Recent Trends in Civil Engineering and Built Environment Vol. 3 No. 1 (2022) 380-388

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

Assessment of Surface Water Quality Using Malaysia Water Quality Index (MWQI) And National Sanitation Foundation Water Quality Index (NSFWQI) During Road Construction Activities

Nuramanina Ayob[1], Mohd Hairul Khamidun[1]*

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rtcebe.2022.03.01.040
Received 4 July 2021; Accepted 13 December 2021; Available online 15 July 2022

Abstract: The study of this project was basically on the assessment of surface water quality by using Malaysian Water Quality Index (MWQI) and National Sanitation Foundation Water Quality Index (NSFWQI) during road construction activities. The site area selected for this study was located at Kampung Rahmat, Batu Pahat, Johor where a new road to cross the Sri Gading Estate was constructed. The purpose of this study was to evaluate the impact of road construction activities on the quality of water bodies. In addition, the determination of water quality index based on six parameters used were biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), ammoniacal nitrogen, pH, and total suspended solids (TSS) at site construction of a new road for Kampung Rahmat is underway. The data used was secondary data collected from previous study to determine the water quality index based on Malaysian Water Quality Index (MWQI) and National Sanitation Foundation Water Quality Index (NSFWQI). High values of water quality index indicated that surface water in that road construction area was less polluted. The importance of this study was to determine the level of surface water quality due to road construction activities. It was very important to assess the quality of water in a place to maintain its cleanliness because water serves as a basic need for living organisms. Based on the calculation of water quality index values by using MWQI and NSFWQI, it showed that the highest value of water quality index recorded compared to other parameters was total suspended solids (TSS) which was 186 mg/L while the lowest value of water quality index recorded was 0.1 mg/L in December by ammoniacal nitrogen. Thus, the comparison of results made between MWQI and NSFWQI showed that MWQI was more effective and accurate to assess the water quality index compared to NSFWQI.

Keywords: Malaysia Water Quality Index (MWQI), National Sanitation Foundation Water Quality Index, Water Quality, Road Construction Activities

Corresponding author: hairulk@uthm.edu.my

1. Introduction

Water, a prime natural resource and a critical national commodity, is the main constituent of the ecosystem. Water sources can be predominantly in form of rivers, reservoirs, rainwater, glaciers and groundwater. Water supplies play a vital role in various sectors of the economy, such as agriculture, livestock production, forestry, activities of industry, generation of hydro power, other innovative activities and fisheries [1]. Rapid industrialization, combined with intensive urbanization, typically starts to degrade the quality of surface water by adding a variety of organic and inorganic contaminants. Road construction gives the impacts towards aquatic life in physical, chemical and biological term. Serious alterations can occur due to building of road [2]. The road construction works indeed gave impact to the surface water quality. Most of significant surrounding effect towards the surface water quality was due to degradation of top soils during the storm. Another problems occurred during the road construction activities are include earth shifting, vegetation removal, vehicle or machine operation and repair, asphalt handling and laying that contribute to the rise of runoff during monsoon, silting, water bodies depletion by filling, changes in patterns of drainage, logging of water, floods and liquid also solid waste discharge into the water bodies[3].

Development of roads, highways and structures interferes with the runoff of storm water. They have got two major impacts. They produce more runoff and contaminants while contributing to the rise in watershed surfaces and intensifying activities [5]. In Malaysia, land clearing due to land growth caused soil erosion and river siltation, leading to extreme water pollution [6]. Storm water transports various contaminants, both organic and inorganic. It is well known at present that storm water transports significant amounts of pollutants to the receiving waters, as a result it becomes the largest contributor to contamination of receiving waters in many countries[7] substantial variations in storm water components for various land-use group [8]. Stormwater at urban conveys toxins from anthropogenic and natural activities. This significant contamination source of surface water in areas of urban and very crucial factors of water quality degradation in water receiving system. Storm water quality is well known for its local and stochastic existence. For a more reliable estimation of local emission loads, data of empirical (based on land use) is important. Relevant local water runoff quality data are therefore critically useful not only for the creation of reliable water runoff quality models, but also for a future and current impacts of land use change on downstream water bodies understanding [9] Highway storm water runoff is time-continuous, not concentrated at a single spot, and prone to climate change, making it a classic non- point pollutant source[10]. Waste and pollution transported by storm water is an amount also quality concerns impacting community health and the climate conditions towards water quality too[7].

