Original Research Article

# CONCENTRATION LEVELS OF HEAVY METALS AND OTHER PARAMETERS IN WATER BOREHOLE AROUND MOGADISHU AREA, SOMALIA

## ABSTRACT

The need for clean and safe consumable water is of vital importance to any society since water is an essential substance for the sustenance of life. Mogadishu is one of the rapidly growing cities in the world with a high population, resulting in poor levels of sanitation and an inadequate clean water supply system. A total of 6 water samples were analyzed from the Mogadishu region in seven sites namely, Rer M.Shiekh, Gorgor, Umu batula, Cisse qodax, Soonikia (digfer), and Tarabuuna (umu caisha) respectively to assess the levels of heavy metals. The levels of selected heavy metals analyzed were Cadmium (Cd), Zinc (Zn), and Lead (Pb) and the analysis was done by Atomic Absorption Spectrophotometer and other parameters analyzed were the level of pH, fluoride, chloride, nitrate, water hardness, electrical conductivity, and total dissolved solids (TDS), and the status of water borehole quality in the Southern Mogadishu region, Somalia. Quality water supply is one of the constraints being experienced in Mogadishu city and heavy metals content is of concern. The results were compared with World Health Organization (WHO). pH values ranged from (8.1-8.9) were below WHO standard limits except for Cisse qodax borehole (8.9) which was higher than WHO standard limits. Other value for parameters were fluoride (0.28-0.596 mg/L); chloride (279.57-888.92 mg/L); nitrate (4.27-146.6 mg/L); electrical conductivity (1.428-3.280 mS /cm); hardness (229.32-501.76 mg/L); total dissolved solids (1340-3428 mg/L); cadmium (0.03-0.07 mg/L). Lead and zinc were not detected. Hardness, chloride, electrical conductivity, total dissolved solids (TDS), cadmium values were higher than WHO standard limits. Nitrate values were below WHO standard limits except for Umu batula borehole (60.92 mg/L) and Rer M.shiekh borehole (146.6 mg/L) which are their values higher than WHO standard limits. All boreholes had low fluoride content. However high cadmium concentration is of much concern health-wise. The presence of heavy metals in the water borehole is of concern since they could impact negatively on human health even at low levels due to their accumulation. This study is of significance in providing information on the heavy metals content of the selected water boreholes in Mogadishu, information that is currently lacking considering the management issues in the Country. Further, it could help in mapping out the boreholes based on their water quality.

**Keywords**: Heavy metals, Groundwater, Boreholes, Water quality, Mogadishu, Somalia

## 1. INTRODUCTION

Water is of fundamental importance to human life, animals, and plants, and it is of equal importance to the air we breathe in maintaining the vital processes of life. It makes up about 60% of body weight in the human body. Among the various sources of water, groundwater is the major source of drinking water. Borehole water is known to meet the criteria for quality water and is the most widely used source of water in most African countries, Somalia inclusive [1]. The quality of borehole water is influenced by all the processes and reactions that act on the water from the moment it is condensed in the atmosphere to the time it is discharged by a well or spring which varies from place to place depending on the depth of the water table [2, 3]. The groundwater that becomes the main source of water that is used by people should be assessed for their safety level whether it is free from the contamination of heavy metals, Microbial, or other harmful minerals.[4, 5]. In nature, the hydrochemistry of the water sources was affected by a rich in metal ions and other physical factors that leads the water more polluted. Heavy metals have been known to be one of the persistent pollutants in water. Heavy metals in the aquatic environment and drinking water are of concern because it bioaccumulates. The heavy metals linked most often to human poisoning are lead, cadmium, zinc, and others. According to WHO guidelines the maximum permissible concentration of lead cadmium and zinc in water are 0.01mg/L, 0.003 mg/L, and 0.05 mg/L, respectively [6, 7]. The toxicity level of heavy metals depends on the type of metal, its biological role, and the type of organisms that are exposed to it [8]. The amount of heavy metals dissolved in natural water depends on Physio-chemical parameters of natural waters such as pH, temperature, dissolved oxygen demand (DOD), turbidity, and alkalinity is pertinent because these parameters can modify toxicities of various heavy metals and therefore indicate the water quality of the ecosystem [9, 10].

The presence of these metals in the water can cause damaged or reduced mental and central nervous function. Abnormal blood composition and damaged lungs, kidneys, liver, human carcinogen especially cadmium, and other vital human organs are also known to be among the consequences of heavy metal toxicity [5, 11]. Therefore, quality of drinking water and its heavy metal concentration detection is essential in safeguarding human health. The aim of this study is to assess the concentration levels of some heavy metals (Cadmium, Lead, and Zinc) and other parameters pH, fluoride, chloride, nitrate, water hardness, electrical conductivity, and total dissolved solids (TDS) in the water of the selected area in Mogadishu, the capital city of Somalia.

## 2. MATERIALS AND METHOD

### 2.1 Study Area

The research was conducted within Mogadishu particularly Hodan district, which is located at 02°02’ S latitude and 45°19’E longitude, Hodan district borders Afgoye to the West, Deynile tothe north, Howl-wadag to East, the Wabari to the south and Wadajir to the southwest. In thisstudy six sampling points were selected in Hodan District. The sampling points were Rer M.Sheikh, Gorgor, UmuBatula, Cise Qodax, Soonikia (Digfer) and UmuCaisha (Tarabuun). TheTable below shows the coordinates of the sampling points.

