ASSESSING THE QUALITY OF DOMESTICWATER CONSUMED BY THE NAGONGERA TOWN COUNCIL COMMUNITY, TORORO DISTRICT-UGANDA

BY

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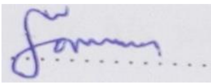
DECLARATION

I, Engwenyu Michael, declare that the information here is my original work to the best of my knowledge and references cited for information from other peoples' work used. The work has not been submitted to any other institution for any award or publication.



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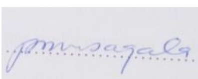

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ABBREVIATIONS

EC - Electrical Conductivity

TDS-Total Dissolved solutes

EDTA - Ethylenediaminetetraacetic acid

EPA - Environmental Protection Agency (USA)

FISE - Fluoride Ion Selective Electrode

IPCS-International Program on Chemical Safety

PPM-parts per million

UNBS-Uganda national bureau of standards

WHO-World Health Organization

EPA-Environmental Protection Agency USA

ABSTRACT

The aim of this study was to monitor the quality of domestic water within Nagongera town council with the specific objectives of determining electrolytic conductivity and its pH, total dissolved solids, water hardness and fluoride ion concentration so as to determine its quality.

Six samples from borehole and four from tap were collected for laboratory analysis. Water samples were collected from the boreholes of Mahanga ss, Nagongera Mosque, pastor Ofumbi, Dubai hostel, Pastor Odongo and campus.The taps included Dasafe hospital tap (A),Fawe hostel(D),down town (C) and Agum hostel (B).

The results from the laboratory analysis showed average pH is slightly acidic and indicates corrosion problems, especially in areas of Dubai hostel borehole. Electrical conductivity and total dissolved solids values are very low; these give a measure of the ionic load and contaminants in the water. Hence, from the EC and TDS values, the water in Nagongera Town Council has low salt concentration.

The water hardness relatively low but greatly high in Down Town Tap (C). Fluoride ion concentration relatively fair but high in campus borehole, Nagongera mosque and pastor Ofumbi hostel borehole. Fluoride ion concentration is very high in Tap (C) thus indicating that water in Tap (C) is not safe for drinking.

The results showed that, the water in Nagongera Town Council can be regarded as being of good quality for drinking and agriculture purposes however, tap (C) and campus borehole should be critically analyzed.

This study recommends further studies with reference to the chemical and microbial analysis to be done especially in Down town tap (C) and campus borehole to have a broader picture of this water quality.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Life on earth was established and has been sustained due to one very essential resource, water. Almost 71% of the earth's total surface is covered with water (Jamdade AB, 2017).Water plays a considerable role in every aspect of our lives-from being the integral part of our bodies to having colossal importance in many operations(Egbuikwem PN, 2017). Water is the most important natural and vital source for the survival of life on the earth (Hasan K, 2019).

The assessment of the quality of domestic water consumed by a community is a crucial aspect of public health and environmental management (Kristianto H, 2017). It involves evaluating various parameters and contaminants present in the water supply to ensure that it meets the required standards for safe consumption. The most common source of drinking water for the rural people is groundwater (Partil RR, 2017).

Groundwater gets polluted as a result of human activities including extensive use of pesticides, herbicides, fertilizers, leaking fuel, chemical tanks, industrial chemical spills, drainage of house hold chemicals and badly managed landfills (Pooja K, 2017),(Frenckens, 1992) This study aims to provide a comprehensive understanding of the background and importance of assessing the quality of domestic water in Nagongera Town Council.

Access to clean and safe drinking water is essential for maintaining human health and well-being (Renuka J, 2017). Contaminated water can lead to various waterborne diseases, such as diarrhea, cholera, typhoid, and hepatitis A. Around 2 billion people worldwide do not have access to water.

1.2 Statement of problem

The quality of domestic water consumed by the community is a critical concern for public health and well-being. Access to clean and safe drinking water is essential for maintaining good health and preventing waterborne diseases. However, in Nagongera Town Council community, the quality of domestic water sources has been compromised(Omollo, 2021) due to various factors such as contamination from pollutants, inadequate treatment processes (otenge, 2023). Therefore, there is need to conduct analysis of fluoride ions and various physicochemical parameters of water to assess the quality of domestic water to identify potential risks and implement appropriate measures to ensure the safety of the community.

Objectives of the study

1.3 General objective

To ensure that the water meets the necessary standards for human consumption and is free from any contaminants or pollutants that may pose a risk to public health.

