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Reassessment of Nutrient Status in Setiu Wetland, Terengganu, Malaysia

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A study was carried out at Setiu Wetland, in the southern part of the South China Sea (Malaysia) to determine the surface water distribution of nitrogen and phosphorus compounds. It was observed that the impact of human activities such as agriculture and aquaculture were responsible for higher nitrogen and phosphorus concentrations recorded in the study area. However, with respect to the Malaysian Marine Water Quality Criteria and Standard, most of the mean concentrations of nutrients were in Class 1 suggesting the nutrients were in line with sustainable conservation of the marine protected areas and marine parks of this wetland area. The results also revealed that most of the nutrients measured were generally higher compared to the previous study carried out in the same study area.

Keywords: Water quality, Surface water, Nutrients, Setiu Wetland, Southern South China Sea (Malaysia).

INTRODUCTION

Surface water quality is controlled by natural and anthropogenic factors. However, the latter factor contributes substantially to the deterioration of water quality resulting from the discharge from urban, domestic, industrial and agricultural activities[1-3]. Nutrient inputs can seriously degrade the water quality of the surrounding areas. The presence of excess quantities of nutrients, mainly nitrogen and phosphorus in aquatic areas may stimulate intensive growth of phytoplankton, cause eutrophication problems and hypoxia events[4,5].

Setiu Wetland is located north of Kuala Terengganu, Terengganu, Malaysia. The area covers many ecosystems including estuaries, mangroves, wetlands and lagoon[6]. Upstream activities which can contaminate freshwater inputs (*i.e.* R. Setiu and R. Ular) at present are limited to agricultural activities including palm oil plantation. Meanwhile, surrounding villages within the wetland produce the well-known Terengganu sauce, fish and seafood based delicacies like fish crackers, dried anchovies and shrimp paste. Aquaculture such as brackish water cage culture, pond culture, pen culture and oyster farming is one of the fastest growing economic activities in Setiu Wetland.

This article reports the findings of a study to measure nutrient compounds in this area. The objective was to establish the concentration of measured parameters within the wetland. Nutrient concentrations were compared to available Malaysia guidelines *i.e.* Malaysian Marine Water Quality Criteria and Standard (MWQCS) (Table-1). The result of the present study was also compared to the previous study carried out by Suratman *et al.*[8].

TABLE-1
MARINE WATER QUALITY CRITERIA AND STANDARD FOR MALAYSIA[7]

Parameter (µg/L)	Class 1	Class 2	Class 3	Class E
Ammonia	35	70	320	70
Nitrite	10	55	1,000	55
Nitrate	10	60	1,000	60
Phosphate	5	75	670	75

Beneficial uses	
Class 1	Preservation, Marine protected areas, Marine parks
Class 2	Marine life, Fisheries, Coral reefs, Recreational and Mariculture
Class 3	Ports, Oil & gas fields
Class E	Mangroves, estuarine & river-mouth water

EXPERIMENTAL

Field sampling was conducted once a month from July until October 2008 (Fig. 1). Water samples were collected from the surface water, stored in acid-washed high density polyethylene bottles and transferred back to the laboratory. At the laboratory, water samples were filtered through 0.7 µm GF/F filter and kept refrigerated until analysis. Filtered water samples

