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Water Quality Monitoring for Trophic State of *Tasik Kemajuan*, Universiti Tun Hussein Onn Malaysia

Muhammad Hafiq Afifi Azman[1] , Rafidah Hamdan[1*], Zarina Md Ali[1], Zuhaib Siddiqui[2]

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

[2]CEC Geotechnical Pty Ltd,
8 Bullet Street North Parramatta NSW 2151, AUSTRALIA

*Corresponding Author

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Abstract: Aquatic ecosystems offer several ecosystem services, including water purification, nutrient recycling, flood reduction, groundwater recharge, irrigation, and animal habitats. One of the most prevalent challenges freshwater systems face globally is eutrophication. Eutrophication refers to the process of increasing the concentration of plant nutrients in water. The Carlson's Trophic State Index (CTSI) categorises an aquatic environment's eutrophication condition. The parameters exclusively employ three water quality parameters, which are Secchi Disc Transparency (SD), Total Phosphorus (TP), and Chlorophyll-a (Chl-a). Biological indicators refer to living organisms, such as plants and macroinvertebrates, that are implemented to identify and assess the presence of pollutants within a specific ecosystem. Therefore, this study focuses on the determination of trophic state and the assessment of biological indicators of Tasik Kemajuan. Water samples were collected for nine weeks using the composite sampling method for laboratory analysis. Water transparency was determined using a Secchi Disc. The Chl-a was determined by using the determination of chlorophyll-a using 90% methanol and measuring the absorption using a Hach DR6000 UV VIS Spectrophotometer at 663 nm and 750 nm, while the Total Phosphorus was determined by using USEPA[1] PhosVer® 3 with Acid Persulfate Digestion Method (Method 8190). Tasik Kemajuan exhibited eutrophic conditions over the duration of the nine-week period. The CTSI values exhibited a range of 60 to 80, thereby demonstrating that the water body under consideration is in a state of eutrophication. The Red Claw Crawfish (*Cherax Quadricarinatus*), Amona Prawn (*Caridina Multidentata*), Freshwater Snail (*Viviparidae*), Tiger Barb (*Puntius Tetrazona*), and Waterlily (*Nymphaeaceae*) are among the biological indicators found in Tasik Kemajuan. In conclusion, the analysis of the result shows that the Tasik Kemajuan is in an eutrophic condition, which has high amounts of algae growth, and the bottom waters are seriously depleted in oxygen.

Keywords: Carlson Trophic State Index, eutrophication, biological indicator, Chlorophyll-a, Total Phosphorus, Secchi Disc Transparency

1. Introduction

Aquatic ecosystems are known to provide a multitude of ecosystem services, which include but are not limited to the water purification process, recycling of nutrients, flood mitigation, groundwater recharge, irrigation, as well as the provision of habitats for diverse wildlife species (Ali *et al.*, 2023). Freshwater inputs influence benthic invertebrate

**Corresponding author: rafidahh@uthm.edu.my*

community structure by establishing substantial gradients in the environment. 90% of Malaysia's water supply comes from rivers, storage dams, and groundwater, which are the country's main sources of raw freshwater (Feisal *et al.*, 2023).

One of the most prevalent challenges freshwater systems face globally is eutrophication. Le Moal *et al.*, (2019) mentioned that the recognition of the eutrophication phenomenon began in the early 20th century in close proximity to major urban and industrial centres in industrialised countries located in the northern hemisphere. During the period spanning from the 1970s until the 1990s, the public initiatives in these nations were primarily centred around addressing the management of both industrial and domestic pollution on the environment. Eutrophication refers to the process of increasing the concentration of plant nutrients in water. Although eutrophication may happen naturally, it is typically linked to human-caused nutrient inputs (Mishra & Tripathi, 2023). Le Moal *et al.*, (2019) also mentioned that anthropogenic eutrophication refers to the excessive production of organic matter caused by human activities that introduce phosphorus and nitrogen into the environment. Despite sharing identical mechanisms, the two terms entail processes that take place on distinct time scales, resulting in disparate ecological as well as social consequences.

Algae growth, resulting from human activities, has become a prevalent issue, causing significant environmental impact. Various water-related ecological problems, including eutrophication, hypoxia, and harmful algal blooms in waterways, estuaries, and seas, have been well-documented as consequences of these activities (Han *et al.*, 2021). Ali *et al.*, (2023) mentioned that the event of eutrophication encounters deleterious effects on both the overall quality of water and the well-being of aquatic life.

The trophic state index has become widely adopted as an approach to evaluating the environmental state of aquatic ecosystems due to its simplicity and reliance on a limited number of parameters. The parameters exclusively employ three water quality parameters, which are Secchi Disc Transparency (SD), total phosphorus (TP), and chlorophyll-a (Chl-a). These parameters have been identified as the primary factors that impact the state of eutrophication. The parameters possess effectiveness in the assessment of eutrophication due to their observed correlations. The Carlson's Trophic State Index (CTSI) offers a straightforward and unified framework for categorising the eutrophication status of an aquatic environment, with the intention of facilitating comprehension among the relevant parties involved (Opiyo *et al.*, 2019).

