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# Evaluation of Physicochemical Properties of water quality of the Taung Tha Man Lake, Amarapura Township, Mandalay City in Myanmar


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# Contents

**Evaluation of Physicochemical Properties of water quality of the Taung Tha Man Lake, Amarapura Township, Mandalay City in Myanmar**

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Abstract

Water quality of Taung Tha Man Lake had currently influenced by environmental pollution and anthropogenic activities. This study aimed to evaluate the current physicochemical properties of the water quality of Taung Tha Man Lake in Mandalay, Myanmar. To perform the study, eleven physicochemical parameters such as pH, water Temperature (WT), Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD), Oxygen Reduction Potential (ORP) and Salinity had conducted for three different sites in the lake. Statistical analysis such as One-way Analysis of Variance (ANOVA) with Tukey's HSD post hoc test, and the Water Quality Index (WQI) computed to assess the status of water conditions. The results indicate that the amount of some physicochemical parameters like EC, TDS, pH and BOD were within the allowable limits of WHO drinking water quality standard and water quality monitoring standard of aquatic life developed by U.S. Environmental Protection Agency while water temperature, DO, Turbidity, and COD values surpassed the permissible limits of these international standards. The one-way ANOVA revealed that there was statistically significant difference ($p<0.05$) between sites in the lake, WT ($F(2,6) = 6.864$, $p =.028$), Turbidity ($F(2,6) = 12.119$, $p =.008$), pH ($F(2,6) = 455.182$, $p =.000$), TSS ($F(2,6) =10.770$, $p =.010$), DO ($F(2,6) =195.126$, $p =.000$), ORP ($F(2,6) =25.667$, $p =.001$), and COD ($F(2,6) =25.590$, $p =.001$). The WQI confirmed that the water quality of Taung Tha Man Lake is highly polluted and very unsuitable for human uses. Generally, the results of the present study point out the status of Taung Tha Man Lake water quality was not convenient for human consumption without proper treatment works. It is critical to take necessary steps before discharging the wastewater into the Lake and to develop future policies by the government authority in terms of development of the water pollution control with intensive cares and some restoration works in order to make the lake water is good for aquatic life.

*Keywords:* Taung Tha Man Lake; Water quality; One-way ANOVA; Water Quality Index (WQI)

# မန္တလေးမြို့၊ အမရပူရမြို့နယ်ရှိ တောင်သမန်အင်း၏ ရေအရည်အသွေးတွင် ရုပ်ပိုင်းဆိုင်ရာနှင့် ဓာတုဗေဒဆိုင်ရာ ဂုဏ်သတ္တိများကို အကဲဖြတ်ခြင်း

စောမောင်သိမ်း၊ ဦးစီးအရာရှိ
ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဦးစီးဌာန

## စာတမ်း**အကျဉ်း**

တောင်သမန်အင်း၏ ရေအရည်အသွေးကို သဘာဝပတ်ဝန်းကျင်ညစ်ညမ်းမှုနှင့် လူသားတို့၏ ပယောဂများက လွှမ်းမိုးလျက်ရှိပါသည်။ ဤလေ့လာမှုသည် မန္တလေးမြို့ရှိ တောင်သမန်အင်း၏ ရေအရည်အသွေးတွင် ရုပ်ပိုင်းဆိုင်ရာနှင့် ဓာတုဗေဒဆိုင်ရာ ဂုဏ်သတ္တိများကို အကဲဖြတ်ရန် ရည်ရွယ်ပါသည်။ လေ့လာမှုပြုလုပ်ရာတွင် ရုပ်ပိုင်းဆိုင်ရာ နှင့် ဓာတုဗေဒ ဆိုင်ရာ ပါရာမီတာများ (parameters) ဖြစ်ကြသော pH၊ Water Temperature (WT)၊ Electrical Conductivity (EC)၊ Turbidity၊ Total Suspended Solids (TSS)၊ Total Dissolved Solids (TDS)၊ Dissolved Oxygen (DO)၊ Biochemical Oxygen Demand (BOD)၊ Chemical Oxygen Demand (COD)၊ Oxygen Reduction Potential (ORP) နှင့် Salinity၊ စုစုပေါင်း ပါရာမီတာ (၁၁) မျိုး၏ အရည်အသွေးကို တောင်သမန်အင်း အတွင်းရှိ မတူညီသော နေရာသုံးခု၌ လေ့လာမှုများ ပြုလုပ်ခဲ့ပါသည်။ တောင်သမန်အင်း အတွင်းရှိ နေရာသုံးခု၏ ရေအရည်အသွေး ကွာခြားမှုကို ဆန်းစစ်ရန် One-way Analysis of Variance (ANOVA) နည်းကို အသုံးပြု၍ Tukey's HSD post hoc test ဖြင့် ခွဲခြမ်းစိတ်ဖြာခြင်းနှင့် ရေအရည် အသွေး၏ အခြေအနေကို အကဲဖြတ်ရန် ရေအရည်အသွေး အညွှန်းကိန်း (Water Quality Index WQI) တွက်ချက်မှုတို့ကို ပြုလုပ်ခဲ့ပါသည်။ လေ့လာမှုရလဒ်များအရ Electrical Conductivity (EC)၊ Total Dissolved Solids (TDS)၊ pH နှင့် Biochemical Oxygen Demand (BOD) ကဲ့သို့သော ရုပ်ပိုင်းဆိုင်ရာနှင့် ဓာတုဗေဒဆိုင်ရာ ဂုဏ်သတ္တိတို့၏ ပမာဏသည် ကမ္ဘာ့ကျန်းမာရေးအဖွဲ့ (WHO) မှ ထုတ်ပြန် ထားသည့် သောက်သုံးရေ အရည်အသွေးစံနှုန်းနှင့် အမေရိကန်သဘာဝပတ်ဝန်းကျင် ကာကွယ်ရေးအေဂျင်စီ (U.S.EPA) မှ သတ်မှတ်ထုတ်ပြန်ထားသော ရေနေသတ္တဝါများအတွက် ရေအရည်အသွေး စောင့်ကြပ် ကြည့်ရှုရေး စံနှုန်းများနှင့် ကိုက်ညီသော်လည်း Water Temperaturer၊ Dissolved Oxygen (DO)၊ Total Suspended Solids (TSS)၊ Turbidity နှင့် Chemical Oxygen Demand (COD) တို့သည် အဆိုပါ နိုင်ငံတကာစံနှုန်းများနှင့် ကိုက်ညီမှု မရှိကြောင်း လေ့လာတွေ့ရှိ ရပါသည်။ One-way ANOVA ဖြင့် စာရင်းအင်းဆိုင်ရာ လေ့လာဆန်းစစ်ချက်အရ တောင်သမန်အင်း အတွင်းရှိ နေရာသုံးခု အကြား သိသာထင်ရှားသောခြားနားချက် တန်ဖိုး($P < 0.05$)ကို တွေ့ရှိခဲ့ပါသည်။ ရေအရည်အသွေး

