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Reassessment of Physico-Chemical Water Quality in Setiu Wetland, Malaysia

(Penilaian Semula Kualiti Air Fiziko-Kimia di Tanah Bencah Setiu, Malaysia)

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ABSTRACT

Setiu Wetland is located in the southern part of South China Sea, Malaysia. This wetland has diverse ecosystems that represent a vast array of biological diversity and abundance in utilizable natural resources. However, there are large scales of aquaculture activities within and nearby the wetland which could threaten the ecosystems of this area. Thus, the main goal of the study was to assess the impact of these activities through the measurement of physico-chemical water quality parameters and then compare this to a previous study carried out in the same study area. The parameters (salinity, temperature, pH, dissolved oxygen, biological oxygen demand and total suspended solids) were monitored monthly at the surface water from July to October 2008. The results showed that the impact of aquaculture activities on the water quality in the area with dissolved oxygen and total suspended solids concentrations were considerably lower than those observed previously. With respect to the Malaysian Marine Water Quality Criteria and Standard, most of the level of parameters measured remained Class 1, suggesting the physico-chemical environment were in line with sustainable conservation of the marine protected areas and marine parks of this wetland area.

Keywords: Aquaculture activities; physico-chemical water quality; Setiu Wetland; South China Sea (Malaysia); surface water

ABSTRAK

Tanah Bencah Setiu terletak di bahagian selatan Laut China Selatan, Malaysia. Tanah bencah ini mempunyai pelbagai ekosistem yang mewakili biodiversiti biologi dan banyak sumber semula jadi yang boleh digunakan. Walau bagaimanapun, terdapat aktiviti akuakultur yang berskala besar di dalamnya dan berhampiran dengan tanah bencah tersebut yang boleh mengancam ekosistem kawasan ini. Maka, tujuan utama kajian ini dijalankan adalah untuk menilai kesan daripada aktiviti ini melalui pengukuran parameter fiziko-kimia kualiti air dan membandingkannya dengan kajian terdahulu yang pernah dijalankan di kawasan yang sama. Parameter (saliniti, suhu, pH, keterlarutan oksigen, kehendak biokimia oksigen dan jumlah pepejal terampai) untuk permukaan air di pantau setiap bulan dari bulan Julai hingga Oktober 2008. Keputusan menunjukkan kesan aktiviti akuakultur terhadap kualiti air di kawasan kajian dengan kepekatan keterlarutan oksigen dan jumlah pepejal terampai adalah rendah jika dibandingkan dengan kajian lepas. Merujuk kepada Piawai dan Kriteria Kualiti Air Marin Malaysia, kebanyakan paras parameter yang diukur adalah dalam Kelas 1 yang menunjukkan persekitaran fiziko-kimia adalah selari dengan pemuliharaan mampan kawasan terkawal marin dan taman marin untuk kawasan tanah bencah.

Kata kunci: Aktiviti akuakultur; fiziko-kimia kualiti air; Laut China Selatan (Malaysia); permukaan air; Tanah Bencah Setiu

INTRODUCTION

Setiu Wetland is located in the north of Kuala Terengganu, Malaysia and encompasses many ecosystems such as estuary, mangrove, wetland and lagoon (WWF 2008). It has diverse ecosystems that offer a vast array of biological diversity and abundance in utilizable natural resources. Seawater intrusion into the wetland occurs near the Tangga Batu estuarine inlet. The wetland area receives fresh water inputs from two main sources, the Setiu River and Lake Berambak. The fresh water from Lake Berambak is connected to the wetland via Ular River. The upstream agricultural activities related to palm oil plantation is the main suspect altering the fresh water inputs to the wetland. Meanwhile, the surrounding villages within the wetland produce the well-known Terengganu anchovies sauce (budu), fish and seafood-based delicacies such as fish crackers, dried anchovies and shrimp paste. Aquaculture activities such as brackish water cage culture, pond culture, pen culture and oyster farming are the major and fastest growing economic activities in Setiu Wetland. Recently, the rapid growth of aquaculture farming activities has raised concern and might have been the main reasons for the loss of mangrove forest, dwindling fish stock due to disease outbreaks and discharge of particulate organic material (Eng et al. 1989; Tovar et al. 2000). In addition, intensive aquaculture activities may contribute significantly to the deterioration of water quality of the area as a result of feed and faecal inputs (Ackefors & Enell 1990; David et al. 2009; Salazar & Saldana 2007).