Table 1: Coordinates and Depths of the Sampling Points in Hodan District

| Sampling point | Longitude | Latitude | Depth in meter (m) |
|---|---|---|---|
| Rer M.shiekh | 045:19.142°E | 02:02.208°S | 43M |
| Gorgor | 045:18.750°E | 02:02.478°S | 86M |
| Umu batula | 045:18.691°E | 02:03.036°S | 85M |
| Cisse qodax | 045:18.479°E | 02:02.412°S | 90M |
| Soonikia (digfer) | 045:17.886°E | 02:02.557°S | 90M |
| Tarabuuna (umu caisha) | 045:18.573°E | 02:02.511°S | 93M |

### Chemicals and reagents

Nassler reagent, ;, pipette 10 ml,25 ml, Burette 50 ml, Beaker 200 ml , 800 ml kjeldahl flask, 100ml, 250ml volumetric flask , distilled water, lead nitrate ,zinc sulphate,cadmium sulphate , standard potassium chloride solution with conductivity 12.88mS/cm, calcium carbonate, methyl red indicator , litmus paper indicator, phenolphthalein indicator, ethylenediaminetetraacetic acid (EDTA), disodium salt dehydrate, 1M Hydrochloric acid,1 M Sodium hydroxide, Erichrome black-T indicator ammonia / ammonium chloride buffer, Potassium chromate, Sodium chloride, potassium chloride and filter paper No,1.

### Equipment

A hand-held Global Positioning System (GPS) receiver was used to obtain the coordinates of the sampling sites. Atomic Absorption Spectrophotometer (AAS)-6300 (shimadzu, Japan), UV-Visible spectrophotometer model (UV-1700) (shimadzu, Japan), flame photometer Model 410 (Sherwood), EC/ pH meter model 15, (Fisher Scientific). pH meter model MI 306 (Apps Enterprises ltd, Australia), fluoride ion selective electrode ion, Analytical balance and digital balance.

### 2.2 Sample collection and storage

Samples of water were collected from different boreholes in Hodan District, Mogadishu, Somalia. Hot water was used to sterilize the pre-cleaned polyethylene plastic containers before collection of the samples. At each sampling borehole, 3L and 1L polyethylene plastic containers were rinsed twice with borehole water from the tap which was then allowed to run for two minutes before collecting the samples. Polyethylene plastic containers were carefully filled with the water and labeled. The water samples were then transported to the laboratory. All the reagents and chemicals used of analytical grade were used without further purification [12].

## 2.3 EXPERIMENTAL PROCEDURE

### 2.3.1 Determination of electrical conductivity (EC) and pH

The EC/pH meter was standardized by potassium chloride with conductivity 12.88mS/cm and with a calibration of solution done at room temperature (25 C°). After standardization, the electrical conductivity and pH were measured by dipping the EC/pH meter directly into the water sample before analyzing other parameters [14]..

### 2.3.2 Determination of total dissolved solids (TDS)

A 100 ml of water sample was filtered into a pre-weighted and washed beaker. The filtered sample in the beaker was oven-dried at 105°C for 5 to 6 hours. The beakers were then removed and placed in a desiccator to cool. The weight of beakers and samples were then found and recorded in separate tables. [6, 7]. The concentration of the TDS has been expressed as mg/L. The following formula was used to calculate TDS:

$$\text{TDS, mg/L} = \frac{(A-B)\times 1000}{C}$$

Where:
A= weight of (beaker + residue) in mg
B= weight of empty beaker in mg
C= ml of sample filtered and dried

### 2.3.3 Determination of hardness

A 25 ml of aliquot of the calcium solution was drawn from a pipetted into a clean conical flask and Erichrome black-T indicator (10 drops) and 2ml of the ammonium-ammonium chloride buffer were added. The solution was then titrated with the EDTA until the initial wine-red color changed to sky blue [14].. The titration was repeated four times. The results obtained were used to calculate the concentration of EDTA.

### Determination of Total Hardness of Water Sample

An aliquot of borehole water sample (10ml) was drawn from a pipetted into a clean 250 ml conical flask and Erichrome black-T indicator (10 drops) and 2ml of the ammonia-ammonium chloride buffers was added. The solution was titrated with the standard EDTA until the initial red color changed to blue [14].. The titration was repeated four times. The results obtained in each borehole were recorded in separate tables.

### 2.3.4 Fluoride Using Total Ionic Strength Adjustment Buffer (TISAB II) with CDTA

Approximately 500 ml of distilled water was transferred into a 1-liter beaker 57 ml of glacial acetic acid, 58g of sodium chloride and 4g of CDTA were added. Mixture was stirred then cooled to room temperature. The pH of solution was adjusted to between 5.0 and 5.5 with 5N sodium hydroxide (about 200ml). The solution was then transferred to a 1- liter volumetric flask and diluted to the mark with distilled water [14]. Sodium fluoride, stock solution: 0.2210 g of sodium fluoride was weighed and transferred into a 1- liter volumetric flask and dissolved in distilled water and diluted to a volume of 1000 ml to make 1000 ppm fluoride. From 1000 ppm, dilution was made to give 100ppm using dilution formula $c_1v_1 = c_2v_2$ where C and V are concentration and volume respectively. From 100ppm a series of dilutions were done to give working standards: 0.5ppm,1.00 ppm,2.00 ppm,4.00 ppm,8.00 ppm,10.00 ppm,20.00 ppm,30.00 ppm,40.00 ppm,50.00 ppm,60.00 ppm,70.00 ppm,80.00 ppm and 100.00 ppm fluoride using dilution formula c1v1=c2v2. The instrument was then calibrated. The samples were then analyzed using fluoride electrode.

### 2.3.5 Chloride

16.987g of $AgNO_3$ was weighed and transferred in to a 500 ml volumetric flask and made up to a mark with distilled water. $AgNO_3$ solution was placed in a burette. It was standardized with 10 ml of NaCl solution in a conical flask and 2 ml of chromate solution was added then the solution was titrated until reddish coloration appeared. The titration was repeated four times, and the concentration of $AgNO_3$ was then calculated. For titration of chloride in boreholes water sample an aliquot of borehole water sample (25ml) was drawn into a clean 250ml conical flask and 2ml of $K_2CrO_4$ indicator was added. The solution was titrated with the standard $AgNO_3$ solution until reddish coloration appeared [14].. The titration was repeated four times. The results obtained were then recorded.