Biological indicators refer to living organisms, such as plants, animals, and microorganisms, that are implemented to identify and assess the presence of pollutants within a specific ecosystem. The term "Biological indicators" refers to a comprehensive term encompassing all biotic and abiotic responses associated with alterations occurring within a specific ecosystem. They are commonly employed to discern and indicate adverse or beneficial impacts in ecological settings. These can also be utilised for the purpose of identifying alterations in ecosystems resulting from pollution occurrences that may have an impact on the biodiversity present within those ecosystems (Zaghloul *et al.*, 2020).

2. Methodology of the Study

2.1 Study Area

The selection of *Tasik Kemajuan* as the study area was based upon the significant flow of pollutants originating from various sources that enter this particular lake. The area of this lake is 14780 m^2. When selecting the specific lake for this study, a comprehensive analysis was conducted, encompassing various factors such as the evaluation of point source and non-point source influences. Figure 1 shows the locations of the water sampling locations, denoted as 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).

Fig. 1 - Sampling location from the Google Image

2.2 Water Quality Sampling

Water samples were collected using the composite sampling method from the chosen study area, Tasik Kemajuan, for laboratory analysis, and the water samples were collected for 9 weeks. The pH, dissolved oxygen (DO), and temperature of the water were measured in situ using a Hanna Instrument HI98196 Multiparameter meter. Water transparency was measured using a Secchi Disc as shown in figure 2 and calculated using equation 1. Samples were collected and analysed for Chlorophyll-a (Chl-a) and Total Phosphorus (TP) at the Wastewater Engineering Laboratory at UTHM. The Chl-a was determined by using the determination of chlorophyll-a using 90% methanol and measuring the absorption using Hach DR6000 UV VIS Spectrophotometer at 663 nm and 750 nm, while the TP was determined by using USEPA[1] PhosVer® 3 with Acid Persulfate Digestion Method (Method 8190).

Fig. 2 - Secchi Disc are used to measure water transparency

$$\frac{Extinction\ Depth + Eruption\ Depth}{2} = Secchi\ Transparency\ Depth \qquad (1)$$

Where:
Extinction Depth = Point where Secchi Disc disappears
Eruption Depth = Point where Secchi Disc appears

2.3 Carslon's Trophic State Index

The Carlson's Trophic State Index (CTSI), which Carlson introduced in 1977, is a trophic index with a numerical range of 0 to 100. The estimation of algae biomass using this approach is widely recognised and serves as a means to classify the trophic state of a lake. The assessment of trophic condition heavily relies on the precise measurement of algae biomass and nutrient loading, as these measurements play a vital role in assessing the status of each trophic category. The lake was characterised by calculating the physical and chemical variables of chlorophyll-a (Chl-a), Total Phosphoros (TP), and Secchi Disc transparency (SD), as described in equations (2) to (4). The average TSI value can be calculated using Equation (5), and subsequently, the final value is going to be compared to the TSI value presented in Table 1.

$$TSI\ (SD) = 10(6 - (\ln \frac{SD}{\ln 2})) \qquad (2)$$

$$TSI(Chl - a) = 10\left(\frac{6 - 2.04 - 0.68\ \ln Chl - a}{\ln 2}\right) \qquad (3)$$

$$TSI\ (TP) = 10(6 - (\ln \frac{48\ TP}{\ln 2})) \qquad (4)$$

$$CTSI = \frac{(TSI(SD) + TSI(Chl - a) + TSI(TP))}{3} \qquad (5)$$

Where:
SD = Secchi Disk Transparency (m)
Chl-a = Chlorophyll-a (μg/L)
TP = Total Phosphorus (μg/L)

Table 1 - Trophic State Index (TSI) for eutrophication (Carlson, 1977)

Trophic State Index (TSI)	Condition
<20	Oligotrophic, very low algal levels
≥20 ≤ 40	Mesotrophic condition with some algal turbidity. It could reduce aesthetic appeal in water, but not likely to be oxygen depletion.
≥ 40 ≤ 60	Mesotrophic condition with obvious algal turbidity. It also reduces aesthetic appeal in water. Oxygen depletion is likely to occur
≥ 60 ≤ 80	Eutrophic condition contains high levels of algal growth, and it is significantly reduced aesthetic appeal. There is a serious oxygen depletion in bottom waters.
≥ 80 + 100	Hypereutrophic.

