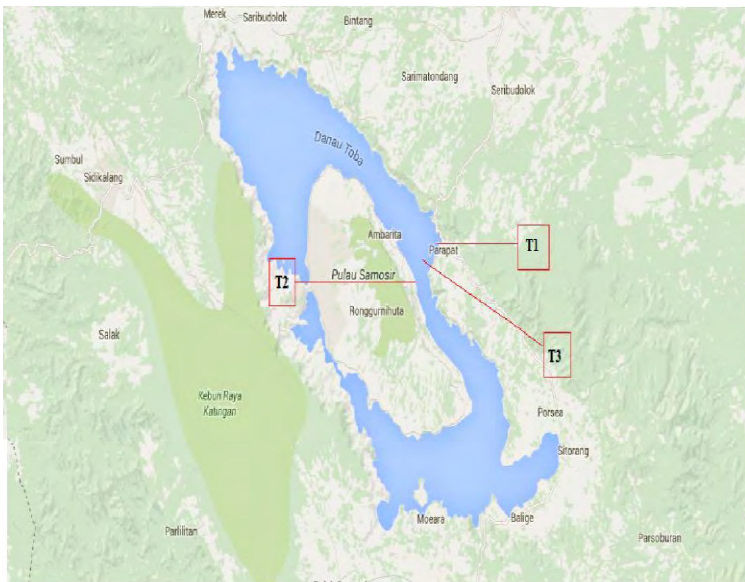

Figure 1. Sites sampling: Parapat Harbour (Ajibata) (T1), Tomok Harbour (Samosir Island) (T2) and nearby floating fish cage (T3)

RESULTS AND DISCUSSIONS

There were at least 31 diatom species identified from Toba Lake that were collected from water (as planktonic sample), epilitic on the rock, and epiphytic on *Potamogeton* sp. The composition of diatom’s community consist of 33% symmetric biraphid (*Adlavia, Anomoeoneis*, *Brachysira, Eolimna, Fallacia, Mastogloia, Navicula, Pinnularia,* and *Sellaphora*), 26% asimatric biraphid (*Amphora, Brebissonia,* and *Cymbella*), 16% araphid (*Ctenophora, Fragilaria*, *Synedra,* and *Tetracyclus*), 13% nitzschioid (*Denticula, Nitzschia)*, 3% epithemoid (*Epithemia*), 3% eunotioid (*Eunotia*), 3% surirelloid (*Surirella*), and 3% of monoraphid (*Achnanthidium,* **Figure 2**). Centric species was not found during this research. Usually, in the eutrophic lake, such as in Rawapening Lake, some species of *Aulacoseira* and *Melosira* were found dominantly (Soeprobowati et al., 2012). This might be related to the pH that tent to neutral around 7 whereas in Rawapening Lake tend to alkali (7-9).

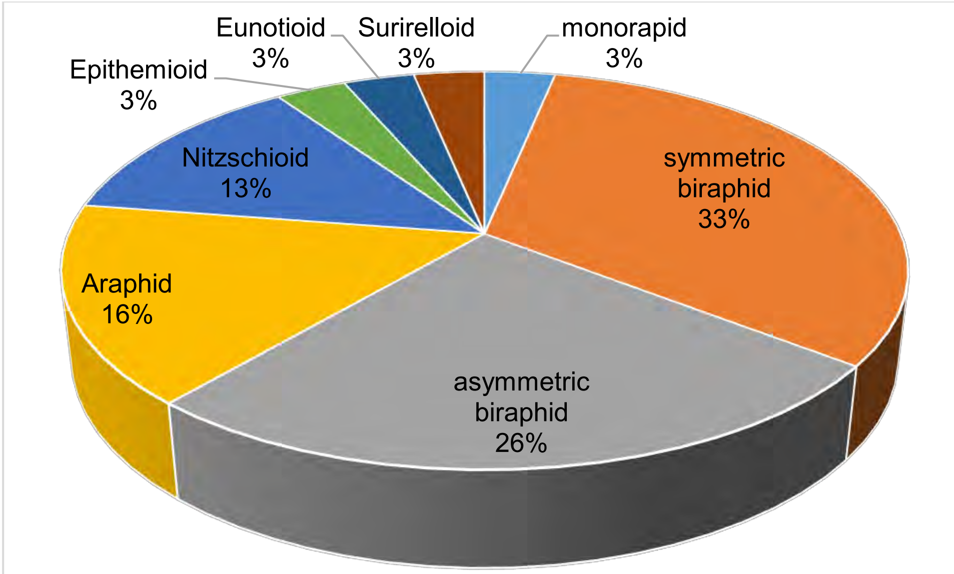

Figure 2. The composition of diatom's community based on morphological categories