Water quality is characterized as a measure of water use for a variety of purposes (drinking, industrial, agricultural, recreation, and habitat) using different criteria, such as physical, chemical, and biological. It varies depending on location, time, weather and source of contamination[11]. By using water quality index where the quality of the water is assessed on the basis of calculated water quality indices, is the one of the best ways to communicate with the water quality. However, to assess quality from a large number of samples that contain concentrations for many parameters is difficult.

Basically, to provide a mechanism for presenting a cumulatively derived numerical expression that defines water quality at a certain level, water quality index is required. The comparison can be made between the water bodies by means of the water quality index and a general analysis of the water quality can be made at different levels. Water quality index is a means of summarizing large amounts of water quality data in single value in terms of poor or good condition for reporting to management and the public in a consistent manner[13].

The importance of this study is to determine the surface water quality level due to the road construction activities. Construction is not usually a conventional source of pollution such as biological chemical and pollutants, but due to vast amount of contaminated land as a result of construction operations, it becomes main contributors to loading of sediment in our nation’s surface water [4].

The aim of this research is to evaluate the impact of road construction activities on water bodies quality and to determine the water quality index based on Malaysia WQI and NSFWQI. The calculation result of water quality index using these two types of indices being compared at last and can classify the classes of water and know the status and level of water too.

2. Materials and Methods

For the assessment of water quality index, secondary data is being analyzed for every parameter used. This assessment was carried out for 12 months and involved two sampling points which were WQ1 at the upstream and downstream. Calculation of water quality index, the selection of parameters is of great value. If too many parameters are used, the water quality index will widen. The importance of different parameters depends on the intended use of water. There are four steps in the formulation of water quality index which is parameter selection, weight establishment, formulation of sub-index and aggregation of weighted sub-indexes [14]. Water quality index is a means of summarizing large amounts of water quality data in single value in terms of poor or good condition for reporting to management and the public in a consistent manner.

$$WQI = 0.22 \times SI_{DO} + 0.19 \times SI_{BOD} + 0.16 \times SI_{COD} + $$
$$+ 0.15 \times SI_{AN} + 0.16 \times SI_{SS} + 0.12 \times SI_{pH}$$

where:

WQI = water quality index,

SI_{DO} = sub-index of DO,

SI_{BOD}= sub-index of BOD,

SI_{COD}= sub-index of COD,

SI_{AN} = sub-index of AN,

SI_{SS}= sub-index of TSS,

SI_{pH}= sub-index of pH,

NSFWQI the proposed new index ranges from 0-100. In order to provide qualitative description of the result of the index, flat description for index data have been developed. The formula for NSFWQI is as below:

$$NSFWQI = \frac{\sum_{i=1}^{n} W_i I_i}{\sum w_i}$$

In this formula, n represents the number of parameters, W represents the factor of weight and I indicates the parameter value.

3. Results and Discussion

The results and discussion section exhibit data and analysis of the study. Qualitative index NSFWQI and WQI are considered as the best index in order for monitoring surface water quality[15]. Generally, to evaluate the overall water quality index is not an easy task particularly when different criteria for different uses are applied.

3.1 Water Quality

The figures below show the water quality data represented by seven parameters at WQ1 for upstream and downstream collected for 12 months. Based on the Figure 1, the highest value for pH recorded was in September which was 7.48 at downstream while the lowest was 5.59 in January at upstream that showed the acidity of water. The overall values recorded in Figure 1 above for pH are mostly at the neutral level that exactly shows the pH does not affected by the waste discharge from the road construction activities except for a few streams. As an example, the pH values of upstream in January and downstream in August are 5.59 and 5.9 respectively that clearly exhibits that these are the most acidic value for the stream. Based on National Water Quality Standards (NWQS), the pH values listed are mostly in Class III which required for a substantial treatment.

