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Nutrients Status of Kemaman River Basin in Southern South China Sea (Malaysia)

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Preliminary study of phosphorus and nitrogen-based nutrients was conducted at the Kemaman River basin, Terengganu, Malaysia. Surface water samples were taken monthly from July-November 2009. In general, higher concentrations of nutrients were recorded at the station near to agricultural activities. The study also showed that the nutrients concentrations were lower compared with other selected study areas. According to the National Water Quality Standards (NWQS) classification for Malaysia, the concentrations of orthophosphate, nitrite and nitrate were in Class I water quality indicating a natural level. No comparison based on National Water Quality Standards could be made for other parameters as they are still not listed in this classification.

Keywords: : Phosphorus and nitrogen-based nutrients, Anthropogenic activities, Kemaman River basin.

INTRODUCTION

Phosphorus and nitrogen are major sources of nutrients to water bodies[1,2]. Runoff from agriculture, for example, increases the flux of these nutrients in the aquatic environment, which then causes eutrophication and stimulates algae and aquatic plant growths. Nitrogen and phosphorus are important chemical properties of fertilizer used in agriculture to improve crop production and soil properties[3]. Fertilizer application in agriculture introduces a great quantity of N and P into the environment and agricultural activities accelerate the N and P transformation to the water body[4,5]. Sewage effluent input is also an important consideration in elevated nutrients concentration in the water column. These effluent sources include municipal wastewater treatment plants, industrial sewage and domestic waste[6,7]. The discharge of untreated or improperly treated wastewater into the water body can result in elevated concentrations of nutrients in the receiving waters.

The Kemaman River basin is located in the Kemaman district of Peninsular Malaysia which faces the southern part of the South China Sea. Kemaman is one of the districts within the state of Terengganu. It has an area of 253,560 hectares and an estimated population of 181,100 people, about 16.15 % of the total 2009 Terengganu population[8]. The socio-economic activities carried out within the Kemaman River basin include agriculture, aquaculture, fishing and eco-tourism. Agriculture and aquaculture activities are definitely the most important activities taking place in Kemaman.

Land in Kemaman is primarily forested (30.1 %) and agricultural (28.8 %). Building (2.8 %) and industrial use (1.2 %) are minimal; while the rest (37.1 %) is used for other purposes. In 2010, palm oil dominated basin agricultural activity with land areas of 85,920 ha (87.26 %). Rubber and fruit orchards consist of 7,602 ha (7.72 %) and 4,643 ha (4.72 %), respectively. Other agricultural activities (paddy, cocoa and vegetables) use less than 1 % the agricultural land areas in the Kemaman district. A preliminary study of nutrients distribution was carried out in the Kemaman River basin. Parameters measured were P-based nutrients (orthophosphate, dissolved organic phosphate (DOP) and total particulate phosphate (TPP)) and N-based nutrients (nitrite, nitrate, urea, dissolved organic nitrogen (DON) and total particulate nitrogen (TPN)). Results obtained for these nutrients parameters were also compared with the Malaysian National Water Quality Standards (NWQS) as listed in Table-1, to determine the suitability of these water bodies to their users[9].

EXPERIMENTAL

Eight sampling stations along the Kemaman River basin were chosen for this study (Fig. 1). Sampling was performed monthly from July-November 2009. In the field, acid-rinsed polyethylene (PE) bottles were pre-rinsed with sample water before collecting the water sample. The water samples were collected at 0.5 m depth from the water surface for the purpose of measuring dissolved and particulate P and N. The collected