Specific objectives

(i) To determine the electrolytic conductivity, TDS, of water using conductivity meter

(ii) To determine the total hardness of domestic water in Nagongera Town Council

(iii) To determine the concentration of fluoride ions in water samples collected from Nagongera town council.

1.5 Justification of the study

The research carried out in order to provide relevant information about the quality of domestic waters around Nagongera Town Council. Contaminated water can lead to various waterborne diseases such as diarrhea, cholera, typhoid, and hepatitis. By assessing the quality of domestic water, potential health risks can be identified and appropriate measures can be taken to mitigate them by the authorities such as the government of the Town Council and community. Thus, achieving SDG 6, which aims to ensure availability and sustainable management of water and sanitation for all according to United Nations' Sustainable Development Goals (SDGs).

1.5 Literature Review

1.5.1 Groundwater as a source of drinking water

Ground water is the water contained beneath the surface in the rocks and soils, and is the water that accumulates underground in the aquifers. Groundwater constitutes 97% of the global fresh water and is an important source of drinking water in many regions of the world. In many parts of the world, groundwater sources are the single most important supply for the production of drinking water, particularly in areas with limited or polluted surface water sources. For many communities it may be the only economically viable option. This is important because ground water is typically of more stable quality and better microbial quality than the surface waters. Groundwater often requires little or no treatment to be suitable for drinking whereas surface water generally needs treatment often extensively. There are many examples of groundwater distributed without treatment. It is vital therefore that the quality of groundwater protected if the public health is not to be compromised (Okeke, 2003). The main cause behind water crisis in the World is, water pollution. Global water quality is threatened by industries, agricultural activities, cities, mining areas and other causes. This pollution is then transferred to surface and groundwater (Frenckens, 1992). In recent years, there has been big increase in the demand for freshwater due to rapid growth of population and fast industrialization (Okeke, 2003). Living organism, ecosystem and human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions (Ramakrishnaiah, 2009). Anthropogenic activities have led to water quality deterioration in many parts of the World (Sharma S, 2017). Water pollution is one of the most important issues for government and scientists. Therefore, protecting water sources and water quality is extremely urgent because of serious water pollution and global scarcity of water resources. To prevent these negative effects, it is primarily necessary to educate people about environment and negative effects of water pollution. In addition, the sensitivity and importance of the subject can be emphasized with such studies.

1.5.2 Natural inorganic constituents in Drinking water

Fluorides and Arsenic are recognized as the most serious inorganic contaminants in drinking water on a worldwide basis, Dental fluorosis characterized by discolored, blackened, molted or chalky white teeth, it is a clear indication of exposure to fluoride during childhood when the teeth were developing. These effects are not apparent if the teeth are grown prior to the fluoride overexposure, therefore, the fact that the adult may show no signs of dental fluorosis does not necessarily mean that his or her fluoride intake is within the safety limit. When tea is heavily consumed from a very young age when put in nursing bottles causes dental fluorosis. Chronic intake of excessive fluoride can lead to severe and permanent bone and joint deformation termed as skeletal fluorosis. Early symptoms include sporadic pain and stiffness of joints, headache. Stomachache and muscle weakness can also be warning signs.

The next stage is osteosclerosis (hardening and calcifying of the bones), and finally the spines major joints, muscles and nervous system are damaged. Research of several investigators during the last 5-6 years has proven that life-long Impart and accumulation of fluorides causes not only human skeletal and teeth damage, but also change in the DNA-structure, paralysis of volition, cancer etc. According to World Health Organization (WHO), the general standard for the concentration of fluoride in drinking water ranges from 0.5-1.5 mg/L, also in the temperate regions it is 1.5 mg/L and some areas have their permissible limit varying.

In South Africa, the permissible limit is 0.75 mg/L, India, the permissible limit is 1 mg/L, and in some parts such as Nakuru of Kenya, the permissible limit is 3 mg/L. In Uganda the permissible limit is 0.6 mg/L.

The occurrence of fluorides in water is considered to result from water rock interaction through weathering of fluoride rich rocks and circulation processes of water in soils and rocks. As a result, fluorides leached out and dissolves in the groundwater and thermal gases. Some of the important rock bearing fluoride materials include volcanic, gneissic and granitic rocks. Fluoride tends to occur in areas where fluoride bearing minerals such as fluorspar (CaF_2), cryolite (Na_3AlF_6),apatite $(Ca_5(PO4)_3F)$ and hornblende $[(Ca,Na)_2(Mg,F,Al)_5(Si,Al)_8O_{22}(OH)_2]$ are most abundant.

