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Status of Water Quality Based on the Physico-Chemical Assessment on River Water at Wildlife Sanctuary Sibuti Mangrove Forest, Miri Sarawak

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Abstract: Problem statement: Mangrove forest is a component of wetlands that has been recognized as one of the most productive ecosystem in the tropic. Rapid development and other land uses in the mangrove areas over the years had negatively affected the ecological functions and its ecosystem. Study was carried out on river water quality at Sibuti Wildlife Sanctuary, Miri based on the physico-chemical properties. **Approach:** A total of 72 water samples were collected from 12 stations or sampling points from Sungai Sibuti (SS) and its tributary, a man-made canal called Sungai Parit Scheme (SPS) at Sibuti Wildlife Sanctuary Miri, Sarawak in the month of June, August and October 2010. In situ data measurement such as temperature, conductivity, Dissolved Oxygen (DO), pH and turbidity were taken and labeled. Analysis for parameter such as ammoniacal nitrogen (NH_3-N), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and total suspended solids (TSS) were conducted in the laboratory. Both *in situ* and *ex situ* data were measured and analyzed according to the Standards Methods APHA, 2005. Results for each water quality parameters are summarized as follows, temperature range (29.3-32.8°C), pH range (6.02-8.07), DO range (2.76-4.7 mg L^{-1}), conductivity (0.805-96.1 μS cm^{-1}), TSS range (0.00119-0.4361 mg L^{-1}), turbidity (10.2-15.3 NTU), BOD range (5.21-6.66 mg L^{-1}), COD (7.5-25) and ammoniacal nitrogen (0.1-0.31 mg L^{-1}). **Results:** Based on Water Quality Index (WQI) and Interim National Water Quality Standards for Malaysia (INWQS) by the Department of Environment Malaysia, river water of SPS and SS fall under Class II. **Conclusion:** The water quality status of river water at Sibuti Wildlife Sanctuary Mangrove Forest, Miri Sarawak is under category class II or good water quality status. All water quality parameters in this study are found to be in class I and II (good water quality) except for the BOD and DO which indicate fairer and moderate river water quality status.

Key words: Water Quality Index (WQI), water quality parameters, mangrove forest, parit skim river, sibuti river, total suspended solids, chemical oxygen demand, biological oxygen demand, water quality parameter, sarawak forestry corporation

INTRODUCTION

Mangroves forest grows well along the river bank, estuaries and coastal with the presence of brackish water or where saline and fresh water meets. Mangroves forest is a type of wetland and is considered as one of the most productive ecosystems in the tropic, high in value and has multiple roles and functions (WWF, 2011; Karami *et al*., 2009). Mangrove forest has various functions such as ecological, socioeconomic and also the physical that are all important components for the stability of biodiversity, coastal lines and communities live in the surrounding (Rambok *et al*., 2010).

Mangrove has unique features and special adaptations like breathing roots, buttresses and above-ground roots that allow and enable them to live and survive in the mud, anaerobic condition; and salty water. Mangroves act as land builder and coastline stabilizer (FAO, 2003; Akram *et al*., 2009). Mangrove forest also has the potential and ability to prevent or reduce the intrusion of tidal flood and saline water. Mangroves in Malaysia cover an area of approximately 586,036 hectares of which 57% is found in Sabah, 26% in Sarawak and the remaining in Peninsular Malaysia (FRIM, 2009). Large area of mangroves had been converted to cater for developments such as housing industry, plantations, aquaculture and other land developments. All these activities within the mangrove areas had an adverse effect on its ecosystem functions (Paul Chai, 2010). Over the years, the mangrove forests in Malaysia had decreased in acreage of about 45%

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from its total cover of 1.1 million hectares to approximately 564,970 hectares at present. Illegal encroachment and other on-going anthropogenic activities in the mangrove areas remained as a potential threat to the existing mangroves forest (Wetland International Malaysia, 2011).