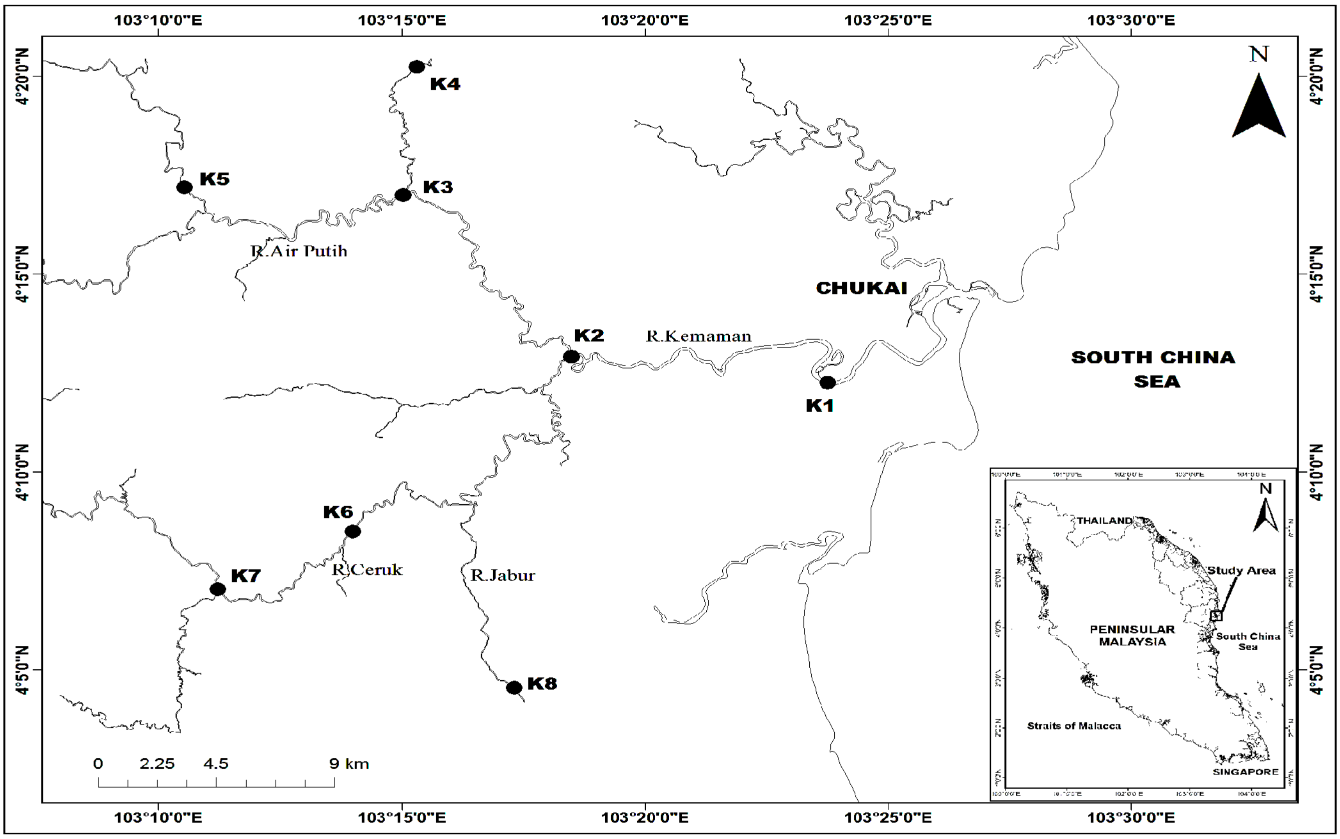

Fig. 1. Sampling sites of the Kemaman River basin

TABLE-1
NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA[9]

Parameter	Class					
	Unit	I	IIA/IIB	III	IV	V
P	mg/L		0.2	0.1	-	
NO_2	mg/L	Natural Level	0.4	0.4 (0.03)	-	Level above IV
NO_3	mg/L		7	-	5	

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

samples were stored in ice chests and returned to laboratory for further analysis.

Sample analysis: Samples were filtered through 0.45 µm membrane filters for dissolved P and N analysis. Filtration was used to separate the dissolved and particulate particle fractions. After filtration, samples were placed in the PE bottles and stored at -20 ºC until analysis. Dissolved inorganic P and N were analyzed using the standard colorimetric method, utilizing a chemical to interact with the nutrient and produce a colored compound. Nitrate and nitrite were analyzed with pink azo dye method, whereas urea was analyzed with diacetyl-monoxime method and orthophosphate by molybdenum blue method[10]. Both dissolved and particulate organic matters for the P and N analysis were analyzed using the wet digestion method by Grasshoff *et al.*[10].

RESULTS AND DISCUSSION

Phosphorus-based nutrients: Histograms based on the nutrient concentrations were presented in Fig. 2 with dissolved organic phosphate showed the lowest concentration compared to orthophosphate and total particulate phosphate. Across the sampling stations, the following range of concentrations were recorded *i.e.* orthophosphate (1.28-26.12 µg/L P), dissolved organic phosphate (0.28-11.27 µg/L P) and total particulate phosphate (4.89-468.30 µg/L P). ANOVA analysis indicated that there was a significant difference between the dates and sampling stations ($p < 0.05$), reflecting there was a marked variation of orthophosphate, dissolved organic phosphate and total particulate phosphate concentrations among the sampling stations.

