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Assessment of Seasonal Variations in Surface Water Quality of Chaungmagyi Dam, Nay Pyi taw

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Abstract

The aim of this study is to assess the seasonal variations in surface water quality of Chaungmagyi Dam, by measuring some physical, chemical and bacteriological parameters. The study was carried out during the period June 2019 to April 2020. Five sampling points were chosen inside the dam. Examination of dam water indicates that most of the mentioned parameters were lower the acceptable limits of WHO and its suitable to use as a source of drinking water. The level of DO of dam water except in rainy season was good enough for aquatic animals and for drinking. DO range in dry seasons was no problem to compare with the WHO standard. According to the standard of WHO, the range of WT of dam water in dry seasons was no problem. However, The EC values of dam water especially in dry seasons exceeded the standard value (250 uS/cm) for drinking water which indicates the pollution of the dam in dry seasons. Moreover, the *E. coli* bacterial counts detected were above the permissible limits for drinking water in all the sampled stations. Therefore, water from the Chaungmagyi dam is not suitable to use for drinking purposes without any treatment in rainy season. If the dam water is to be used for drinking, cooking, brushing teeth etc., consumers are advised to boil the water. Other treatments such as filtrating the particles, setting and decanting to reduce turbidity by letting the water sit for 2 – 24 hours, etc. should also be applied, especially in rainy season.

Key Words: water quality, dam, permissible limits, pollution, *E. coli*

ချောင်းမကြီးဆည်ရေ၏ အရည်အသွေး ရာသီအလိုက်ကွဲလွဲမှုကို အကဲဖြတ်ခြင်း

ဒေါက်တာသီတာချို၊ လက်ထောက်သုတေသနအရာရှိ
ဒေါ်သီတာဆွေ၊ လက်ထောက်သုတေသနအရာရှိ
ဒေါ်နှင်နုနုကျော်၊ သုတေသနလက်ထောက် (၃)

စာတမ်းအကျဉ်း

ဤသုတေသနပြုလုပ်ခြင်း ရည်ရွယ်မှာ ချောင်းမကြီးဆည်ရေ၏ အရည်အသွေး**ကို ရှု၊ ဓာတုနှင့် ဇီဝဂုဏ်သတ္တိများ တိုင်းတာခြင်းအားဖြင့် ရာသီအလိုက်ကွဲလွဲမှုကို အကဲဖြတ်ရန်ဖြစ်ပါသည်။** ဤလေ့လာမှုကို ၂၀၁၉ခုနှစ် ဇွန်လမှစတင်၍ ၂၀၂၀ ပြည့်နှစ် ဧပြီလအထိ ဆောင်ရွက်ခဲ့ပြီး ဆည်အတွင်း နေရာ ၅ နေရာမှ ရေနမူနာများကို ကောက်ယူခဲ့ပါသည်။ ဆည်ရေစမ်းသပ်ချက်မှ ရေဂုဏ်သတ္တိအတော်များများသည် ကမ္ဘာ့ကျန်းမာရေးအဖွဲ့(WHO) ၏ သောက် သုံးရေ စံသတ်မှတ်ချက်အောက်တွင်ရှိပြီး သောက်သုံးရေ အရင်းအမြစ်အဖြစ် အသုံးပြုရန် သင့်လျော်ပါကြောင်း တွေ့ရှိရပါသည်။ ချောင်းမကြီးဆည်ရေ၏ DO ပါဝင်မှု levelသည် မိုးရာသီမှလွဲ၍ ကျန်သောရာသီများတွင် ရေနေသတ္တဝါများနှင့် သောက်သုံးရန် အတွက် ကောင်းမွန် ပါသည်။ ဆည်ရေ၏ DO ပါဝင်မှုပမာဏသည် ကမ္ဘာ့ကျန်းမာရေးအဖွဲ့၏ သောက်သုံးရေအတွက် စံသတ်မှတ်ချက်နှင့် နှိုင်းယှဉ်ပါကလည်း ပြဿနာမရှိနိုင်ပါ။ WHO ၏ စံသတ်မှတ်ချက်အရ ချောင်းမကြီးဆည်ရေ၏ WT သည်လည်း ပြဿနာမရှိနိုင်ပါ။ သို့သော် ဆည်ရေ၏ ECပါဝင်မှုသည် ကမ္ဘာ့ကျန်းမာရေးအဖွဲ့၏ သောက်သုံးရေအတွက် စံသတ်မှတ်ချက် ၂၅ uS/cmထက် များနေကြောင်း ဓာတ်ခွဲတွေ့ရှိရပါသဖြင့် ရေနည်းသော နွေရာသီနှင့် ဆောင်းရာသီများတွင် ဆည်ရေညစ်ညမ်းမှုအခြေအနေ ဖြစ်ပေါ်လာနိုင်ဖွယ် ရှိပါသည်။ ထို့အပြင် ရေနမူနာကောက်ယူသောနေရာများမှ *E. coli ဘက်တီးရီးယားပါဝင်မှုသည် စံသတ်မှတ်ချက်ထက် ကျော်လွန်နေကြောင်း တွေ့ရှိရပါသည်။* မိုးရာသီတွင် E. coli ဘက်တီးရီးယားပါဝင်မှုများသဖြင့် ချောင်းမကြီးဆည်ရေကို သောက်သုံးရေအဖြစ် သုံးစွဲမည်ဆိုပါက treatment မပြုလုပ်ပဲ မသုံးစွဲသင့်ပါ။ ဆည်ရေအား သောက်သုံးခြင်း၊ ချက်ပြုတ်ခြင်း၊ သွားတိုက်ခြင်းများ စသည်တို့ အသုံးပြုလျှင် ရေကိုကျိုချက်ပြီးမှသာသုံးစွဲသင့်ပါသည်။ ထို့ အပြင် ဆည်ရေကို မိုးရာသီတွင် TURB ဖြစ်မှု နည်းပါးစေရန် စစ်ပြီးမှသာ သုံးစွဲခြင်း၊ ရေကို ၂ နာရီမှ ၂၄ နာရီကြာထားရှိ၍ အနည်ထိုင်စေပြီးမှ သုံးစွဲခြင်းစသည့်treatment နည်းစဉ်များကိုလည်း အသုံးပြုသင့်ပါသည်။

Assessment of Seasonal Variations in Surface Water Quality of Chaungmagyi Dam, Nay pyi taw

1. Introduction

A good quality of water implies that it is good in chemically, physically & bacteriologically. It is worth mentioning that water quality of the river and reservoir changes with the change of seasons and geographic areas (Lawson E O., 2011) as because with the change of season, there are several anthropogenic activities such as mining, agricultural, industrial as well as socio-cultural which contribute to change of water quality (Karia G L., 2006). It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. The physio-chemical parameters useful for water quality assessment are determined by the presence of both organic and inorganic compounds that are either suspended or dissolved in water. Ugwu & Wakawa, 2012 reported that water quality characteristics of aquatic environment arise from a multitude of physical, chemical and biological interactions. While some of these compounds are toxic to the ecosystem, some are providing nutrients to aquatic organisms and others are responsible for the aesthetics of the water body (Boukari et al., 1999).

According to current situation of water supply in Nay Pyi Taw, about 50% of urban area has city water supply system and the rest urban area has source of water from tube well or shallow well. Daily water supply amount is 15 million gallons. As the city growth, the population increase and also the water demand increase. Due to the climate change, less rain falls in rainy season of 2020 in Nay Pyi Taw. Y. Zhang, Z. Wu, M. Liu et al., 2015 stated that water quality of reservoirs has been observed to vary seasonally in tandem with changes in temperature and rainfall. So the assessment of water resource quality of Nay Pyi Taw region is an important aspect of developmental activities, because lakes and manmade reservoirs are used for water supply to domestic, industrial, agricultural and fish culture.

Chaungmagyi dam, which is located about 1 mile away from the north of Kyetsuei village in Ottara Thiri Township, Nay Pyi Taw, is an earth embankment man-made reservoir. Dam construction was started in 2002-2003 and completed in 2003-2004. The length of dam is 6000 ft. and its height is 88 ft. The catchment area of the dam is 1400 acres with live storage of 40000 acres feet, and dead storage of 7500 acres feet. The water consumption from Chaungmagyi dam has been increasing due to the expansion of urban development around the watershed area. Water from the dam directly and indirectly supplies 8.90 million gallons of water daily for domestic activities including drinking water to millions of people living around the dam.

The anthropogenic activities like farming, fishing, bathing, poor sanitation, wastewater treatment systems around the watershed area and sewage, animal wastes or fertilizer runoff from the surrounding areas during the rainy season can cause decrease water quality of the dam. The preliminary water quality assessment was initiated during rainy season, (June 2019). Water samples were collected at five different stations; 12 inch water distribution pump, 24 inch main water distribution pipeline, the junction of Chaungmagyi and Chaungmangwe creeks, the middle of the dam and the compartment 5 water distribution pump. All samples were analyzed at the Water Quality Laboratory of Forest Research

Institute (FRI), Yezin. From the results of water samples, it was observed that Escherichia coli (*E. coli)* bacteria content are high in all monitoring stations. Thus, we attempted to study the seasonal variations and water quality of Chaungmagyi dam based on physiochemical properties and bacteriological content for the benefit of the society especially for the people those are directly dependent on it. The all physicochemical and bacteriological parameters were also compared with the World Health Organization (WHO) drinking water quality standards in order to justify the present water quality condition of Chaungmagyi dam. The present baseline information of the physicochemical and bacteriological properties of the dam water would be a useful tool for further ecological assessment and monitoring of the dam quality. In this study, we selected the same sampling points, which collected the water samples in 2019 rainy season.

