Identification of Pollution Sources within the Sungai Pinang River Basin

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Abstract

Sungai Pinang is the main river flowing through the state of Penang, Malaysia. For years the water quality of the river has severely deteriorated and badly affected the environment and the ecosystem surrounding the river. A study was conducted to analyze the physical, chemical and biological characteristics of the water quality through-out the sub-catchment areas to identify factors causing pollution. Detailed surveys were carried out to identify the key problems of each area with respect to water quality and land use. This paper discusses pollution sources of Sungai Pinang from industries, domestic, non-classified wastewater such as hawkers, restaurants, bus stations as well as non-point sources.

Keywords: Water quality; pollution sources, Sungai Pinang

1. Introduction

Water quality refers to the physical, chemical and biological status of the water body. Typically, rivers are diverse and biologically productive environments in their natural form. The presence, abundance, diversity and distribution of aquatic species in surface waters are dependent upon a myriad of physical and chemical factors such as temperature, pH, suspended solids, nutrients, chemicals and in-stream and riparian habitats. The water quality reflects the composition of water as affected by natural causes and human's cultural activities. It is expressed in measurable quantities and is related to intended water use [1].

Water quality and pollution are determined and measured by comparing physical, chemical, biological, microbiological and radiological quantities and parameters to a set of standards and criteria. In Malaysia, the Interim National Water Quality Standard for Malaysia adopted by the Department of Environment is used to assess the river water quality and to classify the river into a number of classes. These classes are matched with their beneficial uses by using a Water Quality Index (WQI), which is in turn based on a number of water quality parameters [2].

Rivers play an important role in assimilating or carrying off industrial and municipal wastewater, manure discharges and runoff from agricultural fields, roadways and streets beside constitute the main water resources in inland areas for drinking, irrigation and industrial purposes. Therefore, rivers are most vulnerable to pollution due to their easy accessibility for disposal of wastewaters. Both the natural processes, such as precipitation inputs, erosion, weathering of crustal materials, as well as the anthropogenic influences viz. urban, industrial and agricultural activities, increasing exploitation of water resources, together determine the quality of surface water in a region [3][4]. Since, rivers constitute the main inland water resources for domestic, industrial and irrigation purposes, it is imperative to prevent and control the rivers pollution and to have reliable information on quality of water for effective management.

Studies have been carried out relevant to the water quality of Sungai Pinang Basin. The outcome of the researches explain that there are several major water pollution sources attributed to anthropogenic activities as well as human attitude such as domestic sewage, waste from animal

husbandry areas and industrial wastes [2][5][6][7]. The objective of this study is to identify pollution sources within the Sungai Pinang River Basin that contribute to the low water quality.

2. Material and Method

2.1 Study Area

The Sungai Pinang River Basin is one of the most polluted river basins in Malaysia [2]. Located at the north-east of the Penang Island (5°24'N 100°19'E), the Sungai Pinang River Basin comprises of the main river, Sungai Pinang, and its six tributaries namely Sungai Air Terjun, Sungai Kecil, Sungai Air Putih, Sungai Air Hitam, Sungai Dondang and Sungai Jelutong. The total area of the river basin is about 50.97 km^2 and the distance of the Sungai Pinang is approximately 3.1 km. About one-third of the river basin area is arable land and over half of the basin is covered with forest.

The Sungai Pinang River Basin runs through the highly developed and densely populated area of Georgetown, the capital city of Penang, Malaysia. Based on an analysis of water quality performed by the Drainage and Irrigation Department (DID) in 1999 [2], the water quality of Sungai Pinang can be categorized as class IV in accordance with proposed Interim National Water Quality Standards for Malaysia, which is considered "very polluted".

2.2Sampling Site

The sampling sites for this study are based on the river tributaries. Ten sampling sites were chosen at the end of each tributary. The details of the location of the sampling sites are tabulated in Table 1 and Table 2.

