

Nitrate, Ammonia and Phosphate Concentrations in the Surface Water of Kuala Gula Bird Sanctuary, West Coast of Peninsular Malaysia

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ABSTRACT

This study was undertaken to compare the concentrations of nitrate nitrogen ($\text{NO}_2\text{-N}$), total ammonia nitrogen (TAN) and soluble reactive phosphorus (SRP) in the surface intertidal waters of Kuala Gula Bird Sanctuary over a four-month period (June to September, 2007). Three sampling stations were established in the Gula river estuary, labelled as Station 1, Station 2 and Station 3. The highest concentrations of SRP ($55.92 \pm 7.88 \mu\text{g/L}$), nitrate-N ($85.68 \pm 24.33 \mu\text{g/L}$) and TAN ($85.91 \pm 6.54 \mu\text{g/L}$) were recorded in the months of June, July and August, respectively whereas, the lowest concentrations of all the nutrients were recorded in September. The highest concentrations of the nutrients observed for the three months (June, July and August) coincided with the planting season of the nearby paddy fields in Kuala Kurau, Kuala Gula, Salinsing and some parts of Bagan Serai. This might indicate contamination of nitrogen and phosphorus nutrients from fertilizer run-off. Therefore, a continuous monitoring, for the content of nutrient in the surface intertidal waters of the bird sanctuary, is recommended to observe any significant changes which may take place in the area. The results of this study would serve as an important baseline information for future reference.

Keywords: Nitrate ($\text{NO}_3\text{-N}$), TAN and SRP concentration, surface intertidal water, west coast, Kuala Gula Bird sanctuary, Peninsular Malaysia

INTRODUCTION

Enhanced availability of phosphorus and nitrogen is a worldwide cause for eutrophication of aquatic ecosystems (Pieterse *et al.*, 2002). Anthropogenic sources of nutrients, coupled with modifications to the environment and climate, are now so pervasive that no aquatic system can be considered as truly pristine. Agricultural activities often provide the dominant input of nitrogen, particularly nitrates (Hunt *et al.*, 2004). In the case of phosphates, there is often a more balanced mix of fluxes from agricultural and various effluent sources. Aquatic ecosystems can eutrophicate when the concentrations of nutrients exceed the critical levels, and this can lead to enhanced primary production (increase of alga biomass), enhanced decay of organic materials, a shortage of dissolved oxygen and

species redistribution within aquatic ecosystems (Tyrell, 1999). Moreover, the effects of high nitrate and phosphate can increase severe toxic phytoplankton blooms in many near shore waters worldwide. In Malaysian waters, nevertheless, studies on nitrates and phosphates as chemical pollutants in the coastal waters are still very scarce. Among the studies on the nutrient level backgrounds in the Malaysian coastal waters was carried out by Yap *et al.* (2005). Their study suggested that nitrate contamination, in the coastal waters of the Straits of Malacca, is not serious although further monitoring has to be undertaken.

Kuala Gula is an important bird sanctuary in Malaysia and the Asian region. It serves as a stop-over site for migratory shorebirds during annual migrations and is along one of the major

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migratory routes between Asia and Australasia (Pepping *et al.*, 1999; Lane and Mundkur, 1992; Riak *et al.*, 2002; Riak *et al.*, 2003a; Riak *et al.*, 2003b; Parish and Wells, 1984; Edward *et al.*, 1986). Shorebirds are important predators of macrobenthos such as crabs, shrimps and other bivalves in coastal areas, specifically along the coastal mudflat (Hawkins and Howes, 1986; Silviu *et al.*, 1987). According to Williams *et al.* (1986), the elevated levels of nitrates, ammonia and phosphorus in the surface waters, in both marine and fresh water, can affect invertebrate diversity in feeding grounds and migratory birds. Since migratory shorebirds, on the west coast of Peninsular Malaysia, spend most diurnal activity feeding on the mudflats to meet their energy and nutrients requirements to continue migration, maintenance of a healthy ecosystem in the feeding ground is a basic requirement to meet such demand. Therefore, the present study was undertaken with the purpose of monitoring changes in the concentrations of nitrate, ammonia and phosphorus in the surface intertidal waters in the Kuala Gula bird sanctuary.