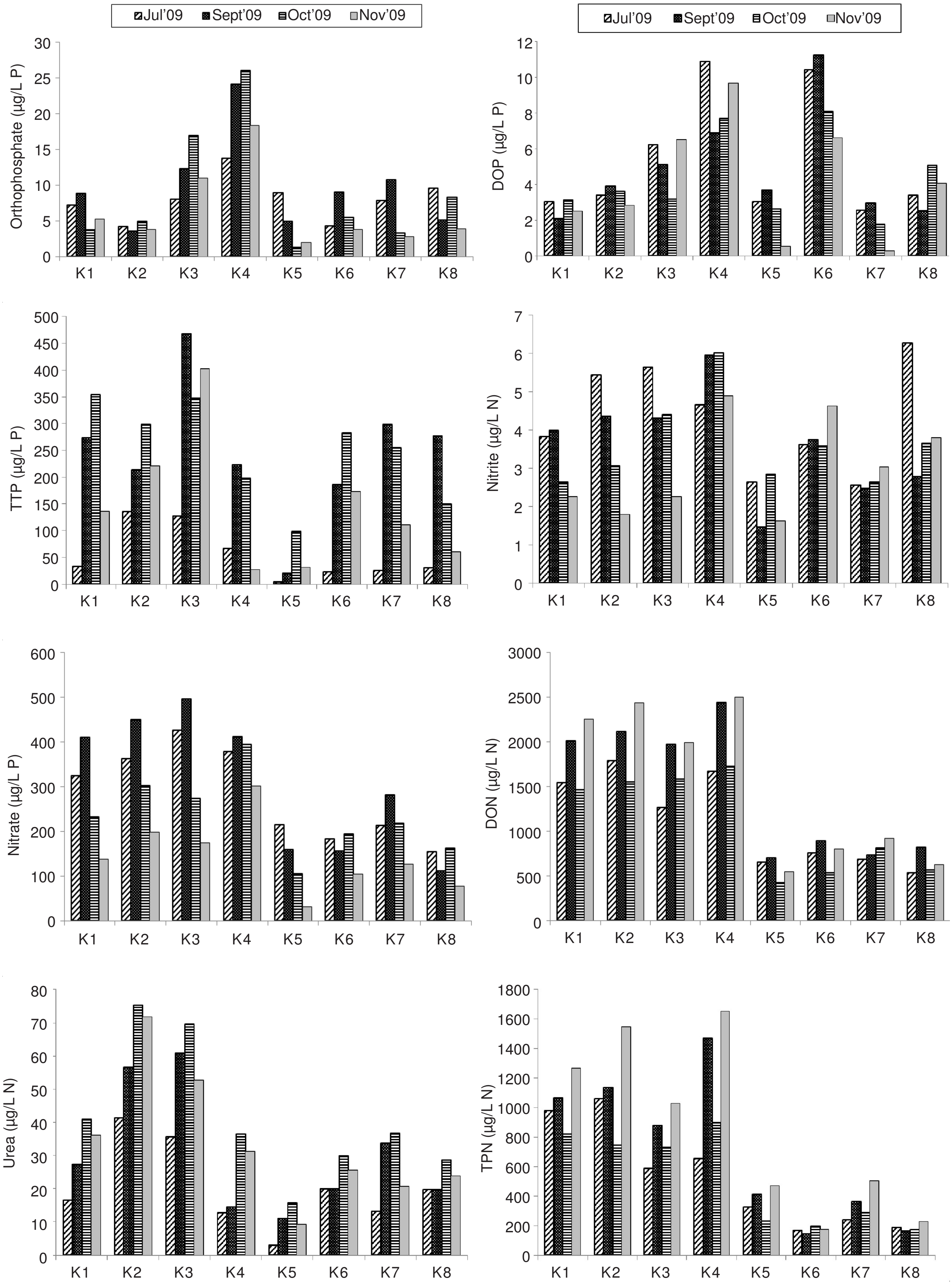

Fig. 2. Variation of P and N-based nutrients concentrations at the Kemaman River basin

