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Assessment of UMS Lake Recent Water Quality and its Suitability for Plant Watering

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Abstract: The Universiti Malaysia Sabah (UMS) Lake, located next to Faculty of Science and Technology, is a free water surface constructed wetland that was designed to treat stormwater in the main campus during its construction period in the late 1990s. Frequent treated pipe water supply interruptions in the campus have led to the consideration of UMS Lake as an alternative water supply for plant watering. This study was intended to investigate some recent water quality parameters to provide quick insight into the suitability of UMS Lake water for plant watering. Sampling points, which included the main inlet (S1), other inlets (S2 – S6) and the outlet (S7) were sampled during dry days to reduce interference from on-the-spot precipitation. Each water sample was analysed for its pH, dissolved oxygen (DO), total suspended solids (TSS), 5-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) and ammoniacal nitrogen (AN) content using Standard Methods for the Examination of Water and Wastewater as well as the Hach Procedural Manual. The pH, DO, TSS, BOD_5, COD and AN were in the range of 6.4 – 7.1, 3.2 – 7.8, 15 – 65, 0.3 –4.3, 1 – 43 and 0 – 5.2 mg/L, respectively. These results indicate that the water in UMS Lake did not exceed the Class IV Water Quality Index Classification and Use; thus, the water can be used for plant watering in the campus.

Keywords: UMS Lake; recent water quality parameters; Water Quality Index; plant watering

1. Introduction

In the late 1990s, when the Universiti Malaysia Sabah (UMS) main campus was under construction, a series of free water surface (FWS) constructed wetlands were created within its compound to manage stormwater and improve water quality. While most of these FWS constructed wetlands may appear to be silt water ponds, the largest was constructed next to the Faculty of Science and Technology. Due to its size and appearance, it is often referred to as the UMS Lake [1].

The frequent treated pipe water interruptions in the Kota Kinabalu district have affected the UMS main campus; therefore, UMS has sought to reduce its dependency on treated pipe water, making the search for an alternative water supply for plant-watering purposes an agenda. The

use of lake water for plant watering would improve UMS's UI GreenMetric performance under the criterion "Water Resource 3 (WR 3)," which emphasises the reduction of treated pipe water consumption [2]. With an area of 24,304 m^2, UMS Lake can be an alternative water source for non-potable use such as plant watering or landscape irrigation.

Nonetheless, prior to its utilisation, the lake water should be assessed. Considering that National Water Quality Standards (NWQS) Classification for Malaysia include 82 parameters, a faster and cost-effective way of assessment is to use the Water Quality Index (WQI) Classification and Use, which consists of six parameters, namely ammoniacal nitrogen (AN), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), pH and total suspended solids (TSS) (Table 1) [3]. As the intention was to use the lake water for plant watering, the focus was on Class IV, which is interpreted as suitable for irrigation use. For safeguarding purposes, the Food and Agriculture Organization (FAO) of the United Nations has established heavy metal limit for water intended for irrigation (Table 2) [4]. However, there is no mention of microplastics either in the WQI Classification and Use or in the FAO heavy metal limit for irrigation at present.

Table 1. Water Quality Index Classification and Use

Parameter	Unit	Class				
		I	II	III	IV	V
AN	mg/L	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
BOD	mg/L	< 1	1 – 3	3 – 6	6 – 12	> 12
COD	mg/L	< 10	10 – 25	25 – 50	50 – 100	> 100
DO	mg/L	> 7	5 – 7	3 – 5	< 3	< 1
pH	-	> 7	6 – 7	5 – 6	< 5	> 5
TSS	mg/L	< 25	25 – 50	50 – 150	150 – 300	> 300

Class	Use
I	Conversation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
II	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species. Recreational use with body contact.
III	Water Supply III – Extensive treatment required. Fishery III – Common of economic value and tolerant species; livestock drinking.
IV	Irrigation.
V	None of the above.

Chong et al. [5] have previously assessed the heavy metal content, namely copper, cadmium, zinc, lead, nickel and chromium, in UMS Lake water. Copper, cadmium, lead and chromium were below the detection limit, while zinc and nickel were in the range of 0.000 – 0.004 and 0.000 – 0.010 mg/L, respectively. Therefore, there was no issue of non-compliance with the FAO heavy metal limits for irrigation. As all UMS buildings are well monitored and maintained by UMS Development and Maintenance Office, and no renovation work bypasses this office, there is a very low possibility of laboratory discharge into the drainage system; thus, there is

unlikely any heavy metal introduction into the UMS Lake. In the light of this, and given the limited research budget, it was deemed unnecessary to reassess the presence of heavy metal in this study.

