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The Water Quality Issue: A Study of Tasik Kemajuan's Water Quality Status

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Abstract

Lakes are crucial for irrigation, drinking water, transportation, and power generation. Tasik Kemajuan, located on UTHM's main campus, is used for kayaking and flood mitigation. However, pollution in the lake, through various contaminants, poses risks to human health and the aquatic environment. This study aims to monitor water quality and determine the Water Quality Index (WQI) of Tasik Kemajuan. Six water parameters were evaluated to calculate the WQI: BOD_5, COD, TSS, pH, AN, and DO. These parameters contributed to determining the water quality subindex and, ultimately, the WQI based on the formula used in Malaysia. An average water quality status was determined for each parameter: AN at 0.56 mg/L (Class III), BOD_5 at 9.75 mg/L (Class IV), COD at 21.93 mg/L (Class IIB), DO at 4.02 mg/L (Class III), pH at 6.45 (Class II), and TSS at 20.33 mg/L (Class I), with the water temperature recorded at 28.50°C (Class IIB). The findings reveal that the WQI for Tasik Kemajuan is on the upper edge of being polluted, with a score of 74, placing it in the Class III category. According to the NWQS, Tasik Kemajuan fails to meet the standards for recreational activities involving direct contact with water and shows that significant purification efforts are necessary to make the water suitable for such purposes.

1. Introduction

Water is a vital resource for meeting diverse needs, including agricultural, industrial, and domestic demands. The recent period has witnessed a concerning surge in the contamination of aquatic bodies, attributed to the rapid industrial expansion, escalated usage of fertilisers, and burgeoning population densities in various regions. Aquatic systems such as lakes and rivers are indispensable to human societies, offering many advantages, including providing potable water, generating hydroelectric power, and mitigating flood risks [1]. The assessment of aquatic quality has emerged as a critical focus over the last few decades. The health of aquatic ecosystems is mainly influenced by the interaction with water's physical, chemical, and biological properties [2].

Point sources of pollution primarily include domestic sewage, pollution from agricultural activities, and pollution from industrial wastewater [3]. On the other hand, sources such as precipitation, roadway drainage, and runoff from agricultural lands are considered non-point sources [4]. Pollution from point sources, also referred to as discharge or outlet pollution, emanates from a specific location and can be introduced into aquatic environments via artificial drainage systems or conduits [5]. Non-point source pollution has a widespread nature,

lacking specific discharge points [6]. The selection of water quality parameters should be based on the National Water Quality Standards (NWQS) [7], which provide a framework for monitoring water quality. A model for evaluating water quality, known as the Water Quality Index (WQI), has been established. The WQI simplifies collecting data from different sources, tackling the changes in water quality over time and across different locations [8]. This method simplifies complex data on water quality into a single and simple indicative figure. Several previous studies have utilised the WQI to evaluate the water quality of various lakes across Malaysia. Notable examples include Varsity Lake at the University of Malaya (UM) in Selangor [9], Tasik Embayu in Perak [10], Engineering Lake and Serumpun Lake at Universiti Putra Malaysia (UPM) in Selangor [11], and Universiti Sultan Zainal Abidin (UniSZA) Lake in Terengganu [12]. These studies provide valuable insights into these aquatic ecosystems' environmental health and sustainability. Therefore, the aims of this study are to observe water quality and determine the WQI value for Tasik Kemajuan.

2. Methodology

2.1 Study Area

The study was conducted at Tasik Kemajuan, within the UTHM Parit Raja Campus. The catchment area encompassing Tasik Kemajuan spans approximately 4780 m^2. This particular lake was selected for the study due to its dual role in flood mitigation and serving as a recreational facility. The current condition of Tasik Kemajuan is shown in Fig. 1. Possible sources of pollution that could affect the lake include drainage from the G3 building, Arked, and the Pejabat Pendaftar and cafeterias, which are likely to contain organic debris such as food remnants, oils, and fats. Additionally, substances used for cleaning, disinfecting, and preparing food in these cafeterias could contribute to pollution. Organic materials such as leaves, grass trimmings, and other garden waste from Tasik Pembangunan might also find their way into Tasik Kemajuan. Pollutants can be transported into the lake through surface runoff, including microplastics from vehicle tyres, nitrogen, heavy metals, oils, and various chemicals. Moreover, landscaping fertilisers containing substances like ammonia and phosphorus could be swept into the water body.