2.4 Biological Indicator Monitoring

The determination of aquatic life was conducted using a portable fishing net with eight holes. The fishing net as shown in figure 3 was set up for a period of 8 hours in order to catch aquatic life inhabiting the lake. After a period of 8 hours, the aquatic life trapped in the net was identified by determining their common names as well as their associated scientific names. The sampling was conducted over a period of five weeks in order to ascertain the possible existence of aquatic life in the lake. Regular monitoring of the aquatic plants surrounding the lakes is also conducted.

Fig. 3 - Portable fishing net with eight holes

3. Results and Discussion

3.1 Water Quality

3.1.1 pH, Dissolved Oxygen (DO) and Temperature

The study involves the measurement of water pH, dissolved oxygen (DO), and temperature. Figure 4 illustrates the DO that was measured for nine weeks during this study. The DO observed in *Tasik Kemajuan* varied between 2.88 mg/L to 4.81 mg/L. The values for DO, expressed as (mean ± standard deviation), were as follows: Week 1 (3.11 ± 0.02 mg/L), Week 2 (4.59 ± 0.05 mg/L), Week 3 (3.10 ± 0.03 mg/L), Week 4 (2.99 ± 0.02 mg/L), Week 5 (2.92 ± 0.04 m), Week 6 (3.83 ± 0.01 mg/L), Week 7 (4.20 ± 0.03 mg/L), Week 8 (4.78 ± 0.04 mg/L), and Week 9 (3.92 ± 0.04 mg/L). The dissolved oxygen (DO) concentration was found to be below 5 mg/L. This concentration is considered inadequate for the survival of aquatic organisms, and this happens due to the consumption of dissolved oxygen (DO) by the plant, leading to a decrease in the DO concentration in the water. The dissolved oxygen (DO) concentration in water is a crucial physical parameter. The presence of an adequate quantity of dissolved oxygen is imperative for maintaining the water's quality. Aquatic life forms need oxygen for their survival and optimal functioning within aquatic environments. The measurement of DO is widely recognised as a crucial parameter, playing an essential role in the maintenance of aquatic ecosystems and contributing to various metabolic processes (Abouelsaad *et al.*, 2022).

The measurement of pH is widely recognised as a critical factor in assessing the quality of water. The term "pH" is commonly identified as the negative logarithm of the concentration of hydrogen ions. Figure 5 illustrates the pH that was measured for nine weeks during this study. The pH observed in *Tasik Kemajuan* varied between 6.37 to 7.57. The values for pH, expressed as (mean ± standard deviation), were as follows: Week 1 (6.42 ± 0.06), Week 2 (7.21 ± 0.17), Week 3 (6.89 ± 0.06), Week 4 (7.02 ± 0.06), Week 5 (6.87 ± 0.05), Week 6 (7.01 ± 0.02), Week 7 (6.84 ± 0.03), Week 8 (7.56 ± 0.01), and Week 9 (7.31 ± 0.01). The data indicates that the pH level was slightly below 6.5 only during week 1. The recommended pH range for water consumption in domestic settings and for the sustenance of living organisms is typically between 6.5 and 8.5 (Hassan Omer, 2020). Pollution has a tendency to alter the pH levels of water, thereby posing a threat to the aquatic flora and fauna inhabiting such ecosystems. Many aquatic organisms, including both animals and plants, have developed adaptations to thrive under particular pH conditions within water. Despite the fact that a minor alteration in pH levels may result in detrimental effects on these organisms. The presence of water with a moderate level of acidity, characterised by a low pH, has the potential to adversely affect various aspects of aquatic life (Hassan Omer, 2020).

Figure 6 illustrates the profile of the temperature that was measured for nine weeks during this study. The temperature observed in *Tasik Kemajuan* varied between 24.94˚C to 31.13˚C. The values for temperature, expressed as (mean ± standard deviation), were as follows: Week 1 (28.94 ± 0.25 ˚C), Week 2 (26.87 ± 0.19 ˚C), Week 3 (29.03 ± 0.23 ˚C), Week 4 (30.12 ± 0.43 ˚C), Week 5 (30.88 ± 0.22 ˚C), Week 6 (28.21 ± 0.01 ˚C), Week 7 (24.97 ± 0.03 ˚C), Week 8 (25.79 ± 0.02 ˚C), and Week 9 (28.55 ± 0.04 ˚C). Temperature has an impact on various factors such as palatability, viscosity, solubility, odors, and chemical reactions. Hence, the processes of sedimentation and chlorination, as well as the measurement of biological oxygen demand (BOD), exhibit a dependence on temperature. Furthermore, it exerts an influence on the biosorption mechanism of heavy metals that are present in aqueous solutions (Hassan Omer, 2020). The temperature of water bodies can undergo natural fluctuations as a result of solar energy absorption as well as human-caused changes. Alterations in the water's temperature have a rapid effect on the spatial distribution of fauna, thereby leading to subsequent modifications in trophic interactions within a specific ecosystem (Wałkuska & Wilczek, 2010).

