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A PRELIMINARY STUDY OF THE DISTRIBUTION OF PHOSPHORUS AND SILICON COMPOUNDS IN TASIK KENYIR, HULU TERENGGANU, MALAYSIA

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Abstract: A preliminary study of phosphorus and silicon compounds in lake water was conducted at the Tasik Kenyir, Terengganu, Malaysia. Monthly water samples were taken from August to October 2010. In general, higher concentrations of both nutrients were recorded at the western part of the lake. The results also showed that the nutrient concentrations were lower compared with other selected study areas. According to the National Water Quality Standards (NWQS) classification for Malaysia, the concentrations of dissolved inorganic phosphorus and silicon were in Class I, indicating a natural level which is suitable for the conservation of the natural environment, water supply without any treatment, and fishery activities.

Keywords: Phosphorus and silicon compounds, National Water Quality Standards, Anthropogenic activities, Tasik Kenyir (Malaysia).

Introduction

A Tasik Kenyir is the biggest man-made lake in Southeast Asia, located in the state of Terengganu on the east coast of Peninsular Malaysia. With a surrounding catchment area of 260,000 ha, it was mainly designed for hydroelectric power generation and flood control purposes. The Terenggan, Petang, Lasir, Pertang, Lepar, Genung, Lawit, Ketiar and Cacing Rivers are the main rivers flowing into the lake. Surrounded by tropical jungle, Tasik Kenyir has been successfully developed for eco-tourism activities. In view of the rapid development in the area and the increase of visitors to Tasik Kenyir, the possibility of increased deforestation and sewage discharge into the lake is high. These factors might then increase the concentrations of nutrient compounds in the lake. A preliminary study was carried out to determine the distributions and current levels of nutrients in Tasik Kenyir. Nitrogen (N), phosphorus (P) and silicon (Si) compounds were measured, but only the latter two are presented in this paper. The results obtained were then compared with the National Water Quality Standard (NWQS) as listed in Table 1 to determine the suitability of these water bodies for their respective potential uses (DOE, 2010).

Table 1: National Water Quality Standards for Malaysia (DOE, 2010)

Parameter	Unit	Class				
		I	IIA/IIB	III	IV	V
P	mg/L P	Natural Level	0.2	0.1	-	Level above IV
Si	mg/L Si	Natural Level	50	-	-	Level above IV

Classes	Uses
Class I	Conservation of natural environment Water supply I – Practically no treatment necessary Fishery I – Very sensitive aquatic species
Class IIA	Water supply II – Conventional treatment required Fishery II – Sensitive aquatic species
Class IIB	Recreational use with body contact
Class III	Water supply III – Extensive treatment required Fishery III – Common of economic value and tolerant species; livestock drinking
Class IV	Irrigation
Class V	None of the above

Material and Methods

Three surveys were conducted in this study, in August, September and October 2010. Two major areas were involved: the eastern part of Tasik Kenyir (ELK; stations K1 to K15), and Terengganu National Park (TNP; stations N1 to N17), which is located at the western part of Tasik Kenyir (Figure 1). Water samples were collected from both surface and bottom waters (i.e. 30 m below the surface) for stations K1 to K15 in the ELK sampling area. In contrast, scattered sampling sites were chosen and only surface water was collected in the TNP area. Water samples were filtered through 0.45 µm membrane filters for the determination of dissolved nutrient concentrations. After filtration, samples were refrigerated prior to the analysis of P and Si compounds which included dissolved inorganic nutrients (i.e. DIP and DISi), dissolved organic nutrients (i.e. DOP and DOSi) and total particulate nutrients (i.e. TPP and TPSi) based on established methods (Grasshoff *et al.*, 1983).

