Diatoms and Water Quality of Telaga Warna Dieng, Java Indonesia

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Abstract. Diatoms are popular name for Bacillariophyta, the microalgae with the specific characteristic of silicious cell walls that well preserved in the sediments. The different diatoms assemblage in the sediment layers indicate different environment at the time of the diatoms live and deposited. Telaga Warna is small lake in Dieng Plateau. Telaga means lake, Warna means colour. It is called Telaga Warna because previously have 4 colours i.e. red, white, blue, and yellow which was influenced by weather, time, and site of view. This study aims to analysis the diatoms communities and water quality of Telaga Warna Dieng, Java, Indonesia. Coring conducted at three different locations. Water sampling carried out on all three spots. Analysis of diatoms consist of three stages: digestion, preparation and identification of diatoms. There were 59 diatoms species found in Telaga Warna Dieng that were belong to 9 groups diatoms of centric, arafid, eunotoid, birafid, monorafid, birafid, epimidal, nitzschoid, and surireloid. Eunotia, Pinnularia, and Melosira were the dominant genus from Telaga Warna. The water quality parameters that exceeded Indonesia Water Quality Standard were pH (2.2 – 5.4), Pb, Cd, Cr, Cu. Based on the abundance of species Eunotia and Pinnularia in Telaga Warna Dieng indicates that water tends to be acidic. The dominance of Melosira indicates waters rich in nitrogen. Based on the total concentration of nitrogen and phosphorous, Telaga Warna was in an eutrophic – hipereutrophic conditions with total nitrogen concentration > 1.9 mg/L and total phosphorus concentration > 0.1 mg/L.

Keywords: diatoms, water quality, Telaga Warna Dieng, pH, eutrophic

1. Introduction

The Dieng plateau is located in Central Java, Indonesia with a 63 km² concession area, approximately 25 km from north of the city Wonosobo. Dieng Plateau, is the second highest plateau in the world after Nepal about 2,093 m asl. The geothermal resource in Dieng was recognized since Dutch colonial period and in 1964/1965 the area was identified as one of the best geothermal prospect in Indonesia by UNESCO[1]. There are many lakes, crater (hydrothermal), valley, water springs, hills, and vulcan complex in one area makes Dieng has unique characteristic and very rare encountered in other countries[2].
Telaga Warna Lake is the famous crater lake and the most interesting and famous in the Dieng area, due to different color reflection, sometimes the color of the lake is red or white or blue and yellow depending on the weather, time, and place to see it. The color is a reflection of sunlight by sediment or rock at the bottom of the lake that supposedly once the volcanic crater. Red and yellow color is a reflection of the element sulphur deposition, the white color comes from the deposition of limestone rocks and quartz. But now, Telaga Warna only visible only blue indicating sediment mud. Its colorful appearance makes the lake an interesting tourist attraction.

Diatoms also known as Bacillariophyte have uniquely ornamented and diversly shaped transparant silicate cell walls, microscopic unicellular algae abundant in almost all aquatic habitat, and part of base aquatic food webs. Diatoms community are responsive to the environmental change such as physical and chemical characteristics include pH, water deph, nutrient availability, salinity also current condition in the environment. Diatoms assemblages are often specific to particular habitats and also used to characterize those habitats. For that reason, characteristic diatoms examination have been widely used to investigate the status of the lake and can explain about pollution state, monitoring program and paleontology for lake environment[4]. Palaeolimnological studies offer an opportunity to improve knowledge about the past environmental conditions[5].

The study about diatoms as indicator for water quality of the lake have been conducted for long periode. Epipelic diatoms preserved in the sediment might tell the story about past climatic changes that can be inferred from changes in species abundant within a sediment core. When diatoms died their cell walls turn down in the bottom of the lake and preserved in the sediment. The use of diatoms to reconstruct past ecological conditions in Rawapening Lake, Java was well established[6]. The general objectives of these journal are to study subfossil diatoms assemblage to access natural and human activity induced environmental changes in Telaga warna Dieng and to study the water quality of Telaga Warna Dieng.

2. Material and Method

The survey was conducted in 31 August 2014 and 2 February 2015. There are 3 sampling sites with different characteristic, D1 located near sulphurous area, D2 located near riparian vegetation, and D3 located near Pengilon lake. At each site, dissolve oxygen, electrical conductivity, pH, temperature, and turbidity were measured with three times replication. The water samples were also collected at each site at the same time.