The criteria of those grouping are based on morphological categories that is used to provide a visual aid in identification and do not strictly evolutionary. Symmetric biraphid is a diatom that has bilateral symmetry to both apical and transapical axis, and raphe system well developed. This group has the greatest diversity among the freshwater diatoms. Asymmetric biraphid is a diatom with valves asymmetrical to apical or transapcial axis or both, well developed raphe system. Araphid is a diatom that lack of a raphe system therefore lack significantly motility, valve with bilateral simmetry, rimoportulae (labiate process) may be present. Nitzschioid is diatom with bilateral symmetry, valve usually simmetrical to both apical and transapical axes, raphid system well developed, positioned near the valve margin, raphe is enclosed within a canal and may be raised onto a keel. Epithemioid is a diatom with bilateral symmetry, valves asymmetrical to apical axis, raphe system enclosed within a canal and positioned near the valve margin. Eunotioid is characterised by bilateral symmetry, valves often asymmetrial to the apical axis, raphe system is short therefore provides weak motility, raphe loacetd on valve mantle and face, cell may possess 2 or more rimoportulae. Surirelloid is a diatom with bilateral symmetry, raphe system extremely well developed and enclosed within a canal, raphe positioned around the entire valve margin and raised onto a kell. Monoraphid is a diatom with bilateral symmetry, raphe system present on one valve (raphe valve), raphe system absent on one walve (rapheless valve), heterovalvar ornamentation (Spaulding et al., 2010).

The dominant species which has more than 5% relative abundance at T1 are and *Ctenophora pulchella* Kutzing, *Gomphonema brasiliense* Grunow, *Denticula vanheurcki* Brun, Navicula aurora Sovereign, and *Synedra famelica* (Kutzing). At T2 the dominant species are *Ctenophora pulchella* Kutzing, *Fallacia pygmaea* (Kützing) Stickle et Mann, *Gomphonema brasiliense* Grunow, and *Synedra famelica* (Kutzing). At T3 the most dominant species is *Ctenophora pulchella* Kutzing, and *Synedra famelica* (**Table 1**). *Ctenophora pulchella* Kutzing formerly known as *Synedra pulchella*, has a wide range distribution, high conductivity and alkalinity in upland peat and forest rivers at Mayo, Ireland[11]], usually in freshwater of high mineral content (Guiry and Guiry, 2017).

Gomphonema has mucilaginous peduncles for attachment to the substrate making *Gomphonema* more resistant to disturbances (Burliga et al., 2013). The highest values for density and richness of diatoms in the lentic system is partly related to their specialized structures that confer a competitive advantage over other species of different classes in stressfull environmental conditions, but usually also found in lotic environments (Tremarin et al., 2009).

Denticula vanheurckii Brun is one species that found epiphytic in *Potamogeton* sp in 1929 (Hustedt, 1935) and recently is still found in Toba Lake. *D. vanheurckii*, appears more similar morphologically to the Rhopalodiales, especially the genus *Epithemia*. The current accepted name for *Denticula vanheurckii* Brun is *Tetralunata vanheurckii* (Brun) Hamsher, Graeff, Stepanek & Kociolek with type locality Java and Bali

(Hamsher et al., 2014). *Denticula* species are often found in the littoral margins of lakes, ponds and streams with high conductivity, particular species inhabiting either cold mountain streams or hot springs (Krammer, 1988). *Denticula vanheurckii* fossil was also dominant in Buyan Lake Bali in core of 360-289 cm, deposited about 7.7-6.5 cal ky BP indicated pyrite (Fukumoto, 2015). This benthic diatom indicated low organic pollution and alkaline water (Taylor et al., 2007), *Fallacia pygmaea* (Kützing) Stickle et Mann is freshwater diatom of high mineral content; sometimes in polluted water (Guiry and Guiry, 2017).

