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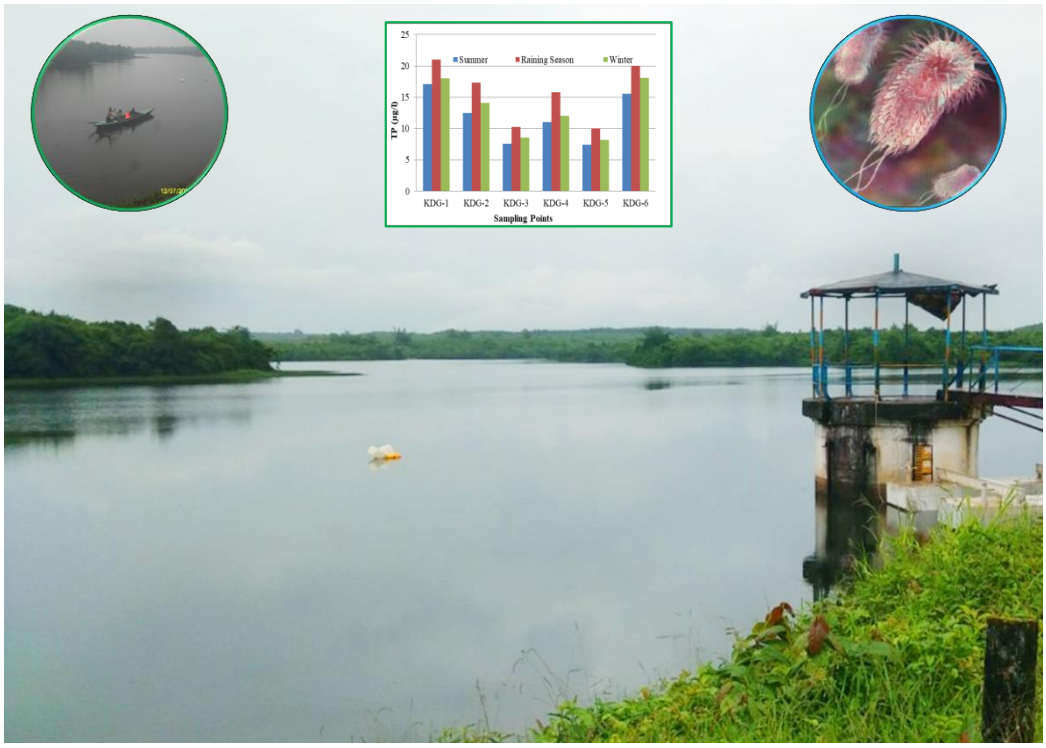
Assessment of Seasonal Variation in Water Quality of Kandawgyi Reservoir, Bago



Khin Hninn

Research Assistant (2)

Forest Research Institute

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Assessment of Seasonal Variation in Water Quality of Kandawgyi Reservoir, Bago

Khin Hninn, Research Assistant -2

Forest Research Institute, Forest Department

Abstract

The Bago Kandawgyi Reservoir was built in 1924 about 6 miles northwest of Bago. Citizens of Bago It is intended to provide drinking water to local people. The reservoir has a storage capacity of 422.7 million gallons and is an earthen dam. At present, Kandawgyi lake has been experiencing anthropogenic stress especially due to the entering dirt from the homes of rubber workers and gravel extractors from air defense barracks living near the lake, planting rubber plantations and making own farms around the lake which use chemical and organic fertilizers and pesticides. Thus, the present study was carried out to evaluate seasonal variation in the physico-chemical parameters of water quality of Kandawgyi Lake. According to the result, Higher concentrations of mineral salts (Ca, K, Na, Mg, Cl, F) in all samples from all sampling pointes were found in the Dry seasons (Summer and Winter). This could be due to decreased water volume and high evaporation rate during the dry seasons. The higher pH, EC and Total Alkalinity concentrations found in dry seasons (Winter and Summer) are mainly due to these increased mineral salts in the lake water. Higher nutrient concentrations (NO_3, TN, TP, PO_4) of water samples from all sampling points were explained by incoming wastewater and fertilizer residues from the surrounding and watershed areas by the rain water. The increased Turbidity and TSS concentrations of water samples in rainy seasons expressed the increased particles in the lake water eroded from the surround areas during the rainy seasons. According to the laboratory analysis, all physical and chemical properties were below the water quality standards set by WHO. However, according to *E. coli* contents, Kandawgyi Lake is polluted with sewage or sanitary from the surrounding areas. Drinking the water contaminated with the bacteria like *E. coli* can cause health problems such as diarrhea, urinary tract infections, respiratory illness, pneumonia, etc. Therefore, water from Kandawgyi Lake is not suitable to use for drinking purposes without any treatment. If the lake water is to be used for drinking, it is recommended to boil the lake 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 the rainy season.

Keywords: physico-chemical parameters, acceptable limits, E. coli bacteria,

ပဲခူး၊ ကန်တော်ကြီးကန်ရေ၏ ရေအရည်အသွေးအား ရာသီအလိုက် ပြောင်းလဲမှုအား ဆန်းစစ် လေ့လာခြင်း

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စာတမ်းအကျဉ်း

ပဲခူးကန်တော်ကြီး ရေလှောင်ကန်သည် ပဲခူးမြို့၏ အနောက်မြောက်ဘက် (၆)မိုင်ခန့် ဝေးသောနေရာတွင် ၁၉၂၄ ခုနှစ်က စတင်တည်ဆောက်ခဲ့ကြောင်း သိရှိရပါသည်။ ပဲခူးမြို့သူ မြို့သားများ၊ ဒေသခံပြည်သူများ သောက်သုံးရေ အသုံးပြုနိုင်ရန်အတွက် ရည်ရွယ်၍ တည်ဆောက်ခြင်းဖြစ်ပါသည်။ ၄င်းကန်၏ ရေလှောင်ပမာဏမှာ (၄၂၂.၇) ဂါလံသန်းရှိပြီး မြေသားတမံ အမျိုးအစားဖြစ်ပါသည်။ ယခုအခါ ကန်တော်ကြီး ရေလှောင်ကန်သည် လူတို့၏ လုပ်ဆောင်မှုလုပ်ငန်းများ အထူးသဖြင့် ကန်စပ်တွင်နေထိုင်သော ရာဘာလုပ်သားများနှင့် လေကြောင်းရန် ကာကွယ်ရေးတပ်ဘားတိုက်များမှ တပ်ရုံပုံငွေအတွက် ကျောက်စရစ် ထုတ်ယူသော အလုပ်သမားများ၏ နေအိမ်များမှ အညစ်အကြေးများ ကန်အတွင်းသို့ ဝင်ရောက်ခြင်း၊ ရာဘာစိုက်ခင်းများနှင့် ကိုယ်ပိုင်ခြံများတွင် ဓါတ်မြေဩဇာ၊ အော်ဂဲနစ် မြေဩဇာနှင့် ပိုးသတ်ဆေး များသုံးစွဲခြင်းများကြောင်း ကန်၏ရေအရည်အသွေးအပေါ် သက်ရောက်လာ နိုင်ဖွယ်ရှိပါသည်။ သို့ဖြစ်ပါ၍ ကန်တော်ကြီးကန်ရေ၏ ရူပနှင့်ဓာတုဂုဏ်သတ္တိများ ရာသီအလိုက် ပြောင်းလဲနိုင်ခြင်း ရှိမ/ရှိသိရှိနိုင်ရန် ဤသုတေသနကို ဆောင်ရွက် ရခြင်းဖြစ်ပါသည်။ ဓာတ်ခွဲတွေ့ရှိချက်များအရ ခြောက်သွေ့သောရာသီများတွင် (နွေရာသီနှင့် ဆောင်းရာသီ) ကယ်လ်စီယမ်၊ ပိုတက်စီယမ်၊ ဆိုဒီယမ်၊မဂ္ဂနီစီယမ်၊ ကလိုရိုဒ်နှင့် ဖလူအိုရိုဒ်ကဲ့သို့သော mineral salts များ၏ ပါဝင်မှုပမာဏ ပိုများနေကြောင်း တွေ့ရှိရပါသည်။ ဖော်ပြပါရာသီ များတွင် ရေပမာဏ လျော့နည်းပြီး ရေငွေ့ပျံမှု နှုန်းများသောကြောင့် ဖြစ်နိုင်သည် ဟုသုံးသပ်ပါ သည်။ ကန်ရေတွင် pH, EC နှင့် Total Alkalinity ပါဝင်မှုပမာဏ ပိုများလာခြင်းကြောင့် ခြောက်သွေ့သောရာသီများတွင် ဖော်ပြပါ mineral salts ပါဝင်မှုမြင့်လာကြောင်း သုံးသပ်ပါ သည်။ ရေနမူနာကောက်ယူသော နေရာအားလုံး၏ NO_3, TN, TP, PO_4 အဟာရဒြပ်ပေါင်း များပါဝင်မှု များရခြင်းမှာ ကန်အနီးဝန်း

