SURFACE WATER QUALITY ASSESSMENT OF TUNGGAK RIVER GEBENG, PAHANG, MALAYSIA

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ABSTRACT

The objective of the study was to assess the water quality of Tunggak River and to find out the impact of industries on it. Water quality parameters were analyzed collecting samples from 8 stations during February-July 2012 across the river basin to fulfill the objective. Temperature, pH, DO, turbidity, TDS, EC and salinity data were collected using YSI during sampling. The physico-chemical parameters were analyzed using APHA & HACH standard methods. Heavy metals were determined using ICP-MS spectrometry. SPSS 16.0 statistical software was used for data analysis. The result showed that, average temperature and DO concentration was recorded 31.30^0C and 2.24mg/L respectively; while the pH was found acidic at upper stream and alkaline at mid-stream region. The ranges of turbidity and TDS was observed 4.55 to 28.75 NTU and 19.6 to 49400mg/L respectively. NH4-N was recorded higher with a mean value of 1.96 mg/L. Average concentration of SO4 and PO43- was observed 193.26 and 1.71 mg/L respectively. Concentration of BOD and COD were found higher at all parts of the river with an average value of 22.04 and 51.16 mg/L respectively. Regarding heavy metals, Pb, Hg, and Co was recorded in toxic level in the surface water of the river.

Keywords: *Water Quality Index (WQI), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen*

1. INTRODUCTION

Surface water is the main source of available water which is polluting all over the world in many ways. Anthropogenic activities are the main causes of that pollution. Ever-increasing industries and their effluents are the major threats to the surface water; as the end destination of industrial effluents is the river (Moorthy and Jeyabalan, 2012). The increasing trend of economy and industry in Malaysia led to environmental degradation including river water pollution (Tan and Yap, 2006; Al-Shami et al. 2011). At the same time, the rivers are contributing significantly for the industrial development in Malaysia (Moorthy and Jeyabalan, 2012) and about 98% of the country's water requirements are fulfilled from river water (Azhar, 2000). So, the river water pollution can cause serious health risk as well as environmental threats in the country. The major sources of industrial pollution in Malaysia are food & beverage, chemical & petrochemical, palm oil, textile, paper and rubber processing industries (Iyagba et al.,2008; Usa, 2007). Speedy growth in industrial sector generates more wastes which could damage to the environment without having proper treatment plant. Industrialization with an increasing demand for heavy metals results in a high emission of these pollutants into the biosphere. Water bodies with heavy metal pollution are a serious threat to the aquatic ecosystem, human health as well as environment (Hossain and Sujaul, 2012).

Tunggak is a strategic river in Pahang state, where the largest industrial park of Pahang Gebeng industrial Estate is situated. Including petrochemical, multifarious industries have been established in this area since 1970. It is the main river that carrying wastes of the industrial estate, as it is adjacent to this area. Rapid developments including the petrochemical industries in the estate generating effluents; which contain a considerable amount of conventional and non-conventional pollutants that deteriorating the water quality of the river. Therefore, the study was conducted to assess the surface water quality based on selected physico-chemical parameters.

2. METHODOLOGY

Study area and selection of monitoring stations

The river Tunggak is situated in between $3^0 56'06''$ to $3^0 59'44''$ N and $103^0 22'42''$ to $103^0 24'47''$ E adjacent to the Gebeng industrial town which is located at 3° 55' 39" N to 4° 00' 10" N and 103° 22' 42" E to 103° 26' 30" E (Fig. 1). The area is near the Kuantan Port. The selection of monitoring stations were done based on location, land use pattern and site elevation. The Global Positioning System (GPS) was used to determine the actual coordinate of monitoring stations and it was reconfirm during the subsequent sampling periods. A total of 8 monitoring stations were selected across the river basin for sampling.