### 2.3.6 Nitrate

A calibration curve is prepared by using suitable aliquots of standard nitrate ($KNO_3$) solution. 2ml of standard $KNO_3$ solutions were taken in separate 100ml beakers and dried in an oven at 120°C for 4 to 7 hours to evaporate the entire solution. 2 ml of phenol sulphonic acid was added to the beaker and residue was dissolved. 7 ml of conc. $NH_4OH$, (to develop color) was added and diluted to 100 ml standard volumetric flasks to obtain a concentration of 20ppm. From 20ppm (1.0 ppm,2.0 ppm,3.0 ppm,4.0 ppm,5.0 ppm,6.0 ppm,7.0 ppm,8.0 ppm,9.0 ppm and 10.0 ppm nitrate) were diluted. Contents were mixed well and the solutions from each of the standard flasks are transferred to a cuvette. The absorbance was measured at 410 nm using UV spectrophotometer.

100 mL of water sample were taken in 6 separate beakers and dried in an oven at 120°C for 6 to 8 hours to evaporate the entire water sample. The beakers were then kept in a desiccator and left to cool. The residue retained in the beakers which is 0.1M $AgNO_3$ was treated in a different volume of distilled water with total of 25 m, then it was warmed using a heater then filtration was done. The filtrate dried in an oven at 120°C for 6 to 8 hours. Then beakers were removed again to and placed a desiccator. 2ml of phenol sulphonic acid was added to beaker and 7ml of $NH_4OH$ added. This was then transferred into 25ml volumetric flask then diluted to the mark. Yellowish color was formed. A blank solution was prepared by excluding the water sample. A calibration curve is drawn by plotting absorbance against the concentration of $NO_3^-$. Using the calibration curve, the concentration of $NO_3^-$ in the water samples is determined [14].

## 2.4 Determination of the Concentration of Heavy Metals in Borehole Water Samples

### 2.4.1 Cadmium

2.0142 g of cadmium sulphate ($CdSO_4.H_2O$) was accurately weighed and placed in 1-liter volumetric flask this was dissolved in distilled water and made to a volume of 1000 ml to make 1000 ppm of Cadmium. From 1000 ppm dilution was made to give 100 ppm using dilution formula $c_1v_1=c_2v_2$ where c and v are concentration and volume respectively. Other dilutions were made to give: 0.00 ppm, 0.1ppm,0.2 ppm,0.5 ppm,1.5 ppm and 2.00 ppm of Cadmium.[10, 13, 14]. The working conditions of the atomic absorption spectrophotometer for the analysis of cadmium were as follows: Lamp current (5mA), Wave length (217.00nm), slit width (1.00nm) fuel acetylene), oxidant (air) and detection limit (0.1 ppm) [13].

### 2.4.2 Lead

1.5985 g of lead nitrate was accurately weighed and dissolved in 50ml of distilled water in a volumetric flask. It was then diluted with distilled water to a volume of 1000 ml to make 1000 ppm lead. From 1000 ppm, dilution was made to give other concentrations using dilution formula $c_1v_1=c_2v_2$ where c and v are concentration and volume respectively. From 100 ppm a series of dilutions were done to give working standards: 0.00 ppm, 0.25 ppm, 0.5 ppm, 1.00 ppm, 2.00 ppm and 4.00 ppm of lead [10, 14]. The working conditions of the atomic absorption spectrophotometer for the analysis of lead were as follows: Lamp current (5mA), Wavelength (217.00nm), slit width (1.00nm) fuel acetylene), oxidant (air) and detection limit (0.25ppm) [13].

### 2.4.3 Zinc

4.398 g of Zinc sulphate ($ZnSO_4.7H_2O$) was accurately weighed and placed in a 1-liter volumetric flask was added to dissolve it then made to make 1000 ppm zinc. From 1000 ppm a dilution was made to give 100 ppm using dilution formula $c_1v_1=c_2v_2$ where c and v are concentration and volume respectively. Other dilution made were: 0.00 ppm, 0.1ppm,0.2 ppm, 0.4 ppm, 0.6 ppm and 1.00 ppm Zinc [10, 14]. The working conditions of the atomic absorption spectrophotometer for the analysis of lead were as follows: Lamp current (5mA), wave length (217.00nm), slit width (1.00nm) fuel (acetylene), oxidant (air) and detection limit (0.1ppm) [13].

## 3. RESULT AND DISCUSSION

### 3.1 Hydrogen Ion concentration (pH)

pH indicates the intensity of acidic or basic character at a given temperature. Measurement of pH is one of the most important and most frequently used tests in determining water quality. The pH of the water samples was found in the range 8.1 to 8.9 and it is slightly alkaline (figure.1). The maximum value of pH was recorded at Cise Qodax (8.9) and the minimum pH value was recorded at GorGor (7.40). The maximum permissible limit of pH according to WHO is 6.5 to 8.5. pH of all boreholes was within the WHO (6.5-8.5) except Cise Qodax (8.9).

