Water quality status of Sungai Petani River, Kedah, Malaysia

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Abstract. Water is one of crucial natural sources for all livings. However, as the burgeoning population growth and excessive development, the quality of water is deteriorated. Hence, assessing the quality of river water is pivotal not only for determining water quality condition but also identifying polluted areas. This study was conducted to determine water quality status of Sungai Petani River located in Kedah, Malaysia involving three sampling stations (S1, S2 and S3). Six water quality parameters were determined following APHA standard method. The results then assessed following Water Quality Index (WQI) assessment and evaluated based on National Water Quality Standards (NWQS) for Malaysia. Both dry and wet seasons shows increasing index value. In wet season the results were 51.33, 73.06 and 74.76 for S1, S2 and S3 respectively while for dry season index value of 47.97, 58.04 and 69.60 for S1, S2 and S3. Increasing index value from upstream to downstream (S1 to S3) indicates the water quality status was from polluted to slightly polluted (S1 to S3) due to pollutant load from nearby activities. The overall classification for the river water was in class III, the uses for this classification water are water supply with the need for an extensive water treatment and fishery and livestock drinking.

1. Introduction

Over the years, the quality and quantity of water has slowly deteriorated. Water scarcity issue is one of the crucial environmental issues that need to be mitigated. The information on river water quality based on detailed water quality monitoring, understanding water quality condition, and identifying polluted areas are vital to secure water resources [1, 2].

Pollution is one of the biggest threats to our rivers and cost for treating contaminated water is high, hence monitoring the quality of water is necessary as to prevent serious water quality issue. The low water quality of the river is a clear indication of the deterioration of the environmental health of the river basin. In 2014 and 2013, 473 rivers were monitored. Number of clean rivers slightly decreased (6.6 %) from 2013 (275 rivers) to 2014 (244 rivers). While for slightly polluted and polluted rivers were increased 2.7 % and 3.8 % respectively [3]. Sources of pollution come from domestic and industrial sewage, effluent from livestock farms, manufacturing and agro-based industries, suspended solids from mining, construction of houses and roads, logging and refining of forests and heavy metals from factories [4]. Apart from that, there is a significant increase in the Individual pollution sources such as food services, rubber mill, public and private wastewater treatment plants and wet market [5].
The levels of river pollution can be determined by studying the Water Quality Index (WQI) of the river. This study focuses on assessing WQI of Sungai Petani River, main river that flows through downtown of Sungai Petani. The commercial center of the city is located on both sides of the river between 4500 to 6000 m confluence. The total length of the Sungai Petani River is 12.5 km and the catchment area is 3,500 hectares [6]. Based on Malaysian WQI, there are six parameters involved, which are biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), pH, total suspended solids (TSS) and ammonia nitrogen (NH3-N). Classification of pollution level by each water quality index parameters follows the standard set by Department of Environment (DOE), shown in table 1. In terms of index classification, value 0-59 is classified as polluted, 60-80 as slightly polluted and 81-100 classified as a clean river (table 2). Land use activities such as agricultural, industrial, commercial and residential and the others in the area near the river should also be known [7].

Table 1. DOE Water Quality Index Classification [7].

| PARAMETER                      | UNIT | CLASS   |
|--------------------------------|------|---------|
|                                |      | I       | II     | III    | IV     | V       |
| Ammoniacal Nitrogen            | mg/l | < 0.1   | 0.1 - 0.3 | 0.3 - 0.9 | 0.9 - 2.7 | > 2.7   |
| Biochemical Oxygen Demand      | mg/l | < 1     | 1 - 3   | 3 - 6   | 6 - 12  | > 12    |
| Chemical Oxygen Demand         | mg/l | < 10    | 10 - 25 | 25 - 50 | 50 - 100 | > 100   |
| Dissolved Oxygen               | mg/l | > 7     | 5 - 7   | 3 - 5   | 1 - 3   | < 1     |
| pH                             | -    | > 7     | 6 - 7   | 5 - 6   | < 5     | > 5     |
| Total Suspended Solid          | mg/l | < 25    | 25 - 50 | 50 - 150 | 150 - 300 | > 300  |
| Water Quality Index (WQI)      | -    | < 92.7  | 76.5 - 92.7 | 51.9 - 76.5 | 31.0 - 51.9 | > 31.0 |

Table 2. DOE Water Quality Classification based on Water Quality Index [7].