Fig. 1 *Tasik Kemajuan, UTHM*

2.2 Water Sampling, In-situ and Laboratory Analysis

Water samples were collected from point 1 (01°51’34.6” N 103°05’08.4” E), point 2 (01°51’36.9” N 103°05’10.9” E) and point 3 (01°51’39.9” N 103°05’12.1” E) within Tasik Kemajuan, as depicted in Fig. 2, using the composite sampling method [13]. Water samples were collected from various locations within the lake to capture potential variations in water quality. These individual samples were then combined in proportions to form a single composite sample. This composite sample comprehensively represented the lake’s overall water quality rather than reflecting the conditions at a single point. This sampling activity was conducted weekly from October 2023 to December 2023, totalling ten weeks. In-situ measurements of the physicochemical properties of the water, like dissolved oxygen (DO), pH, and temperature, were conducted using a Hanna HI98194 multiparameter probe. The composite sampling method was utilised to collect water samples. These samples were then stored in high-density polyethylene bottles to analyse ammoniacal nitrogen (AN), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and total suspended solids (TSS) further. Before chemical analysis, the samples underwent a filtration process. Total Suspended Solids (TSS) analysis was performed using DR6000 (Method 8006). The analysis of BOD employed the Dilution Method (Method 8043), while COD was determined using the USEPA

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Reactor Digestion Method (Method 8000). Additionally, AN concentration was determined through the USEPA Nessler Method (Method 8038).

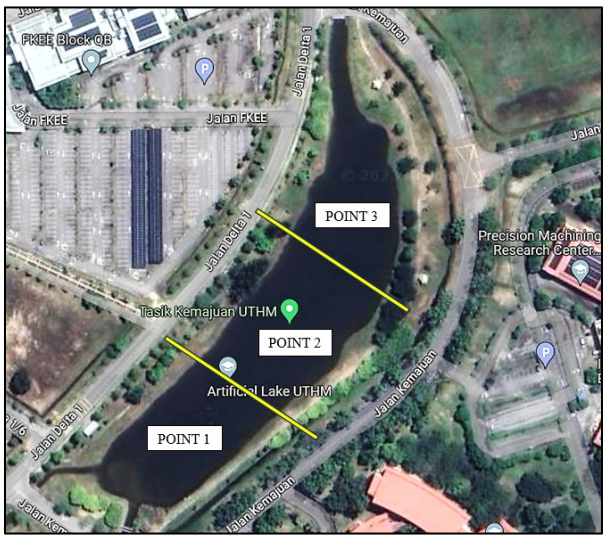

Fig. 2 *Tasik Kemajuan is divided into 3 sampling areas*

2.3 Water Quality Index (WQI)

The Water Quality Index (WQI) is a quantitative evaluation of water quality, and it can provide an overall score by combining the values of the subindexes. The assessment of the WQI for water bodies is determined by using six water parameters based on the NWQS. These parameters include DO, BOD_5, COD, AN, SS, and pH. This evaluation method serves as the basis for water quality determination. The calculation formula for WQI is shown in Eq. (1):

$$WQI = (0.22 \times SIDO) + (0.19 \times SIBOD) + (0.16 \times SICOD) + (0.15 \times SIAN) + (0.16 \times SISS) + (0.12 \times SIpH) \quad (1)$$

where SIDO is the subindex DO (% saturation); SIBOD is the subindex BOD; SICOD is the subindex COD; SIAN is the subindex AN; SISS is the subindex TSS, and SIpH is the subindex pH. Table 1 presents the formula for calculating the sub-indices for each parameter within WQI. Table 2 delineates the water quality classification according to the WQI, whereas Table 3 classifies the water classes and their respective uses.

Table 1 *Sub-index formula [7]*

Sub-index equation	Thresholds value
SIDO = 0	for x ≤ 8
SIDO = 100	for x ≥ 92
$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$	for 8 < x < 92
SIBOD = 100.4 – 4.23x	for x ≤ 5
SIBOD = 108 * exp(–0.055x) – 0.1x	for x > 5
SICOD = –1.33x + 99.1	for x ≤ 20
SICOD = 103 * exp(–0.0157x) – 0.04x	for x > 20
SIAN = 100.5 – 105x	for x ≤ 0.3
SIAN = 94 * exp(–0.573x) – 5 * | x – 2 |	for 0.3 < x < 4
SIAN = 0	for x ≥ 4
SISS = 97.5 * exp(–0.00676x) + 0.05x	for x ≤ 100
SISS = 71 * exp(–0.0061x) – 0.015x	for 100 < x < 1000
SISS = 0	for x ≥ 1000
$SIpH = 17.2 - 17.2x + 5.02x^2$	for x < 5.5
$SIpH = -242 + 95.5x - 6.67x^2$	for 5.5 < x < 7
$SIpH = -181 + 82.4x - 6.05x^2$	for 7 ≤ x < 8.75
$SIpH = 536 - 77.0x + 2.76x^2$	for x > 5