Figure 1)

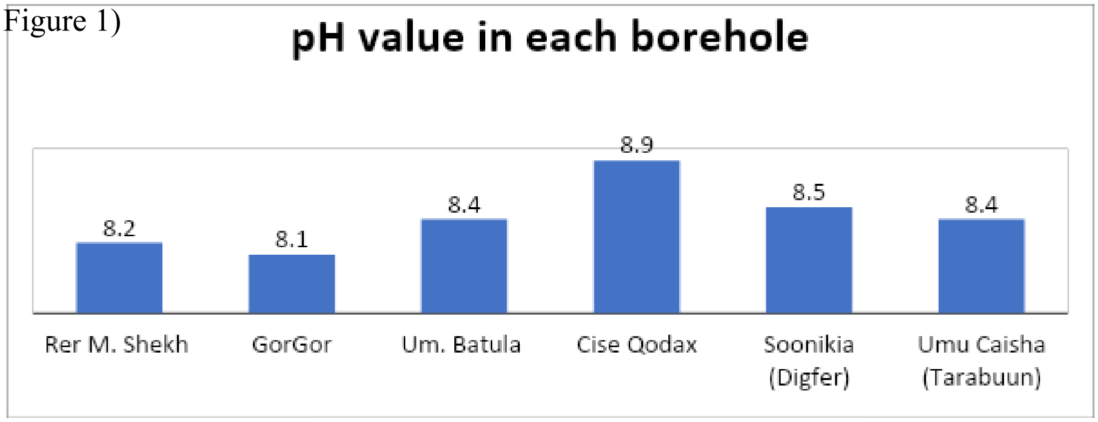

Figure 1 The pH of the water samples at the various sampling Sites

### 3.2 The electrical conductivity

Electrical conductivity is a measure of the ability of an aqueous solution to carry an electric current. It depends on the presence of ions, their total concentration, mobility, and temperature. Higher value of conductivity shows a higher concentration of dissolved ions. Conductivity of water samples were in the range 1.428 to 3.28 mS /cm (figure 2), which is slightly above the WHO standards (0.25 mS /cm). Higher was Rer m. sheikh (3.28 mS /cm) and lowest was at Digfer (1.428 mS /cm). High value of electrical conductivity indicates high level of dissolved salts.

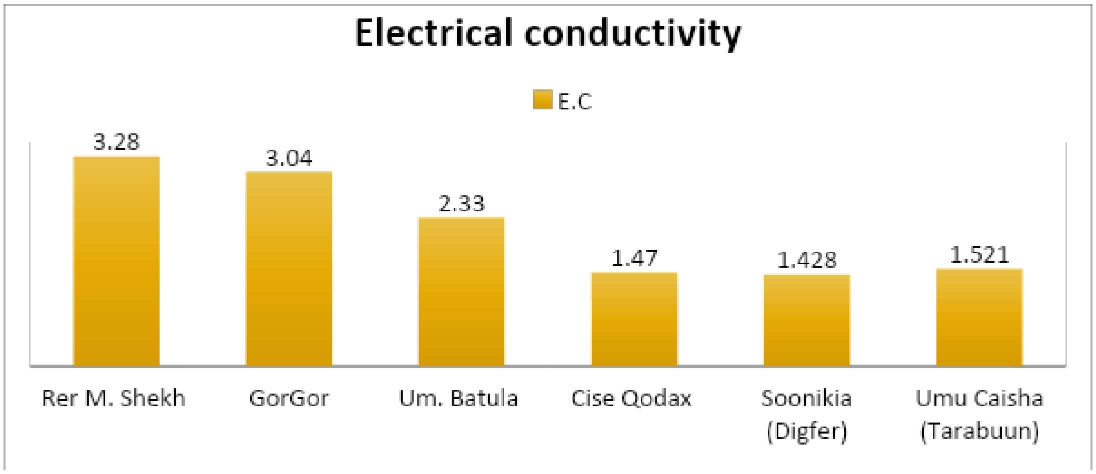

Figure 2 Electrical conductivity values (mS /cm ) at various sites

### 3.3 Total Dissolved Solids (TDS)

The high concentrations of the total dissolved solids could be attributed to the dissolved organic and inorganic compounds associated in the underground water. However, it should also be noted that with increased levels of pollution and poor management practices as observed during the study. Total dissolved solids (TDS) values were above the acceptable WHO limits of 1200mg/L for domestic water with the range of 1340 mg/L to 3428mg/L. The highest concentration of TDS was obtained at GorGor boreholes (3428 mg/L) and lowest at Cise Qodax (1340 mg/L). TDS is not a health hazard although high levels may lead to scale build-up in pipes and aesthetic problems such as salty or bitter taste in water. (Figure 3)

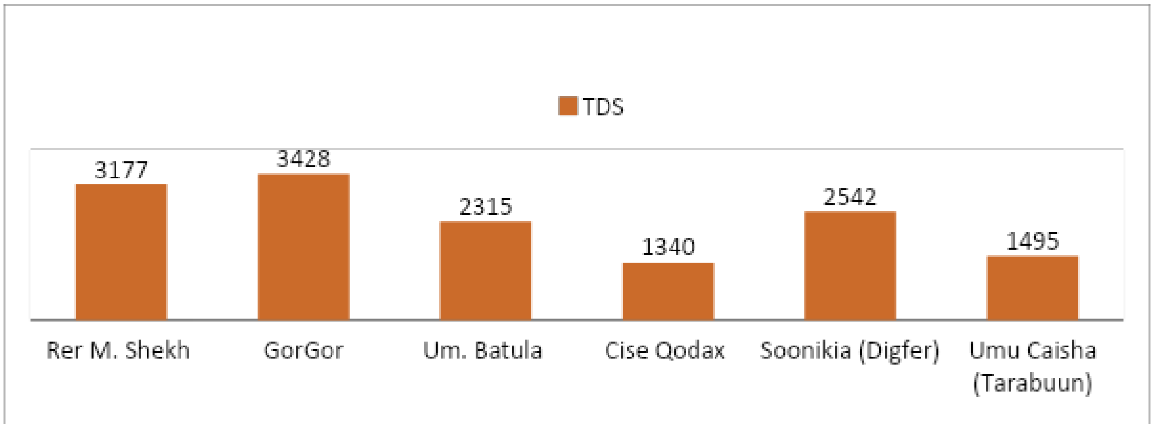

Figure 3 The levels of TDS (mg/L) in water samples at the various sampling sites

### 3.4 Fluoride

Fluoride was determined directly using fluoride ion selective electrode and the result obtained from the instrument was plotted as milliVolt versus concentration. The gradient of the plot is -56 with the y-intercept located at 111.5.

