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Development of Water Quality Model for Sungai Tebrau using QUAL2K

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Abstract: Tebrau River starts in Senai and ends in the Straits of Johor and has been categorized as most polluted river in Malaysia. It has been classified as class III river water quality based on the Interim National Water Quality Standard (INWQS) with the average value of Water Quality Index (WQI) of 59. This study was focussed on simulating the effect of the pollution from industrial area to Tebrau River Basin by using QUAL2K which is the modenization version of QUAL2E. This water quality model involved in simulates two primary parameters which are Biochemical Oxygen Demand (BOD) and Ammoniacal Nitrogen (AN). It has been found out that QUAL2K model can be used as an outstanding tool in managing the river basin.

Key words: Tebrau, QUAL2K, water quality

INTRODUCTION

Water quality modelling are widely used in determining the behaviour and characterization of water body (Chapra, 1997) and become one of the crucial aspects in managing the Malaysia river basin. In this study, QUAL2K has been chosen to model the quality of Tebrau River Basin. It is the water quality models that developed by United State Environment Protection Agency (US EPA) with capability to simulate various water quality parameter in branching streams that are well mixed laterally and vertically. This model is the modenization version of QUAL2E with several modifications was made in the computer code to overcome its limitations. It has an advantage to implement with current Microsoft Windows Environment such as Microsoft Windows XP of Vista operating system. QUAL2K is typically used to assess the environmental impact of multiple pollution discharges along rivers (Chapra and Pelletter, 2003).

Tebrau River Basin is approximately 35 km long which located at the south of Johor and flow from Senai Industrial Area and drains into the Straits of Johor (Selat Tebrau). It stretches over 35 km and covers 225 km^2 of the catchment area. Based on the Water Quality Index (WQI), Tebrau River Basin are classified as polluted with an average value of 59, which falls into class III of Interim National Water Quality Standard (INWQS). Tebrau industrial zone, Kampung Kangkar Tebrau, Kampung Paya Kenangan, Kempas and Plentong town are the mostly effected region with the flooding problem due to low capacity of the river to accommodate the increasing volume of water, rubbish, tide and sediments of Tebrau River. Tebrau River Basin consists of five major tributaries included the Sg. Bala (6 km), Sg. Pandan (6 km), Sg. Sembulung (5.5 km), Sg. Tampoi (5 km) and Sg. Plentong (13 km).

In this study, the QUAL2K water quality model was employed to simulate and verify the characterization of the watershed quality. Two primary constituent which are under scrutiny are Biochemical Oxygen demand (BOD) and Ammoniacal Nitrogen (AN). Pollutants can come from point sources such as industrial and domestic wastewater treatment plant and from non-point sources such as agriculture, housing and commercial areas. As a result of this study, it has been found that QUAL2K model can be used as an outstanding tool in managing the river basin. Based on the simulation result for both constituents (BOD and AN), it is proved that the Tebrau River Basin was categorised as polluted with major contributor of the pollutions. Sources of pollution are from agriculture and effluent from the industrial area that located within the river basin catchment area.

MATERIALS AND METHODS

Sampling and analysis: Low flow analysis were used for creating the worst condition scenarios where the minimal dilution was occur. Commonly, the 7Q10 procedure which defines as the minimum 7 day flow that would be expected to occur every 10 years was used. However, due to the limited data that was available, the low flow was determined based on the Hydrological Procedure (HP) No. 12. It was historical recorded of the stream flow data. Month of February, June and September have been classified as the mean lowest flow for Tebrau River. Sampling and analysis of the river water was done in February 2009. Water samples were collected in 17 locations along the mainstream of Tebrau River and tributaries. Figure 1 shows the sampling location along

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Table 1: QUAL2K reach representation