2. Objectives

Objectives of the present study are:

- To assess and compare the seasonal variations of some physical, chemical and bacteriological parameters of dam water from the study site
- To examine all mentioned parameters are the acceptable limits of WHO and its suitable to use as a source of drinking water.

3. Materials and Methods

3.1 Study Area

The present study was conducted at Chaungmagyi dam as illustrated in Figure 1. It is an earth embankment man-made reservoir. Dam construction was started in 2002-2003 and completed in 2003-2004. The length of dam is 6000 ft. and its height is 88 ft. The catchment area of the dam is 1400 acres with live storage of 40000 acres feet, and dead storage of 7500 acres feet. Water from the dam directly and indirectly supplies 8.90 million gallons of water daily for domestic activities including drinking water to millions of people living around the Chaumagyi dam.

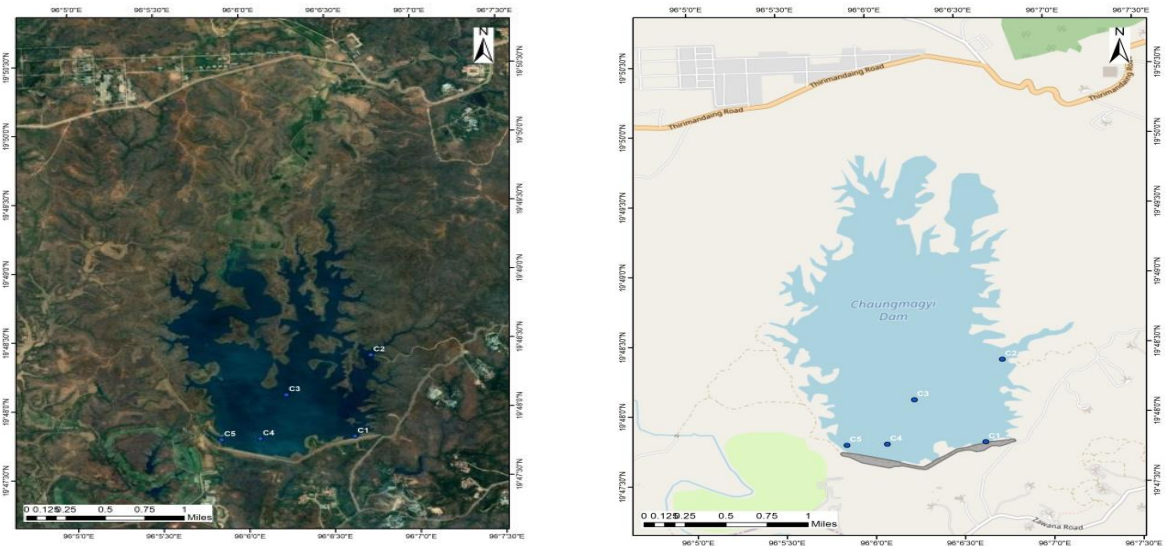

Figure (1) Map of dam and Sampling points

3.3 Water Sample collection

Water samples were collected at five different locations; C1 point is 12 inch water distribution pump for Ottara Thiri City, C2 is 24 inch main water distribution pipeline for the whole Zabu Thiri City, South of hospital hill, Myoma and Thapyaekone markets,, C3 is the junction of Chaungmagyi and Chaungmangwe creeks, C4 point is the middle of the dam and C5 is the compartment 5 water distribution pump for villages nearby dam, football stadium and residential apartments. During the period from June 2019 to April 2020, water samples were collected. Where June and August represent rainy season, November and January state winter and April and May represent summer. The water sampling bottles were well rinsed acid-washed, cleaned, and dried before use and tightly sealed after collection and labelled in the field. Water samples were taken at approx. 20 cm water depth at selected localities in the dam. The water samples were preserved in the field with 4M H_2SO_4 for nutrient analysis (total P, ortho phosphorous, etc.), or not preserved for analysis of turbidity, total alkalinity, color, pH, BOD, COD, TSS, other anions and cations. All samples were placed in an ice box and transported to the Water Quality Laboratory of Forest Research Institute (FRI), Yezin for further analysis.

Table 1. Station and coordinate of Chaungmagyi dam

STATION	LATITUDE	LONGITUDE
C1	19.796536	96.110297
C2	19.806360	96.112036
C3	19.801660	96.103725
C4	19.796396	96.101089
C5	19.796326	96.097321

3.3 Water quality analyses

Escherichia coli (*E. coli)* bacteria and twenty one physicochemical water quality parameters were analyzed on-site and in the laboratory. On-site measurements of dissolved oxygen, temperature, pH, electrical conductivity were done using a HACH, HQ40d portable multi-meter. Other physico-chemical parameters were investigated in the laboratory. The parameters such as pH, total alkalinity, turbidity, conductivity and color were measured with Mantech instrument. Calcium, sodium, magnesium, bromide, potassium, chloride, fluoride, nitrate, ammonia, sulfate analyzes are carried out with Ion Chromatograph-IC device (Dionex ICS-1000). Ortho phosphate and total phosphorus measurements were performed using Sequial Flow Autoanalyzer-SKALAR. Circulation and filtration system was used for total suspended solid –TSS measurement. *Escherichia coli* (*E. coli)* was determined using the NIVA *E.coli* method. Five-day biochemical oxygen demand (BOD) was analyzed by BOD Mantech. Chemical oxygen demand (COD) was determined using the titrimetric method. The analytical methods adopted for analysis of water quality parameters are presented in Table 2. The analytical data quality was ensured through standardization experiments with duplicates and average has been reported.

Table 2. Analytical methods used for determination of physicochemical and bacteriological parameters

S.no	Parameter	Abbreviations	Unit	Analytical method
1	Electrical Conductivity	EC	mS/cm	Potentiometric
2	pH	-	-	ISO 10523:2008
3	Turbidity	TURB	FNU	ISO 7027:1999
4	Color	-	mg Pt/L	ISO 7887:2011
5	Total alkalinity	TAKL	mmol/L	ISO 9963-1:1996
6	Fluoride	F	mg/L	ISO 10304-1:2009
7	Chloride	Cl	mg/L	ISO 10304-1:2009
8	Nitrate	NO_3^-	mg/L	ISO 10304-1:2009
9	Sulphate	SO_4^{2-}	mg/L	ISO 10304-1:2009
10	Sodium	Na^+	mg/L	ISO 14911:1998
11	Ammonium nitrogen	$NH4^+$	mg/L	ISO 14911:1998
12	Potassium	K^+	mg/L	ISO 14911:1998
13	Magnesium	Mg^{2+}	mg/L	ISO 14911:1998
14	Calcium	Ca^{2+}	mg/L	ISO 14911:1998
15	Ortho-Phosphate	O- PO_4^{-3}	mg P/L	NS 4724
16	Total Phosphorus	TP	mg/L	NS 4725
17	Total Suspended Solid	TSS	mg/L	NS 4733:1983/NS-EU 872:2005
18	*Escherichia* coli	E.coli	CFU/100 mL	NIVA E.coli
19	Dissolved oxygen	DO	mg/L	Potentiometric
20	Water Temperature	WT	C°	Potentiometric
21	Biochemical oxygen demand	BOD	mg/L	Spectrophotometry
22	Chemical oxygen demand	COD	mg/L	Titrimetric

3.4 Statistical analyses

The variance of analyses was performed to detect possible differences among the tested water quality parameters of three seasons. The statistical analysis and data plotting were conducted using SPSS 20.0 and with Excel.

4. Results and Discussion

All parameters under study are given in table 3 (rainy season), table 4 (winter) and table 5 (summer).

Table 3. The comparison of WHO standard and the mean values of water quality parameters among five stations at Chaungmagyi dam, during the rainy season

WQ Parameter	C1	C2	C3	C4	C5	WHO STD
DO (mg/L)	5.34	6.9	5.59	6.17	6.04	5
WT (°C)	29.00	29.70	29.10	29.90	29.80	30
EC (uS/cm)	232.5	128.50	233.00	232.00	230.50	250
PH	7.63	8.07	7.96	7.99	7.93	8.5-6.5
TURB (FNU)	9.11	6.78	9.83	8.96	9.17	5-25
TAKL (mmol/L)	1.88	1.65	2.42	2.24	2.20	15.6
Color (mgPt/L)	6.35	8.15	7.28	7.35	7.00	15
F (mg/L)	0.17	0.16	0.17	0.27	0.18	1.5
Cl (mg/L)	1.63	1.30	1.37	1.60	1.44	250
NO_3 (mg/L)	0.04	0.09	0.05	0.06	0.05	50
SO_4 (mg/L)	6.76	6.61	6.73	7.44	6.55	500
Na (mg/L)	9.91	9.56	9.65	9.19	9.02	200
NH_3 (mg/L)	0.18	0.14	0.14	0.12	0.17	NS
K (mg/L)	3.25	3.59	3.58	3.45	3.42	12
Mg (mg/L)	10.15	9.93	10.23	10.03	10.22	50-125
Ca (mg/L)	12.92	13.63	13.85	13.79	13.80	75-200
TSS (mg/L)	3.00	8.5	7.50	11.00	18.00	*
E.coli (CFU/100mL)	33.5	58.50	67.00	74.00	83.50	0
BOD (mg/L)	1.03	0.83	1.08	0.70	0.89	< 5
COD (mg/L)	1.43±..01	1.50±.01	2.18 ±.01	1.25±.01	1.65±.01	10
O-PO_4 (mgP/L)	0.032 ±.00	0.02 ±.00	0.02 ±.00	0.03 ±.00	0.025 ±.00	1
TP (mg/L)	0.04 ±.00	0.03 ±.00	0.03 ±.00	0.028 ±.00	0.03 ±.00	NS

