

The Study of Total Maximum Daily Load of Parit Tiram Using Water Quality Modelling

Nurul Aisyah Shahrulniza¹, Nuramidah Hamidon^{1*}

¹ Department of Civil Engineering, Faculty of Engineering Technology, University Tun Hussein Onn, Pagoh, 84600, MALAYSIA

*Corresponding Author: nuramidah@uthm.edu.my
DOI: <https://doi.org/10.30880/peat.2024.05.02.047>

Article Info

Received: 28 June 2024

Accepted: 30 June 2024

Available online: 25 November 2024

Keywords

Total Maximum Daily Load, Parit Tiram, Qual2k, water quality, pollution

Abstract

The Total Maximum Daily Load (TMDL) is a crucial regulatory framework in environmental science and management that evaluates and regulates water pollution in rivers, lakes, and other water bodies. It establishes the maximum allowable amount of a specific pollutant that a water system can endure daily without violating predetermined water quality standards. TMDL considers diverse pollution sources, including point sources like industrial discharges and diffuse non-point sources like agricultural runoff. It considers the assimilative capacity of the receiving water body, considering factors like flow rates, temperature, and other pollutants. The TMDL process involves identifying the targeted pollutant, establishing water quality criteria, and determining the current pollutant load through comprehensive monitoring and data analysis. This data is used to allocate permissible pollutant loads to different sources, ensuring adherence to water quality standards. TMDL plays a significant role in advancing sustainable water resource management, contributing to the protection of aquatic ecosystems, public health preservation, and ecological equilibrium of water bodies. It encourages practices that minimize pollution, fostering long-term health and resilience of aquatic environments.

1. Introduction

Understanding the level of pollution in water is crucial for assessing water quality. Consequently, it is advisable to regulate water quality to prevent excessive pollution that could pose risks to both human and environmental well-being in the vicinity of reservoirs or rivers. In order to oversee water quality, it is essential to be aware of the river's Total Maximum Daily Load (TMDL). Parit Tiram has been chosen because there are also problems in that place. As we know, TMDL determines the total maximum amount of daily pollutant that can enter the water body. So, TMDL needs to be done because the Parit Tiram area is difficult to assess due to unplanned housing near the area.

Water quality encompasses the chemical, physical, and biological attributes of water. It can also be understood as an indicator of whether water is contaminated. This term evaluates water's suitability for various biotic species and human purposes. The primary criteria for assessing water quality focus on ecosystem health, human safety, and potable water standards. Water quality is inherently complex due to the intricate nature of water itself. The water quality of various sources can be assessed through physicochemical and biological parameters. Determining the suitability of water sources for human consumption is complex. Consequently, the water quality index (WQI) is the most efficient method for monitoring water quality. The WQI consolidates diverse water quality data into a single, comprehensive quantitative value.[1]

The TMDL process typically entails several key steps, commencing with the identification of the targeted pollutant and the establishment of water quality criteria, which define acceptable pollutant concentrations in the water. Subsequently, the current pollutant load is determined through comprehensive monitoring and data analysis. This data serves as the foundation for allocating permissible pollutant loads to different sources, ensuring adherence to water quality standards. By setting constraints on the maximum daily load, TMDL acts as a regulatory instrument guiding the formulation and implementation of effective pollution mitigation strategies. The following equation can be used to simplify the TMDL process:

$$\text{TMDL} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}$$

Fig. 1 TMDL equation

TMDL is derived from WLA (waste load allocation of point sources), LA (load allocation of nonpoint sources), and MOS (margin of safety for future development).[2]

Water quality models can be used for a variety of different purposes including analyzing pollutant spills and predicting long-term water quality in rivers. A popular modelling tool for estimating and evaluating river and stream water quality parameters is QUAL2K. QUAL2K is a tool designed to help with environmental impact assessments and water quality management. QUAL2K models the water quality over time, offering insightful information for planning and decision-making related to the environment. Environmental engineering and water resource management are two fields in which it is frequently used.[3]

2. Methodology

2.1 Water Quality In-situ

On-site testing will be carried out utilizing a sample of the water in order to quickly evaluate the condition and quality of the water. Field testing refers to the process of conducting experiments, assessments, or analyses directly in the natural environment or specific location where the subject of interest is found. Field testing is often employed in various scientific, environmental, and industrial applications to gather accurate data and make informed decisions based on on-the-spot observations.