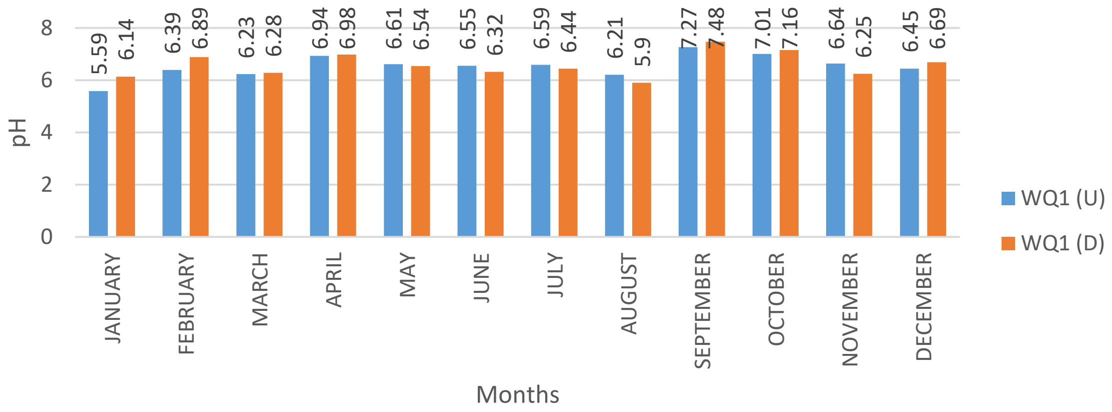

Figure 1: pH values at WQ1 (U) and WQ1 (D) for 12 months

Based on Figure 2 shows the dissolved oxygen (DO) values at upstream and downstream for 12 months and it can be said that the figure has a fluctuate pattern. Referred to National Water Quality Standards (NWQS) stated that the lesser the value of dissolved oxygen (DO), the polluted the water. Based on all the values recorded above, it can be concluded and classified the water quality into Class IIA and Class IIB that required conventional treatment. The major factor that contributes to changes in dissolved oxygen is due to present of pollutants from road construction activities that flow into the stream, temperature of the water, and usage of dissolved oxygen by the microorganisms in order to breakdown the organic matter.

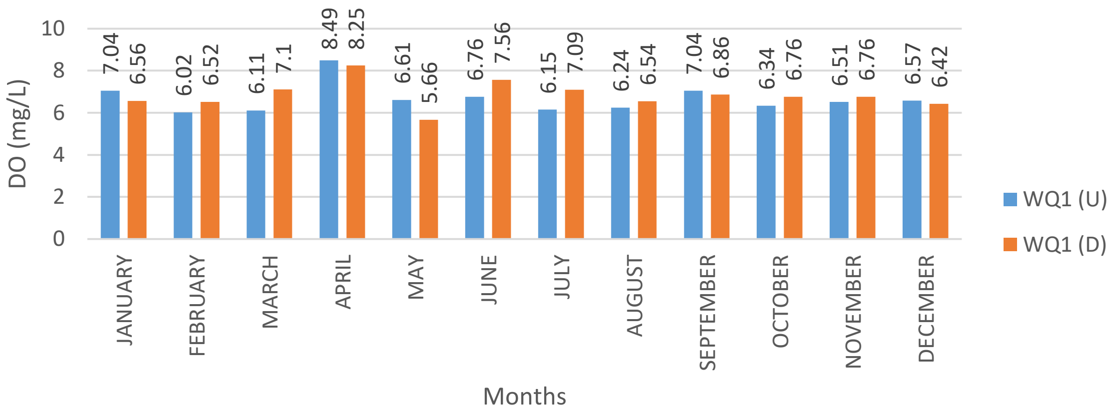

Figure 2: DO values at WQ1 (U) and WQ1 (D) for 12 months

Figure 3 shows that the turbidity values for both streams are in fluctuate pattern too. For the upstream, the highest value turbidity is 73 NTU while the lowest is 8 NTU. Meanwhile for the downstream, the highest value of turbidity recorded is 109 NTU and the lowest is 24 NTU. Turbidity also always viewed as indicators of other potential nutrients and pollutants as most of them are being adsorbed and migrate with the sediment runoff. Basically, materials and the equipment such as wood treated with creosote and chromated copper arsenate, paint, adhesives, solvents, vehicle oils, fuel, and grease are used during the road construction, has high potential in contributing as toxic pollutants.