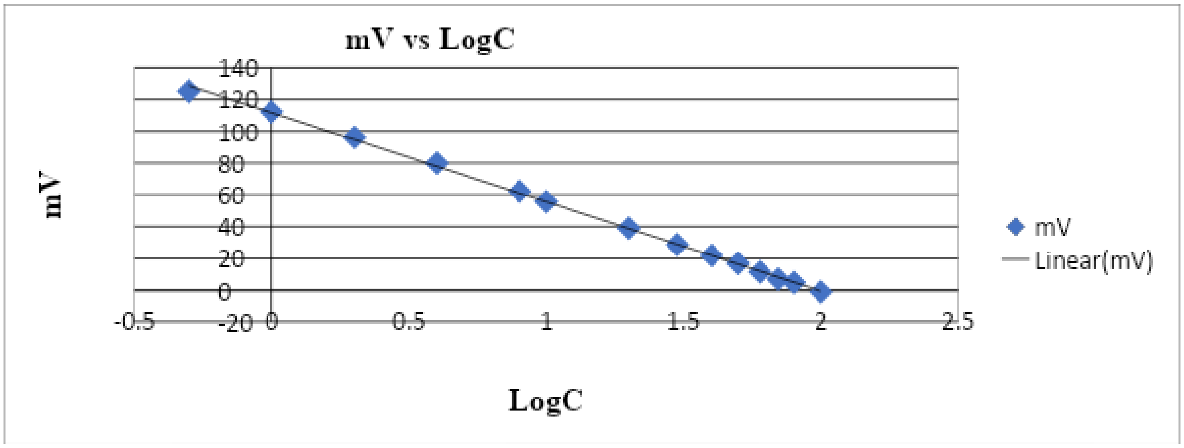

Figure 4: Calibration graph for Fluoride

Table 2 shows sample readings in mV. The corresponding logC was found directly from the graph or from the linear equation, y= -56x + 111.5.

Table 2: mV readings of the samples

| Borehole name | mill volt (mV) (y) | x= LogC $=\frac{y-111.5}{-56}$ | Concentration (C) |
|---|---|---|---|
| Rer M. Sheikh | 124.1 | -0.225 | 0.596 |
| Gorgor | 141.7 | -0.5393 | 0.289 |
| UmuBatula | 140.9 | -0.525 | 0.299 |
| CiseQodax | 132.4 | -0.3732 | 0.42 |
| Soonikia (Digfer) | 137.1 | -0.4571 | 0.349 |
| UmuCaisha(Tarabuun) | 142.1 | -0.5464 | 0.284 |

The value of fluoride was in the range of 0.284 mg/L to 0.596 mg/L. The maximum value was 0.596mg/L and the minimum value was 0.284mg/L of fluoride recorded at Rer M. Sheikh and Umu Caisha (Tarabuun) respectively. The values are within the permissible limit as recommended by WHO (1.5 mg/L). A fluoride concentration of approximately 1.0 mg/L in drinking water effectively reduces dental caries without harmful effects on the health (Murray, 1986). Fluoride may occur naturally in water, or it may be added in controlled amounts. Some fluorosis may occur when the fluoride level exceeds the recommended limit. (Figure 5).

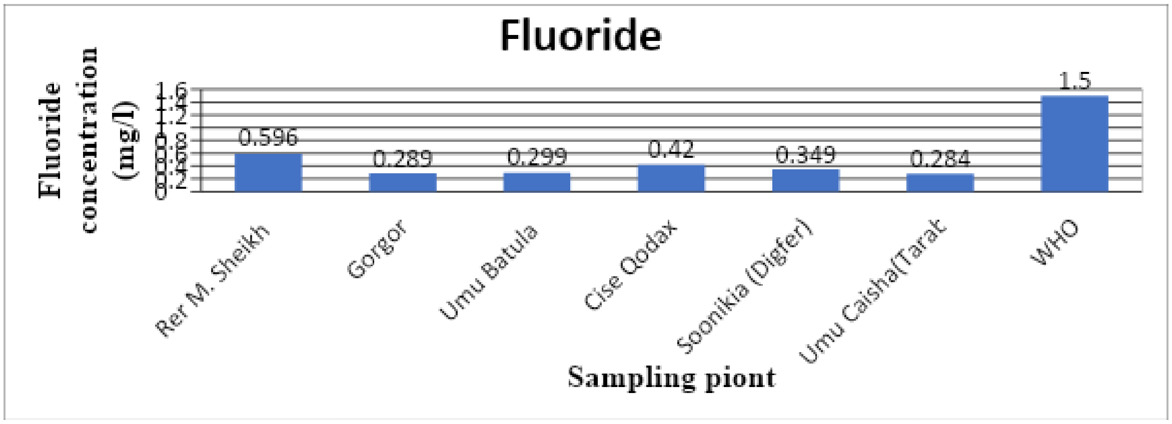

Figure 5: The levels of fluoride ion (mg/L) at the sampling sites

### 3.5 Chloride

The concentration of chloride for all boreholes was high (Figure 6). Chloride values were above the acceptable WHO limits of 250 mg/L for domestic water. The range of chloride in the water samples was 279.57 to 888.92mg/L. The highest concentration of chloride was recorded at GorGor (888.92 mg/L) and the lowest at Cise Qodax (279.57 mg/L). This could be due to the soils that are contaminated by the chloride arising from the geology of the area, anthropogenic activities and pollution by sewerage, intrusion of seawater and other saline water. Anthropogenic sources of chloride include livestock waste, human sewerage. It is widely distributed in nature in form of sodium, phosphate, and calcium salts. There are no health-based guidelines on the values that are recommended for chloride in drinking water; however, chloride concentration in excess of about 250 mg/L can give rise to a detectable taste in water.