MATERIALS AND METHODS

The study was carried out monthly for four consecutive months (from June to September, 2007) at Kuala Gula bird sanctuary, which is N 04° 55' 896" and E100° 26' 791", located about 45 kilometers from Taiping in Larut, Matang and Selama districts in Perak (*Fig 1*). For this purpose, three sampling stations were established in the Gula river estuary, namely Station 1 (04° 55.185'N, 100° 27.840'E), Station 2 (04° 55.085'N, 100° 27.960'E) and Station 3 (04° 55.006'N, 100° 27.761'E). All the sampling stations have an average depth of 0.8m ± 0.1m throughout the sampling periods. Due to the shallowness of the waters in the sampling stations, the water samples were collected only at one depth i.e. at 0.5 m the deepest depth which the sampler could be lowered down without disturbing the muddy sediment surface. Triplicate samples of surface water were collected for the nutrient analysis from each station using a 5-L capacity Niskin water sampler, which were then transferred into a 1-L acid washed polyethylene bottles and kept in refrigerated box and brought back to the laboratory for immediate analysis. The water samples were then filtered using a 0.45µm Millipore membrane filter prior to the analysis. The total ammonia nitrogen (TAN)

and soluble reactive phosphorus (SRP) were analyzed according to the method suggested by Parsons *et al.* (1984); whereas, nitrate-nitrogen concentration was determined using the hydrazine reduction method introduced by Kitamura *et al.* (1984).

Data were statistically analyzed using the one-way analysis of variance (ANOVA). Significant differences, among the individual treatment effects, were determined using a Post Hoc, Tukey's Test (T-HSD) set at P<0.05. In addition, statistical analyses were undertaken using the Statistical Analysis System (SAS Inc. 1992) software program.

RESULTS AND DISCUSSION

The concentrations of nutrients (TAN, SRP and nitrate-N) in the surface waters were found to be different at the three stations. The total ammonia nitrogen was found to be the highest (p<0.05) at Station 1 (82.45 ±6.39 µg/L) and lowest at Station 2 (50.37±8.03 µg/L) (Table 1). In contrast, the SRP concentration was highest (p<0.05) at Station 3 (at 54.48±7.58 µg/L) and lowest at Station 2 (at 27.72± 6.45 µg/L), as shown in Table 1. Nevertheless, no significant differences (p>0.05) were observed in the concentrations of nitrate-N at all the 3 stations (Table 1). During the four-month sampling period, the highest (p<0.05) concentrations of SRP, nitrate-N and TAN were recorded in June, July and August, respectively. On the contrary, the lowest concentrations of all nutrients were recorded in September. The highest SRP concentration (55.92±7.88 µg/L) was recorded in June, while the highest nitrate-nitrogen concentration (85.68±24.33 µg/L) was observed in the month of July (Table 2). The total ammonia nitrogen was found to be the highest (p<0.05) in the month of August, i.e. at 85.91±6.54 µg/L (Table 2). The lowest (p<0.05) concentrations of all nutrients were observed throughout September, with the mean values of 45.10±16.36 µg/L, 36.50±3.77 µg/L and 25.87±1.15 µg/L for TAN, nitrate-N and SRP, respectively. Meanwhile, the highest concentrations of nutrients observed were present during the three months (June, July and August), which coincided with the planting season of the nearby paddy fields located in Kuala Kurau and Kuala Gula (Kerian Irrigation Scheme Malaysia- DOA, 2008). On the other hand, most of the local paddy fields were dry and ready for harvesting in the month of

TABLE 1

The comparison in the concentrations ($\mu\text{g/L}$) of $\text{NO}_2+\text{NO}_3 - \text{N}$, TAN and SRP of the surface water of Kuala Gula bird sanctuary according to stations. The values are mean \pm SE

Station	$\text{NO}_2 \text{NO}_3$	TAN	SRP
Station 1	48.59 ^a \pm 8.72	82.45 ^a \pm 6.39	27.72 ^b \pm 6.45
Station 2	67.14 ^a \pm 17.84	50.37 ^b \pm 8.03	31.05 ^{ab} \pm 6.59
Station 3	66.42 ^a \pm 16.63	80.91 ^{ab} \pm 11.50	54.48 ^a \pm 7.58

Columns with the same superscript are not significantly different at ($p>0.05$)

TABLE 2

The comparison in the concentrations ($\mu\text{g/L}$) of $\text{NO}_2+\text{NO}_3 - \text{N}$, TAN and SRP of the surface water of Kuala Gula bird sanctuary according to months. The values are mean \pm SE

Months	Parameters		
	NO_2+NO_3	TAN	SRP
June	42.06 ^{ab} \pm 2.68	79.43 ^a \pm 3.53	55.92 ^a \pm 7.88
July	85.68 ^a \pm 24.33	74.52 ^a \pm 10.55	33.36 ^{ab} \pm 11.85
August	78.63 ^{ab} \pm 20.80	85.91 ^a \pm 6.54	35.87 ^{ab} \pm 8.70
September	36.50 ^b \pm 3.77	45.10 ^b \pm 16.36	25.87 ^b \pm 1.15