ကျင် ရေဝေရေလဲဒေသများမှ ညစ်ညမ်းရေများနှင့် မြေဩဇာအသုံးပြုထားသော နေရာများမှ ရေများ မိုးရေနှင့်အတူ စီးဝင်လာ ခြင်းကြောင့် ဖြစ်ပါသည်။ မိုးရာသီတွင် ရေနမူနာများ၏ Turbidity နှင့် TSS concentrations များ မြင့်ရခြင်းမှာ ကန်တော်ကြီးကန်ပတ်ဝန်းကျင်မှ နုန်းအနည်အနှစ်များ မိုးရေနှင့်အတူ ကန်အတွင်း ရောက်ရှိခြင်းကြောင့် ပါဝင်မှု ပမာဏများရခြင်း ဖြစ်ပါသည်။ ဓာတ်ခွဲစမ်းသပ်ချက်ရလဒ်များအရ ကန်တော်ကြီးကန်ရေ၏ ရူပနှင့်ဓာတု ဂုဏ်သတ္တိ အားလုံးသည် ကမ္ဘာ့ကျန်းမာရေးအဖွဲ့၏ သောက်သုံးရေ စံသတ်မှတ်ချက်များ အောက်တွင် ရှိကြောင်း ဓာတ်ခွဲတွေ့ရှိရပါသည်။ သို့သော် ကန်တော်ကြီး ကန်ပတ်ဝန်းကျင်မှ အညစ်အကြေးရေများ သို့မဟုတ် မိလ္လာရေဆိုးရေများမှ ကန်ရေအပေါ်သက်ရောက်မှု ရှိခြင်း ကြောင့် ရာသီ(၃)မျိုးလုံးတွင် ကန်တော်ကြီးကန်ရေ၏ *E. coli* ဘက်တီးရီးယား ပါဝင်မှုမှာ မြင့်မားနေကြောင်းတွေ့ရှိရပါသည်။ သောက်သုံးရေတွင် E. coli ဘက်တီးရီယားများ ပါဝင်နေပါက ဝမ်းပျက်ဝမ်းလျောခြင်း၊ ဆီးလမ်းကြောင်းဆိုင်ရာ ရောဂါများ၊ အသက်ရှူလမ်းကြောင်း ဆိုင်ရာရောဂါများ၊ အဆုတ်ရောင်ရောဂါစသည့် လူတို့၏ ကျန်းမာရေးကို ထိခိုက်စေနိုင်သည့် ရောဂါများဖြစ်စေနိုင်ပါသည်။ သို့ဖြစ်ပါ၍ ကန်တော်ကြီး ရေလှောင်ကန်မှ ရေကို သောက်ရေ အဖြစ် အသုံးပြုမည်ဆိုပါကရေသန့်စင်စေသော နည်းတစ်မျိုးမျိုးကို ပြုလုပ်ပြီးမှသာ သောက်သုံး သင့်ပါသည်။ အထူးသဖြင့် မိုးရာသီတွင် အနည်များ စစ်ထုတ်ခြင်း၊ ရေနောက်မှု လျော့နည်း စေရန် ရေကန်မဟုတ် စည်ပိုင်းတွင်ထည့်၍ ရေအား ၂-၂၄ နာရီ အနည်ထိုင်စေပြီးမှ သုံးစွဲခြင်း များဆောင်ရွက်သင့်ပါသည်။ ထို့အပြင် ၄င်းကန်ရေကို သောက်သုံးရေအဖြစ် သုံးစွဲမည်ဆို ပါက ရေကိုကျိုချက်ပြီးမှသာ သောက်သုံး သင့်ပါကြောင်း အကြံပြုအပ်ပါသည်။

Assessment of Seasonal Variation in Water Quality of Kandawgyi Reservoir, Bago

1. Introduction

Water plays an important role in maintaining human health and welfare. Water is essential for all living things. Water is used for drinking, irrigation, sanitation and many other human needs. 97% of the water on the Earth is salt water and only three percent is fresh water; Most of this fresh water is located under glaciers, and only about 1% is in easy use. Today, rapidly increasing population, rising standards of living and exponential growth of industrialization and urbanization have exposed the water resources and has degraded the water quality and climate change, threatening the health of living things. As the world's population grows, so does the demand for water, and the main problem facing the world today is the balance between water supply and demand. In addition, clean water is one of the most important and valuable natural resources in the world.

In Myanmar, an integrated water resources management system has been implementing for inland waters at national level. The inland fresh water is an integral part of natural environment and its quality is very sensitive and critical issue in Myanmar. With an increased understanding of the importance of drinking water quality to public health and raw water quality to aquatic life, there is a great need to assess surface water quality (Ouyang 2003). Water quality means the evaluation of the chemical, physical and biological characteristics of water. Freshwater ecosystems are getting deteriorated because of the developmental activities and highest degradation are caused by humans and their related activities in their immediate catchment areas and drainage basins (Rast 2009, Mishra and Garg 2011, Amin et al. 2014). In accordance with increasing population and development of industries, numerous water bodies have becoming polluted in Myanmar. The major problem with the lake is implemented by rainy water or other feeding sources that once contaminated, it is defaulted restore its quality (Dubey 2016).

The quality of surface water is governed by the natural and anthropogenic processes including rainfall, erosion, hydrological features, industrial and agricultural activities (Bhat and Pandit 2014). The qualities of water in lakes, reservoirs, rivers are determined by physico-chemical and biological parameters. Water quality monitoring is one of the key tools, to identify and keep a check on the pollution status and ensure about the efficiency of management plans (Singh and Jayakumar 2016).

The local people around Kandawgyi Reservoir (lake),Bago use only lake water for drinking water. They are used daily for bathing and drinking water. It is very important that the water we use every day is clean. The Kandawgyi Reservoir was built in 1924 about 6 miles northwest of Bago. It is intended to provide drinking water to local people. The area of the reservoir is 141 acres and the catchment area is 1310 acres. The reservoir has a storage capacity of 422.7 million gallons and is an earthen dam. At present, Kandawgyi lake have been experiencing many anthropogenic stresses such as entering dirt from the homes of rubber workers and gravel extractors from air defense barracks living near the lake, planting rubber plantations and making own farms around the lake which use chemical and organic fertilizers and pesticides, dam closure; own hydropower. Thus, there is a need to attempt to evaluate the water quality of the lake. In this background, the present study was made an

attempt to evaluate the seasonal variation in the biological, physico-chemical parameters and water quality of the lake.

2.Literature review

Safe drinking water is a basic need for good health, and it is also a basic right of humans. Fresh water is already a limiting resource in many parts of the world. In the next century, it will become even more limiting due to increased population, urbanization, and climate change (Jackson et al. 2001).

Nowadays, developing countries have suffered from a lack of access to safe drinking water from improved sources and to adequate sanitation services (WHO 2006). As a result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells. Since these sources are open, they are highly susceptible to flood and birds, animals and human contamination (Messeret 2012).