| WATER QUALITY INDEX             | INDEX RANGE                |
|---------------------------------|----------------------------|
|                                 | CLEAN | SLIGHTLY POLLUTED | POLLUTED |
| Water Quality Index (WQI)       | 81 – 100 | 60 - 80         | 0 - 59   |

2. Material and method

2.1. Sampling

Three sampling stations were selected as shown in figure 1. Station 1 (S1) located at Kampung Sungai Pasir Kechil (upstream), which is surrounded by factories, domestic and farms. Station 2 (S2) at Taman Kampung Raja (midstream), which is surrounded by wood factories and restaurants, while Station 3 (S3) at Taman Pekan Baru (downstream), which is surrounded by huge farms. The collection of the samples was done twice every season for two seasons, wet season and dry season. The collection process...
is done once for every month starting October 2019 and until January 2020. The water sample was collected approximately 10-30 cm below the water surface. The sample was ensured that there were no bubbles trapped in the container to prevent laboratory analysis errors. The water samples were stored in polyethylene bottles, which were later preserved in an ice box before the laboratory test was conducted to stop any organism reaction in the water and to obtain the exact data during the analysis [8].

![Sampling stations for Sungai Petani river.](image)

2.2. Procedure
All six water quality parameters were determined following APHA standard method. The dissolved oxygen (DO) concentrations were measured using YSI 556 multi parameter, chemical oxygen demand (COD) concentrations using DR 2800 spectrophotometer (APHA 5220 D), whereas biochemical oxygen demand (BOD) in which river water samples were incubated at 20 °C in the incubator for 5 days following APHA 5210 B standard method, total suspended solids (TSS) following APHA 2540 D standard method and pH value were obtained using YSI 556 Multi Parameter. The result for all six water parameters obtained from the laboratory were compared with the INWQS for Malaysia (table 1) and DOE-WQI (table 2) as to identify the pollution level of all the sampling stations. Each point was calculated using the following WQI equation (1) [7].

\[
WQI = 0.22S_{IDO} + 0.19S_{IBOD} + 0.16S_{ICOD} + 0.15S_{IAN} + 0.16S_{ISS} + 0.12S_{IpH} \tag{1.0}
\]

3. Result and discussion
Six parameters were defined as the principal component to evaluate the water quality of the Sungai Petani River. Parameters used to assess the Water Quality Index (WQI) were biological oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD), total suspended solid (TSS), ammoniacal nitrogen (NH₃-N) and pH. The range of average pH for wet season and dry season is from pH 6.6365 to 7.615 as shown in figure 2. The highest value was recorded at S1 (pH 7.615) during dry season while the lowest value is pH 6.365 at S3 during wet season. During wet season, pH value was recorded as 6.7115, 7.118 and 6.6365 for S1, S2 and S3 respectively which categorized as class II (S1 and S3) and class 1 (S2). While for dry season, all sampling points were categorized under class 1 with the pH value of 7.615, 7.120 and 7.375 for S1, S2 and S3. Overall, the pH ranges from 6.5 to 8 is generally appropriate for aquatic life. It is therefore very necessary to maintain the aquatic environment within this range, since high and low pH in nature can be destructive [9].
Figure 3 shows TSS ranges from 20 to 258 mg/L. The highest and lowest reading was recorded at S2 with the value of 258 mg/L (dry season), while the lowest reading (20 mg/L) during wet season. The average of TSS for wet season at S1 is 110 mg/L (class III), at S2 is 20 mg/L (class I) and at S3 is 35 mg/L (class II). The average TSS for dry season for all stations was under class IV with the value of 174, 258 and 230 mg/L for S1, S2 and S3 respectively. The increment of the concentration in S2 was due to the lack of rain during dry season. In addition, the activities nearby the location were industrial institutions and factories including cement factories that will discharge out their solid wastes into the river, causing the increment of the concentration.

Figure 3. Concentration of total suspended solids.

The range of average BOD for wet season and dry season is from 5 to 26.77 mg/L (figure 4). Based on the findings, lowest value for BOD was 5 mg/L at S3 during dry season. While the highest value for BOD was 26.77 mg/L at S1 during wet season. During wet season, BOD value for S1 is 26.77 mg/L indicated as class V while for S2 and S3 categorized as class IV with the concentration of 9.17 and 10 mg/L. BOD concentration during dry season were recorded as 24.45 (class V), 9.85 (class IV) and 5 (class III) mg/L for S1, S2 and S3. During the wet season the BOD value was higher in S1 due to higher organic material concentrations. As for the dry season, the BOD value is slightly lower than the wet season value for S1 and S3. During the wet season, the BOD concentration for S2 had decreased and increased at S3. Similar study done by [10], reported that the reason for this differentiation between the ratios is due to the sudden input of organic waste from certain industries and municipal household waste. During this time, the flow of the river remained very low and even a small amount of waste can radically increase its value [11].
Figure 4. Concentration of biochemical oxygen demand.

