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COMPARISON BETWEEN WATER QUALITY INDEX (WQI) AND BIOLOGICAL WATER QUALITY INDEX (BWQI) FOR WATER QUALITY ASSESSMENT: CASE STUDY OF MELANA RIVER, JOHOR

(Perbandingan di antara Indeks Kualiti Air (WQI) dan Indeks Kualiti Air Biologi (BWQI) bagi Penilaian Kualiti Air: Kajian Kes Sungai Melana, Johor)

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Abstract

A study of water quality in Melana River, Johor was carried out in three consecutive months (March - May 2012). This study aims to determine the comparative results through biological monitoring as well as conventional method (physical and chemical analysis). Assessment is carried out through collection and identification of the biological indicator which comprises of macrobenthos based on Biological Water Quality Index (BWQI). Comparison was done based on two methods namely invertebrate analysis and also laboratory analysis. For invertebrate analysis, Melana River consist of three types of Family groups namely Nymphs, Larvae and Molluscs. The result for Water Quality Index (WQI) and also Biological Water Quality Index (BWQI) analysis showed that the level of Melana River is polluted and classified in Class III. This study shows that even though different methods were used, the similar results were obtained for both rivers and can be applied to any river to identify their level of cleanliness.

Keywords: Melana River, benthic macroinvertebrate, Water Quality Index, Biological Water Quality Index

Abstrak

Satu kajian kualiti air di Sungai Melana, Johor telah dijalankan dalam tiga bulan berturut-turut (Mac - Mei 2012). Tujuan kajian ini dijalankan adalah untuk melihat perbandingan hasil melalui kaedah pemonitoran biologi serta konvensional (analisis fizikal dan kimia). Penilaian dijalankan melalui pengumpulan dan mengenal pasti penunjuk biologi yang terdiri daripada makrobentos berdasarkan Indeks Kualiti Air Biologi (BWQI). Perbandingan telah dilakukan berdasarkan kepada dua kaedah iaitu invertebrat analisis dan juga analisis makmal. Untuk analisis invertebrat, Sungai Melana terdiri daripada tiga jenis kumpulan Famili iaitu Nimfa, Larva dan Moluska. Hasil analisis Indeks Kualiti Air (WQI) dan Indeks Kualiti Air Biologi (BWQI) menunjukkan bahawa tahap Sungai Melana adalah tercemar dan dikelaskan dalam Kelas III. Kajian ini menunjukkan bahawa walaupun kaedah yang berbeza telah digunakan, hasil yang sama telah diperolehi bagi kedua-dua sungai dan boleh digunakan untuk mana-mana sungai bagi mengenal pasti tahap kebersihan sungai tersebut.

Kata kunci: Sungai Melana, bentik makroinvertebrat, Indeks Kualiti Air, Indeks Kualiti Air Biologi

Introduction

The purpose of this paper is to determine the effectiveness of the method using macrobenthos as biological indicator in determining the level of water pollution in terms of assessment and results and compared with conventional methods commonly used. This method is taken as an alternative way for determining the level of pollution of a river. The results of this study can help in reducing river pollution by increasing public awareness among the community.

River rehabilitation program has become an important issue for water authorities and river manager in many countries throughout the world. Term 'rehabilitation' is referring to reinstatement of feature of the river ecosystem, be it structural or functional; that may have been impaired or lost [1]. The objective for river rehabilitation program is for protection against flood, nature development to enhance the amenity and recreational potentials of a river, and improvement of reverie fish habitats and communities to improve water quality [2]. The implementation of river rehabilitation program has shown positive effect and significantly improved the water quality conditions of our stream and river, at the same time enhance the amenity and landscapes of the riverside.

River water quality monitoring is important in achieving the objectives of river rehabilitation program. Water quality data were used to determine the water quality status whether in clean, slightly polluted or polluted category and to classify the rivers in Class I, II, III, IV or V based on Water Quality Index (WQI) every year. Water Quality Index (WQI) is computed based on six main parameters which are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia Nitrogen (AN), Acidic and Alkaline (pH), Dissolved Oxygen (DO) and Total Suspended Solids (TSS). In addition, river water quality status also can be determined by using macrobenthos based on Biological Water Quality Index (BWQI). The reason in choosing macrobenthos as the indicator because they are varying in their adaptation to environmental conditions and their tolerance of sensitivity to pollution and can be used to reflect environmental quality. Besides, water quality status also can be predicted using water quality modeling. The main objective of water quality modeling is to describe and predict the observed effects of a change in the river system [3].