Columns with the same superscript are not significantly different at ($p>0.05$)

September. The changes in the concentrations of N and P were associated with the applications of local fertilizer at the nearby paddy fields. This demonstrated that agricultural use of fertilizers was responsible for the local fluctuations in the organic nutrients of the bird sanctuary water. There are other possible sources of pollutants in the coastal ecosystems which include waste water effluents from municipal and industrial origins, run-off from adjacent pasture ranch and septic tank leachate (Novonty and Olem, 1994). These sources, however, are available all year round and close to the bird sanctuary therefore, their effects are more likely to be constant throughout the year. The results of the present study showed a trend which correlated with the planting and harvest seasons of the paddy fields in the locality. If this relationship is confirmed as the contamination of N and P nutrients from the fertilizer, it may pose a significant threat to the local waters. According to Neal *et al.* (2005), agriculture is one of the main sources of nitrates and phosphates in the local rivers. Excessive use of readily available conventional chemical fertilizers and livestock manure on agricultural land is widely recognized as the major source

of surface waters contamination (Adams *et al.*, 1994; Chang and Entz, 1996; Levallois *et al.*, 1998). The scarcity of the available data on the nutrient concentrations, in the local (Malaysia) surface waters along the rivers estuaries and coastal waters, has made it entirely impossible to compare the present results. However, Yap *et al.* (2005) studied the nitrate profile of waters along the Straits of Malacca and reported the concentrations of nitrate from several coastal waters along the straits. In their study, the concentrations of nitrate in the coastal waters were found to range from 107–330 $\mu\text{g/L}$, which was significantly higher as compared to the results (36.50 – 85.68 $\mu\text{g/L}$) of the present study. In addition, the concentrations of all nutrients measured in this study were found to be below the maximum levels of the standard water quality limits approved by the National Water Quality Standards of Malaysia (2005). According to the National Water Quality Standards of Malaysia (2005), for Class IIA water (water appropriate for sensitive aquatic species) phosphorus, ammoniacal nitrogen and nitrate concentrations should not exceed 200 $\mu\text{g/L}$, 300 $\mu\text{g/L}$ and 400 $\mu\text{g/L}$, respectively.

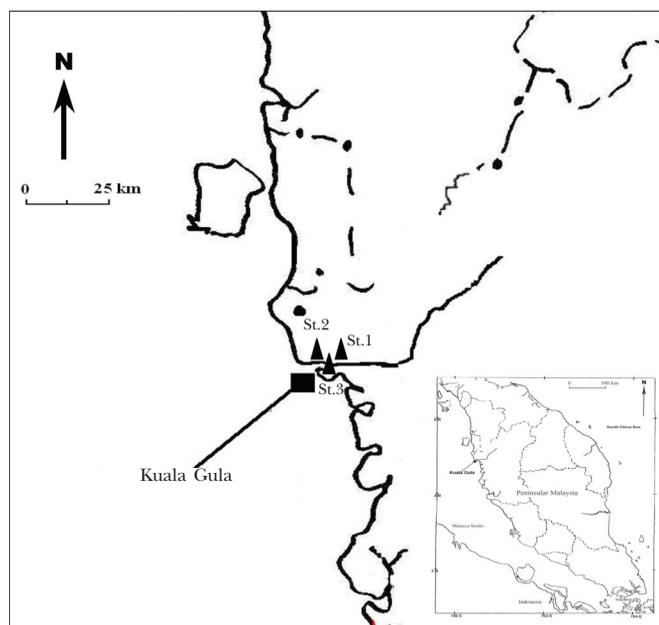


Fig. 1: Map showing the sampling stations along the Kuala Gula, Perak

CONCLUSIONS

The concentrations of nitrite-N, ammonia and phosphate in Kuala Gula bird sanctuary surface intertidal waters fluctuated during the study period, but they never rose above the recognized water quality standards. A positive relationship was also observed; however, this was between the higher levels of nitrate, phosphorus and ammonia and the use of fertilizers for the production of rice at the local paddy fields. Nitrate, phosphorus and ammonia are of great toxicological interest, and they are important macronutrients which can cause eutrophication of waters at raised level. A continuous monitoring of these nutrients in the study area should be conducted more widely. This monitoring data should be able to address the potential around Kuala Gula Sanctuary for the negative impacts on migratory bird habitats in Malaysia.

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