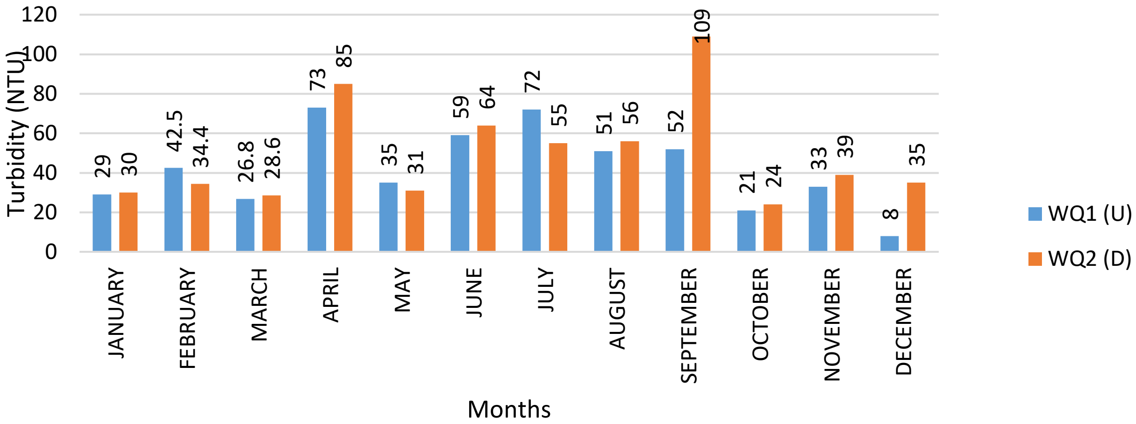

Figure 3: Turbidity values at WQ1 (U) and WQ1 (D) for 12 months

Figure 4 shows the results obtained for the concentration of total suspended solids (TSS) at both upstream and downstream of Kg Rahmat for 12 months. Based on National Water Quality Standards (NWQS), the higher the value, the more pollute of the water. In the figure above, the highest value recorded is in July where the total suspended value for upstream and downstream on that month is 186 mg/L and 104 mg/L respectively. These can be classified into Class III that required extensive treatment. Meanwhile, the lowest value of total suspended solids is in January where 6 mg/L recorded for the upstream and 8 mg/L recorded for the downstream. Due to level of runoff, the data for total suspended solids (TSS) loading in streams might differ. Total suspended solids (TSS) results will decrease due to increase level of runoff which is the rainfall rate because of stream water dilution.

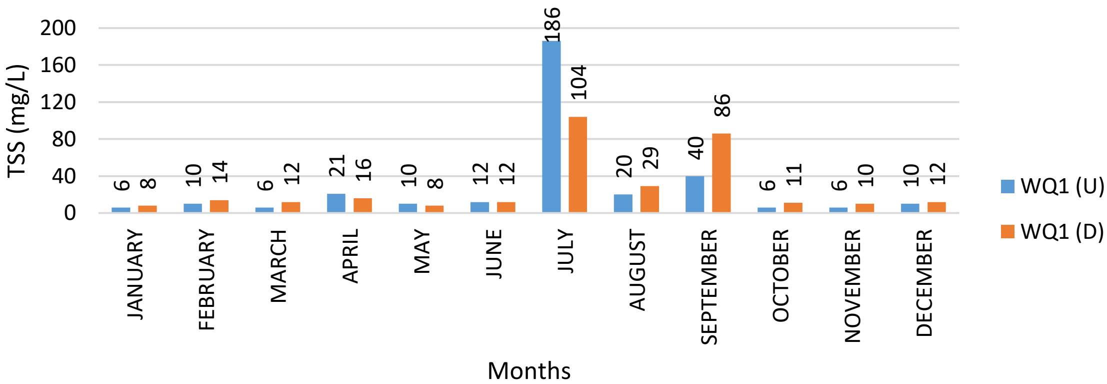

Figure 4: TSS values at WQ1 (U) and WQ1 (D) for 12 months

For this parameter it can be defined as the quantity of oxygen need by the bacteria in order for the stabilization of organic matter under aerobic situations. According to the parameter limits of National Water Quality Standards (NWQS) for Malaysia, upstream and downstream in January classified as Class IIA and it is the lowest value compared to others. The highest value of biochemical oxygen demand recorded is 18 in September at downstream. High value of biochemical oxygen demands indicates that the water is polluted. Hence, the value is more than 12 mg/L, so it classified as Class V.