Figure 1. 4 Sites sampling in Telaga Warna Dieng.
Samples were taken at four points of the study. Measurement of water quality such as measure the temperature, pH, conductivity, turbidity and dissolved oxygen. Each parameter was measured three times as replicates. Water sampling is done at 20 cm from the surface for analysis of heavy metals Pb, Cd, Cr, Cu, silicate, chlorophyll-a, total phosphorus and total nitrogen. Coring was done by modification of sediment corer. Sediment samples were sliced every 1 cm for diatoms analysis. Separation the diatoms from the sediment carried by the addition of 10% HCl followed by 10% HNO3. Preparations for the diatoms uses adhesives with refractive index of 1.7, in this study used Naphrax. Diatoms identification with 1,000x magnification using mainly using Kramer-Bertalot books. Shannon Wiver Diversity, Species Richness, and Dominance Indices of diatoms were calculated.

3. Result and Discussion

A total of 59 diatoms preserved in the sediment belong to 8 groups diatoms of centric, araphid, eunotoid, monoraphid, biraphid, epithecid, nitzschioi, and surirelloid. *Eunotia, Pinnularia,* and *Melosira* were the dominant genus from Telaga Warna (Table 1).

| No. | Species | % Domination |
|-----|---------|--------------|
|     |         | D1    | D2    | D3    |
| 1   | Achnanthis minutissimum (Kützing) | 26.49 | 37.60 | 10.05 |
| 2   | Cyclotella (Kützing) | - 0.82 | 0.64 |
| 3   | Amphora copulata (Kützing) | - 1.36 | 5.74 |
| 4   | Amphora pedivelus (Kützing) | - - 3.35 |
| 5   | Amphora veneta (Kützing) | - - 5.58 |
| 6   | Asterionella formosa (Hassall) | - - 0.16 |
| 7   | Aulacoseira ambiguia (Grunow) | 0.99 - - |
| 8   | Aulacoseira granulata (Ehrenberg) | - - 0.16 |
| 9   | Brachysira vitrea (Grunow) | 1.73 0.54 - |
| 10  | Caloneis bacillum (Grunow) | 10.37 6.81 4.78 |
| 11  | Cocconeis placentala (Ehrenberg) | 1.24 1.09 - |
| 12  | Craticula halopedia | - - 0.32 |
| 13  | Cyclotella (Kützing) | 5.45 8.72 4.78 |
| 14  | Cyclotella compta (Kützing) | 1.49 3.54 0.32 |
| 15  | Cyclotella meneghiniana (Kützing) | - 2.72 - |
| 16  | Diatoma hyemalis (Roth) | - - 1.12 |
| 17  | Diploneis finnica (Ehrenberg) | - - 0.64 |
| 18  | Eucyrtis microcephala | 0.99 - - |
| 19  | Encyonema silesiacum (Bleisch) | - 0.82 0.64 |
| 20  | Encyonema minuta (Hilse) | - 0.27 0.48 |
| 21  | Entomoneis alata (Ehrenberg) | - - 0.64 |
| 22  | Eolimminimima (Grunow) | 0.25 0.27 - |
| 23  | Eunotia biliaris (Ehrenberg) | - - 1.44 |
| 24  | Eunotia minor (Kützing) | - - 2.71 |
| 25  | Eunotia monodon (Ehrenberg) | 1.98 0.27 3.51 |
| 26  | Eunotia pectinalis (Kützing) | - - 2.71 |
| 27  | Eunotia septentrionalis (Strup) | - - 0.16 |
| 28  | Eunotia sudetica (O.F. Müller) | 0.25 - 0.48 |
| 29  | Eunotia andulata (Ralfs) | 1.24 2.18 2.39 |
| 30  | Eunotia angustior (Grunow) | - - 1.59 |
| 31  | Entomoneis paludosa (W. Smith) | 0.25 - - |
| 32  | Fallacia pygmae (Kützing) | 1.98 - 0.48 |
| 33  | Fragillaria cappucina | 3.47 0.27 3.99 |
| 34  | Gomphonema cf. affine (Kützing) | - - 2.07 |
| 35  | Gomphonema gracile (Ehrenberg) | - - 1.12 |
| 36  | Hantzschia amphioxys (Ehrenberg) | 1.73 0.27 4.47 |
| 37  | Ikabe tenuis (Brun) | 3.22 - 0.32 |
Telaga Warna has middle diversity (Shannon Wiener Index of 2.67–3.5), low uniformity (Species Richness Index of 7.45–13.77) and low dominance (Dominance Index of 0.03–0.18, Table 1). This was meaning that no species dominance. Achnanthidium minutissimum (Kützing) has a highest dominance index, indicated that Telaga Warna was acid. These result in accordance with research that A. minutissimum tolerate in acid condition about 2.8-3.3. The abundance of species Eunotia and Pinnularia in the sediment samples indicate that the pH waters tend acidic to neutral [7]. This is supported by the results of water quality analysis of the specific lake color that is highly acidic pH (2.2 - 3.35, Table 2), so the only species that are tolerant to acid which will be able to grow in the lake of Telaga Warna.