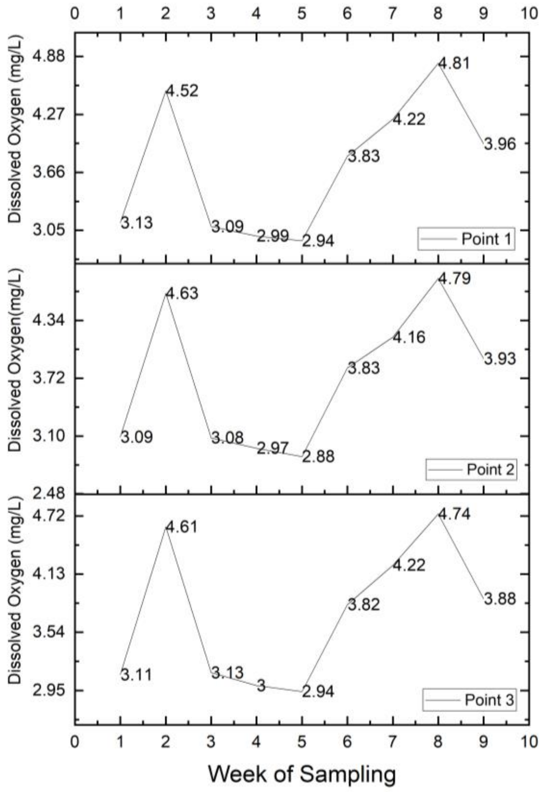

Fig. 4 - Profile of Dissolved Oxygen (DO)

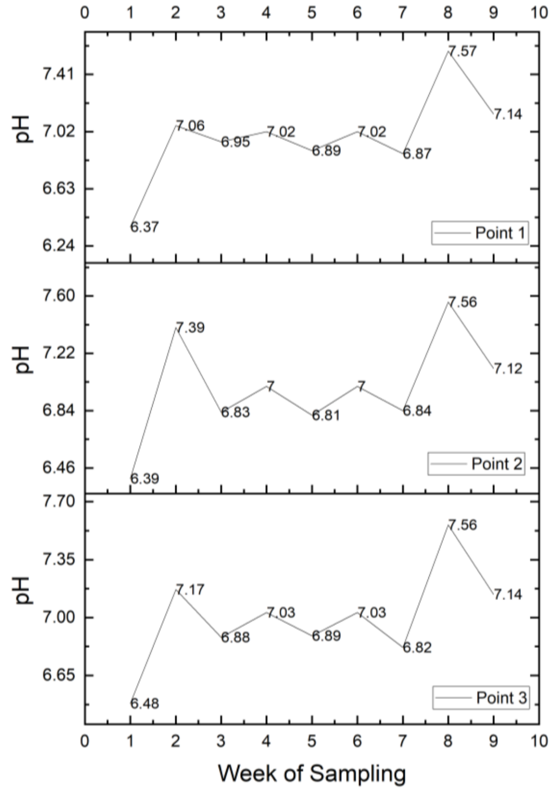

Fig. 5 - Profile of pH

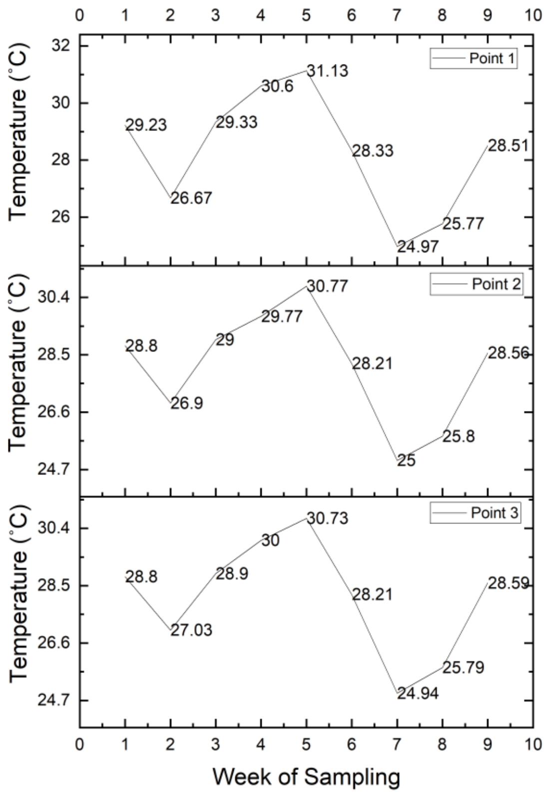

Fig. 6 - Profile of Temperature (ºC)

3.1.2 Secchi Disc Transparency (SD)

Table 2 depicts the Secchi Disc (SD) transparency in three-point samples, demonstrating the variation of transparency across different weeks. The SD transparency observed in *Tasik Kemajuan* varied between 1.27 m to 1.41 m. The values for transparency, expressed as (mean ± standard deviation), were as follows: Week 1 (1.38 ± 0.02 m), Week 2 (1.29 ± 0.01 m), Week 3 (1.31 ± 0.01 m), Week 4 (1.32 ± 0.04 m), Week 5 (1.33 ± 0.02 m), Week 6 (1.29 ± 0.02 m), Week 7 (1.31 ± 0.02 m), Week 8 (1.37 ± 0.02 m), and Week 9 (1.34 ± 0.01 m).