During the sampling, the highest concentrations of orthophosphate and dissolved organic phosphate were noted at station K4. Elevated orthophosphate concentrations primarily occurred at the station K4 as this station located near palm oil plantations, which could be attributed to fertilizers runoff into the adjacent river as observed in other study areas[11,12]. In addition, highest concentrations of dissolved organic phosphate were also recorded at station K6. Besides it was near the agricultural activities, it was also located closed to a farming area. The finding suggested that agricultural-influenced was the main reason for the higher dissolved organic phosphate concentrations. Manure, used as organic fertilizer could be leaching into the river from the palm oil fields and farming areas and elevating the dissolved organic phosphate concentrations[13,14]. This finding was consistent with the study carried out Wang *et al.*[15] who reported that concentrations of P in the surface waters increased significantly following fertilizer and manure P application to the rice fields. In contrast to orthophosphate and dissolved organic phosphate, the general trend of total particulate phosphate was highest at station K3, which situated under a main road. Neal *et al.*[16] found that there is a clear link to runoff from the land surface when the river has less permeable (clay dominated) catchments. Since station K3 is near a road, particles contained P might run off especially when it rains. The higher particulate P in the water column might also result from shoreline erosion and re-suspension of benthic sediments, consequences of rough weather conditions and rain[17].

According to the NWQS, orthophosphate concentration at Kemaman River basin was in Class I indicating a natural level. Class I represents water body suitable for conservation of natural environment, protection of very sensitive aquatic species and for water supply with practically no treatment necessary. However, no comparison could be made for dissolved organic phosphate and total particulate phosphate because these parameters were still not listed in the NWQS classification for Malaysia.

Phosphorus-based nutrients concentrations in the present study were compared with some selected previous studies (Table-2). When compared with two studies in Terengganu, Malaysia, orthophosphate concentration in the Kemaman River basin was lower than the concentration ranges reported in the Nerus[12] and Setiu River basins[18]. The Serin River in Sarawak[19], the Tamar estuary in southwest England[20] and the Scottish East Coast Rivers[21] also recorded a higher range of orthophosphate than the present study. The concentration range for dissolved organic phosphate in the Kemaman River basin was similar to that of the Tamar estuary but lower than the Serin and Setiu Rivers and the Scottish East Coast Rivers. Total particulate phosphate was higher in the Kemaman River basin than in the Scottish East Coast Rivers. In general, all selected previous studies have higher ranges of P-based nutrient concentrations than the Kemaman River basin. As reported for the Nerus and Setiu River basins, domestic sewage from nearby towns and palm oil plantation fertilizers were the most likely source. The higher range of P-based nutrients in the Serin River was most likely caused by animal farm effluent discharge which contains high organic matter, N and P. The slightly higher concentrations of orthophosphate and dissolved organic phosphate in the Tamar estuary were most likely due to the weathered small catchment surface area in the lower estuary and industrial and urban-influences. The higher P-based nutrients reading in the Scottish East Coast Rivers can be attributed to the agricultural and point sources impact.

Nitrogen-based nutrients: The following was the range of concentrations: nitrite (1.47-6.28 µg/L N), nitrate (31-496 µg/L N), urea (2.95-75-34 µg/L N), dissolved organic nitrogen (427-2502 µg/L N) and total particulate nitrogen (143-1652 µg/L N). Stations K1 through K4 had high levels of N species, while lower concentrations occurred at stations K5 through K8, with a significant difference of concentrations between dates and sampling stations ($p < 0.05$). According to the NWQS, the concentrations of nitrite and nitrate belong to Class I but other N-based nutrients were still not listed in this classification.

Station K4 had the maximum concentration of nitrite for every sampling. Since orthophosphate followed the same trend, the fertilizers of palm oil fields were most likely the source for both nitrite and orthophosphate. Nitrate and dissolved organic nitrogen concentrations had an identical pattern with higher levels occurring at stations K1 through K4 and lower levels at stations K5 through K8. The high concentrations of nitrate and dissolved organic nitrogen corresponded to the gradient of increasing human land use (agriculture and rural). Like most of the nutrients measured in this study, nitrate and dissolved organic nitrogen also had the highest concentration at station K4. From the data of SEPU[8], palm oil fields utilize more than 80 % of the agricultural land in the Kemaman district and most likely introduced N to the study area[19,22]. Ritter and Bergstrom[23] state that the N leaching usually occurs as nitrate under irrigation through agricultural soil. Manure, used as organic fertilizer, contains N and is a probable agricultural source. In addition, residential sewage discharge into the water column is another source for elevated nitrate, urea and dissolved organic nitrogen concentrations[11,24,25]. Sampling sites K1, K2,

