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Water Quality Classification Based on Water Quality Index in Sungai Langat, Selangor, Malaysia

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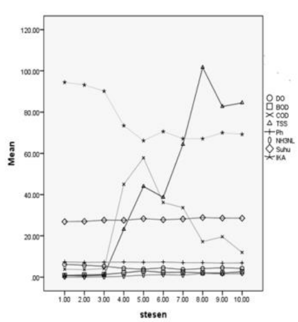
Graphical abstract



Abstract

A study to determine the Water Quality Index (WQWQII) of Sungai Langat was conducted in which 10 sampling stations were selected. Water quality samples were taken according to the standard methods recommended by the American Public Health Association (APHA) and manual HATCH for the lab tests. The measurements done on site were to obtain reading parameters such as temperature, pH and dissolved oxygen (DO) levels using the meter YSI 556 MPS. Laboratory analysis was conducted to get parameter readings such as total suspended solids (TSS), biochemical oxygen demand (BOD5), chemical oxygen demand (COD) and ammoniacal-nitrogen (NH3-N). All the parameters tested were the sub index needed in the calculation of the water quality classification. River classification is done according to the National Water Quality Index (WQS). The Pearson statistical correlation analysis was carried out to show the relationship between the sub-index parameter of (0.01) and the sampling stations for all parameters studied. Stations 1 and 2 were categorized in class I with an average value of (93.55 ± 2.27) and (92.56± 2.54) respectively. Station 3 recorded an average WQI reading of (91.55 ± 2.33) in class II while stations 4 to 10 recorded readings from (76.03 ± 4.72) to (68.60 ± 4:51) in class III. Generally the results show that the Water Quality Index from the sampling stations are categorized between classes I to III.

Keywords: Water quality index, parameter sub-index, Sungai Langat

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1.0 INTRODUCTION

Water is a basic resource needed by all living things. As a result of the diversity in water usage and the limited resources has led to the effort in ensuring the quality and resource control, aside from enhancing a diversity of usage. Water has the advantage in terms of density, boiling point, heat capacity and being good solvent [1]. Water contamination from the chemical aspect is rarely caused by nature, as the water chemistry has a large random value and is influenced by the geography and local climates [2]. According to Tanji water is usually referred to as the universal solvent and this capacity is likely to attract impurities when it interacts with gas, liquid or solids [3]. The Hydrology cycle shows that water is very mobile and it carries the contaminants downstream.

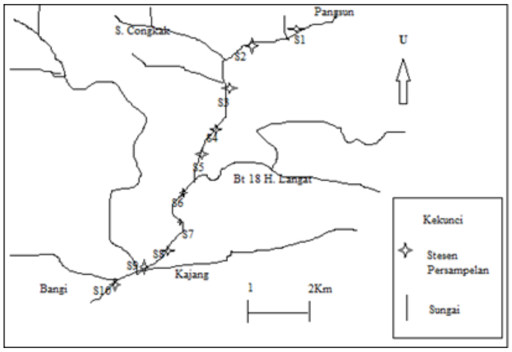

Figure 1 Ten sampling stations along Langat River

Previously, the water quality in the Langat river is not something to worry about, but now with the increased demand for water usage, population growth, agricultural and industrial activities in the surrounding area had lead to increased pollution of the river which affected their function [4].

The interim classification of the Malaysian rivers is guidelines gazette as a reference to the status of river water quality in Malaysia by the Department of Environment [5]. Factors of river pollution can be determined via the comparison and measurement of water quality based on recommended sub-indices such as; total dissolved solids (TDS), pH level, temperature (°C), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) and ammonia nitrogen (NH_3N).