အညွှန်းကိန်း (WQI) အရ တောင်သမန်အင်း၏ ရေအရည်အသွေးသည် အလွန်ညစ်ညမ်းနေပြီး လူတို့ အသုံးပြုရန်အတွက် အလွန်ပင် မသင့်တော်ကြောင်း လေ့လာ တွေ့ရှိခဲ့ပါသည်။ လေ့လာမှု၏ ရလဒ်များအရ လက်ရှိ အခြေအနေတွင် တောင်သမန်အင်း၏ ရေအရည် အသွေးသည် သင့်သင့်လျော်ပတ်သော ကုစားမှုများ မပြုလုပ်ပါက လူတို့ အသုံးပြုရန် အတွက် မသင့်လျော်ကြောင်း ဖော်ပြနေ ပါသည်။ ရေဆိုးရေကို တောင်သမန်အင်း ထဲသို့ မစွန့်ထုတ်မီ လိုအပ်သော ပြုပြင်ရေး အဆင့်များ လုပ်ဆောင်ရန် အလွန် အရေးကြီး သကဲ့သို့ ရေထုညစ်ညမ်းမှုကို ထိန်းချုပ် နိုင်စေရန် ထိရောက်စွာ ကြီးကြပ်နိုင်ရေးနှင့် ရေနေသတ္တဝါများ အတွက် ရေအရည်အသွေး ကောင်းမွန်လာစေရန် ပြန်လည်ထူထောင်ရေး လုပ်ငန်းများကို ဖော်ဆောင်နိုင်ရန်အတွက် သက်ဆိုင်ရာ အစိုးရအာဏာပိုင်များက အနာဂတ်အတွက် ရည်မှန်း၍ မူဝါဒများ ချမှတ်နိုင်ရန် လွန်စွာ အရေးကြီးပါကြောင်း အကြံပြုပါသည်။

# Evaluation of Physicochemical Properties of water quality of the Taung Tha Man Lake, Amarapura Township, Mandalay City in Myanmar

## 1. Introduction

Water covers more than two-thirds of the surface of our planet. Nearly 98 per cent of Earth's water is found in oceans and other saltwater bodies, while the majority of the remaining freshwater is frozen in ice sheets and glaciers [1]. It is fundamental to life on our planet, but this precious resource is increasingly in demand and under threat [2].

The earth's surface is made up of 70% water including rivers, lakes, streams, seas, oceans, groundwater, and all these forms are very important in the life cycle [3] and only 2.5 per cent of that is fresh water and less than 1 per cent is available to our exploding population [4].

Water is an essential component for the survival of life on earth, which contains minerals, important for humans as well as for the world and aquatic life [5]. Lakes and surface water reservoirs are the planet's most important freshwater resources and provide numerable benefits [5]. They have important social and economic benefits as a result of tourism and recreation, are culturally and aesthetically important for people throughout the world [6].

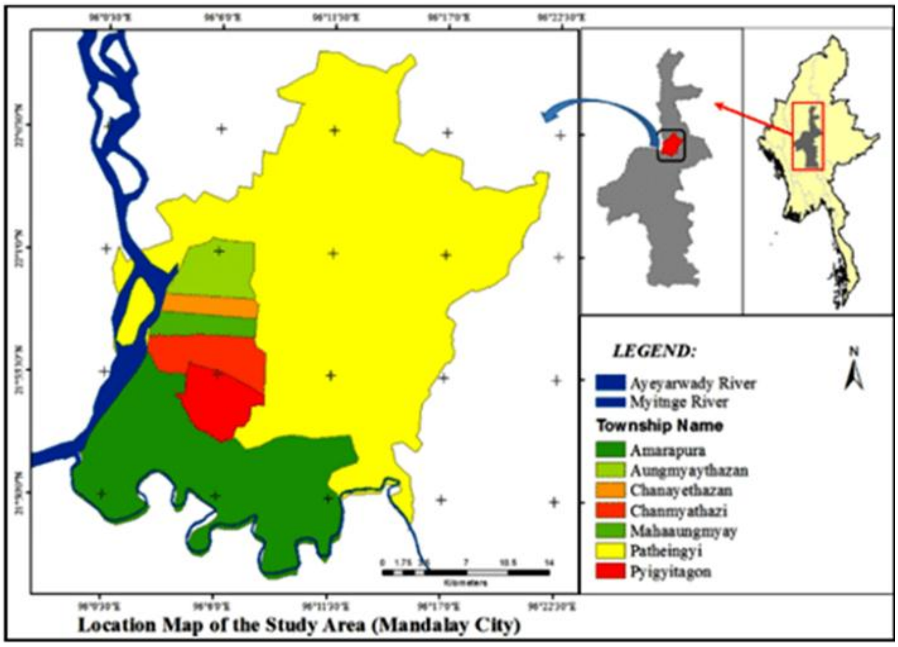
Water quality analysis is important to protect the natural ecosystem [7]. The physicochemical parameters are very essential and important to test the water before it is used for drinking, domestic, agricultural, or industrial purpose [5]. Water must be tested with different physicochemical parameters because it is very important to get an exact idea about the quality of water and then we compare the obtained results with international standard values [5]. Physicochemical properties of the water get varied season-wise and also, anthropogenic activities such as agriculture, urbanization, domestic sewage, etc. in the catchment area result in the deterioration of water quality [8].

Water quality index (WQI) provides a nominal number that represents overall water quality at a certain location and time, based on several water quality parameters [9]. The objective of the water quality index is to turn complex water quality data into detailed information useful for the public [9]. WQI indicates the water quality in terms of index number and offers a useful presentation of the overall quality of water for the public or any intended use as well as in the pollution abatement programs and water quality management [10].

The present study conducted some physicochemical parameters, pH, Temperature, Electrical Conductivity (EC), Turbidity, Total Suspended Solid (TSS), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), Oxygen Reduction Potential (ORP) and Salinity, conducted the Pearson’s correlation between these parameters, and water quality index of Taung Tha Man Lake had been determined.

### 1.1 Background Information on the Study Area

Mandalay is the second-largest city in central Myanmar with a population of 1,225,000 people that lacks a wastewater management system and access to treated drinking water (Figure 1)[16]. The Amarapura Township is an urban area that 235,000 people live and is located on the south side of Mandalay surrounding Taung Tha Man Lake [16]. Since 2008, untreated wastewater has been discharged from the Mandalay Industrial Zone into a canal that supplies water for the Nat Yay Kan fishery ponds and feeds into Taung Tha Man Lake that has been caused a series of large die-offs in the fish populations in it [17]. The Mandalay Industrial Zone area includes facilities that cause severe pollution such as tanneries, distilleries, sugar factories, and battery factories [17]. Thus, it is vital to investigate the water quality level and monitor the physical and chemical properties of water quality in the Taung Tha Man Lake in Amarapura Township.




(Source: Department of Meteorology and Hydrology, Myanmar, 2016)
Figure 1: Location Map of Mandalay City

### 1.2 Justification of the study

Pollution of surface water, ground water, and sea water are all threats to human and animal health. Water pollution is detrimental to livelihood of human and aquatic life because of its adverse effects on properties of water quality. To improve the water quality management of Taung Tha Man Lake, a regular monitoring and evaluation of the Lake water quality is extremely critical. Moreover, it was not found that, Water Quality Index (WQI) level of the Lake for both potable water uses and aquatic life requirements. Consequently, there is no aggregated information about the water quality status of the lake for specific uses. Due to the limitation of the spatial analysis of the traditional water quality measurement techniques, evaluating water quality parameters could be help to identify water pollution site more specifically. Thus, it is vital to investigate the physicochemical properties of water quality and evaluate the water quality level in the Taung Tha Man Lake. Moreover, the Lake being an important ecological site, this study had aimed at providing useful information for the management of environmental aspects of the lake.