Table 1. Locations of sampling sites

Sampling site	Name of tributary	Longitude	Latitude
1	Sungai Air Hitam I	05° 24' 4.6"N	100° 18' 28.7"E
2	Sungai Air Hitam II	05° 24' 5.5"N	100° 17' 40.5"E
3	Sungai Air Hitam III	05° 24' 9.2"N	100° 17' 17.0"E
4	Sungai Air Putih	05° 24' 8.9"N	100° 17' 17.0"E
5	Sungai Air Terjun	05° 24' 4.5"N	100° 18' 31.3"E
6	Sungai Dondang	25° 24' 5.0"N	100° 17' 39.4"E
7	Sungai Jelutong	05° 23' 8.5"N	100° 19' 12.4"E
8	Sungai Pinang	05° 24' 3.7"N	100° 19' 53.2"E
9	Sungai Kecil I	05° 24' 7.5"N	100° 17' 59.5"E
10	Sungai Kecil II	05° 24' 37.5"N	100° 17' 59.5"E

Table 2. Land use of sampling sites

Sampling site	Name of tributary	Land use
1	Sungai Air Hitam I	- residential area - wet market - commercial area
2	Sungai Air Hitam II	- residential area - commercial area
3	Sungai Air Hitam III	-residential area - industrial area - commercial area
4	Sungai Air Putih	- residential area - commercial area - industrial area (textile)
5	Sungai Air Terjun	- residential area
6	Sungai Dondang	- residential area - commercial area
7	Sungai Jelutong	- residential area - commercial area
8	Sungai Pinang	- Industrial area (food, textile) - wet market - slaughter house - residential area - commercial area
9	Sungai Kecil I	- residential area - industrial area (textile) - wet market
10	Sungai Kecil II	- animal husbandry - cemetery

2.3 Sampling Methodology

The technique used for collection of water samples was grab sampling. Water samples were taken at each of tributary using a bucket attached to a rope. Samples for laboratory analysis were collected in HDPE bottles that were pre-soaked in HCl for 24 hours and copiously rinsed with deionised water and sample containers are filled slowly to the brim to avoid entrainment of air bubbles. Samples collected are then stored at 4°C. The samplings were carried out during the dry weather.

2.4 Parameters Selected for Analysis

The parameters selected for the analysis are dissolved oxygen (DO), pH, temperature, biological oxygen demand (BOD_5), chemical oxygen demand (COD) and total suspended solids (TSS). The methods of analysis are according to the requirements of Standard Methods [8].

2.5 Water Quality Assessment

The results of the analysis of the water samples are compared to a set of water quality standard-National Water Quality Standards for Malaysia (Table 3) adopted by Department of Environment.

Table 3. Interim National Water Quality Standard for Malaysia

Parameter	Interim National Water Quality Standard for Malaysia					
	Classes					
	I	IIA	IIB	III	IV	V
DO	7	5-7	5-7	3-5	<3	<1
pH	6.5-8.5	6-9	6-9	5-9	5-9	-
Temp.	-	Normal ±2	-	Normal ±2	-	-
NH_3N	0.1	0.3	0.3	0.9	2.7	>2.7
BOD_5	1	3	3	6	12	>12
COD	10	25	25	50	100	>100
TSS	25	50	50	150	300	>300
Total Coliform	100	5000	5000	5000	5000	>5000

3. Results and Discussion

The samples collected from point 1 to point 10 were analyzed and compared to the Interim National Water Quality Standard for Malaysia adopted by Department of Environment (DOE). DOE has also classified the river system in Malaysia into five classes namely as Class I, Class II, Class III, Class IV and Class V. Each of classification has its own beneficial uses (Table 4).

Table 4. Water quality classification

Class	Uses
I	Conservation of natural environment Water Supply I- practically no treatment necessary (except by disinfection or boiling only) Fishery I- very sensitive aquatic species
IIA	Water Supply II- conventional treatment required Fishery II- sensitive aquatic species
IIB	Recreational use with body contact
III	Water Supply III- extensive treatment required Fishery III- common, of economic value and tolerant species Livestock drinking
IV	Irrigation
V	None of the above

In-situ measurements were done at the sampling site. Certain parameters require on site measurement due to the rapid changes in the reading caused by various factors such as temperature, activity of microorganism etc. The measurements carried out in-situ are for the following parameters: DO, pH and temperature.

3.1 Dissolved Oxygen (DO)

The concentrations of DO for point 1 to point 10 are shown in Figure 2. From the figure, it can be seen the differences of DO concentration recorded during the study at different sampling sites.

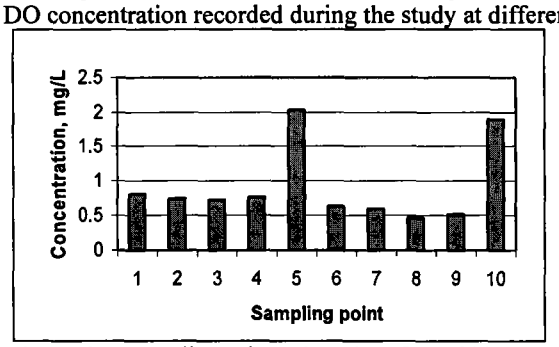

Figure 2. DO level at various sampling points taken along Sungai Pinang and its tributaries

Sampling sites 5 and 10 demonstrate higher DO level while others reflect less than 1 mg/L. This is due to the reason that the concentration of DO is affected by factors such as flow of the river, present of sources of organic pollution, temperature of the water and assimilative capacity of the river. Most of DO concentrations presented were very low especially at points 8and 9. Compared to the standard, the DO concentrations at these sampling sites fall within Class V. Point 5 which is Sungai Air Terjun recorded the highest of DO concentration with 2.04 mg/L.