The selected study area is a recreational area and it is important for the water quality to be monitored and controlled to ensure its safety. Sungai Langat is located in Selangor and flows from Mount Nuang in the Hulu Langat district. Several towns and villages are built on the banks of Sungai Langat like Dusun Tua, Ulu Langat, Cheras, Kajang town, Sungai Chua, Jenderam, Dengkil, Sungai Manggis, Olak Lempit, Banting, Jenjarom, Teluk Datok, Teluk Panglima Garang and Bandar Baru Bangi. A total of 10 sampling stations have been identified from the upstream areas in the Pangson Hydroelectric power stations towards downriver in the Bangi area (Figure 1). Sungai Langat Dam or Pangson Dam is also a major source of water to seven water treatment plants in Selangor namely Sg Langat Water Treatment Plant, Bukit Tampoi Water Treatment Plant, Cheras Batu 11 Water Treatment Plant, Salak Tinggi Water Treatment Plant, Sg Pangsoon Water Treatment Plant, Sg Serai Water Treatment Plant and Sg Lolo Water Treatment Plant. In recent years, due to rapid modernization and development especially in Selangor, Sungai Langat was threatened by severe water pollution which caused the water crisis. The objective of this study among others was to monitor the changes in the water quality index in Sungai Langat from time to time to ensure the water quality is at its optimum level.

2.0 MATERIAL AND METHODS

The sampling was done twelve times, once every month in the morning. A total of ten sampling locations were selected with two replicate samples taken at each station. The position of each sampling station was determined by using the DXL Model Global Positioning System device from Germany. Before water samples were taken, the bottles were rinsed with the river water itself. The bottles were then submerged underneath to fill them with the river water sample [6]. Water samples for the BOD test were taken using dark glass bottles to prevent the sample from sunlight exposure. The bottles were capped while they were still submerged in the water to prevent oxygen in the atmosphere to dissolve in the samples. Water samples collected were stored in ice boxes with the temperature of 4°C to be preserved before laboratory analysis were done [6]. Water samples were then loaded into two separate BOD bottles. DO was determined using the YSI 5000 DO meter and the results were recorded as early DO readings. Samples were then incubated at 20° C in the dark for five days. Then the DO content was measured using the same meter and the findings are listed as the final DO readings. BOD can be determined from the difference between the initial and final DO content. Reactor digestion method was used to measure COD. COD reactor is heated up to 150°C and the vial cap containing reagents digestion COD was opened.7 2 ml of the sample was piped into a vial and sealed. The outer surface of COD vial was rinsed with water and dried. Vials were rotated several times slowly and placed in the COD reactor and heated for 2 hours. The reactor was shut down after 2 hours and left for 20 minutes. Again, each vial was rotated several times while they were still hot and placed in the test tube racks. When the vials have cooled to room temperature, the analysis was done by adjusting the HACH DR 2500 spectrophotometer to program 430 and 420 nm wavelengths. A blank solution (2 ml de-ionized water) is provided as a reference [7].

The Nessler method was used to measure the concentration of NH3-N. A total of 25 ml of water and 25 ml of de-ionized water sampling inserted into different cylinders. Three drops of mineral stabilizer were added into the cylinders and shaken to mix [7]. Then, 3 drops of poliovinil alcohol dispersing agent were added to the cylinders and shaken thoroughly to mix well [7].Then 1 ml of Nessler reagent is added into the cylinders and shut immediately. The contents were left to stand for 1 minute. The mixture was then inserted into the sample cell and analyzed by HACH DR 2500 spectrophotometer which was adjusted to program 380 and 425 nm wavelengths. De-ionized water was used as the standard [7]. Total suspended solids were measured using the gravimetric method. The GF / F type Whatman cellulose-nitrate filter paper with 0:45 pm thickness and diameter size of 47 mm was dried at 103°C in an oven for 2 days. It was then weighed using an electronic weighing scale after it was cooled in a drying jar to determine the dry weight of the filter paper. A total of 200 ml water samples filtered using filter paper and dried in a petri dish at a temperature of 103°C in an oven for 2 days. Then the filter paper was weighed again to obtain the total weight of suspended solids (TSS).

Parameters determined by in-situ or on site are the DO, pH and temperature. All these parameters have to be determined by in-situ because these parameters are easily changed. All these parameters are measured using a Hydrolab DataSonde®Surveyer® 4 and 4a. The sample measurement device was calibrated prior to sample measurement being performed.