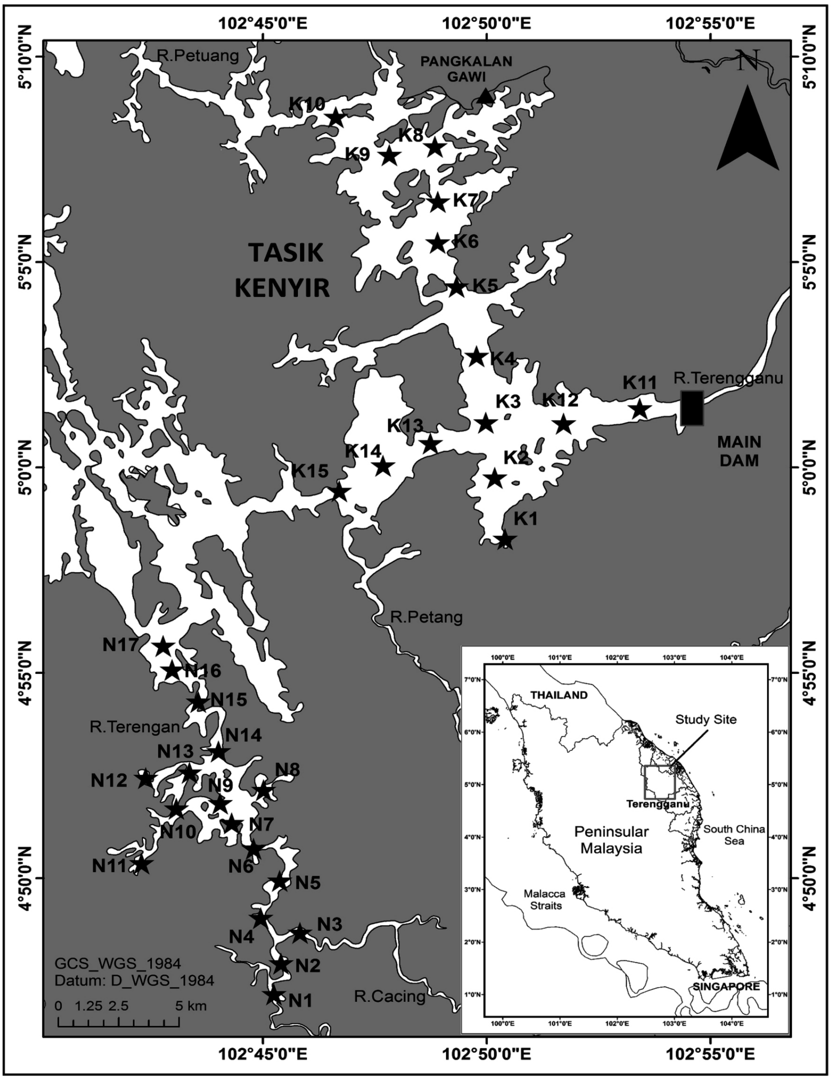

Figure 1: Sampling stations at Tasik Kenyir

Results and Discussion

Spatial Distribution of P Compounds in Tasik Kenyir

For the ELK transect, the DIP concentrationsfor surface and bottom waters were in the range 6.9-35.8 µg/L P (mean 20.9 ± 9.4 µg/L P) and 1.2-20.6 µg/L P (mean 10.4 ± 5.5 µg/L P), respectively (Figure 2). The maximum DIP concentrations for both surface and bottom waters were found in the northern part of the ELK transect. A pronounced high in DIP levels for both surface and bottom waters was found at station K4 extending to station K10, with respective maximum DIP concentrations of 35.8 µg/L P for surface water and 20.6 µg/L P for bottom water recorded at stations K5 and K8. Those stations south of station K4 are, apart from Pangkalan Gawi which serves as a jetty, areas with lakeside restaurants and homesteads, resulting in lower DIP levels in this region. Further, the vertical distribution of these nutrients in Tasik Kenyir is characterized by higher DIP concentrations in surface waters compared to bottom waters for almost all the sampling stations.