Materials and Methods

Study Area

This study is located at Melana River catchment (Figure 1). This river started from Gunung Pulai until Skudai River reach at Taman Perling district of Johor Bahru. Melana River is one of network in Skudai River basin. This watershed is located in Mutiara Rini area, Skudai in Johor Bahru district. The area of Melana watershed is about 22.92 km^2 with many changes occurred in this area because of vast development. Many housing area and light industry being constructed in this watershed such as Taman Teratai, Taman Universiti, Taman Mutiara Rini, Taman Sri Pulai, and Taman Pulai Perdana to cater the increasing of population. The river substrates were mainly muddy type with murky and smelly water.

Methodology

A rectangular dip net with 500µ mesh size attached with long pole was used to collect the macrobenthos. Dip net was placed resting on the river bed with the opening mesh against the current flow. The substrates were disturbed and rock and boulders were rubbed by hand in order to dislodge the organisms. Samples collected were put into polyethelene bottles and preserved with 70% alcohol for further analysis in laboratory using light microscopy. In the laboratory, speciments were washed with tap water, sorted, enumerated and identified. Finally, samples were analysed and calculated according to Biological Water Quality Index, BWQI [4], as shown below:

$$BWQI = \Sigma S / \Sigma J \quad (1)$$

where:

BWQI = Biological Water Quality Index,
S = Total score,
J = Number of animal type

River morphology and water quality parameters (temperature, conductivity, depth, width, DO and pH) were measured in-situ. Dissolved oxygen and pH were determined using YSI 55 Proplus meter (Multi sensor) while others (BOD, COD, TSS and AN) were analysed in laboratory. These parameters were then calculated to obtain the water quality index based on equation below:

$$WQI = 0.22*SIDO + 0.19*SIBOD + 0.16*SICOD + 0.15* SIAN +0.16*SISS + 0.12*SipH \quad (2)$$

where:

WQI = Water Quality Index,
DO = Dissolved oxygen,
BOD = Biochemical oxygen demand,
COD = Chemical oxygen demand,
AN = Ammonia Nitrogen,
SS = Suspended solids,
pH = acidic value

