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Analysis of Hydrological Characteristics of River, Canal, and Lake: A Case Study Sun Ye In –Se Gon Area Sint Gaing and Kyaukse Townships, Mandalay Region

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ABSTRACT

Among the most significant branches of the Zawgyi River (ZGR) are the Thindwe dam (TDD), Thindwe canal (TDC), and Sun Ye In (SYI), all of which are known to be impacted by household and agricultural pollution. In this study, many physicochemical parameters (temperature, conductivity, salinity, TDS, pH, and ORP) were measured to assess the water quality of ZGR, TDD, TDC, and SYI. Between March 2024 and March 2025, water samples were taken from ZGR, which is situated at the bottom of SYI Lake, on average, ten times per month. All experimental data were gathered in the field and assessed as drinking water based on WHO (World Health Organization) and EC (European Communities) standards. The surface water's pH, temperature, ORP, TDS, and EC were distributed spatially. ArcGIS 10.7 was used to identify the seasons based on the water quality by using the spatial distribution of pH, temperature, ORP, TDS, and EC in the surface water. Additionally, TDS and EC accumulations in TDC water were found to be significantly greater than drinking water limitations.

INTRODUCTION

Natural ecosystems and human advancement depend on freshwater supplies, which are essential for industry, agriculture, and human survival in general (Tibebe et al., 2019). Freshwater lakes are valuable among these resources and are vital to ecosystems all around the world (Reynaud & Lanzanova, 2017). The great affinity of organic matter for metals through adsorption or complexation makes it the primary carrier of sediments (Bao et al., 2022; Duan et al., 2022; Förstner, 2020; Van Vliet et al., 2021). As a result, the conservation of water ecosystems greatly depends on the assessment of sediment pollution status(Tavakoly Sany et al., 2014; Xu et al., 2017). It is important to examine a vast quantity of physico-chemical and chemical water quality data for successful pollution control and helpful water resource management, which is often difficult to understand and draw meaningful conclusions (Dixon & Chiswell, 1996; Ferahtia, 2021; Koklu et al., 2010).

Today, fresh water quality is a major worldwide concern (du Plessis, 2022; Mishra, 2023; Van Vliet et al., 2021). Because of their function in removing runoff from land for farming and metropolitan and industrial waste products from their extensive drainage basins, streams are among the most susceptible water bodies to pollution(Jahan & Singh, 2023; Kumar et al., 2021; Tariq & Mushtaq, 2023). Prior research has demonstrated that incorporating lake effects into climate models can significantly enhance their performance by lowering simulation errors for surface air temperature, heat flux, convection, and precipitation over lakes (Mallard et al., 2014; Notaro et al., 2013; Zhou et al., 2023). Effective pollution control and practical water resource management require the evaluation of numerous physico-chemical and chemical water quality data (Ackerman et al., 2013; Edition, 2011), which are frequently challenging to understand and derive significant conclusions (Bhuiyan et al., 2011; Dixon & Chiswell, 1996; Koklu et al., 2010). Temperature, potential of Hydrogen pH (WHO, 2012, 2022), (TDS) Total Dissolved Solids (Kushwah & Singh, 2024; Miranzadeh et al., 2011), (Chang & Hao, 1996; Racys et al., 2010; Suslow, 2004) Oxidation-Reduction Potential (ORP) and Electrical conductivity (EC) (Xianhong et al., 2021) measurements have performed for water quality (Putri et al., 2023; Rusydi, 2018; Saalidong et al., 2022). The use of multivariate statistical approaches aids in the understanding of intricate data matrices to enhance comprehension of the ecological status and water environment quality of the ecosystems under study (Mavukkandy et al., 2014; Muniz & Oliveira-Filho, 2023; Zhong et al., 2018).