## 2. Research Objectives

The objectives of this study were:

1. To examine the physicochemical properties of water quality of the Taung Tha Man Lake, Amarapura township, Mandalay city
2. To evaluate the water quality level among the study sites of the Lake.

It only considered for the water quality for aquatic life protection and drinking purpose.

## 3. Materials and Methods

### 3.1 Study Area

Taung Tha Man Lake is situated in Amarapura Township of Mandalay Region on the eastern bank of the Ayeyarwady River [20]. It lies between 21°53' N to 21°54' N latitude and 96°03' E to 96°05' E longitude (Figure 2). Its depth is 8-15 feet (2.4-4.57 meters) with an area of about 1000 acres (404.7 hectares) [20].

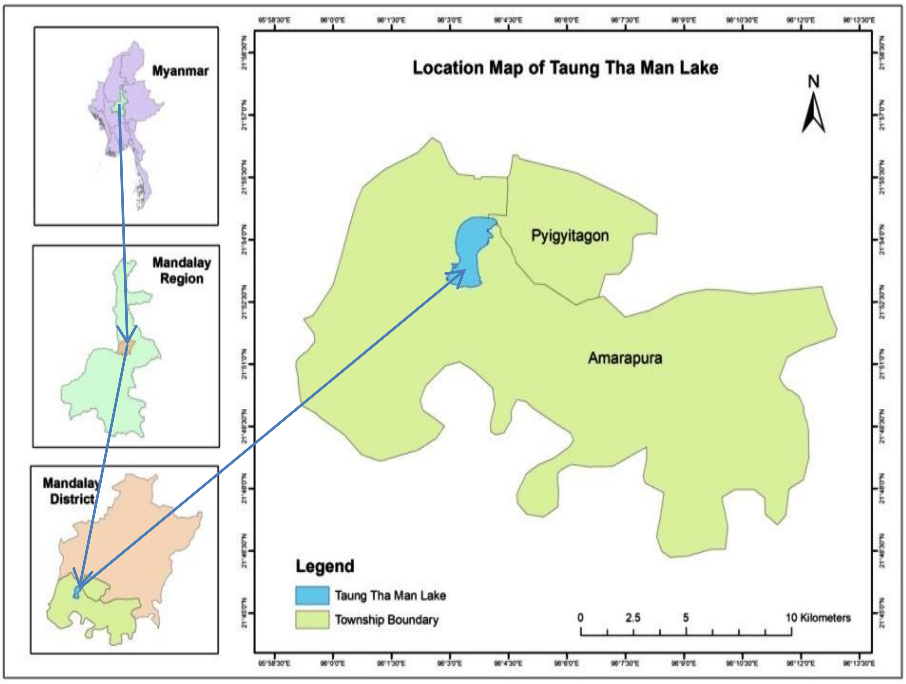



Figure 2: Map of the study area

The Lake is a natural flood plain flooded by the inflow of the Ayeyarwady River in the rainy season [20]. This natural flood plain is transformed into a permanent lake by the construction of water control gates for fishery [20]. The water from the lake flowed down in the winter and hot seasons [20]. In the winter season, the crops and vegetables are cultivated in the southern part of the lake. Due to industrial zone development, chemically deposited from the fertilizer used in agricultural farms, sewage disposal, and human activity cause lake pollution.

Taung Tha Man Lake is a eutrophic lake receiving its water from agricultural drains from the southern part of the lake and industrial waste effluents are also mixed with domestic effluents and are discharged into the north side of the Lake [62]. It has been used to be a highly productive fishing and duck farming lake as well as a recreational lake for tourism [18]. The eastern side of the lake has a denser population near the residential area than the western side of it had filled with domestic waste. Few kinds of literature exist on the physicochemical parameters of Taung Tha Man Lake. Thus, the water quality index of Taung Tha Man Lake had attempted to determine.

The main goal was to find the present status of the physicochemical properties of the water quality of Taung Tha Man Lake, to compare water quality at three different areas in the Lake and to assess the correlation between and among the physicochemical water quality parameters. The Water Quality Index (WQI) computed to assess the present status of water conditions and to assess if future restoration activities improve water quality.

**3.2 Research Materials**

In this research, the primary data had measured directly from study area, Thaung Tha Man Lake, and laboratory tests. Selected physicochemical water quality parameters and analytical methods had summarized in Table 1.

**Table 1: Physiochemical water quality parameter and analytical methods**

| Variables | Abbreviations | Units | Analytical methods |
|---|---|---|---|
| Water temperature | WT | ℃ | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| pH | pH | S.U | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Electrical conductivity | EC | µS/cm | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Salinity | Salinity | ppt | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Turbidity | Turbidity | NTU | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Oxidation Reduction Potential | ORP | mV | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Total suspended solids | TSS | mg/L | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Dissolved Oxygen | DO | mg/L | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Total Dissolved Solids | TDS | mg/L | Multi- parameter Water Quality Meter (U-53G), HORIBA |
| Biochemical Oxygen Demand | BOD | mg/L | Manual Method, Pro DO Sensor |
| Chemical Oxygen Demand | COD | mg/L | Titrimetric Method, Titrictor |
| Total Suspended Solid | TSS | mg/L | Circulation and Filtration System, NS 4733-1983/NS-EU 872-2005 |

Selected water parameters including water temperature (WT), dissolved oxygen (DO), Oxidation Reduction Potential (ORP), electrical conductivity (EC), total dissolved solids (TDS), Turbidity, pH, and Salinity had conducted by using a multi-parameter water quality meter (HORIBA U-53G) on site, and Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS) had accomplished by carrying out laboratory experiments. The water samples were analysed for the selected parameters in the laboratory of Forest Research Institute, Forest Department under the Ministry of Natural Resources and Environmental Conservation, MONREC.

### 3.2.1 Sampling design and sample collection

Selected physical and chemical parameters had measured and samples had collected from the three different sites of the lake. It traversed the lake using a boat and collected water samples. During the sample collection, it was guided by a standard procedure [30].


Figure 3: Map of sampling points

In the study, three water samples were collected from three different locations from three peculiar sites, i.e. site A, or inlet into the lake (human activities active, e.g. urban run-off and wastewater discharge from the industries); site B, water flows from the lake into the river; and site C, area with the active agricultural area as shown in Figure 3.

All the samples were collected during the dry season; last week of May 2021 and in the morning; began at 5:30 a.m. and ended at 8:30 a.m. The water samples for physicochemical analysis had collected randomly from different areas of Taung Tha Man Lake. Three water samples i.e. S1, S2, and S3 had collected from each location of site A, site B, and site C areas respectively. There were nine water samples for the testing of each parameter in the method.

