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The water quality parameters controlling diatoms assemblage in Rawapening Lake, Indonesia

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Abstract. *Soeprobowati TR, Tandjung SD, Sutikno, Hadisusanto S, Gell P, Hadiyanto. 2016. The water quality parameters controlling diatoms assemblage in Rawapening Lake, Indonesia. Biodiversitas 17: 657-664.* Diatoms are microalgae that have an important role in aquatic ecosystem. The silicious diatoms fossil had been used for paleolimnological analysis. However, data set diatoms of Indonesia does not develop yet. The aims of this research were to assess water quality parameters controlling diatoms assemblage of Rawapening Lake, to assess transfer function, to develop diatoms data set of Rawapening, and to compare Rawapening diatoms data set with European diatoms data set for the reconstruction of total phosphorous and pH. Water samples were taken from 3 sites of Rawapening Lake for water quality analysis. Sediment samples had been taken from 3 sites in Rawapening Lake using hand auger, and were sliced every 0.5 cm for diatoms analysis. Diatoms slides were prepared from about 5 g of dry sediment using 10% of chloride acid followed by 10% of peroxide to remove organic matters and carbonates, respectively.300 diatom valves were calculated on the entire samples, calculation the number of valve's diatom aims to identify the lowest level of taxonomy. Phosphate, temperature, and calcium were the environmental parameters that influence the diatoms assemblage of Rawapening Lake. Phosphate was contributed 50% on diatoms assemblage. Internal based transfer function of diatoms provides more suitable diatoms data set rather than European diatom data set. The Rawapening diatoms data set of total phosphorous is the initial Indonesian diatoms data set for past trophic status, therefore, research has to be continued spatially for other Indonesian lakes and temporary on specific Indonesian lake to develop Indonesia diatoms data set.

Keywords: Diatoms, Indonesia, phosphate, Rawapening Lake, water quality

INTRODUCTION

Global concern on the environmental issue had been focused on the sustainability of the availability, management and conservation of freshwater ecosystem. The phenomenon of increasing population growth, urbanization, wastewater management, will influence water quality problem in the future, particularly in Asia, therefore required an effort to overcome the problem of water quality degradation (Avans et al. 2012).

Freshwater quality problem were also occurred in Indonesia, and become a national problem. In 2009 there was an agreement between 9 Indonesian ministers about 7 lakes priority criteria, regarding to the lake degradations: (i) sedimentation; (ii) pollution, eutrophication, and water quality degradation; (iii) lake usage: power electricity, agriculture, fisheries, drinking water, social and religious life, tourism; (iv) commitment between government and community; (v) lake strategy for national function; (vi) biodiversity (endemic species); and (vii) level of risk disaster. There were 7 programs for 15 lakes priority, set about lake ecosystem management, scientific and technological approach on using lakes resources; the development of lake monitoring, evaluation and information systems; preparation of adaptation and mitigation steps; the impact of environmental changes to the lakes; the development of capacity, regulation and coordination; improvement of community involvement; and sustainable funded. There are 15 lakes national priority in the year 2010-2014 that are Lakes of Toba Maninjau, Singkarak, Kerinci, Tondano, Limboto, Poso, Tempe, Matano, Cascade Mahakam Semayang-Melintang-Jempang, Sentarum, Sentani, Rawa Danau, Batur, and Rawapening (MoE 2010).

Rawapening Lake is located in the S 7^{o}04'-7^{o}30' and E 110^{o}24'46"-110^{o}49'06" in the urban area between of 3 cities in the Central Java, i.e.: Yogyakarta, Solo, and Semarang. Despite of its small size (26.23 km^2), 207,438 people depend their life to Rawapening Lake. The catchment area of the lake is consists of 55.40 km^2 paddy's fields; 1,126.42 km^{2}of plantations; 44.08 km^2 of settlements; and 21.64 km^2 of forests (BPS 2010). Ecologically, Rawapening Lake had been changed particularly because there are plants that grow uncontrollably due the influence of eutrophication, 70% of lake area are covered by water hyacinth. Eutrophication and sedimentation were huge problem that had induced lake shallowest. This environmental degradation had threatened its function for electricity power, irrigation, fisheries, source of drinking water and recreation area. These were typical problem of Indonesian lakes. Limnological research was 1 out of 6 super priority programs for Save Rawapening Lake have to be developed as a basic national policy (MoE 2011).

It was not doubtly about the potential use of diatoms for bioindicator of water quality, and used diatoms to reconstruct past water quality changes (Gell et al. 2007; Reid and Ogden 2009; Soeprobowati et al. 2012; Adams et al. 2014; Yun et al. 2014). Diatoms are dominant microalgae almost in all aquatic ecosystems, contribute 20-25% primary production, have an important role in the silica and carbon cycle (Soeprobowati et al. 2012). Different taxa have different toleration to the environmental parameters. Therefore, diatoms assemblage reflects water quality effectively. Quantitatively, reconstruction of past condition can be done by 3 approaches namely indicator species approach, involving bioclimatic modeling that was causal relationship between species distribution and climate variable; assemblage approach involving modern analog technique and response surfaces; and multivariate calibration-functional that known as a transfer function have an important role in future quaternary paleoecology (Birks et al. 2010).

The aims of this research were to assess water quality parameters controlling diatoms assemblage of Rawapening Lake Indonesia, to assess transfer function and to develop diatoms data set of Rawapening, and to compare Rawapening diatoms data set with European diatoms data set on reconstruction of total phosphorous and pH.