1.5.3 Physical-chemical properties

1.5.3.1 pH measurement

pH meter measures the level of acidity of water of the sample. The pH indicated by the concentration of hydrogen ions present according to UNESCO 2009. It is expressed on the scale of 0-14 where 7 Is neutral, below 7 is acidic and above 7 is basic. Practically, every phase of water treatment such as softening, precipitation, coagulation, disinfection and corrosion are pH dependent (Dwarapureddi, 2016). Natural water has pH values in the range 4-9 and most are slightly basic due to the presence of bicarbonates and carbonates of alkali and alkali earth metals.

According to WHO (2008) guideline, the accepted pH is the range 6.5-8.5, outside that range, it is not accepted

1.5.3.2 Electrolytic conductivity

This is a quantitative measure of ability of water to conduct electric current and defined as a numerical expression of the ability of an aqueous solution to carry an electric current. Electrical conductivity influence by the presence of dissolved salts such as sodium chloride and potassium chloride, which produce ions, that migrate in solution and then generate electric current (L.A., 1954). Electrical conductivity is also a measure of the total dissolved solid (TDS) or salinity. The standard limit is set by WHO (2008).

1.5.3.3 Total Dissolved Solids

These are due to soluble materials, which refer to portion of total solids that pass through the filter and is expressed in mg/L. High water with dissolved solid is generally of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer The flora and fauna of the rivers experience change and reduction in number due to death by suffocation e.g. High concentration of dissolved solid in water is also responsible for hardness, turbidity, odors, taste, color and alkalinity (Wang. X., 2010). According to WHO 1996,the maximum possible concentration of TDS is 1500mg/L in potable water.

1.5.3.4 Total Hardness

Hardness of water is a phenomenon, which occurs when soap does not lather easily with water; scales are produced in pipes and boilers/kettles. Hardness is caused by metallic salts (ions) of calcium and magnesium and sometimes Fe. These salts are usually in the form of bicarbonates, sulphates and chlorides. Water hardness could be temporary or permanent. Dissolved calcium and magnesium bicarbonates cause temporal hardness and can be removed by boiling. Hardness is determined by EDTA titration (Dwarapureddi KB, 2016).Sulphates cause permanent hardness and chlorides of calcium and magnesium and cannot be removed by boiling but by addition of sodium carbonate or exchange methods. Water hardness usually expressed as mg/L $CaCO_3$.

CHAPTER TWO

EXPERIMENTAL

2.1 Apparatus

Weighing was done using Analytical balance (OHAUS) Mode (AX 523) power input 12V=0.844 NEO TECH-SA. Stirring was done using glass stirring rod 330 mm-Philippine, Volume measurements were done using polyethylene volumetric flask (GRIEF CHEM 1000 mL in 20 °C (MC) and 50 mL, 25 mL pipette (one- mark volumetric pipette), 250 mL conical flask (PYREX ® ENGLAND), 100 mL polyethylene beaker (plastic round beaker), water sampling bottles of 500 mL,50 mL EX Burette (DESCO), Measuring cylinder 250 ml (BOROSIL glass 27 °C). Fluoride ions were measured using fluoride ion selective electrode

Electrical conductivity was measured using conductivity meter (HI 2210, Hanna instrument) Lodge (Kingwoods, Bristol) BSI51LD

pH measurement was done using pH meter (Hanna instrument HI 2210).

Boiling was done by the water bath (Memmert NEO-TCH S.A) made in Germany, heating will be done by the laboratory oven (memmert).

Drying was done using desiccator (Vakuumfest DN200 with knob lid)

2.2Materials

Reagent grade chemicals were used in all tests. Distilled water, glacial acetic acid, grade sodium chloride, CDTA or 1,2-cyclohexanedinitrilo-tetraacetic acid, sodium hydroxide, sodium fluoride, Eriochrome black T, ethylenediaminetetraacetic acid (EDTA)

2.2.1 Preparation of Reagent and Buffer solution

a) Preparation of TISAB I

TISABI solution was prepared by adding (500 mL) of distilled waterfollowed by (57 mL) of glacial acetic acid and (58.0 g) of reagent grade sodium chloride, (4.0 g) of 1,2-cyclohexanedinitrilo-tetraacetic acid were dissolved by stirring and the beaker placed in the water bath for cooling set at (25 ºC) for 30 minutes. The calibrated pH electrode was immersed into the solution slowly and about (150 ml) of (5 M) sodium hydroxide solution was added until the pH was between (5-5.5). The solution was transferred to 1000 mL volumetric flask and distilled to the mark with distilled water.

b) Preparation of standard 5 M sodium hydroxide solution

Sodium hydroxide solution (5 M) was prepared by dissolvingsolid sodium hydroxide (200 g) in distilled water make 1000 mL of a solution. The solution was stored in a tightly sealed plastic bottle.