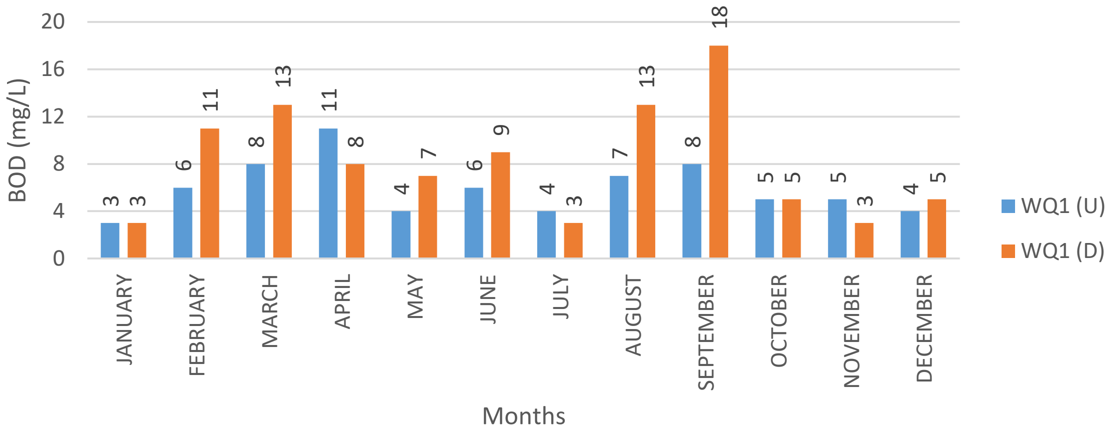

Figure 5: BOD values at WQ1 (U) and WQ1 (D) for 12 months

Literally in Figure 6 for the upstream region, the highest value of chemical oxygen demand (COD) is 26 while the lowest is 8. Meanwhile, for the downstream recorded that the highest value is 54 and the lowest is 7. But the top three highest value of chemical oxygen demand (COD) is at downstream in February, August and September which are 44, 54 and 47 respectively. These show that they are classified as Class III based on National Water Quality Standards (NWQS). In conclusion, the higher amount of chemical oxygen demand (COD) value, the lower water quality level.

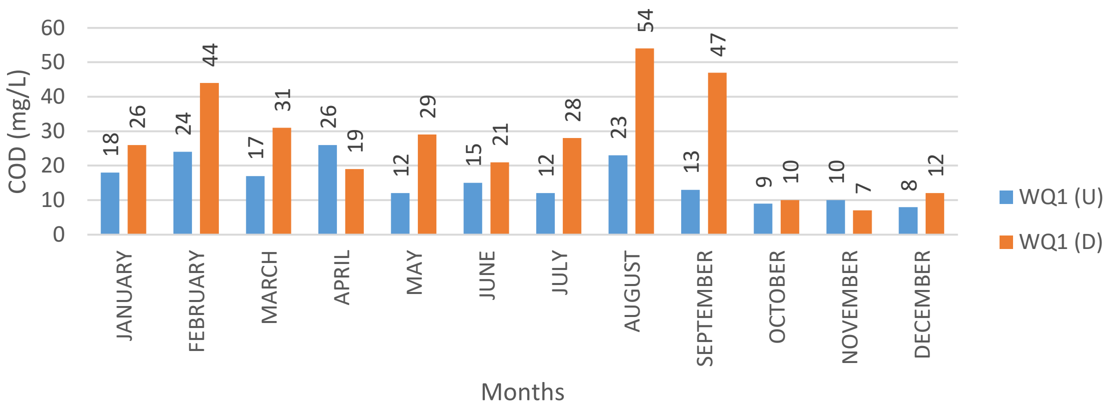

Figure 6: COD values at WQ1 (U) and WQ1 (D) for 12 months

Ammoniacal nitrogen, NH3N maintains to be one of the parameters that becomes a critical environmental and worldwide focused on because it contributes to eutrophication. It can be shape into ammonia, organic, nitrate, nitrite and nitrogen gaseous. Status of nutrients, water body health and enrichment of organics also can be show by this parameter. If the value of ammoniacal nitrogen, NH_3N is higher, then the water is surely polluted. Refer to Figure 7, the very highest value of this parameter is 2.2 which is in July at the downstream while the rest values are not more than 1.0. The lowest value stated is 0.1 that indicates the Class I, and Class IIA for the value of 0.3 like the value in February, May, and July for the upstream also 0.3 for downstream in August. For the value of ammoniacal nitrogen in September for both streams are 0.9 which is classify as Class III that required extensive treatment.