MATERIALS AND METHODS

Three research sites were chosen based on representative of inlet, outlet, and water body of the Rawapening Lake, Central Java, Indonesia (Figure 1). Hand-auger was used to collect sediment samples, and then slice every 0.5 cm thick for diatoms analysis. 5 gr of dry sediment was digested by heated with 10% of chloride acid followed by 10% of peroxide for 2 hours to remove organic matters and carbonates, respectively (Battarbee et al. 2001). Distilled water was added when the solution almost dry. After settled for at least 4 hours, supernatant was discharged and added with distilled water until 50 mL and allowed to settle for another 4 hours. This was done repeatedly until the pH was neutral (7). The washed frustules were mounted in Naphrax and examined by optical microscope at 1,000 magnifications. In each sample, an average of 300 valves was counted in order to establish the relative abundance of the species (Soeprobowati 2010). Diatom taxonomy followed the guidelines Kramer and Lange-Bertalot (2010a,b (teil 1-2), 2008 (teil 3), 2011 (teil 4) volume 1-4; Guiry and Guiry 2016) and valves were identified to the lowest taxonomic level possible.

The water quality measurements was done in-situ by measuring the temperature, pH, dissolved oxygen, turbidity, conductivity, and water clarity on the depth of 20 cm from surface water. The Rawapening lake depth was measure from the surface water until the bottom of the lake. Water samples were also taken to analyze the concentration of dissolved silicate, total suspended solid (particulate material), biological oxygen demand (BOD), calcium, Fe, Mg, Na, Pb, Cd, Cu, Cr, phosphate, total phosphorous, total nitrogen, nitrite, nitrate, ammonia, and chlorophyll-*a*. BOD was measure by counted of dissolved oxygen on the first day and 5 days. Total phosphorous and total nitrogen was the total of minerals and organics part. 40 data from 2004-2008 had been compiled to develop training set of Rawapening (RP40), that were chosen for the same parameter from the same site as time series. Water quality variables were transformed by log (x+1).

Principle Component Analysis (PCA) followed by Canonical Component Analysis (CCA) was done to determine the water quality parameters that influence the diatoms assemblage and its distribution. CANOCO version 4.56 (ter Braak and Smilauer 2009) was used to do PCA and CCA. CCA was designed to detect the variation trend of diatoms species due to environmental variables, the CCA had combine regular ordination aspect and regression (Kireta et al. 2012). The relationship between diatoms distribution and environmental dataset was assessed by direct gradient technique by CCA with the limited axis ordination as a linier combination of environmental variables (ter Braak and Smilauer 2009). Forward selection was used to reduce redundancy variables and select significantly variables that able to reflect the variation on the diatoms data set by unlimited Monte Carlo permutation. The variables that significantly responsible to the diatoms distribution are when $p < 0.05$ on the 199 permutation. Insignificant variables were not included in the further analysis. Samples of data set as well as environmental parameters were selected. The samples with inflation variant > 20 have a stable data effect, so those samples did not include in the analysis (ter Braak and Smilauer 2009).

Furthermore, transfer function was analyzed with Computer Program C2 1.7.6 (Juggins 2014). The diatoms species with more than 5% of relative abundance had been included in the analysis with 3 significant environmental parameters, i.e. phosphate, calcium, and temperature. *Weighted Averaging* (WA) with inversed and deshrinking was the model that implemented for multivariate calibration function to estimate water quality based on diatoms (Birks et al. 2010). Prediction model was assessed based on correlation coefficient (R^2) between observed diatoms and inference diatoms in the form of Root Mean Square Error (RMSE). The validation for prediction error had assessed with leave-one-out jackknifing (Juggins 2014).

Reconstruction past condition of nutrient status of the lake was done based on the European diatom data set with Computer Program of ERNIE (Environmental Reconstruction using the European Diatom Database (Juggins 2016), compare to Rawapening diatom data set.