The measurement of water transparency using the Secchi Disc is a common practise in the fields of limnology and oceanography. Zeng *et al.*, (2020) stated that it provides crucial data for the evaluation of the quality of water and the determination of its trophic state. The biomass of algae (Chl-a) becomes a significant factor in SD in numerous eutrophicated lakes (Brezonik *et al.*, 2019). The Secchi Disc depth refers to the vertical distance at which the disc, when lowered into the water from the surface, becomes invisible to the observer. This measurement serves as an indicator of the body of water's transparency or downward visibility. The measurements of the Secchi Disc are contingent upon the intensity of light, water molecules, and optical components such as chlorophyll-a, as well as suspended matter. These parameters are of utmost importance in comprehending the fluctuations in the aquatic setting and the biogeochemical reactions that occur within it (Zeng *et al.*, 2020).

Based on Brezonik *et al.*, (2019) the application of SD is frequently employed as a proxy for determining the biomass of algae and trophic state. In numerous lakes, SD has proven to be a reliable indicator of trophic status on its own. SD can also serve as a valuable indicator for assessing the suitability of a water body for recreational purposes, as individuals frequently consider water clarity when determining its suitability for recreational activities.

Table 2 - Secchi Disc transparency for 3 points in 9 weeks

Week	Secchi Disc Transparency (m)		
	Point 1	Point 2	Point 3
1	1.36	1.37	1.41
2	1.30	1.30	1.28
3	1.29	1.32	1.31
4	1.34	1.34	1.27
5	1.34	1.31	1.32
6	1.31	1.30	1.27
7	1.34	1.30	1.30
8	1.39	1.36	1.35
9	1.35	1.33	1.33

3.1.3 Total Phosphorus (TP)

Table 3 illustrates the concentration of TP in three-point samples, revealing that the content of TP varies for each week. The TP concentrations observed in *Tasik Kemajuan* varied between 0.50 mg/L and 1.90 mg/L. The values for TP, expressed as (mean ± standard deviation), were as follows: Week 1 (1.70 ± 0.13 mg/L), Week 2 (1.18 ± 0.08 mg/L), Week 3 (1.40 ± 0.05 mg/L), Week 4 (1.17 ± 0.08 mg/L), Week 5 (1.48 ± 0.06 mg/L), Week 6 (1.15 ± 0.05 mg/L), Week 7 (0.55 ± 0.02 mg/L), Week 8 (0.56 ± 0.01 mg/L), Week 9 (0.52 ± 0.02 mg/L). The aforementioned values are indicative of eutrophic conditions, characterised by heightened nutrient concentrations and augmented biological productivity.

Phosphorus (P) has become a vital nutrient for the sustenance of both plant and animal life. However, excessive presence of phosphorus in aquatic ecosystems can expedite the process of eutrophication (Chanamé-Zapata *et al.*, 2020). Wojtkowska & Bojanowski, (2021) stated that the introduction of an excessive amount of nutrients, specifically P, into reservoirs and watercourses as a consequence of human activities, along with additional variables such as hydrological changes, alterations in temperature, or changes in insolation, can lead to the occurrence of eutrophication. Eutrophication is characterised by the substantial accumulation of organic matter originating from aquatic plants and the excessive growth of algae.

Opiyo *et al.*, (2019) mentioned that the assessment of the trophic state of aquatic environments is commonly conducted using TP, which is considered to be the most appropriate and extensively utilised parameter for this objective. The fact that P is the most constraining nutrient in aquatic environments in comparison to nitrogen is the basis for its importance and integration into Carlson's trophic state index.