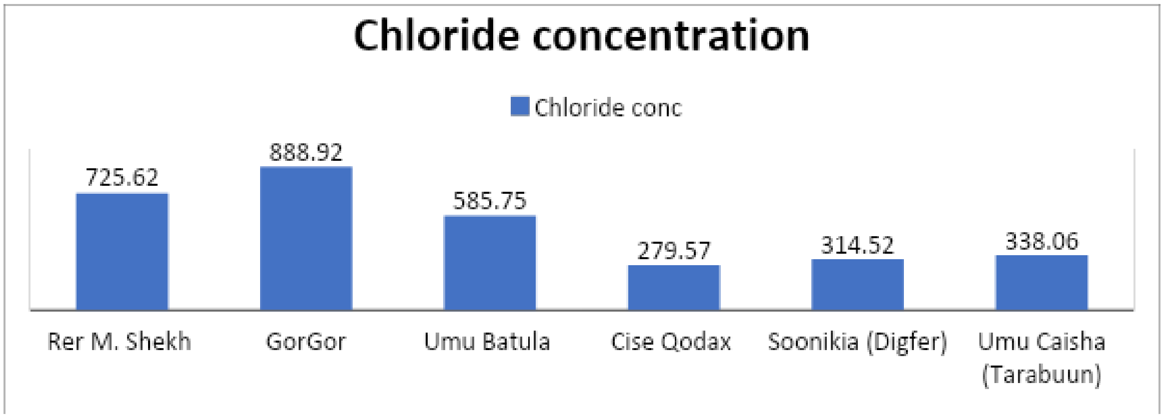

Figure 6 Chloride ion concentration of water samples at the sampling sites

### 3.6 Nitrate

Nitrate was determined using UV-Visible spectrophotometer and the result obtained from it was then used to plot absorbance versus concentration.

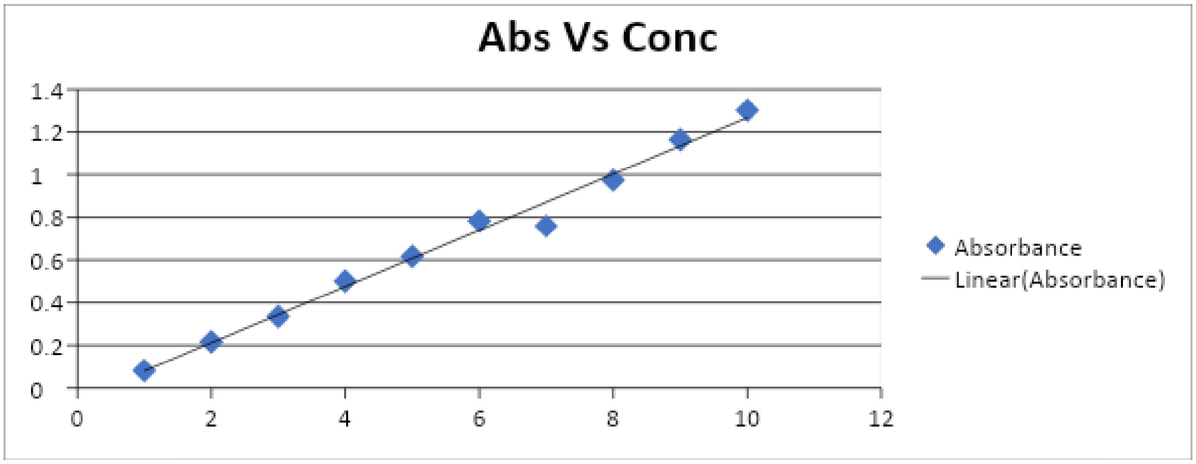

Figure 7 Calibration graph for the nitrate Standards

After calculation was done, we found that all nitrate values were lower than WHO (50mg/L) except Umu Batula (60.92mg/L) and Rer. M. sheikh (146.6mg/L). (Figure 8).

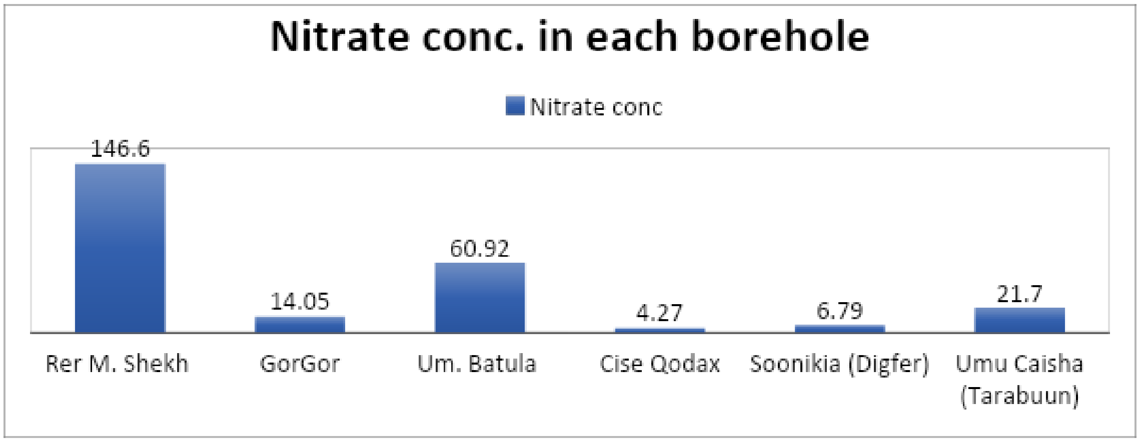

Figure 8 The nitrate ion concentration (mg/L) at the various sampling sites

### 3.7 Heavy Metals level in Water Borehole Samples

The levels of selected heavy metals obtained are presented in table 3 [6, 7]