Table 2 *Sub-index formula [7]*

Sub-Index and Water Quality Index	Index Range		
	Clean	Slightly Polluted	Polluted
Biochemical Oxygen Demand (BOD)	91-100	80-90	0-79
Ammoniacal Nitrogen (AN)	92-100	71-91	0-70
Total Suspended Solids (TSS)	76-100	70-75	0-69
Water Quality Index (WQI)	81-100	60-80	0-59

Table 3 *Water classes and uses [7]*

Class	Uses	Range
Class I	Conservation of the natural environment	>92.7
	Water Supply I – Practically no treatment necessary	
	Fishery I – Very sensitive aquatic species	
Class IIA	Water Supply II – Conventional treatment required	76.5-92.7
	Fishery II – Sensitive aquatic species	
Class IIB	Recreational use with body contact	76.5-92.7
Class III	Water Supply III – Extensive treatment required	51.9-76.5
	Fishery III – Common, of economic value and tolerant species; livestock drinking.	
Class IV	Irrigation	31.0-51.9
Class V	None of the above	<31.0

3. Results and Discussion

3.1 Water Quality Monitoring

Temperature, DO, pH, BOD, COD, AN, and TSS of Tasik Kemajuan were meticulously measured and analysed as part of a comprehensive water quality monitoring activity. Fig. 3 delineates the water temperature measurements collected from Tasik Kemajuan over 10 weeks, encompassing data points from three locations within the water body. The average temperatures recorded at these positions were as follows: for Point 1, it was 28.55±1.31°C; for Point 2, 28.47±1.38°C; and for Point 3, 28.47±1.36°C. According to the NWQS, the temperature threshold for Class IIB aquatic environments should not surpass a limit of 28+2°C. Analysing the compiled data to these guidelines, it is evident that the temperature conditions within Tasik Kemajuan comply with the established NWQS criteria for water temperature. Temperature significantly influences factors, including palatability, viscosity, solubility, odours, and chemical reactivity. Consequently, procedures such as sedimentation and chlorination, alongside assessing BOD, demonstrate a reliance on temperature variations [14].

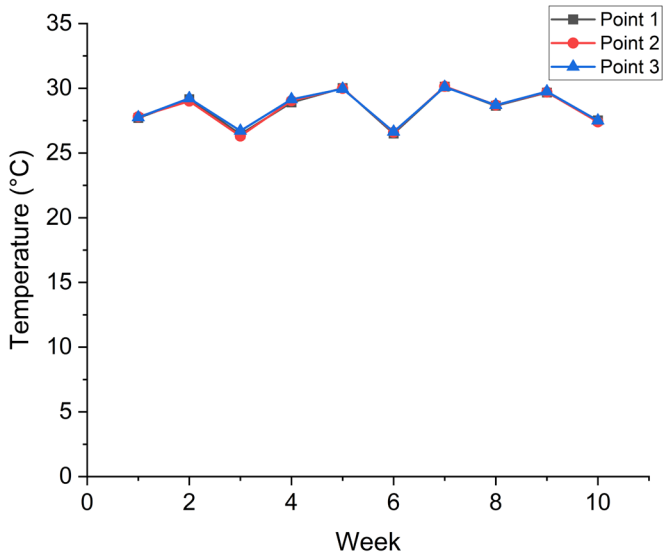

Fig. 3 *Water temperature of Tasik Kemajuan for 10 weeks*

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Fig. 4 presents the results of pH evaluations conducted at Tasik Kemajuan over 10 weeks. The assessments were carried out at three distinct points, with the findings indicating average pH levels of 6.12±0.44 for Point 1, 6.60±0.41 for Point 2, and 6.62±0.38 for Point 3, respectively. These recorded pH levels fall within the acceptable range of 6.0 to 8.5 for preserving typical freshwater ecosystems, as mentioned by Adu & Oyeniyi [15]. According to the NWQS, the pH level of water for Class IIB, used for recreational activities involving body contact, must be within the range of 6 to 9. The pH levels measured over ten weeks at Tasik Kemajuan consistently fell within this acceptable range of 6 to 9, as per the NWQS guidelines. There is no substantial difference between the pH value of this study and that of a study conducted by Miswan et al. [16] in Tasik Teknologi, UTHM, which is 6.51. The pH levels of Varsity Lake [9] and Tasik Embayu [10] were measured at 7.80 and 6.36, respectively. Both values meet the NWQS standard, similar to the lake observed in this study.

