

**Assessment of Physicochemical Parameters in Groundwater Quality of Mella Sub-County,  
Tororo District**

**By**

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Requirement for the Award of the Degree of  
Bachelor of Science Education of Busitema University**

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**DECLARATION**

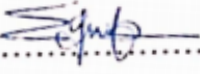
I, Ndigi Shamiru declare that this is my own original work and it has not been submitted before to any university for any award.

Signed .....  .....

Date ..... 01.11.2024 .....

**APPROVAL**

This research report by Ndigi Shamiru was done under my supervision and is now approved for submission.

Sign .....  .....

Date ..... 01.11.2024 .....

Dr. Egor Moses

SUPERVISOR

## **DEDICATION**

i dedicate this work to my lovely parents Muhammed Nanguda and Mariam Kafuko for their encouragement words, patience and support in different circumstances and times during my studies.

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I express my sincere and deepest gratitude to my supervisor; Dr. Egor Moses for his expertise, invaluable guidance, constant encouragement, affectionate attitude, understanding, patience and healthy criticism added considerably to my experience. Without his continual inspiration, it would have not been possible to complete this study.

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## **ABSTRACT**

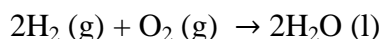
Groundwater is the major source of drinking water in many areas which is abstracted through boreholes and wells for domestic and industrial use. Effective water quality monitoring assists in checking the equality of water available for consumption. This study was carried out to evaluate the physicochemical quality of borehole and well water parameters in Mella sub-county, eastern region of Tororo district where groundwater is the main source of drinking water. The physicochemical parameters analyzed include; Electrical Conductivity (EC), temperature, Total Dissolved Solids (TDS), pH, milliVolts (mV) and turbidity using standard methods of analysis. Obtained results were compared with the World Health Organization (WHO), for drinking water. E.C ranged from 88.37-558.6  $\mu\text{S}$ , temperature ranged from 27.3-28.0  $^{\circ}\text{C}$ , TDS ranged from 46.48-293.6 ppm, pH ranged from 5.11-6.68 and turbidity ranged from 0.06-397 NTU.

## CHAPTER ONE INTRODUCTION

### 1.1 Background

Water is one of the most crucial and valuable natural resource. It is essential in the life of all living organisms from the simplest plants and microorganisms to the most complex living system called as human body (Okonko et al., 2008).

Water make up about 70% of the body weight of almost all living organisms. Life is not possible on this planet without water (Adesogan, 2014). Water is a universal dissolver, which comprise of hydrogen and oxygen atoms. Chemically, it can be defined as a chemical substance with two atoms of hydrogen and one atom of oxygen connected by covalent bonds in each of its molecules; hence the molecular formula is H<sub>2</sub>O. It is formed by the direct reaction of hydrogen with oxygen as shown below (Olubanjo et al., 2019).



Water is substantial due to its unique chemical and physical properties. It is an inorganic substance that occurs in three states; liquid, gaseous and solid states and is known to be the most abundant compound (70%) on earth (Obi & Okocha, 2007). Water in its pure form has a pH of 7.0, freezing point of 0oC and boiling point of 100oC at 760 mmHg. It is also a colorless, transparent, odorless and tasteless liquid (Adogo et al., 2016). Water originate from several sources which include rain water, surface water and groundwater. But the most important one is the groundwater which originate as a result of rainfall infiltration into the ground through the pores of rocks and soil thus meeting the water table. It is normally abstracted through the domestic boreholes and wells, and essential for human consumption (Bhat, 2014). On earth, it is found mostly in oceans and other large water bodies e.g. lakes, with 1.6% of water below ground in aquifers and 0.001% in the air as vapor clouds (formed from the solid and liquid water particles suspended in air), and precipitation. Oceans hold 97% of surface water, glacier and polar ice cap 2.4% and other land surface water such as rivers, lakes and ponds 0.6% (Olubanjo et al., 2019). A very small amount of earth's water is contained within biological bodies and manufactured products.

The characteristics of groundwater are determined by geological processes e.g. weathering of minerals, precipitation, dissolution, ion exchange, oxidation, reduction and residence time (flow rate) of groundwater (Budhathoki, 2014).