Table 2. FAO heavy metal limit for irrigation

Heavy metal	Maximum concentration (mg/L)
Cadmium, Molybdenum	0.01
Selenium	0.02
Cobalt	0.05
Arsenic, Beryllium, Chromium, Vanadium	0.1
Copper, Manganese, Nickel	0.2
Zinc	2.0
Lithium	2.5
Aluminium, Ferrum, lead	5.0

Recent work by Ali and Bolong [6], quickly assessed and found that the TSS level in the UMS Lake was classified as Class V. Nonetheless, the levels of AN, BOD, COD, DO and pH were not reported; thus, there exist a data gap. The objectives of this study were to quickly investigate the levels of AN, BOD, COD, DO, pH and TSS in the UMS Lake water and to assess its suitability for plant watering.

2. Materials and Methods

2.1. Study Area

The UMS Lake is located next to the Faculty of Science and Technology building in the UMS main campus, Kota Kinabalu, Sabah with a coordinate of 6° 1'50.59"N and 116° 7'16.12"E. The UMS Lake has an area of 24,304 m^2 according to the calculations performed using ArcMap v10.8.2 software. An aerial photo of UMS Lake, taken on 25th July 2024, was obtained from Google Earth and then digitised using ArcMap v10.8.2 software to produce Figure 1.

2.2. Water Sampling and Laboratory Analysis

Water samplings were conducted in May – July 2025 at selected sampling points (Figure 1) as indicated by the white arrows in Figure 2. While S1 and S7 were the main inlet and sole outlet of UMS Lake, S2 – S6 were easily accessible sampling points. Drainage water and stormwater from higher ground of the UMS main campus mostly flow into the lake via S1. These waters eventually exit the lake via S7 into Sungai Darau. There is a cemented jogging track in some parts of the lake, which enabled quick access for water samplings at S2 – S6. S2 and S3 received drainage water from Faculty of Science and Technology building and the Preparatory Centre for Science and Technology building, respectively, while S5 and S6 received drainage water from Faculty of Psychology and Social Work building.

At each sampling point, a 5 L water sample was collected into high density polyethylene (HDPE) container, of which was rinsed with the UMS Lake water prior to water sample collection via grab sampling. In-situ measurement was conducted using YSI Pro DSS multiparameter for dissolved oxygen (DO), total dissolved solid (TDS) and electrical conductivity (EC). These field activities (grab sampling and in-situ measurement) were conducted between 0700 and 0800 hrs during dry days to avoid dilution from on-the-spot precipitation.