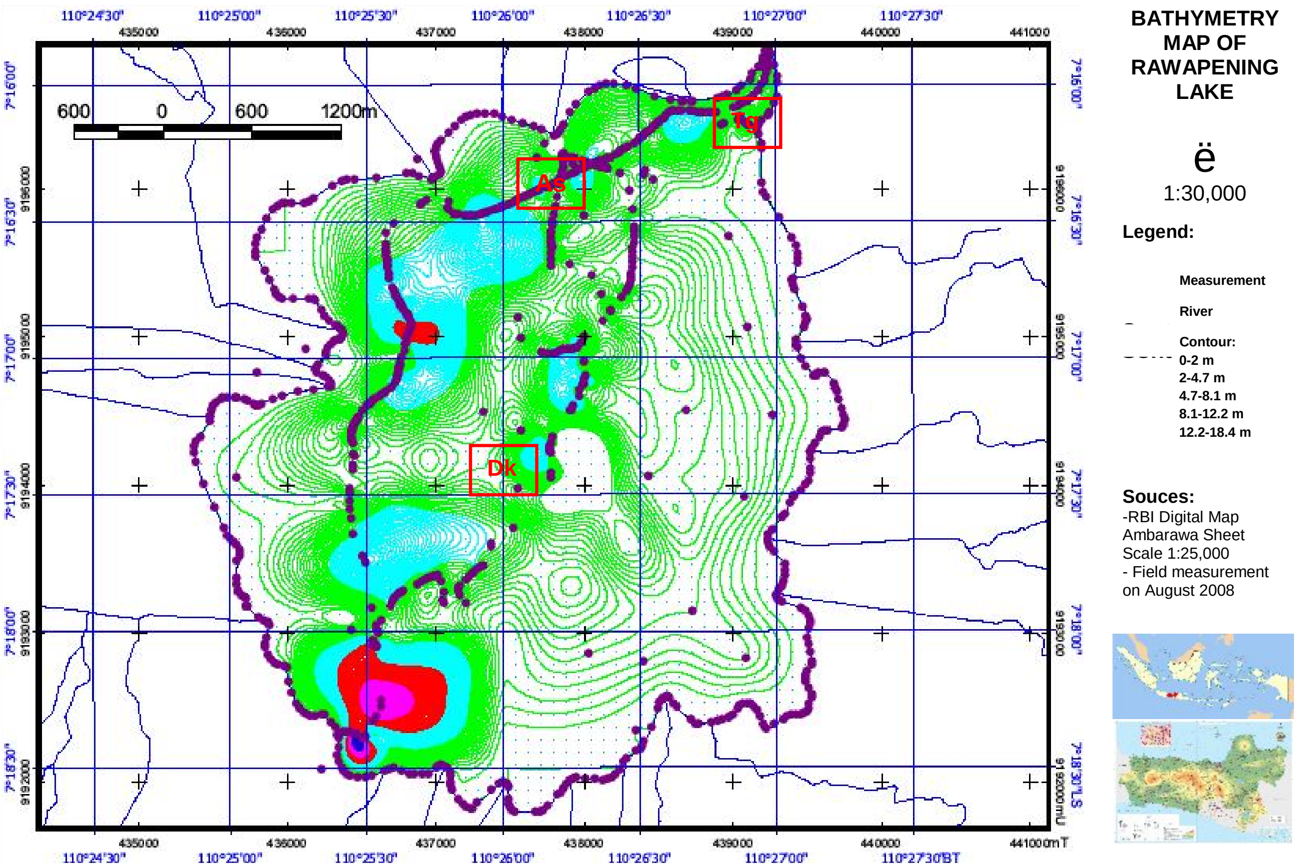

Figure 1. Research site for water quality and diatoms in Rawapening Lake, Central Java, Indonesia

Table 2. Marginal and conditional effect of environmental variables on the diatom variation in Rawapening Lake, Indonesia

Variable	Marginal effects		Conditional effects			
	Var. N	Lambda1	Var. N	LambdaA	P	F
Phosphate	13	0.36	13	0.36	0.005	3.51
Calcium	23	0.32	23	0.3	0.005	3.03
Temperature	3	0.3	3	0.16	0.001	1.7
Turbidity	27	0.35	27	0.13	0.06	1.37
Silica	10	0.3	10	0.12	0.125	1.28
Conductivity	2	0.16	2	0.12	0.175	1.21
Fe	26	0.24	26	0.1	0.365	1.12
Water clarity	4	0.14	4	0.1	0.27	1.1
Depth	5	0.16	5	0.11	0.225	1.2
pH	1	0.32	1	0.1	0.5	1.01
Mg	24	0.3	24	0.09	0.445	1
TSS	17	0.15	17	0.09	0.55	0.92
Pb	6	0.08	6	0.08	0.56	0.9
Nitrite	16	0.18	16	0.08	0.605	0.88
Nitrate	15	0.22	15	0.09	0.56	0.95
Total phosphorous	11	0.14	11	0.08	0.68	0.79
Cd	7	0.09	7	0.07	0.695	0.73
Cr	8	0.08	8	0.12	0.275	1.29
Cu	9	0.08	9	0.12	0.235	1.27
BOD	29	0.19	29	0.06	0.76	0.7
Na	25	0.28	25	0.09	0.57	0.9
Chlorophyll	20	0.27	18	0.08	0.64	0.83
NH_3	14	0.31	14	0.06	0.74	0.67
Dissolved oxygen	28	0.23	28	0.06	0.93	0.55
Total nitrogen	12	0.25	12	0.11	0.405	1.09

RESULTS AND DISCUSSION

The Rawapening diatoms data set was started by Principle Component Analysis (PCA) on the water quality, followed by Canonical Correspondence Analysis (CCA). PCA is a multivariate analysis with an ordination technique which developed theoretical variables by minimized total residual after fitted the strike line and regression (Jongman et al. 2005).Using 21 environmental parameters from 40 sites compiling with previous research (2004-2008) in Rawapening Lake, the Eigen value to axis 1 and 2 were 0.417 and 0.108, which reflected 65.2% environmental variation (Table 1). Axis 1 was dominated by phosphate and temperature, whereas axis 2 was connected with more heterogeneous variables. The environmental variable was significantly influence the diatoms assemblage if $p<0.05$ with the permutation 199. Temperature and phosphate were in thefirst axis, whereas calcium was in the fourth axis (Figure 2). Phosphate explained 41.7% species variation on the Rawapening diatoms data set whereas calcium explained 65.2% species variation in Rawapening (Table 1).

All environmental variables, consisting of temperature, pH, dissolved oxygen, turbidity, conductivity, water clarity, dissolved of silicate, total suspended solid (particulate material), BOD, calcium, Fe, Mg, Na, Pb, Cd, Cu, Cr, phosphate, total phosphorous, total nitrogen, nitrite, nitrate, ammonia, and diatoms data set from 40 sites were analyzed. Furthermore, based on the Monte Carlo permutation test, the environmental variables from marginal effect with lambda >0.2 were reduced from the data. However, based on conditional effect, 3 variables that responsible to the diatoms assemblage ($p<0.05$) were phosphate, calcium, and temperature (Table 2). Those result related to the allochtonous effect from the inlet.

Based on the CCA, the variation of Rawapening's diatoms was controlled by phosphate, temperature and calcium (Figure2). The diatom species that correlate to the environmental parameters were provided in Table 3. Phosphate was the strongest variable that influenced diatoms assemblage in Rawapening Lake with lambda of 0.36 and $p < 0.005$ (Table 2).