Note; WQ - water quality, DO - dissolved oxygen, WT-water temperature, EC - electrical conductivity, TURB - turbidity, TAKL - Total alkalinity, F - fluoride, Cl - chloride, NO_3 - nitrate, SO_4 - sulphate, Na - sodium, NH_3 - ammonia, K - potassium, Mg - magnesium, Ca -calcium, TSS - total suspended solids, *E.coli* - *Escherichia* coli, BOD - biological oxygen demand, COD - Chemical oxygen demand, O-PO_4 - ortho phosphate, TP - total phosphorus,

Table 4. The comparison of WHO standard and the mean values of water quality parameters at five stations of Chaungmagyi dam during winter

WQ Parameter	C1 Mean	C2 Mean	C3 Mean	C4 Mean	C5 Mean	WHO STD
DO (mg/L)	8.64	7.69	9.08	8.76	9.83	5
WT (°C)	29.50	29.89	30.00	30.55	30.05	30
EC (uS/cm)	790.5	776	791.50	789	801.5	250
PH	7.85	8.11	8.02	8.06	8.10	8.5-6.5
TURB (FNU)	1.35	1.26	1.62	1.39	1.40	5-25
TAKL (mmol/L)	2.15	1.85	2.18	2.31	2.39	15.6
Color (mgPt/L)	6.23	7.91	7.10	7.13	6.79	15
F (mg/L)	0.11	0.15	0.15	0.19	0.15	1.5
Cl (mg/L)	2.10	1.79	1.65	1.70	1.72	250
NO_3 (mg/L)	0.03	0.03	0.04	0.05	0.03	50
SO_4 (mg/L)	5.87	6.25	6.54	6.56	6.42	500

Na (mg/L)	9.99	9.82	9.83	9.84	9.33	200
NH_3 (mg/L)	0.12	0.11	0.12	0.07	0.13	NS
K (mg/L)	3.73	4.36	3.98	3.62	3.51	12
Mg (mg/L)	10.17	10.65	11.07	10.37	10.53	50-125
Ca (mg/L)	13.93	13.83	13.90	13.99	14.00	75-200
TSS (mg/L)	2.45	4.00	3.00	2.00	2.50	*
E.coli (CFU/100mL)	7.50	7.00	9.00	3.50	9.00	0
BOD (mg/L)	0.85	0.78	0.98	0.61	0.75	< 5
COD (mg/L)	1.21	1.27	1.97	1.23	1.35	10
O-PO_4 (mgP/L)	0.02	0.01	0.01	0.01	0.02	1
TP (mg/L)	0.02	0.02	0.01	0.02	0.02	NS

Table 5. The comparison of WHO standard and the mean values of water quality parameters at five stations of Chaungmagyi dam during summer

WQ Parameter	C1 Mean	C2 Mean	C3 Mean	C4 Mean	C5 Mean	WHO STD
DO (mg/L)	9.55	9.55	10.58	10.59	10.90	5
WT (°C)	30.01	31.00	31.10	31.45	31.25	30
EC (uS/cm)	809.50	788.00	799.50	804.00	801.50	250
PH	8.05	8.29	8.19	8.25	8.18	8.5-6.5
TURB (FNU)	1.29	1.15	1.53.00	1.27	1.30	5-25
TAKL (mmol/L)	2.27	2.32	2.22	2.47	2.44	15.6
Color (mgPt/L)	6.05	6.67	6.46	6.23	5.99	15
F (mg/L)	0.10	0.10	0.13	0.10	0.10	1.5
Cl (mg/L)	2.18	2.22	2.25	2.32	2.25	250
NO_3 (mg/L)	0.02	0.03	0.03	0.03	0.02	50
SO_4 (mg/L)	6.29	6.14	6.25	6.32	6.33	500
Na (mg/L)	10.57	9.89	9.93	9.97	9.48	200
NH_3 (mg/L)	0.11	0.11	0.11	0.05	0.12	NS
K (mg/L)	3.89	4.58	4.23	3.78	3.65	12
Mg (mg/L)	11.13	13.94	11.57	11.12	10.95	50-125
Ca (mg/L)	14.26	14.05	14.05	14.17	14.17	75-200
TSS (mg/L)	2.00	3.00	3.00	2.00	2.00	
E.coli (CFU/100mL)	7.5	7.00	7.00	3.50	9.00	0
BOD (mg/L)	0.66	0.70	0.82	0.54	0.67	< 5
COD (mg/L)	1.18	1.04	1.63	1.05	1.15	10
O-PO_4 (mgP/L)	0.01	0.01	0.01	0.01	0.01	1
TP (mg/L)	0.01	0.02	0.01	0.02	0.01	NS

4.1 Dissolved oxygen (DO)

The World Health Organization (WHO) standard of dissolved oxygen (DO) in fisheries and aquatic life is 5 to 9 and for drinking water is 4.0 (Mar Lar Htwe, 2008). Chapman (1992) also stated that the concentration of DO below 5 mg/L may adversely affect the functioning and survival of biological communities and below 2 mg/L may lead to death of most fish. Park and Shin (2007) reported that DO values 7.3 to 7.9 mg/L observed during experimental time indicated the suitable environmental condition for the growth of

organisms. The average concentration of DO of Chaungmagyi dam water varied from 5.34 to 6.90 mg/L during rainy season, 7.69 to 9.83 mg/L in winter and 9.55 to 10.90 mg/ L in summer. There is statistically significant difference among the DO of three seasons. During the study period, the DO content in summer is highest followed by winter and then rainy seasons. The level of DO of dam water except in rainy season was good enough for aquatic animals and for drinking. In this range DO was no problem to compare with the WHO standard. According to the Kumara and Belagali, 2010 finding, the high value of DO may be due to prominence of plankton density. In addition, more sunlight and warmer temperatures also bring increased activity levels in some plants and aquatic life. This may increase or decrease the DO concentration.

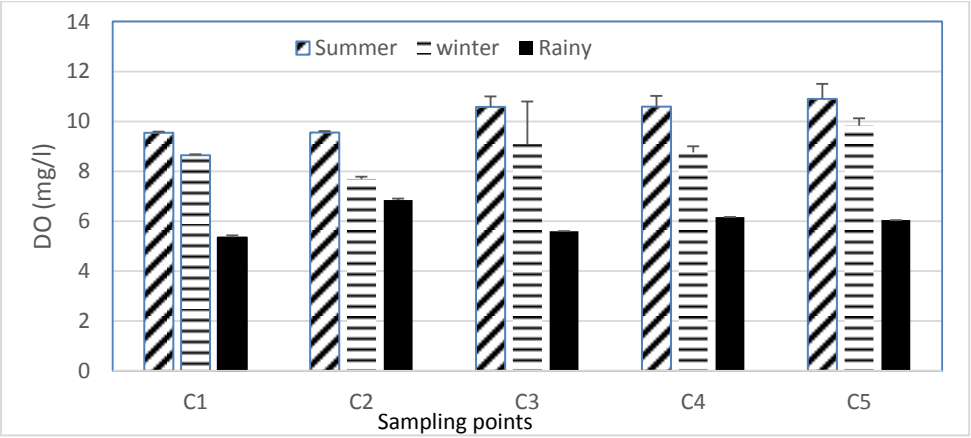

Fig (2) Seasonal comparison chart of DO value of Chaungmagyi dam water

4.2 Water temperature (WT)

The average water temperature (WT) varied from 29.00 to 29.90 °C in rainy season, 29.89 to 30.55 °C in winter and 29 to 31.45 °C in summer with higher temperature in summer. According to the laboratory analysis, the WT during the rainy season is suitable to sustain warm-water aquatic life. The observed maximum dry seasons (winter and summer) temperature is most likely associated with heat raising temperature of surface water as a result of higher air temperature. According to statistical analysis, the significant differences of seasonal WT were observed at 0.95%. The WT values for drinking water set by WHO is 30 °C. According to the standard of WHO, the range of WT of dam water in dry seasons was no problem.

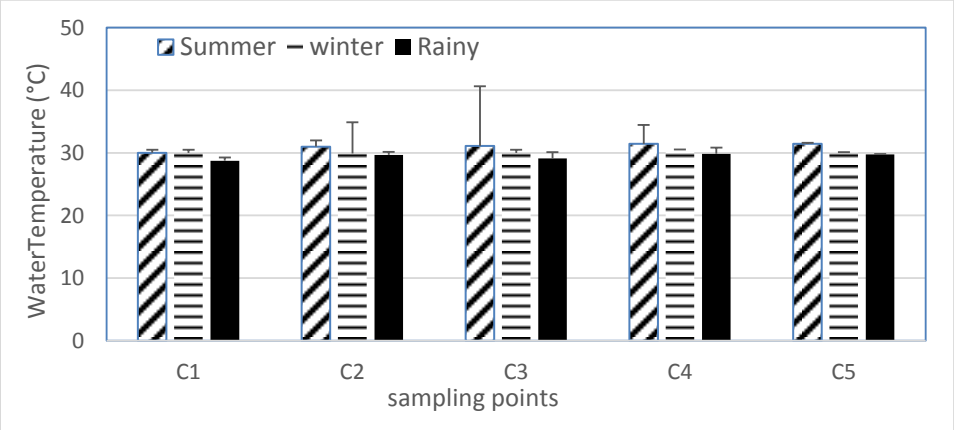

Fig (3) Seasonal comparison chart of WT value of Chaungmagyi dam water

4.3 Electrical conductivity (EC)

The average electrical conductivity (EC) ranged from 128.5 to 233 µS/cm in rainy season, 776 to 801.5 µS/cm during winter and 789 to 812 µS/cm in summer. The seasonal variations of EC were statistically significant at 0.95 %. The high EC value of the dam in summer and winter could be due to increased concentration of dissolved solids, mineral salts and increased evaporation in the dry periods. The EC values of dam water exceeded the standard value (250 uS/cm) for drinking water proposed by WHO which indicates the pollution of the dam in dry seasons.