The pH of Telaga Warna was fluctuated. In 2 October 2014, pH in Telaga Warna Dieng was in the range of 2.1 – 2.3. Based on monitoring data from Conservation Department, when dry season pH was very acid (1–2) due to the dry up water. Sulphate and Chloride contents in Telaga Warna moderately higher than the other telaga. The emissions show considerable fluctuations instrength. The pH of Sinila Crater Lake was 6.5 and has lower sulfate and chloride contents[3]. Telaga Pengilon is near Telaga Warna with the distance about 50 m from Telaga Warna has a higher pH (5.1-6.6 at October 2, 2016). Dissolve oxygen at 31 August 2014 about 6.67-10.61 mg/L, at 20 February 2015 about 3.32-5.99 mg/L, and in the last monitoring at 2 October 2016 decrease about 0.8–1.7 mg/L (Table 2).

The interesting found from the research was appreance of E. septentrionalis a taxon that was reported by Hustedt (1937–1939) as living in acid waters (pH ca.3) in the sulphur-springs of Sumatra. The name E. septentrionalis var. intermedia was created for forms with intermediate striae counts. Negoro reported these varieties are occurring and epiphytic from many highly acidic environments in Japan [7]. From this result may the condition of Telaga Warna Dieng similar to Sulphure springs in Sumatra. The dominance of Melosira indicates waters rich in nitrogen. Based on the analysis of water quality, Telaga Warna in eutrophic – hipereutrophic conditions with total nitrogen concentration above 1.9 mg/L and total phosphorus concentration above 0.1 mg/L.

| Species                     | Dominance Index | Shannon Wiener Index (H') | Species richness index (R) | E. septentrionalis |
|-----------------------------|-----------------|---------------------------|---------------------------|-------------------|
| Luticola gomezpepperiana    | 0.50            | 2.67                      | 9.08                      | 13.77             |
| Luticola mutica (Kützing)   | 0.99            | 2.26                      | 7.45                      | 12.77             |
| Luticola mutica var tropica (Kützing) | -   | -                         | 7.45                      | 12.77             |
| Melosira varians (O.F.Müller) | -        | 2.26                      | 7.45                      | 12.77             |
| Navicula hodgeana (Patrick & Freese) | 0.50 | 2.26                      | 7.45                      | 12.77             |
| Navicula lanceolata (Ehrenberg) | 0.50  | 2.26                      | 7.45                      | 12.77             |
| Pinnularia gibba (Ehrenberg) | 8.42            | 2.26                      | 7.45                      | 12.77             |
| Pinnularia neomajor (Krammer) | -          | 2.26                      | 7.45                      | 12.77             |
| Pinnularia stomatophora (Grunow) | -    | 2.26                      | 7.45                      | 12.77             |
| Pinnularia sub gibba (Ehrenberg) | -        | 2.26                      | 7.45                      | 12.77             |
| Pinnularia valetolerans (Mayama) | -     | 2.26                      | 7.45                      | 12.77             |
| Pinnularia viridiformis (Krammer) | 0.74  | 2.26                      | 7.45                      | 12.77             |
| Planothidium lanceolatum (Brébisson) | -   | 2.26                      | 7.45                      | 12.77             |
| Rhoicosphenia curvata (Kützing) | -          | 2.26                      | 7.45                      | 12.77             |
| Sellaphora bacillum (Ehrenberg) | 6.93     | 2.26                      | 7.45                      | 12.77             |
| Sellaphora pulpula (Kützing) | 2.72            | 2.26                      | 7.45                      | 12.77             |
| Sellaphora seminulum (Grunow) | 10.15           | 2.26                      | 7.45                      | 12.77             |
| Stauroneis colhui (Hilse) | 3.47            | 2.26                      | 7.45                      | 12.77             |
| Stauroneis geopertiana (Bleish) | -          | 2.26                      | 7.45                      | 12.77             |
| Straurophora vislouchii | 0.25            | 2.26                      | 7.45                      | 12.77             |
| Synedra acus (Kützing) | 0.50            | 2.26                      | 7.45                      | 12.77             |
| Tabellaria fenestra (Lyngbye) | 1.24     | 2.26                      | 7.45                      | 12.77             |
Based on Indonesian water quality standard regulation number 82/2001 about criteria of water quality for specific purposes. Class I used for source of drinking water, Class II used for recreation, livestock and fish farming, Class III used for livestock, fish farming and agriculture, and Class IV used for agriculture. From Table 2 Cadmium and Lead concentration higher than Indonesian water quality standard. For fisheries and animal husbandry, the lead content in the water should not exceed 0.1 mg/L, for agricultural alkaline or neutral soil, the lead does not allow exceed 10 mg/L, whereas in acid soil is not more than 5 mg/L.