Water on earth moves continually through a cycle of evaporation, transpiration, precipitation and runoff normally reaching the sea. Overland, evaporation and transpiration contribute to the precipitation. Small amount of gases like nitrogen, oxygen and carbon dioxide in the atmosphere are contained in all-natural water. Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other crucial things to life (Olubanjo et al., 2019).

Man can go without food for twenty-eight days, but only three days without water, and two thirds of a person's water consumption per day is through food while one third is got through drinking (Bhat, 2014). Water is the most common dissolver for many substances and it rarely occurs in its pure nature (Bhat, 2014). Water can be obtained from a number of sources, among which are streams, lakes, rivers, ponds, rain, springs and wells (Okonko et al., 2008).

Clean and fresh drinking water is essential for human and other forms of life. There is abundance of water on the earth surface but the quality as well as the quantity to serve its intended purpose is where the problem lies. Drinking water has been a major issue in many countries like Uganda and majority of the rural population in Uganda do not have access to potable water (Rajini et al., 2010). Only few people can afford and rely on purified and treated bottled water basically for consumption therefore, borehole and well water serve as the major sources of domestic water used in the local population of Uganda.

Access to safe drinking water has improved steadily and sustainably over the last decades in almost every part of the globe, especially Uganda (Adesogan, 2014), but approximately 1.1 billion people still lack access to safe water and over 2.6 billion people world-wide lack access to adequate sanitation which cause water (Fadaei et al., 2014).

The presence of nitrate compounds, heavy materials, pesticides etc. in our drinking water can constitute undesirable pollutant when they are not within World Health Organization (WHO) guidelines for drinking water. Agricultural processes involving the use of fertilizers, herbicides and pesticides produce toxic substances that are transported as effluents into water sources and these pollute water bodies (Budhathoki, 2014). Similarly, industries emit wastewater that contains organic dyes which introduce different ion into water that can alter its composition (Bisschops & Spanjers, 2003).

A number of scientific procedure and tools have been developed to assess the water contamination.

These procedures include the analysis of different parameters such as turbidity, electrical conductivity, temperature, total dissolved solids and pH. 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 (Organization (WHO) & Health, 2011). Therefore, the investigation of the drinking water quality by researchers and governmental departments has been performed regularly throughout the world ((WHO), 2004). There is a gap in the knowledge of anthropogenic, geological and hydrological factors impacting on the borehole and well water quality and the patterns of water consumption to identify areas with water stress and understand consumption patterns (Taiwo et al., 2015).

## **1.2 Problem Statement**

Water quality has a direct impact on public health (Khan et al., 2003). The water supply in Mella sub-county is insufficient as per demand of consumers. Mostly driven by the unreliable and quality compromised borehole and well water supply and in part due to the perception and expectation of pure and safe drinking water. With the increasing and insufficient supply, it seems that in the near future, the urban dwellers would not have an option other than using bottled water for drinking. Thus it is high time to check the quality and monitor borehole and well water. However, very few studies have been carried out to assess their quality and there are no agencies that regularly monitor their quality (Mbura et al., 2018).

## **1.3 Objectives of the Study**

### **1.31 General Objective**

This study aimed at assessing the physicochemical parameters of groundwater quality of Mella sub-county, eastern region of Tororo district.

### **1.32 Specific Objectives**

- i.** To determine the physicochemical parameters of borehole and well water used in Mella sub-county.
- ii.** To compare the values obtained from the analysis with the World Health Organization (WHO) standards with a view to improve the quality of borehole and well water.

#### **1.4 Research Questions**

- (i) How do the physicochemical parameters vary across different sampling points within Mella sun-county?
- (ii) How do the measured physicochemical parameters compare with established the World Health Organization (WHO) standards and guidelines?

#### **1.5 Research Justification**

Safe drinking water is a fundamental right of every human being. However, is the water that we drink safe? The answer is obviously “NO” as shown by the death statistics from water borne diseases which accounts to 80% (Organization (WHO) & Health, 2011). This is due to pollution of the water sources.

The consumption of water from polluted water sources is capable of causing water or chemical related diseases (Ikeme et al., 2014). Driven by the perception of purity, people switch to buy bottled water. It is on this basis that an attempt is being made to analyze the water quality basing on their physicochemical parameters such as turbidity, electrical conductivity, temperature, total dissolved solids and pH in Mella sub-county.