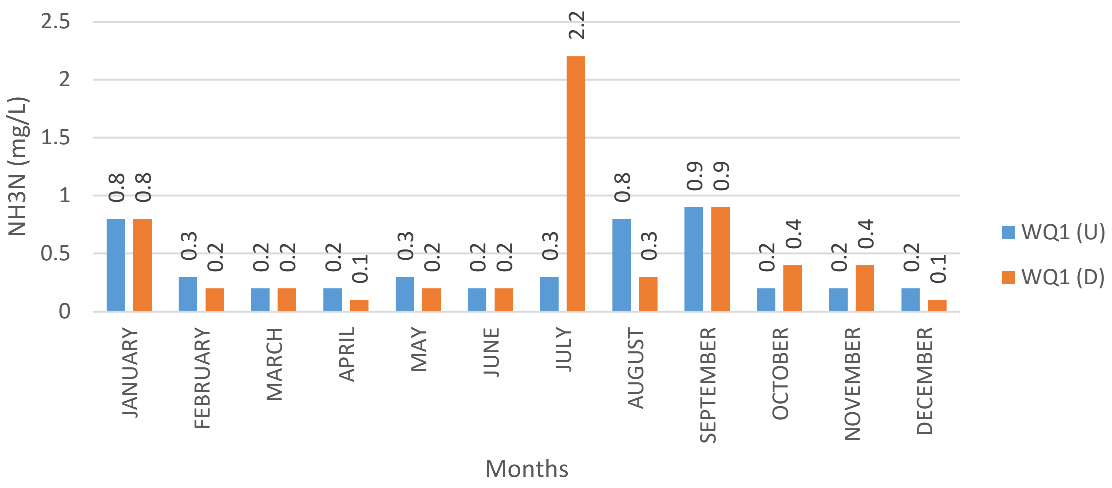

Figure 7: NH_3N at WQ1 (U) and WQ1 (D) for 12 months

3.2 Comparison of Water Quality index (WQI)

Figure 8 and Figure 9 show the comparison data of water quality index calculated by using two different water quality indices which are MWQI and NSFWQI at the upstream and downstream respectively. The blue line represents for Malaysia WQI while the red line represents for NSFWQI. Figure 4.9 exhibits that the value of Malaysia WQI that calculated is higher compared to NSFWQI while for the Figure 4.10 also the same and the Malaysia WQI major the data althought there are a few of intersections.