More than three quar- ters of the earth's surface is made up of water and only 2.8 percent of the earth's water is available for human consumption and the rest 97.2 percent is in the oceans. Rapidly increasing population, rising standards of living and exponential growth of industrialization and urbanization have exposed the water resources and has degraded the water quality. The major sources of water pollution are domestic waste and industrial wastes, which are discharged into natural water bodies (P. Singh, et.al.,2010). Pollutants such as herbicides, pesticides, fertilizers, hazardous polych- lorinated biphenyls and synthetic organic chemicals can also make their way into water supply. The major problem with the lake is implemented by rainy water or other feeding sources that once contaminated, it is defaulted restore its quality (Dubey 2016).

Drinking water quality is a relative term that relates the composition of water with effects of natural processes and human activities. Deterioration of drinking water quality arises from introduction of chemical compounds into the water supply system through leaks and cross connection (Napacho and Manyele 2010).

A number of scientific procedures and tools have been developed to assess the water contaminants (G. E. Dissmeyer., 2000). These procedures include the analysis of different parameters such as pH, turbidity, conductivity, total suspended solids (TSS), totaldissolvedsolids (TDS), totalorganiccarbon (TOC), and heavy metals. These parameters can affect the drinking water quality, if their values are in higher concentrations than the safe limits set by the World Health Organization (WHO) and other regulatory bodies (World Health Organization (WHO),2011).

With an increased understanding of the importance of drinking water quality to public health and raw water quality to aquatic life, there is a great need to assess surface water quality (Ouyang 2005). It gets affected through various factors mainly by anthropogenic activities. Freshwater ecosystems are getting deteriorated because of the developmental activities and highest degradation are caused by humans and their related activities in their immediate catchment areas and drainage basins (Mishra and Garg 2011, Amin et al. 2014).

3. Objectives

Objectives of the present study are:

- ✓ To measure the level of the some physical, chemical and biological properties of the Bago Kandawgyi Lake water
- ✓ To compare the seasonal occurrence of biological, physio-chemical parameter of kandawgyi water from study site

4.Materials and Methods

4.1 Study area

Kandawgyi Lake is located about 6 miles northwest of Bogo city. It is a man-made lake, established in 1924, with an area of 141 acres. Water from the lake directly and indirectly supplies one million gallons of water daily for domestic activities including drinking water to millions of people living in the Bago regions.

In the six places of the lake, summer, rain, during the three winter seasons, water samples are collected at points below the map.

Sample Code	GPS (Lat &Long)	Descriptions
KDG-1	N 17.375576 E 96.430136	Outlet
KDG-2	N 17.377364 E 96.426596	Inlet (near to rubber plantation)
KDG-3	N 17.379304 E 96.427201	Open lake area
KDG-4	N 17.38012 E 96.423821	Inlet (near to rubber plantations)
KDG-5	N 17.382709 E 96.423758	Inlet (near to rubber plantations)
KDG-6	N 17.382772 E 96.420433	Inlet (near to rubber plantations)

Figure 1. Map of Lake and Sampling points

4.2 Water Sampling

Water samples were collected at six different locations; one point in the middle of the lake (KDG-3), one in the outlet area and 4 points near to different rubber plantation sites (KDG-2, KDG-4, KDG-5, KDG-6) in every two months from April 2019 to February 2020. The water sampling bottles were well rinsed before sampling and tightly sealed after collection and labelled in the field. In-situ measurements of dissolved oxygen (DO), Temperature, pH, Electrical conductivity (EC) were made using the multi-parameter

instrument (Hach, HQd Portable Meter). Samples were preserved with 4M H_2SO_4 for nutrient analysis and not preserved for analysis of Turbidity, Total Alkalinity, Color, and other cations and anions analysis. The parameters such as pH, Alkalinity, Turbidity, Conductivity, Calcium, Sodium, Magnesium, Potassium, Chloride, Fluoride, Nitrate, Ortho Phosphate, Ammonia, Sulfate, Silicate, Total Nitrogen and Total Phosphate, Total Suspended Solid and Bacteria were analyzed at the Water Quality Laboratory of Forest Research Institute (FRI), Yezin. Seasonal variations in water quality parameters were assessed in accordance with Drinking Water Limits set by the World Health Organization (WHO, 1993).

5. Results and Discussion

5.1 pH

pH is a measure of the amount of free hydrogen ions and hydroxyl ions in water. A pH of 7 has no other properties, but a pH below 7 indicates an acid, and a pH above 7 indicates alkaline. The chemical content of water can be determined by knowing the pH level. The value of pH below 6.5 causes discontinuation in the making of vitamins in human body. When pH becomes more than 8.5, the taste of water becomes more salty and causes eye irritation and skin disorder (Gupta et al. 2017). Water with an average pH value of 6.64 to 8.5 is considered the most suitable drinking water according to WHO standard. The present investigation indicates that the water from Bago Kandawgyi reservoir is slightly acidic at the points of KDG-1, KDG-4 and KDG-5 and neutral at point KDG-2, KDG-3 and KDG-6. The average pH content of the whole lake ranges between 6.1 and 7.41 which are within the permissible level for drinking purposes according to WHO and Myanmar National Drinking Water Quality standards.

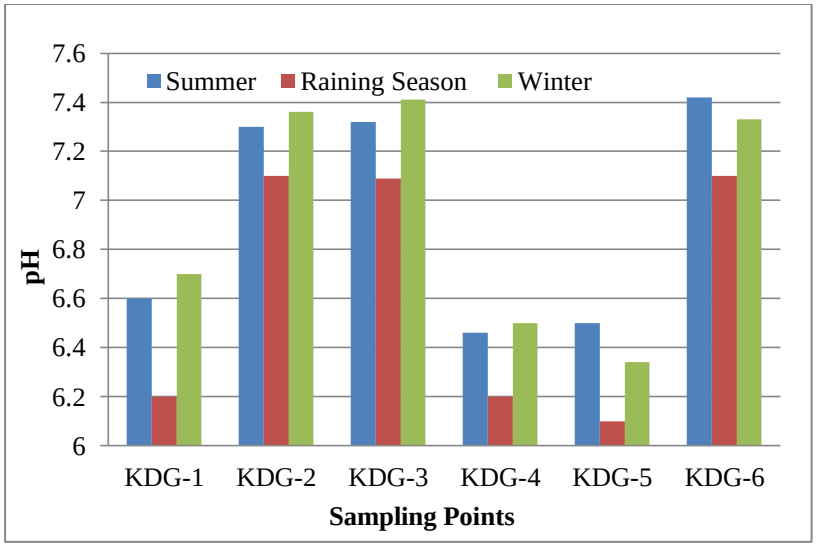


Figure 2. Seasonal variations of average pH contents of Kandawgyi lake

5.2 Total Alkalinity

Total carbonate and bicarbonate are the main suppliers of alkalis. Alkalinity of a water sample may have the ability to neutralize acids. Due to the high evaporation rate during the dry season, mineral salts such as calcium may be high in water. The alkalinity concentration of the Kandawgyi Lake was measured between 0.19 and 0.28 mmole/L. The highest alkalinity content was found in winter season. According to the laboratory analysis,

the total alkalinity values of all water samples collected from the Kandawgyi lake were below the standard set by the World Health Organization (WHO) for drinking water (5 mmol/l).