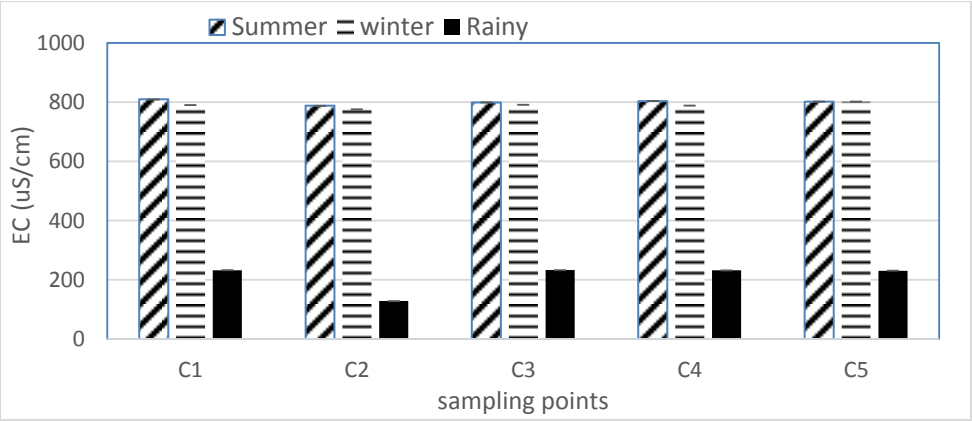

Fig (4) Seasonal comparison chart of EC value of Chaungmagyi dam water

4.4 pH

Overall, the average pH values ranged from 7.63 to 8.07 during the rainy season, 7.85 to 8.11 in winter and 8.05 to 8.29 in summer. It was significantly highest in summer followed by winter and then rainy seasons, which may be due to the high photosynthesis of micro and macro vegetation resulting in high production of free carbon dioxide, shifting the equilibrium towards alkaline side (Trivedi, 1989) or due to low water levels and concentration of nutrients in water. Moreover, Rajasegar (2003) stated that fluctuations in pH values during different season of the year were attributed to factors like removal of CO2 by photosynthesis through bicarbonate degradation, dilution of waste with fresh water, reduction in salinity and temperature, and decomposition of organic matter. The pH values of all samples were slightly alkaline and within the pH range assigned by WHO as the standard for drinking water (6.5 - 8.5).

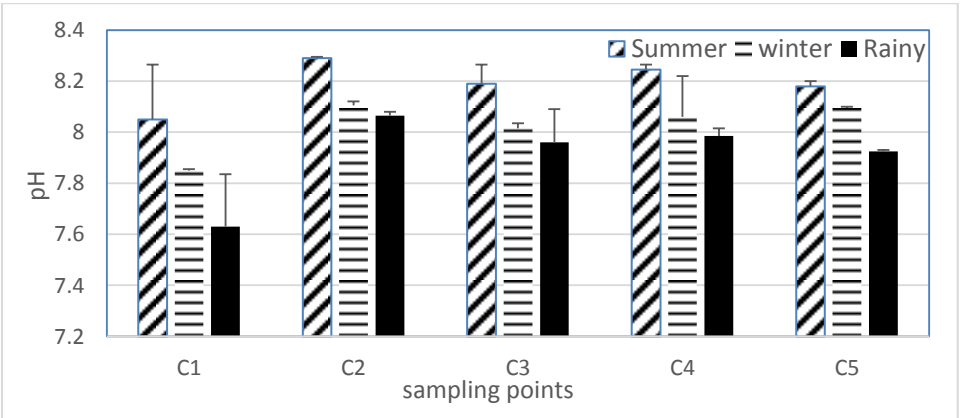

Fig (5) Seasonal comparison chart of pH value of Chaungmagyi dam water

4.5 Turbidity (TURB)

Turbidity in water is caused by suspended matters and colloidal organic materials such as clay, silts, plankton, microscopic organisms, finely divided organic and inorganic matter. The average turbidity (TURB) values of Chaungmagyi dam were measured between 6.78 to 9.83 FNU in rainy season, 1.26 to 1.62 FNU during winter and 1.15 to 1.53 FNU in summer. The statistically significant highest turbidity value was found in rainy season than that in summer and winter seasons. It is due to entering of high rain fall runoff causing erosion particles, water from watershed area and forest runoff, industrial runoff, mining runoff, agricultural runoff along with domestic runoff to the water of dam in large scale [Kalavathy S et.al., 2005 and Panda P K et.al.,2015). The lower value of turbidity in summer in comparison to other seasons may be due to silt & settling of dissolved salts (Ndubi D et al., 2015 and Moshood K M., 2008). The turbidity values of dam water found in all seasons were within the drinking water limit (5 – 25 FNU) proposed by WHO.

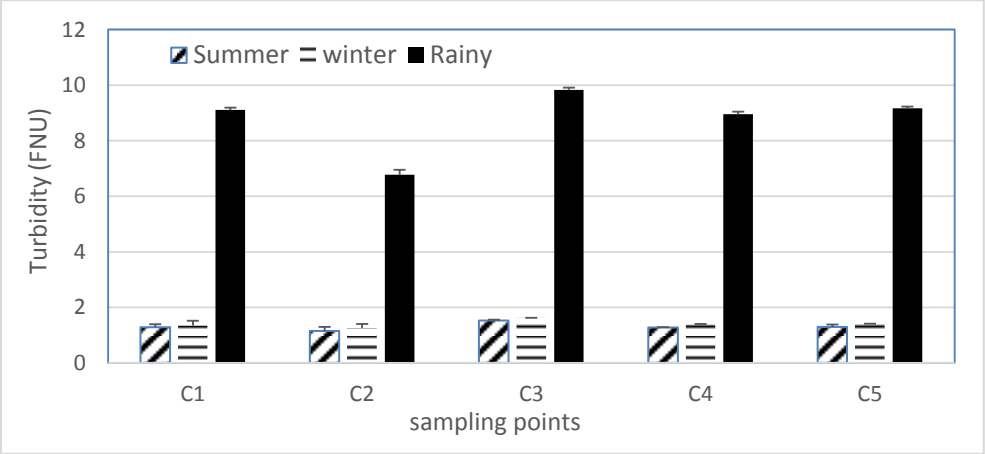

Fig (6) Seasonal comparison chart of TURB content of Chaungmagyi dam water

4.6 Total alkalinity (TAKL)

The total alkalinity (TAKL) indicated the present of natural salts in the water. Natural water contain high alkalinity are more in phytoplankton, mainly due to the blue greens. The degradation of plants, living organisms and organic waste also be the reason for increase in carbonate and bicarbonate levels thereby increasing alkalinity. In the present investigation the average total alkalinity ranged from 1.65 to 2.42 mmol/L in rainy season, 1.85to 2.39 mmol/L in winter and 2.22 to 2.47 mmol/L in summer. It was higher in summer, moderate in winter and lower in rainy season. However, no significant differences among the seasons were found. Higher alkalinity in summer season attributed to improve the rate of decomposition, throughout which CO_2 is produced which react with water to produce bicarbonate increasing the total alkalinity in the summer. According to the laboratory analysis, the total alkalinity values of all water samples collected from the Chaungmagyi dam were below the standard set by the WHO for drinking water (5 mmol/L).

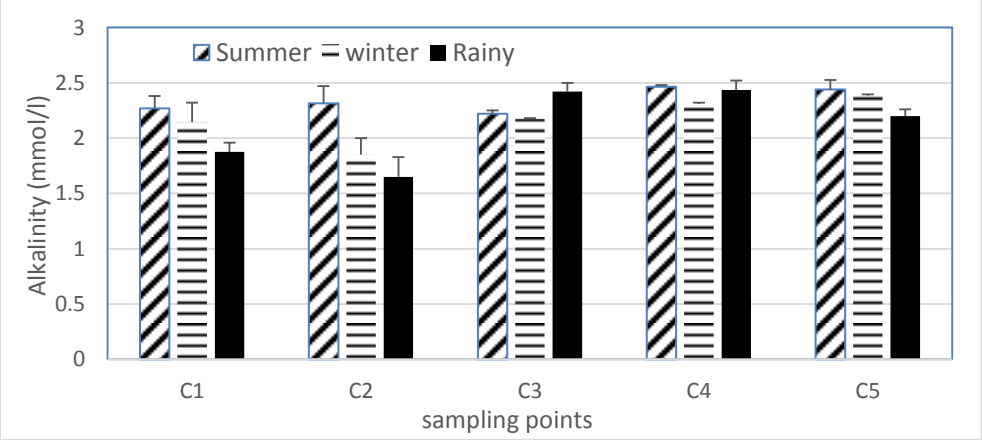

Fig (7) Seasonal comparison chart of Alkalinity value of Chaungmagyi dam water

4.7 Color

The color content in all samples analyzed ranged between 6.35 to 8.15 mgPt/L in rainy season, 6.23 to 7.91 mgPt/L during winter and 5.99 to 6.67 mgPt/L in summer, which are lower than the standard limit 15 mgPt/ L assigned by WHO. The Color of the water samples is higher in rainy season than that of winter and summer seasons. Statistical analysis also showed the significant differences among the seasons. Pure water has no color (Gupta, 2001). Color in water is due to the presence of humic or fulvic acids, metallic ions and colored wastes.