This paper present the research findings on the water quality status based on physico-chemical characteristics and assessment on river water at Sungai Parit Scheme (SPS) and Sungai Sibuti (SS) at Sibuti Wildlife Sanctuary Miri Sarawak.

MATERIALS AND METHODS

Study area: The location of the study area is at Sibuti Wildlife Sanctuary Mangrove Forest, Miri Sarawak, Malaysia latitude 3° 58' 60 N and longitude 113° 43' 60 E. The area is bounded by Sungai Sibuti at the south and east and Bungai farmlands on the north. Sungai Sibuti is a natural river while the Sungai Parit Scheme (SPS) is main made drainage built by Sarawak Forestry Corporation (SFC) in the mangrove area. Sibuti Wildlife Sanctuary is a reserve covered by mangrove forest, dominated by Rhizophora species.

Water sampling and preservation: Water samples were collected from 12 stations located along Sungai Parit Scheme (SPS) and Sungai Sibuti (SS) at Sibuti Wildlife Sanctuary Mangrove Forest, Miri Sarawak area on three different months, June, August and October 2010. The water samples were collected from the upstream and downstream of both rivers. Six replicates of the water samples were taken from each station. The surface water sample was collected about 10 cm below water using plastic bottles (500 mL) and BOD bottles. The water samples for physico-chemical analysis were kept in ice for further analyses in laboratory. Standard procedures were followed for water samples collection and water samples analysis (APHA, 2005; Amadi *et al*., 2010).

In situ data measurement was recorded using Water Quality Meter (Model WQC-24). The data included temperature, pH, Dissolved Oxygen (DO), conductivity and turbidity. Other water quality parameter includes ammoniacal nitrogen (NH_3-N), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS) was analyzed in laboratory.

Data Analysis: Water quality status and classification is obtained by using the Water Quality Index (WQI). Calculations were done by entering the six water quality parameters mean values which include DO, BOD, COD, pH, ammonia (NH_3-N), and total suspended solids (TSS) into a WQI formula. The values were then converted to Sub Indices (SIs) according to the equation below (DOE, 2006; Othman *et al*., 2002, Rosli *et al*., 2010). The WQI or status of the water is derived through the calculation using the following formula:

$$WQI = [0.22 \text{ X } SIDO]+[0.19 \text{ X } SIBOD]+[0.16 \text{ X } SICOD]+[0.15 \text{ X } SIAN]+[0.16 \text{ X } SISR]+[0.12 \text{ X } SIpH]$$

Statistical analysis: Statistical analysis of data was carried out using Statistical Analysis System (SAS) version 9.2. Comparison of mean between stations was done by using Analysis of Variance (ANOVA).

RESULTS

The result of the water quality parameters collected from both SPS and SS rivers in the month of June, August and October 2010 are depicted in the graph below. From the results, the pH, turbidity, COD and TSS are in class I, ammonia in class II while the DO and BOD are in class III. The WQI of river water at both rivers (SPS and SS) was found to be under class II. Statistical analyses show that all the water quality parameters in the two different rivers (SPS and SS) at Sibuti Wildlife Sanctuary Mangrove Forest, Miri Sarawak area shows significant difference between stations using ANOVA at $p \leq 0.05$.

DISCUSSION

Temperature values varied from 29.3-32.8°C at SPS and 29.5-30°C at SS as indicated by the in situ measurement. The mean value of temperature was 30.47°C at SPS and 29.76°C at SS (Fig. 1). Mangrove forest growing in the latitudes that experience an average sea surface temperature of about 24°C. The sea surface temperatures are constant throughout the year range from 26 -32°C. The water temperature ranged from 26-29°C during northeast monsoon, 28-30°C during off monsoon period and 29-32°C during south-west monsoon. Water temperature at mangrove must exceed 24°C in the warmest month and 20°C or above in the coldest month (Kathiresan, 2001; Petronella *et al*., 2009).