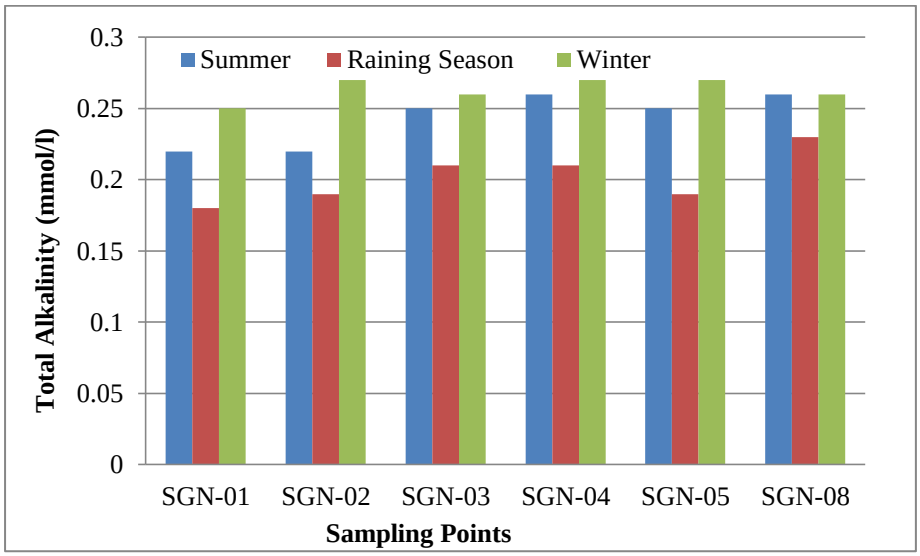


Figure 3. Seasonal variations of average alkalinity contents of Kandawgyi Lake

5.3 Turbidity

Turbidity is the water content of various particles and is a key factor in the analysis of drinking water. The average turbidity values of Kandawgyi Lake were measured between 3.18 and 7.45 FNU. The slightly higher turbidity value was found in the rainy season than that in summer and winter seasons. According to Khan and Chowdhury (1994) high value of turbidity during rainy seasons may be due to heavy load of silt or the particles eroded into the lake water from the surrounding ares. Since the turbidity values found in all seasons were in the drinking water limit (5 – 25 FNU) proposed by WHO and Myanmar, the water quality in terms of turbidity value is in good condition.

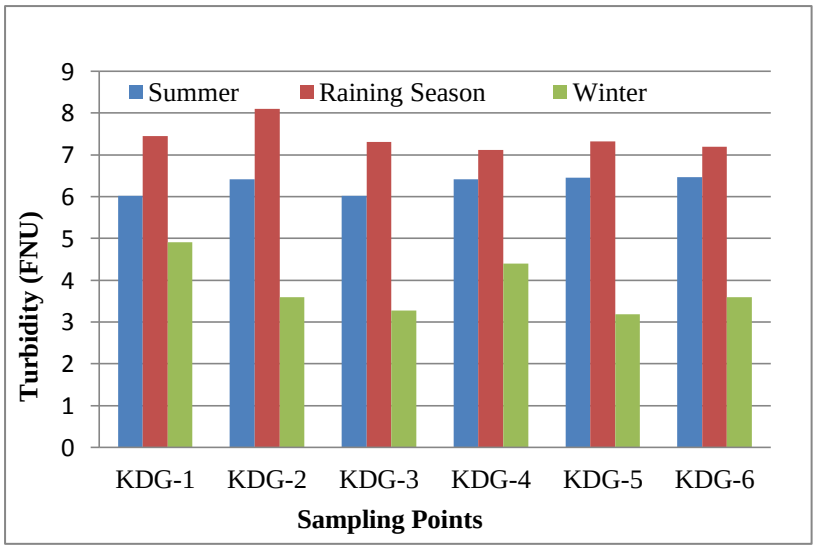


Figure 4. Seasonal variations of the average Turbidity content of Kandawgyi Lake

5.4 Conductivity

Electric current means that any medium has the ability to conduct electricity. Transmission EC is a measure of the current contained in water. Water conductivity is mainly attributed to the dissolved ions liberated from the decomposed plant matter (Sarwar and Majid, 1997) and input of organic and inorganic waste (Wright, 1982). It is associated with water-soluble salts. The average conductivity of Kandawgyi lake is measured in the range of 1.21 mS/m to 2.45 mS/m. The conductivity content in summer is highest followed by winter and then rainy seasons. The high conductivity value of the lake in summer and winter could be due to high mineral content as a result of evaporation process in the dry periods. The amounts of conductivity from all sampling points were under the acceptable limit (25 mS/m) for drinking water proposed by WHO.

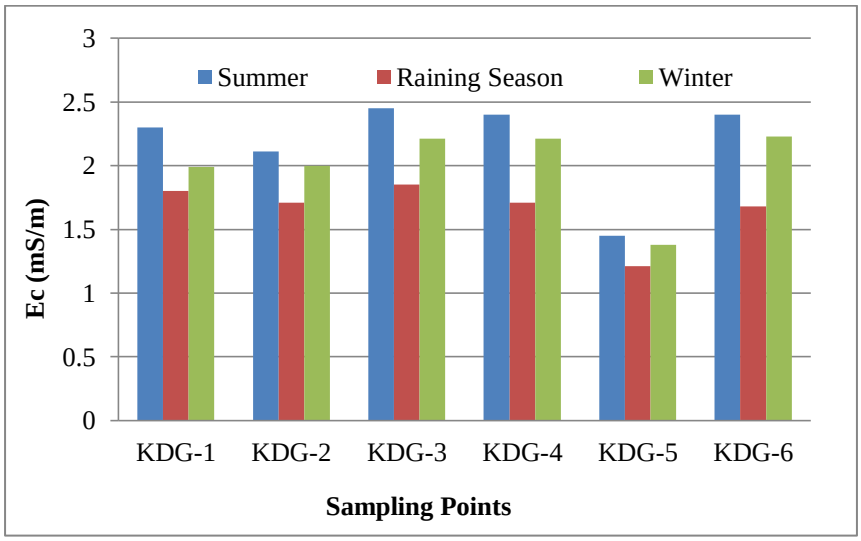


Figure 5. Seasonal description of the Conductivity content of Kandawgyi lake

5.5 Calcium (Ca)

The calcium concentration of the Kandawgyi lake is higher in winter than that of rainy and summer seasons. The proposed WHO World Drinking Water Limit for Ca is 200 mg/ l. The Ca concentration in all samples analyzed ranged between 0.73 mg/l to 1.55 mg l which is lower than the standard limits. The Ca concentration in all points of the lake is considered to be good.

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). The Ca concentration of Kandawgyi Lake is highest in Winter season and the lowest in rainy season. The proposed WHO World Drinking Water Limit for Ca is 200 mg/l. The Ca concentrations from all sampling points analysed ranged between 0.73 mg/l to 1.55 mg/l which are lower than the standard limit.

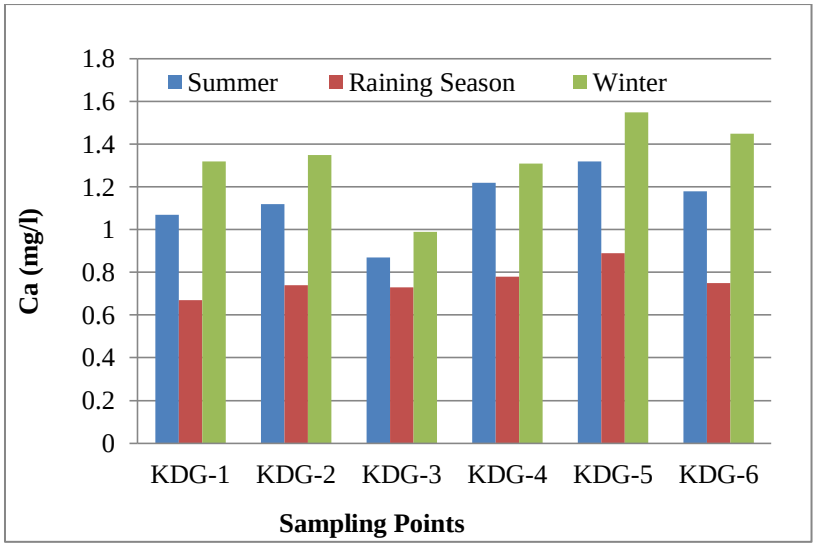


Figure 6. Seasonal variations of Calcium (Ca) contents of Kandawgyi Lake

5.6 Sodium

The sodium content of Bago Kandawgyi Lake was measured in the range of 1.03 mg/l to 2.65 mg/l. The sodium concentration of water samples is higher in winter season than in summer and then rainy seasons, which could be due to lower water volume and high evaporation rate during the dry seasons (winter and summer). But the sodium concentrations from all sampling areas are lower than WHO drinking water stand limit, which is 200 mg/L.