Reach label	Reach No.	Headwater reach	Reach length (km)	Location (km) Upstream	Location (km) Downstream	Element No. ≤1
Senai industrial area	1	Yes	27.50	34.500	7.000	10
Sungai Bala	2	Yes	6.00	6.000	0.000	10
Pandan City	3		1.00	7.000	6.000	10
Sungai Pandan	4	Yes	6.00	6.000	0.000	10
Pandan-Sembulung	5		1.00	6.000	5.000	10
Sungai Sembulung	6	Yes	5.50	5.500	0.000	10
Sembulung-Tampoi	7		1.00	5.000	4.000	10
Sungai Tampoi	8	Yes	5.00	5.000	0.000	10
Tampoi-Plentong	9		3.00	4.000	1.000	10
Sungai Plentong	10	Yes	15.00	15.000	0.000	10
Muara	11		1.00	1.000	0.000	10

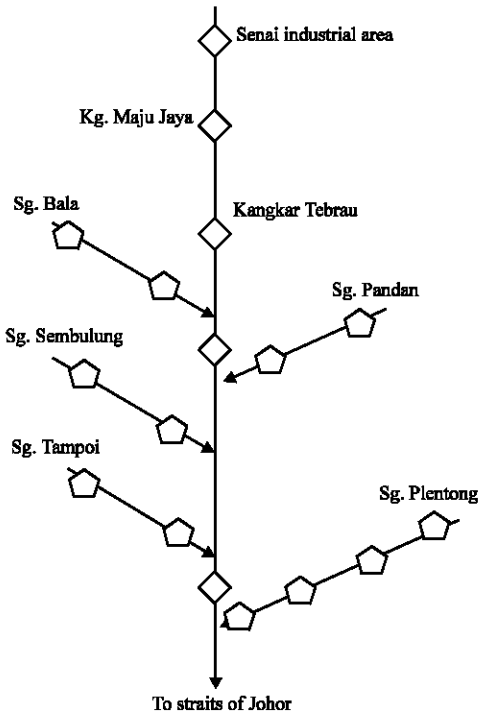

Fig. 1: Sampling location along the Tebrau River Basin

the river basin and this location was selected based on the modelling requirement where the water quality for the headwater for each river was an important input data. Additional on that, other locations were selected because of the purpose of calibration and validation of the model.

The *in situ* measurement was carried out for dissolve oxygen, temperature, salinity, conductivity and pH using the YSI 85. Hydraulics data such as depth and width was also recorded. Grab sampling for laboratory analysis was conducted for each location. The identification of pollution sources along the river basin needs to be considered. Sample was preserve in cooler box before being transfer to laboratory for analysis. Finally, the analysis of the sample was carried out in laboratory for the AN and BOD_5 using the standard methods for the examination of water and wastewater methods as soon as possible within the recommended holding time.

Reach representation: The QUAL2K reach representations are show in Table 1 where Reach 1 shows the headwater (initial) of the Tebrau main stream. Reach 2, 4, 6, 8 and 10 represent the headwater for the main tributaries along the Tebrau River consists of Bala, Pandan, Sembulung, Tampoi and Plentong River. Senai Industrial area, Kawasan Tebrau industrial area I and IV, Desa Plentong industrial area and Tampoi Jaya industrial area were identified as a main contributor for the pollution along the Tebrau River.

RESULTS AND DISCUSSION

Figure 2 shows the result of *in situ* and laboratory analysis where the concentration versus the distance for the main stream of river basin was plotted. From the Fig. 2, Kangkar Tebrau which located at approximate 8 km from the sea was affected by the tidal where the BOD concentration decreased. However, some increment in value of BOD was observed after the Pandan City. This may due to collecting and sampling time during the low tidal.

Figure 3 shows the BOD_5 QUAL2K simulation result. Its shows that the BOD_5 concentration falls into class III of Interim Nasional Water Quality Standard (INWQS) at the upstream of the river basin where Senai Industrial area effluent was identified as the major contributor of the pollutant. However, at the 25th km from the upstream, the increment of BOD_5 was observed up to 60 mg L^{-1} that falls in class V INWQS. This illustrate that the significant effluent contributor was from the Tebrau industrial area that located nearby. On the other hand, others pattern was observe where the BOD_5 concentration was decrease at the downstream of Bala River. This area was identified as the tidal effected region, where the dilution of the river water was high.