Sun Ye In Lake, a natural freshwater inland lake, is positioned in Sintgaing Township, Mandalay Region, Myanmar. In recent years, numerous studies have investigated using catch data from the Sunye Lake landing site. An assessment of the species composition, abundance, and meteorological data impacting fish species diversity has been carried out (Sun et al., 2019; Winn, 2021). Moreover, research on fish has shown that they are one of the biological markers of the health of lake ecosystems, which helps to preserve fisheries resources for current and future generations as well as the health of lake ecosystems (Banaduc et al., 2022; Lapointe et al., 2014). The Thindwe Dam (TDD), Thindwe Canal (TDC), and Sun Ye In (SYI) are one of the most important branches of the Zawgyi River (ZGR), and all of the contaminations on TDD and TDC threatens the SYI. Therefore, direct application of water on agricultural fields is prohibited for drinking.

Furthermore, up till now, no study on water quality based on a selection site has been conducted. Despite these studies, the absence of practical pollution mitigation techniques makes it difficult to pinpoint the origins of the pollution that exists today. Thus, the present study focused on the quantitative assessment of the water quality of the entire ZGR, SYI, TDD, and the TDC multi (cluster analysis and factor analysis) statistical techniques. Additionally, a thorough study and analysis of the ZGR, SYI, TDD, and the TDC were conducted in order to systematically identify regions that require immediate attention in terms of pollution mitigation as well as places that require additional examination.

MATERIALS AND METHODS

The Project area is situated about 22.4 km Northeast of Kyaukse, Mandalay Region. Latitudes 21° 30' 00" to 21° 41' 30" north and longitudes 96° 10' 00" to 96° 15' 00" east define the boundaries of the current study area. About 140 square kilometers are covered by this study area Fig 1. From Kyaukse, this area is reachable by car and motorcycle all year round. From Wet -2024 to dry-2025 (March 2024 and March 2025), the sample of the study area was collected in the field. GPS, a UTM map, and a waterproof meter multiparameter (Sebicho et al., 2024; Vero, 2021) were used and carried in the field (Vero, 2021). The geographic positions of the sample sites were recorded by GPS (Map, model: 78s). It was used to determine the locations of the water sample localities. Water samples were systematically collected for each variety of ZGR, TDD, W-STO, N-STO, NE-MSP, NE-TPL, KKVM, SW-MS, NW – BLK, SW – YBL, NE – YBL, TDC, DTC, NW-DT, P-SYISL, SYI-1, SYI-2, NW-SYI, and NW-SYI in (Fig 1 and Fig 2).

Photographing of the necessary water sample collection site, rock types, and structures had been done in the field Table 1. The distance of the Sampling Location from the project area is shown in Table 2. Temperature, pH, TDS, ORP, and conductivity measurements (El Nahhal et al., 2021) were performed in situ with a portable meter equipped with a temperature sensor and a membrane electrode (HANNA Instruments, model: HI 98194). The water samples were analyzed within 24 hours.

