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The Minimum Number of Valvae Diatoms Identified for Water Quality Monitoring of Lake Balekambang, Dieng Central Java

Tri Retnaningsih Soeprobowati[1,2,3, a)], Riche Hariyati[2,3, b)], Jumari Jumari[2,3, c)], Geyga Pamrayoga[3,4, d)], Henk Heijnis[3,5, e)]

[1]*School of Postgraduate Studies, Universitas Diponegoro, Semarang, Indonesia*
[2]*Department Biology, Faculty Science and Mathematics, Universitas Diponegoro, Semarang, Indonesia*
[3]*Center for Paleolimnology (CPalim), Universitas Diponegoro, Semarang, Indonesia*
[4]*Conservation Region I, Natural Resources Conservation Center, Nusa Tenggara Barat, Indonesia*
[5]*Australian for Nuclear and Technology Organization, Sydney, Australia*

[a)]*Corresponding author: trsoeprobowati@live.undip.ac.id*
[b)]*richehariyati@gmail.com*
[c)]*jumari@live.undip.ac.id*
[d)]*pamrayogageyga@gmail.com*
[e)]*hhx@ansto.gov.au*

Abstract. The success of interpretation from fossil diatom data is dependent upon the representativeness data. There is a standard for the minimum number of valves for diatom identification from Rawapening Lake in Indonesia. The standard from other lakes also has to be developed for a precise result. This research aims to determine the minimum number of valves that have to be identified from Lake Balekambang Dieng for monitoring water quality. Balekambang is an ancient lake situated next to the Arjuna Temple in Dieng, Central Java. Balekambang Lake has a significant history as part of human activities. Sediment samples were collected from 4 sites for diatom analysis. Diatoms were separated from sediment using 10% chloride acid, followed by 10% peroxide. Naphrax was used to mount diatom on the slide. Identification under a microscope with 1,000 magnification. The number of valves found was noted, and the efficiency was calculated to determine the minimum number of diatoms valves to be performed to monitor water quality. Based on the maximum efficiency and number of species found from Lake Balekambang, the minimum number of 300 valves was representative for water quality assessment.

INTRODUCTION

Diatoms are microalgae, the common name for Bacillariophyta. Diatoms are cosmopolite and can be found in varied habitats from humid soil, freshwater, and marine ecosystems [1]. The widespread distribution and easy colonization are related to the genetic diversity resulting from the evolution process since 180 million years ago. It is recorded that at least 285 genera and more than 100,000 diatom species globally [2,3].

The unique feature of the siliceous cell wall, photonic structure, and nano -porous frustule interact with a light spectrum for easy identification [4]. Diatoms have an essential role in the aquatic ecosystem as a significant oxygen producer [5,6].

The use of diatom as bioindicator water quality is undoubtedly due to their fast response to environmental changes [7,8]. A good bioindicator has a narrow ecological range and correlates with the environment [1]. Diatoms were well performed in water quality assessment in the river [8,9,10,11,12,13,14,15) and lakes [16,17,18,19,20]. The precise interpretation depends on the representativeness of the data.

The understanding and quantification of the uncertainty in quality assessment of running waters using diatoms. The variation in multimetric analysis shows that the choice of site and substrate for sampling, the inter -operator

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differences in diatom taxonomy, and the counting techniques are the primary sources of uncertainty. To some extent, this variation also reveals the robustness of specific metrics concerning the sources of uncertainty.

Diatom analysis consisted of 3 steps: digestion for separate diatom from sediment materials; secondly, mounting sample on the coverslip, and identification and enumeration. Commonly these steps follow [21], sometimes with modification due to the local condition. The variation method is on the identification step. Battarbee identified 300-600 diatom valves. When this method was applied in Indonesia, very time-consuming, especially when the diatom population was low [22]; this research aims to determine the minimum number of valves in the identification stage of diatom from Lake Balekambang for water quality monitoring.

MATERIAL AND METHODS

Dieng Plateau is a highland area with an elevation between 2.000-2.100 meters above sea levels and has been used by people since the Hindu Buddhist period to carry out religious rituals. Its location has extreme weather conditions and the threat of eruption from its volcanic mountains. In 1927, there were 28 lakes and tents to reduce into 14 lakes in 1981, 10 lakes in 2004, and 8 lakes in 2010. One of those lakes is Balekambang that have an essential role as a water reservoir to protect flooding in Arjuna Temple.