Calcium carbonate is the most contributors for water alkalinity. Alkalinity was buffer capacity for water pH. Bicarbonate was alkali due to the reaction with H^+, meanwhile when hydrolyzed it may produce OH^-. The alkalinity of CO_3^{2-}were stronger than CO_2, therefore in equilibrium condition, OH^-in the bicarbonate solution always exceed H^+. Based on this research, the major cation dominated in Rawapening was calcium. People living surrounding Rawapening were used calcium carbonate on the production of organic fertilizer from water hyacinth. The tailing from fertilizer process diffuses to Rawapening Lake. Diatoms used bicarbonate ion as source of carbon and induced hydroxide accumulation ($CO_3^{2-} + H_2O \leftrightarrow HCO_3^- + OH^-$). In turn, this hydroxide accumulation may induce an increase of pH (9-10). This alkali condition had also indicated by blooming of *Aulacoseira granulata* (Ehr.) Simonsen (Soeprobowati et al. 2012).

Development of transfer function basically was based on the Weighted Averaging (WA) with inversed and deshrinking. WA calibration was more suitable rather than WAT (Weighted Averaging with Tolerance-down weighting) as a predictive model of phosphate. Diatoms assemblage was correlated with phosphate ($R^2= 0.50$, RMSE = 0.22, Table 4). Phosphate contributes 50% on diatom assemblage, and the rest were another factors.

Generally, diatom data set and transfer function was developed based on some lakes numbers. Mills (2009) developed transfer function based on 86 Uganda's lakes. However, Mackay et al. (2003) had successfully developed transfer function based on the internal diatoms of Baikal Lake. The exploration of quantitative correlation between diatom species and environmental variables had been calculated based on the environmental internal gradient of Rawapening Lake and shown a quite good trend.

Table 1. Eigen value 4 axis resulting from PCA

Axis	1	2	3	4	Total variant
Eigen value	0.417	0.108	0.067	0.059	1.0
Correlation species-environment	0.853	0.829	0.793	0.826	
% cumulative species data	41.7	52.6	593	65.2	
Sum of Eigen value = 1					
Sum of canonical Eigen value = 0.681					

The reconstruction of total phosphorous of Rawapening Lake based on the European diatoms data set compare to Rawapening diatoms data set shown a similar pattern for Asinan and Tuntang sites (Figure 3). There was an increase of total phosphorous in between 1984-1990 which was related to the low of rainfall. Total phosphorous from catchment area were entered to Rawapening Lake from16 inlets, whereas the only one outlet did not discharge the water during the dry season to maintain water level for electricity power. This condition had induced a sharp increase of total phosphorus content.

However, the reconstruction from Dangkel site shown a different pattern. There was a total phosphorous concentration decreasing trend in the middle layers with European diatoms data set, but an increase trend with Rawapening diatoms data set (Figure 3). For Dangkel site, total phosphorous content more representatively reconstruct with Rawapening diatoms data set rather than European data set, due to diatoms variation species at Dangkel site which was higher than European data set, which are not represented in European diatoms data set.

The reconstruction of pH of Rawapening lake had differ patter for different sites both using European diatoms data set and Rawapening diatoms data set. For examples, Asinan site shown fluctuate pH when reconstruct by European diatoms data set. However, based on Rawapening diatoms data set, the Rawapening pH tends to increase by year (Figure 4). Many diatoms species found in Rawapening Lake, do not found in European diatoms data set. In Rawapening diatoms data set, those species characterized such specific condition.

The pH of Rawapening Lake was fluctuant. In 1978, pH in Rawapening was neutral about 7.2-7.6 (Goltenboth 1979). In 1999, pH tent to increase, in the range of 7.5-8.8 (BPDL-PPLH Undip 1999). In 2003, pH relatively neutral, in the range of 6.5-7.7 (Wibowo 2004). In 2004 and 2005, pH in the inlet rivers tent to neutral, but in the site near spring and floating island, the pH tent to be highwhich was 9.52 (Soeprobowati et al. 2012). In this research (2009), the pH of Rawapening Lake was neutral, except near the spring and floating island that were 11 and 9.2.Naturally, lake will be more acid by time, but in Rawapening as stated before, the pH tent to increase. This condition is caused by the decomposition of organic materials by microbes in the peat sediment. The other reason is the use of calcium for treat organic fertilizer from water hyacinth. In the rainy day, the calcium leaches and enters to the lake. In recent study, those paleoreconstruction of ecological change in Rawapening was proven a trend of increasing pH. In the measurement in June 2015, pH of Asinan site was 7.8-8.1 (Soeprobowati 2015).

Internal based diatoms of Rawapening Lake developed from different 40 sites and time scale, shown quite good results since it was usually represent the specific diatoms. The diatoms data set of Rawapening was initial Indonesian diatoms data set for reconstruction total phosphorous, therefore, research has to be continued to add and fulfill data of water quality and diatoms from other Indonesian lakes.