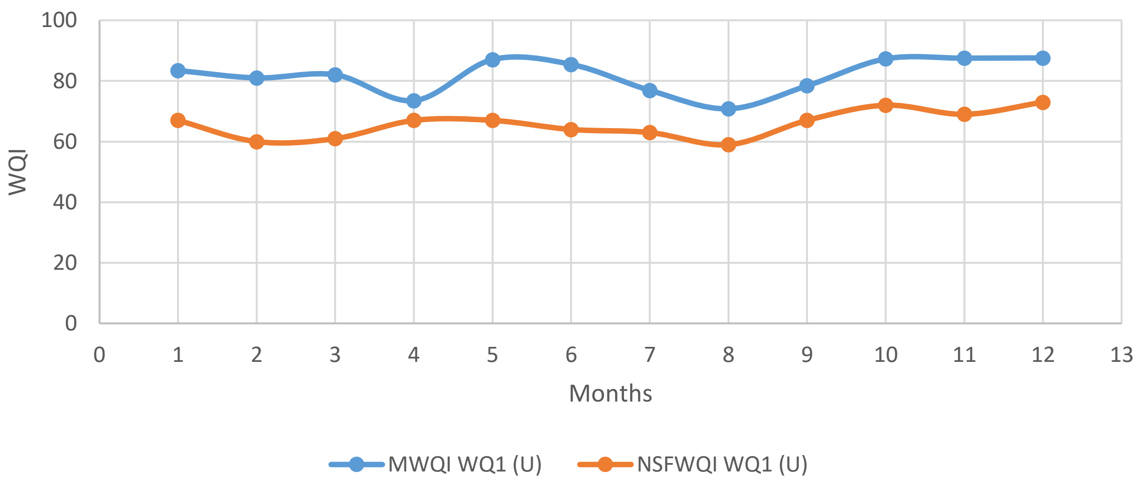

Figure 8: Comparison between MWQI and NSFWQI at WQ1 (U)

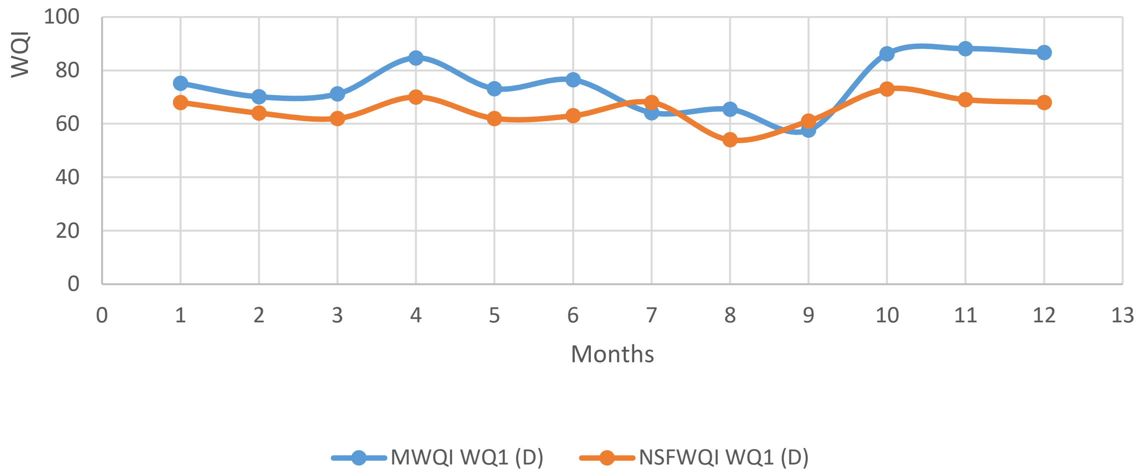

Figure 9: Comparison between MWQI and NSFWQI at WQ1 (D)

4. Conclusion

Both value for water quality index of Malaysia WQI and NSFWQI are different due to some factors.First, Malaysia WQI use six common water quality parameters which are BOD, COD, DO, TSS, NH_3N and pH while NSFWQI use all the three aspects of parameters which is physical, chemical and biological. For sub-index generation, Malaysia WQI use quality function curve where the calculate value was transformed to sub-index value for each type of parameter. Compared to NSFWQI, range of 0 to1 is the value of sub-index for the parameters. But when the value is within the recommended guideline, the sub-index becomes 1 or 0 otherwise. How the differential of parameter threshold could impact the respective sub-index concentrated by index uncertainty analysis.The fundamental feature of model and might linked with specific parameters defined the uncertainty. Sources of WQI model that varies is related to uncertainty in the final indices of WQI models based on previous research. By comparing Malaysia WQI and NSFWQI, it can be concluded that the physiochemical properties of water are what Malaysia WQI more on focus. Based this study, the calculation of these two indexes actually used different number and types of parameters. For example, Malaysia WQI used six common water quality parameters which are BOD, COD, DO, TSS, NH_3N and pH. Meanwhile, NSFWQI only use five parameters which are turbidity, total solids, pH, BOD and DO. Hence, index value for both Malaysia WQI and NSFWQI are differ because difference number of parameters apply during the calculation give the different value that might affected the index value. NSFWQI can be accurate if the value of nitrate and total phosphate is available.

Acknowledgement

We appreciate and thank the faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia and my supervisor, Dr. Mohd Hairul bin Khamidun for supporting this study.