TABLE-2
COMPARISON OF PHOSPHORUS-BASED NUTRIENTS WITHIN SELECTED STUDY AREAS

Location	Phosphorus (µg/L P)			References
	Orthophosphate	DOP	TPP	
Kemaman River basin, Terengganu, Malaysia	1.28-26.12	0.28-11.27	4.89-468.30	Present study
Nerus River basin, Terengganu, Malaysia	4-29	-	-	12
Setiu River basin, Terengganu, Malaysia	10.23-68.51	82.07-166.91	-	18
Serin River, Sarawak, Malaysia	40-4640	450-21100	-	19
Tamar estuary of SW England, United Kingdom	8.8-61	1.1-22	-	20
Scottish East Coast Rivers, United Kingdom	Undetectable-1538	Undetectable-550	1.0-130	21

Note: DOP = Dissolved Organic Phosphorus, TPP = Total Particulate Phosphorus

TABLE-3
COMPARISON OF N-BASED NUTRIENTS WITHIN SELECTED STUDY AREAS

Location	Nitrogen (μg/L N)			References
	Nitrite	Nitrate	Dissolved organic nitrogen	
Kemaman River basin, Terengganu, Malaysia	1.47-6.28	31-496	427-2502	Present study
Nerus River basin, Terengganu, Malaysia	-	174-743	-	12
Setiu River, Terengganu, Malaysia	-	728-2289	2001-5124	18
Serin River, Sarawak, Malaysia	-	10.0-90.0	240-3900	19
Riverine and coastal water of North-East Langkawi, Malaysia	5.6-53.2	43.4-204.4	-	28
Cape Rachodo, Malaysia	14-112	70-616	-	29

K3 and K4 are mostly dominated by agricultural and rural areas, explaining the elevated concentrations of nitrate and dissolved organic nitrogen.

Higher urea concentrations recorded at stations K2 and K3 compared to station S4 because these two stations situated closed to rural areas instead of station K4. Rural areas might not have proper septic systems, or proper effluent treatment and disposal system. Direct disposal of domestic waste into the water column could be the main reason for the higher urea concentration at stations K2 and K3[24,26].

The analysis of total particulate nitrogen showed a broad range of values. A threefold increase in total particulate nitrogen occurred between stations K1 to K4 (808-1169 μg/L N) and stations K5 to K8 (171-360 μg/L N). Particulate N in the water column was always largely associated with suspended particulate matter and total organic matter[27]. Irrigation, water and rainfall could wash out soil together with N from the agricultural land and discharge it into water bodies, which then increased the concentration of total particulate nitrogen at station K4.

The present study recorded lower concentrations for N-based nutrients, except nitrate compared to other studies (Table-3). These studies focused on inorganic N-based nutrients and urea and total particulate nitrogen were not analyzed. As compared with the some Malaysia River systems such as Nerus[12] and Setiu River basins[18], the Kemaman River basin recorded a lower range of nitrate and dissolved organic nitrogen concentrations. In contrast, the Serin River[19] recorded a lower range of nitrate concentration but a higher range of dissolved organic nitrogen compared to the present study area. The higher level of nitrate at the Nerus and Setiu River basins could be attributed to the input of domestic wastes, excessive use of fertilizers in agricultural areas and aquaculture activities. For the Serin River basin, village and human activities have likely contributed to the higher organic N concentrations. Only nitrate was measured as the oxides forms of N compounds in the Setiu and Serin River basins, without the nitrite analysis. Conversely, both nitrite and nitrate, as inorganic N, were measured but not involved in organic and particulate N analysis in the riverine and coastal waters of northeast Langkawi[28] and the surface water of Cape Rachodo[29]. The range of nitrite concentrations covered in these two areas was higher than in the present study. The range of nitrate for the present study was lower than for the riverine and coastal waters of northeast Langkawi, but higher than for the water at Cape Rachodo. Unfortunately, there were no detailed discussions about the N-based nutrients or their sources in either study as stated above.

Conclusion

The present study of nutrients carried out in the Kemaman River basin showed that station K4 exhibited the highest concentration for most of the nutrients. This is possibly due to the runoff of P and N-based fertilizers from agricultural areas, especially palm oil fields. This result suggests that the increased agricultural land usage in the Kemaman district corresponded to the higher usage of fertilizers on the crops. The widespread use of fertilizers and improper management of fertilizers application, may cause the runoff of nutrients toward the river and elevated nutrient concentrations in the river water body. However, based on NWQS classifications, the orthophosphate, nitrite and nitrate concentrations were still acceptable and in Class I which is under natural level. Comparison with other studies showed that the nutrient concentrations in the Kemaman River basin are still considered as low.