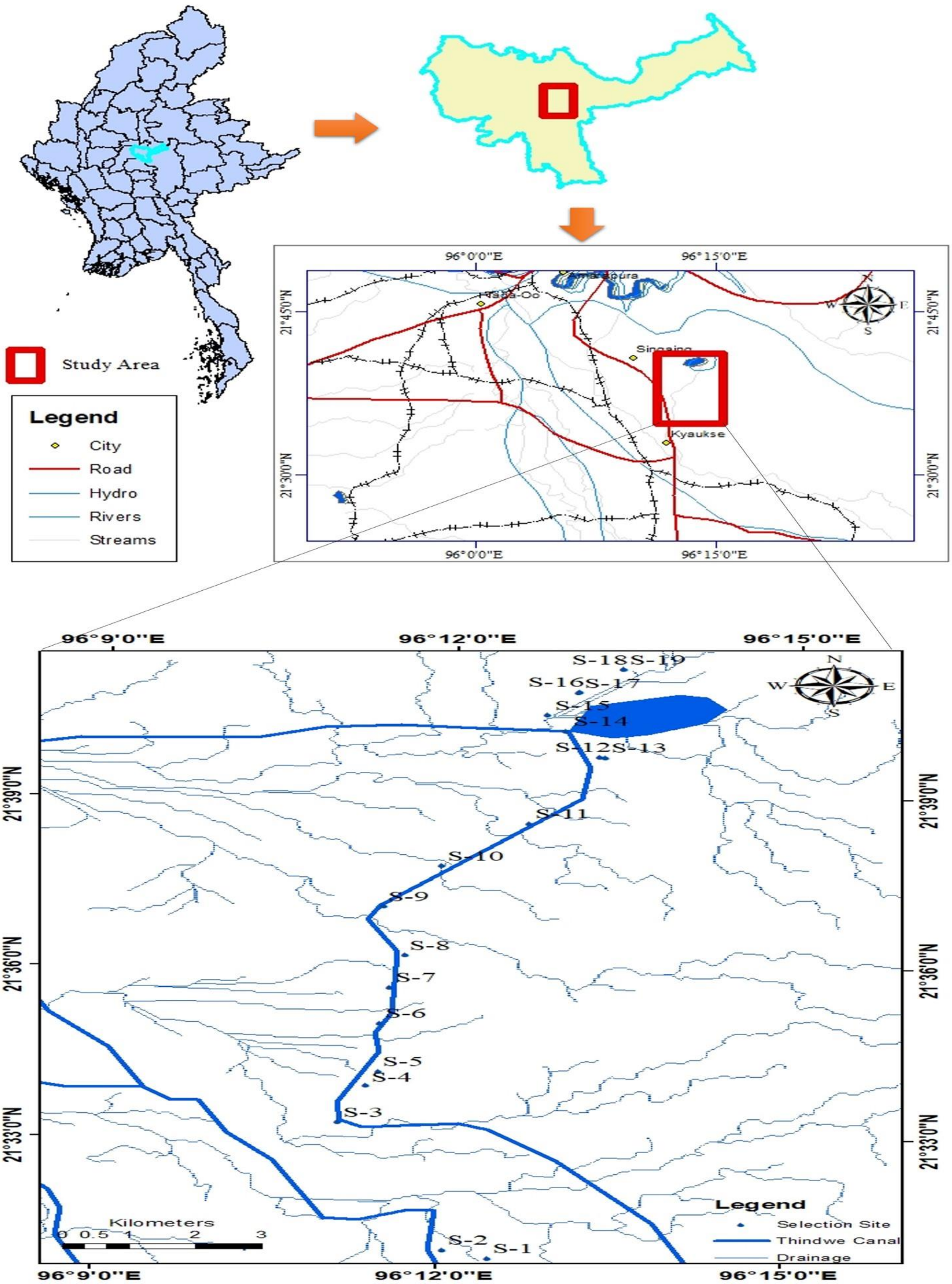

Figure 1. Map of the study area. Considering geographical location, nature, and Type of Sun Ye In –Se Gon Area, Sint Gaing and Kyaukse Townships, Mandalay Region

Table 1. Sampling Location of the Sun Ye In –Se Gon Area

Site No.	Selection Site	Selection Site description	Short Name	Coordinate
S-1	Zawgyi River	Zawgyi River	ZGR	N 21° 30’ 53" E 96° 12’ 02"
S -2	Thindwe Dam	Thindwe Dam	TDD	N 21° 31’ 02" E 96° 12’ 03"
S -3	Thindwe Canal	West of Shantaung U	W-STU	N 21° 33’ 16" E 96° 11’ 07"
S -4		North of Shantaung U Village	N-STU	N 21° 33’ 54" E 96° 11’ 20"
S-5		Northeast of Myin Saing Pagoda	NE-MSP	N 21° 34’ 09" E 96° 11’ 26"
S-6		Northeast of Taungpalu village	NE-TPL	N 21° 35’ 00" E 96° 11’ 27"
S -7		Kalar Kyaung Village Monastery	KKVM	N 21° 35’ 38" E 96° 11’ 31"
S -8		Southwest of Myin Saing (latthe)	SW-MS	N 21° 36’ 13" E 96° 11’ 38"
S -9		Northwest of Ba Li Kin Village	NW-BLK	N 21° 38’ 32" E 96° 12’ 40"
S -10		Southwest of Thazi	SW-TZ	N 21° 37’ 04" E 96° 11’ 26"
S -11		Eastern of Ye Baw Lay Village	NE-YBL	N 21° 37’ 47" E 96° 11’ 55"
S -12		Thindwe canal (Southwest of Sun Ye In)	TDC	N 21° 39’ 43" E 96° 13’ 16"
S -13		Datttaw Canal (South of Sun Ye In)	DTC	N 21° 39’ 42" E 96° 13’ 19"
S -14		Northwest of Dattaw	NW-DT	N 21° 40’ 10" E 96° 12’ 58"
S -15	Sun Ye In Lake	Meet point of Sun Ye In and Shan Kan Canal	P- SYISKC	N 21° 40’ 27" E 96° 12’ 48"
S -16		Sun Ye In near Restaurant-1	SYI-1	N 21° 40’ 52" E 96° 13’ 04"
S -17		Sun Ye In near Restaurant - 2	SYI-2	N 21° 40’ 50" E 96° 13’ 03"
S -18		Northwest of Sun Ye In (near water treatment)	NW-SYI	N 21° 41’ 15" E 96° 13’ 26"
S -19		Northwest of Sun Ye In	NW-SYI	N 21° 41’ 15" E 96° 13’ 26"