Table 3 - Total Phosphorus concentration for 3 points in 9 weeks

Week	Total Phosphorus (mg/L)		
	Point 1	Point 2	Point 3
1	1.85	1.60	1.65
2	1.20	1.25	1.10
3	1.45	1.40	1.35
4	1.25	1.15	1.10
5	1.55	1.45	1.45
6	1.20	1.15	1.10
7	0.58	0.55	0.54
8	0.57	0.55	0.56
9	0.54	0.52	0.49

3.1.4 Chlorophyll-a (Chl-a)

Table 4 represents the concentration of Chlorophyll-a (Chl-a) in three-point samples, demonstrating the fluctuation in Chl-a levels across different weeks. The observed concentrations of Chl-a in *Tasik Kemajuan* exhibited a range of values spanning from 0.50 µg/L to 1.90 µg/L. The values for Chl-a, expressed as (mean ± standard deviation), were as follows: Week 1 (67.10 ± 9.92 µg/L), Week 2 (49.78 ± 7.50 µg/L), Week 3 (38.96 ± 6.49 µg/L), Week 4 (43.29 ± 13.52 µg/L), Week 5 (45.45 ± 6.49 µg/L), Week 6 (41.13 ± 9.92 µg/L), Week 7 (34.63 ± 9.92 µg/L), Week 8 (41.13 ± 3.75 µg/L), Week 9 (41.13 ± 9.92 µg/L). The concentration of total phosphorus (TP) plays a significant role in the regulation of Chl-a in aquatic environments (Mamun *et al.*, 2021). Therefore, the management of phosphorus loading was identified as a crucial measure to implement to mitigate the biomass of algae and effectively address eutrophication.

Chl-a is widely recognised as a suitable indicator for estimating phytoplankton biomass in main productivity studies (Guo *et al.*, 2022). Chl-a, a green photosynthetic pigment, is present in algae and serves as a valuable indicator for assessing the density (biomass) of the phytoplankton community. A higher level of chlorophyll-a serves as a signal of water quality pollution, making it a prominent marker for assessing the trophic status of aquatic ecosystems (Opiyo *et al.*, 2019).

Table 4 - Chlorophyll-a (Chl-a) for 3 points in 9 weeks

Week	Chlorophyll-a (µg/L)		
	Point 1	Point 2	Point 3
1	64.94	77.92	58.44
2	45.45	45.45	58.44
3	38.96	32.47	45.45
4	32.47	58.44	38.96
5	38.96	45.45	51.95
6	32.47	38.96	51.95
7	25.97	32.47	45.45
8	38.96	38.96	45.45
9	32.47	38.96	51.95

3.2 Carlson's Trophic State Index (CTSI)

Based on the data presented in Table 5, it consistently indicates that *Tasik Kemajuan* exhibited eutrophic conditions over the duration of the nine-week period. The Carlson Trophic State Index (CTSI) values exhibited a range of 60 to 80, thereby demonstrating that the water body under consideration is in a state of eutrophication. This phenomenon is distinguished by an abundance of nutrients, particularly phosphorus, resulting in heightened algae proliferation and decreased water transparency. The eutrophic condition is characterised by elevated levels of algae growth, which leads to a notable decrease in visual appeal. The bottom waters are experiencing a significant depletion of oxygen.

In summary, the observed patterns of consistent eutrophic trophic status, elevated phosphorus levels, higher chlorophyll-a concentrations, and relatively low water clarity over the course of nine weeks suggest the occurrence of enrichment of nutrients and overgrowth of algae. The aforementioned findings underscore the imperative need for implementing strategies aimed at effectively managing and mitigating the influx of nutrients into the aquatic environment. The implementation of appropriate agricultural practises, treatment of wastewater, and land-use planning can effectively mitigate the adverse impacts of eutrophication and preserve the overall well-being and equilibrium of the aquatic environment.

Table 5 - Carlson's Trophic State Index for *Tasik Kemajuan* in UTHM

Week	CTSI	Trophic Status	Condition
1	79.51	Eutrophic	Eutrophic condition contains high levels of algal growth, and it is significantly reduced aesthetic appeal. There is a serious oxygen depletion in bottom waters.
2	77.08	Eutrophic	
3	76.96	Eutrophic	
4	76.40	Eutrophic	
5	77.78	Eutrophic	
6	76.30	Eutrophic	
7	72.10	Eutrophic	
8	72.54	Eutrophic	
9	72.02	Eutrophic	

3.3 Biological Indicators

The outcomes of the assessment that was carried out after a 5-week sampling period indicate the existence of several biological indicators in *Tasik Kemajuan*, namely the Red Claw Crawfish (*Cherax Quadricarinatus*) in figure 7, Amona Shirmp (*Caridina Multidentata*) in figure 8, Freshwater Snail (*Viviparidae*) in figure 9, Tiger Barb (*Puntius Tetrazona*) in figure 10, and Waterlily (*Nymphaeaceae*) in figure 11.

