Environmental Technology & Science Journal
Vol. 10 Issue 1 December 2019

Water Quality Assessment of Domestic Water Sources in Nasarawa Town, Nasarawa State

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Water supply to most communities in most parts of the world has suffered serious setbacks as a result of human activities. This has lowered the quality and quantity of water from various sources for a variety of uses including domestic. It is in the regard that this study assessed water quality from different water sources for domestic use during the rainy season in Nasarawa Local Government Area Nasarawa State, Nigeria. A total of fourteen (14) water samples were collected from different water sources, six samples from boreholes, another six from wells and two samples from Kurafe and Haderi Rivers. Samples were preserved by storing in ice-filled cooler boxes and transported to the laboratory. The results showed that some of the samples contain E- coli and the mean concentrations of pH, EC, BOD, TDS, Nitrates and Total hardness fall below WHO standard for drinking water purpose. Though on average basis parameters such as TSS is within the WHO permissible limit for drinking use, parameters such as Fe, E-coli and Total Coliform Count are above the WHO standard for drinking water purpose. The study concluded that, boreholes water is safer for domestic use and water from other sources such as wells and rivers are not portable for domestic use due to microbial contamination. The study therefore, recommends among others that there is the need to treat water especially from the wells and rivers in the study area to avoid any possible damage to human health likely to occur from the use of the water. Pipe borne water should be made available to the inhabitants of the community; there is need for public enlightenment campaign to reduce human activities that are likely to pollute the water sources, communal water treatment plants and filter system could be set up for ground water sources in the study area. Finally, open wells should be lined with cement with level of cover above ground level to avoid surface runoff of pollutant especially during the rains.

Key words: water, water quality, domestic water, pollution, well, rivers, physical, chemical, and biological properties.

Introduction

There is growing deterioration of water quality due to increasing human population and activities that have led to both shortage and poor quality of water consumed globally. Water sources are usually polluted by human activities such as mining, waste dumping, defecation and use of agro chemicals. The implication of water pollution is more evident in developing countries like Nigeria where there is little or no treatment of water before supply. The inadequate water supply especially in the rural areas make the population to depend on any available sources as human cannot live without water (Asante, Ovarcoopome & Amevenku, 2008). Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities (United Nation Environmental Program, 2000).The quality of any body of surface or ground water is a function of either or both natural influences and human activities (Atasoy *et al*., 2006; Kolawole *et al.,* 2008).

Water quality describes the condition of water, in terms of its chemical, physical, and biological characteristics, usually with respect to its suitability for a particular purpose such as drinking. Domestic uses (drinking, cooking, bathing, washing and sanitation) are the fundamental and most important uses of water that must be met sustainably (Mozie, 2010). Domestic water is a basic need that arises from daily human activities that fulfill certain demand related to survival, leisure, comfort, hygiene, convenience, and aesthetics.

Water quality deterioration has continued to place great pressure on global water resources. A very large percentage of the world's population is under water stress and therefore, it is a resource worthy of conservation and protection (Femi, 2007; Singh *et al*, 2007). Thus, several studies have been carried out on water quality globally and in Nigeria including Nasarawa local government and several findings had been made. For examples it has been reported by Mostafaei (2014) that safe drinking water supply and basic sanitation are vital to human health and efficiency. According to the World Health Organization (World Health Organization, 2011), about 30,000 people die every day globally due to unsafe water consumption and insufficient supply. Several studies have linked poor water quality to health challenges and death. In this vein, WHO (2010) affirmed that more than one billion people lack access to safe drinking water and this is the major cause of diseases and death in the world. Egwari *et al*. (2002) and Ogwueleka *et al*. (2015) also noted that about 2.6 billion people in the world lack access to improved sanitation. At any given time about half of the world's hospital beds are occupied by patients suffering from water-related diseases. Every 15 seconds a child dies from water related diseases and children under the age of five in whom they usually manifest as acute gastroenteritis and diarrhoea often require hospitalization. About 1.8 million children die each year of Diarrhoea; that is more deaths now occur through water-related diseases than through war (Chima & Digha, 2010).

Nasarawa Local Government Area was chosen for this study because of the high rate of population growth and human activities which resulted to land use change especially within the Local Government Headquarters (Nasarawa Town). Population growth lead to increase in the volume of waste generation, deforestation, urban land uses, irreversible disturbances of hydrological systems via constructions and consequently, alteration and pollution of surface water and its effects such as water borne disease like typhoid fever, skin rashes, diarrhoea and so on. The human activities that pollute water vary both in time and space.

As a result of the complex nature in water quality in both temporal and spatial dimension, there is therefore the need for effective management of water quality. This study assessed water quality of domestic water sources in Nasarawa Local Government Area Nasarawa State, Nigeria to ascertain the safety of such sources for domestic purposes.

Materials and methods

Materials

Nasarawa Local Government is located in South Western part of Nasarawa State, on Latitude 7^0 50' and 9^0 30'N and Longitude 6^0 50' and 9^0 45'E. It shares boundaries with Keffi and Karu Local Government Areas to the north, Toto on the south west, Doma Local Government Area on the east and Benue State on the south. The area experiences a tropical wet and dry climate characterized by two distinct seasons. The rainy season starts from about the beginning of April and ends in October while the dry season is experienced between November to April. Annual rainfall figures of the area range from 1100mm to about 2000mm and about 90% of the rain falls between May and September.