The highest diversity index are at the station 1 (H '= 3.03) and 2 (H' = 2.91) and the lowest diversity index are at the station 3 (H'=2.14), that indicating the ecosystem stability. Site 3 that located in next to the floating fish cage has the lowest diversity index, lowest number of diatom species due to a high covering water hyacinth in this area.

Based on water quality, the problem in Toba Lake is heavy metal Pb and Cu. The content of Total Nitrogen about 1.085 to 2.03 mg/L and Total Phosporous ranged between 0.37 to 0.42 mg / L (Table 2), indicated hypereutrophic condition. Based on the chlorophyll-a content (Table 2), Toba Lake is eutrophic - hypereutrophic category. Hypertrophic lake has a Total Nitrogen >1.9 mg/L, Total Phosporous > 0.1 mg/L, and chlorohyll-a content >2mg/L (Ministry of Environment Republic of Indonesia, 2008).

This condition had been reported in 2012 that based on average chlorophyll-a data, Toba Lake is classified as eutrophic to hypereutrophic (Lehmusluoto, 2000). The water quality of Toba Lake was moderate to ligh polluted (EPANS, 2014).

Table 1. The composition and relatif abundance of diatoms in Toba Lake

No	Species	T1	T2	T3
1	*Adlafia muscora* Moser, Lange-Bertalot and Metzeltin	1,67	2,94	7,14
2	*Achnantes minutisimum* (Kutzing)	1,67	-	-
3	*Amphora ovalis* (Ehrenberg) Kützing	1,67	-	-
4	*Anomoeoneis sp*	1,67	2,94	-
5	*Brachysira brebissonii* (R. Ross)	1,67	2,94	7,14
6	*Ctenophora pulchella* (Kutzing)	15,00	11,76	28,57
7	*Cymbela amplificata* (Krammer)	6,67	-	-
8	*Cymbella cistula (Ehrenberg) Cleve*	1,67	-	-
9	*Cymbella tropica* Krammer	-	2,94	-
10	*Denticula subtilis Grunow*	1,67	2,94	-
11	*Denticula tenuis* Kutzing	1,67	2,94	-
12	*Denticula vanheurcki Brun*	6,67	2,94	7,14
13	*Encyonema yellowstonianum* Krammer	3,33	2,94	-
14	*Eolimna martinii* (Schiller and Lange-Bertalot)	0,00	5,88	7,14
15	*Ephitemia turgida* (Ehrenberg)	1,67	2,94	7,14
16	*Eunotia exigua* (Brébisson in Kutzing)	1,67	-	-
17	*Fallacia pygmaea* (Kützing) Stickle et Mann	3,33	11,76	-
18	*Fragillaria capucina* (Desmazieres)	6,67	2,94	-
19	*Gomphonema brasiliense* Grunow	10,00	11,76	-
20	*Gomphonema johnsonii* Bahls	3,33	2,94	-
21	*Gomphonema olivaceum* (Hornemann) Brébisson	1,67	5,88	7,14
22	*Mastogloia grevillei* (W. Smith)	1,67	0,00	-
23	*Navicula aurora* (Sovereign)	6,67	0,00	-
24	*Navicula subbacillum Hust*	1,67	2,94	-
25	*Nitzschia linearis (Agardh) W Smith*	1,67	2,94	-
26	*Pinnularia acoricola Hust*	3,33	2,94	7,14
27	*Sellaphora meriodionalis* (Grunow)	1,67	-	-
28	*Surirella angusta Kutzing*	-	2,94	-
29	*Synedra bacillaris* (Grunow)	1,67	2,94	7,14
30	*Synedra famelica* (Kutzing)	6,67	5,88	14,29
31	*Tetracyclus rupestris (Braun ex Rabenhorst) Grunow*	1,67	-	-
	Number of species	28	23	11
	Shannon Wiener Index	3,03	2,91	2,14
	Eveness Index	0,91	0,93	0,89

The composition of diatom's community in Toba Lake do not indicate eutrophic condition. The relatively high content of chlorophyll-a in Toba Lake related to the abundance of phytoplankton population of *Spyrogyra, Zygnema, Pediastrum*, and *Chladophora*, and aquatic plant of *Potamogeton*. Cyanophyceae is a dominant phytoplankton in Toba Lake that was controlled by orthophosphate and nitrate, whereas Dinophyceae was controlled by ammonium (Rahman et al., 2016).