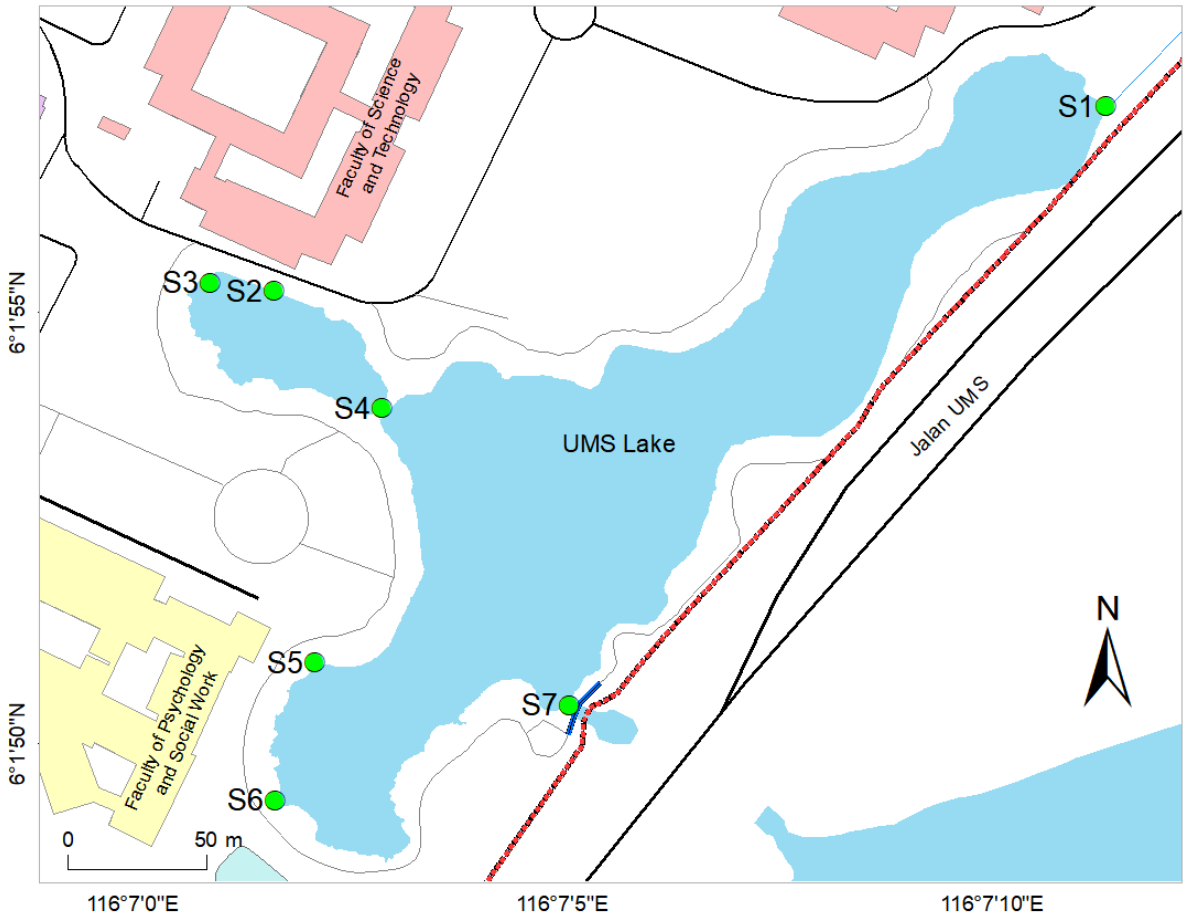

Figure 1. Sampling points in UMS Lake

All water samples were analysed within 2 h after collection in accredited laboratory. The TSS and BOD_5 were analysed according to the Standard Methods for the Examination of Water and Wastewater, Method 2540 D and Method 5210 B, respectively [7]. No dilution was employed for BOD_5 analysis, as the BOD_5 levels of UMS Lake were expected to be low. The COD and AN were analysed based on Hach Procedural Manual of Method 8000 (USEPA Reactor Digestion Method) and Method 8155 (Salicylate Method) which coupled with DR6000 spectrophotometer [8]. The COD and AN analyses utilised low-range COD digestion reagent vials and low-range ammonia salicylate and ammonia cyanurate powder pillows, respectively. No dilution was employed for COD; however, for AN analysis, the dilution factors employed are summarised in Table 3.