2.2.2 Preparation of Calibration standards

a) **Fluoride calibrationstock solution of 1000 mg/L**

The Fluoride calibration stock solution of 1000 mg/L was prepared by accurately weighing sodium fluoride (0.2210 g),placed in petri-dish and dried in the oven at (110 ºC) for 2 hours,stored in the desiccator for 30 minutes, dissolved in the plastic volumetric flask with distilled water to make 1L. (10 mL) of stock solution was diluted to (1000 mL) with water in a polyethylene volumetric flask and this yielded (100 mg/L) of the sodium fluoride solution. A series of four calibration standards werepreparedby pipetting (0.5,1.5,2.5 and 5.0 mL) from (100 mg/L) stock to make (1.0,3.0,5.0 and 10 mg/L) respectively. The solutions were used to calibrate the electrode starting with a low concentration to the highest. The fluoride ion selective electrode was filled with potassium chloride and rinsed thoroughly with distilled water and gently shaken off excess water.

2.2.3 pH procedure

A sampleMahanga ss borehole (100 mL) was measured and placed in a beaker. The pH meter was rinsed with distilled water and placed in the sample; The pH meter reading was read out and recorded. The procedure was repeated for other samples

2.2.4 Electrolytic conductivity

A sample Mahanga ss borehole (100 cm^3)was added in a beaker. The electrode of the conductivity meter was rinsed in distilled water and placed in a sample to read the electrical conductivityand recorded. The procedure was repeated for other samplesof Nagongera Mosque, pastor Ofumbi, Dubai hostel, Pastor Odongo and campus boreholes. Dasafe hospital tap (A), Fawe hostel(D), down town (C) and Agum hostel (B).

2.2.5 Total dissolved solids procedure

A sample of Mahanga ss borehole (100 cm^3) was added in a beaker, the conductivity meter was rinsed with distilled water and placed in a water sample to read TDS and recorded. The procedure was repeated for other samples of Nagongera Mosque, pastor Ofumbi, Dubai hostel, Pastor Odongo and campus boreholes. Dasafe hospital tap (A), Fawe hostel(D), down town (C) and Agum hostel (B).

2.2.6 Test for Total harness

A buffer solution (2 mL) was added to each sample of Mahanga ss, Nagongera Mosque, pastor Ofumbi, Dubai hostel, Pastor Odongo and campus boreholes. Dasafe hospital tap (A), Fawe hostel(D), down town (C) and Agum hostel (B).Small amount of Eriochrome black T were added to each sample, The color changes were noted. Ethylenediaminetetraacetic acid (EDTA) was titrated until a blue color was observed.

The values obtained above were recorded and used for calculating the total hardness as shown below

Total hardness $= (Volume\ of\ EDTA\ used \times 1000)/(volume\ of\ water\ sample\ measured).$

CHAPTER THREE

RESULTS AND DISCUSSION

3.1 RESULTS

Table 1: Borehole water samples

S/N	BOREHOLE LIST	pH	EC(μ/m)	TDS (PPM)	WATER HARDNESS (mg/L)	FLOURIDE ION CONCENTRATION (mg/L)
	Mahanga ss	7.4	358.6	180.7	46	1.35
	Mosque	6.97	491.3	246.2	58	1.6
	Pastor Ofumbi	6.72	264.5	132.2	22	0.61
	Dubai	6.42	167.5	84.03	12	2.22
	Pastor Odongo	6.92	277.5	138.6	38	1.23
	Campus	7.28	498	246.8	68	3.35

Table 2: Tap water samples

S/N	TAP LIST	pH	EC(μ/m)	TDS (PPM)	WATER HARDINESS (mg/L)	FLOURIDE ION CONCENTRATION (mg/L)
1	TAP A	6.93	423.3	211.4	50	1.45

2	TAP B,	6.89	423.4	211.6	60	1.4
3	TAP C	7.65	853	425.8	152	4.2
4	TAP D	6.89	422.1	211.1	58	2.6

Table 3: Classification of Total Hardness of $CaCO_3$ according to the WHO (1973) guideline limits

Classification	**Concentration of $CaCO_3$ (mg/L)**
Soft water	< 75
Moderately hard	75 – 150
Hard	150 – 300
Very hard	> 300