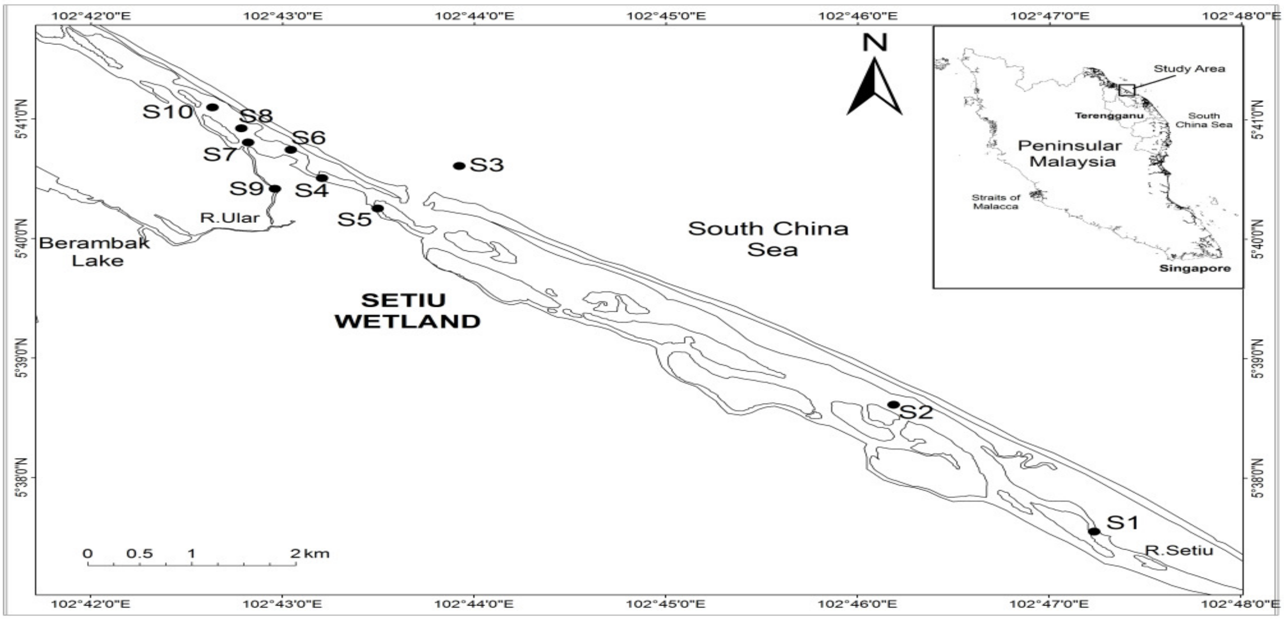

Fig. 1. Location of sampling stations in Setiu wetland

were analyzed for dissolved inorganic nutrients [nitrate, nitrite, ammonia and dissolved inorganic phosphate (DIP)] using standard manual colorimetric methods[9]. Meanwhile, dissolved organic N and P (DON and DOP, respectively) and particulate organic N and P (PON and POP, respectively) were determined by wet digestion method[9].

RESULTS AND DISCUSSION

Table-2 shows the range of concentrations for the parameters measured. The concentration of ammonia was low among the nitrogen compounds and varied from 0.01 to 0.61 µg/L N (mean 0.21 ± 0.15 µg/L N). The nitrite concentration ranging from 0.03-2.56 µg/L N (mean 0.74 ± 0.62 µg/L N). Nitrate concentrations were between 17-261 µg/L N (mean 80 ± 61 µg/L N). However, higher concentrations of DON and PON were recorded which ranged from 1100 to 15124 µg/L N (mean 5155 ± 3510 µg/L N) and 226-2890 µg/L N (mean 1415 ± 696 µg/L N), respectively. The concentrations recorded for the three forms of phosphorus compounds such as DIP, DOP and TPP were in the similar range *i.e*. 1.40-18.65 µg/L P (mean 4.79 ± 3.73 µg/L P), 0.64-10.35 µg/L P (mean 4.22 ± 2.13 µg/L P) and 0.40-20.90 µg/L P (mean 7.18 ± 6.14 µg/L P), respectively. The data were then tested by one-way analysis of variance (ANOVA) at 95 % significance level to show diffe-rences between sampling dates and sampling stations. This statistical test shows that the nutrient concentrations were significantly different ($p < 0.05$) between sampling dates and sampling stations. In comparison with the MWQCS classification, the mean concentrations of ammonia, nitrite and DIP are in Class 1 representing the concentration suitable for sustainable conservation of the marine protected areas and marine parks. In contrast, nitrate mean concentration is in Class 2 representing water body which is suitable for marine life, fisheries, coral reefs, recreational and mariculture. However, no comparison could be made for other nutrients because these parameters are still not listed in this classification for Malaysia.