This is a preliminary study to investigate the distribution of surface water quality of Setiu Wetland. The parameters measured were physico-chemical water quality i.e. salinity, temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD_5) and total suspended solids (TSS). The values obtained were then compared to available Malaysia guidelines i.e. Malaysian Marine Water Quality Criteria and Standard (MMWQCS) (DOE 2010). The result of the present study was also compared to the previous study carried out by Suratman et al. (2005) in order to assess physico-chemical water quality changes over a time period of seven years brought about by various anthropogenic activities in the area.

METHODS

Field sampling was conducted once a month from July until October 2008 at 10 sampling stations (Figure 1). Water samples were collected during the high tide from subsurface water (~0.1 m) into 1L high density polyethylene (HDPE) bottles prewashed with dilute hydrochloric acid (10%) and rinsed three times with the water sample, stored at 4°C and were transported to the laboratory for analysis. Field measurements that include salinity, pH and DO were taken *in situ* by using a multi-parameter water quality instrument (YSI incorporated, Yellow Springs, Ohio, USA). The instrument sensors were calibrated before every sampling according to the manufacturer's specifications and recommendations. Additional basic water quality parameters such as BOD_5 and TSS were also analyzed in laboratory using a method by APHA (1998). In brief, BOD_5 was determined through quantifying the DO of the samples before and after the 5-day incubation at 20°C. The TSS was calculated based on the weight of the filter after samples were filtered through 0.45 μm pore size membrane filters and dried at 103-105°C. Statistical analysis was conducted by two-factor without replication ANOVA test to determine the significant difference of parameters between sampling times and sampling stations in the present study.

RESULTS AND DISCUSSION

The distribution of physico-chemical parameters is presented in Figure 2. Salinity was in the range of 12.0 to 33.5 ppt. ANOVA shows no significant different (p>0.05) between sampling times and sampling stations. The highest and the lowest salinities were recorded at Stations S3 and S1, respectively. Station S3 was located in the inshore area about 500 m outside the wetland. Thus, the station represents the seawater condition and conveniently served as a baseline station as there is very little anthropogenic activities within the surrounding areas. On the other hand, Station S1 was located in the downstream of the Setiu River and showed low salinity due to the mixing of fresh and seawater. As far as temperature is concerned, the results did not differ significantly (p>0.05) among the sampling times and sampling stations. The range of temperature values was narrow i.e. from 28.8 to 31.1°C. The phenomena may be due to the samplings being carried out during day-time only. The temperature recorded in this study is typical of the tropical coastal waters (Alongi et al. 2009; Arulampalam et al. 1998; Trott & Alongi 2000).