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REFERENCES

1. F. Li, A. Yuasa, Y. Muraki and Y. Matsui, *Sci. Total Environ.*, **345**, 99 (2005).
2. M. Nausch and G. Nausch, *J. Mar. Syst.*, **87**, 37 (2011).
3. R. Michalski and I. Kurzyca, *Pol. J. Environ. Stud.*, **15**, 5 (2006).
4. T. Liang, S. Wang, H. Cao, C. Zhang, H. Li, H. Li, W. Song and Z. Chong., *J. Environ. Sci. (China)*, **20**, 1195 (2008).
5. S. Xia, R. Ruan, M. Yan and Y. She, Procedia, *Environ. Sci.*, **10**, 2294 (2011).
6. N. Mehrdadi and A. Bagvand, *Asian J. Chem.*, **18**, 2009 (2006).
7. S. Suratman, M. Awang, A.L. Loh and N. Mohd Tahir, *Sains Malaysiana*, **38**, 125 (2009).
8. State Economy Plan Unit (SEPU), State of Terengganu Basic Data, Terengganu Islamic Foundation Press, Kuala Terengganu, pp. 98 (2010) (In Malay).
9. Department of Environment (DOE), Malaysia Environmental Quality Report 2010, Ministry of Natural Resources and Environment Malaysia, pp. 78 (2010).
10. K. Grasshoff, M. Ehrhardt and K. Kremling, Methods of Seawater Analysis, Verlag Chemie, Florida, edn. 2, pp. 419 (1983).
11. J.J. Rothwell, N.B. Dise, K.G. Taylor, T.E.H. Allott, P. Scholefield, H. Davies and C. Neal, *Sci. Total Environ.*, **408**, 841 (2010).
12. N. Mohd Tahir, S. Suratman, S.R. Jusoh, S.N. Yahaya, N. Mohd Yusoff and A.T. Law, *Mal. J. Anal. Sci*, **8**, 193 (2005).
13. J.E. Gilley and L.M. Risse, *Trans. ASAE*, **43**, 1583 (2000).
14. B.J. Turner, Organic Phosphorus Transfer from Terrestrial to Aquatic Environments, CABI Publishing, UK, pp. 399 (2003).
15. K. Wang, Z. Zhang, Y. Zhu, G. Wang, D. Shi and P. Christie, *Chemosphere*, **42**, 209 (2001).

16. C. Neal, M. Neal, G.J.L. Leeks, G. Old, L. Hill and H. Wickham, *J. Hydrol.*, **330**, 142 (2006).
17. T. Mayer, K.M. Kuntz and A. Moller, *J. Great Lakes Res*., **17**, 446 (1991).
18. S. Suhaimi, N. M. Tahir and S. Suriyati, *Bull. Environ. Contam. Toxicol*., **73**, 1094 (2004).
19. T.-Y. Ling, R. Srikaran, C.-P. Kho and N. Lee, *World Appl. Sci. J*., **8**, 496 (2010).
20. P. Monbet, I.D. McKelvie and P.J. Worsfold, *Geochim. Cosmochim. Acta*, **73**, 1027 (2009).
21. H. Ernstberger, A.C. Edwards and P.W. Balls, *Biogeochemistry*, **67**, 93 (2004).
22. H.P. Jarvie, P.J.A. Withers, M.J. Bowes, E.J. Palmer-Felgate, D.M. Harper, K. Wasiak, P. Wasiak, R.A. Hodgkinson, A. Bates, C. Stoate, M. Neal, H.D. Wickham, S.A. Harman and L.K. Armstrong, *Agric. Ecosyst. Environ*., **135**, 238 (2010).
23. W.F. Ritter and L. Bergstrom, Nitrogen and Water Quality, Lewis Publishers, London, pp. 342 (2001).
24. P.M. Glibert, J. Harrison, C. Heil and S. Seitzinger, *Biogeochemistry*, **77**, 441 (2006).
25. E.H. Stanley and J.T. Maxted, *Ecol. Appl*., **18**, 1579 (2008).
26. T. Switzer, *Harmful Algae*, **8**, 66 (2008).
27. C.-T.A. Chen, C.-M. Lin, B.-T. Huang and L.-F. Chang, *Mar. Chem*., **54**, 179 (1996).
28. C.W. Bong and C.W. Lee, *Mal. J. Sci*, **24**, 29 (2005).
29. C.-W. Lee, C.-W. Bong, C.-C. Ng and S.-A. Alias, *Malay. J. Sci*, **25**, 55 (2006).