Balekambang Lake situates 7º12’44” - 7º12’53” S and 109 º54’47”- 109054’56” E, has a diameter of 75 m, the depth about 12 m, covered by graminoid floating on the lake [23]. Landuse change had induced sedimentation. Another problem was reducing water quantity due to the water pumping for irrigation.

Samples were collected from 4 sites in Balekambang Lakes; B1 was an inlet to Balekambang Lake, B2 was part of the graminoid lake, B3 part of the lake with high sedimentation, and B4 part of the lake that has been changed into an agricultural area (Figure 1). Surface sediment samples were collected from each site with triple replication.

One gram sediment samples were digested with 50 mL 10% HCl for 2 hours, settled for at least 6 hours; the supernatant was discharged and replaced by distilled water, repeated three times until neutral pH. Furthermore, added with 50 mL 10% H2O2, heated for 2 hours, settled for a minimum of 6 hours, discharged supernatant for at least three times until neutral pH.

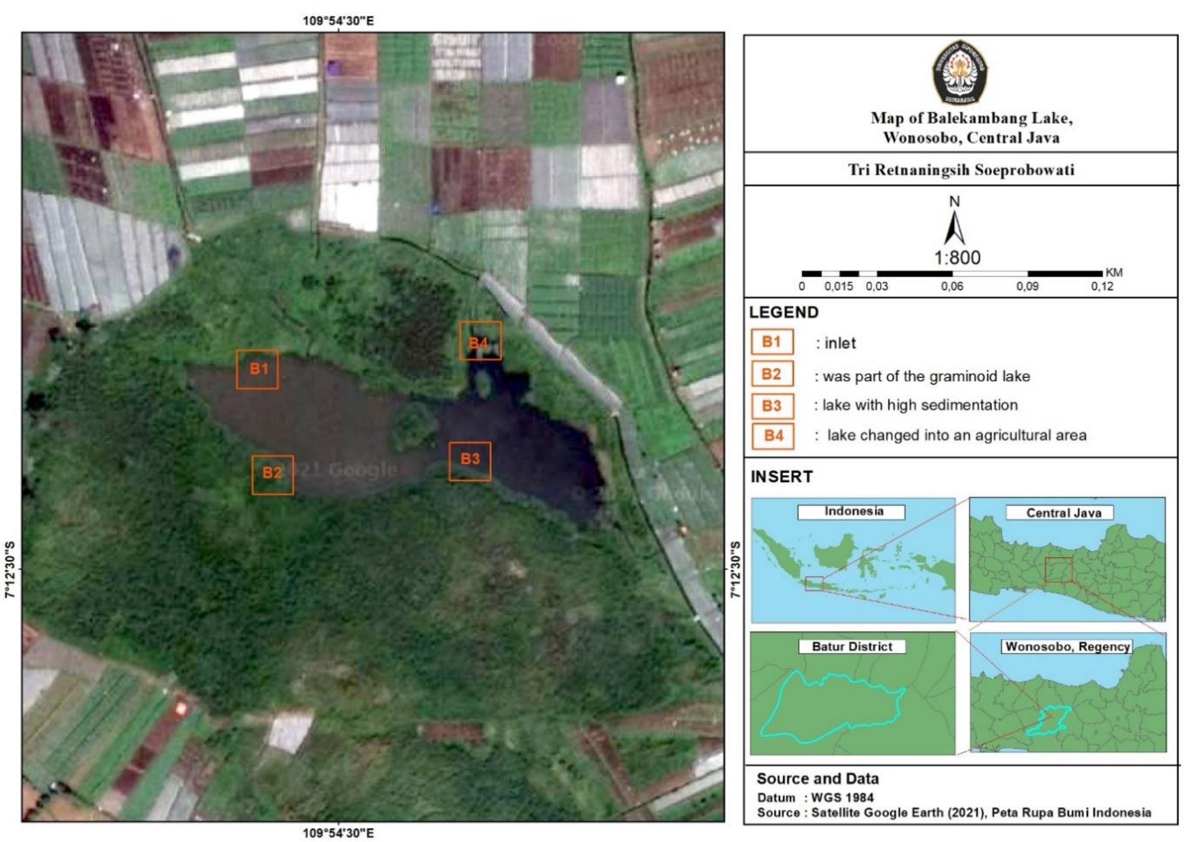

FIGURE 1. Research sites to collect sediment samples from Balekambang Lake Dieng

To prepare slides, 400 µl residual diatom was dropped onto the coverslip, dried up on the hot plate, and mounted to the slide with Naphrax. Identification was made under microscope 1,000 magnification. The minimum number of frustules identified were performed of 100, 200, 300, 400, and 500 were noted to determine the efficiency. The diatom identification was carried out by reference to the standard books of [24,25,26,27,28,29] by checking photomicrographs in AlgaBase.org [30].

Species accumulation curves were applied to identify the minimal number of valves to calculate maximum efficiency with formula 1.

$$\text{Efficiency} = 1 - \frac{Number\ of\ Species}{Number\ of\ individuals} \quad (1)$$