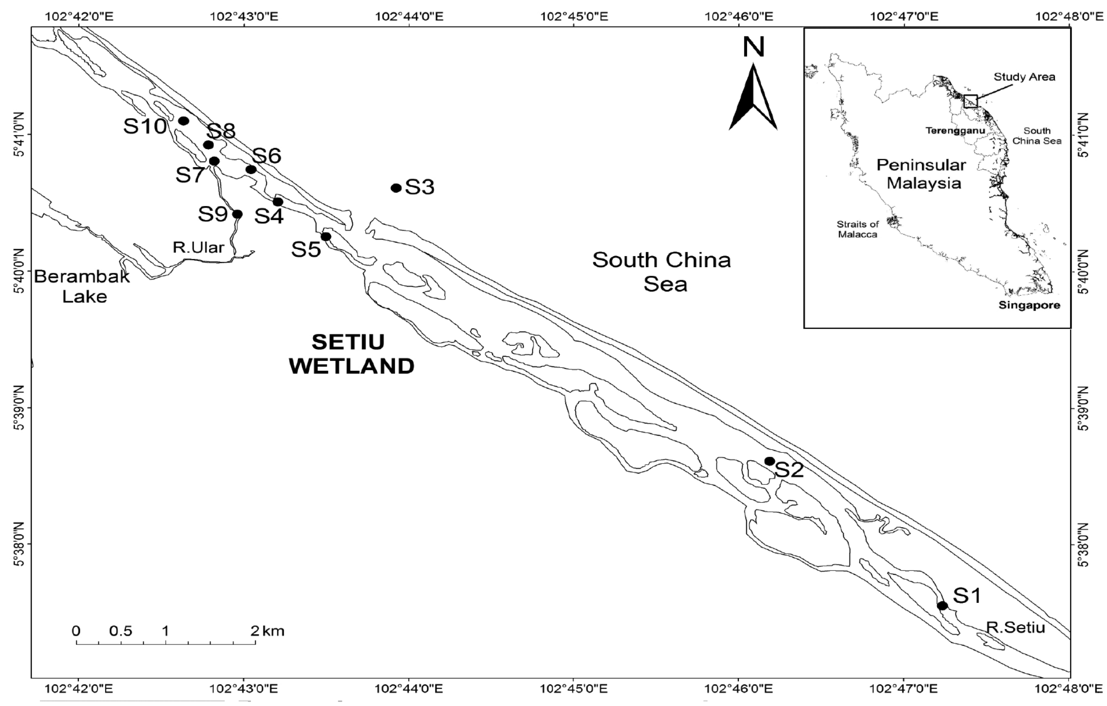

FIGURE 1. Location of sampling stations in Setiu Wetland

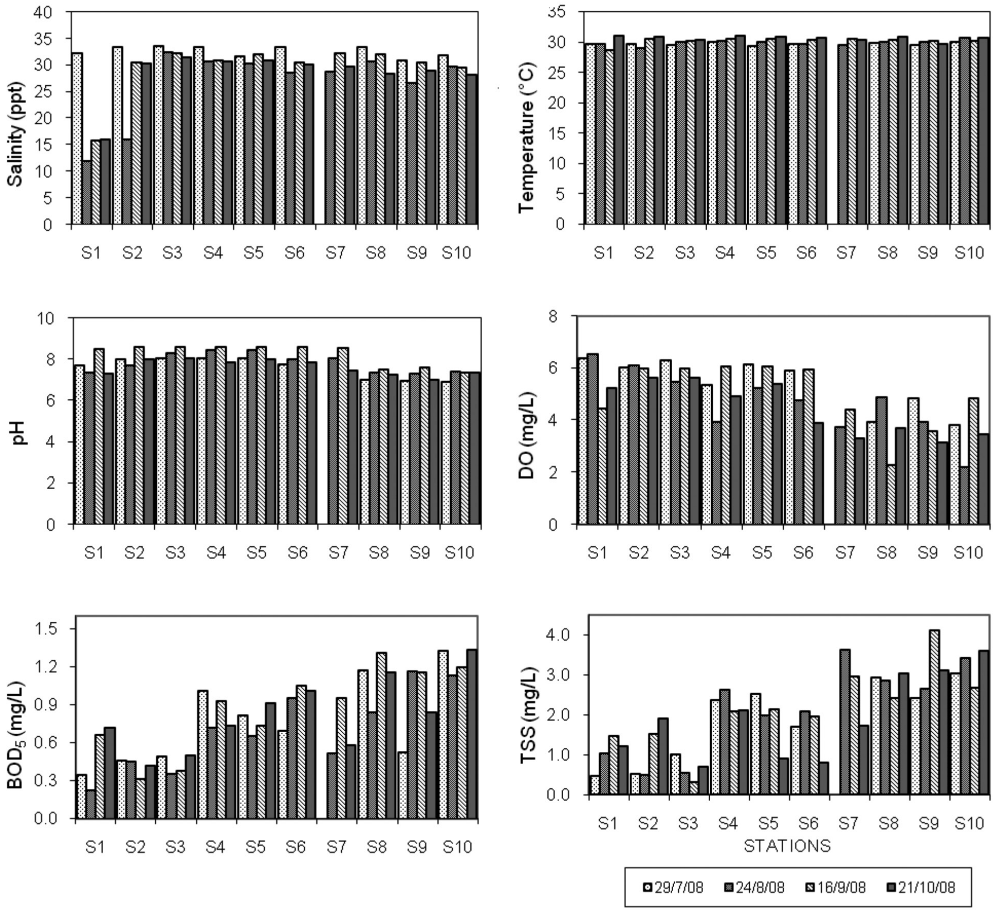

FIGURE 2. Physicochemical parameters measured in Setiu Wetland
(No data at S7 on 29/7/08 due to data lost)

In contrast to salinity and temperature, other parameters showed a significant different (p<0.05) between sampling times and sampling stations. The range of pH was from 6.9 to 8.6 with lower and higher pH values recorded at Stations S10 and S2, respectively. In general, the pH values remain constant throughout Stations S1 to S7 and exhibiting low values at Stations S8, S9 and S10. The present study showed the DO concentration ranging from 2.21 to 6.52 mg/L. The highest concentration of DO was recorded at Station S1 and the lowest concentration was at Station S10. Similar trend was observed for DO where higher concentrations were recorded at Stations S1 to S6 but lower concentrations were recorded at Stations S7 to S10. The BOD_5 concentration varied from 0.22 (Station S1) to 1.33 (Station S10) mg/L while the TSS concentration ranged between 0.31 (Station S3) and 4.11 (Station S9) mg/L. Both BOD_5 and TSS concentrations were lower at Stations S1 to S6 in comparison to those recorded at Stations S7 to S10.