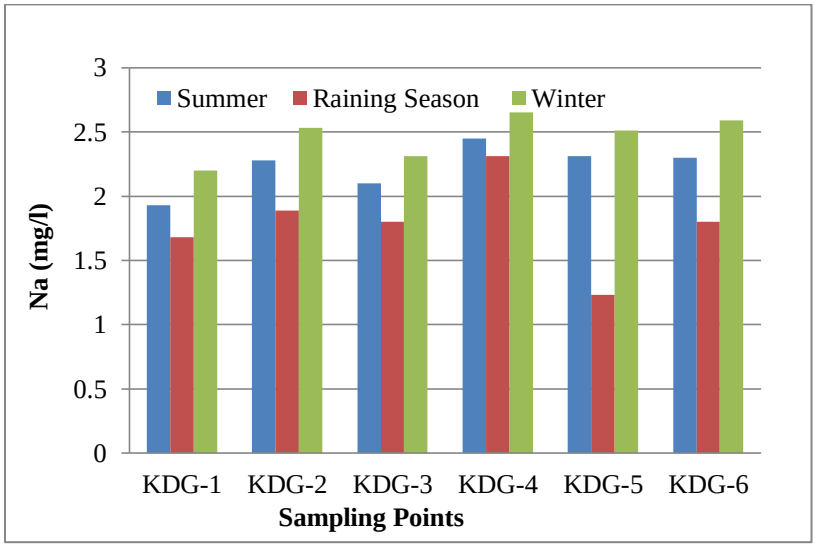


Figure 7. Seasonal variations of Sodium (Na) content of Kandawgyi Lake

5.7 Magnesium

The magnesium content is within the range of 0.27 mg/l to 1.66 mg/l. The magnesium content was higher in the winter season than in the summer and rainy seasons. Magnesium Limestone Contains Magnesium natural melting of magnesite and other minerals; The National Drinking Water Standard for Magnesium proposed by Myanmar is 150 mg/l. The Magnesium concentration of the lake water is below this standard, so the magnesium content of the lake is considered to be in good condition.

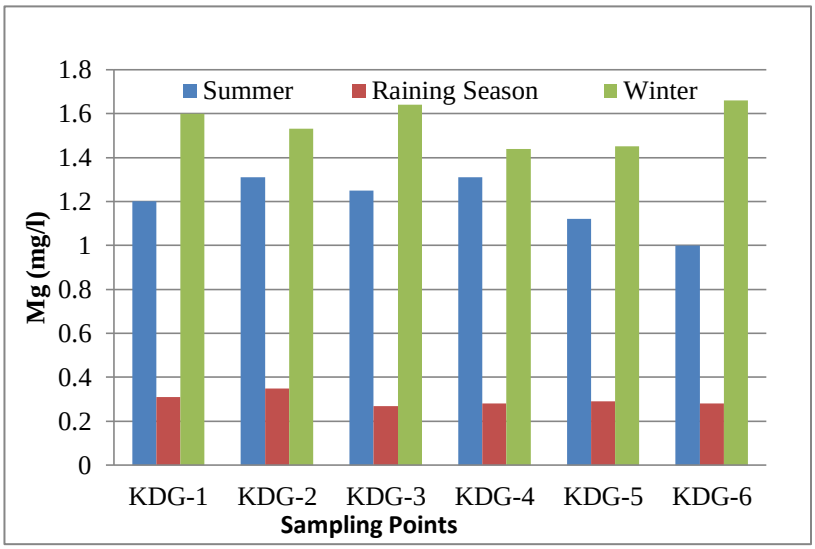


Figure 8. Seasonal variations of Magnesium (Mg) content of Kandawgyi lake

5.8 Potassium

In general, concentration of potassium in natural water is low, but high value being an indication of pollution by domestic waste (Trevedy &Goel, 1984). The potassium content of Kandawgyi Lake was measured in the range of 1.51-1.88 mg/ l. The higher potassium contents of water samples from all sampling points were found in winter and followed by that in summer time. Potassium content can be increased due to lower water level and high evaporation rate during the dry seasons (winter and summer). There is no WHO standard limit for potassium.

Potassium salts, such as potassium, which are eroded into the lake by rainwater, evaporate during the dry season, increasing the salt content. The World Health Organization (WHO) Limit does not specify a standard for potassium.

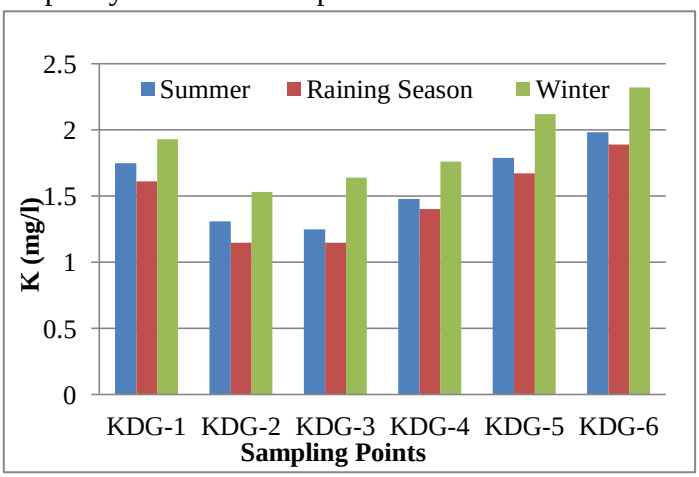


Figure 9. Seasonal variations of potassium (K) content of Kandawgyi Lake

5.9 Chloride

The chloride contents of Bago Kandawgyi Lake were ranged between 0.62 mg/L and 1.25 mg/l. The average chloride content in summer time is higher than in the rainy season and winter due to the lower water level and evaporation. The decomposition of chlorinated salts can lead to natural seepage into surface and groundwater, as well as water seepage from landfills. Chloride content of water can also be affected by man-made activities such as leaking agricultural water using fertilizers. Excess chloride would reduce the DO content of water, which turns harmful to aquatic organisms (Deepa et al.2016). Large contents of chloride in freshwater is an indicator of organic pollution (Venkatasubramani and Meenambal, 2007). Chloride contents of all water samples from Kandawgyil Lake are below the standard of Drinking Water Limit proposed by WHO.

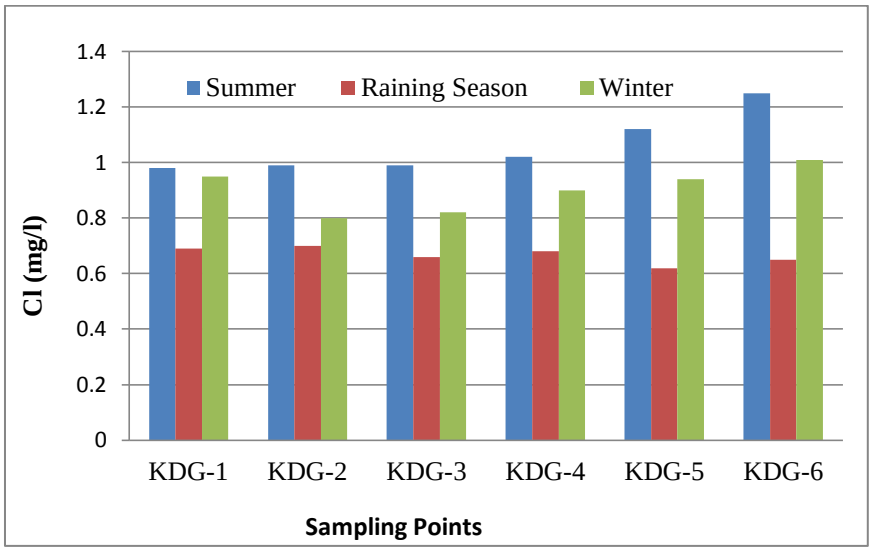


Figure 10. Seasonal variations of Chloride (Cl) content of Kandawgyi Lake

5.10 Fluoride

The fluoride content of Bago Kandawgyi Lake was measured in the range of 0.02 - 0.13 mg/l. The fluoride content of the Lake is higher in summer than in rainy season and winter. Naturally, the fluoride content of drinking water below 0.1 mg/l can prevent tooth decay, but above 1.5 mg/l to 2.0 mg/l can cause tooth decay. Stains can occur. Prolonged consumption of fluoride-rich water can lead to health problems such as high fluoride concentrations in teeth and bones.