2.2 Water Quality Laboratory Testing

Biochemical oxygen demand (BOD) is an analytical parameter that measures the amount of dissolved oxygen consumed by aerobic bacteria growing on the organic material present in a water sample at a specific temperature over a specific time period usually in a 5 day incubation at 20 °C. BOD has been accepted as an important water quality parameter to indicate the degree of organic pollution.[4]

Alkalinity is a metric assessed in practically all environmental samples, including drinking water, natural waterways, contaminated waters, sewage and industrial waste. The ability of water samples to neutralise acidic pollutants from rainfall or wastewater is referred to as alkalinity.

2.3 Flowchart

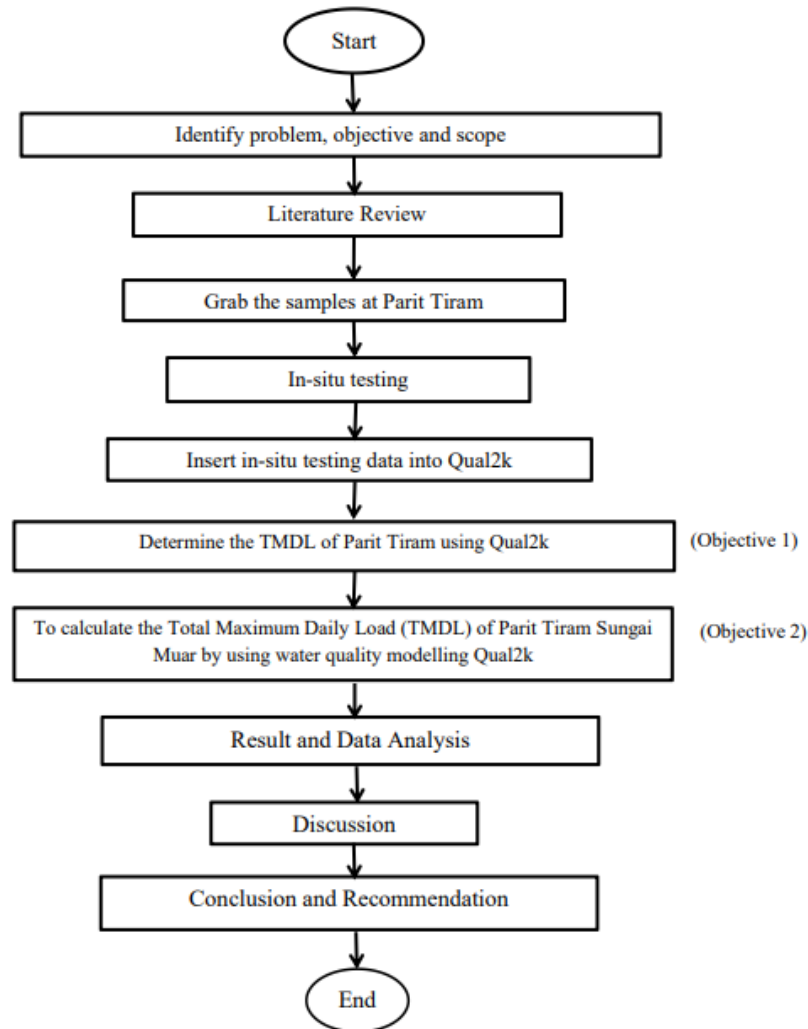


Fig. 2 flowchart research

The water quality testing of total maximum daily load from Parit Tiram wastewater. Experimental studies in this field often focus on understanding pollutant sources, transport mechanisms, and the effects of various mitigation strategies on water quality. The water quality methods are in-situ testing and laboratory testing that using parameter Dissolve Oxygen, BOD, Turbidity, pH and Alkalinity.