#### **1.6 Scope of the Study**

Water samples are collected in different water sources from Mella Sub county located in Eastern region, Tororo district. The research was conducted at Busitema University, Nagongera Campus Chemistry laboratory where the analysis of water parameters took place.

## CHAPTER TWO LITERATURE REVIEW

### 2.1 Water Quality

Water quality is a measure of condition of water relative to the requirements of one or more biotic species and to any human need or purpose (Likambo, 2014).

Water quality can be classified into four types; potable water, palatable water, contaminated water (polluted) water and infected water (Ngozi et al., 2018). The most common scientific definitions of these types of water quality are as follows;

Potable water; It is one that is safe to drink, pleasant to taste and usable for domestic purposes.

Palatable water; It is that water that is esthetically pleasing, it considers the presence of chemicals that do not cause a threat to human health. Contaminated (polluted) water; It is that water containing unwanted physical, chemical, biological or radiological substances and it is unfit for drinking or domestic use.

Infected water; It is that water that is contaminated with pathogenic organisms.

#### 2.1.1 Water Quality Study

Water quality study is the process of determining the physical, chemical and biological characteristics of water and identifying the possible contamination sources that degrade the quality of water (Bhat, 2014). Degradation of the quality of water resources may result from waste discharges, pesticides, heavy metals, nutrients, microorganisms and sediments (Huat et al., 2011). Different water quality standards have been developed to aid in checking the extent of water pollution and consequently to maintain these quality standards (Organization(WHO) & Health, 2011).

### 2.2 Water Quality Parameters

There are three types of water quality parameters and these include physical, chemical and biological parameters (Palamuleni et al., 2015). Since this study is aimed at assessing the physicochemical parameters, the literature review will be basically on physical and chemical water quality parameters.

### **2.2.1 Electrical Conductivity (EC)**

The electrical conductivity of water is the ability of a solution to carry or conduct an electric current (Saxena et al., 2017). Since the electrical current is carried by ions in solution, the conductivity increases as the concentration of ions increases. Therefore, it is one of the main parameters used to determine the suitability of water.

Units of its measurement are as follows;

S.I units = milliSiemens/m (mS/m) or dS/m (deciSiemens/m)

Where (mS/m) = 1000  $\mu$ S/cm = 1 dS/m

The electrical conductivity can be used to estimate the TDS value of water.

### **2.2.2 Temperature**

Water temperature is a physical property expressing how hot or cold water is. Temperature can further be defined as a measurement of the average thermal energy of a substance (Taiwo et al., 2015). Thermal energy is the kinetic energy of the atoms and molecules. This energy can be transferred between substances as the flow of heat.

Temperature is an important parameter when assessing the water quality. In addition to its own effects, it influences several other parameters and can alter the physical and chemical properties of water. Temperature is expressed in degrees Celsius ( $^{\circ}$ C) or degrees Fahrenheit ( $^{\circ}$ F).

### **2.2.3 Total Dissolved Solids (TDS)**

Total dissolved solids is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium and potassium cations and carbonates, hydrogen carbonate, chloride, sulphate and nitrate anions (Olubanjo et al., 2019). TDS is measured in parts per million (ppm).

Total dissolved solids correlates positively with conductivity (Mbura et al., 2018). The presence of dissolved solids in water may affect its taste. It is important to monitor the TDS level of drinking water for various reasons. When a water source has a high level of TDS, it is likely that there are other harmful contaminants in water.

### **2.2.4 pH**

pH can be defined as the negative logarithm of the hydrogen ion concentration. It is a dimensionless number indicating the strength of an acidic or a basic solution.

pH of water is a measure of how acidic or basic water is. Acidic water contains extra hydrogen ions ( $H^+$ ) and basic water contains extra hydroxyl ions ( $OH^-$ ). pH ranges from 0 to 14, with 7 being neutral. pH of less than 7 indicates acidity whereas a pH greater than 7 indicates a base solution. Pure water is neutral with a pH close to 7.0 at 25 °C. The pH of water can vary depending on various factors, including the presence of dissolved minerals and the amount of organic matter, including industrial and agricultural practices, can also influence the pH of water (Ishaku et al., 2011). Excessively high and low pH can be detrimental for the use of water, a high pH makes the taste of water bitter.