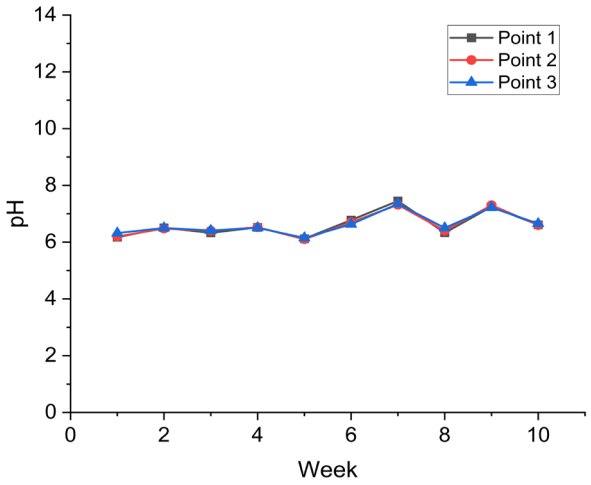

Fig. 4 *pH of Tasik Kemajuan for 10 weeks*

Fig. 5 displays the DO concentration in Tasik Kemajuan for ten weeks. The mean DO levels were recorded as 4.01±0.41 mg/L at Point 1, 4.03±0.45 mg/L at Point 2, and 4.03±0.44 mg/L at Point 3. According to the NWQS, the recommended DO concentration for Class IIB water bodies should fall between 5 mg/L and 7 mg/L. The observed DO levels in Tasik Kemajuan fall below the minimum recommended level of 5mg/L, indicating non-compliance with NWQS standards. The DO concentration of Tasik Kemajuan can be classified as Class III based on NWQS because all the values fall between 3 to 5 mg/L. When the DO concentration falls below 5-6 mg/L in freshwater, aquatic organisms experience hypoxic conditions [17]. The DO level identified in this study differs from the findings of a study by Miswan et al. [16], where the DO concentration in Tasik Teknologi was reported as 9.4±0.4 mg/L. This result indicates that the DO concentration in Tasik Kemajuan is comparatively lower. However, the DO concentrations in Engineering Lake (0.77 mg/L) and Serumpun Lake (0.84 mg/L) were lower than Tasik Kemajuan's DO [11]. Those lakes can be classified in Class V.