DISCUSSION

3.2 Variation of pH and electrolytic conductivity

The pH recorded for domestic water was in the range 6.42-7.4 which was generally in the normal range of 6.5-8.5. However, the pH was slightly low in Dubai borehole (refer figure 1a)) and high in tap C (down town) with reference to figure 1b)) which indicated that the domestic water of Nagongera Town Council is acidic and basic in other areas. Acidity of domestic water arises from hydrolysis of polyvalent cations in it. The observed near-neutral pH of the domestic water enhances the dissolution of F^- containing minerals through a mechanism described below (Haldar et al., 2020);

$$CaF_2 + 2HCO_3^- \longrightarrow CaCO_3 + 2F^- + H_2O + CO_2$$

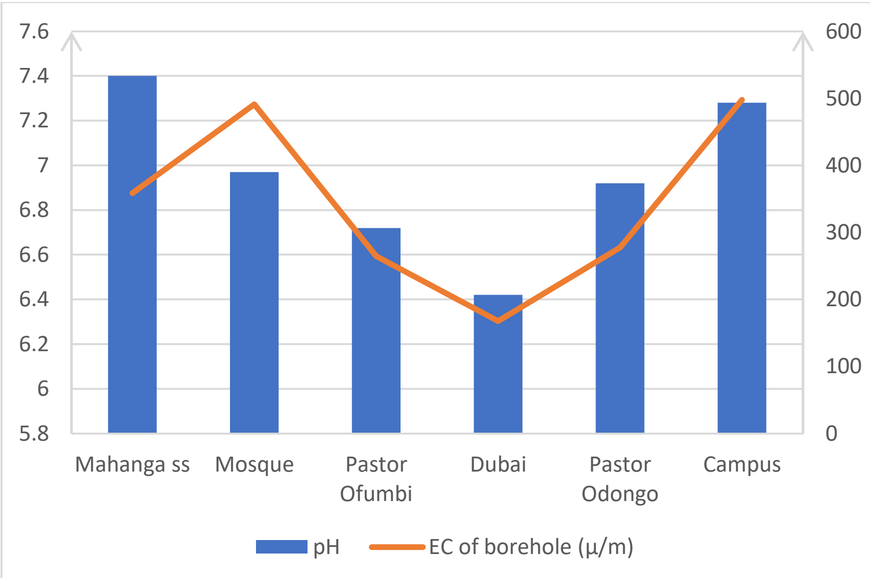

Figure 1 a): variation of pH and electrolytic conductivity for borehole water

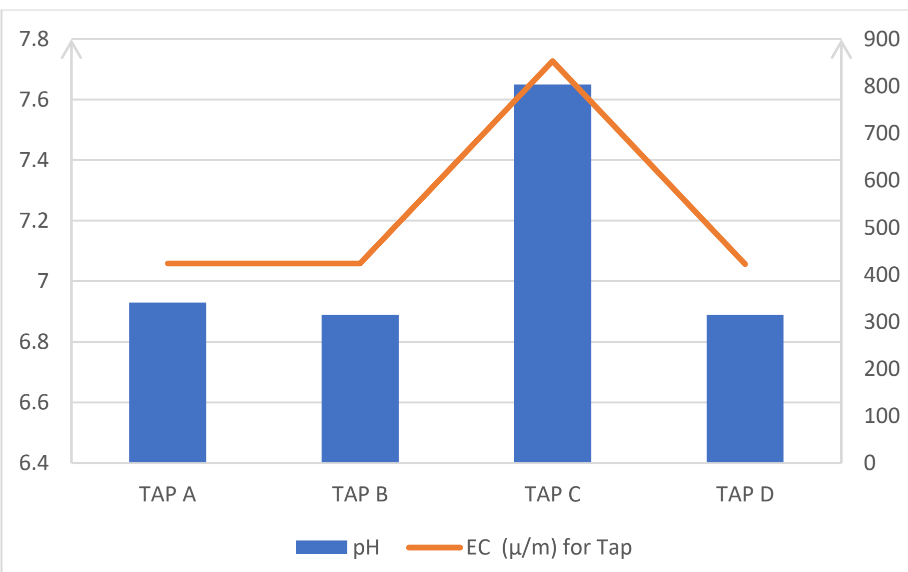

Figure :1b) variation of pH and electrolytic conductivity for Tap water

Increase in pH decreases the Electrolytic conductivity, this is because high pH contains high concentration of hydroxide ions which are weak electrolytes and hence reduced the overall conductivity. This evidenced in figure1a) and 1b). However, water in tap C, has an abnormally greater pHindicating high concentration of dissolved solids