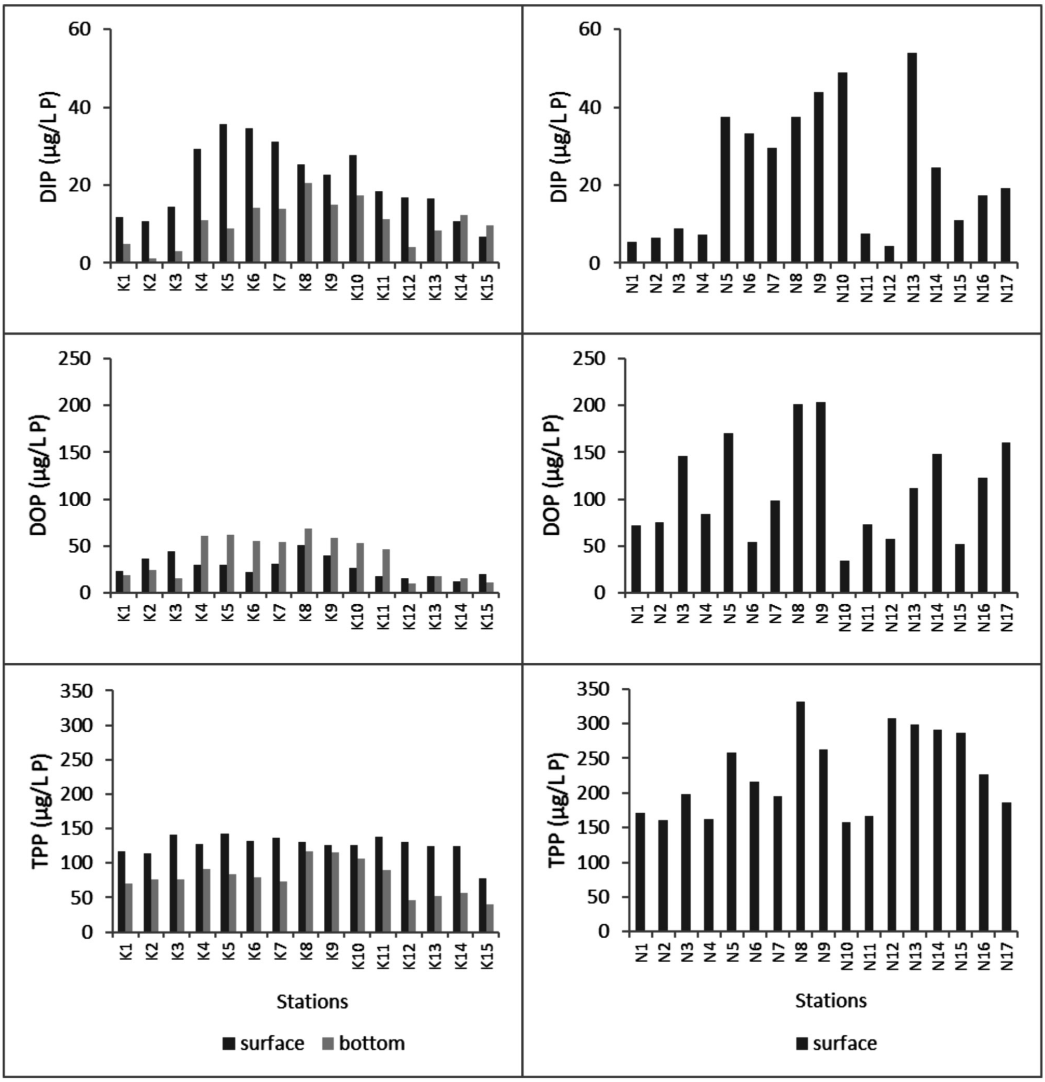

Figure 2: Variation of P compounds in Tasik Kenyir

Figure 2 shows that the DOP concentrations in the ELK transect were in a higher range compared to the DIP concentrations. The DOP concentrations were 12.2-50.7 µg/L P (mean 27.9 ± 11.0 µg/L P) for surface waters and 10.6-68.9 µg/L P (mean 38.3 ± 22.0 µg/L P) for bottom waters. The DOP concentrations in bottom waters showed a similar trend to DIP, i.e. higher nutrient concentrations occurred at the northern part of the transect (stations K4 to K10). Yet, surface water DOP did not follow the trend of bottom water DIP; higher DOP concentrations extended from most of the southern part to the northern part of transect (stations K1 to K10). Comparing surface and bottom water DOP, the bottom water DOP showed rather high concentrations for most of the stations in this study.

In general, comparisons of the surface water TPP concentrations (78.0-142.5 µg/L P; mean 125.8 ± 15.6 µg/L P) among the stations revealed little difference throughout the ELK transect (Figure 2). Even so, TPP levels for bottom waters recorded a marked increase from station K8 to station K10 (40.3-116.3 µg/L P; mean 78.2 ± 23.4 µg/L P), which are the stations close to Pangkalan Gawi. The stations following the south to north transect (stations K1-K10), which are influenced by water that flows across Pangkalan Gawi, generally appeared to have higher bottom water DOP than stations from east to west (stations K11-K15), which are influenced by water flowing towards the dam area. The phenomenon of higher nutrients in surface waters compared to bottom waters also occurred in the TPP distribution.

Spatial Distribution of Si Compounds in Tasik Kenyir

Figure 3 shows the concentrations of DISi, DOSi and TPSi in Tasik Kenyir. The highest DISi concentration in surface waters along the ELK transect was recorded at station K14 (0.53 mg/L Si), while the lowest DISi concentration was observed at station K2 (0.05 mg/L Si). Meanwhile, the concentration of DISi for the bottom waters ranged from 0.04 mg/L Si (station K2) to 0.41 mg/L Si (station K13). The trends of DISi both for surface and bottom waters contrasted with those for P compounds, whereby higher levels of DISi were found at the east-west stations (station K12-K15) instead of the south-north stations, although some higher DISi concentrations were found at stations K7-K10. However, like most of the P compounds, surface waters revealed higher DISi concentrations compared to bottom waters.