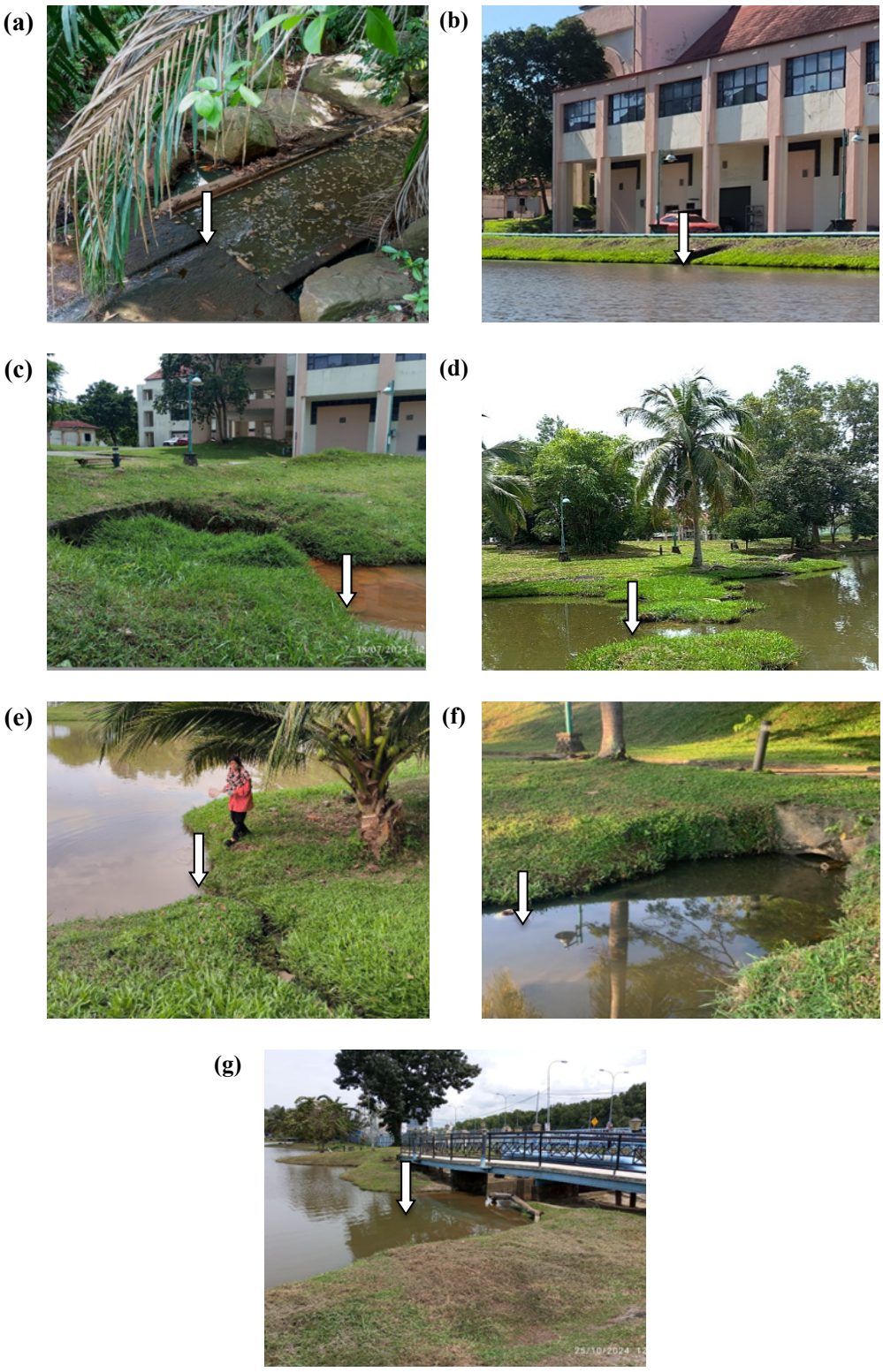

Figure 2. The exact sampling point at (a) S1, (b) S2, (c) S3, (d) S4, (e) S5, (f) S6 and (g) S7

2.3. Water Quality Index Classification and Use

Data obtained from the AN, BOD, COD, DO, pH and TSS analyses were compared to the WQI Classification and Use table (Table 1) to determine the water class and potential use of UMS Lake water at the specific sampling point. Due to the intention of this study, which focused on the application of the lake water for plant watering, Class I – IV were deemed suitable, while only Class V was considered unsuitable for plant watering.

Table 3. The dilution factor employed in 100 mL volumetric flask for AN analysis

Sampling point	Dilution factor
S1	50
S2	50
S3	50
S4	5
S5	5
S6	5
S7	5

3. Results and Discussion

3.1. Water Quality

The pH of all sampling points for May, June and July ranged from 6.35 to 7.13; this finding indicates that the UMS Lake was slightly acidic to near neutral. Sampling point S7 which was the outlet, had the most consistent neutral pH of 7.03 ± 0.02 which was not surprising as the lake was a functional FWS constructed wetland. The DO level varied between 3.17 to 7.75 mg/L, with S7 exhibiting the highest mean DO of 6.79 ± 4.49 mg/L which further indicated the functionality of the lake as a FWS constructed wetland. The pH, DO, TSS, BOD_5, COD and AN levels of the UMS Lake water were summarised in Figure 3.

The TSS concentration ranged from 15.2 mg/L to 64.6 mg/L, where the water that entered S2 loaded the highest level of TSS into UMS Lake in comparison to the water that entered the main inlet (S1). This anomaly was caused by construction work to manage eroded soil under the building in the perimeter of Faculty of Science and Technology during the sampling period. Due to the nature of FWS constructed wetland design, settled TSS eventually becomes sludge and should be removed periodically to maintain its functionality. The removed sludge can be mixed with agricultural waste or manure to produce compost as an effort towards valorisation [9–12].