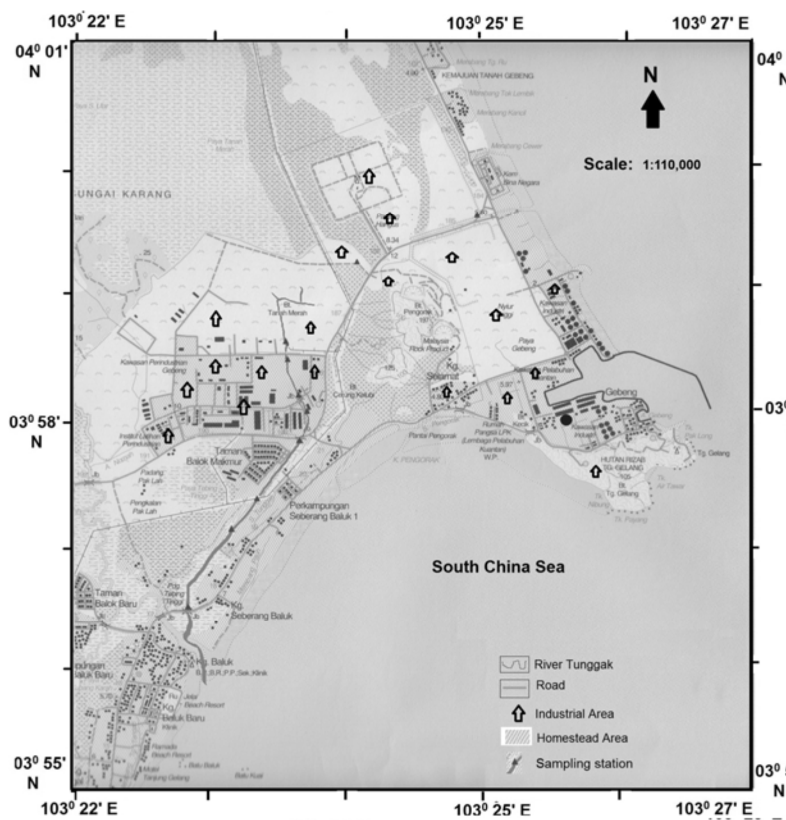

Figure 1: Location of the study area

Sampling, sample analysis and data collection

Water samples were collected monthly from February- July 2012. Water from about 10 cm below the water surface was collected using 1000ml HDPE bottles. For BOD samples the dark BOD bottles (300 ml) were used. In-situ parameters such as temperature, pH, dissolved oxygen (DO), turbidity, electrical conductivity (EC), and total dissolved solids (TDS) were measured during sampling. Collected samples were preserved and transported to the laboratory for analysis following standard procedure (APHA, 2005; HACH, 2003). The samples were analyzed in laboratory for measuring selected ex-situ parameters in accordance with APHA and HACH standard methods (APHA, 2005; HACH, 2003). The selected heavy metals were determined using ICP-MS (Inductively Coupled Plasma Mass Spectrometry). For water quality classification the DOE-WQI index was used to classify stretches of the studied water bodies into classes, according to the system adopted by the DOE (DOE, 2008).

Statistical Analysis

Statistical software (SPSS 16.0) was used for statistical analysis. The mean, standard deviation and analysis of variance (ANOVA) was done to determine the significant differences of the factors of the study area.

3. RESULTS AND DISCUSSION

In-situ Parameters

Temperature of the surface water ranged from 26.16ºC to 35.24ºC among the monitoring stations; where the mean temperature recorded was 28.78 ±1.07ºC. Except at station 6 to 8 the water temperature was within the normal limit of Malaysia (DOE, 2008) in the most of the stations (Table 1). The mean pH recorded at the study area was 6.23±0.52, and it ranged from 4.16 to 9.12. The highest pH value (9.12) was recorded in station 6 followed by station 5 and station 7. It is seen that the highest pH was observed at the middle-stream region where the density of industries was also higher. So it might be the due to the presence of industrial estate effluence consist of polymer, chemical, metal, gas and power industries. On the contrary, the lowest value (4.16) was recorded at station 8; these values were below the standard level. Perhaps the industrial effluents at the area of station 8 contained acidic substances Table 1). However, the average pH values at the most stations were found to be within the standard level of Malaysia (DOE, 2008).

Regarding conductivity, the values were found to be above the normal limit at the stations 1, 2 and 3; but at all other stations it was recorded within the normal limit (Table 2). It was probably due to the entering of saline water in those 3 stations during tide from the South China Sea (Haris, and Maznah, 2008). The concentration of DO; which is the most important parameters for water quality was recorded very low at all the stations ranged from 1.10 mg/L at station 2 to 4.40 mg/L at station 1. Based on DO concentration, all the stations were categorized as class III and IV according to INWQS threshold level for Malaysia surface water. The TDS concentration was recorded higher in the lower stations compare to the uppermost stations. Perhaps due to the tidal disturbance (Haris, and Maznah, 2008) higher amount of TDS was recorded at station 1. The TDS concentration was also higher at station 2 because of some agricultural activities adjacent to the station 2. However, the level of TDS at stations 7 to 8 were in permissible limits 500 mg/L (DOE, 2008). The values of turbidity in the study area varied from 4.83 NTU at station 8 to 34.50 NTU at station 5 (Table 1). Overall, all stations of the river contained higher value of turbidity according to the INWQS threshold level for Malaysian surface water (DOE, 2008).