Table 2. Distance of Sampling Location from the Sun Ye In –Se Gon Area

Selection Site No.	Distance
S (1 – 2)	0.32 km
S (2 – 3)	5.76 km
S (3 – 4)	1.28 km
S (4 – 5)	0.8 km
S (5 – 6)	1.28 km
S (6 – 7)	1.12 km
S (7 – 8)	1.12 km
S (8 – 9)	1.6 km
S (9 – 10)	2.56 km
S (10 – 11)	1.76 km
S (11 – 12)	2.24 km
S (12 – 13)	0.07 km
S (13 – 14)	0.96 km
S(14 – 15)	0.64 km
S (15 – 16)	0.96 km

RESULTS AND DISCUSSION

A boxplot diagram of the range, mean, and deviations of the parameters pH, ORP, and Temperature is found in ZGR, TDD, TDC, and SYI Lake water is displayed in Figure 2. The boxplot diagrams indicate that seasonal variations were the primary reason for the notable variations in the water temperature readings.

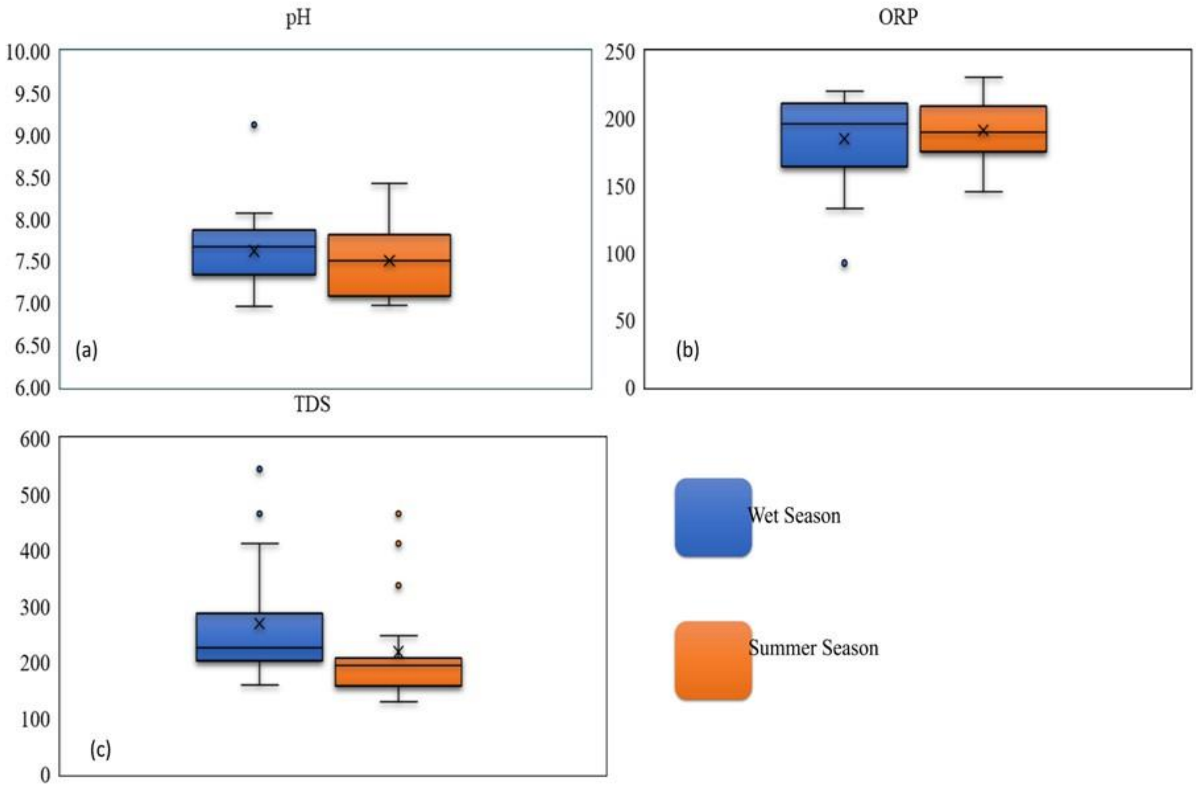