3.2.2 Variation of electrolytic conductivity and total dissolved solids

The electrolytic conductivity recorded for domestic water in Nagongera Town Council was in the range (167.5-498.0)$(\mu s/m)$ and Total dissolved solutes from (132.2-246.8) PPM for borehole water, tap water has Electrolytic conductivity range between (422.1-853)$(\mu s/m)$ and Total Dissolved Solids between the range of (211.1-425.8) PPM but no health guideline value was proposed by WHO in 2006 guidelines. However, the presence of high levels of Total Dissolved Solids in domestic water (greater than 1500 mg/L) may have adverse effects to the consumers. Also, high TDS values enhances the ionic strength and thus increases the solubility of F^- minerals such as fluorite according to WHO, 1996. Low levels of TDS may be unacceptable because of its flat, insipid taste (Egor, 2019). Generally, the TDS and Electrolytic conductivity values of Nagongera Town Council were within the normal range of domestic water (<1000 mg/L).

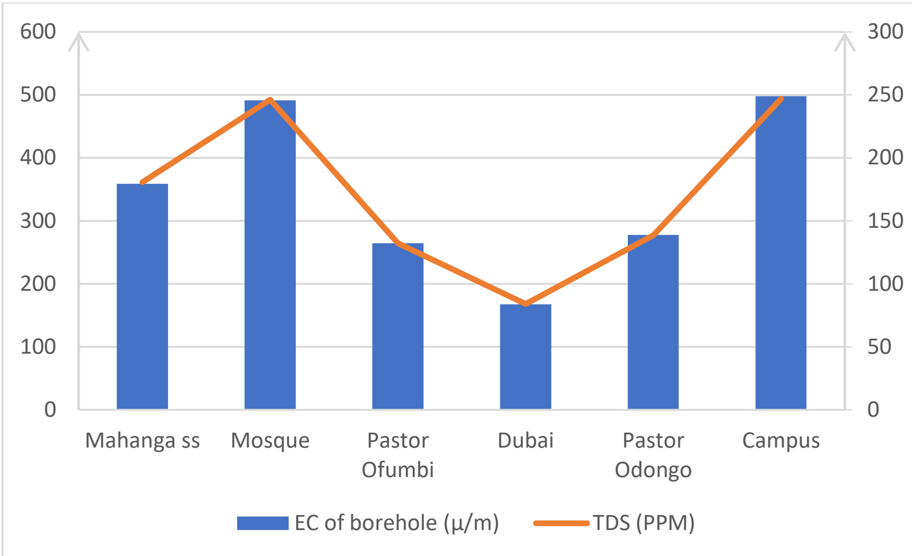

Figure: 2a) **Variation of electrolytic conductivity and total dissolved solids for boreholes**

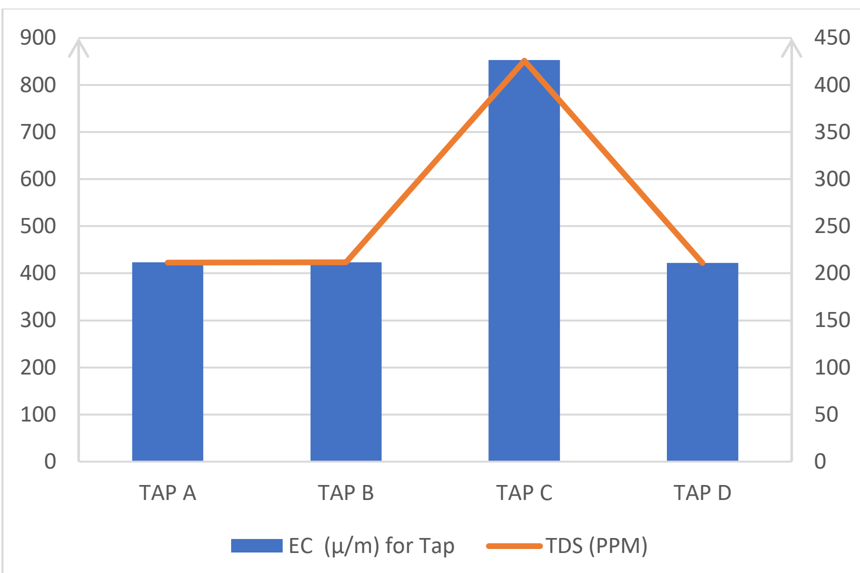

Figure 2b) variation of electrolytic conductivity and Total Dissolved solids for tap