Each sample had collected at the depth of about 20-50 cm and 1000 mL plastic bottles had used to collect the water samples. The sample bottles have immediately kept in an ice cooled polystyrene box and transported to the lab during 24 hours.

## 3.3 Research Methods

### 3.3.1 Statistical analysis

The data obtained from the water samples had analysed by using the SPSS software ver.20. Water quality variables had compared among sites using a one-way ANOVA, with Tukey's HSD post hoc test. For all statistical tests, p-values <0.05 were considered significant.

### 3.3.2 Water Quality Index (WQI)

**Weighted Arithmetic Water Quality Index Method**

Water quality index may be defined as a rating, reflecting the composite influence of different water quality parameters on the overall quality of water. The main objective of computing of Water Quality Index (WQI) is to turn the complex water quality data into information which is easily understandable and usable.

The Water Quality Index (WQI) of Taung Tha Man Lake was calculated using the weighted arithmetic index formula as follows:

$$WQI = \Sigma W_i Q_i / \Sigma W_i$$

The quality rating scale ($Q_i$) for each parameter is calculated by using this expression:

$$Q_i = 100[V_i - V_o / S_i - V_o]$$

Where,

$V_i$ is estimated concentration of $i$th parameter in the analyzed water

$V_o$ is the ideal value of this parameter in pure water

$V_o$ = 0 (except pH =7.0 and DO = 14.6 mg/l)

$S_i$ is recommended standard value of $i$th parameter

The unit weight ($W_i$) for each water quality parameter is calculated by using the following formula:

$$W_i = K / S_i$$

Where,

$K$ = proportionality constant and can also be calculated by using the following equation:

$$\mathrm{K} = 1 / \sum_{i=1}^{n} \left(\frac{1}{Si}\right)$$

WQI indicates the quality of water in terms of an index number that represents the overall quality of water for any intended use.

## 4. Results

### 4.1 Statistical Results

The mean of measured water quality parameters with their minimum, maximum and standard deviation values were summarized in Table 2 that the differences among parameters were explained by significant differences between sites ($p<0.05$).

**Table 2: Physicochemical properties of water quality at three different sites in the lake (Mean ± St Dev.) and significant differences between sites (p<0.05)**

| Parameters | Site A | Site B | Site C | Mean | Min. | Max. | p-value |
|---|---|---|---|---|---|---|---|
| WT (°C) | 31.63±.55 | 31.38±.09 | 30.56±.32 | 31.19±.58 | 30.21 | 32.26 | .028 |
| EC (µS/cm) | 714.67±13.2 | 717.67±5.68 | 721.67±4.72 | 718±8.19 | 707 | 730 | .640 |
| TDS (mg/L) | 459.67±3.06 | 459±3.46 | 460±1 | 459.56±2.40 | 457 | 463 | .902 |
| Salinity (ppt) | .34±.01 | .35±.01 | .36±.01 | .35±.01 | .34 | .36 | .068 |

| Parameters | Site A | Site B | Site C | Mean | Min. | Max. | p-value |
|---|---|---|---|---|---|---|---|
| Turbidity (NTU) | 97.26±11.24 | 62.51±12.83 | 98.58±4.45 | 86.12±19.78 | 53.74 | 107.1 | .008 |
| pH | 6.75±.07 | 7.57±.06 | 8.41±.07 | 7.58±.72 | 6.69 | 8.48 | .000 |
| BOD (mg/L) | 4.28±1.04 | 4.37±.67 | 4.41±1.00 | 4.35±.80 | 3.08 | 5.46 | .983 |
| TSS (mg/L) | 66.67±6.66 | 45.33±4.16 | 61.33±6.43 | 57.78±10.87 | 42 | 74 | .010 |
| DO (mg/L) | .68±.08 | 1.70±.20 | 4.67±.58 | 2.35±1.82 | .61 | 5.00 | .000 |
| ORP (mV) | -236.3±4.16 | -164.0±29.7 | 24.67±1.15 | -125.2±117 | -241 | 26 | .001 |
| COD (mg/L) | 18.66±1.17 | 6.38±1.57 | 5.11±.81 | 10.05±6.57 | 4.20 | 20.0 | .001 |

### 4.1.1 ANOVA test result

The ANOVA had based on a significance level (α) of 0.05. One-way ANOVA had performed to check the differences among parameters between sites.

There was a statistically significant difference between sites in the lake as determined by one-way ANOVA, WT ($F(2,6) = 6.864$, $p = .028$), Turbidity ($F(2,6) = 12.119$, $p = .008$), pH ($F(2,6) = 455.182$, $p = .000$), TSS ($F(2,6) = 10.770$, $p = .010$), DO ($F(2,6) = 195.126$, $p = .000$), ORP ($F(2,6) = 25.667$, $p = .001$), and COD ($F(2,6) = 25.590$, $p = .001$).

On the other hand, the means of water quality parameters of EC ($F(2, 6) = .481$, $p = .640$), TDS ($F(2, 6) = .104$, $p = .902$), Salinity ($F(2, 6) = 4.333$, $p = .068$), and BOD ($F(2, 6) = .017$, $p = .983$) were not significantly different between sites in the lake.

### 4.1.2 test Post-hoc result

***Water Temperature (WT)***

A one-way ANOVA had performed to compare the effect of three different sites on water temperature. A one-way ANOVA revealed that there was a statistically significant difference in mean water temperature between at least two sites. Tukey's HSD Test for multiple comparisons found that the mean value of water temperature was significantly different between Site A and Site C (p = .028, 95% C.I. = .1439, 1.9961). There was no statistically significant difference in mean between Site A and Site B (p=.694) or between Site B and Site C (p=.079).

***Dissolved Oxygen (DO)***

A one-way ANOVA had performed to compare the effect of three different sites on DO. A one-way ANOVA revealed that there was a statistically significant difference in mean DO between at least two sites. Tukey's HSD Test for multiple comparisons found that the mean value of DO was significantly different between Site A and Site B (p = .029, 95% C.I. = -1.9107, -.1293), between Site A and Site C (p = .000, 95% C.I. = -4.8807, -3.0993), and between Site B and Site C (p = .000, 95% C.I. = -3.8607, -2.0793).

**Oxidation Reduction Potential (ORP)**

A one-way ANOVA had performed to compare the effect of three different sites on ORP. A one-way ANOVA revealed that there was a statistically significant difference in mean ORP between at least two sites. Tukey's HSD Test for multiple comparisons found that the mean value of ORP was significantly different between Site A and Site B (p =.005, 95% C.I. = -115.77, -28.90), between Site A and Site C (p = .000, 95% C.I. = -304.43, -217.57), and between Site B and Site C (p = .000, 95% C.I. = -232.10, -145.23).

The redox potential (Eh) characterizes the oxidation-reduction state of natural waters [27]. Oxidation-reduction potential (ORP) measures the ability of a lake or river to clean itself or breakdown its waste products [28]. When ORP is high, there is a lot of oxygen present in the water [28].