RESULTS AND DISCUSSION

Counting the diatom in the identification step is an integral part of providing data about the lake's ecological condition. This study analyzed 12 samples from Balekambang Lake, comparing the valves counts at 100, 200, 300, 400, 500 from the uppermost of sediment samples. The result showed that maximum efficiency was in the range of 0.76 – 0.98 (Figure 2). There was a striking difference between the count of 100 and 200 valves, while in the count of 400 and 500 valves, there is a slight difference, which was by following the under [21]. The new species found in the count above 400 valves was determined as a contaminant species, which may cause bias for further analysis. Therefore, the species found less than 1% were considered rare species and were not included in the data analysis [31]. Dominant species provide more evidence of water quality [22].

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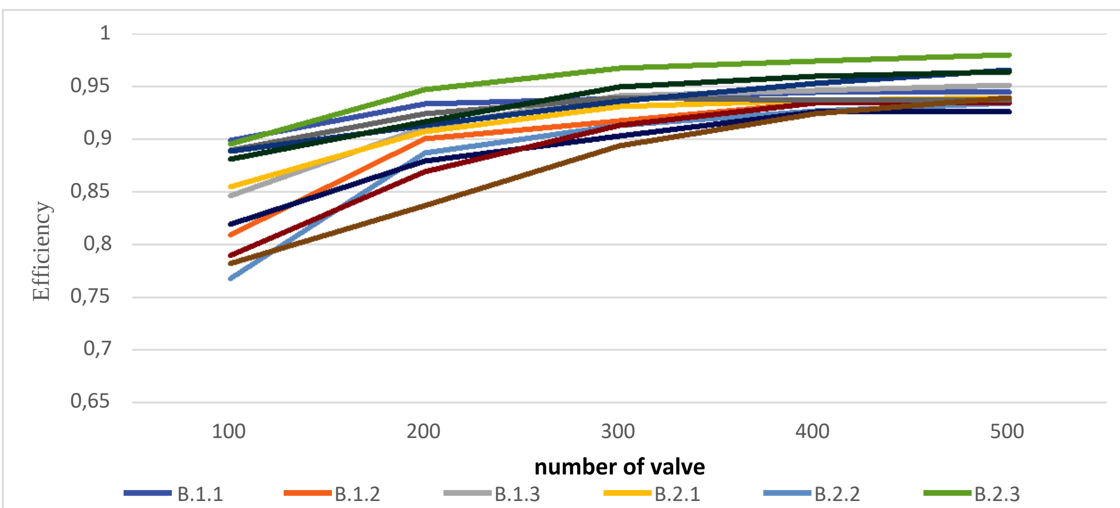

FIGURE 2. Efficiency Count from Epipelic Diatoms from Lake Balekambang, Dieng Central Java

In this study, a total of 83 diatom taxa were identified, which belong to 27 genera. Most taxa were pennate diatoms, and higher richness was mainly observed in Eunotia (14 taxa), Gomphonema (7 taxa), Navicula (7 taxa), and and Pinnularia (12 taxa). The dominant species with the relative abundance of more than 1% included *Nitzschia sp., Gomphonema parvulum, Sellaphora pupula, Ulnaria contracta, Lemnicola hungarica, Navicula sp., Caloneis bacillum, Diploneis subovalis, Gomphonema sp., Denticula vanheurckii, Eunotia minor, Nitzschia clausii, antzschia amphioxys, Frustulia vulgaris, Luticola acidoclinata, Pinnularia subcapitata, Eunotia bilunaris, Brachysira sp.,* and *Epithemia adnata*. The taxa with a high occurrence were determined by more than 1% [31].

