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Report

Water quality status of Liwagu River, Tambunan, Sabah, Malaysia

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ABSTRACT. A study on water quality at selected sites along the two main tributaries of Liwagu River was carried out. Eight water samples were collected along the river for physical and chemical analysis. The physical and chemical water quality analyses were carried out according to APHA procedures. The result of water quality analysis (physico-chemical) indicated that both of the tributaries are characterised by excellent water quality with an average of 94.5 value of WQI. This river was classified into Class I - Class II based on National Water Quality Standards for Malaysia (NWQSM) and the Water Quality Index (WQI).

INTRODUCTION

Rivers play a major role for communities especially in fisheries and as a source of water for people residing within the vicinity.Water quality is of utmost importance and it covers a wide range of approaches and conflicts. The continuos increase in socio-economic activities in this area has been accompanied by an even faster growth in pollution stress on river quality. One of the challenges in evaluating and improving water quality are the many different factors affecting water quality. Water quality is affected by air quality, pesticides and toxics (Cunningham *et al.*, 2007). Pollution mayoriginate from point sources or non-point sources. The major point sources of pollution to freshwater originates from the collection and discharge of domestic wastewater, industrial waste or certain agricultural activities, such as animal husbandry (Watson & Burnett, 1995). Most other agricultural activities, such as pesticide spraying or fertilizer application, are considered as non-point sources (Loague & Corwin, 2005). An important difference between a point and a diffuse source is that a point source may be collected, treated or controlled while diffuse sources consisting of many point sources may also be controlled provided all point sources can be identified. By definition a point source is a pollution input that can be related to a single outlet (Watson & Burnett, 1995). Untreated, or inadequately treated, sewage disposal is probably still a major point source of pollution of rivers. Some point sources are characterised by a relatively constant discharge of the polluting substances over time, such as domestic sewers, whereas others are occasional or fluctuating discharges, such as leaks and accidental spillages (Fang *et al.*, 2005). A sewage treatment plant serving a fixed population delivers a continuous load of nutrients to a receiving water body. Therefore, an increase in river discharge causes greater dilution and a characteristic decrease in river concentration. Diffuse sources cannot be ascribed to a single point or a single human activity although, as pointed out above, they may be due to many individual point sources to a water body over a large area. Typical examples are agricultural run-off, including soil erosion

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from surface and sub-soil drainage (Bianchi & Harter, 2002). These processes transfer organic and inorganic soil particles, nutrients, pesticides and herbicides to adjacent water bodies.

In Malaysia, six chemical parameters are measured as a standard to determine the water quality using a Water Quality Index (WQI). This parameter includes pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonical Nitrogen (AN), Suspended Solids (SS) and Dissolved Oxygen (DO). A pH indicates the contamination and acidification in a natural water system (Palaniappan *et al.*,2010). Biochemical Oxygen Demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions (Perry &Vanderklien, 1997). COD indicates the amount of organic pollutants in water. Ammonical nitrogen indicates nutrients status, organic enrichment and health of the water body (Radojevic *et al.*, 2007). Nutrients such as phosphorus and nitrogen are essential for the growth of algae and other plants. Excessive concentration of nutrients however, can over stimulate aquatic plant and algae growth and enhance the process of eutrophication which can lead to an abundant supply of vegetation and causes low DO (Addy & Green, 1997; Kramer, 1987). Dissolved oxygen is the amount of oxygen dissolved or carried in the water (Francis-Floyd, 1993). Fertilizer, failing septic systems, wastes discharge from pets and farm animals are typical sources of excess nutrients in surface waters. Suspended solid is the suspended or dissolved matter in water or wastewater. Suspended solids are the residue in a well mixed sample of water which will not pass a standard filter. Natural weathering and decomposition of rocks, solid and dead plant materials and the transport or dissolution of weathered product in water contributes a natural background of suspended and dissolved materials to natural waters (Johnson *et al.*, 2009).

Other parameters that can describe water quality status are fecal and total coliform, conductivity and temperature. Fecal coliform is the bacteria which can be found in the intestines of warm-blooded animals (APHA, 1998). Fecal coliform bacteria do not cause disease but are used as an indicator of disease causing pathogens in the aquatic environment. Conductivity is the ability of substance to conduct electricity and it has more or less linear function of the concentration of dissolved ions in water (APHA, 1992). If the conductivity of the streams suddenly increases, it indicates that there is a source of dissolved ions in the vicinity.The chemical, physical and biological aspects of water quality are inter-related and must be considered together. Also, water quality is highly variable over time due to both natural and human factors (Cunningham *et al.*, 2007). The objective of this study is to define the status of water quality in the two main tributaries of Liwagu River based on the National Water Quality Standards for Malaysia (NWQSM) and the Water Quality Index (WQI).