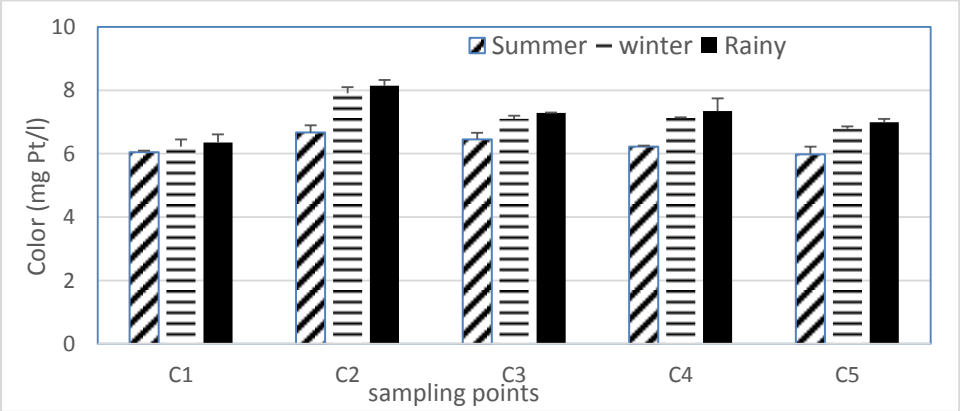

Fig (8) Seasonal comparison chart of color content of Chaungmagyi dam water

4.8 Fluoride (F)

The present of small concentrations of fluoride (F) in water may be useful to human beings. Fluoride up to 1.2 ppm will prevent the dental caries of children. Exposure to high concentration of fluoride (3 ppm and above) during childhood, when teeth are developing, can cause in mild dental fluorosis or mottled. Seasonal averages of all the stations of Chaungmagyi dam measured as 0.12 to 0.27 mg/L during the rainy season, 0.11 to 0.19 mg/L in winter and 0.10 to 0.17 mg/L during summer. The higher fluoride value was found in rainy season than that in winter and summer, but not statistically significance. The elevated level of fluoride was because of the increase of mineral dissolution in rainy season. According to the laboratory results, the fluoride content of the dam is below the WHO drinking water standard.

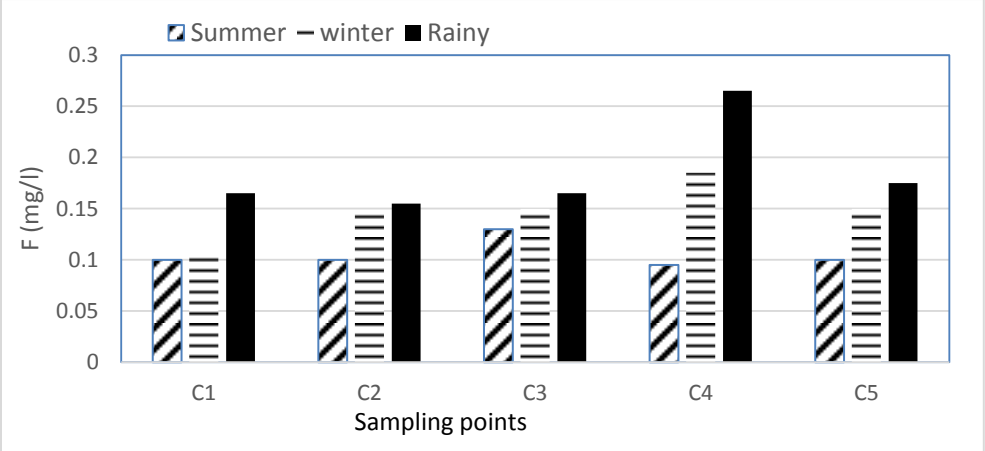

Fig (9) Seasonal comparison chart of F value of Chaungmagyi dam water

4.9 Chloride (Cl)

As the chloride (Cl) ion is easily movable, it is move out to nearby waters in rainy period. The more chloride ion concentration in water is an index of pollution. The high chloride values would decrease the water DO, which leads to risk of the aquatic organisms (S.Dey et.al.,2021). The average chloride ranged in water between 1.30 mg/L to 1.63 mg/L in rainy season, 1.65 to 2.10 mg/L during winter, and 2.18 to 2.32 mg/L in summer . Its content in summer time is higher than in rainy season and winter due to the lower water level and evaporation. In this study, chloride contents of all water samples from the dam are below the standard of drinking water limit prescribed by WHO.

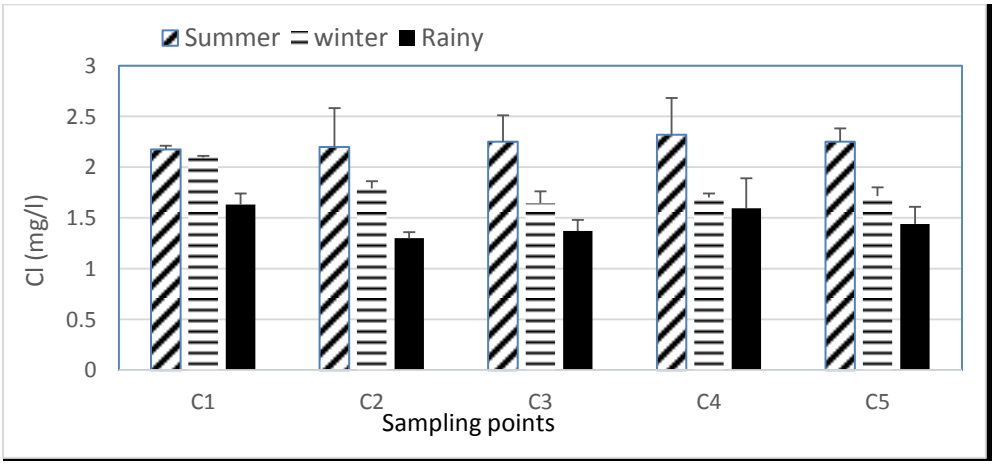

Fig (10) Seasonal comparison chart of Cl value of Chaungmagyi dam water

4.10 Nitrate (NO_3)

The average nitrate (NO_3) content of Chaungmagyi dam is within the range of 0.04 to 0.09 mg/L in rainy season, 0.03 to 0.05 mg/L and 0.02 to 0.03 mg/L in winter and summer times. The nitrate content of water samples collected in rainy season is higher than in summer and winter. The nitrate values at different seasons were not statistically significant. The higher concentration of nitrate in the dam during the rainy season could be due to the increased run off from the agriculture lands, plantation and watershed areas nearby.

Agricultural practices have been linked to elevated levels of nitrates in drinking water. Nitrogen fertilizers from the agricultural lands, sewage discharge, improper disposal of human and animal wastes, and wastewater from domestic are the major factors for increasing the nitrate and organic content of water. Nitrate levels in drinking water can also be an indicator of overall water quality. Elevated nitrate levels may suggest the possible presence of other contaminants such as disease-causing organisms, pesticides, or other inorganic and organic compounds that could cause health problems. The proposed WHO standard for nitrate is below 50 mg/L. In this study the nitrate content of Chaungmagyi dam is lower than the standard limit.

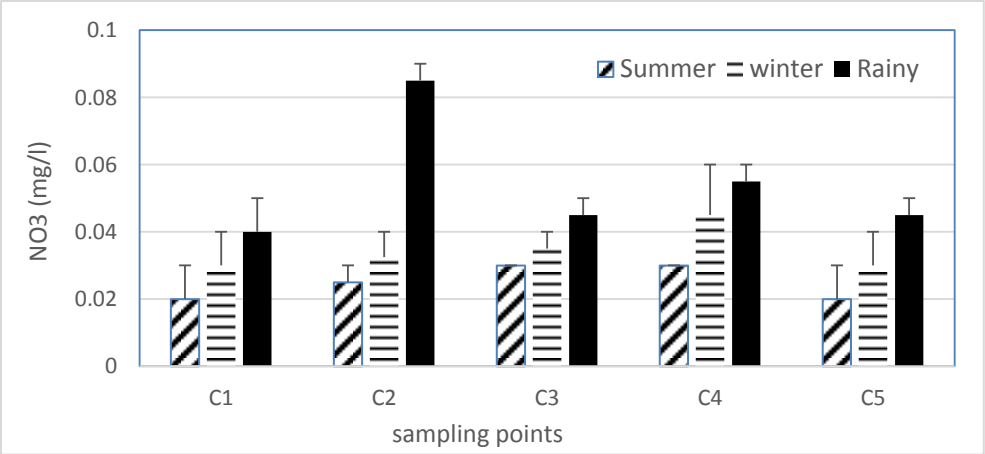

Fig (11) Seasonal comparison chart of (NO_3) value of Chaungmagyi dam water

4.11 Sulphate (SO_4)

The average sulphate (SO_4) content in study area was found from 6.44 to 6.76 mg/L in rainy season, 6.35 to 6.56 mg/L, and 6.14 mg/L to 6.33 mg/L in winter and summer seasons respectively. The values are significantly higher in rainy season, than summer and winter seasons. The increased transport of sulphate minerals eroded by the rain into the dam and entering of urban wastes, agricultural wastes along with forest runoff to the dam cause the highest sulphate content of the dam during the rainy season. All the values are below the standard of drinking water limit (500 mg/L) proposed by WHO.