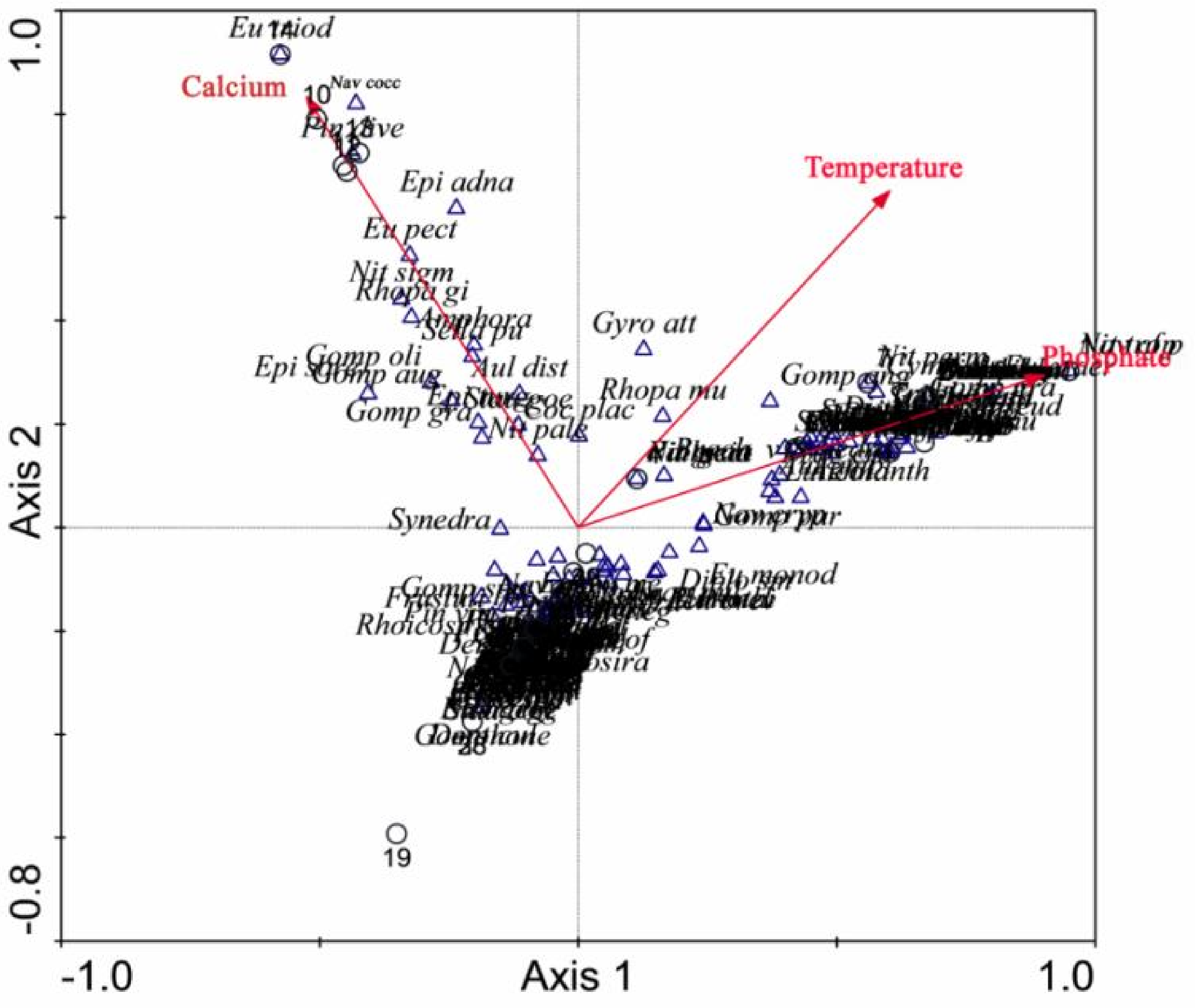

Figure 2. Triplot CCA; Phosphate, temperature and calcium the major of environmental variables which influence diatom variation of Rawapening Lake, Central Java, Indonesia

Table 3. List of diatom species of Rawapening Lake, Central Java, Indonesia in correlation with water quality as mention in Figure 2.

Abbreviation	Name of species
Ach brev	*Achnanthes brevipes* Agardh
Ach exi	*Achnanthidium exiguum* (Grunow)
Ach exi1	*Achnanthidium exiguum1* Grunow
Ach inf	*Achnanthidium inflata* (Kutzing) Grunow
Ach min	*Achnanthidium minutissimum* (Kutzing) Czamecki
Ach neo	*Achnanthidium neomicrocephalum* Kutzing
Amp cop	*Amphora copulata* (Kutzing) Schoeman & R.E.M. Archibald
Amp hol	*Amphora holsatica* W. Smith
Amp ova	*Amphora ovalis* (Kutzing) Kutzing
Amp sp	*Amphora* sp.
Amp ven	*Amphora veneta* Kutzing
Amph ala	*Amphipora alata* (Ehrenberg) Kutzing
Amph cof	*Amphora coffeaeformis* Kutzing
Ano sphae	*Anomoeoneis sphaerophora* Pfitzer
Aul ambi	*Aulacoseira ambigua* (Grunow) Simonsen Manitoba
Aul dis	*Aulacoseira distans* (Ehrenberg) Simonsen
Aul gran	*Aulacoseira granulata* (Ehrenberg) Simonsen
Bac pax	*Bacillaria paxillifer* (O. F. Muller) T. Marsson
Brach breb	*Brachysira brebissonii* Ross
Brach neo	*Brachysira neoexilis* Lange-Bertalot
Brach vit	*Brachysira vitrea* Grunow
Calo ven	*Caloneis ventricosa* (Egrenberg) F. Meister
Camp nor	*Campylodiscus noricus* Ehrenberg ex Kutzing
Coc pla	*Cocconeis placentula* Ehrenberg
Cy atom	*Cyclotella atomus* Hustedt
Cy men	*Cyclotella meneghiniana* Kutzing
Cy pse	*Cyclotella pseudostelligera* Hustedt
Cym pros	*Cymbella prostata* (Berkeley) Cleve
Cym sol	*Cymatopleura solea* (Brebisson) W Smith
Cymb af	*Cymbella affinis* Kutzing
Cymb cae	*Cymbella caespitosum* Kutzing
Cymb cis	*Cymbella cistula* (Ehrenberg) O. Kirchner
Cymb tum	*Cymbella tumida* (Brebisson) Van Heurck
Den ele	*Denticula elegans* Kutzing
Den sp	*Denticula* sp.
Dia cont	*Diadesmis contenta* (Grunow) D.G. Mann
Dia conf	*Diadesmis confervacea* Kutzing
Dia hie	*Diatoma hiemale (*Roth) Heiberg
Dia vul	*Diatoma vulgare f.brevis* (Grunow) Bukhtiyarova
Diplo el	*Diploneis elliptica* (Kutzing) Cleve
Diplo ova	*Diploneis ovalis* (Hilse) Cleve
Diplo smi	*Diploneis smithii* (Brebisson) Cleve
Disc stel	*Discostella stelligera* (Cleve & Grunow) Houk & Klee
Ency mes	*Encyonema mesiana* (Cholnoky) DGMann
Eny min	*Encyonema minutum* (Hilse) DGMann
Epi ad	*Epithemia adnata* (Kutzing)Brebisson
Epi ar	*Epithemia argus* Kutzing
Epi tur	*Epithemia turgida* (Ehrenberg) Kutzing