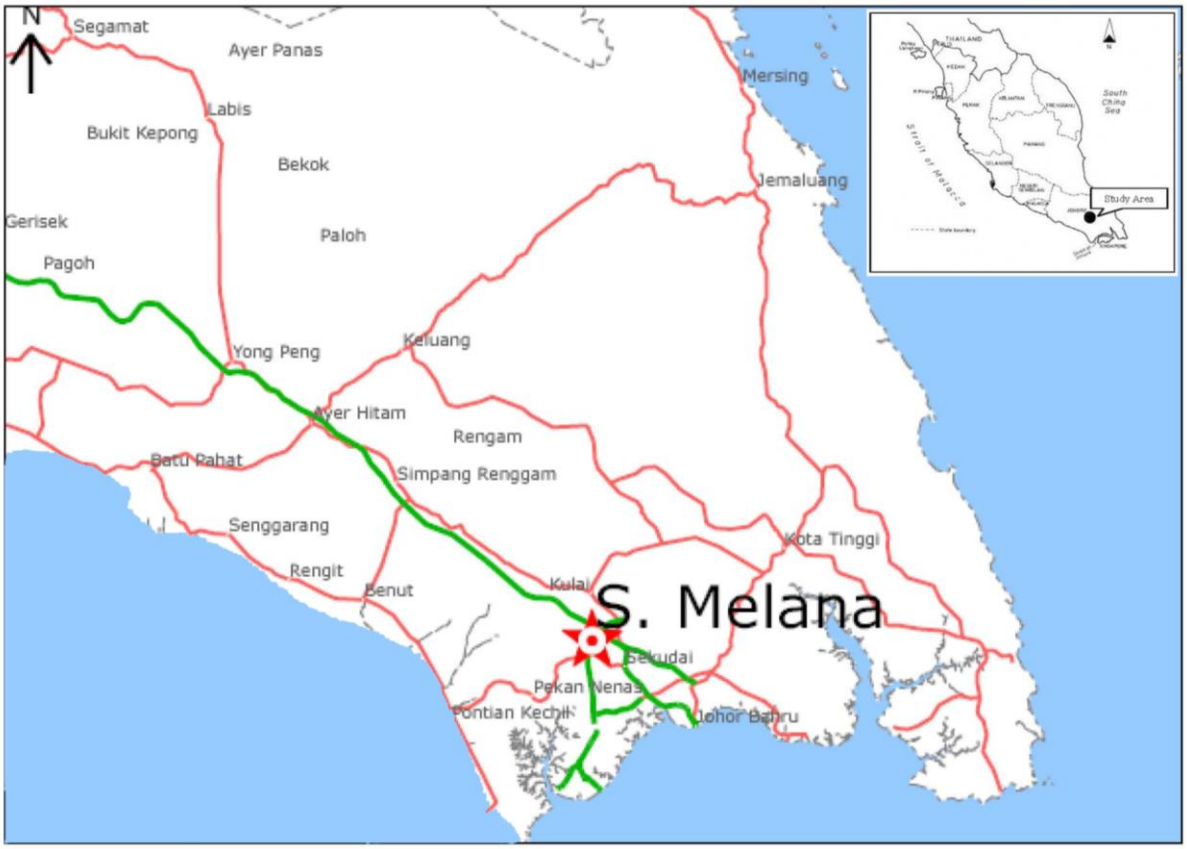

Figure 1. Study area of Melana River, Johor

Results and Discussion

Physico-chemical Water Quality

Dissolved Oxygen (DO) is the most important parameter in classifying a river's class in WQI. Based on the coefficient of DO, it influence the water quality index by 22% [5]. When the value of DO is lower, WQI tends to have lower value and if the value of DO is higher, it is vice versa. The average DO recorded for Melana River was 3.16 mg/L. The highest concentration of DO (4.07 mg/L) was recorded on April at Station 3 whereas the lowest DO

(2.33 mg/L) was on March at Station 2. The value of DO depends on the activities at those stations. The town area is the main cause of the depletion of DO content in the river due to the high organic pollutants released from the town center. The rubbish, detergent, grease as well as suspended solids tend to accumulate on the surface of the river which directly affects the surrounding oxygen from dissolving into the river. According to [6] during high tide, the flow of the river is stronger and faster therefore more oxygen can easily dissolve in the water, making DO concentration higher compared to during low tide where the flow is quite stagnant.

BOD is related to the dissolved oxygen content in the river and is the main indicator of the organic pollution in the river. A decrease in the DO value usually denotes an increase in the BOD value. BOD is also the second most important parameter in classifying a river in the Water Quality Index as it holds 19% of the classification [5]. Based on study conducted, the average concentration of BOD for Melana River was 13.16 mg/L. The highest BOD (16.47 mg/L) was observed on March at Station 2 while the lowest BOD (10.14 mg/L) was on May at Station 1. BOD concentration was higher in Melana River due to the commercial activities as well as the residential areas along the river. The untreated sewage from squatters and food waste which is disposed directly into the river will also increase the BOD content in the river [7].

The accountability of Chemical Oxygen Demand (COD) to the WQI is the third most important parameter when determining a river's WQI as it takes up 16% together with suspended solid (SS) [5]. Generally, the average value for COD in rivers are usually ranged from 0 to 150mg/L. This study found that the average COD concentration for Melana River was 33.3 mg/L. The highest COD was recorded on May at Station 2 with 40.6 mg/L while the lowest COD was 24.0 mg/L on April at Station 1. This result indicated that there were much organic substances which are non-biodegradable and reactive. Even domestic waste also contributes to high COD content. All these effluents are toxic and harmful to living things [7].

Total Suspended Solid (TSS) contribute 16% of the amount to the value of WQI. TSS include all the suspended particle which will not pass through the filter paper during the laboratory experiment in determining the TSS. The average of TSS for Melana River was 44.3 mg/L. The highest TSS was on March at Station 3 (132.5 mg/L) meanwhile the lowest (2.6 mg/L) was on April at Station 1. Significant difference in the value of the two month period is influenced by rainfall factor. Sampling in March was done in rainy season. Rain cause water to carry any particle on land into the river, thus contribute in increasing of suspended solid in river.