2.4 Qual2k

To start using QUAL2K, gather pertinent data from the study region, such as flow rates, water temperatures, and pollutant concentrations. Together with other essential elements like stream geometry and characteristics, enter this data into the QUAL2K model. Specify the simulation time frame and the model's segments and boundaries. Run the simulation to evaluate the dynamics of water quality throughout the given time period, including the dispersion and transformation of pollutants along the water body.

3. Results and Discussion

3.1 Data of pH, DO, BOD, Alkalinity and Turbidity

Table 1 data sheet

Point	pH	DO	BOD	Alkalinity	Turbidity
CP1 Low	5.72	4.40	7.32	35	27.2
CP1 High	5.93	4.53	7.44	39	28.3
CP2 Low	5.98	5.21	10.8	35	24.3
CP2 High	6.03	5.29	11.6	37	25.0
CP3 Low	5.57	5.51	7.02	30	29.6
CP3 High	5.63	5.75	7.14	32	30.2
CP4 Low	7.19	3.13	7.86	35	23.3
CP4 High	7.30	3.45	7.95	37	23.7
CP5 Low	7.21	3.45	9.42	30	22.5
CP5 High	7.31	3.62	9.54	32	22.9

3.2 Qual2k

3.2.1 Dissolved Oxygen

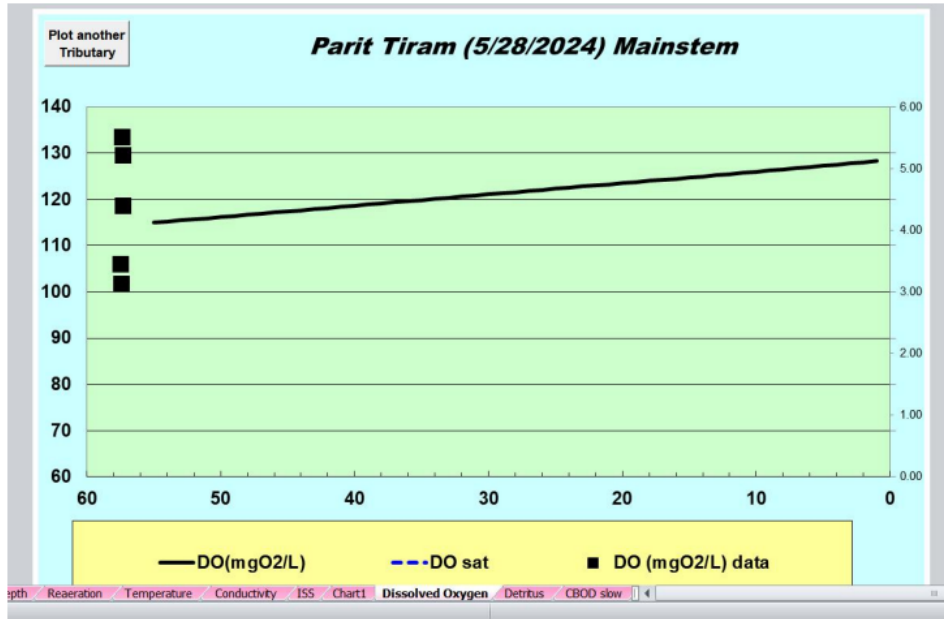


Fig. 3 dissolved oxygen

3.2.2

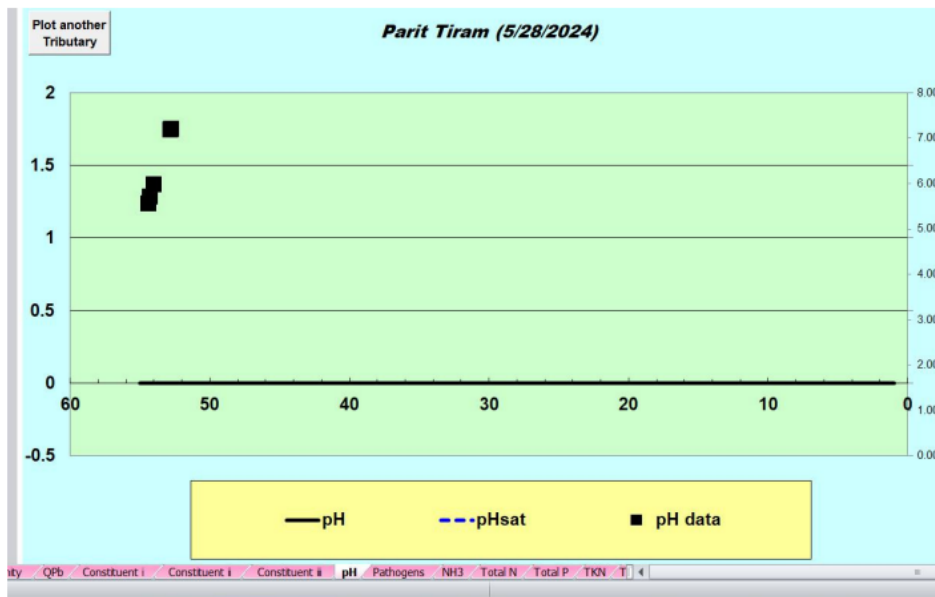


Fig. 4 pH

3.2.3 Biochemical Oxygen Demand

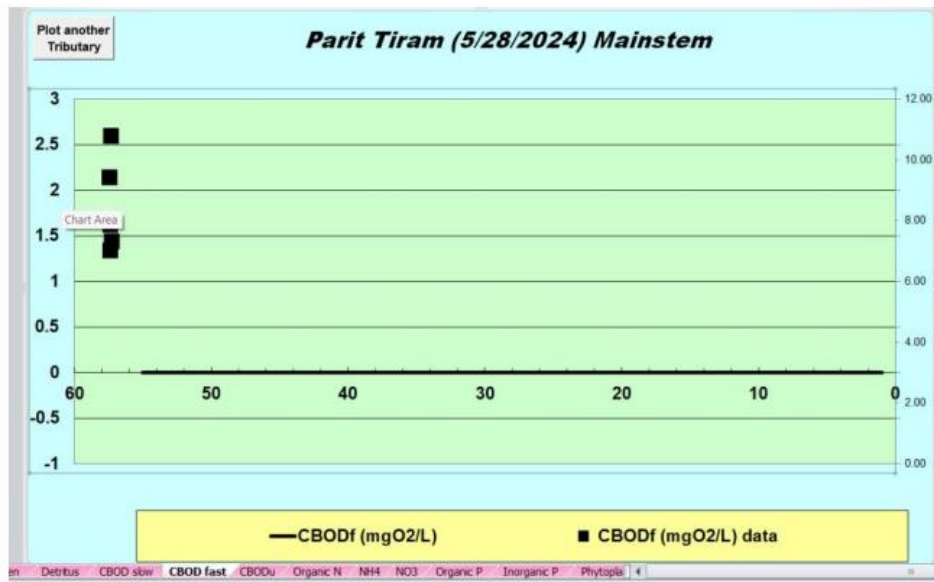


Fig. 5 Biochemical oxygen demand

3.2.4 Alkalinity

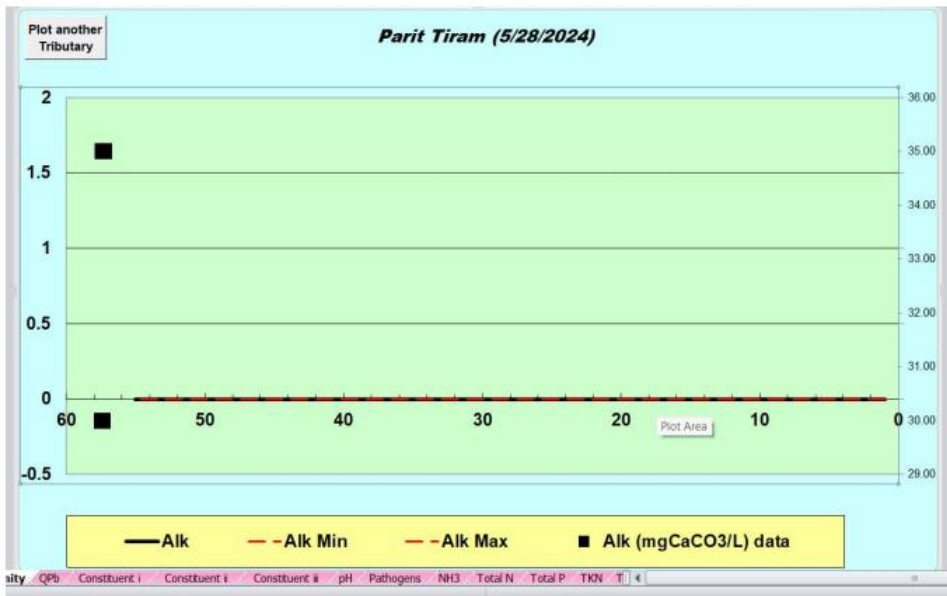


Fig. 6 alkalinity

4. Conclusion