STUDY AREA AND METHOD

Sampling was conducted from 10th to 14th November, 2011. Sampling was undertaken along the Nukakatan River and Mensangoh River, which represents the main tributaries of Liwagu River (Figure 1). This site has an average elevation of 744 meters above sea level. Part of the area, has been gazetted for protection through the Crocker Range Park since 1984. A total of eight sampling stations (Figure 1) within the study area were identified for water quality analysis. Out of the eight sampling stations, two were located at the upstream of the river and were not affected by any residential area or agricultural activities.

Physico-chemical water quality was measured *in-situ* by using multiparameter probe Hanna HI9828 for dissolved oxygen, pH, conductivity, temperature, salinity and TDS concentrations. Water sampling at all locations were performed using the grab sampling technique. Water samples were collected and preserved in a polyethylene bottle for analysis of phosphate, sulfate, nitrate, ammonical-nitrogen, fecal and total coliform, BOD, COD and total suspended solids. The samples were analysed using standard procedure (APHA, 1998). Samples for chemical analysis were analysed at

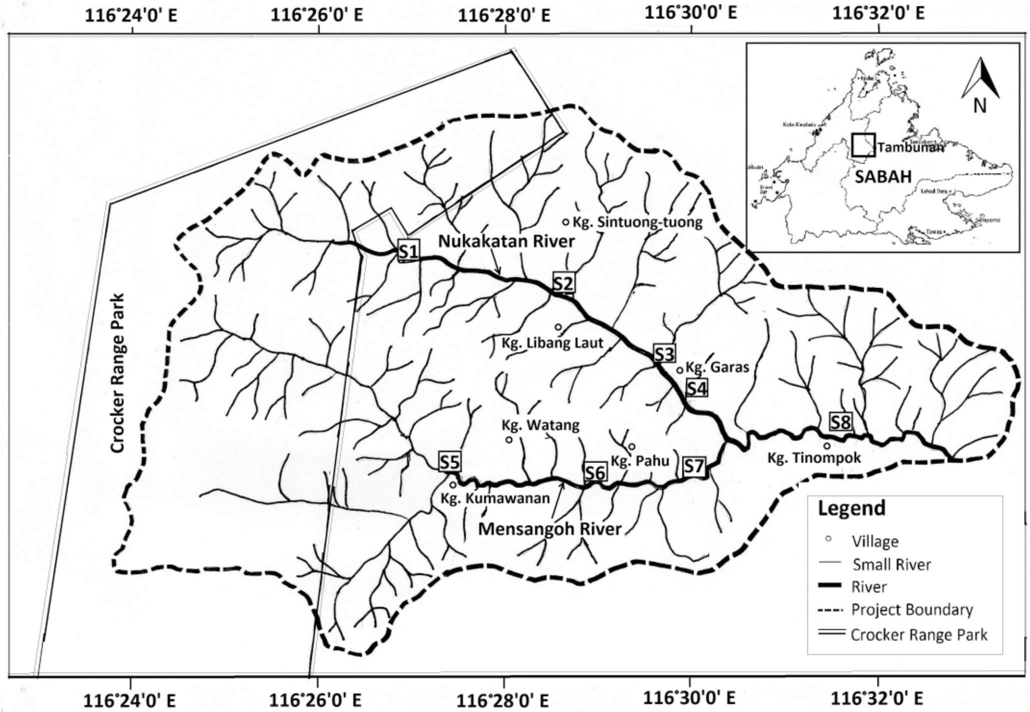

Figure 1. Map showing location of Liwagu River catchment area with eight water sampling stations. Inset map shows the location of the catchment area in Sabah.

the laboratory within 48 hours of collection. Samples were subjected to filtration prior to chemical analysis. The determination of Total Suspended Solids (TSS) was done by a gravimetric process. The Winkler's method was followed for the analysis of BOD, while COD was determined using the titrimetric procedure. Nitrate, phosphate and sulfate were determined spectrometrically using HACH Water Analysis Kit Model DR/2010. Fecal coliform and total coliform population were analysed using MPN/100ml method by growing on M-FC medium at temperature 44.5°± 1°C for 24 hours and 35°± 1°C for 48 hours respectively. Data was processed and calculated for Water Quality Index:

WQI = 0.22 X SIDO + 0.19 X SIBOD + 0.16 X SICOD + 0.15 X SIAN + 0.16 X SISS + 0.12 X SIpH

Which:
SIDO = Sub-Index DO (in % saturation)
SIBOD = Sub-Index BOD
SICOD = Sub-Index COD
SIAN = Sub-Index NH3N
SISS = Sub-Index SS
SIpH = Sub-Index pH

RESULTS AND DISCUSSION

The physical and chemical water quality of tributaries of Liwagu River

Generally, the two tributaries of Liwagu River are characterised by good water quality. Water quality data for each main tributary is tabulated in Table 1. The pH of water samples varied between 6.34 at the upstream to 8.3 at the downstream of the Nukakatan River. In the Mensangoh River, the pH varied from 7.79 to 8.18 from upstream to downstream. pH value classified these two tributaries as belonging to Class I. Because pH is measured on a logarithmic scale, an increase of one unit indicates an increase of ten times the amount of hydrogen ions. Results show that pH values for

Table 1. The physical and chemical water quality status for each sampling station along Mensangoh and Nukakatan rivers.

Station	Parameter												Colonies per 100 ml	
	Colour	pH	Conductivity (mS/cm)	DO (mg/l)	Temp (°C)	NH_3-N (mg/l)	NO_3 (mg/l)	PO_{3-} (mg/l)	SO_4 (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	*F. coli*	*T. coli*
S1	Clear	6.34	0.05	6.19	19.27	0.09	1.2	0.06	7	0.38	0.67	0.6	4	19
S2	Clear	8.05	0.07	6.81	22.66	0.24	0.7	0.46	7	0.42	3.33	1.3	0	17
S3	Clear	8.27	0.09	6.65	24.14	0.21	1	0.12	8	0.56	2.1	4.0	0	18
S4	Clear	8.3	0.09	6.49	24.87	0.27	0.6	0.14	8	0.59	3.4	0.1	9	169
S5	Clear	7.79	0.05	7.79	19.91	0.32	1.7	0.23	9	0.57	3.5	1.0	7	137
S6	Clear-greyish	8.14	0.06	7.76	21.8	0.03	1.7	0.12	9	0.52	3.6	2.0	5	130
S7	Brownish	8.18	0.06	6.95	23.78	0.05	3.5	0.48	13	0.65	4.8	3.4	1	33
S8	Clear	7.81	0.14	6.21	23.73	0.2	1.5	0.29	10	0.69	4.33	2.7	5	163

all sites fall within the acceptable limit of 6 to 8.5. In general, pH values recorded were almost at neutral level, indicating that waste discharge did not affect the water's pH.

Dissolved oxygen varied between 6.19 mg/l to 7.79 mg/l for every sampling station. The average DO concentration for every sampling station is 6.93 mg/l, and as regards to the Malaysian Interim Water Quality Standard, the tributaries can be classified into Class II A. The BOD varied from 0.38 mg/l to 0.59 mg/l at the upstream to the downstream of Nukakatan River. At the Mensangoh River, the BOD value varied from 0.57 mg/l to 0.65 mg/l from the upstream to the downstream of Mensangoh River. The amount of COD in the river varied between 0.67 mg/l to 4.8 mg/l and as regards to the Malaysian Interim Water Quality Standard, this amount classified both rivers to Class I. Fish and other aquatic animals depend on dissolved oxygen to live and the amount of DO is dependent on water temperature, quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, stream flow and aeration (Ostrander, 2000). Dissolved oxygen (DO) concentrations in the tributaries were much higher than the minimum requirement for aquatic organisms at 5 mg/L (Mallya, 2007). In most of the stations, the pH is closer to 7.0 and dissolved oxygen higher than 5 mg/l indicating the healthy state of the river system.