### **2.2.5 Turbidity**

Turbidity is the cloudiness of water. It is the ability of light to pass through water. It is caused by suspended materials such as clay, silt, organic material, plankton and other particulate materials in water (Edbert et al., 2019).

Turbidity is measured by an instrument called nephelometric turbidimeter, which express turbidity in terms of Nephelometric Turbidity Units (NTUs) or TU. TU is equivalent to 1 mg/L of silica in suspension. Turbidity more than 5 NTU can be visible to the average person while turbidity in muddy water, it exceeds 100 NTU. Groundwater basically has very low turbidity because of the natural filtration that occurs as the water penetrates through the soil. Turbidity is an important indicator of suspended sediments in water, the presence of pathogens, bacteria and other contaminants, which can negatively affect aquatic life and water quality.

## CHAPTER THREE MATERIALS AND METHODS

### 3.1 Study Area

Groundwater samples in this study were collected from Mella sub-county in the eastern region of Tororo district. It has an area of 50.38 km<sup>2</sup> with five parishes of Amoni, Malaba, Apokor, Mella and Kuitangiro. It is estimated to have a population of 22,200 people and 440.7 km<sup>2</sup> population density by 2020. From 2015-2020, it is estimated to have an annual population change of 2.5%.



#### Key



Sampling Sites

**Figure 1: Map of Mella Sub-county**

### 3.2 Sample Collection

Water samples were collected from seventeen sampling sites where thirteen samples were for different borehole and four were for different wells. Simple sampling method was employed on

selecting the different thirteen boreholes and the different four hand-dung wells from each site of the study area.

Water samples were collected in plastic water bottles previously washed with detergents, rinsed twice with rain water and then finally rinsed with sample water three times before filling the sample water. At each sample collection, the plastic bottle was labeled, and after all the samples were collected, they were transported to Busitema University, Nagongera campus laboratory for analysis. Standard methods were used for sample collection, handling and storing to ensure data quality and consistency (Myers & Mark, 2006).

**Table 1: Study site locations**

Sample ID	Latitude	Longitude
B1	0.604132	34.083694
B2	0.601573	34.069681
B3	0.593693	34.059095
W1	0.608912	34.084885
B <sub>4</sub>	0.616371	34.086239
B5	0.618263	34.087271
B6	0.680069	34.064664
W2	0.631594	34.08584
W3	0.631555	34.085825
W4	0.621594	34.085724
B7	0.655202	34.078063
B8	0.682607	34.086239
B9	0.67569	34.075123
B10	0.699886	34.073761
B11	0.759916	34.050394
B12	0.796371	34.056239
B13	0.795942	34.054885

Where;

B – Borehole

W – Well



**Figure 2: Collecting the water samples**

### **3.3 Analysis of physicochemical parameters in the water samples**

The water samples were analyzed for physicochemical parameters such as electrical conductivity (EC), temperature, total dissolved solids (TDS), pH, milliVolts and turbidity using standard analytical methods.

Electrical conductivity, temperature, total dissolved solids, pH and milliVolts were measured using Thermo scientific EUTECH PC 450 pH/mV/Conductivity/TDS/°C/°F meter. The meter was calibrated before the electrode was infused into the samples.



**Figure 3: Thermo scientific EUTECH PC meter**

The turbidity of the water samples was measured using Thermo scientific EUTECH TN-100 Waterproof Turbidimeter.



**Figure 4: Thermo scientific EUTECH TN-100 Waterproof Turbidimeter**

### 3.4 Analysis of Results

The physicochemical parameters were compared with World Health Organization (WHO) guidelines for drinking water. The relationship between the different physicochemical parameters in the water samples were analyzed by plotting graphs(Bhat, 2014).