Table 3: Heavy metals levels in water from six borehole samples

| | Heavy Metals | | |
|---|---|---|---|
| Borehole name | Cadmium (mgl/L) | Lead (mgl/L) | Zinc (mgl/L) |
| Rer M. Sheikh | 0.03 | ND | ND |

| | | | |
|---|---|---|---|
| Gorgor | 0.05 | ND | ND |
| UmuBatula | 0.06 | ND | ND |
| CiseQodax | 0.04 | ND | ND |
| Soonikia (Digfer) | 0.06 | ND | ND |
| UmuCaisha(Tarabuun) | 0.07 | ND | ND |

*ND =Not detected

**Recommended values in drinking water**

| | | | |
|---|---|---|---|
| WHO | 0.003 | 0.01 | 3.0 |

### 3.7.1 Cadmium level in water borholes

Cadmium was used to run atomic absorption spectrophotometer the result obtained from it was then used to plot absorbance versus concentration.

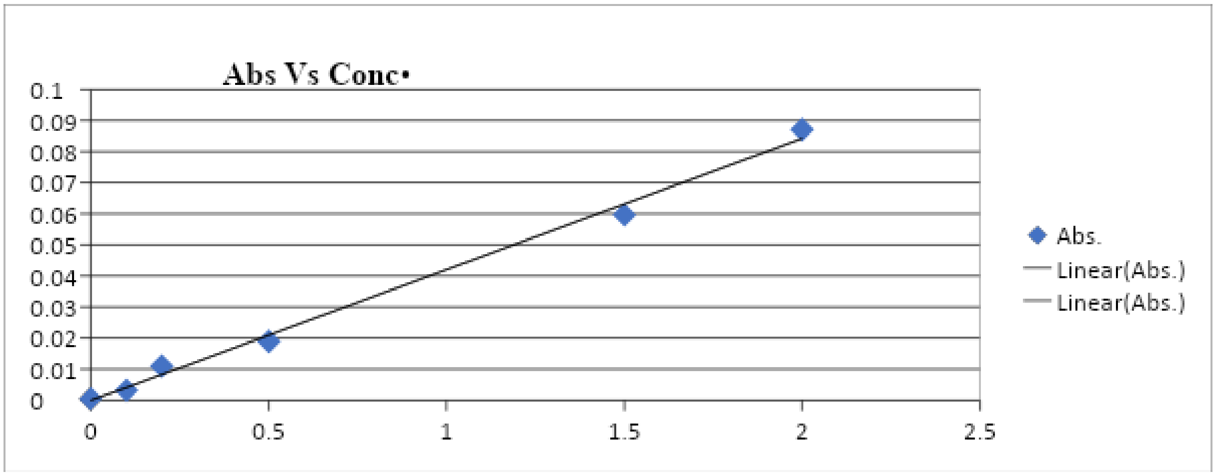

Figure 9 Calibration graph for Cadmium Standards

The concentration of cadmium was observed to be high (Figure 3.10). This could be due to the dissolution of cadmium from its ores in the soil. Its concentrations in all the sampling points were found to be higher than WHO limits of 0.003 mg/L for domestic water [6, 15]. The range was 0.03 to 0.07 mg/L (Table 4).

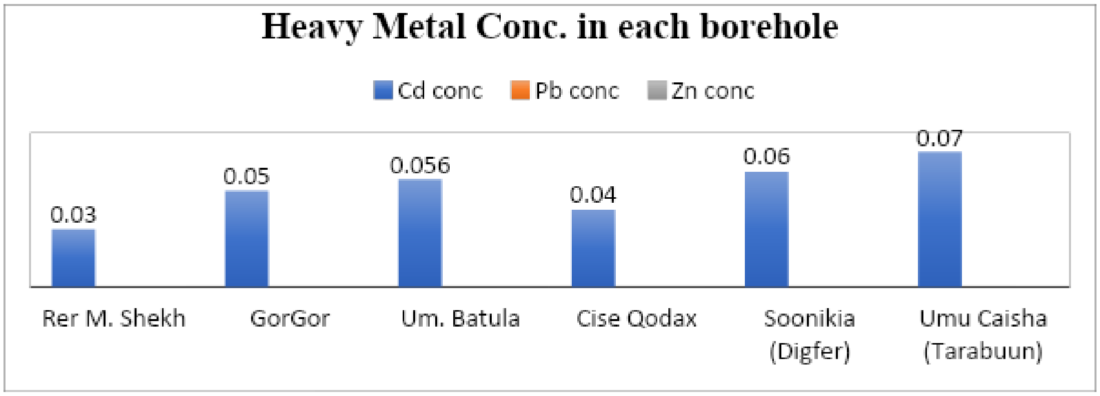

Figure 10: The concentration of heavy metals (mg/L) at the various sampling sites

### 3.7.2 Lead level in water boreholes

The lead (Pb) was not detected in all sampling points. The concentration of lead in some water samples was not detectable indicating that the concentration was less than the detection limit of the instrument which was 0.25 ppm therefore, the Lead levels from all the sampling sites were below the WHO guidelines in drinking water (Table 3). Lead was used to run atomic absorption spectrophotometer the result obtained from it was then used to plot absorbance versus concentration.