Table 1: The range, SD and mean value of in-situ parameters at different monitoring stations

Station No.		Temperature (^{o}C)	pH	Conductivity (μS/cm)	DO (mg/L)	TDS (mg/L)	Turbidity (NTU)
1	Range	27.05-30.17	5.66-7.02	14200-27080	2.62-4.40	9040-24300	7.69-22.50
	Mean	28.78±1.07	6.23±0.52	18013±4946	3.30±0.61	16137±769	16.66±6.41
2	Range	28.04-29.2	6.97-7.71	7700-13660	1.10-2.17	5160-7270	10.05-24.70
	Mean	28.55±0.59	7.28±0.34	10880±2836	1.58±0.41	6250±1088	17.72±5.81
3	Range	29.01-29.81	7.32-8.40	1244-1800	1.33-1.80	650-869	9.78-20.70
	Mean	29.34±0.38	7.69±0.38	1395±207	1.69±0.36	767±112	13.70±3.90
4	Range	30.92-32.57	7.51-8.51	1119-1320	1.62-4.12	527-821	10.05-17.27
	Mean	31.74±0.75	7.95±0.35	1212±95	2.71±0.96	613±108	14.14±3.42
5	Range	30.92-33.1	6.96-8.95	1380-1630	1.93-3.91	642-748	11.26-34.50
	Mean	31.98±1.07	7.96±0.99	1505±107	3.12±0.91	700±50	23.44±12.03
6	Range	31.63-34.14	7.25-9.12	1423-1740	1.56-3.16	649-778	11.73-28.80
	Mean	32.88±1.35	8.01±0.76	1585±164	2.32±0.79	715±68	20.98±8.01
7	Range	33.2-35.24	6.77-8.60	923-1210	2.85-3.93	203-529	6.69-12.35
	Mean	33.78±0.88	7.65±0.62	1068±149	3.28±0.51	365±171	9.82±2.30
8	Range	32.5-34.1	4.66-5.42	51-58	2.78-4.25	19.6-24.8	4.83-10.06
	Mean	33.27±0.56	4.96±0.29	55±3.31	3.38±0.59	21.78±2.25	6.59±1.81

Ex-situ parameters

Collected Surface water samples from all monitoring stations were analyzed in laboratory to determine the concentration of NH3-N, nitrate-nitrogen (NO3-N), phosphate (PO43-), sulphate (SO42-), BOD, COD and TSS.

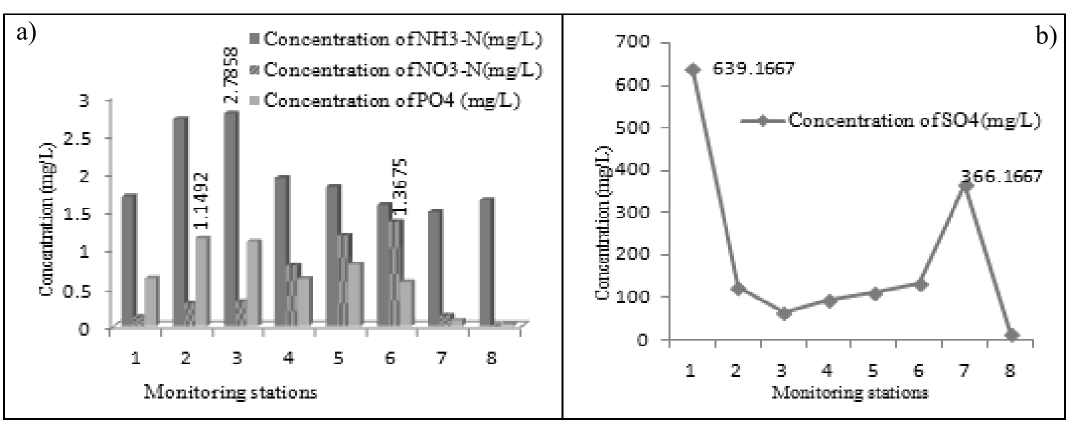

Figure 2: Concentration of a) ammoniacal nitrogen, nitrate nitrogen & phosphate and b) sulphate in the study area

Results showed that, the concentration of NH3-N varied from 0.31 mg/L at station 6 to 3.47 mg/L at 3. The maximum average value was at station 3 (Figure 2). All values exceeded the INWQS threshold level; and the water of mid-stations was classified as class V (Saad et al. 2008). The value of NO3-N content was within the safe level (<0.4) (DOE, 2008) except station 4, 5 and 6; those stations were in the vicinity of industries including polymer, chemical, metal, gas and power, and wooden industries and received most of the effluents. From the study, the highest value of PO43- (2.07 mg/L) was recorded at station 2 followed by station 3; while the other stations contained relatively lower value of PO43- (Fig .2). The highest sulphate value was recorded at station 1, 7, 2 and 6 (Fig. 2). It was due to the location of stations 1 and 2 are near the sea (Haris, and Maznah, 2008) and some chemical industries are adjacent to station 6 & 7 which produced detergent and discharged sulfur reach effluents into the river flow.