3.0 RESULTS AND DISCUSSION

The average values of physical and chemical parameters of water are shown in Table 1. The mean values for the Langat River water quality parameters studied were; the °C, pH value, DO, TSS, BOD, COD and NH3-N. Temperature data obtained indicates that the maximum average for all sampling stations was listed at 28.86°C and the minimum average of 27.14°C (Figure 2). The temperature difference on the survey conducted were influenced also by the time of sampling, the position of the sampling stations where there were stations that were open and which were covered by the trees, and the weather of which the day of the sampling was done. Water temperature affects the rate of physiological processes of the organism, such as the respiration of microorganisms which depend on the cleanup in water bodies. High temperatures lead to a rapid growth rate and allow for certain "biota"s to reach a large population. Under natural conditions, the temperature of the water flow is between 0°C and 30°C and the temperature usually increases gradually from upstream to downstream. Cooling water activities into the river done by various parties like the power stations can cause the temperature to rise from normal. This temperature rise caused problems to sensitive organisms as there were increased oxygen demand which in turn lowered the oxygen saturation and increase the level of toxicity with hazardous materials and thus affected the aquatic life [8]. Pearson correlation analysis has shown that temperature has a negative correlation with the concentration of dissolved oxygen or DO value, i.e (r = - 0.409, P, 0.01).

pH value obtained over the sampling period recorded the minimum value of 27.14 and a maximum value 28.86 27.14 (Figure 2). pH test were conducted to determine whether the river is in acidic or alkaline conditions. PH value standards allowed in the current flow of the river is between pH 6.0 to 9.0 [5]. Note that station five recorded the maximum pH reading, the factors among which show that the cause of this condition is due to exposed sampling station and the waste factor from the drainage made from several homes around the area. However, this value is still classified as safe for wildlife in the area. There were no radical changes occurred in other sampling stations except at stations nine and ten which recorded an average pH values of less than 7.0. Generally geological soil can affect the pH value, and probably the pH reading in the area is naturally low. High pH values can occur when the rate of photosynthesis by aquatic plants is high which causes the reduction of carbon dioxide that leads to a reduction of carbonic acid in the water [9]. The process of decomposition of plants and animals need oxygen and this will also cause a decrease in the pH readings. Pearson correlation analysis was conducted to prove that the pH has a negative or inverse correlation with dissolved oxygen or DO, ie (r = - 0.021 p <0.01) (Table 2). Average minimum and maximum values for dissolved oxygen (DO) at all stations were 3:47 mg / L and 5.87mg / L respectively (Figure 2). Studies show that the average value obtained DO is at minimum level of between 3-5 mg / L under the class III category. This is important because the suitable DO for other freshwater life is at 5.0 mg / L and above [12]. This is because at 3 mg / l and below would create threats to the aquatic life, furthermore could kill many of the fish species if the reading drops to 2 mg / L [10]. The results obtained also showed that station five recorded the lowest average reading.

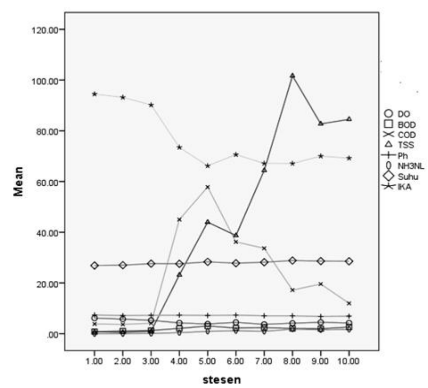

Figure 2 Ratio of DO, BOD, COD, TSS, pH, NH_3NL, Temperature and WQI

From observations made on site sampling, it was found that the station covered a fairly wide area with slower currents, without strong currents which would have caused a lot of rock surfaces to allow gas from the air to dissolve into the surface waters of the river, and will increase the DO (Yule & Yong 2004) [11]. Correlation analysis conducted proved that the DO value obtained had a negative correlation with temperature (r = - 0.409, P <0.01) and pH (r = - 0.021, P <0.01).