For the month of June, the river water pH value was 6.74, 6.15 on August and 6.18 on October at SPS. While at SS, the water pH value is 8.07 on the first month, 6.02 at the second month and 6.05 at the third month. Mean value for river water pH is 6.35 at SPS and 6.71 at SS (Fig. 2). The pH value increase due to the photosynthetic algae activities that consumes CO_2 dissolved in water (Driche *et al*., 2008). According to DOE of Malaysia, a pH range from 6.5-8.5 is acceptable for domestic water supply. River water pH that ranges from 6.5-9 at day time is the most suitable for aquatic life. Therefore it is important to protect the aquatic ecosystem from excessive acidic or basic agent of pollution. This is to ensure the pH will remains between 6.5, 8.5 or 9.0. Under normal circumstances, most water pH is lower than 6.5 and some are higher than 9.0. Both low and high waters pH can be will be corrosive in nature (Boyde, 2000; DOE, 2006; Rosli *et al*., 2010).

The concentration of DO from both rivers has a medium value ranged from 3.2-4.7 mg L^{-1}, at SPS and 2.76-3.74 mg L^{-1} at SS. The DO value was 4.7 mg L^{-1} at first month and 3.2 mg L^{-1} at the second and third month at SPS. The DO value at SS was 3.74 mg L^{-1} at first month, 3.4 mg L^{-1} at second month and 2.76 mg L^{-1} at the third month. The mean value of DO was 3.7 mg L^{-1} at SPS and 3.3 at SS (Fig. 3).

Dissolved Oxygen (DO) is a volume of oxygen contained in the water. Amount of oxygen that can be hold by water depends on the water temperature, the salinity and also the pressure. The cold water and freshwater can holds more oxygen than in warm water and saltwater because oxygen dissolved very easily in cold water than in warm water. At dry periods and on hot climate, the flow of water is reduced and given the higher water temperatures while wet weather periods increasing the flow of water that resulting a great mixing of the atmospheric oxygen. The flowing water is high in DO compare to the stagnant water (APEC, 2011). The DO levels found to be low in this study. The level of DO in mangrove water is normally low than the water in the open sea area. The reason for low DO level is caused by the high discharge of organic pollution and nutrient along the river which will normally increase respiration during organic matter degradation (Yisa and Jimoh, 2010). Mangrove forest known to be a place that are highly productive source of an organic matter that give an energy to supports variety of estuarine near shore life (Hasrizal *et al*., 2009; Kamaruzzaman and Ong, 2008; Kamaruzzaman *et al*., 2008; Zannatul and Muktadir, 2009).

The conductivity value at SPS was low and ranged from 1.05-96.1 µS cm^{-1} and 0.805-89.5 µS cm^{-1} at SS. The highest and lowest value obtained was 96.1 32.74 µS cm^{-1} on the first month at SPS and 0.805 µS cm^{-1} on second month and third month at SS. The mean value of conductivity was 32.74 µS cm^{-1} at SPS and 30.44 32.74 µS cm^{-1} at SS (Fig. 4).

Conductivity showed the presence of an ion in the water. Conductivity in the water was affected by the inorganic dissolved solids such as aluminum cations, calcium, chloride, iron, nitrate, magnesium sulfate and sodium. Organic compound such as alcohol, oil, phenol and sugar can affect the conductivity of the water. The temperature can also affect the conductivity. The warmer the water, the higher the conductivity and vice versa (EPA, 2011). Most of the freshwaters conductivity is ranging from 10-1000 µS cm^{-1}. But, the value can exceed about 1000 µS cm^{-1} in the water that receiving pollution (Harun *et al*., 2010).