Table 2. Water quality of Toba Lake

Parameter	Unit	Toba Lake			Indonesian Water Quality Standard PP No. 82/2001			
		T1	T2	T3	Class I	Class II	Class III	Class IV
pH	-	7.85	8.14	7.83	6-9	6-9	6-9	6-9
Lead (Pb)	mg/L	0.006	0.004	0.005	0.03	0.03	0.03	1
Cadmium (Cd)	mg/L	0.003	0.005	0.003	0.01	0.01	0.01	0.01
Cromium (Cr)	mg/L	0.002	0.003	0.004	0.05	0.05	0.05	1
Copper (Cu)	mg/L	0.185	0.229	0.218	0.02	0.02	0.02	0.2
Silika (SiO_2)	mg/L	0.045	0.018	0.03	-	-	-	-
Total P	mg/L	0.42	0.395	0.37	-	-	-	-
Total N	mg/L	1.085	2.03	1.452	-	-	-	-
Chlorophyll a	mg/L	4.025	5.113	4.37	-	-	-	-

Notes

Class I : used for drink

Class II : used for recreation, live stock and fish farming

Class III : used to live stok, fish farming and agriculture

Class IV: used for agriculture

Water pollution load capacity and floating fish cage capacity exceeded the carrying capacity of Toba Lake, particularly for total phosphorous. Recently this condition still remain degrade, suppose to reduce 43% of phosphoous from catchment area and 44% from floating fish cage (EPANS, 2014). Lake Toba Ecosystem Management Plant (LTEMP) had been started on 2004 to monitor water quality of Toba Lake, then strengthened by Governour Regulation No 1 Year 2009 regrading Water Quality Standard for Toba Lake. Furthermore on 2014 Save Lake Action (in Indonesia called Gerakan Penyelamatan Danau (Germadan) Toba had been launched as a guideline for conservation action.

CONCLUSIONS

In Parapat and Tomok Harbours and around traditional fish culture cage of Toba Lake, there are 31 diatom’s species. The high population of *Ctenophora pulchella* Kutzing indicates a high conductivity and alkalinity and high mineral content. *Denticula vanheurckii* Brun is specific diatom from Toba Lake that was reported since 1929 until now, which indicates high conductivity low organic pollution and alkaline water. *Fallacia pygmaea* (Kützing) Stickle et Mann is freshwater diatom of high mineral content; sometimes in polluted water. The diatom’s composition do not reflect eutrophic-hypereutrophic condition of Toba Lake.

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REFERENCES

1. Chesner, CA, 2011. Thr Toba Caldera complex. Quaternary International (2011), doi:10.1016/j.quaint.2011.09.025
2. Lukman & Ridwansyah, I. 2010. Kajian kondisi morfometri dan beberapa parameter stratifikasi perairan Danau Toba. *Limnotek* 17(2): 158-170.
3. ME (Ministry of Environment of Republic Indonesia). 2011. Profil 15 danau prioritas nasional. Edisi pertama. Minstry of Environment of Republic Indonesia