**Table 2.** Water quality of Telaga Warna Dieng

| Parameter          | Unit | Telaga Warna (31 Aug 2014) | Telaga Warna (20 Feb 2015) | Indonesian Water Quality Standard | Government Regulation No. 82/2001 |
|--------------------|------|----------------------------|----------------------------|----------------------------------|----------------------------------|
|                    |      | T1                         | T2                         | T3                               | Class I-III                      | Class IV                        |
| pH                 | -    | 2.2                        | 2.4                        | 2.3                              | 5.35                             | 5.23                             | 4.91                             |
| Conductivity       | mS/cm | 5.08                       | 7.9                        | 16.02                            | 0.83                             | 1.13                             | 3.92                             |
| Turbidity          | NTU  | -                          | -                          | -                                | 46.33                            | 21                               | 53.33                            |
| Temperature        | °C   | 20.45                      | 26.6                       | 21.6                             | 15.35                            | 19.97                            | 19.46                            |
| Dissolved oxygen   | mg/L | 6.67                       | 10.61                      | 9.83                             | 3.34                             | 5.04                             | 5.99                             |
| Lead (Pb)          | mg/L | 0.02                       | 0.016                      | 0.012                            | 0.023                            | 0.056                            | 0.035                            | 0.03                            | 1                                |
| Cadmium (Cd)       | mg/L | 0.01                       | 0.006                      | 0.016                            | 0.135                            | 0.023                            | 0.014                            | 0.01                            | 0.01                            |
| Chromium (Cr)      | mg/L | 0.012                      | 0.009                      | 0.012                            | 0.013                            | 0.028                            | 0.0335                           | 0.05                            | 1                                |
| Copper (Cu)        | mg/L | 0.015                      | 0.01                       | 0.017                            | 0.022                            | 0.032                            | 0.057                            | 0.02                            | 0.2                             |
| Silica (SiO₂)      | mg/L | 0.144                      | 0.13                       | 0.155                            | 0.13                             | 0.167                            | 0.14                             | -                               | -                               |
| Total P            | mg/L | 0.24                       | 0.161                      | 0.182                            | 0.284                            | 0.185                            | 0.267                            | -                               | -                               |
| Total N            | mg/L | 2089                       | 1035                       | 1.14                             | 2,005                            | 1.87                            | 2,775                            | -                               | -                               |
| Chlorophyll a      | mg/L | 4,318                      | 3.09                       | 4.08                             | 6.19                             | 5.668                            | 5,776                            | -                               | -                               |

4. Conclusion

Based on the abundance of species *Eunotia* and *Pinnularia* in Telaga Warna Dieng indicates that water tends to be acidic. The dominance of *Melosira* indicates waters rich in nitrogen. Based on the analysis of water quality, Telaga Warna in eutrophic conditions – hipereutrophic.

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