Figure 2. Box and whisker plots of the water quality parameters of catchments in Zawgyi River, Thindwe Dam, Thindwe Canal, and Sun Ye In Lake (a) potential of Hydrogen pH, (b) Oxidation-Reduction Potential ORP, and (c) Total Dissolved Solids TDS (From Wet Season-2024 and dry Season-2025)

A boxplot diagram of the range, mean, and deviations of the parameters Electrical conductivity EC and Temperature is found in the From Wet Season-2024 and dry Season-2025 is shown in Figure 2.

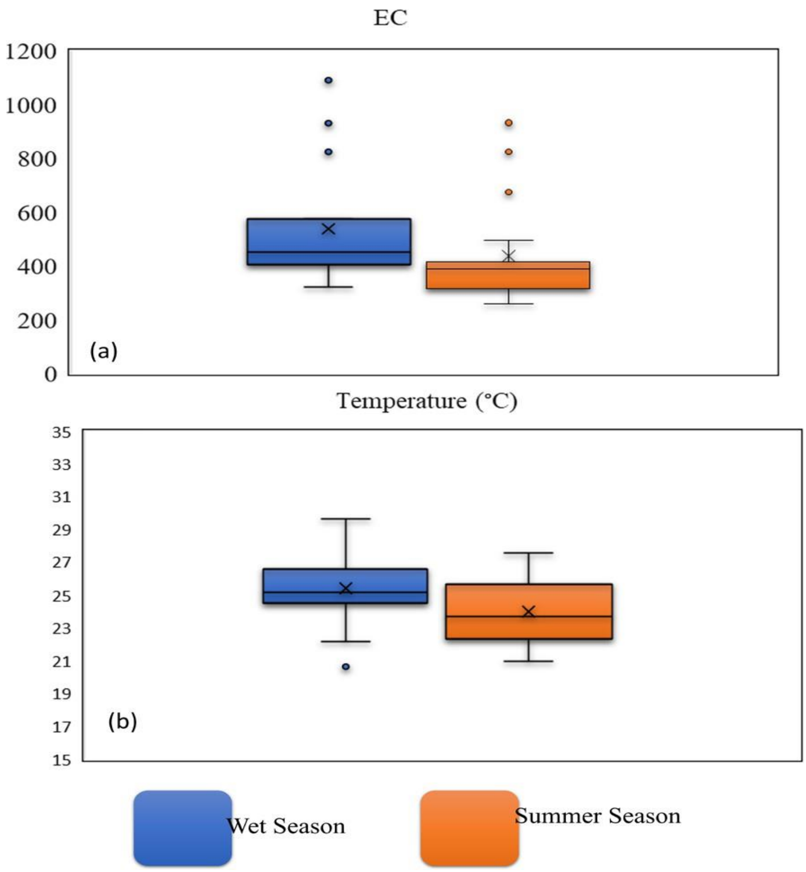

Figure 3. Box and whisker plots of the water quality parameters of catchments in Zawgyi River, Thindwe Dam, Thindwe Canal, and Sun Ye In Lake (a) Electrical conductivity EC and (b) Temperature (From Wet Season-2024 and dry Season-2025)