Figure 5 shows the range of average ammoniacal nitrogen (NH$_3$-N) for wet and dry season, ranging from 1.04 to 3.58 mg/L. The lowest value for ammoniacal nitrogen was 1.04 mg/L at S3 during wet season, while the highest value for ammoniacal nitrogen was 3.58 mg/L at S1 during dry season. The average of NH$_3$-N value for wet season at S1 is 2.71 mg/L which is in class V, at S2 is 2.5 mg/L which is in class IV, at S3 is 1.04 mg/L which is in class IV, and the average of NH$_3$-N value for dry season at S1 is 3.58 mg/L which is in class V, at S2 is 3.205 mg/L which is in class V, at S3 is 1.295 mg/L which is in class IV.

Figure 5. Concentration of ammoniacal nitrogen.

COD value for wet season and dry season is from 26 mg/L to 74.5 mg/L (figure 6). For both seasons, S1 was classed as class IV with the concentration value of 72.75 and 74.5 mg/L for wet and dry season. While S2 and S3 were categorized as class II with concentration ranges from 29.5 to 29.25 mg/L for S2 and 33 to 26 mg/L for S3. The high pollutant loading from tributaries, especially organic matter, and increased growth of bacteria, thereby increases S1 COD concentration. Typical sources of excess nutrients in surface waters are fertilizers, ineffective septic systems, wastewater treatment plant discharges, and waste from pets and farm animals. Meanwhile, for S2 and S3, the lowest concentration reported since rapid flow regenerates during low tide, atmospheric mixing due to good photosynthesis of wind and algae increases oxygen to the water [12].
The range of average DO concentration as shown in figure 7 obtained for wet season and dry season is from 7.228 to 10.095 mg/L. S3 recorded lowest (7.228 mg/L during dry season) and highest (10.095 mg/L during wet season) DO concentration. The average of DO concentration during wet season were classed as class I for all sampling stations with the value of 9.140, 8.995, 10.095 mg/L for S1, S2 and S3. Like wet season, all sampling stations also categorized as class I during dry season. The average of dissolved oxygen concentration for S1, S2 and S3 were 9.328, 8.998 and 7.228 mg/L. During the dry season, the lowest concentration recorded was as S3 (7.228 mg/L). The factor causing low DO is decomposed by bacteria from organic material which uses oxygen to degrade to more material. Chemical waste, sewage treatment plant, and run-off farming cause high organic matter in water. After an analysis, DO rates revealed that DO values within the WQI range were used to promote aquatic life. This argument, based on DOE WQI, indicates that the concentration of DO is within the importance of class I, and that a substantial consistency is seen to be preserved in Sungai Petani River.

River classification is achieved to evaluate the level of pollution in Sungai Petani River, therefore allowing the objective of the studies to be achieved. By applying the formula of WQI, the status of river water quality based on DOE – WQI in wet and dry season is class III in the most stations. S1 classified as polluted, S2 and S3 classified as slightly polluted. The overall classification for the river water was in class III. The uses for this classification water are water supply with the need for an extensive water treatment and fishery and livestock drinking. A water quality assessment research specifically indicates that the state of the water body is eutrophic and unfit for human usage. It is also observed that the pollution load during the dry season is comparatively high compared to the wet season as shown in
Figure 8. Classification of river water on wet and dry seasons.

4. Conclusion

The water parameters (DO, COD, BOD, NH$_3$-N, TSS, pH) for Sungai Petani River were investigated. It is important to understand the relationship between water quality and quantity and their effect. Monitoring water quality is important as such activities are detrimental to aquatic organisms and public health. From the result determination, the target determination for the WQI parameter value for Sungai Petani River was achieved. It was found that in the dry season, the S1 to S3 (upstream to downstream) of the WQI was 47.97, 58.04 and 69.60, respectively. In the wet season, the S1 to S3 (upstream to downstream) of the WQI was 51.33, 73.06 and 74.76, respectively and the water quality was classified as class III. The uses for this classification water are water supply with the need for an extensive water treatment and fishery and livestock drinking.

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