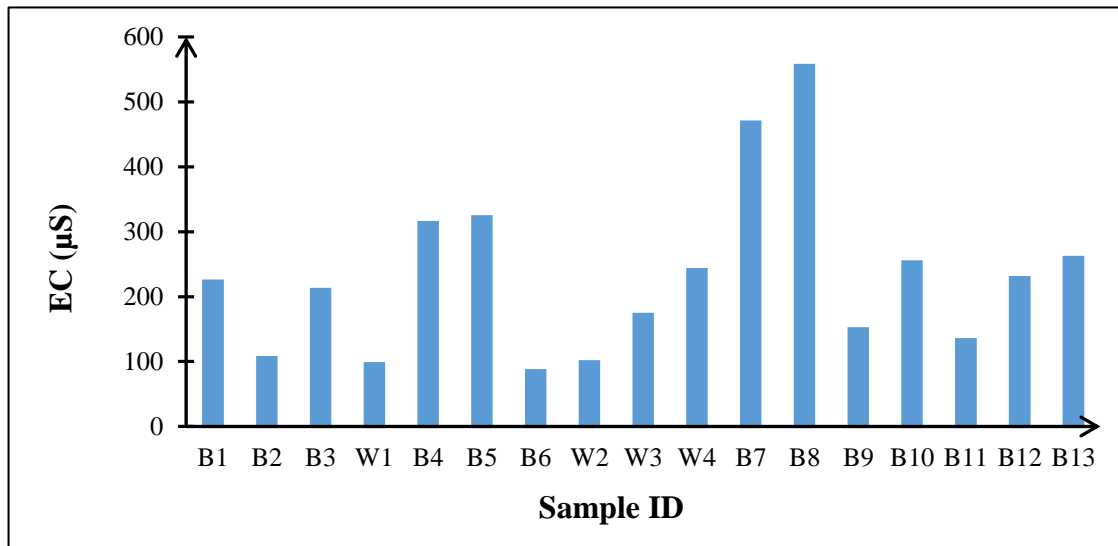
## CHAPTER FOUR RESULTS AND DISCUSSION

### 4.1 Results

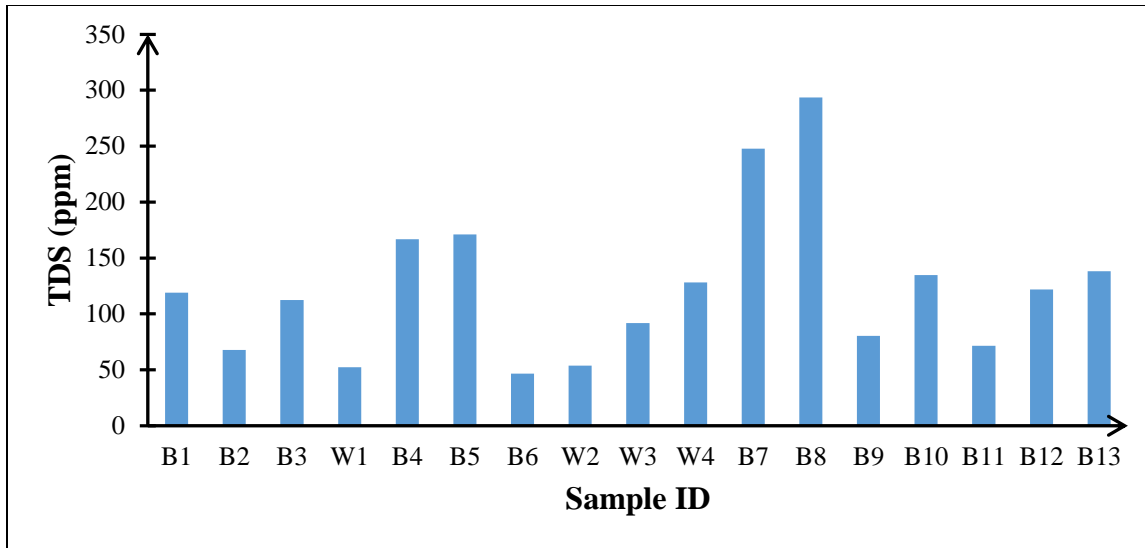
**Table 2: Results of physicochemical parameters**

Sample ID	EC ( $\mu$ S)	Temp ( $^{\circ}$ C)	TDS (ppm)	pH	mV ( $\mu$ S)	Turbidity (NTU)
WHO value	400	15	500	6.5-8.5	-	Not more than 5
B1	226.5	27.5	119.0	5.85	89.4	1.40
B2	108.8	27.4	67.70	5.45	113.4	27.6
B3	213.7	27.3	112.5	5.83	89.4	0.12
W1	99.34	27.5	52.21	6.12	76.7	213