Distribution of pH, Temperature, and ORP Characteristics in Surface Water

The pH values in the Sun Ye In-Se Gon area frequently exhibit notable seasonal and regional variations. The pH ranges from 6.99 to 9.12 during the wet season, Figure 4 (a and b), which is in line with the ambient water quality recommendation of 6.5 to 8.0 for aquatic life (Park et al., 2018; WATER, 2001). This recommendation is greatly exceeded during the dry season, when pH values vary from 5.03 to 8.43. The primary cause of this high alkalinity is the blue-green algae's increased photosynthetic activity, which raises pH levels by absorbing carbon dioxide. Furthermore, a variety of contaminants that might affect pH levels are introduced by urban runoff. Rainfall dilutes these contaminants during the rainy season, lowering pH levels relative to the dry season. Notably, the wet and dry seasons showed a noticeably lower pH value of high TDC, suggesting localized variability. Overall, the research period showed that TDC maintains year-round alkaline conditions, with significant pH variations caused by rural runoff activity.

In the wet and summer, among the 19 samples, the temperature was found not significantly different between 32.75ºC. The temperature value ranges from 20.64ºC to 32.75ºC. The highest Temperature value of 32.75ºC was recorded from NW-SYI(S-19) in June, while the lowest temperature value of 20.64ºC was recorded from SW-YBL (S-10) in December. The temperature standard value set by WHO was between 20ºC and 25ºC. The temperature value 32.75ºC is less than the WHO standard. The highest Temperature value in the area, 32.75ºC, was well above the standard limit, while the lowest Temperature value in the area, 20.64ºC, was within the standard range Figure 4 (c and d).