The low concentration of DO recorded for most sampling points indicate that the input of organic pollutants upstream of the sampling site affects the DO concentration at the sampling site downstream due to the utilization of the DO by microorganism to breakdown the organic matter [2]. Most of the organic pollutants are from food waste and sewerage which are flow into the water. As observed, the food processing, food stalls and residential areas can be noticed bordering to these tributaries.

3.2 pH

Figure 3 shows that pH values for all sites fall within the acceptable limit of 6 to 8. In general, the pH values recorded are almost at the neutral level, indicating that the wastes discharge did not affect the pH water.

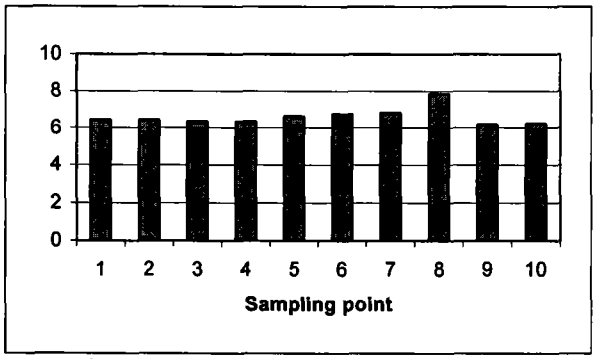

Figure 3. pH values at various sampling points taken along the Sungai Pinang and its trabutaries.

3.3 Temperature

Temperature measured and recorded at points 1 to 10 are shown in Figure 4. From the figure, it is explained that most temperatures of the water fall within the normal range of 27°C to 31°C. However, at point 8, 9 and 10 which is Sungai Pinang, Sungai Kecil I and Sungai Kecil II respectively, the temperature of the samples exceed the normal range with temperature between 31.8°C and 33.1°C.

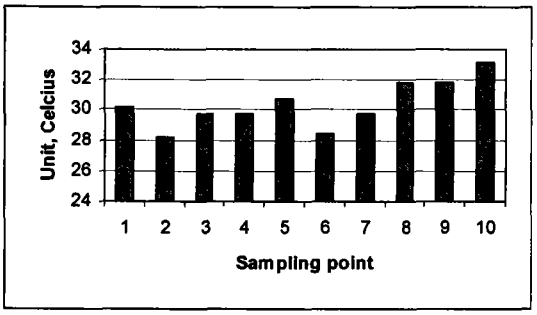

Figure 4. Temperature at each sampling sites

Within these areas, there are industries such as textile (Sungai Kecil), food, workshop and etc. (Sungai Pinang) which discharging their wastes directly into the river [9]. The temperature of these wastes is high which affects the temperature of the river.

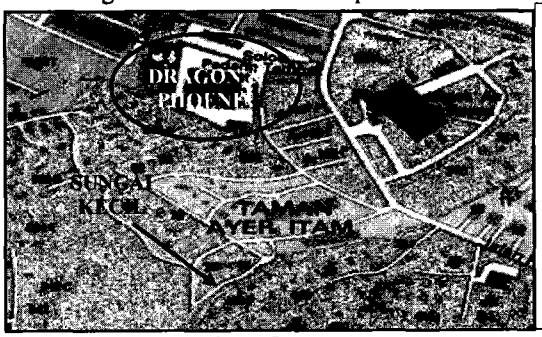

Figure 5

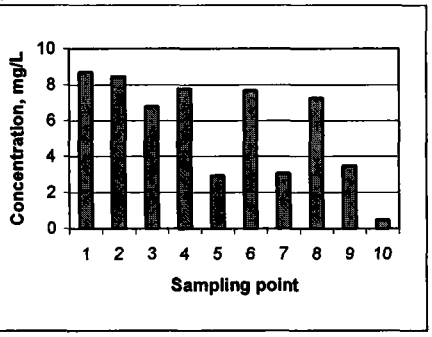

Figure 6

Figure 5. Textile waste from Dragon & Phoenix flows into Sungai Kecil
Figure 6. BOD level at various sampling sites

3.4 Biological Oxygen Demand (BOD_5)

Biological oxygen demand (BOD_5) is the quantity of oxygen utilized by the microorganisms to breakdown the organic matter. The concentrations of BOD_5 observed at sites 1 to 10 are shown in Figure 6. As shown in the figure below, point 5 and point 10 show the lower concentration of BOD_5 between 1-3 mg/L. These concentration values are parallel with normal concentration of BOD_5 for non-polluting river.