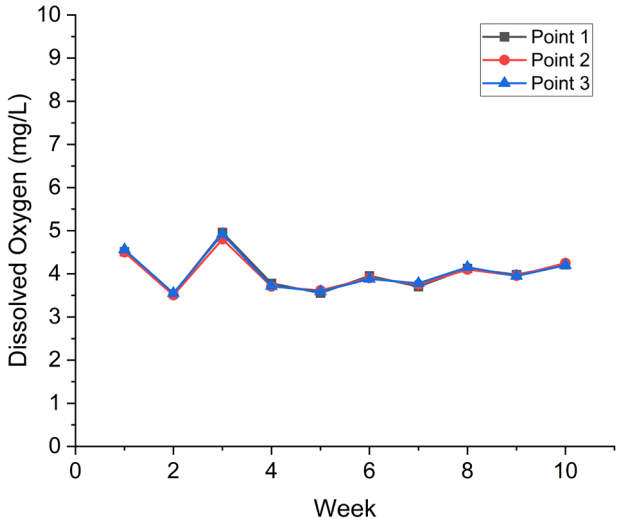

Fig. 5 *DO of Tasik Kemajuan for 10 weeks*

Data on the BOD_5 at Tasik Kemajuan was gathered over ten weeks, as illustrated in Fig. 6. This data encompasses measurements from three specific locations within the lake, referred to as Point 1, Point 2, and Point 3. The mean BOD_5 levels at these points were recorded as 10.04±1.73 mg/L, 9.43±1.22 mg/L, and 9.78±2.43 mg/L, respectively. According to the NWQS, the BOD_5 level in water bodies is classified as Class IIB, and it is set for recreational activities involving body contact, which should not surpass 3 mg/L. The BOD_5 readings from Tasik Kemajuan did not meet these NWQS guidelines, with all observed values significantly exceeding the 3 mg/L threshold. The BOD_5 value for Tasik Kemajuan can be classified as Class IV, which is unsuitable for recreational activities. The elevated BOD_5 levels in Tasik Kemajuan could originate from organic materials entering the lake. This includes runoff from the land, leaves, cut grass, garden debris, and waste from cafeterias. The increase in BOD_5 is mainly due to biodegradable substances found in water, like sewage, runoff from agriculture, and rotting plant matter, which all add to the problem [18]. A BOD_5 level below 1 mg/L indicates high water quality, whereas a level above 12 mg/L suggests poor water quality [19]. The BOD_5 level in this lake was found to be lower compared to the BOD_5 level in Tasik Teknologi, which was 105.7±0.42 [16]. In a manner akin to Engineering Lake and Serumpun Lake, the BOD_5 levels in both lakes were higher than Tasik Kemajuan, with BOD_5 values recorded at 78.33 mg/L and 48.6 mg/L, respectively [11]. Tasik Teknologi, Engineering Lake and Serumpun Lake might receive more organic waste than Tasik Kemajuan, and these organic materials increase the BOD_5 as microorganisms consume more oxygen to decompose them.

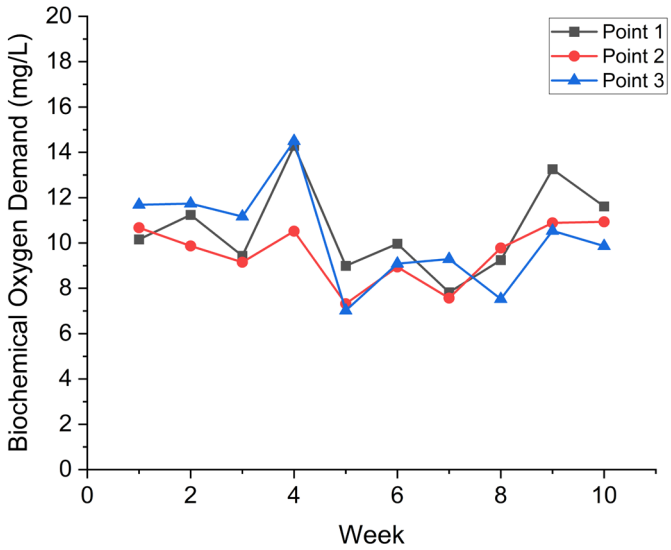

Fig. 6 *BOD_5 of Tasik Kemajuan for 10 weeks*

The data regarding the COD for Tasik Kemajuan was documented over 10 weeks, as depicted in Fig. 7. This data encompasses measurements from three specific locations within the lake, labelled as Point 1, Point 2, and Point 3. The average COD measurements for these locations were recorded as 22.55±4.59 mg/L, 21.60±3.98 mg/L, and 21.65±4.51 mg/L, respectively. According to the NWQS, the COD levels for Class IIB aquatic environments should not exceed 25 mg/L. The recorded average COD levels for Tasik Kemajuan fall within this guideline, indicating compliance with the NWQS, as they are all below the 25 mg/L threshold. The COD level in Tasik Kemajuan, at 21.93 mg/L, is higher than the 10.3 mg/L recorded in the previous study conducted in Tasik Teknologi [16]. However, a previous study conducted at UniSZA Lake [12] reported a COD value of 55.6 mg/L, which is higher, whereas Tasik Kemajuan exhibited a lower COD value. Compared to Engineering Lake and Serumpun Lake [11], this lake demonstrates a higher COD value than Tasik Kemajuan, with 212.4 mg/L and 212.63 mg/L, respectively.

Data regarding AN concentration in Tasik Kemajuan was gathered over 10 weeks. This information is depicted in Fig. 8, focusing on three specific locations within the lake: Point 1, Point 2, and Point 3. The average concentrations recorded at these locations were 0.60±0.14 mg/L, 0.60±0.14 mg/L, and 0.54±0.08 mg/L, respectively. These AN concentrations did not meet the standards set by the NWQS, which states that for Class IIB water bodies set up for recreational activities involving direct contact with water, the AN concentration should not surpass 0.3 mg/L. The AN concentration for Tasik Kemajuan can be classified in class III, which ranges from 0.3 to 0.9 mg/L. Effluent releases and agricultural runoff flow into water bodies, leading to a rise in ammonia concentrations. This increase in ammonia makes the water toxic to aquatic life, often resulting in their death [13]. The AN concentration in this lake was found to be lower compared to the AN concentration in Tasik Teknologi, which was 3.95±0.38 [16]. The concentration of AN observed in this study is lower than the average AN value of 0.91 mg/L reported for UniSZA Lake [12].