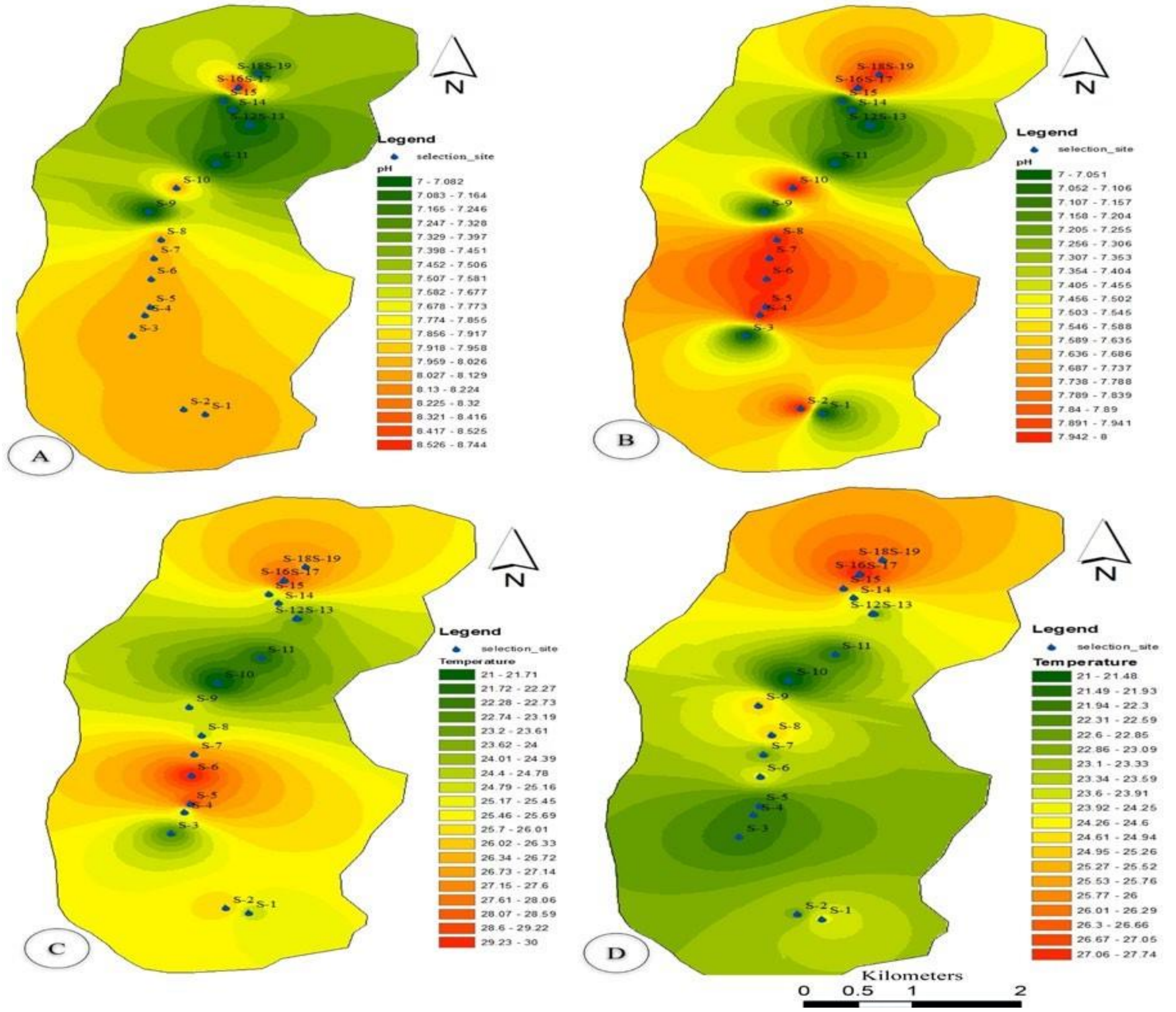

Figure 4. Spatial distribution of pH (A and B) and Temperature (C and D) in the surface water (From Wet Season-2024 and Dry Season-2025)

One of the most important water quality parameters used to assess the biochemical state of water, particularly in wastewater treatment, is oxidation-reduction potential (ORP), Figure 5. The ORP of TDC and SYI is higher than the river water surface runoff, ZGR, and TDD, which may cause high 220 mg/L in wet and 230 mg/L values during the wet season. pH and ORP (oxidation-reduction potential) parameters are different measurements, but they are closely related. When the acidic water is positive in ORP, alkaline water contains negative ORP, which is also known as an antioxidant (Manahan, 2010; Putri et al., 2023).

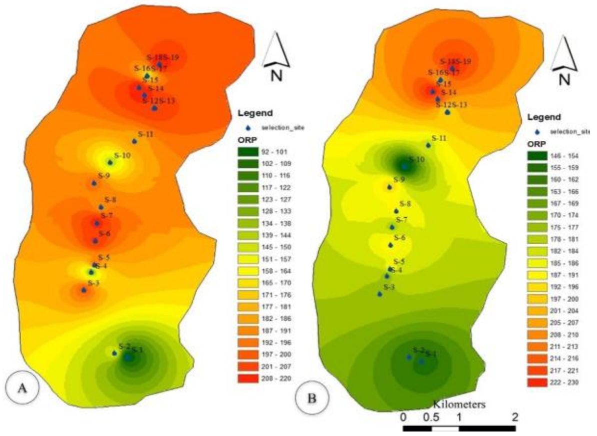

Figure 5. Spatial distribution of Oxidation-Reduction Potential ORP (A and B) in the surface water (From Wet Season-2024 and Dry Season-2025).