**pH**

A one-way ANOVA had performed to compare the effect of three different sites on pH. A one-way ANOVA revealed that there was a statistically significant difference in mean pH between at least two sites. Tukey's HSD Test for multiple comparisons found that the mean value of pH was significantly different between Site A and Site B (p = .000, 95% C.I. = -.9918, -.6549), between Site A and Site C (p = .000, 95% C.I. = -1.8251, -1.4882) and between Site B and Site C (p = .000, 95% C.I. = -1.0018, -.6649).

**Turbidity**

A one-way ANOVA had performed to compare the effect of three different sites on Turbidity. A one-way ANOVA revealed that there was a statistically significant difference in mean Turbidity between at least two sites. Tukey's HSD Test for multiple comparisons found that the mean value of Turbidity was significantly different between Site A and Site B (p = .014, 95% C.I. = 9.2570, 60.2430) and between Site B and Site C (p = .012, 95% C.I. = -61.5563, -10.5704). There was no statistically significant difference in mean Turbidity between Site A and Site C (p=.986).

**Total Suspended Solids (TSS)**

A one-way ANOVA had performed to compare the effect of three different sites on TSS. A one-way ANOVA revealed that there was a statistically significant difference in mean TSS between at least two sites. Tukey's HSD Test for multiple comparisons found that the mean value of TSS was significantly different between Site A and Site B (p = .010, 95% C.I. = 6.65, 36.01), and between Site B and Site C (p = .036, 95% C.I. = -30.68, -1.32). There was no statistically significant difference in mean TSS between Site A and Site C (p=.540).

**Chemical Oxygen Demand (COD)**

A one-way ANOVA had performed to compare the effect of three different sites on COD. A one-way ANOVA revealed that there was a statistically significant difference in mean COD between at least two sites. Tukey's HSD Test for multiple comparisons found that the mean value of COD was significantly different between Site A and Site B (p = .000, 95% C.I. = 9.2043, 15.3623), and between Site A and Site C (p = .000, 95% C.I. = 10.4777, 16.6357). There was no statistically significant difference in mean COD between Site B and Site C (p= .461).

**4.1.3 Water Quality Index (WQI) of Taung Tha Man Lake**

All the physicochemical water quality parameters except ORP and salinity were involved for determining Weight Arithmetic Water Quality Index (WQI). Nine water quality parameters were also selected for calculating Drinking Water Quality Index (DWQI). There is no "rule of thumb" on the selection of input or important variables; however, parameter selection should be based on measurements of water quality relevant to the study issue [22]. That's why ORP and salinity were omitted in the calculation as they have no significant impact on drinking requirements. After all the necessary calculations were completed, the general water quality status of Taung Tha Man Lake using Arithmetic Weighted WQI was calculated for three different sites ( Table 3).

**Table 3: WQI results of three different sites in the Taung Tha Man Lake**

| Para-meters | Unit Weight (Wi) | Site A | | Site B | | Site C | |
|---|---|---|---|---|---|---|---|
| | | Qi | WiQi | Qi | WiQi | Qi | WiQi |
| DO | 0.241 | 11.04 | 2.66 | -18.17 | -4.37 | -103.23 | -24.86 |
| pH | 0.142 | -1.96 | -0.28 | 4.50 | 0.64 | 11.03 | 1.56 |
| WT | 0.048 | 126.53 | 6.09 | 125.52 | 6.04 | 122.25 | 5.89 |
| BOD | 0.201 | 71.28 | 14.30 | 72.89 | 14.62 | 73.50 | 14.75 |
| TDS | 0.001 | 45.97 | 0.06 | 45.90 | 0.06 | 46.00 | 0.06 |
| Turbidity | 0.241 | 1945.27 | 468.37 | 1250.27 | 301.03 | 1971.53 | 474.70 |
| EC | 0.004 | 238.22 | 0.96 | 239.22 | 0.96 | 240.56 | 0.97 |
| TSS | 0.002 | 13.33 | 0.03 | 9.07 | 0.02 | 12.27 | 0.03 |
| COD | 0.120 | 186.67 | 22.47 | 63.83 | 7.68 | 51.10 | 6.15 |
| | ∑Wi=1 | | ∑WiQi= 514.67 | | ∑Wi= 326.69 | | ∑WiQi= 479.24 |
| WQI | | | 514.67 | | 326.69 | | 479.24 |

## 5. Discussions

It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose [63].

### 5.1 Physicochemical Water Quality Parameters

Water parameters include water temperature (WT), dissolved oxygen (DO), Oxidation Reduction Potential (ORP), electrical conductivity (EC), total dissolved solids (TDS), Salinity, pH, Turbidity, Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD). They are the most important water quality parameters for drinking and aquatic life for surface water assessment [22].

### Water Temperature (WT)

Temperature is crucial factor, which regulates the biogeochemical activities in the ecosystem of water body [22]. Water temperature had generally influenced by air temperature and intensity of solar radiations. The sites in the lake could influence the spatial variability of temperature [22].

Temperature of all the water samples measured in situ and varies between 30.21 °C to 32.26 °C in Table 2. The minimum water temperature (30.56±.32°C) was recorded at site C (area with the active agricultural area) and the maximum (31.63±.55°C) was recorded at site A (inlet into the lake) (Table 2). There was a statistically significant difference between sites in the lake, Water Temperature ($F(2, 6) = 6.864$, $p = .028$). The mean value of water temperature was significantly different between Site A and Site C ($p = .028$, 95% C.I. = .1439, 1.9961).

In previous study, the temperature of Taung Tha Man Lake water ranged from 23.73˚C to 30.06˚C during the dry season [21]. In present study, the water temperature of study was higher than that of the previous study. The water temperature of the Lake indicates higher than maximum permissible limits of drinking and aquatic health (< 25°C) developed by WHO [64] and U.S.EPA [65].

The high temperature in the dry season had related to heat or sunlight that plenty in the dry season. It can also affect photosynthesis, concentration of Dissolved Oxygen, pH level and toxicity of some compound such as ammonia, zinc, etc. rather than the metabolic rate of aquatic life [23].

**Dissolved Oxygen (DO)**

Dissolved oxygen is the main indicator of the ecological health of aquatic ecosystems [70]. It determines the gaseous oxygen amount dissolved in water serving as fundamental role in the life of cultured organisms [71].

DO content recorded during the investigation ranged from .61 to 5.00 mg/L while the mean was 2.346±1.821 mg/L (Table 2). Low DO (.676±.076 mg/L) had recorded at site A (inlet into the lake) and the maximum DO (4.666±.577 mg/L) had recorded at site C (area with the active agricultural area) of the lake (Table 2). There was a statistically significant difference between sites in the lake, Dissolved Oxygen (F (2, 6) =195.126, p =.000).

In previous study, the dissolved oxygen of Taung Tha Man Lake water ranged from 3.1 to 18.18 mg/L [21]. In present study, the DO content of study was lower than that of the previous study. The mean of DO values was lower than the acceptable bounds of drinking water quality standard (4-6 mg/L) developed by WHO [64] and maximum permissible limits of aquatic life (> 5mg/L) guided by U.S.EPA [65] for aquatic desires of surface water. Dissolved oxygen concentration in Taung Tha Man Lake has decreased with increasing water temperature.