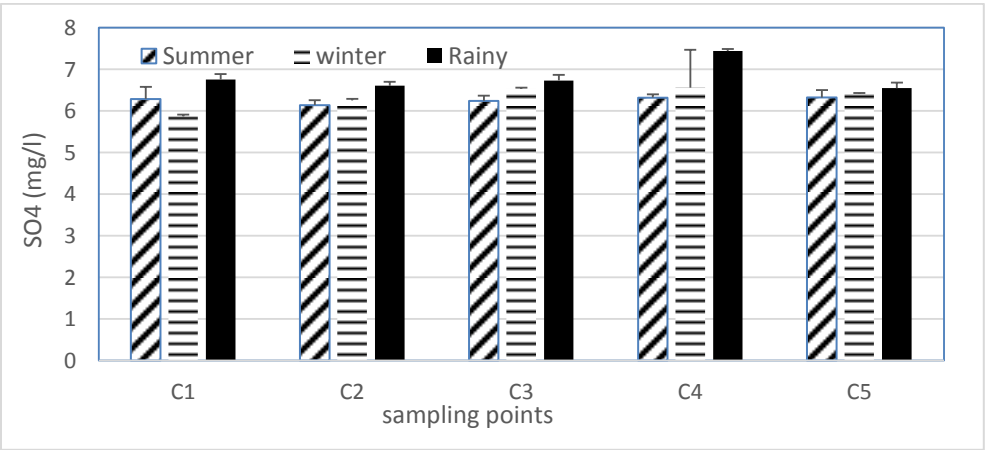

Fig (12) Seasonal comparison chart of SO_4 value of Chaungmagyi dam water

4.12 Sodium (Na)

The average sodium (Na) content of the dam water is within the range of 9.02 to 9.91 mg/L in rainy season, 9.33 to 9.99 mg/L and 9.48 to10.57 mg/L during winter and summer periods. The sodium concentration of water samples is higher in summer than in winter and then rainy seasons, which could be due to lower water volume and high evaporation rate during the dry seasons (winter and summer). The sodium concentrations from all sampling areas are lower than WHO drinking water stand limit, which is 200 mg/L.

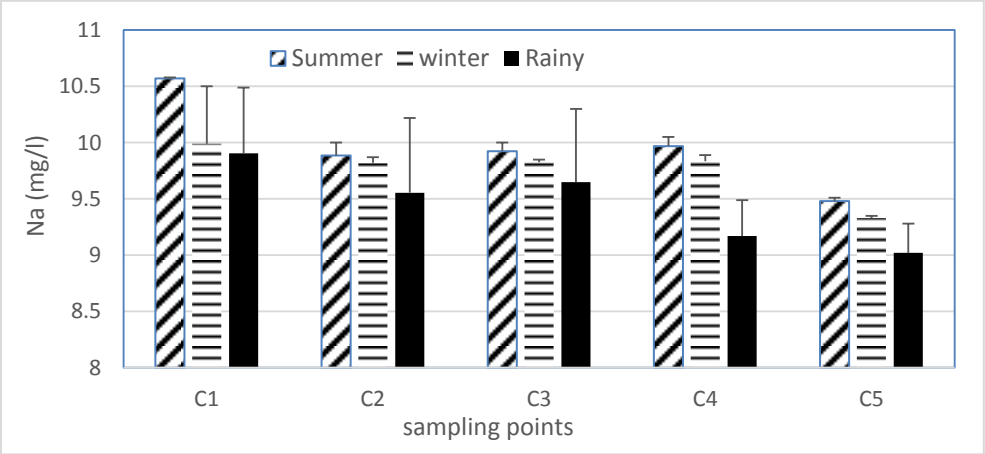

Fig (13) Seasonal comparison chart of Na value of Chaungmagyi dam water

4.13 Ammonia (NH_3)

The average ammonia values of Chaungmagyi dam were measured between 0.12 to 0.18 mg/L in rainy season, 0.07 to 0.13 mg/L, and 0.05 to 0.12 mg/L in dry seasons (winter and the summer).The slightly, but significantly, higher ammonia value was found in rainy season than that in summer and winter seasons. That could be due to the sewage, animal wastes or fertilizer runoff from the surround and watershed areas during the rainy season. Ammonia is rarely found in unpolluted surface water or well water, but water contaminated with organic wastes or fertilizer runoff may contain elevated levels. The WHO has not established a maximum contaminant level for ammonia in drinking water.

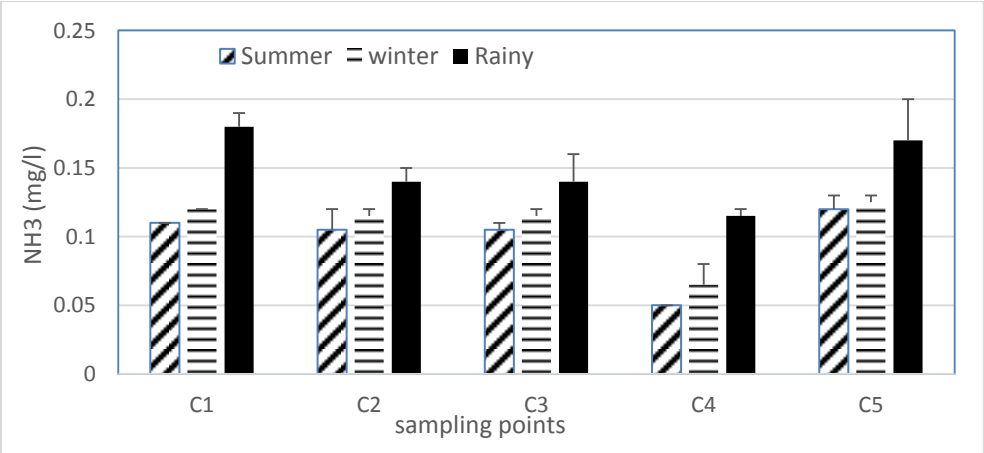

Fig (14) Seasonal comparison chart of NH_3 value of Chaungmagyi dam water

4.14 Potassium (K)

The main sources of potassium concentration are use of potassium from industries, chemical fertilizers in the agriculture lands, and also from human and animal wastes. Potassium salts, which are eroded into the dam by rainwater, evaporate during the dry season, increasing the salt content. The average potassium content of Chaungmagyi dam was 1.51 to 1.88 mg/ L. The higher potassium contents of water samples from all sampling points were found in winter and followed by that in summer time. There are significant differences among K contents of different seasons. Potassium content can be increased due to lower water level and higher evaporation rate during the dry seasons (winter and summer). The proposed WHO standard for potassium is 12 mg/L. In this study the potassium content of Chaungmagyi dam is lower than the standard limit.

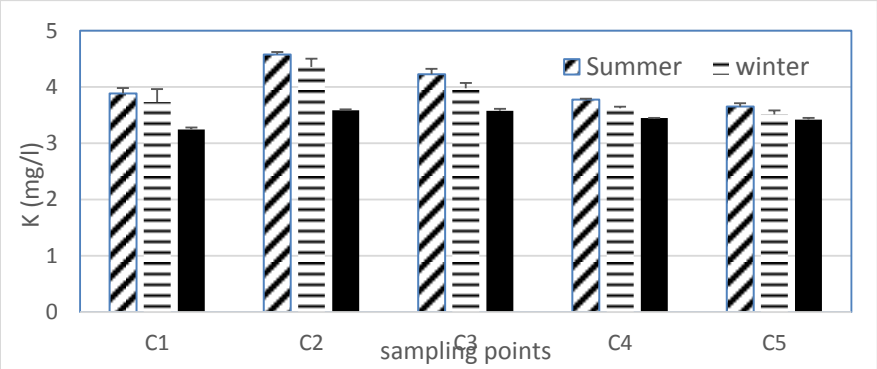

Fig (15) Seasonal comparison chart of K value of Chaungmagyi dam water

4.15 Calcium (Ca)

Calcium (Ca) is the constituent of different aquatic shells and bones of vertebrates. The presence of Calcium (Ca) in water is mainly due to its passage through deposits of limestone, dolomite, gypsum and other gypsiferous materials (DWAF, 1996). Mostly, Ca is found in the natural waters, but the discharge of sewage and wastewater enhances its concentration. The average range of Ca in this study varied from 12.92 to 13.98 mg/L during the rainy season, 13.83 to14.00 mg/L and 14.05 to 14.26 mg/L during the dry seasons (winter and summer). So, the calcium concentration of the dam is higher, but not statistically, in summer than that of winter and rainy seasons. This could be due to decreased water volume and high evaporation rate during the dry seasons. The drinking water limit proposed by WHO for Ca is 75 mg/ L. The Ca concentration in all samples was lower than the standard limit.

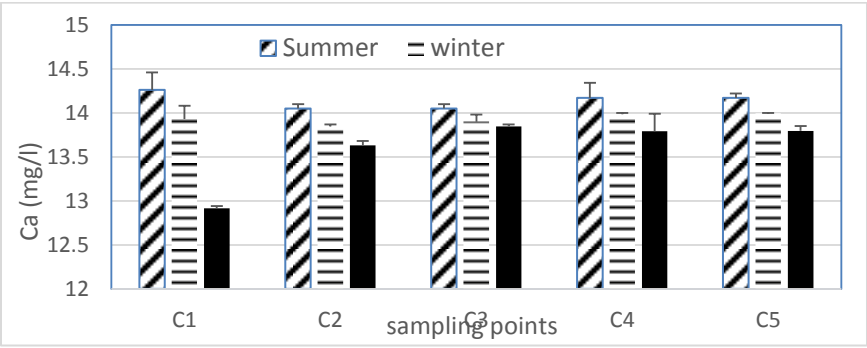

Fig (16) Seasonal comparison chart of Ca value of Chaungmagyi dam water

4.16 Magnesium (Mg)

Magnesium is mainly content in chlorophyll. It is found together with calcium and contributes to hardness of water. The average magnesium (Mg) values of water samples were 9.93 to 10.23 mg/L during the rainy season, 10.17 to 11.07 mg/L in winter and 10.95 to 13.94 mg/L during summer. Like Ca, its content was significantly higher in summer than in winter and rainy seasons ($p=<0.05$). In order to decrease water volume, high evaporation rate occur during the dry seasons. The drinking water standard for magnesium set by WHO is 50 mg/L. The magnesium concentration of the dam water is below this standard.