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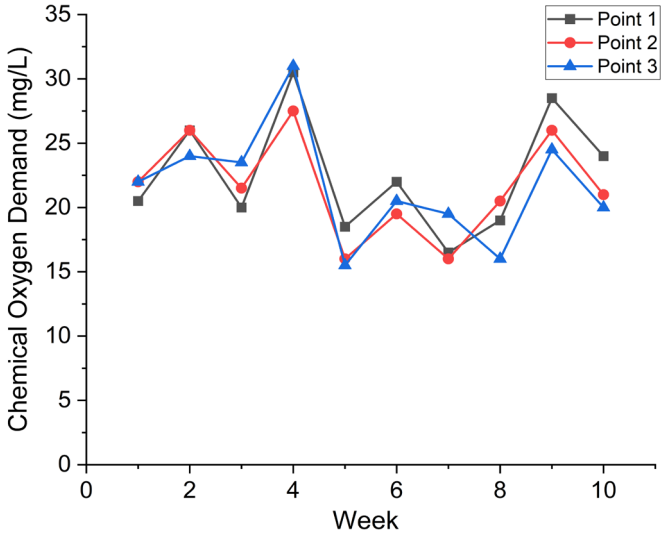

Fig. 7 *COD of Tasik Kemajuan for 10 weeks*

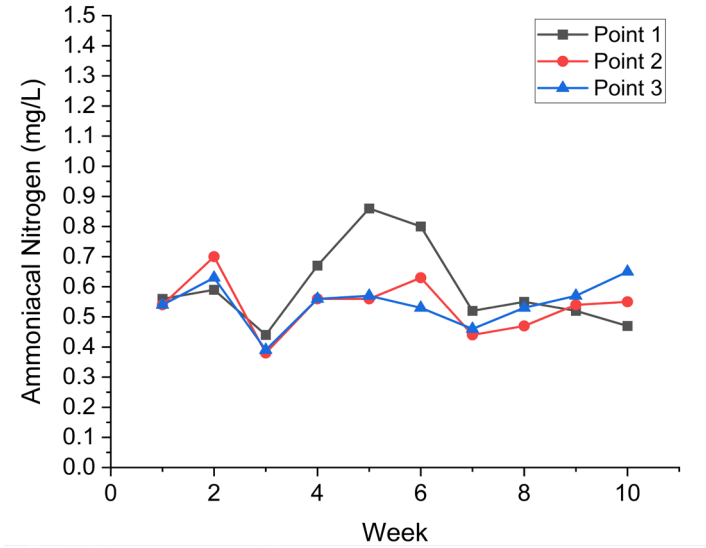

Fig. 8 *AN of Tasik Kemajuan for 10 weeks*

The TSS measurements for Tasik Kemajuan were recorded over 10 weeks, as depicted in Fig. 9. The average TSS concentrations at the designated sampling locations were 20.80±3.65 mg/L at Location 1, 19.90±3.25 mg/L at Location 2, and 20.30±2.62 mg/L at Location 3. According to NWQS, the TSS concentration in aquatic environments classified as Class IIB should not exceed 50 mg/L. The recorded TSS levels for Tasik Kemajuan consistently remained beneath this threshold, suggesting compliance with this parameter's NWQS criteria. Water quality is considered good if the TSS measure is below 25 mg/L, whereas a measure exceeding 300 mg/L indicates pollution in the water [13]. The TSS level in Tasik Kemajuan, at 20.33 mg/L, is quite similar to the previous study conducted in Varsity Lake, UM [9], which is 23.3 mg/L. Tasik Embayu was observed to have a higher TSS value of 62.81 mg/L, classifying it as Class III compared to Tasik Kemajuan [10]. According to a study conducted at UTHM on a different lake, Tasik Teknologi [16], there is no significant difference in the TSS values between this lake and Tasik Kemajuan.