4. Lehmusluoto, P. 2000. Toba Lake.The first sound science initiative to Abate change in the lake environment. http://www.kolumbus.fi/pasi.lehmusluoto/247_toba_initiative.PDF.
5. MEF (Ministry of Environment & Forestry of Republic Indonesia). 2016. The grand desigm of Indonesian Lake conservation and rehabilitation. Ministry of Environment & Forestry of Republic Indonesia
6. Hustedt, F. (1935): Die fossile Diatomeenflora in den Ablagerungen des Tobasees auf Sumatra. – Tropische Binnengewässer, Band VI. – Archiv für Hydrobiologie, Supplement 14: 143–192.
7. Soeprobowati, TR; Tandjung, SD; Sutikno; Hadisusanto, S; Gell, P; Hadiyanto; Suedy, SWA. 2016. The water quality parameters controlling diatoms assemblage in Rawapening Lake, Indonesia. Biodiversitas 17(2): 657-664. DOI: 10.13057/biodiv/d170239
8. Magguran, A. 2004. Measuring biological diversity. Blackwell Science, USA.
9. Soeprobowati TR, Hadisusanto S, Gell P, Zawadski A. 2012. The diatom stratigraphy of Rawapening Lake, implying eutrophication history. Am J Environ Sci(3):334-44. http://thescipub.com/PDF/ajessp.2012.334.344.pdf.
10. Spaulding, S.A., Lubinski, D.J. and Potapova, M. (2010). Diatoms of the United States. http://westerndiatoms.colorado.edu Accessed on 09 February, 2017.
11. O'Driscoll C, de Eyt E, Rodgers M, OConnor M, Asam ZUZ, Xiao, L. 2012. Diatom assemblages and their associated environmental factors in upland peat forest rivers. Ecological Indicators 18 (2012): 443-451. www.elsevier.com/locate/ecolind
12. Guiry, M.D. & Guiry, G.M. 2017. *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 24 January 2017.
13. Burliga, a.l. ang Schwarzbold, a. 2013. Perifíton: diversidade taxonômica e morfológica. In Ecologia do perifíton (A. Schwarzbold, A.L. Burliga & L.C. Torgan, eds) Rima, São Carlos, p.1-6.
14. Tremarin, P.I., Ludwig, T.A.V., Bertolli, L.M., Faria, D.M. and Costin, J.C. 2009. Gomphonema Ehrenberg and Gomphosphenia Lange-Bertalot (*Bacillariophyceae*) from Mauríciorive r, Paraná, Brazil. Biota Neotrop., 9:111-130
15. Hamsher, S.E., Graeff, C.L., Stepanek, J.G. & Kociolek, J.P. (2014). Frustular morphology and polyphyly in freshwater *Denticula* (Bacillariophyceae) species, and the description of *Tetralunata* gen. nov. (Epithemiaceae, Rhodopalodiales). *Plant Ecology and Evolution* 147(3): 346-365. http://www.ingentaconnect.com/content/botbel/plecevo/2014/00000147/00000003/art00006
16. Krammer K., Lange-Bertalot H. (1988) Bacillariophyceae 2. Teil:Bacillariophyceae, Epithemiaceae, Surirellaceae. In: Ettl H,Gerloff J., Heynig H, Mollenhauer D. (eds) Süsswasserflora von Mitteleuropa, Band 2/2. Stuttgart & New York, G. Fischer Verlag.
17. Fukumoto Y, Li X, Yasuda Y, Okamura M, Yamada K, and Kashima K. The Holocene environmental changes in southern Indonesia reconstructed from highland caldera lake sediment in Bali Island. Quaternary International 374 (2015) 15e33. http://dx.doi.org/10.1016/j.quaint.2015.03.020
18. Taylor, J.C.; Harding, W.R. & Archiblad, C.G.M. 2007. A methods manual for collection, preparation and analysis of diatom samples version 1.0. – WRC Report TT 281/07. Retriever from: http://docs.niwa.co.nz/library/public/1770054839.pdf; searched on 14 May 2015.
19. ME. 2008. Pedoman Pengelolaan ekosisitem danau. Kementerian Lingkungan Hidup Republik Indonesia.
20. EPANS (Environemental Protection Agency of North Sumatra=Badan Lingkungan Hidup Provinsi Sumatera Utara). 2014. *DAYA TAMPUNG BEBAN PENCEMARAN AIR DANAU TOBA*. Presentation prepared for Toba Lake Conference, LIPI, Bogor, 17 June 2014.
21. Rahman, A; Pratiwi, NTM; and Hariyadi, S. 2016. The struktur of phytoplankton communities in Lake Toba, North Sumatera (Struktur komunitas fitoplankton di Danau Toba, Sumatera Utara). Jurnal Ilmu Pertanian Indonesia (JIPI) 21(2): 120-127. DOI: 10.18343/jipi.21.2.120