The number of diatom species remains stable after 300 valves (Figure 3), with an efficiency above 0.89 (Figure 2). The number of diatom species from 4 sites has differed. The more diatom valves identified, the more species were able to be found. In general, the number of species found was in the range of 15 – 29 species, except for Site B 2.2

that has 29-46 species (Figure 3). Sites B was part of the lake with the graminoid. The plants provide a habitat for diatom epiphytic to colonize, such as *Gomphonema parvulum* with a high population in Site B2.2, associated with *Encyonema minutum, Eunotia minor, Hantzschia amphioxys, Lemnicola, Navicula, Nitschia palea, Pinnularia viridis.*

Gomphonema parvulum is a benthic species that is sensitive to changes in water quality and is abundant in various freshwater environmental conditions, including salt lakes and brackish water [32]. The genus Encyonema is a freshwater benthic diatom community with low electrolyte content [33].

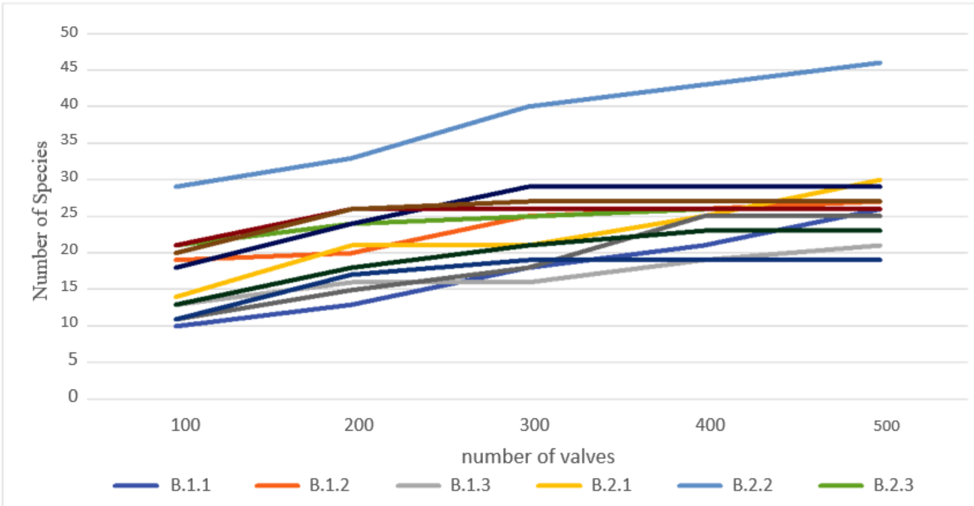

FIGURE 3. The Number of Diatom Species Identified from Lake Balekambang Dieng, Central Java

This minimum of 300 valves can be applied for monitoring water quality in Lake Balekambang. The identified valves number must to has a maximum efficiency of more than 0.85. The maximum efficiency is sufficient to represent the value of the diatom species because the formula for calculating the maximum efficiency includes the number of individual valves [22,34]. The identification diatoms with the minimum valves count of 300 had been applied for assessment of the ecological status of the lakes in France [35] In the UK [36], Dongping Lake North China [37].

In Indonesia, the minimum number identified diatom vales of 300 had been applied for paleolimnological analysis in Rawapening Lake [7], Warna Lake Dieng [38,39], Pengilon Lake Dieng [40,41], Cilalay, and Cibuntu Ponds Cibinong [42]. Some predominant species were not found in the diatom identification of fewer than 300 valves [22]. Identifying the minimum number of diatom valves is essential for ecological analysis to get a reliable approach to gauge species composition at sampling sites [43].

CONCLUSION

Eighty diatom species were found from Lake Balekambang. The minimum diatom valves count of 300 was representative for water quality monitoring for Lake Balekambang Dieng.

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