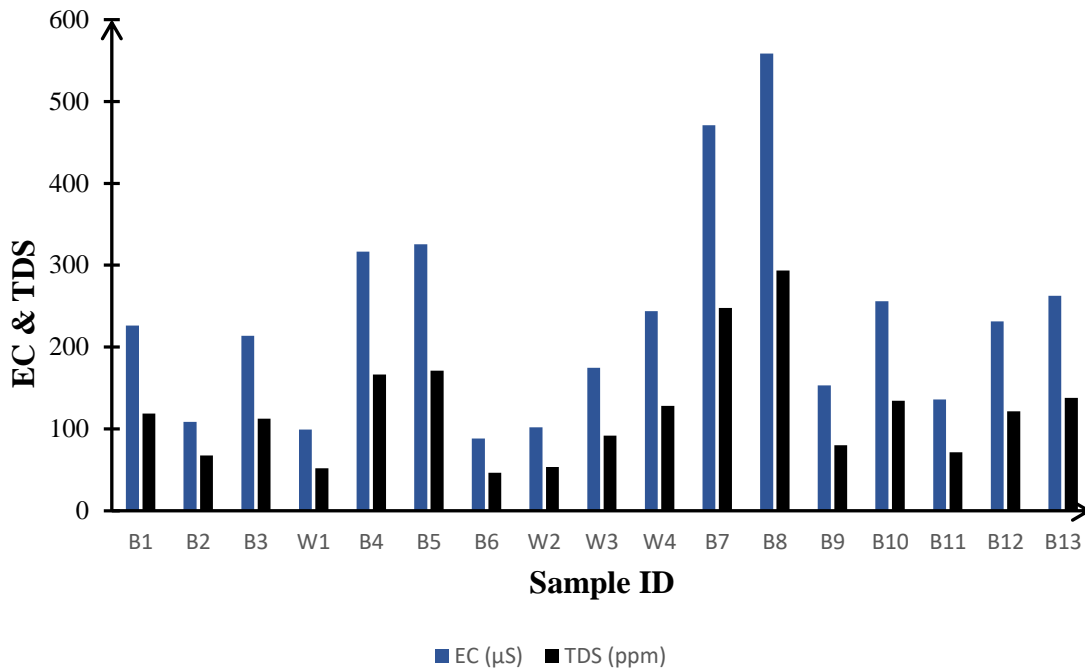
B4	316.7	27.5	166.7	6.03	78.2	0.35
B5	325.6	27.8	171.2	5.80	83.9	0.94
B6	88.37	28.0	46.48	5.31	116.8	61.6
W2	102.1	27.4	53.66	6.36	61.3	176
W3	174.9	27.4	91.94	6.45	52.0	397
W4	244.1	27.5	128.2	6.68	30.6	210
B7	471.1	27.9	247.8	6.27	65.6	0.22
B8	558.6	27.9	293.6	6.24	62.4	5.31
B9	153.1	27.5	80.41	6.23	67.5	0.06
B10	256.1	28.1	134.6	5.52	97.4	2.15
B11	136.0	28.0	71.52	5.11	124.6	15.85
B12	231.6	27.8	121.8	5.55	101.8	1.68
B13	262.8	28.1	138.2	5.63	101.8	1.14



**Figure 5: EC and Sample ID**



**Figure 6: TDS and Sample ID**



**Figure 7: Relationship of EC and TDS against Sample ID**

## **4.2 Discussion**

### **4.21 Electrical Conductivity (EC)**

The ability of water to grant the flow of electric current is measured by electrical conductivity (EC). The concentration of ions in water determines EC. These ions come from dissolved salts and inorganic elements (Jameel et al., 2006). As recommended by World Health Organization (WHO), the EC value should not exceed 400  $\mu\text{S}/\text{cm}$  in drinking water (Organization(WHO) & Health, 2011). The result of the study indicates that EC values ranged from 88.37  $\mu\text{S}$  to 558.6  $\mu\text{S}$ . However, the EC values for B7 (471.1  $\mu\text{S}$ ) and B8 (558.6  $\mu\text{S}$ ) were above the WHO limits. Higher EC values in the study area pictured high quantities of salt in groundwater.