According to the World Health Organization and the Myanmar National Drinking Water Quality standards, the Limit for fluoride is 1.5 mg/l, and the fluoride content of the Lake is below the standard, so the fluoride content of the lake water is considered to be good.

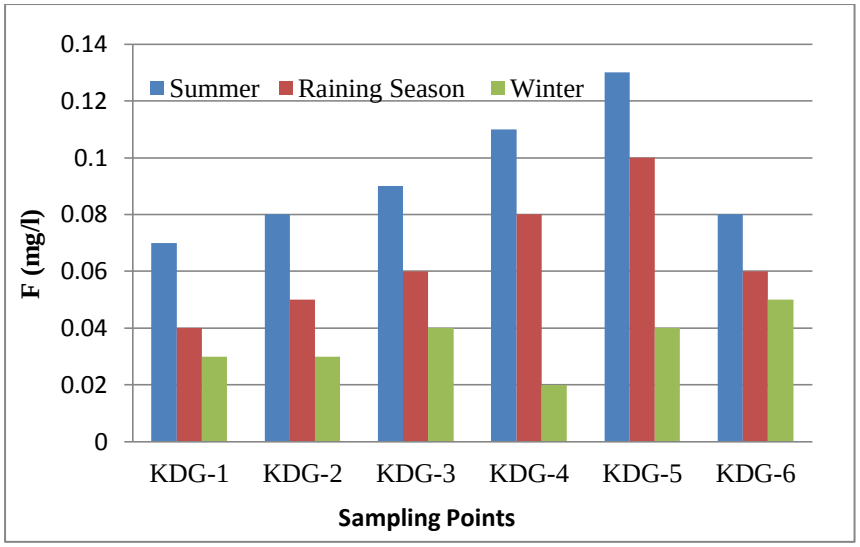


Figure 11. Seasonal variations of Fluoride (F) contents of Kandawgyi Lake

5.11 Nitrate

The nitrate content of the Kandawgyi Lake is within the range of 0.02-0.09 mg/l. The nitrate content of water samples collected in the rainy season is higher than in summer and winter.

The higher concentrations of nitrate in the lake during the rainy season could be due to the increased run off from the agriculture lands/plantation areas nearby. Fertilizers from the agricultural lands, sewage discharge, improper disposal of human and animal wastes, wastewater from domestic and industrial areas are the major factors for increasing the nitrate and organic content of water.

The nitrate–nitrogen contents higher than 10 mg/l in drinking water can cause methemoglobinemia or "blue baby syndrome" in infants. The proposed World Health Organization standard for nitrate is below 50 mg/l. According to the analysis result, the nitrate content of the Kandawgyi Lake is lower than the standard limit. So, the nitrate content of the lake can be considered as good.

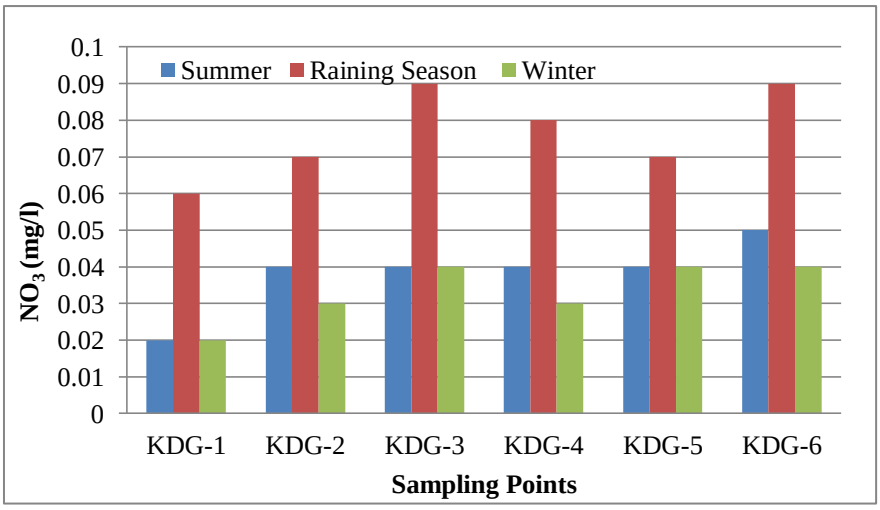


Figure 12. Seasonal variations of nitrate (NO_3) contents of Kandawgyi Lake

5.12 Ortho-phosphate

Phosphorus is commonly used in agricultural fertilizers. It is found in organic wastes such as cow dung and industrial wastes. Phosphorous is an essential element for plant life, but if there is too much of phosphorous in water, it can speed up eutrophication of rivers and lakes.

Ortho-phosphate content of the samples collected is higher in the rainy season than samples collected in winter and summer. The reason could be due to the erosion of man-made effluents and the discharge into lakes. The low values of the nutrient during summer and winter season might be probably due to lowering in input of pollutant in the lake which conforms the findings of Clarke (1924). The average Ortho-phosphate content of this lake water was measured in the range of 4 - 12.36 µg/l (0.004 mg/L to 0.012 mg/L) which is below the standard limit and suitable. There is no standard for Ortho-phosphate in the Drinking Water Limit proposed by Myanmar. According to WHO (1992) report, the concentration of PO_4-P in water above 0.005 to 0.02 mg/L is largely responsible for eutrophication of the water bodies.

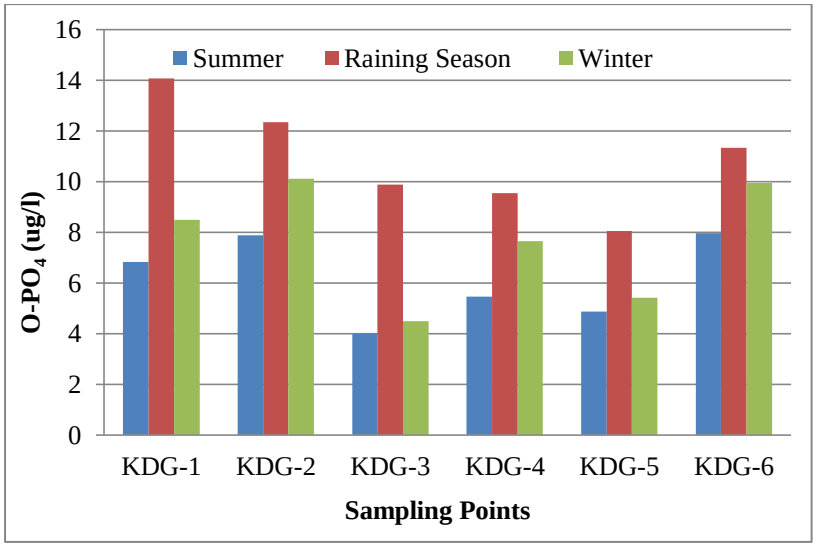


Figure 13. Seasonal variations of Ortho-phosphoate (O-PO_4) content of Kandawgyi Lake

5.13 Ammonia

Ammonia can be found in ground and surface waters through discharge of industrial wastes containing ammonia and fertilizers. The ammonia content of the Kandawgyi Lake is in the range of 0.01 - 0.3 mg/l. The ammonia content was significantly higher in winter than in other seasons. High levels of ammonia in drinking water may indicate a pollution problem and may cause odor problems. The World Health Organization (WHO) standard is 2 mg/l. The ammonia content of the lake is below this limit, so the ammonia content of the lake is considered to be good.