Nevertheless, the concentration of BOD_5 detected at most of the sampling points is high. The value of concentration is due to the utilization of the DO by microorganism to breakdown the organic matter. This is proved by the industries located within these areas such as food processing, slaughter house, residential areas and wet market which discharging their wastes into the stream (Figure 7).

Prevention is an especially important strategy for controlling the pollutant. Pollution prevention can be implementing if society reduces its consumption of resources and recycles these materials. Business activities which contribute pollutants to the river should work with those businesses to control the release of those pollutants. Proper waste management should be applied [10].

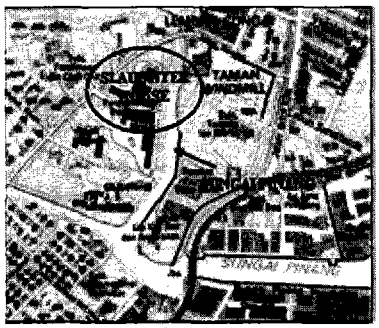

Figure 7. Waste from slaughter house is release into Sungai Pinang

3.5Chemical Oxygen Demand (COD)

As defined, Chemical Oxygen Demand (COD) is the amount of oxygen required to chemically oxidize organic and inorganic matter.

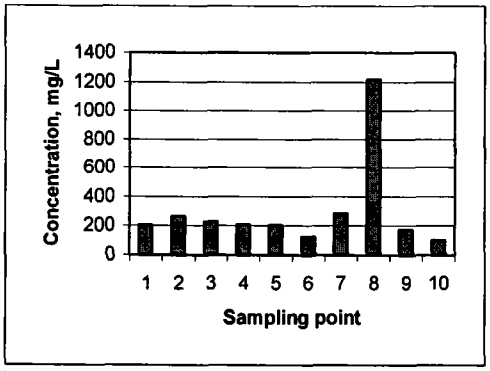

Figure 8. Chemical oxygen demand of each sampling sites

COD gives an estimation of the amount of organic and inorganic matter present. Normally, the value of COD is higher than that of the BOD. The concentrations of COD observed for point 1 to 10 are shown in Figure 8. The points which are being analyzed within the basin are in Class V of National Water Quality Standard for Malaysia. Point 8 which represents Sungai Pinang demonstrates the highest concentration of COD with 1219.33 mg/L. As observed, activities such as slaughter house, workshop, and food stalls adjacent to this river. Citizens should adopt a higher sense of responsibility to ensure that water resources being protected. Environmental education plays an important role in educating the public and industries. From the environmental education, population will learn to understand the concept of conservation and be able to apply simple conservation measures in their lives [10].

3.6Total Suspended Solids

Figure 9 shows the average of SS concentration observed ranged between 8 to 100 mg/L. According to the Interim National Water Quality Standard, the levels of suspended solids fall within Class I to II. As for point 8, the concentration of SS detected exceeds Class II level with 560 mg/L. The possible sources of pollution contributing to this high suspended solids present could be due to the soil erosion from the construction and earthworks activities within this area [5].

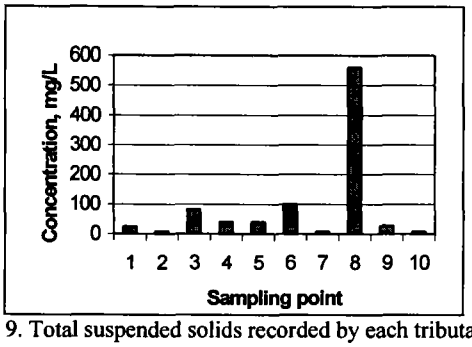

Figure 9. Total suspended solids recorded by each tributaries

4. Conclusions

Water quality of Sungai Pinang River Basin can be classified as very polluted. The result shows that almost of the parameter tested on the water samples fall down to Class V. It was identified that the main sources of pollution are from domestic sewage, waste from animal husbandry areas and industrial wastes. Soil erosion from construction site and urban runoff are also identified as sources of pollution within the study area. Pollutant prevention and environmental education to citizens should be implemented.

5. References

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