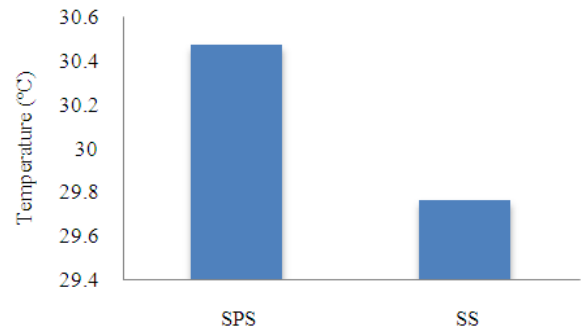

Fig.1: Temperature of the river water at SPS and SS on three month sampling

Fig. 2: pH of the river water at SPS and SS on three month sampling

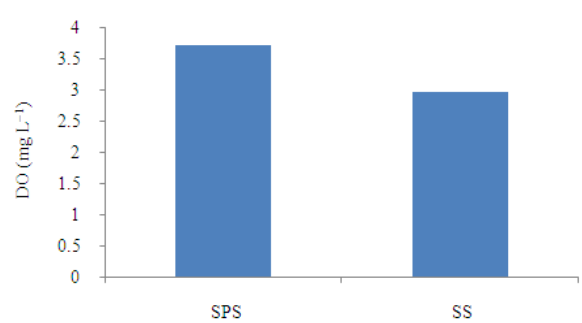

Fig. 3: DO of the of the river water at SPS and SS on three month sampling

Fig. 4: Conductivity of the river water at SPS and SS on three month sampling

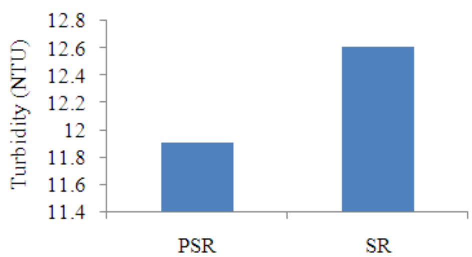

Fig. 5: Turbidity of the river water at SPS and SS on three month sampling

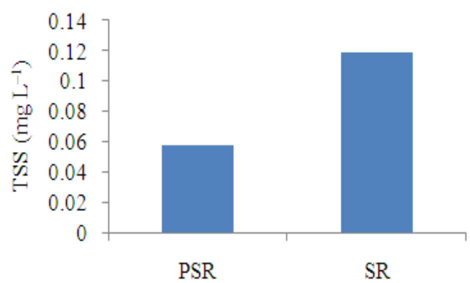

Fig. 6: Amount of TSS of the river water at PSR and SR on three month sampling

Fig. 7: The concentration of ammonia of the river water at SPS and SS on three month sampling

The turbidity of river water measured on the three months period varied from 10.2-15.3 NTU at SPS and 11.2-14.3 NTU at SS. The highest value obtained was 15.3 NTU getting on the third month and lowest value of 10.2 measured on first and second month at SPS. While at SS, the highest value was 11.2 NTU measured at first month and the lowest value was 14.3 NTU on the third month (Fig. 5).

Turbidity resulted by the presence of suspended particles such as clay, silt, organic matter, plankton and other microscopic or decomposers organisms. The clarity of the water decreased due to presence of these suspended particles that deposited in the water. The murkier the water indicated the higher amount of TSS. This can also be the indicator of a high measured of turbidity.

Surface-runoff, stream flow and overland flow in natural waters also increase the turbidity levels in water (APHA, 2005; Yisa and Jimoh, 2010). The turbidity level in this study was low and found less than 15 NTU where the value below 25 NTU is still acceptable for domestic use (DOE, 2006; Rosli *et al*., 2010).

The total suspended solids (TSS) of river water samples collected from both rivers varied from 0.0119-0.4361 mg L^{-1} at SPS and 0.02853-0.88345 mg L^{-1} at SS. The mean value of TSS is 0.05709 mg L^{-1} at SPS and 0.1191 mg L^{-1} at SS (Fig. 6). Suspended solids or particles are one of the natural pollutants in surface water that will cause turbidity in waters especially the river water (Mahvi and Razazi, 2005).

TSS includes an organic particles and mineral that are transported in the water. TSS in the water can also as be an indicator level for land erosion that took place. Level of TSS can range from less than 5-30,000 mg L^{-1} or more and is varied between rivers (UN GEMS/Water, 2005; Amadi *et al*., 2010). Both of the rivers at the study area have low level of TSS that is less than 5 mg L^{-1} or in class I. This suggests that there was no heavy erosion or pollution taken place along the study area.