Ammonia Nitrogen (NH_3N) contribute 15% of the amount to the value of WQI. One of the sources of NH_3N in a river is come from the microbial degradation of nitrogenous organic material. The other sources of this compound are come from the sewerage treatment plant, the using of fertilizer for agriculture as well as other by products which flow into the river. The average NH_3N for Melana River was 2.86 mg/L. The highest NH_3N obtained was 3.72 mg/L at Station 3 while the lowest was 1.47 mg/L at Station 1. The level of NH_3N significantly increase as it meets with connecting tributaries and drains indicating that the pollutant carried by them is very high.

Biological Water Quality Index (BWQI)

Using the macrobenthos as a biological indicator is another way in determining the class and status of river. This method classified the river based on the Biological Water Quality Index (BWQI). The analysis of macrobenthos as a biological indicator is an easy, fast and low cost method. Anyone can do it due to this method does not need any special tools. This method requires collecting of macrobenthos at the river with appropiate tools for safety and environmental purpose, and stored it for further identification. The identification on types of macrobenthos is based on the Identification Index as provided by Jabatan Pengairan dan Saliran Malaysia. Table 1 shows the status of Melana River based on macroinvertebrate analysis.

This study found that, there were four types of macrobenthos with three family groups which were Nymphs, Larvae and Molluscs populated at vicinity of Melana River. The types of macrobenthos were dragonfly nymphs, rat-tailed maggots, mosquito larvae as category as other fly larvae and pagoda snails. All those types of macrobenthos can live in clean and average river water. Family group Larvae got the highest score of macrobenthos with the value of 8. The rat-tailed maggots and mosquito larvae were grouped in same family. Rat-tailed maggots breathe fresh air through long extending 'tails' for their survival. Dragonfly nymphs and pagoda snails shared the same score with

the value of 3. However, the dragonfly nymphs belong to the nymphs family meanwhile pagoda snails belongs to molluscs family. Dragonfly nymphs are very active hunters with large jaws. They feed on insect, tadpoles and even small fish, and are probably important natural pest controllers of animals such as mosquitoes and blackflies. The pagoda snails from molluscs family were collected with 5 individuals. Pagoda snails are shell animal that survive by eating plant.

Table 1. Classification of water quality in Melana River, Johor based on biological index

Total Score	Number of Animals Type	BWQI	Class	Status
20	4	5.0	III	Rather dirty - average

Water Quality Index (WQI)

Water Quality Index (WQI) is used to classify the class and status of river. The value of WQI depends on the value of the sub index for each parameter. According to Table 2, Melana River was classed in Class III with status as polluted river based on WQI. There are many factors contributing to the water pollution of Melana River either from point source or non-point source. Sewerage treatment plant is one of the point source contributing pollution to Melana River. The discharge of sewerage treatment plant that has contaminant entered the river, cause changes in the ecosystem of the river. Furthermore, Melana River is sourrounded by residential area, sewerage treatment plant, and also the huge industrial area at the downstream of rivers. The materials used for the enrichment plant would normally flow and seep into the ground and then into rivers. The major source of pollution is from animal manure, agricultural and domestic waste. Surface runoff from the heavy rains act as non-point source pollution to the Melana River as the surface runoff carried contaminant with it before entering the river.

Table 2. Classification of water quality in Melana River, Johor based on water quality index

SIDO	SIBOD	SICOD	SISS	SIAN	SIpH	WQI	Class	Status
48	51	62	14	75	99	56	III	Polluted

Conclusion

As a whole, Melana River can be categorized as polluted or Class III based on the assessment of Water Quality Index (WQI) and Biological Water Quality Index (BWQI). The level of pollution at this river was found affected by its surrounding. From the observation, many activities contribute to river pollution such as industrial, commercial and residential activities. On the other hand, by using biological monitoring can give the information on biological conditions of water body which is consist of survey or other direct measurement for aquatic life. Based on group of macrobenthos sampled, the composition of macrobenthos as biological indicator is very important to determine the level of river pollution because macrobenthos live in water for all or most of their life and they only live in area which suitable for their survival. From the macrobenthos analysis, Larvae were major group of macrobenthos found along the Melana River.

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