Distribution of EC and TDS Characteristics in Surface Water

There are significant distinctions in the temporal and geographical fluctuations of EC and TDS. The TDS and EC of TDC is higher than the river water surface runoff in Figure 6, TDD and SYI lake, which may cause high TDS (Highest-545.00 mg/L, mean-268.96 mg/L) and EC (Highest-1090.0 µS/cm, mean- 538.52 µS/cm) values during the wet season and low levels during the dry season (Highest-465.67 mg/L, mean-217.98 mg/L) and EC (Highest- 932.00 µS/cm, mean-124.37µS/cm). For this report, data from wet and dry were analyzed, with a Focus on TDS and EC values compared against the World Health Organization (WHO) guideline of 400 µS/cm (Canton, 2021). In the wet and dry, among the 19 samples, the lowest TDS and EC values were found at Sun Ye In Lake SYI (S16), TDS (measuring 193.67 µS/cm and measuring 160.00 µS/ cm), and EC (measuring 320.33 µS/cm and measuring 387.67 µS/cm). This indicates low iron content based on EC and suggests that the water may be suitable for consumption. In dry, most TDS and EC values in wet were lower than those in wet. Figure 2 visually represents the decrease in TDS and EC values from wet and wet.

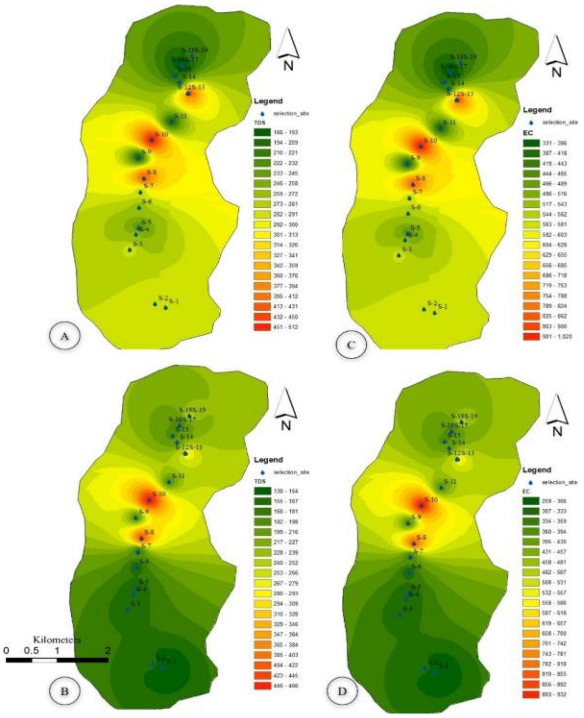

Figure 6. Spatial distribution of Electrical conductivity EC (A and B) and Total Dissolved Solids TDS (C and D) in the surface water (From Wet-2024 and dry-2025)

Throughout the wet, there is a considerable difference in the spatial variation of EC and TDS across the ZGR, TDD, and SYI lakes, and the TDC displays high mean values for both components. The TDC runoff delivers residues from domestic activities that primarily wind up in surface waters or rivers, which are important sinks of pollutants associated with humans, including pesticides (Ramírez-Morales et al., 2021). Since there are a lot of agricultural fields in these places, the wastewater may contain more dissolved ions than suspended particles in the wet season. Additionally, bedrock contamination, water balance changes (restricting inflow, increasing water use), and agricultural effluents are the main causes of lake EC and TDS pollution (Weerasinghe & Handapangoda, 2019). This fact is confirmed, as ZGR, TDD, TDC, and SYI show significant differences ($p < 0.05$) between the two seasons for EC and TDS Figure 3. The main reason for the recorded peak values of TDS, salinity, and conductivity is thought to be runoff from agricultural lands and residential areas in the TDC.

CONCLUSION

The pollution level and suggested factors for creating the ZGR, SYI, TDD, and TDC's water quality index were evaluated in this study. The purpose of this study was to examine the geographical linkages between the ZGR, SYI, TDD, and TDC, as well as the relationships between these locations and physicochemical parameters (pH, Temperature, ORP, EC, and TDS). The recorded peak values of pH, ORP, TDS, and conductivity in the TDC were statistically significant than that the ZGR, SYI, and TDD, which is thought to be runoff from agricultural lands in residential areas during the Wet-2024 and dry-2025. TDS and EC accumulations seen in TDC were at critical levels, based on the data observed. This inorganic pollution could be a major limiting factor for aquatic life in the area and could have a negative impact on human health in the near future if no action is taken in the basin as soon as possible. Principal component analysis, correlation analysis, and expert judgment are used in conjunction to guarantee that the WQI parameters chosen are thorough and pertinent to the demands of local water quality management.

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