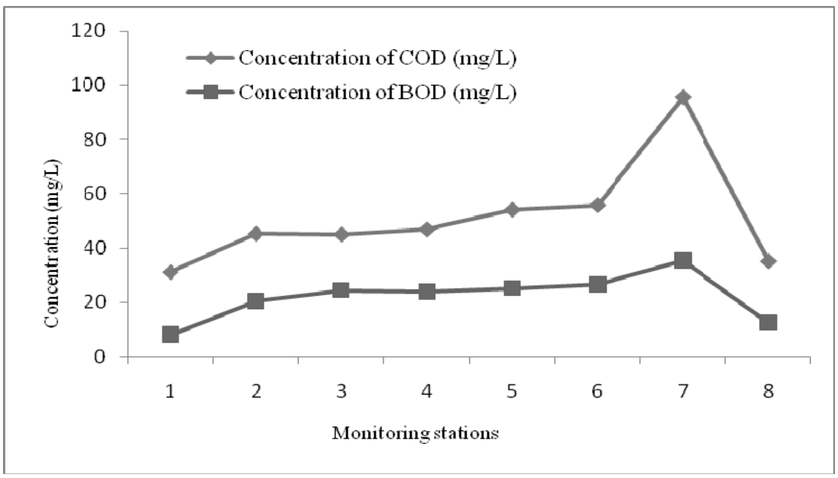

Figure 3: Concentration of BOD and COD in the study area

The study showed that, the highest BOD (32.88 mg/L) was recorded at station 7 and the lowest (2.9 mg/L) at station 1. The values of BOD at all stations were higher compare to the threshold level of Malaysia (DOE, 2008), and it might be due to the discharge of industrial effluents to the river flows. Similarly, the highest COD value was also recorded at station 7 and the lowest at station 1(Fig 3). Based on the concentration of COD and BOD the river water was categorized as class IV (DOE, 2008).

Selected heavy metal of the study area was determined and the results have been shown in Table 2. The results revealed that water in the study area was bearing chromium (Cr), cobalt (Co), copper (Cu), zinc (Zn), barium (Ba), lead (Pb) and mercury (Hg); but, Pb, Co and Hg was found to be toxic at maximum part of the river. The concentration of Pd was found to be toxic at all stations compared to the threshold level (DOE, 2008). The highest concentration of Pb was recorded at station 1 followed by 2, 5 and 3 (Table 2). The Cu concentration was beyond the threshold limit at station 1 and 7 (Table 2). The study also showed that, Co content was recorded higher at all stations except at station 7- to 8 and the Cr concentration were higher at station 8. Regarding Hg it was observed higher in all stations with a mean value 0.0903. The highest concentration of Hg was observed at station 5; while the lowest was recorded at station 4 (Table 2). In most of the cases the heavy metal concentration was found to be higher at the mid- upper stream stations where the density of industries was higher.

Table 2: Concentration of heavy metals (ppm) in the studied water samples

Stations	Cr	Co	Cu	Zn	Ba	Pb	Hg
1	0.0082	0.0926	0.4496	1.0717	0.0303	0.5415	0.0974
2	0.0010	0.2243	0.0033	0.9441	0.0291	0.4956	0.0911
3	0.0015	0.1740	0.0032	0.3431	0.0282	0.4827	0.0923
4	0.0013	0.2502	0.0023	0.4778	0.0236	0.4801	0.0490
5	0.0134	0.6191	0.0154	1.9435	0.0503	0.4937	0.2104
6	0.0135	0.6716	0.2357	0.8405	0.0256	0.2323	0.0661
7	0.0395	0.0000	0.4496	1.0003	0.0196	0.2349	0.0601
8	0.0575	0.0003	0.0033	0.8810	0.0072	0.2305	0.0561

The main sources of toxic heavy metals were possible wastewater and effluents from major industries, especially the chemical, polymer, metal, petrochemical gas and energy, and wooden industries that generated the organic and inorganic pollutants which ultimately contaminated the river water. However, the value of Zn and Ba content were observed below the permissible limit (DOE, 2008).

4. CONCLUSION

The physico-chemical study of the water quality reveled that the most of the water quality parameters were higher in the Tuggak River. From assessment results it is clear that, station 3, 4, 5, 6, 7 and 8 (middle and upper station) were more polluted compared to the lower monitoring stations. These stations were polluted by the industrial activities. On the other hand, due to tidal interference at station 1 and 2; which washed out the wastes everyday two times was the cause of the less pollution in lower stations. This study also showed that the major sources of pollutant were possibly the presence of different types of industries and their activities. Furthermore, the water quality status was affected by the land use pattern of its catchment area. It is therefore recommended that all the industries that generate effluent and exceed the nation and international standards should treat it before discharging into the river stream. We also suggest that close monitoring of industrial activities should be ensure and emphasis also given on recycling of industrial waste to reduce the pollution level and their possible effects on the level of heavy metals pollutions.

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