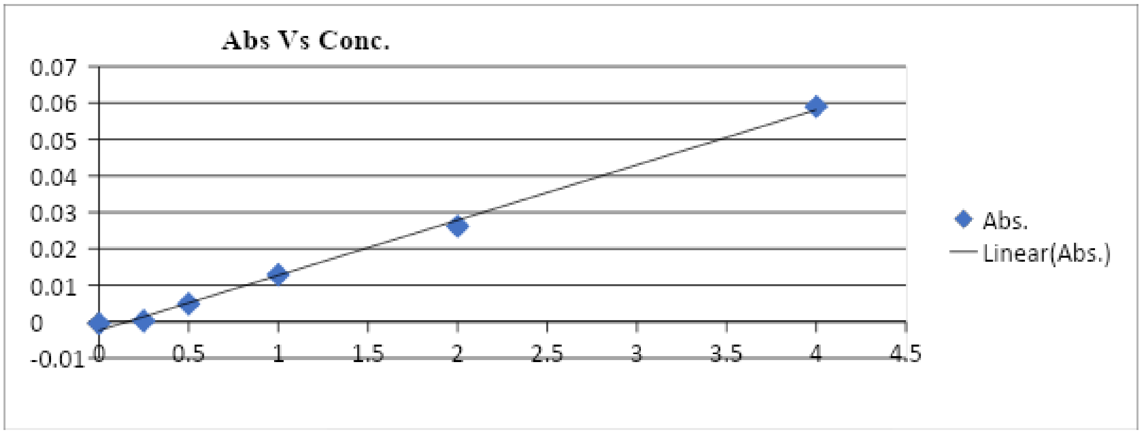

Figure 11 Calibration graph for lead standards

### 3.7.3 Zinc level in water borholes

Zinc was not detected in all the sampling points. The concentration of zinc in water was not detectable indicating that the concentration was below the detection limit of the instrument which was 0.1ppm. This mean that the zinc levels from all the sampling sites were below the WHO guidelines in drinking water (Table 3). Zinc was used to run atomic absorption spectrophotometer the results obtained from it was then used to plot absorbance versus concentration.

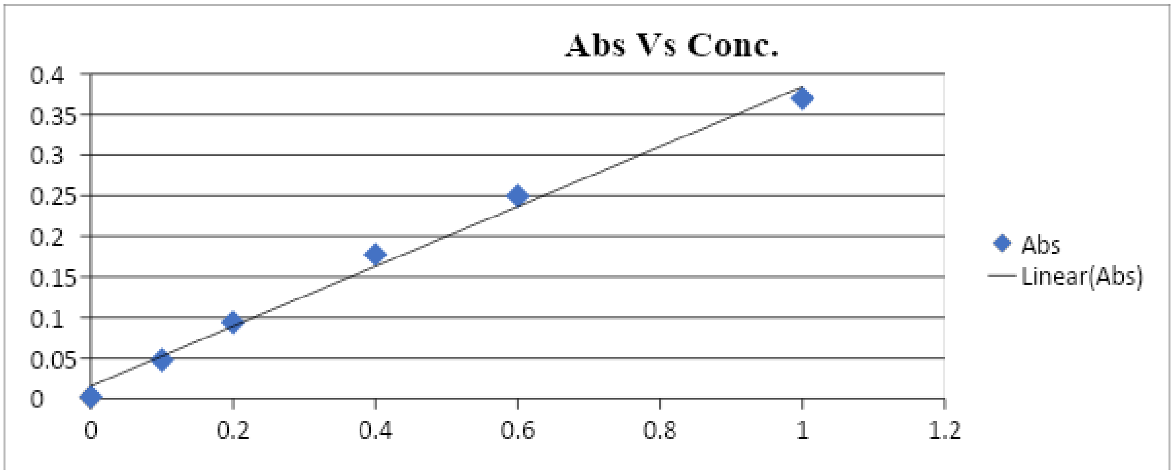

Figure 12 Calibration graph for the Zinc Standards

## 4. CONCLUSION

This study has shown that water borehole in all places of the study area was mostly contaminated by cadmium. Cadmium poisoning is very difficult to treat because it is rapidly and irreversibly absorbed by the kidneys. Immediate medical attention should be sought if cadmium poisoning is suspected. Zinc can be used to mitigate the effects of cadmium. On the contrary, Pb and Zn which have been found to be responsible for quite a number of diseases in humans such as chronic neurological disorders especially in fetuses and children were not detected which means it was found at a level lower than the permitted level by WHO guidelines. The concentration of cadmium was observed to be high. Its concentrations in all the sampling points were found to be higher than WHO limits of 0.003 mg/L for domestic water. This could be due to the dissolution of cadmium from its ores in the soil or due to solid waste and wastewater around the sampling area. Because during the sampling it was observed that there was unhygienic handling of drinking water including poor storage practices. All these enhance that human health is at risk and the effects of cadmium can cause renal failure as well as kidney disease; drinking water with very high cadmium levels severely irritates the stomach, leading to vomiting and diarrhea, and sometimes death. The study also revealed that all the six boreholes contained elevated levels of the water quality parameters such as Electrical conductivity, Hardness, TDS, Chloride, all these were above the WHO permissible limits for drinking water. The main sources of pollution of these boreholes are the human settlement around the boreholes and their activities and the geological characteristics of the area. The pH and nitrate content in the entire six boreholes were below the WHO permissible limits for drinking water except for Cise Qodax for pH (8.9) and Rer. M.Sheikh for nitrate (146.6 mg/l). The fluoride content in all the six boreholes was below the permissible limits according to WHO limits. Therefore, there is an urgent need for basic health care in the area of study.

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