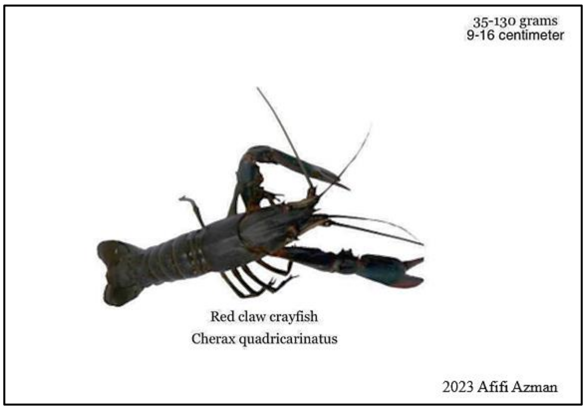

Fig. 7 - Red Claw Crawfish (*Cherax Quadricarinatus*)

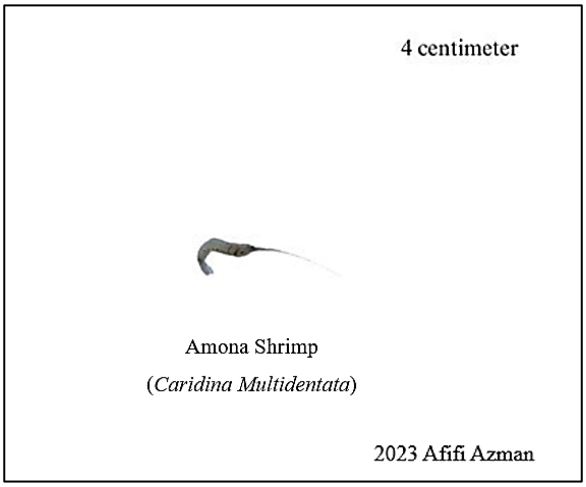

Fig. 8 - Amona Shrimp (*Caridina Multidentata*)

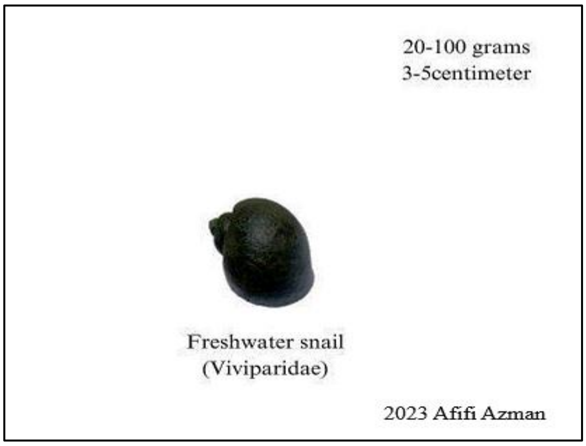

Fig. 9 - Freshwater Snail (*Viviparidae*)

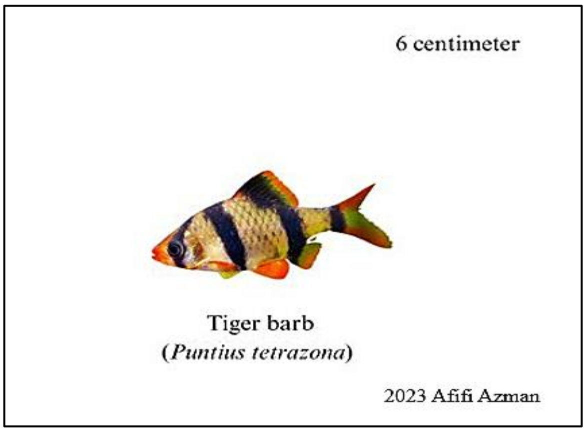

Fig. 10 - Tiger Barb (*Puntius Tetrazona*)

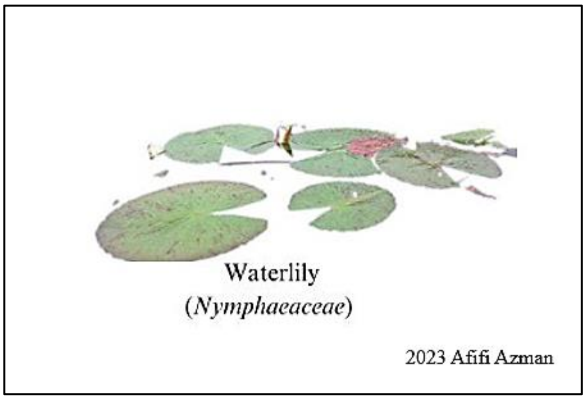

Fig. 11 - Waterlily (*Nymphaeaceae*)

An indicator species is defined as a species that can provide insights into the state of an area of concern, such as its habitat, health of the community, integrity of the ecosystem, or pollution levels, based on its existence, absence, or abundance. A species of indicator serves as a prognosticator for alterations in conditions in the environment due to their heightened sensitivity compared to other species within an ecological system. Biological indicators exhibit prompt responsiveness to alterations in the environment and are extensively employed in the evaluation and surveillance of various categories of undisturbed and disrupted ecosystems. The presence of contamination can be inferred from various alterations in the structure and function of species, populations, communities, relative density, frequency, and abundance. The existence or absence of a specific species can serve as an indicator of beneficial or detrimental alterations within its respective ecological systems. (Ali Ansari *et al.*, 2017).