Ammoniacal nitrogen (NH_3-N) ranged from 0.16-0.31 mg L^{-1} at SPS and 0.1-0.16 mg L^{-1} at SS. The ammoniacal nitrogen value was 0.16 mg L^{-1} both at first and third month and 0.31 mg L^{-1} on second month at SPS. The ammoniacal nitrogen value at SS was 0.1 mg L^{-1} on first month, 0.21 mg L^{-1} on second month and 0.16 mg L^{-1} at the third month. The mean value of ammoniacal nitrogen at SPS is 0.21 mg L^{-1} and 0.15 mg L^{-1} at SS (Fig. 7). According to the Interim National Water Quality Standards for Malaysia (INWQS), the concentration of ammonia in this study was low and fall into Class II. The value found still below the permissible limit where ammoniacal nitrogen levels for aquatic life in river of Malaysia is 0.90 mg L^{-1} (DOE, 2006; Rosli *et al*., 2010).

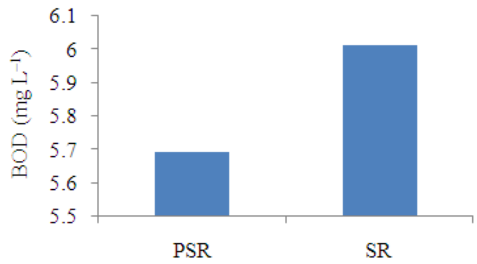

Fig. 8: BOD of the river water at PSR and SR on three month sampling

Fig. 9: The concentration of COD of the river water at PSR and SR on three month sampling

Ammonia acts as indicator of the pollution from excessive usage of ammonia especially from fertilizers. Ammonia concentration in waters must not exceed the recommended limit because it is very dangerous and can harm an aquatic life in the river water.

The biological oxygen demand (BOD) levels of river water at SPS ranging from 5.21-5.98 mg L^{-1} and 5.68-6.66 mg at L^{-1} SS. The BOD value was 5.21 L^{-1} at first month, 5.98 mg L^{-1} at second month and 5.8 mg L^{-1} at the third month at SPS. The BOD value at SS was 6.6 mg L^{-1} at first month, 5.68 mg L^{-1} on second month and 5.69 mg L^{-1} at the third month. Mean value for BOD was 5.69 mg L^{-1} on SPS and 6.01 mg L^{-1} at SS (Fig. 8). The level of BOD in this study was categorized under Class 3 or moderately clean water quality status (DOE, 2006; Zainudin *et al*., 2010). BOD is an indicator for the amount of the biodegradable organic substances. BOD also accounts the oxygen that is required in organic matter decomposition (Amadi *et al*., 2010). BOD value will rise when there is more organic matter such as leaves, wood, wastewater or urban storm water runoff took place at the river water.

The chemical oxygen demand (COD) concentration results found to be low at all sites. The COD concentration found to be less than 20 mg L^{-1} at all sampling station during three month sampling at both rivers. The mean value for COD at SPS was 14.1 mg L^{-1} and 17.5 mg L^{-1} at SS (Fig. 9). In this study, it is found that COD is belonging to Class II which is considered as a good condition of water. COD measured the pollutant of water by referred to the chemical-decomposition of an organic and inorganic contamination. The higher level of COD indicated the higher pollution of water of while lower level of COD indicated low level of pollution of water at the study area (Waziri and Ogugbuaja, 2010).

CONCLUSION

This study showed that the physical-chemical parameters of water quality of river water at Sibuti Wildlife Sanctuary Mangrove Forest, Miri Sarawak were in normal range or in class I and class II that is considered as good water quality status. The WQI of the river water at both rivers fall under class II (good water quality) respectively. The mangrove forest of the area must always be protected and conserved. Continuous monitoring of water quality of the river water at the area also should be done to monitor the water quality status. All agencies involved include the local communities play an important role and should be more effective to prevent the destruction of the mangrove forest ecosystem and the aquatic environment of the mangrove forest.

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