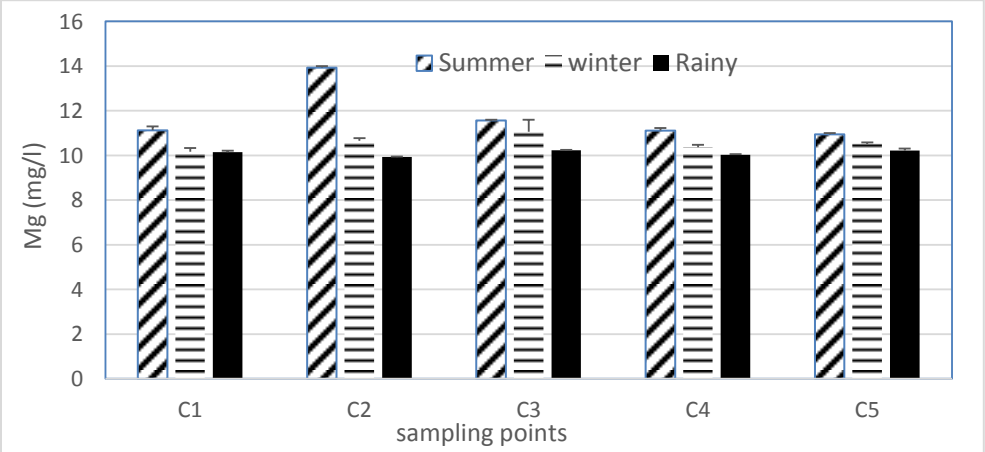

Fig (17) Seasonal comparison chart of Mg value of Chaungmagyi dam water

4.17 Total Suspended Solid (TSS)

TSS is typically composed of fine clay or silt particles, plankton, organic compounds, inorganic compounds or other microorganisms. These suspended particles range size from 10nm to 0.1nm. These suspended particles can come from soil erosion, runoff, discharges, stirred bottom sediments or algal blooms. TSS as well as TDS can be influenced by changes in pH. The pH changes will affect the suspended matter's solubility. The average total suspended solid (TSS) ranged in water samples between 3.00 to 18.00 mg/L in rainy season, 2.00 to 4.00 mg/L in winter, and 2.00 to 3.00 mg/L in summer. The statistically significant differences were observed among TSS contents of three seasons. The high content of TSS in the samples collected in rainy season could be due to increased particles from the surrounding areas eroded during the rainy season. The water with elevated TSS levels can increase bacteria, nutrients, pesticides and heavy metals' concentration.There is no standard for TSS by the World Health Organization (WHO).

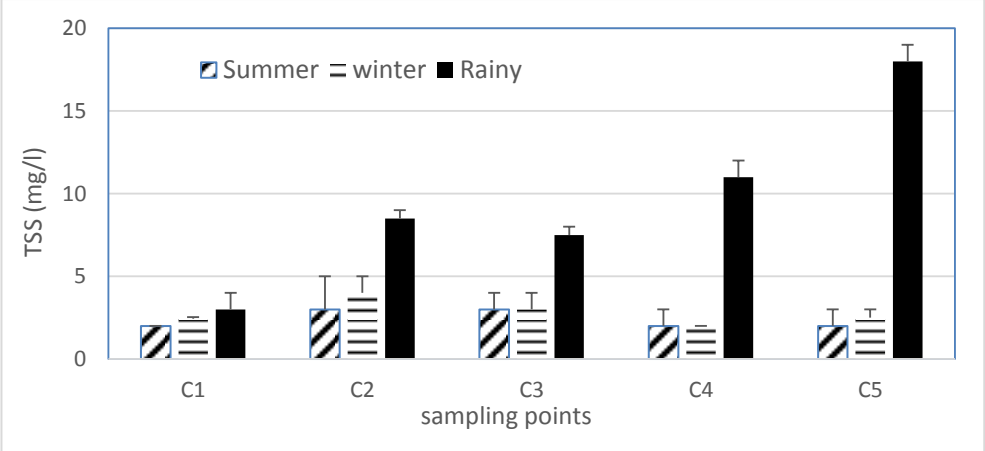

Fig (18) Seasonal comparison chart of TSS value of Chaungmagyi dam water

4.18 *Escherichia coli* bacteria (*E. coli*)

Escherichia coli (*E. coli*) is a type of fecal coliform bacteria that is used to monitor fecal contamination in the water and commonly found in the intestines of animals and humans. *E. coli* in water is a strong indicator of sewage or animal waste contamination. Most types of *E. coli* are harmless, and their presence in the water suggests only that fecal pollution may have occurred and that disease causing pathogens may be present. The average range of *E. coli* bacteria in this study varied from 34 to 84 CFU/100mL during the rainy season, the same amount 4 to 9 CFU/100mL during winter and summer. The elevated *E. coli* concentrations were observed in rainy season than that of winter and summer. Surface or agricultural runoff from the surrounding areas has been implicated in increases in bacterial contamination in rainy season. The WHO standard limit of *E. coli* for drinking purposes is 0 CFU/100mL.

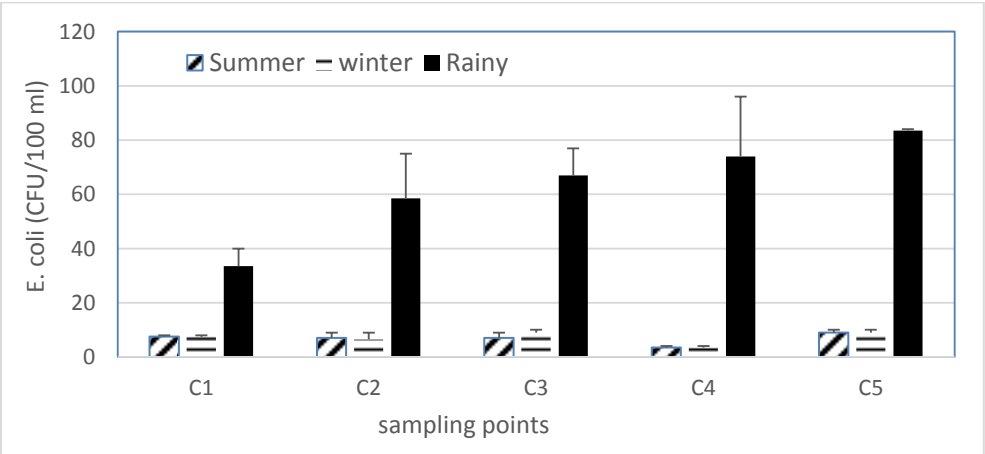

Fig (19) Seasonal comparison chart of *E. coli* value of Chaungmagyi dam water

4.19 Biological Oxygen Demand (BOD)

The biological oxygen demand (BOD) measures the amount of oxygen requires by microorganisms to decompose organic substances in water. Its concentration increases when decaying plants, human or animal waste, and other organic materials are added to water supply. The mean of BOD were ranged between 0.70 to 1.03 mg/L in rainy season, 0.65 to

0.98 mg/L in winter and 0.60 to 0.89 mg/L in summer. Higher BOD contents, but not significantly, were found in rainy season than that in the dry seasons. This may be attributed to additional organic matter introduced into the dam as a result of runoff and soil erosion caused by rainfall in rainy season. The drinking water limit for BOD set by WHO is less than 5 mg/L. The BOD content of the dam water is below this standard limit.

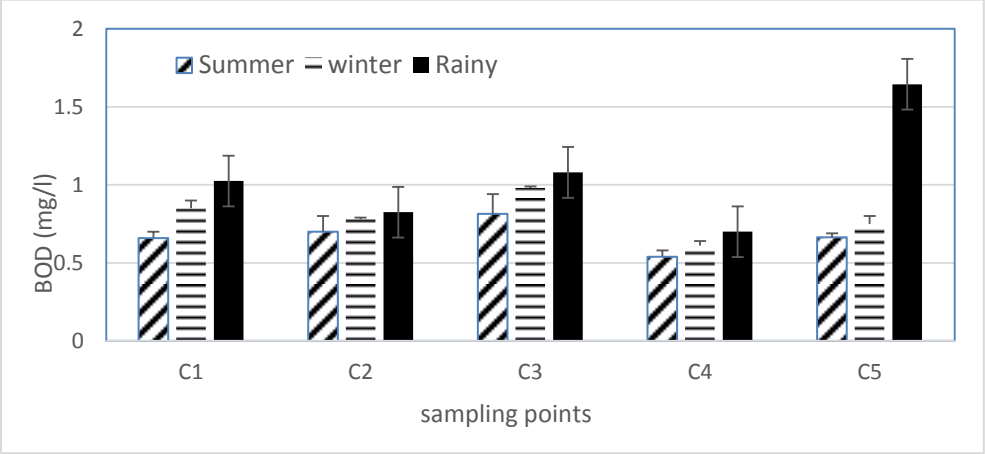

Fig (20) Seasonal comparison chart of BOD value of Chaungmagyi dam water

4.20 Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) is the amount of oxygen consumed to chemically oxidize organic water contaminants to inorganic end products. According to literature, COD value is always higher than BOD. The COD has a direct relationship with BOD. As the BOD content of Chaungmagyi dam water was higher in rainy season, we can conclude that the COD composition of dam water must be higher in that season. The water with zero COD content should be very pure. The average COD ranged in dam water between 1.25 to 2.18 mg/L in rainy season, 1.21 to 1.97 mg/L in winter, and 1.04 to 1.63 mg/L in summer. The COD of dam water was higher, but not significantly, the rainy season than the dry seasons (winter and summer). The high COD load could be due to runoff from the surrounding areas. The amounts of COD from all sampling points were lower than the acceptable limit (10 mg/L) for drinking water prescribed by WHO.