The BOD_5 was consistently very low to low, at 0.25 mg/L – 4.31 mg/L throughout the study period. This finding was consistent with field observations, where the BOD sources were leaves litter and detritus from the vicinity that entered the drainage system and eventually ended up in the lake. For COD, the value ranged from 1 to 42.5 mg/L and considered low to moderate for lake water. Anomalies were observed at S2 and S5, which had approximate COD mean of 25 mg/L. Both S2 and S5 received some dishwashing water from cafes operating in the Faculty of Science and Technology and Faculty of Psychology and Social Work buildings, respectively.

Throughout the study period, the mean AN varied from 0.36 to 2.79 mg/L. Due to the lake's design, where S1 and S3 were the largest and second largest inlets by input volume, both S1 and S3 had mean AN values above 2 mg/L. The mean AN of slightly more than 1 mg/L detected

at S2 was most likely attributed to residual fertiliser runoff from landscaping around the Faculty of Science and Technology compound. Mean AN values of approximately 0.5 mg/L at S4 and S7 demonstrated the functionality of the FWS constructed wetland. The results obtained indicated the potential of planting emergent ornamental plants such as *Canna austria* beside the lake, preferably in the vicinity of S1 and S3.

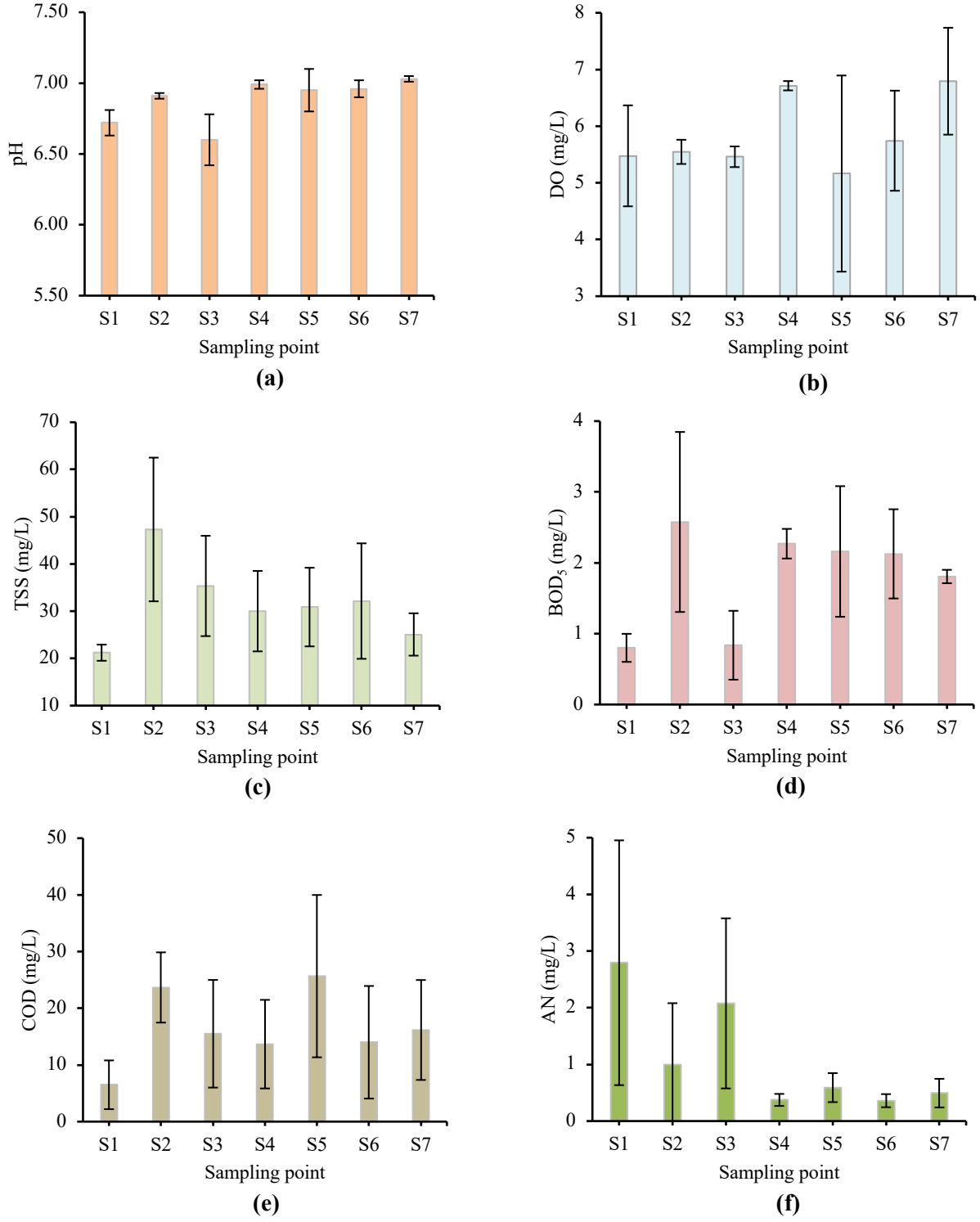

Figure 3. The levels of (a) pH, (b) DO, (c) TSS, (d) BOD_5, (e) COD and (f) AN of UMS Lake

The pH, DO, TSS, BOD, COD and AN data of the entire UMS Lake (S1 – S7) were computed and averaged into Table 4, to provide some relative comparison against data from other lakes and FWS constructed wetlands found locally in Malaysia. All lakes and FWS constructed wetlands had the pH of acid near neutral or alkali near neutral. The Engineering Lake and Serumpun Lake in Universiti Pertanian Malaysia showed