Variation of Electrolytic conductivity and water hardness

Total hardness was found to be in the range (12-68) mg/L for borehole water and (50-152) mg/L for tap; which indicates that it lies within the acceptable limit of <500 mg/L for total hardness as stated by WHO (2006). Tap C, shows the highest concentration of hardness due to high concentration of calcium and magnesium ions. This concentration increase is brought by types of the rocks and soils for example dolomite bedrock which contain a high concentration of magnesium and calcium ions.in addition, evaporation and evapotranspiration which dissolves minerals in the underground water. Refer figure 3b)

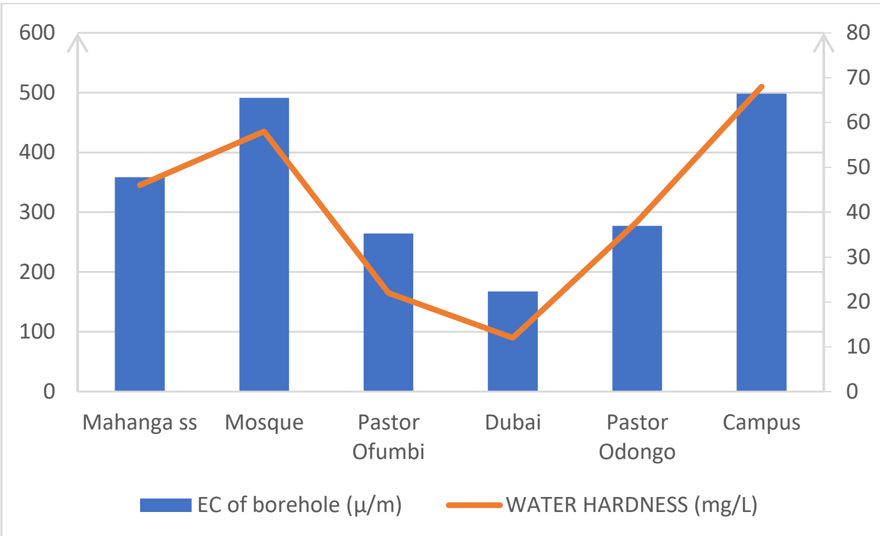

Figure:3a) variation of Electrolytic conductivity and water hardness for boreholes

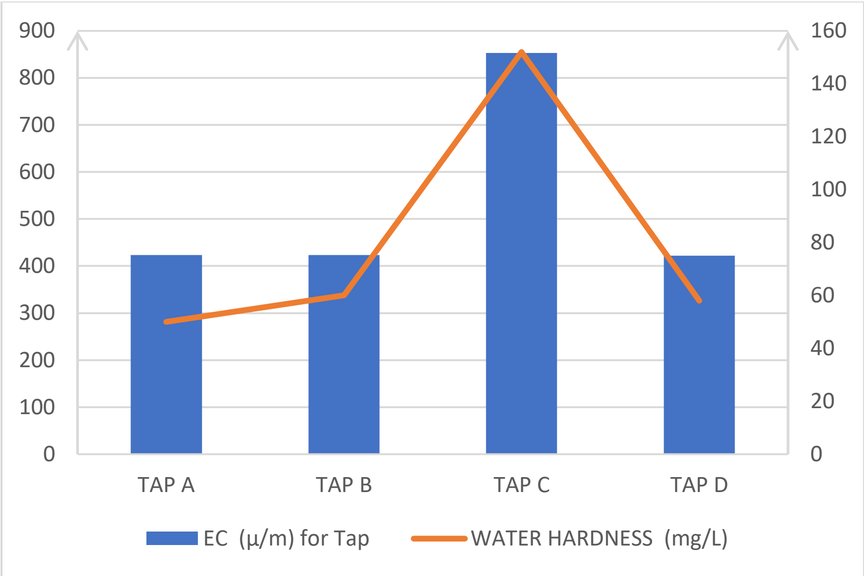

Figure: 3b) **variation of Electrolytic conductivity and water hardness forVariation of fluoride concentration and electrolytic conductivity**

The fluoride ion concentration has a positive correlation with the physiochemical properties like pH, TDS and EC in that the observed near-neutral pH of domestic water enhances dissolution of fluoride ions containingminerals which is attributed to the geology of the area indicating high mineralization, known to contain ores of phosphorus, iron, calcium among others whose dilution increases the mineralization of groundwater.