Throughout the ELK transect, DOSi concentrations for the surface and bottom waters ranged from 0.05 to 0.55 mg/L Si (mean 0.27 ± 0.16 mg/L Si) and 0.04 to 1.33 mg/L Si (mean 0.68 ± 0.46 mg/L Si), respectively. The higher surface DOSi concentrations appeared to have the same distribution as DISi (station K14, 0.53 mg/L Si and station K15, 0.55 mg/L Si), as well as some higher surface water DOSi concentrations at stations across the south-north ELK transect (stations K4-K8). Comparing surface and bottom water concentrations of DOSi, DOSi tends to be higher in bottom waters.

The TPSi concentrations in the surface and bottom waters were in the range 2.01-3.98 mg/L Si (3.02 ± 0.70 mg/L Si) and 1.41-2.72 mg/L Si (2.11 ± 0.44 mg/L Si), respectively (Figure 3). From the graph it can be observed that the trend of surface water TPSi across the ELK transect was somewhat similar to that of bottom water DOSi, where higher surface TPSi concentrations only occurred at stations close to Pangkalan Gawi (stations K4-K10). It is also interesting to note that the trend of bottom water TPSi differs to that of surface water TPSi, where a dramatic peak of concentration was not observed in bottom water TPSi. Looking at the vertical distribution of TPSi, higher TPSi concentrations mostly appeared at the surface waters compared to the bottom waters.

Comparison with Some Selected Previous Studies

The concentrations of P and Si compounds were compared with some selected previous studies (Table 2). However, most of the previous studies focused primarily on inorganic nutrients. Generally, the DIP in the current study covered a lower range of concentrations compared to