3.2 Water Quality Index (WQI)

The WQI consolidates various water quality metrics into a singular numerical representation that encapsulates the general water quality condition. It is important to acknowledge that numerous other parameters influencing water quality are not encompassed within this index. Nevertheless, an index formulated from critical parameters offers a straightforward metric for assessing water quality. The sub-index values for BOD, AN, SS, and the overall WQI were assessed for Tasik Kemajuan, as shown in Table 4. The mean SIBOD was recorded at 62.50, categorising it as polluted, referring to NWQS. Similarly, the average SIAN stood at 61.22, also deemed polluted by NWQS criteria. Conversely, the SISS average was 85.90, reflecting a clean condition. Additionally, the WQI for Tasik

Kemajuan was found to be 73.46, which is considered slightly polluted. The overall WQI of Tasik Kemajuan can be classified as Class III. Based on the NWQS, the water may not meet the necessary criteria for recreational activities involving direct contact with the body, necessitating comprehensive treatment to render it safe. The WQI value of Tasik Kemajuan, 73.46, was comparable to that of Tasik Embayu, located in Tanjong Malim, Perak [10], which is 76.53 and classified as slightly polluted. The calculated WQI for UniSZA Lake [12], which falls within Class II and Class III, indicates that the water is suitable for recreational activities and supports the survival of aquatic organisms. Meanwhile, Engineering Lake and Serumpun Lake, UPM [11], have WQI values of 31.6 and 32.5, respectively, indicating that both lakes are polluted. Similar to Tasik Kemajuan, the water quality of Varsity Lake at UM is also classified as Class III according to the NWQS [9].

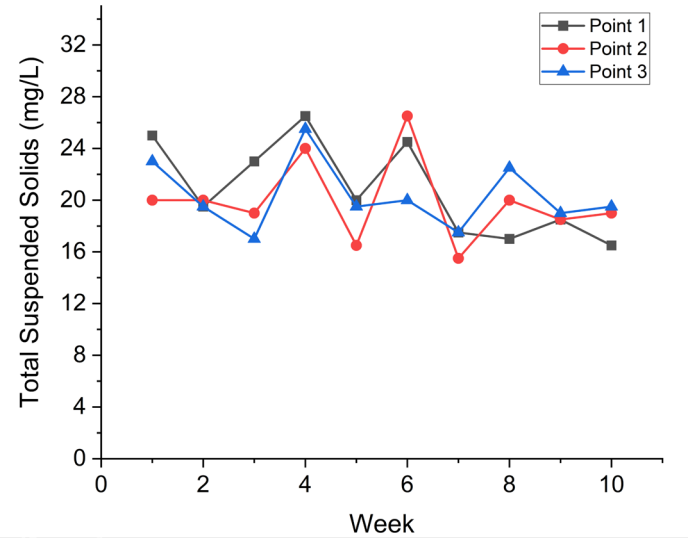

Fig. 9 *TSS of Tasik Kemajuan for 10 weeks*

Table 4 *Water quality classification based on WQI*

Sub-Index and Water Quality Index	Index	Status
Biochemical Oxygen Demand (BOD)	62.50	Polluted
Ammoniacal Nitrogen (AN)	61.22	Polluted
Total Suspended Solids (TSS)	85.90	Clean
Water Quality Index (WQI)	73.46	Slightly Polluted

4. Conclusion

The study findings suggest that the water quality in Tasik Kemajuan varies across different metrics. The water quality parameters, such as water temperature, pH, COD, and TSS, were all within the acceptable range, aligning with the standards of Class IIB as per the NWQS. However, the levels of DO and AN in Tasik Kemajuan did not adhere to the NWQS standards, resulting in the water being categorised as Class III for these specific parameters. Furthermore, the BOD values recorded in Tasik Kemajuan failed to meet the NWQS guidelines, placing it in Class IV. This classification denotes that the water is not fit for recreational purposes. The WQI for Tasik Kemajuan was observed to be marginally polluted over 10 weeks, with an average WQI of 73.46. The WQI of Tasik Kemajuan falls under Category III. Tasik Kemajuan does not fulfil the required standards for recreational activities involving direct human contact based on the NWQS, indicating that this lake needs monitoring and management activities to make the water safe for such uses.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***Study conception and design:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan, Zarina Md Ali;* ***Data collection:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan, Muhammad Aliff Iman Shamsudin;* ***Analysis and interpretation of results:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan, Zuhaib Siddiqui;* ***Draft manuscript preparation:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan. All authors reviewed the results and approved the final version of the manuscript.*

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