The results from this study showed that anthropogenic activities especially aquaculture were affecting the water quality of the study area. In comparison to the baseline Station (S3), the pH and DO values were lower especially at Stations S7 to S10. In addition, these four stations had also recorded higher concentrations of BOD_5 and TSS. The results from this study were consistent with that of the previous studies where aquaculture activities gave severe impacts to the water quality (David et al. 2009; Neofitou & Klaoudatos 2008; Paez-Osuna 2001; Salazar & Saldana 2007; Tovar et al. 2000). For example, Tovar et al. (2000) reported that about 9100 kg TSS and 235 kg organic matter expressed as BOD were discharged to the environment from fish farm activities in San Pedro River, Spain. In the same study, they found that particulate organic matter contributed to about 843 kg of BOD. In addition, it was estimated that organic wastes produced by the fish farm can be reached until 2500 kg weight for each ton of life weight fish (Demirak et al. 2006). This suggests that most of the effluent from aquaculture discharge contained high levels of organic matters mainly originating from feed, faeces and organic fertilizers (Alongi et al. 2009; Kelly et al. 1996; Tacon et al. 1995).

Contribution of organic materials from aquaculture discharge will decrease the DO contents of the water column through the consumption of oxygen during the degradation process by microorganism (Hargrave et al. 1993). As a result of microorganism activity, the high BOD_5 concentrations coincide with the lower DO value (Suratman et al. 2009). In addition, this process will also cause the increase of carbon dioxide production in the water bodies as a result of respiration that can lead to low pH values. Riley and Chester (1971) had suggested that pH values in aquatic ecosystem were influenced by carbon dioxide during the photosynthesis process, respiration and decomposition. Thus, DO concentration at Stations S7, S8 and S10 (cage culture area) was also found to be low probably due to the respiration activities of the fish inside the cage area. Similar observation was reported by Madihah et al. (2008). The highest concentration of TSS in these particular stations was due to waste production from aquaculture activities such as animal waste, manure and suspended food residue (Neofitou & Klaoudatos 2008; Troell & Berg 1997).

Comparison of the present study with that of the previous study is presented in Table 1 and shows that pH and BOD_5 did not appear to be different between these two studies. In contrast, a lower concentration of TSS was recorded as compared to the previous study. This observation can be explained by the different condition of sampling in the present study where the sampling was conducted during the high tide. Thus, there was a reduction of water movement disturbing the bottom sediments that led to low TSS concentration. Input of organic matter from fish farm might have contributed to low DO concentration in this study. Each parameter measured was compared to MMWQCS based on their beneficial used (Table 2). The results showed that the temperature and TSS concentrations was in Class 1 with sustainable conservation of the marine protected areas and marine parks. In contrast, the DO concentration was in Class 2 which suitable only for marine life, fisheries, coral reefs, recreational and mariculture. No comparison could be made for pH and BOD_5 as these parameters are not included in MMWQCS.

CONCLUSION

The present study showed that the water quality of Setiu Wetland has been subjected to environmental pressures by rapid growth of aquaculture activities in the downstream areas. However, in comparison with the previous study, only DO concentration showed lower values. This study also showed that most of the parameters measured can be categorized in Class 1 based on MMWQCS. Therefore, this area is pristine but we would recommend to have continuous monitoring of the water quality to ensure that the anthropogenic pressures do not result in the degradation of environmental quality and the ecosystem being impacted beyond sustainable levels.

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TABLE 1. Comparison with the selected results obtained in 2001

Parameter		Present study	2001*
pH	Range	6.9 - 8.6	5.2 - 8.0
	Mean	7.6 ± 1.3	7.2 ± 0.7
DO (mg/L)	Range	2.21 - 6.52	4.89 - 6.85
	Mean	4.73 ± 1.39	6.05 ± 0.47
BOD_5 (mg/L)	Range	0.22 - 1.33	0.04 - 1.8
	Mean	0.77 ± 0.34	0.65 ± 0.46
TSS (mg/L)	Range	0.31 - 4.11	1.3 - 19.7
	Mean	1.98 ± 1.05	8.3 ± 4.3

*Suratman et al. 2005

TABLE 2. Malaysia marine water quality criteria and standards

Parameter	Class 1	Class 2	Class 3	Class E
Beneficial uses	Preservation, marine protected areas, marine parks	Marine life, fisheries, coral reefs, recreational and mariculture	Ports, oil & gas fields	Mangroves estuarine & River-mouth water
Temperature (°C)	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient
DO (mg/L)	>80% saturation	5	3	4
TSS (mg/L)	25 mg/L or ≤ 10% increase in seasonal average, whichever is lower	50 mg/L (25 mg/L) or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 30 % increase in seasonal average, whichever is lower

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