lower DO but higher TSS, BOD and COD when compared to UMS Lake; this most likely because the lakes in Universiti Pertanian Malaysia received relatively more organic loads. The AN concentration in UMS Lake was comparable to those in Universiti Sains Malaysia Constructed Wetland and Putrajaya Wetlands, which indicated its functionality as a FWS constructed wetland.

Table 4. Relative comparison of local lake and FWS constructed wetland WQI parameters

Venue	Parameter (mg/L)						Reference
	pH	DO	TSS	BOD	COD	AN	
UMS Lake, Universiti Malaysia Sabah	6.88 (0.18)	5.84 (1.07)	31.70 (12.38)	1.80 (0.94)	16.45 (10.96)	1.1 (1.4)	This study
	-	-	628.4	-	-	-	[6]
	6.72 (0.36)	4.55 (0.50)	15.5 (7.4)	2.2 (0.5)	6.98 (2.14)	0.15 (0.1)	[5]
Teknologi Lake, Universiti Tun Hussein Onn	6.51 (0.10)	9.4 (0.4)	19.7 (0.6)	10.3 (9.0)	105.7 (0.4)	3.95 (0.38)	[13]
Engineering Lake, Universiti Pertanian Malaysia	7.28 (0.17)	0.77 (0.36)	66.07 (31.51)	48.6 (18.9)	212.63 (106.05)	0.42 (0.14)	[14]
Serumpun Lake, Universiti Pertanian Malaysia	7.20 (0.11)	0.84 (0.41)	60 (36.15)	78.2 (43.2)	212.40 (42.02)	0.37 (0.14)	
Universiti Sains Malaysia Constructed Wetland	7.18 (0.10)	8.07 (0.50)	0.0014	2.69 (0.34)	15.33 (8.24)	0.16 (0.97)	[15]
Cempaka Lake, Bandar Baru Bangi	6.63	3.24	6.75 (2.50)	0.97	22.17	2.46 (0.32)	[16]
Putrajaya Wetlands	6.85 – 7.65	2.5 – 5.02	7.2 – 73.2	-	0.38 – 1.65	0.21 – 1.67	[17]
	5.5 – 7.4	0.78 – 13.25	10.25 – 137.5	-	24 – 48.75	0.13 – 0.72	

Note: pH has no unit and number in parenthesis indicates standard deviation

3.2. Suitability of Water for Plant Watering

The water quality parameters analysed in this study provide a quick insight into the suitability of UMS Lake water for plant watering. The WQI Classification and Use (Table 1) and Salinity Classes (Table 5) were used as reference benchmarks to determine the suitability of UMS Lake water for plant watering.