The change in DO concentrations is an indicator of undesirable conditions in physical, chemical and biochemical factors in Taung Tha Man Lake. Temperature, turbulence, precipitation events, plant productivity, and level of aquatic life are some kinds of factors that contribute to the low level of dissolved oxygen in the lake [75]. The low DO values with the high COD values of water quality must be due to the discharges of agricultural and urban waste sources.

**Oxidation Reduction Potential (ORP)**

The oxidation-reduction potential (ORP) or redox potential indicates the availability of free electrons and the oxidizing or reducing tendency of a water [76].

The ORP values in the study range from -241 to 26 mV and the mean of ORP values was -125.2±117 mV (Table 2). The minimum ORP (-236.3±4.16 mV) was recorded at site A (inlet into the lake) and the maximum ORP (24.67±1.15 mV) was recorded at site C (area with the active agricultural area) of the lake (Table 2).There was a statistically significant difference between sites in the lake, Oxidation Reduction Potential (F(2,6) =25.667, p =.001). The mean value of ORP was significantly different between Site A and Site B (p =.005, 95% C.I. = -115.77, -28.90), between Site A and Site C (p = .000, 95% C.I. = -304.43, -217.57), and between Site B and Site C (p = .000, 95% C.I. = -232.10, -145.23).

A positive value of the ORP indicates that water has oxidation potential which means corrosion and destructive/corrosive effects, while a negative value indicates antioxidant properties that are anticorrosive [70].

The redox potential (Eh) characterizes the oxidation-reduction state of natural waters [27]. Oxidation-reduction potential (ORP) measures the ability of a lake or river to clean itself or breakdown its waste products [28]. When ORP is high, there is a lot of oxygen present in the water [28]. Elements like dissolved oxygen and chlorine contribute heavily to a higher ORP level in the water and the increased breakdown of unwanted contaminants.

Oxidation Reduction Potential (ORP) or redox reflects the micro scale electrical potentials that influence cellular and molecular processes that are responsible for energy cycling. Reductive processes (e.g. respiration) consume dissolved oxygen, and oxidative processes liberate oxygen from molecules, and a healthy situation is where a balance is present [26]. Different oxidation-reduction processes and conditions have different ORP values, with aerobic conditions having higher ORP values and anaerobic conditions having lower ORP values [34].

***Electrical conductivity (EC)***

Electrical conductivity (EC) is the ability of current conduction and in case of water it is also an estimator of the amount of total dissolved salts or ions in water [38]. Conductivity is the ability of water to conduct an electric current: the dissolved ions are the conductors while salinity is the measure of the amount of salts in the water, and dissolved ions increase salinity as well as conductivity [73].

The values of EC in this study ranged from 707 to 730 µS/cm and the overall mean value was 718±8.185 µS/cm in (Table 2). The low value of conductivity (714.67±13.2 µS/cm) was recorded at site A (inlet into the lake) and the high value (721.67±4.72 µS/cm) was recorded at site C (area with the active agricultural area) of the lake because of inflowing much of agricultural runoff and other solids (Table 2). The means of EC ($F(2, 6) = .481$, $p = .640$) was not significantly different between sites in the lake.

The EC values of Taung Tha Man lake was completely agreed with drinking water quality standard (<750 µS/cm) developed by WHO [64] and aquatic health (<1000 µS/cm) water quality standard stated by U.S.EPA [65].

The sources of material in TDS and EC can come from nature, i.e. geological condition and seawater, and from human activities, i.e. domestic and industrial waste and also agriculture [39]. Agricultural runoff or a sewage leak may be the primary cause of rise in conductivity due to the additional chloride, phosphate and nitrate ions [38].

Electrical Conductivity (EC) is a readily-measurable analogue of salinity. As salts and other inorganic chemicals dissolve in water, they break down into ions. When ions and dissolved salts are present in the water, they increase the ability to conduct electricity, therefore as salinity increases in water, so does the electrical conductivity (EC).

**Total Dissolved Solids (TDS)**

The amount of dissolved or soluble materials in water is termed as total dissolved solid (TDS) [38]. Different ions like sodium, potassium, chloride, carbonate, sulphate, calcium, magnesium etc. contribute to the TDS of water [22].

The values of TDS found in the present study fluctuated from 457 mg/L to 463 mg/L in Table 2. Minimum value (459.67±3.06 mg/L) had recorded at site A (inlet into the lake) and maximum value (460±1 mg/L) had found at site C (area with the active agricultural area) of the lake (Table 2). The means of TDS ($F(2, 6) = .104$, $p = .902$) was not significantly different between sites in the lake.

In previous study, the TDS of Taung Tha Man Lake water ranged from 24.8 to 1090 mg/L [21]. In the present study, TDS concentration of all the water samples were found in accordance with water quality monitoring standards of aquatic life (<1000mg/L) and drinking purpose (<500mg/L) stated by U.S. Environmental Protection Agency [65] and WHO [64] respectively to protect aquatic and human health.

TDS in water is caused by natural sources, sewage wastes, surface rainwater and industrial wastewater [77]. Higher TDS can be toxic to aquatic life through changing the composition of the water [46]. A high content of dissolved solid reduces solubility of gases (e.g. $O_2$) and result into eutrophication of the aquatic ecosystem.

Conductivity (EC) and total dissolved solids (TDS) are water quality parameters, which are used to describe salinity level. TDS is the dissolved inorganic salts come from the natural sources, domestics, runoff, and industries. When a sewage leak or agricultural runoff occurs, it increases the EC because of additional ions such as chloride, phosphate, and nitrate.

***Salinity***

Salinity is simply the measure of dissolved salts in water [41]. It refers to the total concentration of dissolved inorganic ions in water and is, therefore, a component of all-natural waters [42]. Conductivity and salinity also have a strong correlation [23]. Salts and other substances affect the quality of water used for irrigation or drinking [43].

Salinity is the concentration of salt in water [5]. It is one of the most important parameters affecting dissolved oxygen concentration in water [70].

Salinity measurement results ranged between .34 ppt and .36 ppt (Table 2). The minimum value (.343±.006 ppt) had recorded at site A (inlet into the lake) and the maximum value (.357±.006 ppt) had found at site C (area with the active agricultural area) of the lake (Table 2). The means of Salinity ($F(2, 6) = 4.333$, $p = .068$) was not significantly different between sites in the lake.

Changes in salinity can occur as a result of weather patterns, such as droughts or storms, or increased urban runoff and sewer discharge [41]. It was reported a positive correlation between Dissolved Oxygen and Salinity [73]. Salinity is an important indicator to determine the chemical compositions of water and is used in the evaluation of irrigation water applicability[26]. Fresh water has a salinity of 0.5 ppt or less [41].

**pH**

pH level is controlled by dissolved chemical compounds and biochemical processes in water [22]. Industrial effluents, atmospheric deposition, as well as photosynthesis and respiration of algae can affect the natural acid-base balance of aquatic systems [32].

During the present study, pH values ranged from 6.69 to 8.48 with overall mean value of 7.58±.72 (Table 2). The minimum pH recorded was 6.75±.07 at site A (inlet into the lake) and maximum was 8.41±.07 at site C (area with the active agricultural area) of the lake (Table 2). There was a statistically significant difference between sites in the lake, pH ($F(2, 6) = 455.182$, $p = .000$). The mean value of pH was significantly different between Site A and Site B ($p = .000$, 95% C.I. = -.9918, -.6549), between Site A and Site C ($p = .000$, 95% C.I. = -1.8251, -1.4882) and between Site B and Site C ($p = .000$, 95% C.I. = -1.0018, -.6649).