TABLE-2
COMPARISON WITH THE RESULTS OBTAINED IN 2001

Parameter (µg/L)	Present study	Previous study
Ammonia	0.01-0.61 (0.21 ± 0.15)	0.06-0.16 (0.13 ± 0.10)
Nitrite	0.03-2.56 (0.74 ± 0.62)	Not determined
Nitrate	17-261 (80 + 61)	2-90 (38 ± 23)
DON	1100-15124 (5155 ± 3510)	53-324 (175 ± 69)
PON	226-2890 (1415 ± 696)	Not determined
DIP	1.40-18.65 (4.79 ± 3.73)	0.19-2.85 (0.91 ± 0.63)
DOP	0.64-10.35 (4.22 ± 2.13)	0.1-5.0 (2.0 ± 0.7)
POP	0.40-20.90 (7.18 ± 6.14)	Not determined

( ) = Mean ± SD

In general, the lowest mean concentration of nutrients was observed at station S3 as this station is situated at the coastal area, away from the wetland and acts as a control station (Fig. 2). There were no major anthropogenic activities around this station, therefore the lower mean concentration of nutrients was observed. In contrast, the data obtained from all sampling, showed higher concentration of nutrients were observed especially at stations S1, S8, S9 and S10 associated with high human activities in the surrounding area (Fig. 2). Station S1 is located downstream of Setiu river which receives an input of domestic wastes from the urban area of Penarik town. Many studies have used nutrients particularly P and N compounds as important indicators of the enriched discharges from domestic sewage inputs in their study area[1,10,11].

Higher nutrient concentrations recorded at station S9 was probably due to fertilizer runoff from large scale palm oil plantation activities upstream of the station. Gunduz *et al.*[12] reported that there is various P containing fertilizers used in agriculture and the extensive P input by over fertilization results to over abundance in aquatic media[13]. In addition, the poor uptake efficiencies of fertilizer applied to the crops may cause the nutrient especially nitrate and ammonia accumulated in the soil and finally the heavy rainfall will leach the excessive nitrate into the surface water system[14,15].