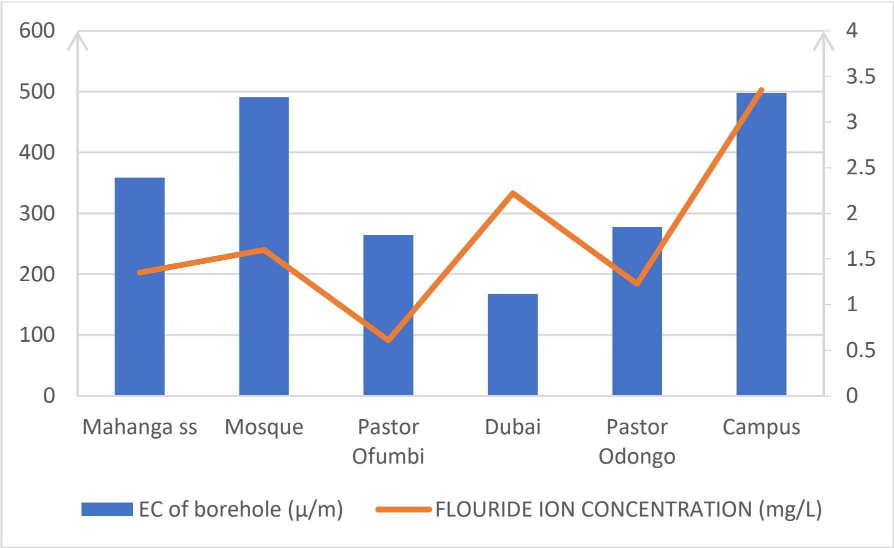

Figure:4a) variation of fluoride concentration and electrolytic conductivity for boreholes

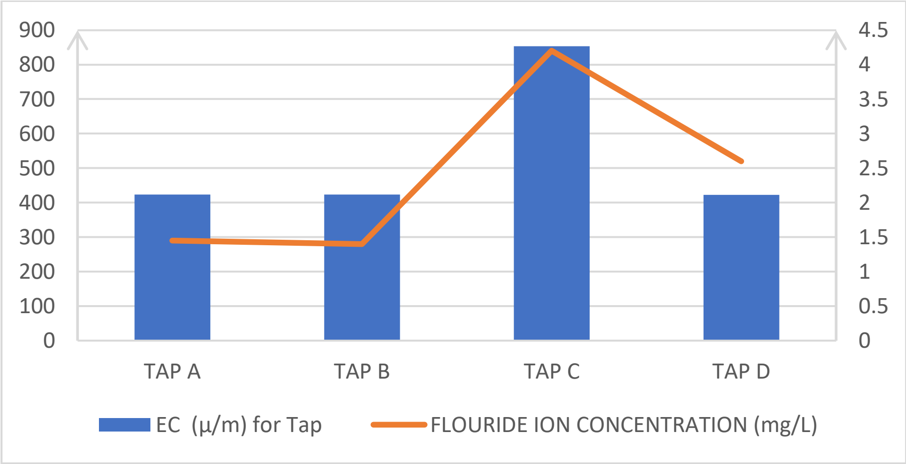

Figure 4b) variation of fluoride concentration and electrolytic conductivity for tap

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATION

4.1 Conclusion

From the results and discussion above, not all domestic water sources in Nagongera Town Council meet the physicochemical parameters (pH, EC, TDS and Total Hardness) and fluoride concentration meet the requirements for domestic usage as prescribed by WHO, UNBS and US-EPA.This is shown by the results of tap C, campus borehole and the mosque borehole with high concentration of fluoride ions.

Also, from the average weather temperature of eastern Uganda of about 31 ^{0}C and the geology of the areas, known to contain ores of phosphorus, iron, calcium, and many others whose dissolution increases mineralization which makes the intake of water high increases in the exposure of fluoride ions and also increases dissolution of fluoride ions containing minerals making drinking water for Eastern Uganda unsafe for drinking. This implies that the local population is exposed to the toxic effects of excess fluoride ions. It is therefore essential for the relevant authorities to sensitize the local people about the dangers associated with consumption of water with excess fluoride ions considering alternative sources of domestic water, and adopt water treatment technologies to remove excess fluoride ions.

4.2 Recommendations

1. From the result obtained water quality monitoring should be a continuous process that should be encouraged around Nagongera Town Council.
2. Proper sanitation should be strictly observed around the vicinity of the boreholes on daily basis.

3. Proper and appropriate treatment should be done according to seasonal variation with respect to the important physio-chemical parameters.
4. Relevant authorities should sensitize people on the dangers associated with consumption of water with excess fluoride ions and consider alternative sources of domestic water, and adopt water treatment technologies to remove excess fluoride ions.

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