In reference to Figure 2, it was noted that the average total of suspended solids recorded the maximum value of 89.98 in station eight and the minimum value of 0.41 at station one. The average total of suspended solid readings recorded relatively high at 48.95 at station five. Among the factors identified as the cause of the increase in readings at this station was the turbid river conditions, ongoing industrial activities and housing projects are underway between stations four and five. The average values of BOD for all stations provide the readings with the minimum value of 0.82 mg / L and the maximum value of 2.98 mg / L (Figure 2). In view of the points of sampling stations, station five was found to read the highest number at 2.98 mg / L. From observations made at the sampling stations, it was found that there were drainage has been built by some houses near the sampling station. These factors can be classified as one of the organic contamination that could affect the BOD value at sampling stations. Pearson correlation analysis was conducted between the BOD and Ammonia Nitrogen (Table 2) and the result found that the BOD had a positive interaction with Ammonia Nitrogen namely ($r = 0.515$, $P < 0.01$), where the polluting agents Ammonia Nitrogen is often associated with pollution compounds of organic fertilizers and cleaning agents such as soap [12]. BOD value can also be associated with an increase in the value of the DO as BOD readings can cause the readings DO concentration decreased due to the biodegradation of organic matter in the water requiring oxygen gas in the decomposition process [13]. Pearson correlation analysis was carried out again to prove this explanation and found that there is a negative correlation ($r = -0794$, $P < 0.01$), namely, DO content is inversely proportional to the BOD.14

COD was also a key indicator parameter for the pollutant substances [5]. The average value of COD for ten sampling stations within the study found that the maximum value for the average COD reading is at 57.09 mg / l at station five and the minimum average value of 4.69 mg / l at station three (Figure 2). Previous studies have shown that low COD concentrations were detected in the unpolluted rivers, while the high COD concentration was detected in river environments that receive high effluent pollutant discharge [14]. According to the Department of Environment, COD is a parameter that is used as the main indicator to measure chemical pollution [5]. It is noted that there are some drainage waste is channeled from the residential area around the station five entered directly into the river. This is among the factors that cause an increase in the concentration of COD in the station. Apart from that, DO content is inversely proportional to the BOD [14]. This phenomenon showed that the river with low DO values and high BOD reading was categorized as polluted.14 Pearson correlation test was conducted to examine the relationship between COD and DO and proved that it has a negative correlation ($r = - 0.58$, p 0.01). While the average content of Ammonia Nitrogen recorded the maximum value of 1.76 mg / l at station ten and the minimum value of 0.00 mg / l at station one (Figure 2). High concentration of Ammonia Nitrogen will increase the pulse, respiration rate, aquatic life balance and affect their metabolic rates. Normally, natural water has low ammonia content of 0.1 mg / l. High content of ammonia nitrogen in the water usually indicates that the river is polluted by livestock and agricultural waste, or domestic sewage. Ammonia Nitrogen (AN) is a key indicator parameter for the pollution associated with waste disposal, rubber factories and agro-based industries [5].From the observations made, the content of ammonia nitrogen at station ten may be caused by the flow of livestock and agricultural waste, and domestic sewage that flows from the upstream river areas. Pearson correlation analysis was conducted and found that the Ammonia Nitrogen has a negative correlation with dissolved oxygen ($r = -0501$, $P < 0.01$).

The identification of the WQI values for 10 sampling stations in general noted decreased readings from the upstream to the downstream sampling sites (Figure 2). Specifically, the first three stations recorded an average WQI range between 91.5 to 93.55 which put these stations under class I to II based on the water quality index in Malaysia. The locations of these stations are in more upstream areas and lacked social activities, thus factors that contribute to the naturally good water quality index. The next station still did not show a drastic reduction of the water quality index. Station four recorded an average WQI value of 76.03 which placed it under class III. However it can be seen that the average WQI value for station five are on the lowest reading of 62.9 (Figure 2) under class III. The impact of outdoor activities had disrupted the ecosystem in this area, making it among the factors contributing to the decline in the WQI value at this station. Other factors on the other hand, such as high levels of suspended solids content or other parameters can affect the readings too. An overall observation of the average WQI values from stations six to ten note that the WQI reading ranges are between 68.49 to 71.16 in class III. Based on the positions of the sampling stations, stations six to ten are in the downstream sampling site areas. These are among the significant factors that contribute to the low WQI values compared to others stations..