Crayfish are recognized for their susceptibility to freshwater contamination. Due to their susceptibility to variations in water quality, these creatures exhibit a strong capacity to adapt to alterations within aquatic ecosystems. Crayfish have been extensively employed as bioindicators in both aquatic environments and controlled laboratory settings. These organisms exhibit a propensity for the accumulation of pollutants in their tissues and provoke reactions to various substances. Consequently, there exists a possibility for their utilization as bioindicators in the context of practical monitoring within industrial settings (Malinovska *et al.*, 2019).

The pattern of distribution of macrophytes was primarily influenced by the level of nutrients such as Total Nitrogen and Total Phosphorus, chlorophyll-a, suspended matter, dissolved oxygen, and pH. Macrophytes, including submerged, floating-leaved, free-floating, and emergent species, play a substantial role in influencing water body hydrology and sediment dynamics. Moreover, they offer an effective solution for revitalising eutrophic aquatic environments by absorbing excessive nutrients and stimulating microbial behaviour. The presence of floating-leaved macrophytes in eutrophic shallow lakes has been found to have a major influence on algal abundance, turbidity, along with water transparency (Wang *et al.*, 2022).

Kumari & Kumar Paul, (2020) mentioned that particular aquatic animals and zooplankton effectively perform their role of monitoring the environment in the water. Contaminants such as heavy metals, pesticides, and radioactive pollution can be readily observed. One example of effective observation of metal pollution is the use of buildup indicators such as molluscs like freshwater snails. Mo *et al.*, (2017) stated that freshwater snails serve as a prevalent component of the invertebrate assemblage within aquatic environments. Past studies have demonstrated that the inclusion of snails in aquatic environments has a positive impact on the transparency of water. By excreting compounds that foster the process of coagulation in suspended particles. Nevertheless, alternative scholarly perspectives propose that the behaviours exhibited by snails have the potential to lead to the resuspension of sediment, leading to an increased discharge of nutrients into water bodies, thus exacerbating the issue of eutrophication (Mo *et al.*, 2017).

Susilo *et al.*, (2020) mentioned that the freshwater shrimp is classified as an invertebrate species that commonly resides in tropical freshwater environments. Its existence plays a significant role in both the trophic structure and the cycling of nutrients. Freshwater shrimps are found in various aquatic environments, including swamps, lakes, and watersheds, exhibiting a wide-ranging distribution structure. The aforementioned findings have significant effects on the presence and mechanisms of modification of the current environmental conditions. Changes at the level of species can occur as a consequence of internal responses to alterations in environmental conditions across various environments. Morphological differences manifest as a result of organisms adapting to a wide range of environmental conditions. Shrimp, as a macroinvertebrate, serve as indicators of the quality and state of equilibrium of an ecosystem of freshwater. The evaluation of specific macroinvertebrates can act as a valuable indicator for evaluating the water quality of a body of water (Susilo *et al.*, 2020).

Fish are widely acknowledged as biological indicators of environmental pollution, offering comprehensive perspectives into the condition of their surroundings over prolonged periods (Dietrich *et al.*, 2022). Fish have been highly susceptible to pollution owing to their diets and habitat preferences in aquatic environments, as they lack the ability to evade or avoid the harmful impacts of pollutants. Fish, when compared to invertebrates, exhibit greater sensitivity to various toxic substances and serve as an ideal model organism for assessing the overall health of ecosystems. Fish have been recognised as important biological indicators in aquatic environments for evaluating the extent of metal contamination. They possess distinct advantages in characterising the inherent properties of aquatic systems and evaluating alterations to environments (Okwuosa *et al.*, 2019).

4. Conclusion

In summary, the evaluation and comparison of trophic states through the application of Carlson's Trophic State Index (CTSI) play a pivotal role in the management of water quality and the process of making informed decisions. The application of this tool facilitates the assessment of the trophic state of UTHM Lake especially *Tasik Kemajuan*. According to the results of the study consistently indicates that *Tasik Kemajuan* exhibited eutrophic conditions over the duration of the nine-week period. The CTSI values exhibited a range of 60 to 80, thereby demonstrating that the lake under consideration is in a state of eutrophic. The findings of the analysis also indicate that *Tasik Kemajuan* UTHM is presently experiencing eutrophication, characterised by an overabundance of algae growth and nutrient concentrations that accelerate the process of eutrophication. In order to effectively tackle this issue, it is imperative to implement remedial measures and adopt appropriate management strategies. The UHTM’s authority can make well-informed decisions aimed at mitigating the effects of eutrophication and working towards enhanced standards of water quality of the lake. In conclusion, *Tasik Kemajuan* UTHM can be classified in eutrophic condition based on the analysis that was conducted in this study.

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