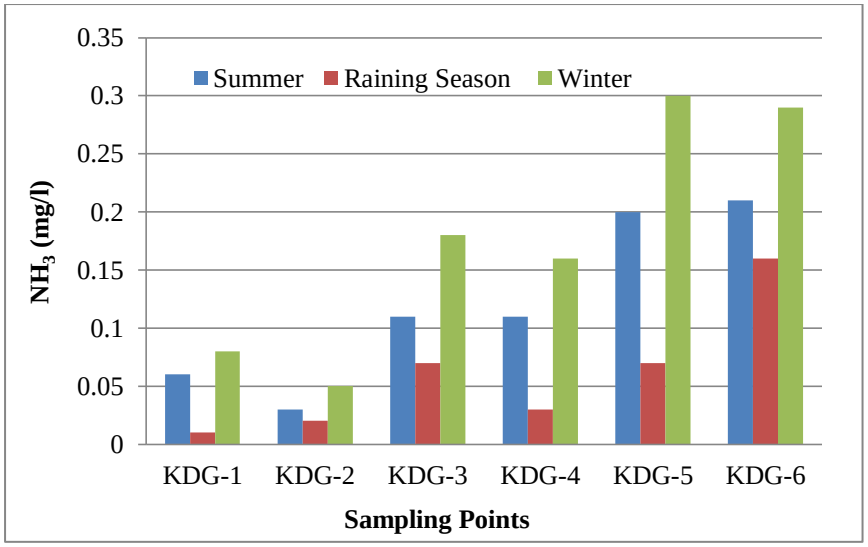


Figure 14. Seasonal variations of ammonia (NH_3) content of Kandawgyi lake

5.14 Sulphate

Most of the sulphate in water comes from dissolved minerals. Sulphate can also come from fertilizer or sewage treatment or industrial discharges. The increased transport of sulphate minerals eroded by the rain into the lake cause the highest sulphate content of the lake during the rainy season. The higher sulphate contents were found in the water samples collected from the points near to rubber plantation sites (KDG-4, KDG-5, KDG-6) than the samples from KDG-1 (outlet), KDG-2 (inlet), KDG-3 (open lake area).

The sulphate contents of water samples from Kandawgyi lake were measured in the range of 0.1 - 0.6 mg/l. WHO proposed the standard limit of sulphate for drinking is lower than 250 mg/l. Since the sulphate content of all water samples from Kandawgyi Lake is lower than the standard limit, the sulphate content of the lake water is considered to be good.

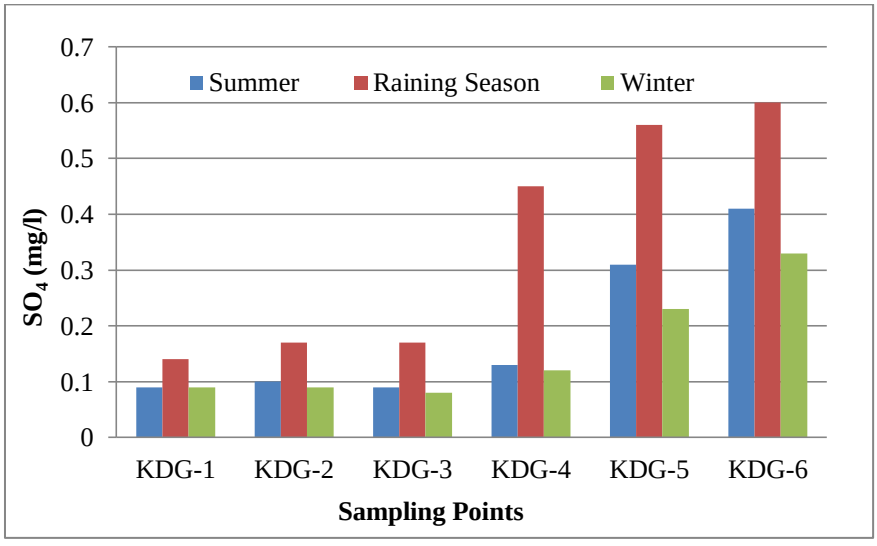


Figure (15) Seasonal variations of the sulphate (SO_4) contents of the lake

5.15 Total Suspended Solid (TSS)

Total suspended solids (TSS) include all particles suspended in water which will not pass through a filter. Suspended solids are presented in sanitary wastewater and many types

of industrial wastewater. There are also nonpoint sources of suspended solids such as soil erosion from agricultural and construction sites. The Total Suspended Solid content of the Kandawgyi lake was measured between 6 mg/l and 11 mg/l. 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. There is no standard for TSS by the World Health Organization (WHO). However, the National Drinking Water Quality Standard (NDWQS) used in Malaysia set the standard limit of 25 mg/l for TSS. According to this standard, the TSS content of the lake water is lower than the limit. According to the classification of clearness based on TSS concentrations by DWAF (1996) as shown in the table (2), the lake water can be defined as "Clear".

Table 2. Clarity of water based on TSS level

Total Suspended Solid (mg/L)	Description of Clearness
< 20	Clear
40 - 80	Cloudy
>150	Dirty

Source: DWAF (1996)

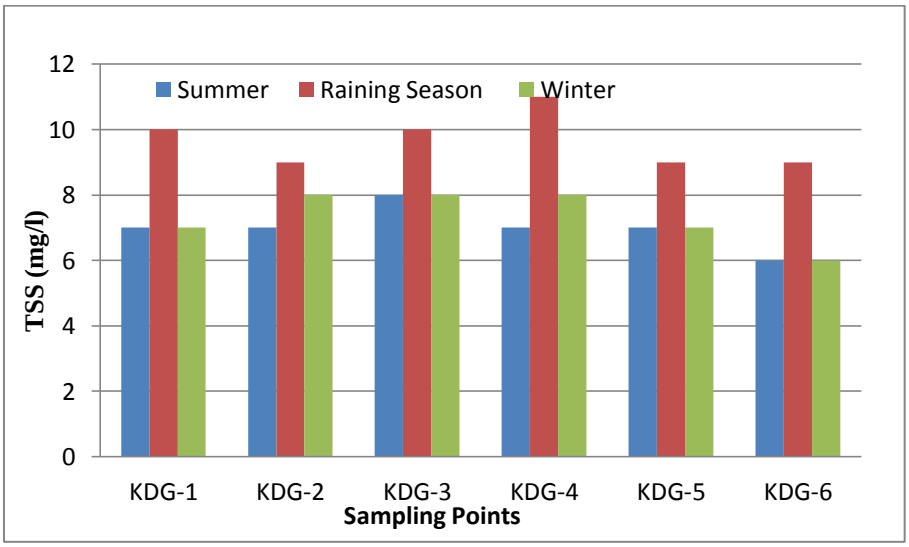


Figure 16. Seasonal variations of Total Suspended Solid (TSS) contents of the lake

5.16 Total Nitrogen

Total Nitrogen is the total amount of kjeldahl nitrogen (ammonia, organic and reduced nitrogen) and nitrate-nitrate. The total nitrogen content of lake water ranged between 70.25 to 86.95 ug/l (0.07 mg/L to 0.09 mg/L). The total nitrogen content of lake water is higher in rainy season than in summer and winter. Use of fertilizers on agricultural lands, sewage flows into the lake, animal waste, wastewater for domestic and industrial use are the major sources for increasing the nitrate and organic content of water. The proposed WHO standard for total nitrogen is 50 mg/L. The total nitrogen contents of the lake water from all sampling points are far lower than the standard limit. So the total nitrogen content of the lake is considered to be good.