Table 5. Classes of irrigation water salinity

Salinity class	EC (µS/cm)	TDS (mg/L)
Low	< 250	< 200
Medium	250 – 750	200 – 500
High	750 – 2250	500 – 1500
Very high	> 2250	> 1500

3.2.1. Water Quality Index Classification and Use Perspective

The WQI value and classifications of each sampling station are tabulated in Table 6, where none of the sampling stations was classified as Class V. In other words, all sampling stations were classified as Class III – IV, which were deemed suitable for plant watering. However, it is not advisable to withdraw water from S5 for plant watering, as its WQI of 41.88 ± 12.10 has a large standard deviation, indicating a risk of falling into Class V, which is not suitable for plant watering. Water for plant watering is therefore recommended to be withdrawn from the vicinity of S1, with the average WQI of 66.22 ± 6.97.

Table 6. The WQI value and classifications of UMS Lake throughout the study period

Description	WQI value						
	S1	S2	S3	S4	S5	S6	S7
May	57.86	45.89	62.03	64.82	39.53	64.06	63.54
June	65.88	59.32	58.02	60.33	57.73	61.09	63.81
July	74.92	62.94	62.84	56.33	28.38	42.18	46.65
Average	66.22 (6.97)	56.05 (7.34)	60.96 (2.11)	60.49 (3.47)	41.88 (12.10)	55.78 (9.69)	58.00 (8.03)
Class	III	III	III	III	IV	III	III

Note: Number in parenthesis denotes standard deviation

3.2.2. Salinity Perspective

The salinity of water for plant watering or irrigation can be categorised into four classes, namely low, medium, high and very high salinity (Table 5). Water classified as low to medium salinity is deemed suitable for plant watering [18]. Nonetheless, water categorised as high to very high salinity must not be used for plant watering, as its salts may accumulate at the plant roots and cause exosmosis [19].

Throughout the study duration, the UMS Lake collectively had EC and TDS measurements of 188.6 – 419.6 µS/cm and 168 – 287 mg/L, respectively (Figure 4); therefore, the lake water was collectively categorised as low to medium salinity which was considered suitable for plant watering. Taking the mean and standard deviation into account, S2 – S7 were consistently classified as medium salinity. S1, on the other hand, was consistently classified as low salinity, with mean EC and TDS values of 235.47 µS/cm and 145 mg/L, respectively. Thus, strategically, water for plant watering should be withdrawn from the vicinity of S1, as lower salinity poses a lower risk of salt accumulation in the root zone of plants [20].

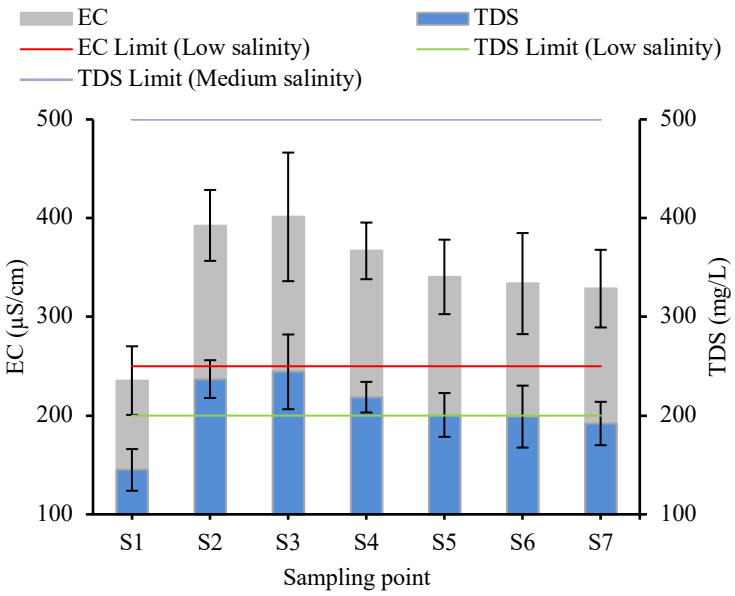

Figure 4. The EC and TDS level at UMS Lake

4. Conclusions

In this study, the results showed that UMS Lake water was classified as Class IV and above according to WQI Classification and Use, which indicates that it was suitable for plant watering. This was further supported from the salinity point of view, where the lake water was classified as low to medium salinity, which means it can be used for plant watering; the lower the salinity, the more suitable the water. The overall data suggested that, holistically, the best place to withdraw the lake water for plant watering was from S1. Considering that UMS has several other lakes within its campuses, these lake waters should be assessed in the future.

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Conflicts of Interest

The authors declared no potential conflicts of interest.

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