The pH value of the present study is lower than the previous study between 6.76 and 8.58 that was performed during 2018-2019 [21]. Although the maximum pH value of 8.48 was found slightly alkaline, pH of all the water samples were found in compliance within the permissible limits of drinking water quality standards range of 6.5 to 8.5 developed by both U.S.EPA [65] and WHO [64]. Because of this study, the analysed average pH values at each sampling site were almost neutral.

The lower pH was thought to be high decay of organic matter in the dry season, because the high intensity of sunlight entering the waters [78]. The decreased of pH at the bottom was increased in microbial activity to decompose organic matter so that $O_2$ decreased and $CO_2$ increased. Increased $CO_2$ would make the waters became more acidic (pH decreases) [78]. Low-pH water will corrode or dissolve metals and other substances [30]. The amount of oxygen in water increases as pH rises [29]. It was found a direct relationship between water pH and salinity; a higher value of pH is given by the high content of mineralization [80].

The variations at different locations may be an indication for the disparity mixing of wastewater into the lake and were also attributed to factors like dilution of waste with fresh water, fluctuation in salinity and temperature, and decomposition of organic matter [22]. pH is closely related to water solubility, chemical form, attribute, activities and effects, and it also has a significant impact on the activities of aquatic life. pH level is high when the eutrophication occurred [21].

**Turbidity**

Turbidity reflects the loss of transparency in a liquid, i.e. in our case urban wastewater or storm water, due to the presence of colloidal and/or suspended solids [81].

During the present study, Turbidity values ranged from 53.74 to 107.10 NTU with overall mean value of 86.12±19.78 NTU (Table 2). The minimum Turbidity recorded was 62.51±12.83 NTU at site B (water flow from the lake into the river) and maximum was 98.58±4.45 NTU at site C (area with the active agricultural area) of the lake (Table 2). There was a statistically significant difference between sites in the lake, Turbidity ($F (2, 6) = 12.119, p =.008$). The mean value of Turbidity was significantly different between Site A and Site B ($p = .014$, 95% C.I. = 9.2570, 60.2430) and between Site B and Site C ($p = .012$, 95% C.I. = -61.5563, -10.5704).

In previous study, the Turbidity of Taung Tha Man Lake water ranged from 174 to 394 NTU [21]. In present study, the Turbidity in the water was lower than that of the previous study. Turbidity of all the water samples indicates higher than maximum permissible limits of water quality standards of aquatic life (<29 NTU) and drinking purpose (<5 NTU) stated by U.S. Environmental Protection Agency [65] and WHO [64] respectively to protect aquatic and human health.

Turbidity can be caused by the presence of suspended solids, such as clay, silt, sand, from inorganic materials and organic matter such as algae and/or plankton [59]. Turbidity is related with the TSS and with the *E.coli*, reaffirming the origin of the contamination from animal faeces (principally from livestock) carried by surface runoff [82].

For most waters containing suspended particles, there will typically be a defined relationship between turbidity and total suspended solids [59]. The eventual relationship between TSS and turbidity is affected by density, size, and shape of particles and water colour [59]. Increased turbidity in water increases suspended particles in the aquatic environment and this can lead to fish kills [26].

***Total Suspended Solids (TSS)***

Total suspended solids are a significant factor in observing water clarity and are often related to the turbidity of water [48]. The more solids present in the water, the less clear the water will be [48].

Total Suspended Solids (TSS) of the water samples ranged between 42 mg/L and 74 mg/L in Table 2. Minimum value (45.33±4.16 mg/L) was recorded at site B (water flow from the lake into the river) and maximum value (66.67±6.66 mg/L) was found at site A (inlet into the lake) of the lake (Table 2). There was a statistically significant difference between sites in the lake, Total Suspended Solid ($F (2, 6) =10.770, p =.010$). The mean value of TSS was significantly different between Site A and Site B ($p = .010$, 95% C.I. = 6.65, 36.01), and between Site B and Site C ($p = .036$, 95% C.I. = -30.68,-1.32).

Most manuals on water quality criteria suggest the allowable change in total suspended solids or turbidity should not be greater than 10 per cent of the seasonal mean concentration in order to prevent adverse impacts on aquatic organisms [83]. Waters with low concentrations of total suspended solids (TSS) are clearer and less turbid than those with high TSS concentrations [47].

Untreated wastewater discharges from households, industrial plant, commercial establishment, erosion from urban runoff and agricultural land, bank erosion, bottom feeders, algae growth all contribute to high concentrations of suspended solids in the water [84].

TSS is a physical parameter which is used to describe the inorganic and organic particles of the water body which would be affected by the discharge of industry and residential area. The high concentration of TSS will reduce the light penetration in the surface water and affect the aquatic life and interfere with the sufficient oxygen transfer. It will give the rise to septic and offensive conditions and may indicate the presence of unsatisfactory sewage effluent discharge [26].

***Biochemical Oxygen Demand (BOD)***

BOD refers to the separation of organic substances by bacteria under aerobic conditions and the amount of oxygen they consume during mineralization which is usually higher in the wastewaters [70].

The BOD content of the study sites ranged from 3.08 to 5.46 mg/L with the overall mean value was 4.353±.798 mg/L (Table 2). The low BOD Concentration (4.277±1.036 mg/L) had found at site A (inlet into the lake) and high BOD value (4.410±1.004 mg/L) had recorded at site C (area with the active agricultural area) of the lake (Table 2). The means of BOD ($F (2, 6) = .017$, $p =.983$) was not significantly different between sites in the lake.

The mean of BOD values indicates nearly a little bit higher than maximum permissible limits of drinking water quality (<5mg/L) guided by WHO [64], but below the maximum permissible limits of drinking water quality (<10 mg/L) stated by U.S. Environmental Protection Agency [65].

BOD is an indicator of sewage and industrial pollution because it is used as a measure of the power of sewage; strong sewage has a high BOD and weak sewage has low BOD [51]. Unpolluted waters typically have BOD values of 2 mg/L $O_3$ or less, whereas those receiving wastewaters may have values up to 10 mg/L $O_2$ or more, particularly near to the point of wastewater discharge [27]. In other words, BOD of clean freshwater is 2mg/L whereas a value exceeding 5 mg/L indicates contamination.

The values of BOD and COD were much higher than DO in Taung Tha Man Lake, showing that biological activities are depleting the DO. Domestic sewage reduces dissolved oxygen and increases biochemical oxygen demand levels in water bodies due to presence of excessive quantities of organic matter [56]. When sewage enters lakes or streams, microorganisms begin to decompose the organic materials and oxygen is consumed. When the dissolved oxygen levels drop too low, many aquatic species perish [56].

The high concentration of BOD may be due to the over loaded input of organic matter by human activities and the decomposition of organic matter. The greater the BOD, the more rapidly oxygen is depleted in the lake. This is because the demand for oxygen by the bacteria is high.