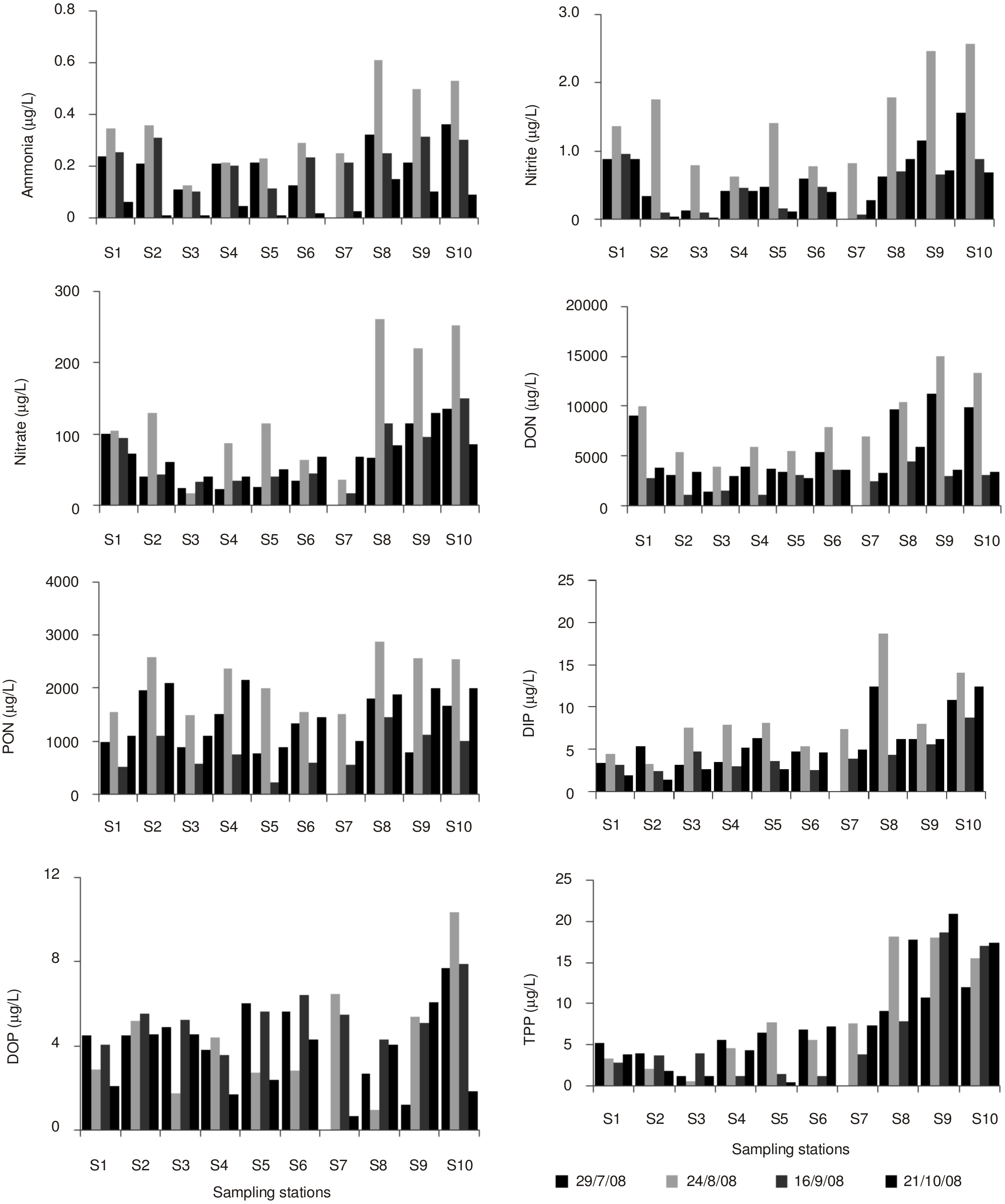

Fig. 2. Nutrient parameters measured in Setiu wetland

Higher mean concentrations of nutrients at stations S8 and S10 were probably due to the waste from brackish cage culture and oyster production in the surrounding areas. This can lead to increases of fish food, manure, animal waste, fish debris and fish skeletons beneath the cages. Consequently, the accumulation of these wastes could contribute to the high nutrient concentration at these particular stations. Numerous studies have revealed that fish farms generate a wide range of dissolved and particulate nutrients in the water column and sediments and their effects have been reported[16,17,18]. For example, Matijevic *et al*.[18] recorded the DIP concentration at stations under tuna cages were between 0.01 and 3.09 mmol and the values increased up to 47 times higher compared to unaffected stations. This observation is similar to those obtained in a study at Gaeta Gulf in the Tyrrhenian Sea where the DIP concentration increased to 6 fold at station under the tuna cages[19].

In addition, the resuspension of sediments during the high tide in cage area at station S6, S7, S8 and S10 probably also lead the increase of nutrient concentration of the water column. According to Kalantzi and Karakassis[17], a possible explanation of occasional increases in nutrient concentration was caused by the presence of strong currents in fish farming areas which lead to high suspended solids. During high tide, resuspension of the bottom sediment in fish farming area could be contribute to high suspended solids that includes total nutrient such as the fish debris and also from waste excretion of fishes[18].

In comparison with previous study carried out by Suratman *et al.*[8] in the same study area, there is an increase of mean concentration of most nutrients which is probably due to increasing of anthropogenic activities such as fish and shrimp aquaculture, palm oil plantation, boat manufacturing, fish landings jetty and the industry to make crackers, shrimp paste and others. Although there is no data of aquaculture activities recorded for early 2000, but based on the data in 2008 and 2009 by Department of Fisheries[20], there is increasing number of brackish water cage culture and oyster farming in Setiu wetland. In addition, the wide areas of brackish water cage culture also increase from 65,574 m^2 in 2008 to 82,864 m^2 in 2009. Due to this, the aquaculture production in this area rose from 1,443.68 metric tonnes in 2008 to 1,834.48 metric tonnes in 2009 and was predicted to reach 3,000 metric tonnes by 2012. Thus, it is expected that this project will deteriorate the water quality in the Setiu wetland in terms of their nutrient parameters.

Conclusion

The present study shows that the water quality of in Setiu wetland was influenced by the aquaculture and agricultural activities and surrounding environmental conditions. Higher concentrations of nutrients were observed at stations situated near agricultural activities such as oil palm areas and fish and shrimp farms. In addition, results of the study shows the distribution of nitrogen and phosphorus compounds in Setiu wetland was generally higher compared to the previous study. However, with respect to the Malaysian MWQS, the level of nutrients in this study area was within Class 1 and 2. The study shows the importance of assessing the past and present water quality in that study area for the sustainable management of Setiu wetland.

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