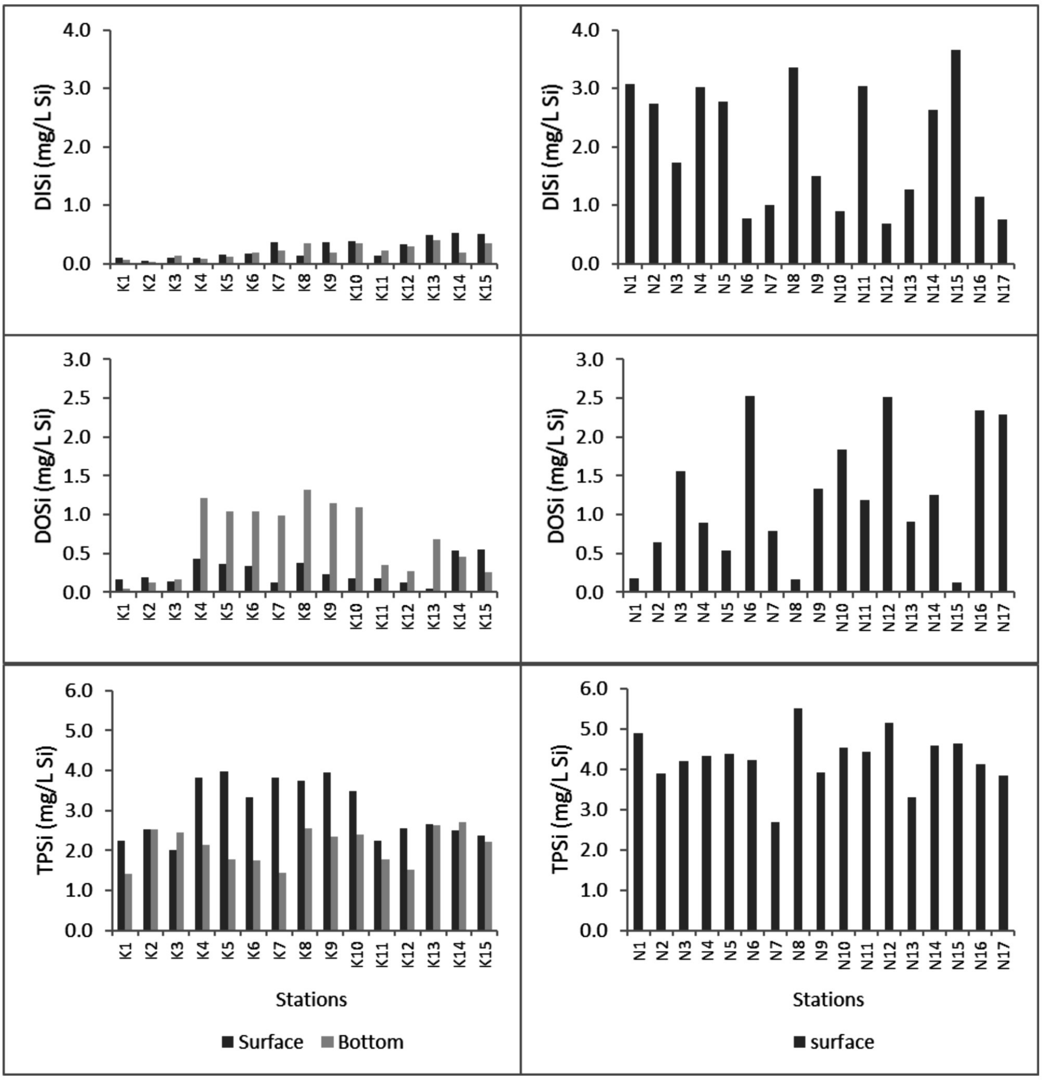

Figure 3: Variation of Si compounds in Tasik Kenyir

Table 2: Comparison of P and Si compounds within selected study areas

Location	DIP (µg/L P)	DISi (mg/L Si)	References
Tasik Kenyir, Malaysia	1.2-35.8	0.04-0.53	Present study
Chini Lake, Pahang, West Malaysia	7.0-123.0	-	Shuhaimi-Othman *et al.* [3]
Lake Egirdir, Turkey	5.0-70.0	-	Gunes [4]
Patagonian lakes	0.5-305.6	0.7-72.4	Diaz *et al.* [5]
Small lakes in European Russia	-	0.001-13.1	Moiseenko *et al.* [6]

Chini Lake (Shuhaimi-Othman *et al.*, 2007), Lake Egirdir (Gunes, 2008) and Patagonian lakes (Diaz *et al.*, 2007). Similar results was also found for Si compounds where lower ranges of DISi were recorded in the present study compared to the study carried out at Patagonian lakes (Diaz *et al.*, 2007) as well as that carried out at small lakes in European Russia (Moiseenko *et al.*, 2013). The study from Chini Lake reported that high values of phosphate in this area generally occurred at the stations near to the settlements of indigenous people, resorts and the National Service Centre camp (Shuhaimi-Othman *et al.*, 2007). The study concluded that the main source of inorganic P was from the daily activities of the local community around the lake such as human excretion and the use of detergents. Diffuse sources from agricultural activity was also found to be important to the contribution of anthropogenic P into aquatic systems, although this kind of influence is always masked by important point sources. In the case of Lake Egirdir in Turkey, Gunes (2008) found that the greatest amount of P discharge into the Lake Egirdir originated from cultivated agricultural lands. Geographical factors had the most influence on the water chemistry, such as nutrient concentrations, in the studies of Patagonian lakes (Diaz *et al.*, 2007) and small lakes in European Russia (Moiseenko *et al.*, 2013). The high values of DISi in both of these studies were found to be mainly due to the location of the watershed rock and the gradients in bedrock geology.

Comparison of Nutrients between ELK and TNP

In order to evaluate the potential different regional inputs of nutrients, comparisons have been made between ELK and TNP (a national park area). The P concentrations in the TNP area fell within the ranges of 4.4-53.9 μg/L P (mean 23.3 ± 16.6 μg/L P), 35.0-203.2 μg/L P (mean 109.9 ± 53.5 μg/L P) and 158.5-331.4 μg/L P (mean 228.1 ± 59.2 μg/L P) for DIP, DOP and TPP, respectively (Figure 2). In addition, the DISi, DOSi and TPSi concentrations obtained in the TNP area in this study were in the ranges of 0.68-3.66 mg/L Si (mean 2.0 ± 1.06 mg/L Si), 0.13-2.53 mg/L Si (mean 1.24 ± 0.82 mg/L Si) and 2.69-4.89 mg/L Si (mean 4.27 ± 0.66 mg/L P), respectively (Figure 3). Ideally, a national park is a protected area with low pollution levels due to low disturbances from anthropogenic activities (DEP, 2009). However, it is somewhat surprising that the higher ranges of nutrients were generally observed in the TNP area compared to the ELK area. One of the potential explanations could be the increase of visitors to TNP for fishing activities, which has resulted in elevated sewage inputs into the water column and therefore increased nutrient concentrations. Even though TNP appeared to have higher nutrient concentrations, it still lies within Class I based on the NWQS classification, which is similar to ELK.

Conclusion

The results from this preliminary study have shown that relatively higher concentrations of P and Si compounds were found in the northern part of the lake for the ELK transect surveys. However, the concentrations recorded at ELK were still low compared to TNP. In comparison with other study areas, the nutrient levels in Tasik Kenyir were still low due to low anthropogenic activities around Tasik Kenyir.

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