### **4.22 Temperature**

Temperature is a crucial water property because it influences chemical and biological responses of aquatic organisms (Rajini et al., 2010). The temperature of the water samples was determined to be between 27.3  $^{\circ}\text{C}$  and 28.0  $^{\circ}\text{C}$ . During the investigation, there were no great differences between the temperatures of the water samples. However, none of these values are under the WHO criteria of 15  $^{\circ}\text{C}$  (Organization(WHO) & Health, 2011). Water samples had values that were higher than those recommended by WHO.

### **4.23 Total Dissolved Solids (TDS)**

Water dissolve a variety of inorganic and organic minerals and salts including calcium, magnesium, sodium and potassium, carbonates, hydrogen carbonates, chlorides, sulphates and nitrates (Jameel et al., 2006). The minerals can significantly impact water quality by altering the taste and odor. The acceptable threshold of TDS in drinking water is 500 ppm. TDS greater than the permissible limit can cause gastrointestinal problems (who, 2004). The results of TDS of the water samples in the studied area were ranging from 46.48 ppm to 293.6 ppm which were below the WHO limits.

### **4.24 pH**

The concentration of hydrogen ions present in the solution is the measurement of pH of that solution. The permissible range of pH of drinking water is 6.5 to 8.5 according to WHO ((WHO), 2004). If the pH is below 6.5, it is considered to be acidic water and tends to be corrosive to pipes and hand pumps whereas pH above 8.5 is alkaline water and may tend to have a bitter or soda-like taste (Organization (who) & Health, 2011). In this study, the pH in most water samples was observed to be under the minimum permissible limit of 6.5.

#### **4.25 Turbidity**

Turbidity is defined or measured as the degree of cloudiness or muddiness of the water sample. It is a measurement of optical property that causes light to be scattered and absorbed by the water samples (Likambo, 2014). Turbidity cannot be correlated with the concentration of suspended particles present in the water sample. The turbidity of the water samples ranged from 0.06 NTU to 397 NTU. Some of the values of turbidity of the water samples analyzed were exceeding as per the guidelines of WHO of not more than 5 NTU (Organization(who) & Health, 2011). Turbidity occurred due to the presence of soil, organic and inorganic matter, plankton and other microscopic organisms.

#### **4.26 Relationship between EC and TDS of the water samples**

Electrical conductivity gives an indication of the amount of total dissolved solids in the water samples. This is because EC and TDS are generally positively correlated(Okeola et al., 2010). High EC value indicate higher concentrations of dissolved ions and salts in the water sample which contribute to high TDS levels. This is evidenced by the values of EC and TDS recorded where the water sample which had the lower EC value (B7; 88.37  $\mu\text{S}$ ) resulted to a lower TDS value of 46.48 ppm whereas the water sample with a higher EC value (B8; 558.6  $\mu\text{S}$ ) resulted to a higher TDS value of 293.6 ppm. However, the relationship between EC and TDS is not linear depending on the specific ionic composition of the samples (Okeola et al., 2010).

## **CHAPTER FIVE CONCLUSION AND RECOMMENDATIONS**

### **5.1 Conclusion**

The prime objective of this research was to assess the level of some physicochemical parameters of water sample from Mella sub-county. The results showed that the EC of only two water samples (B7 and B8) were above the WHO permissible limit of 400 $\mu$ S. The temperature results were above the WHO criteria of 15 °C. The TDS results for all the water samples were within the permissible limit of the World Health Organization of 500 ppm. The results of the pH showed that most water samples had their pH below the minimum permissible value of 6.5 except one water sample (W4) with 6.68 but still within the range of 6.5 TO 8.5 as per WHO guidelines of drinking water. The turbidity results showed that some water samples had turbidity permissible limit as by the guidelines of WHO whereas other water samples had their turbidity values beyond that recommended by WHO.

### **5.2 Recommendations**

Assessing the physicochemical parameters of water of an area such as electrical conductivity, temperature, total dissolved solids, pH, turbidity and milliVolts is crucial for ensuring its quality and sustainability. Since only EC, temperature, TDS, pH and turbidity were mostly discussed about, therefore;

I do recommend other researchers to proceed with analyzing the causes and effects of low and high levels of milliVolts in the different water samples, the relationship between milliVolts and other physicochemical parameters of an area.

I also do recommend the government of Uganda to establish regular monitoring program to track changes in key physicochemical parameters of water of an area.

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