***Chemical Oxygen Demand (COD)***

COD determines the oxygen amount needed for oxidizing the biodegradable and non-biodegradable organic matter in water by a strong chemical oxidant [85]. It is also an indication of both sewage and industrial pollution.

Chemical Oxygen Demand (COD) of water samples ranged between 4.20 and 20.00 mg/L with the overall mean value was 10.05±6.57 mg/L (Table 2). The low COD concentration (5.11±.81 mg/L) was found at site C (area with the active agricultural area) and high COD value (18.66±1.17 mg/L) was recorded at site A (inlet into the lake) of the lake (Table 2). There was a statistically significant difference between sites in the lake, COD ($F_{(2, 6)}$ =25.590, $p$ =.001).

The mean of COD values indicates a little bit higher than maximum permissible limits of drinking water quality (< 10 mg/L) guided by WHO [64].

High level of biochemical oxygen demand and chemical oxygen demand is due to the presence of chemicals that may be organic or inorganic caused by the inflow of domestic, livestock and industrial waste that contains elevated levels of organic pollutants [46]. The source of COD in Taung Tha Man Lake may be due to input of domestic and industrial discharges, human activity, sewage disposal and chemical deposited from the respective fertilizer used in agricultural farms [28].

The higher COD value the wastewater has, the more oxygen it consumes in the water bodies [19]. COD is normally higher than BOD because more organic compounds can be chemically oxidised than biologically oxidised and the ratio between them will vary depending on the characteristics of the wastewater [60]. The low DO values with the high COD values of water quality must be due to the discharges of agricultural and urban waste sources.

## 5.2 Water Quality Index (WQI)

Water quality index had defined as a rating, reflecting the composite influence of different water quality parameters on the overall quality of water. The main objective of computing of Water Quality Index (WQI) is to turn the complex water quality data into information which is easily understandable and usable [46].

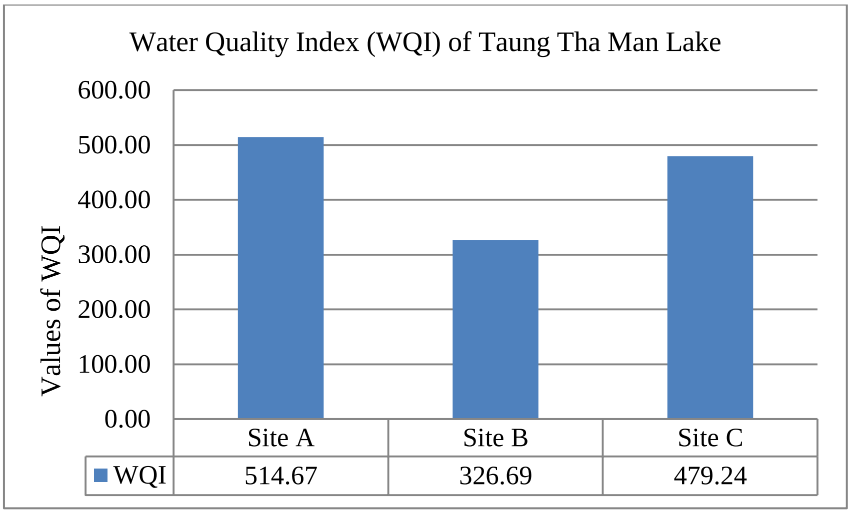



Figure 4: Graphs of Spatial Variations of WQI in Taung Tha Man Lake

The values of the calculated water quality index (WQI) were 514.67, 326.69, and 479.24 for the Site A (inlet into the lake), Site B (water flow from the lake into the river), and

Site C (area with the active agricultural area) respectively (Figure 4) which was not suitable for irrigation, fish farming, industrial use or any human use (Table 4). The WQI represented extremely poor quality of water of Taung Tha Man Lake.

The present study revealed that the water quality of Taung Tha Man Lake had found differently with locations. The minimum or finest WQI (326.69) had verified at the Site B (water flow from the lake into the river). The maximum or poorest WQI (514.67) was also recorded at the Site A (inlet into the lake).

**Table 4: Water quality status and descriptions based on Weight Arithmetic Water Quality Index Method**

| WQI Value | Water Quality Status (WQS) | Description/Possible Usage |
|---|---|---|
| **0-25** | **Excellent** | Water quality is protected with a virtual absence of threat or impairment conditions very close to natural or pristine levels. Suitable for drinking, irrigation and industrial usage |
| **26-50** | **Good** | Water quality is protected with a slight presence of threat or impairment conditions close to natural or pristine levels. Suitable for drinking, irrigation and industrial usage. |
| **51-75** | **Poor** | Water quality is usually protected but occasionally threatened or impaired conditions sometimes depart from natural or desirable levels. Suitable for irrigation and industrial usage. |
| **76-100** | **Very poor** | Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels. Suitable for irrigation. |
| **Above 100** | **Highly polluted** | Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels. Unsuitable for drinking and fish culture. Proper treatment required before use. |

These results are associated with the inflow of the turbid water, untreated wastewater discharges from households and erosion from urban runoff and agricultural land into the lake that makes the lake water deteriorated. That is why WQI indicates highly polluted water in all parts of the lake.

## 6. Conclusions and Recommendations

### 6.1 Conclusions

This study was conducted to assess the physicochemical properties of water quality collected from three different sites in Taung Tha Man Lake.

The one-way ANOVA test showed that there was a statistically significant difference between sites in the lake, Water Temperature, Turbidity, pH, Total Suspended Solid, Dissolved Oxygen, Oxidation Reduction Potential, and Chemical Oxygen Demand.

This experiment confirmed that some physicochemical parameters like EC, TDS, pH and BOD met the acceptable limits of WHO drinking water quality standard and water quality monitoring standard of aquatic life developed by U.S. Environmental Protection

Agency while water temperature, DO, Turbidity, and COD did not meet these international standards.

The calculated WQI provided an easy way of understanding the overall water quality and water management. The WQI showed extremely poor water quality of Taung Tha Man Lake which was unsuitable for irrigation, fish culture, industrial use or any human use. Therefore, the results of WQI indicate that the status of Taung Tha Man Lake water quality is highly polluted and do not fit for human consumption without proper treatment works but with some great cares and restoration works the water quality of lake can be good for aquatic life.

### 6.2 Recommendations

There are things to improve the quality of Taung Tha Man Lake. Educating the public on efficient water use and the attention of the environmental awareness as to the best ways to decrease urban and agricultural runoff is an important step to improve water quality. Engaging the public and helping raise awareness is crucial to restoring water quality of the Lake.

Related to the issue of Taung Tha Man Lake, many studies were done so far and being done. However, the studies shown, the lake water quality is still deteriorating. Therefore, this study recommended the further development of the environmental pollution control and a routine monitoring of water quality of the Lake by responsive authority.

### 6.3 Limitations of the Study

There were a number of limitations to this study. Due to the Covid-19 pandemic and unstable political situation in Myanmar, the onsite measurements had only taken once and had limited laboratories to make experiment. The limitations of financial resource were also critical for this research. If time and resources were not constraints, measurements could make for longer periods and more samples. This research also did not cover water quality analysis throughout the year of the lake.

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