This research uses the QUAL2K model to simulate and validate the Total Maximum Daily Load of Parit Tiram. The selected water quality prediction indices are pH, BOD, alkalinity, turbidity, and dissolve oxygen. The QUAL2K model, which uses the Microsoft Office Excel interface and has comparatively basic VB programming, is straightforward to use and understand. In the meantime, figuring out the parameters for the water quality is crucial to solving the model. The Qual2k water quality modeling tool was effectively utilized in the study to ascertain and compute the Total Maximum Daily Load (TMDL) of Parit Tiram in Sungai Muar. Through the simulation of dissolved oxygen levels and other parameters related to water quality, the model yielded a thorough comprehension of the present pollution load and its influence on the waterway. The outcomes showed that Parit Tiram's TMDL was within reasonable bounds, guaranteeing the river's water quality would be managed sustainably. The aforementioned results highlight the value of Qual2k in precisely evaluating and directing efficient water resource management tactics to preserve environmental well-being and legal adherence. Further research on how to best optimize the model's parameter for various rivers especially ones with insufficient data should be done in the future.

Acknowledgement

The author would like to thank the Faculty of Engineering Technology. Communication of this research is made possible through monetary assistance by Universiti Tun Hussein Onn Malaysia and the UTHM Publisher's Office via Publication Fund E15216.

References

- [1] Boyacioglu, H. (2009). Development of a water quality index based on a European classification scheme. *Water SA*, 33(1). <https://doi.org/10.4314/wsa.v33i1.47882>
- [2] Che Osmi, S. A., Wan Ishak, W. F., Azman, M. A., Ismail, A. S., & Samah, N. A. (2018). Development of water quality modelling using InfoWork river simulation in Malacca River, Malaysia and contribution towards Total Maximum Daily Load approach. *IOP Conference Series: Earth and Environmental Science*, 169, 012073. <https://doi.org/10.1088/1755-1315/169/1/012073>
- [3] Adnan, M., Roslen, H., & Samsuri, S. (2022). The Application of Total Maximum Daily Load (TMDL) Approach in Water Quality Assessment for The Batu Pahat River. *IOP Conference Series: Earth and Environmental Science*, 1022(1), 012074. <https://doi.org/10.1088/1755-1315/1022/1/0120>
- [4] Chen, X., Chen, Y., Lin, H., Liu, Z., Peng, C., Xu, X., Jia, J., Zhang, M., & Liu, C. (2023). In situ and self-adaptive BOD bioreaction sensing system based on environmentally domesticated microbial populations. *Talanta*, 261, 124671. <https://doi.org/10.1016/j.talanta.2023.1>