Eu bi	*Eunotia bilunaris* (Ehrenberg) Schaarschmidt
Eu cam	*Eunotia camelus* Ehrenberg
Eu exi	*Eunotia exigua* (Brebisson ex Kutzing) Rabenhorst
Eu inc	*Eunotia incisa* W. Smith ex W Gregory
Eu mon	*Eunotia monodon* Ehrenberg
Eu nae	*Eunotia naegelli* Migula
Eu par	*Eunotia parallela* Ehrenberg
Eu pec var pec	*Eunotia pectinalis* var. *pectinalis* Kutzing
Eu prae	*Eunotia praerupta* Ehrenberg
Eu sep	*Eunotia septentrionalis* Geniculata .Berg
Eu ten	*Eunotia tenella* (Grunow) Hustedt
Eu trio	*Eunotia triodon* Ehrenberg
Fal pyg	*Fallacia pygmaea* (Kutzing) Stickle & D.G.Mann
Frag cap	*Fragilaria capitata* (Ehrenberg) Lange-Bertalot
Frag capu	*Fragilaria capucina* Desmazieres
Frag capu var rum	*Fragilaria capucina* var. *rumpens* (Kutzing) Lange-Bertalot
Frag croto	*Fragilaria crotonensis* Kitton
Frag int	*Fragilaria intermedia* Grunow
Frag pin	*Fragilaria pinnata* Ehrenberg
Frag pul	*Fragilaria pulchella* (Ralfs ex Kutzing) Lange-Bertalot
Frag vau	*Fragilaria vaucheriae* (Kutzing) J. B. Petersen
Frag vir	*Fragilaria virescens* Ralfs
Frus rhom	*Frustulia rhomboides* (Ehrenberg) De Toni
Frus vul	*Frustulia vulgaris* (Thwaites) De Toni
Gomp acu	*Gomphonema acuminatum* Ehrenberg
Gomp af	*Gomphonema affine* Kutzing
Gomp ang	*Gomphonema angustum* C. Agardh
Gomp aug	*Gomphonema augur* Ehrenberg
Gomp clav	*Gomphonema clavatum* Ehrenberg
Gomp grac	*Gomphonema gracilis* Hustedt
Gomp grac tur	*Gomphonema gracilis turris* Hustedt
Gomp oli	*Gomphonema olivaceum* (Hornemann) Brebisson
Gomp par	*Gomphonema parvulum* (Kutzing) Kutzing
Gomp spp	*Gomphonema* spp.
Gomp trun	*Gomphonema truncatum* Ehrenberg
Gomp ven	*Gomphonema ventricosum* W. Gregory
Gyro acu	*Gyrosigma acuminatum* Kutzing Rabenhorst
Gyro at	*Gyrosigma attenuatum* (Kutzing) Rabenhorst
Gyro obt	*Gyrosigma obtusatum* (Sullivant & Wormley) C.S Boyer
Gyro par	*Gyrosigma parkerii (*M.B. Harrison) Boyer
Gyro scal	*Gyrosigma scalproides* (Rabenhorst) Cleve
Gyro spen	*Gyrosigma spencerii* (Bailey ex Quekett) Griffth & Henfrey
Han arc	*Hannaea arcus* (Ehrenberg) R.M. Patrick
Hantz amp	*Hantzschia amphioxys* (Ehrenberg) Grunow
Lut hal	*Luticola halophila* Grunow
Lut mut	*Luticola mutica* (Kutzing) D.G. Mann
Mas el	*Mastogloiea elliptica* (C. Agardh) Cleve
Mel var	*Melosira varians* C. Agardh
Mer cir	*Meridion circulare* (Greville) C. Agardh
Nav amp	*Navicula amphioxys* Kutzing
Nav at	*Navicula atomus* (Kutzing) Grunow
Nav car	*Navicula cari* Ehrenberg W. Gregory ex Greville
Nav cf pla	*Navicula* cf. *placentula* (Ehrenberg) Kutzing
Nav cf pse	*Navicula* cf. *pseudoscutiformis* (Hustedt)
Nav coc	*Navicula cocconeiformis* W. Gregory ex Greville
Nav cons	*Navicula constans* Hustedt
Nav cryp	*Navicula cryptotenella* Lange-Bertalot
Nav cus	*Navicula cuspidata* (Kutzing) Kutzing
Nav daf	*Navicula distans* W. Smith
Nav elg	*Navicula elginensis* (W. Gregory) Ralfs