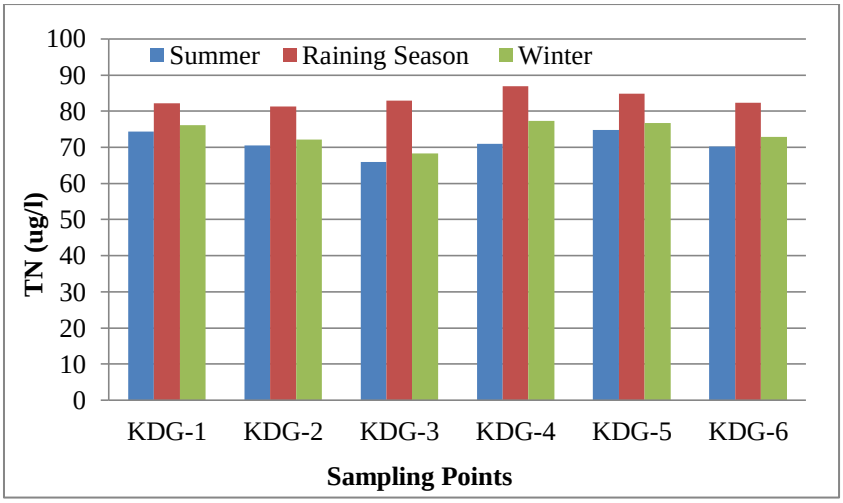


Figure 17. Seasonal variations of total nitrogen (TN) contents of Kandawgyi Lake

5.17 Total Phosphorus

Ortho-phosphate, the three types of condensed phosphate and organic phosphate are called total phosphorus. Total Phosphorus is mostly used in agricultural fertilizers. Like Ortho-phosphate, it is also a major source of organic wastes. Too much of phosphorous in water can induce the eutrophication of rivers and lakes. According to the laboratory analysis, the total phosphorus content of Kandawgyi Lake ranged between 7.42 µg/l and 21 µg/l.

The highest total phosphorous found in the raining season could be due to incoming wastewater and fertilizer residues into the lake from the surrounding and watershed areas by the rain water. There is no standard for Total phosphorus in the Drinking Water Standards proposed by the World Health Organization (WHO). But Environmental Protection Agency (EPA) set the acceptable range for total phosphorous is 10 to 40 µg/L. According to EPA standard, the total phosphorous contents of the lake water from all sampling points are lower than this limit.

It should be noted that the adding of even a small amount of phosphorous to a water body can have negative consequences for water quality. The adverse effects of being high levels of phosphorous in the water include algae blooms and low dissolved oxygen. Algae blooms can produce toxins which can affect the health of human and animal who directly used the water.

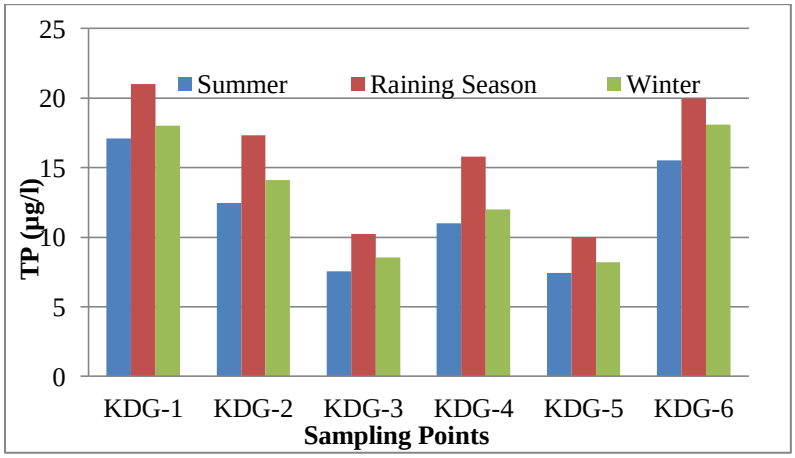
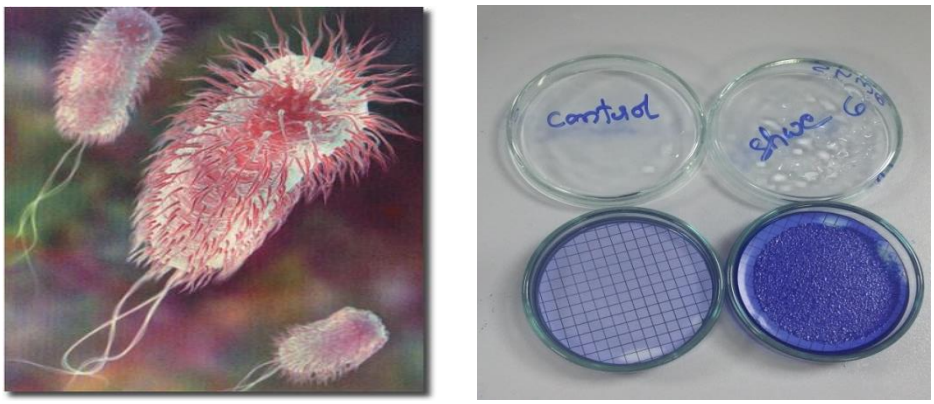


Figure 18. Seasonal variations of total phosphorus (TP) contents of Kandawgyi Lake

5.18 *Escherichia coli* bacteria – *E. coli*

Esherichia coli (*E. coli*) are bacteria found in the environment, foods, and intestines of people and animals (EPA). *E. coli* can also be found in water sources, such as private wells that have been contaminated with feces from infected humans or animals. Although most strains of E. coli are not harm, some kinds of *E. coli* can cause diarrhea, urinary tract infections, respiratory illness and pneumonia and other illnesses. *E. coli* bacteria in Kandawgyi Lake is measured to be innumerable in all samples from all sampling points the whole year round. The WHO standard limit of *E. coli* for drinking purposes is 0 CFU/100ml. The pollution status of the Lake by E.coli indicated that there seems incoming sewage or sanitary seeped from the housing areas near to the lake.



E. coli lab analysis photos

Figure 19. E. coli (Credit: U.S. Environmental Protection Agency)

6. Conclusions

Seasonal variations of physico-chemical and biological (*E. coli*) parameters of Kandawgyi Lake were presented in this paper.

Higher concentrations of mineral salts (Ca, K, Na, Mg, Cl, F) in all samples from all sampling pointes were found in the Dry seasons (Summer and Winter). This could be due to decreased water volume and high evaporation rate during the dry seasons. The higher pH, EC and Total Alkalinity concentrations found in dry seasons (Winter and Summer) are mainly due to these increased mineral salts in the lake water.

Higher nutrient concentrations (NO_3, TN, TP, PO_4) of water samples from all sampling points were explained by incoming wastewater and fertilizer residues from the surrounding and watershed areas by the rain water. The increased Turbidity and TSS concentrations of water samples in rainy seasons expressed the increased particles in the lake water eroded from the surround areas during the rainy seasons.

According to the laboratory analysis, all physical and chemical properties were below the water quality standards set by WHO. However, according to *E. coli* contents, Kandawgyi Lake is polluted with sewage or sanitary from the surrounding areas. Drinking the water contaminated with the bacteria like *E. coli* can cause health problems such as diarrhea, urinary tract infections, respiratory illness, pneumonia, etc. Therefore, water from Kandawgyi Lake is not suitable to use for drinking purposes without any treatment. If the lake water is to

be used for drinking, it is recommended to boil the lake 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 the rainy season.

There are many private rubber plantations around the Kandawgyi Lake. Based on this study it is recommended to analyse the organic pollutants which mainly come from chemical fertilizers and pesticides used in the plantation areas. The continuous monitoring and assessment of water quality changes are required to prevent the entry of contaminated water and to improve the overall water quality of the lake.

7. Acknowledgements

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