Other form of nitrogen detected in the water is ammoniacal nitrogen (NH_3N) which is also associated with the use of fertilizer for land and agricultural development. Ammoniacal nitrogen was detected in concentration varying from 0.05 mg/l to 0.3 mg/l. According to the Department of Environment (2011), the amount of ammoniacal nitrogen found in the water was categorised in Class II of the Water Quality Index classification except at the upstream of the Nukakatan River, where very low concentration was detected. Most of the nutrient levels were detected at low concentration except for phosphate which was found to be slightly high in most areas except at the upstream of Nukakatan River (S1). The concentration of phosphate varied from 0.06 mg/l to 0.48 mg/l in every sampling station. In the aquatic natural ecosystem, phosphorus is available in the lowest amount, and it is usually the limiting nutrient for plant growth. The excessive amount of phosphorus in a system can lead to an abundant supply of vegetation and cause low DO (Cech, 2010). Nitrate (NO_3) and sulphate (SO_4) were also detected but in low concentration. Concentration of nitrate varied from 0.7mg/l to 3.5 mg/l, while SO_4 was detected between 7mg/l to 13 mg/l. While level of these nutrients may be naturally high in a water body, elevated levels of nutrients may be caused by human activities such as continual use of soap and fertilizer that contribute to nutrient input into rivers.

Total suspended solids (TSS) values were observed to vary between 0.6 mg/l to 4.0 mg/l at every sampling station. The amount can still be accepted even though these rivers are affected by human activities such as construction and residential activities. Stations S6, S7 and S8 are located close to a road construction and residential area, and the water has changed to a brownish colour. Total coliform counts in every sample varied between 17 to 169 colonies per 100 ml. At the same time, fecal coliform count in the water samples varied between 0 to 9 colonies per 100 ml. Human are believed to be the only significant source these enteric viruses in water. Although the percentage of pathogen in freshwater may be low, risks can still be considered significant because of low numbers of some enteric pathogens, such as viruses, necessary to cause infection (Petterson *et al.*, 2001).

Water Quality Index

Water Quality Index provides a single number that expresses the overall water quality based on several water quality parameters. There are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality. A water quality index for every sampling station has an average value of 94.5 which has classified both of the Liwagu River tributaries as clean and received a minimum anthropogenic pollution in relation to the Water Quality Index shown in Figure 2. This water quality rating clearly shows that the water body is clean and suitable for human use. It is also found that pollution load is relatively low and has no significant effect to the quality of the river.

Nevertheless, water quality is highly variable over time due to both natural and human factors (Ahmad *et al.*, 2009). The chemical, physical and biological aspects of water quality are inter-related and must be considered together. Flows and suspended sediment can vary daily with rainfall while nutrient load can vary with season.

CONCLUSION

With regards to the Malaysian Interim Water Quality Standard, the physical and chemical water quality classify both of the Liwagu main tributaries as being between classes I and II, which indicates that these tributaries has good water quality. However, the quality of a river is determined by land activities. Mensangoh River and Nukakatan River is used by the local community for many purposes such as bathing, cleaning and agriculture. The continuous harmful human activities could contribute more pollutants into the river and change the water quality. Therefore, continuous monitoring and comprehensive sampling are necessary to ensure the river's status in the long term.

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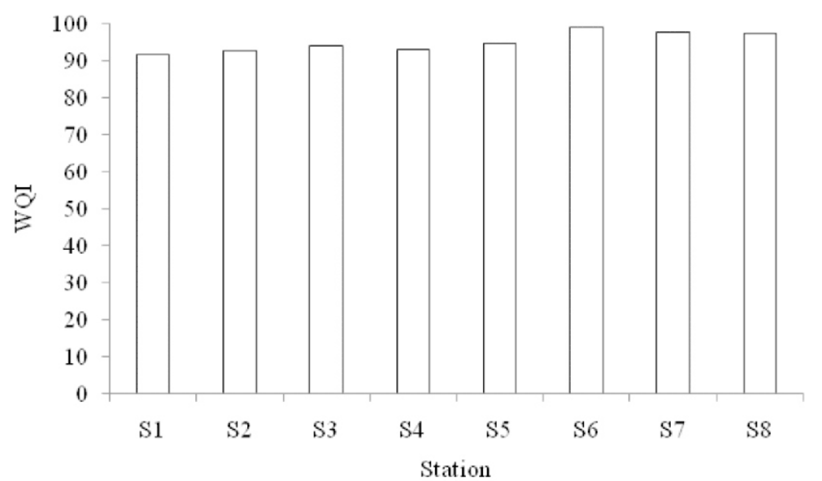

Figure 2. Water Quality Index (WQI) for each sampling stations of Liwagu River tributaries.

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