Nav greg	*Navicula gregaria* Donkin
Nav has	*Navicula hasta* Pantocsek
Nav rad	*Navicula radiosa* Kutzing
Nav rhyn	*Navicula rhyncocephala* Kutzing
Nav spp	*Navicula* spp.
Nei aff	*Neidium affine* (Ehrenberg) Pfitzer
Nit aci	*Nitzschia acicularis* (Kutzing) W.Smith
Nit cap	*Nitzschia capitellata* Hustedt
Nit clau	*Nitzschia clausii* Hantzch
Nit clos	*Nitzschia closterium* (Ehrenberg) W. Smith
Nit dis	*Nitzschia dissipata* (Kutzing) Rabenhorst
Nit fil	*Nitzschia filiformis* (W. Smith) Van Heurck
Nit gra	*Nitzschia gracilis* Hantzsch
Nit lin	*Nitzschia linearis* W. Smith
Nit pal	*Nitzschia palea* (Kutzing) W. Smith
Nit per	*Nitzschia perminuta* (Grunow) M. Peragallo
Nit sig	*Nitzschia sigmoidea* (Nitzsch) W. Smith
Nit trop	*Nitzschia tropica* Hustedt
Ortho ros	*Orthoseira roseana* (Rabbenh.) O'Meara
Pin bor	*Pinnularia borealis* Ehrenberg
Pin brau	*Pinnularia braunii* Cleve
Pin div	*Pinnularia divergentissima* (Grunow) Cleve
Pin gen	*Pinnularia gentilis* (Donkin) Cleve
Pin gib	*Pinnularia gibba* Ehrenberg
Pin int	*Pinnularia interrupta* W. Smith
Pin meso	*Pinnularia mesolepta* (Ehrenberg) W. Smith
Pin micro	*Pinnularia microstauron* (Ehrenberg) Cleve
Pin neo	*Pinnularia neo-major* Krammer
Pin nob	*Pinnularia nobilis* Ehrenberg (Ehrenberg)
Pin sp	*Pinnularia* sp.
Pin sto	*Pinnularia stomatophora* Grunow
Pin subcap	*Pinnularia subcapitata* W. Gregory
Pin subgib	*Pinnularia subgibba* Krammer
Pin supdiv	*Pinnularia superdivergentissima* Chaumont & H. Germain
Pin vir	*Pinnularia viridis* (Nitzsch) Ehrenberg
Pla del	*Planothidium delicatulum* Kutzing
Pla lan	*Planothidium lanceolatum* Brebisson
Pleu	*Pleurosira* sp.
Psam didy	*Psammothidium didymium* Hustedt
Rhoi abb	*Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot)
Rhoi cur	*Rhoicosphenia curvata* (Kutzing) Grunow
Rhop gib	*Rhopalodia gibba* (Ehrenberg) Otto Muller
Rhop mus	*Rhopalodia musculus* (Kutzing) Otto Muller
Sel pup	*Sellaphora pupula* (Kutzing) Mereschkovsky
Sel sem	*Sellaphora seminulum* (Grunow) D.G. Mann
Sel wis	*Sellaphora wislouchii* Poretzky
Stau an var jav	*Stauroneis anceps* var. *javanica* Hustedt
Stau coh	*Stauroneis cohnii* Hilse
Stau cons	*Staurosira construens* Ehrenberg
Stau goep	*Stauroneis goeppertiana* Bleisch(Navmutvartrop)
Stau jav	*Stauroneis javanica* (Grunow) Cleve
Stau phoe	*Stauroneis phoenicenteron* (Nitzsch) Ehrenberg
Sur ang	*Surirella angusta* Kutzing
Sur lin	*Surirella linearis* W. Smith
Sur ova	*Surirella ovalis* Brebisson
Sur rob	*Surirella robusta* Ehrenberg
Sur ten	*Surirella tenera* W. Gregory
Syn ac	*Synedra acus* Kutzing
Syn tab	*Synedra tabulata* (C. Agardh) Kutzing
Syn ul	*Synedra ulna* (Nitzsc) Ehrenberg
Tab fasc	*Tabularia fasciculata* (C. Agardh) D.M. Williams & Round
Tab floc	*Tabellaria flocculosa* (Roth) Kutzing
Try cal	*Tryblionella calida* (Grunow) D.G. Mann