References

[1] L. Sharma, “Riverbank filtration: Modeling fate of dissolved organic carbon, transport of *Escherichia coli* and coupling with aquifer storage to address temporal water scarcity,” *ProQuest Diss. Theses*, p. 153, 2012, [Online]. Available: http://ezproxy.lib.ryerson.ca/login?url=https://www.proquest.com/dissertationstheses/riverbankfiltrationmodelingfatedissolved/docview/1267134770/se2?accountid=13631%0Ahttp://eq6sp2kj9f.search.serialssolutions.com/directLink?&atitle=Riverbank+filtrat.

[2] M. Ghorbani Mooselu, H. Liltved, M. R. Nikoo, A. Hindar, and S. Meland, "Assessing optimal water quality monitoring network in road construction using integrated information-theoretic techniques," *J. Hydrol.*, vol. 589, no. July, p. 125366, 2020, doi: 10.1016/j.jhydrol.2020.125366.

[3] R. Vijay, V. K. Kushwaha, T. Mardikar, and P. K. Labhasetwar, "Impact of highway construction on water bodies: a geospatial assessment," *Environ. Monit. Assess.*, vol. 189, no. 8, 2017, doi: 10.1007/s10661-017-6111-3.

[4] D. L. Houser and H. Pruess, "The effects of construction on water quality: A case study of the culverting of Abram Creek," *Environ. Monit. Assess.*, vol. 155, no. 1–4, pp. 431–442, 2009, doi: 10.1007/s10661-008-0445-9.

[5] M. Zaimi *et al.*, "Green Highway Development Features to Control Stormwater Runoff Pollution," *J. Environ. Treat. Tech.* , no. July 2016, pp. 2–5, 2015, [Online]. Available: http://www.jett.dormaj.com/docs/Volume3/Issue 4/Green Highway Development Features to Control Stormwater Runoff Pollution.pdf.

[6] I. A. R. Al-ani, L. M. Sidek, and H. Basri, "Mitigating Stormwater Pollution During Construction Activities in Malaysia," no. September, pp. 1–5, 2014.

[7] A. E. Barbosa, J. N. Fernandes, and L. M. David, "Key issues for sustainable urban stormwater management," *Water Res.*, vol. 46, no. 20, pp. 6787–6798, 2012, doi: 10.1016/j.watres.2012.05.029.

[8] A. Expressway, "Distribution Characteristics of Pollutants and Their Mutual Influence in Highway Runoff," pp. 956–963, 2011, doi: 10.1002/clen.201000422.

[9] H. Song, T. Qin, J. Wang, and T. H. F. Wong, "Characteristics of stormwater quality in Singapore catchments in 9 different types of land use," *Water (Switzerland)*, vol. 11, no. 5, pp. 1–10, 2019, doi: 10.3390/w11051089.

[10] S. Division and D. Branch, "Highway stormwater runoff quality: d e v e l o p m e n t of surrogate parameter relationships," pp. 307–347, 1997.

[11] M. Camara, N. R. Jamil, A. Fikri, and B. Abdullah, "Impact of land uses on water quality in Malaysia : a review," 2019.

[12] M. A. Hossain, I. M. Sujaul, and M. A. Nasly, "Water Quality Index : an Indicator of Surface Water Pollution in Eastern part of Peninsular Malaysia," vol. 2, no. 10, pp. 10–17, 2013.

[13] F. dos S. Simões, A. B. Moreira, M. C. Bisinoti, S. M. N. Gimenez, and M. J. S. Yabe, "Water quality index as a simple indicator of aquaculture effects on aquatic bodies," *Ecol. Indic.*, vol. 8, no. 5, pp. 476–484, 2008, doi: 10.1016/j.ecolind.2007.05.002.

[14] Y. J. Wong, Y. Shimizu, K. He, and N. M. Nik Sulaiman, "Comparison among different ASEAN water quality indices for the assessment of the spatial variation of surface water quality in the Selangor river basin, Malaysia," *Environ. Monit. Assess.*, vol. 192, no. 10, 2020, doi: 10.1007/s10661-020-08543-4.

[15] M. G. Uddin, S. Nash, and A. I. Olbert, "A review of water quality index models and their use for assessing surface water quality," *Ecol. Indic.*, vol. 122, p. 107218, 2021, doi: 10.1016/j.ecolind.2020.107218.