Figure 4 shows the BOD_5 loading profile. The graph shows two line that represent the real condition of the

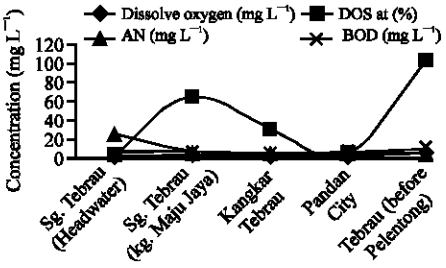

Fig. 2: Tebrau constituent profile along River

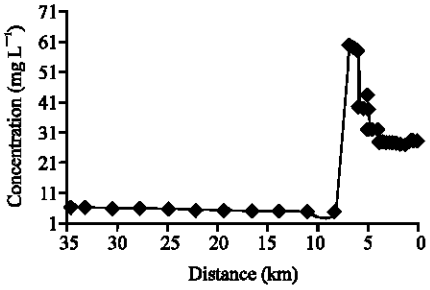

Fig. 3: BOD_5 concentration profile

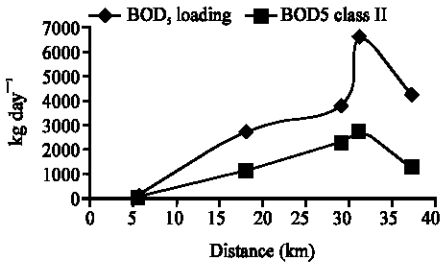

Fig. 4: BOD_5 loading profile

river basin and the class II loading that must be achieve in order to improve the water quality and suitable for daily used. From that graph, it can calculate that, approximate of 2000 to 3000 kg day^{-1} of BOD_5 loading need to be reduced along the river basin.

Figure 5 shows the Ammoniacal Nitrogen (AN) concentration outline within the Tebrau River Basin. At the upstream of the river, the AN concentration was recorded about 25 mg L^{-1} which falls into class V of INWQS that categorized as polluted water. Based on the location and site observation, most of the land used within the area is the palm oil plantation. Therefore, this is the main reason for the highly concentration of the AN. Similar to the BOD_5 concentration profile, the AN concentration was also observed decreased after the 10th km that may cause by the effect of the dilution from the tide.

Figure 6 shows the AN loading profile. Based on the profile, the AN loading per day need to be reduced until it reach the value of the class II allowable loading.

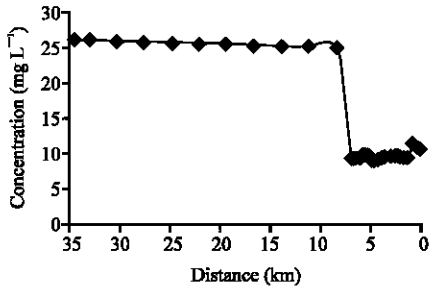

Fig. 5: Ammoniacal nitrogen concentration profile

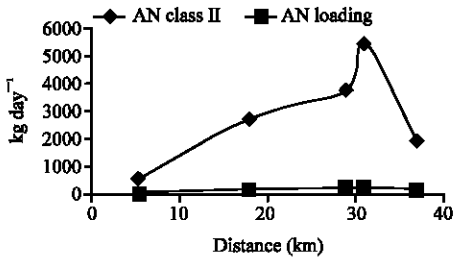

Fig. 6: AN loading profile

CONCLUSION

Its can be concluded that the Tebrau River Basin can be categorised as polluted river and is not suitable to be used as protable waters supply. At the upper stream of the river, the main contributor of the pollutant come from the agriculture, especially the palm oil plantation that contribute high concentration of ammoniacal nitrogen. However, at the downsteram of the river, the industrial discharge was the major contributor of the pollutant. It has been found out that QUAL2K model can be used as an outstanding tool in managing the river basin. As a recommendation, the Total Maximum Daily Loaded (TMDL) assessment was the best solution in reducing the pollution problem.

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REFERENCES

Chapra, S., 1997. Surface Water-Quality Modeling. McGraw Hill, USA.

Chapra, S. and G. Pelletter, 2003. QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality. US Environmental Protection Agency, USA.