Table 4.WA and *WA* tolerance down-weighted (WAT), RMSE, regression of 40 samples for transfer function development

Code	RMSE	R^2	Ave_Bias	Max_Bias	Jack_R^2	Jack_Ave_Bias	Jack_Max_Bias	RMSEP
WA_Inv	0.22	0.50	0.00	0.75	0.04	-0.01	1.16	0.33
WA_Cla	0.31	0.50	0.00	0.31	0.07	0.00	1.11	0.40
WATOL_Inv	0.23	0.46	0.00	0.95	0.03	0.05	1.66	0.40
WATOL_Cla	0.34	0.46	0.00	0.67	0.01	0.11	1.99	0.58

Note: WA_Inv: Weighted averaging model (inverse deshrinking) for Total P. WA_Cla: Weighted averaging model (classical deshrinking) for Total P. WATOL_Inv: Weighted averaging model (tolerance down weighted, inverse deshrinking) for Total P. WATOL_Cla: Weighted averaging model (tolerance down weighted, classical deshrinking) for Total P

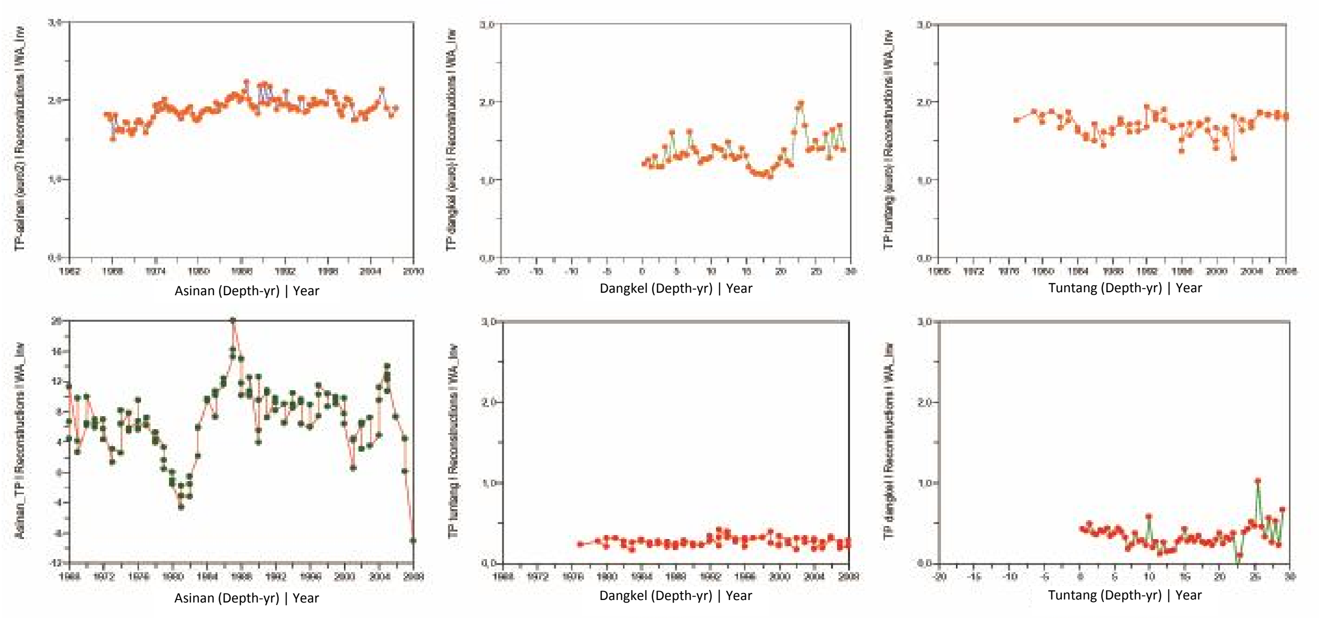

Figure 3. The past total phosphorous reconstruction of Rawapening Lake, Central Java, Indonesia with European diatom data set (above) and Rawapening diatom data set (below)

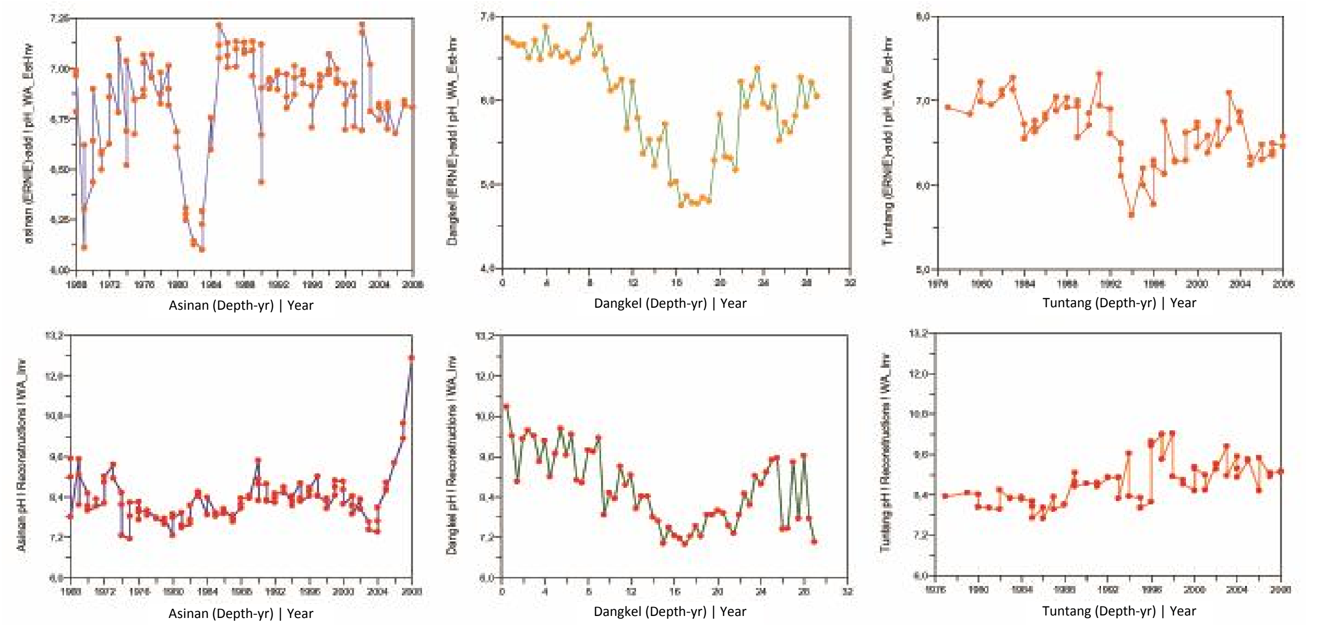

Figure 4. Reconstruction of pH at 3 sites using European data set (above) and Rawapening Lake dataset (below)

The conclusion shows that phosphate, temperature, and calcium were the environmental parameters that influence the diatoms assemblage of Rawapening Lake. Phosphate was contributed 50% on diatoms assemblage. Internal based transfer function of diatoms provides more suitable diatoms data set rather than European diatoms data set. The Rawapening diatom data set of total phosphorous is the initial Indonesian diatom data set for past trophic status, therefore, research has to be continued spatially for other Indonesian lakes and temporary on specific Indonesian lake to develop Indonesia diatoms data set.

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