Table 1 Ratio of physio-chemical parameters of Langat River

Parameters	Sn. 1	Sn. 2	Sn. 3	Sn. 4	Sn. 5	Sn. 6	Sn. 7	Sn. 8	Sn. 9	Sn. 10	Ratio
DO (mg/l)	5.87 ± 0.75	5.65 ± 0.67	5.47 ± 0.58	4.42 ± 0.51	3.47 ± 1.04	4.41 ± 0.55	3.87 ± 0.49	4.32 ± 0.79	4.50 ± 0.81	4.08 ± 0.91	4.61 ± 0.79
BOD (mg/l)	0.82 ± 0.34	0.96 ± 0.40	1.05 ± 0.48	2.05 ± 0.38	2.98 ± 0.35	2.10 ± 0.37	2.24 ± 0.52	2.07 ± 0.67	1.95 ± 0.51	2.38 ± 0.55	1.86 ± 0.69
COD (mg/l)	4.80 ± 2.34	5.38 ± 2.47	4.69 ± 0.97	41.5 ± 14.1	57.0 ± 15.2	37.8 ± 13.2	31.9 ± 11.7	18.4 ± 6.99	17.0 ± 10.9	13.14 ± 4.54	57.09 ± 4.69
TSS (mg/l)	0.41 ± 0.53	0.46 ± 0.52	0.77 ± 0.48	18.8 ± 7.18	48.9 ± 29.8	38.9 ± 13.9	71.7 ± 25.3	89.9 ± 22.0	79.9 ± 18.3	82.95 ± 19.76	89.98 ± 0.41
pH	7.22 ± 0.28	7.20 ± 0.24	7.27 ± 0.43	7.20 ± 0.27	7.49 ± 0.80	7.18 ± 0.55	7.08 ± 0.51	7.06 ± 0.50	6.80 ± 0.46	6.87 ± 0.42	7.49 ± 6.8
NH_3NL (mg/l)	0.00 ± 0.01	0.01 ± 0.04	0.05 ± 0.12	0.30 ± 0.29	1.22 ± 1.04	0.99 ± 0.69	0.69 ± 0.45	1.74 ± 0.55	1.50 ± 0.34	1.76 ± 0.63	1.76 ± 0.00333
Temperature (°C)	27.1 ± 0.50	27.1 ± 0.36	27.5 ± 0.29	27.7 ± 0.43	28.0 ± 0.48	28.0 ± 0.66	28.0 ± 0.57	28.6 ± 0.94	28.7 ± 0.68	28.86 ± 0.83	28.86 ± 27.14
WQI	93.5 ± 2.27	92.5 ± 2.54	91.5 ± 2.33	76.0 ± 4.72	62.9 ± 9.68	71.1 ± 3.70	68.9 ± 4.35	68.4 ± 4.09	70.7 ± 3.40	68.60 ± 4.51	76.46 ± 11.56

Table 2 Linear Coefficient between water quality parameters and water quality index

Parameter	pH	DO	BOD	COD	NH_3N	SUHU	TSS	WQI
pH	1	-0.021	-0.014	0.167	-0.039	-0.15	-0.17	-0.005
DO	-0.021	1	-.794	-.508	-.501	-.409	-.545	.370
BOD	-0.014	-.794	1	.567	.515	.450	.568	-.305
COD	0.167	-.508	.567	1	0.168	0.164	0.163	-.259
NH_3N	-0.039	-.501	.515	0.168	1	.586	.741	-.329
Temperature	-0.15	-.409	.450	0.164	.586	1	.602	-.373
TSS	-0.17	-.545	.568	0.163	.741	.602	1	-.380
WQI	-0.005	.370	-.305	-.259	-.329	-.373	-.380	1

4.0 CONCLUSION

The outcome of the studies conducted showed that the study areas considered to be slightly polluted. The WQI values that had dropped at the sampling stations downriver showed that the river ecosystem was not disturbed by nature. Instead, the main reasons for the trend in the water quality index were the economic activities in the agriculture, industrial and residential areas in the sampling stations' vicinity in the region. Constant monitoring is important to ensure water quality of Sungai Langat is at its optimum level.

Acknowledgement

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