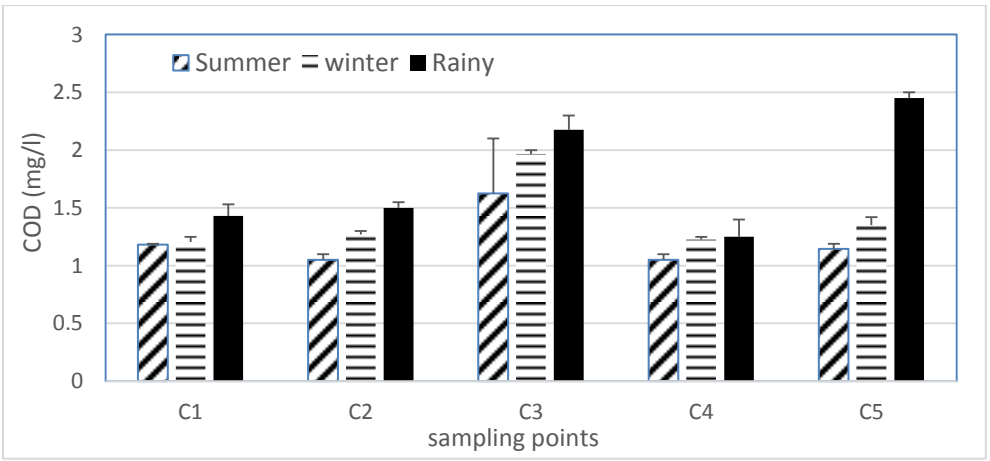

Fig (21) Seasonal comparison chart of COD value of Chaungmagyi dam water

4.21 Ortho-phosphate ($O\text{-}PO_4$)

Phosphorus is mostly found in agricultural fertilizers, manure, and organic wastes and industrial effluent. The phosphorus content is too much in water, it can speed up eutrophication of **water bodies.** This study has found that the average value of ortho-phosphate ($O\text{-}PO_4$) (0.02-0.032 mg/L) was recorded during the rainy season, while (0.01-0.02 mg/L) and 0.1 mg/L were measured in the dry seasons. Ortho-phosphate content of the samples collected is higher in rainy season than that in winter and summer. The statistically significant differences were also observed among the O-PO4 contents of three seasons. The reason could be due to the rain ran off fields, forests, yards and paved surfaces, carrying an array of pollutants into the dam including phosphate from fertilizer. The drinking water standard limit for PO_4 proposed by WHO is 0.1 mg/l. The ortho-phosphate concentration of the dam water is below this standard limit. According to WHO (1992) report, the concentration of ortho-phosphate in water above 0.005 to 0.02 mg/L is largely responsible for eutrophication of the water bodies.

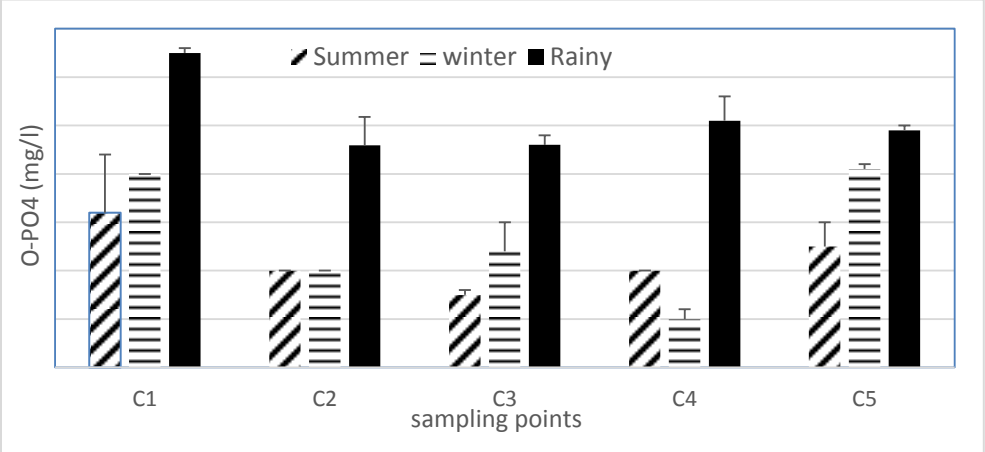

Fig (22) Seasonal comparison chart of $O\text{-}PO_4$ value of Chaungmagyi dam water

4.22 Total Phosphorus (TP)

Like Ortho-phosphate, total phosphorus (TP) is also a major source of organic wastes. Too much of phosphorous in water can cause the eutrophication of water bodies. The average total phosphorus (TP) content of Chaungmagyi dam ranged from 0.03 to 0.04 mg/L and from 0.01 to 0.02 mg/L during the wet and dry seasons, respectively. There are statistically significant differences among the TP contents of three seasons. TP concentration was higher during the rainy season. This shows that incoming wastewater and fertilizer residues into the dam from the surround and watershed areas by the rain water. There is no standard for total phosphorus in the drinking water standards assigned by the World Health Organization.

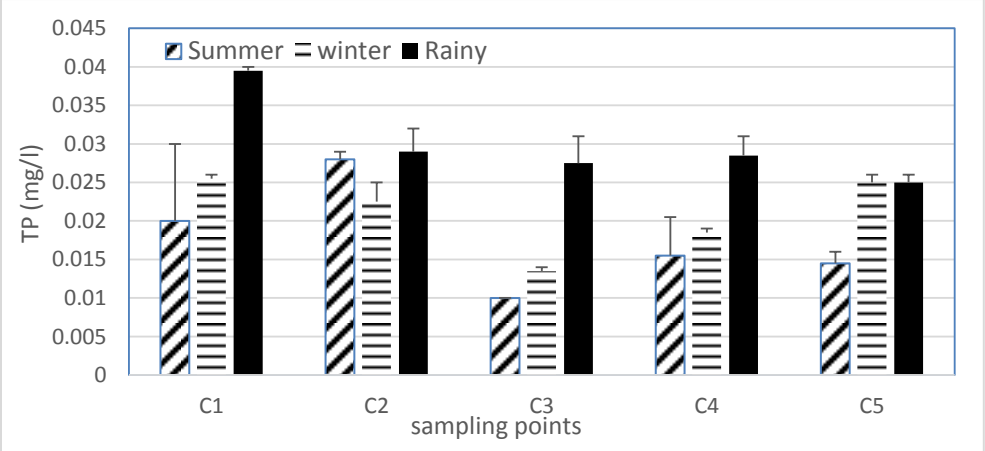

Fig (23) Seasonal comparison chart of TP value of Chaungmagyi dam water

5. Conclusions

In this study, laboratory tests for the physical and chemical as well as bacteriological properties of water samples from Chaungmagyi dam have been studied to evaluate the seasonal variations and quality of water for the dam as a source for human use for drinking.

In the present study, dissolved oxygen (DO) content was higher in dry seasons (winter and summer). This may be due to prominence of plankton density. Higher water temperature found in dry seasons (winter and summer) is associated with heat raising temperature of surface water as a result of higher air temperature. The higher pH, EC and total alkalinity concentrations found in dry seasons (winter and summer) are mainly due to these increased concentrations of dissolved solids and increased evaporation in the dam water. The increased turbidity and TSS concentrations of water samples in rainy season expressed the increased particles in the dam water eroded from the surrounding areas during rainy season.

Analytical result of the physicochemical analysis indicated that the concentration of minerals salts (Ca, K, Na, Mg, Cl) in all samples from all sampling points were found higher in the dry seasons (summer and winter). Higher mineral salts concentration could be due to the lower water level and high evaporation rate during the dry seasons. Water nutrients such as NH_3, NO_3, TP, PO_4 values of water samples from all sampling points were higher in rainy season. The reason could be due to runoff wastewater and fertilizer residues from the surround and watershed areas during the rainy season. Higher concentrations of BOD and COD of the dam water from all sampling points were observed in rainy season. This may be attributed to additional organic matter introduced into the dam as a result of runoff and soil erosion caused by rainfall in rainy season.

Examination of dam water indicates that most of the mentioned parameters were lower the acceptable limits of WHO and its suitable to use as a source of drinking water. The level of DO of the dam water except in rainy season was good enough for aquatic animals and for drinking. In this range DO was no problem to compare with the WHO standard. According to the standard of WHO, the range of WT of the dam water in dry seasons was no problem. However, EC values of the dam water especially in dry seasons exceeded the standard value (250 uS/cm) for drinking water which indicates the pollution of the dam in the dry seasons. Moreover, the *E. coli* bacterial counts detected were exceeded the specified

permissible limits for drinking water in all the sampled stations. According to *E. coli* contents, Chaungmagyi dam is face with bacterial contamination of surface or agricultural runoff from the surround and watershed areas especially in rainy season. The water contaminated with the bacteria like *E. coli* can cause gastrointestinal illness, skin, ear, respiratory, eye, neurologic, and wound infections. The most commonly reported symptoms are stomach cramps, diarrhea, nausea, vomiting, and low-grade fever. Therefore, water from the Chaungmagyi dam is not suitable to use for drinking purposes without any treatment in rainy season. If the dam water is to be used for drinking, cooking, brushing teeth etc., consumers are advised to boil the water. Other treatments such as filtrating the particles, setting and decanting to reduce turbidity by letting the water sit for 2 – 24 hours, etc. should also be applied, especially in rainy season. In conclusion, since monitoring is very important for dam conservation like water quality monitoring which is used as the indicator of dam health. It is important for the assessment of dam diagnosis, continuous monitoring on water quality of Chaungmagyi dam is needed. Public awareness is essential in playing vital role in the preservation of dam.

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