Methods

A total of fourteen water samples were collected during the rainy season, six samples each from boreholes and wells and one each from Rivers Kurafe and Haderi. The water samples were collected at the peak of rainy season in the month of September. Water samples were collected in 2-liter plastic containers which were adequately washed and rinsed. Samples were preserved by storing in ice-filled cooler boxes and transported to the laboratory. This is to prevent chemical reaction and maintain the original quality till laboratory analysis.

The following water quality parameters were tested.

i. The physical parameters (temperature, turbidity, conductivity and pH) were measured in-situ with hydro lab kit and a pH meter.

ii. The chemical parameters (fluoride, sodium, total suspended solids, total dissolve solids, phosphates, magnesium, calcium, total hardness and nitrates) were determined in a laboratory using hatch kits and a colorimeter. Heavy metals (iron, chromium, copper, cadmium, zinc, manganese and lead) were determined by Atomic Absorption Spectrophotometer (AAS).

The biological parameters (total coli forms and E coli forms) were obtained by culturing on selective media. The results of laboratory test were summarized in tables and graphs. The results from laboratory analysis were discussed and compared with WHO standard for domestic uses.

Results and Discussions

The domestic water sources in Nasarawa Local Government Area were tested for physiochemical and biological properties during rainy season (Table 1). The results were compared with WHO standard for drinking purpose (Table 2).

Table 1: The Properties of Domestic Water Sources in Nasarawa Local Government Area

Parameter	W1	B1	W2	B2	W3	B3	W4	B4	W5	B5	W6	B6	R1	R2
Temp. (Oc)	29	28.7	28.9	28.7	28.6	28.5	26.8	26.86	26.52	26.97	26.83	27.9	26.7	26.78
Ph	6.94	7.1	6.91	7.82	6.26	7.01	6.86	6.52	6.97	6.83	6.71	7.9	6.7	7.09
E.C($\mu s/cm^3$)	1160	180	2380	310	390	210	580	880	370	200	260	510	40	40
Turbidity	0.82	0.18	0.67	0.23	0.61	0.44	0.72	0.33	0.46	0.54	0.63	0.69	0.9	1
TDS	770	110	1590	210	270	140	390	590	250	130	170	340	20	20
TSS	1.5	1.7	1.6	1.6	1.4	1.5	1.5	1.4	1.3	1.4	1.3	1.4	1.3	1.4
K	0.1	0.05	0.11	0.15	0.04	0.08	0.13	0.43	0.1	0.12	0.07	0.2	0.25	0.61
Na	0.11	0.621	0.036	0.067	0.651	0.014	0.003	0.002	0.46	0.341	0.096	0.02	0.04	0.038
Cl-	3.54	1.42	0	0	3.54	0	0	0	1.48	0	0	0	1.42	7.09
Mg	2.03	1.83	36.86	6.21	7.04	40.22	11.05	34.24	5.43	3.86	1.2	8.36	0.96	3.01
Ca	78.03	3.75	42.86	64.25	14.08	2.05	22.11	68.49	10.92	4.11	2.41	15.96	4.2	3.86
NO_3	0.93	0.86	1.67	2.18	1.23	1.69	0.89	1.67	1.25	1.23	2.06	1.78	2.28	1.74
PO_4	0.12	0.09	0.13	0.08	0.14	0.06	0.1	0.07	0.21	0.18	0.16	0.21	0.08	0.11
DO	2.2	4.2	2.2	2.2	4.2	2.2	2.2	2.2	4.2	2.2	2.2	2.2	4.2	4.2
BOD	0	2	0	0	2	0	0	0	0	2	2	2	2	2
COD	35.6	39.5	41.3	45.1	54.3	30.1	43.9	65.4	52.7	38.1	54.7	59.2	70.3	23.5
T. Hardness	202	46	560	114	84	110	160	330	120	74	80	162	28	20
Fe	1.358	1.863	1.362	2.01	2.036	1.793	1.674	1.763	1.467	1.367	1.796	1.862	3.7793	4.367
F	0.005	0	0.001	0.002	0.006	0	0.086	0	0.002	0.003	0	0	0.086	0.003
Zn	0	0.001	0	0	0	0.002	0	0.001	0	0	0	0	0	0
Lead	0.008	0.054	0	0.016	0.072	0	0.09	0.002	0	0.004	0.0076	0.0024	0.086	0.077
Cr	0.048	0.047	0.021	0.014	0.063	0.031	0.015	0.008	0.016	0.088	0.013	0.016	0.045	0.031
Cd	0.029	0.0023	0.0118	0.0171	0.0059	0.0392	0.0202	0.0236	0.0649	0.0115	0.0278	0.0044	0.0096	0.0007
Cu	0	0.001	0.001	0	0.001	0.001	0.004	0.003	0.001	0.002	0.001	0	0.003	0.001
Mn	0.0396	0.1424	0.0982	0.0281	0.0103	0.0525	0.0191	0.0119	0.1055	0.01509	0.431	0.0669	0.0396	0.0462
B	0.067	0.064	0.035	0.038	0.075	0.054	0.028	0.074	0.06	0.057	0.06	0.042	0.049	0.026
M/E Coli	60	43	20	3	80	1	22	100	0	7	19	0	112	28

Table 2: The Properties of Domestic Water Sources in Nasarawa Local Government Area during Rainy Season and WHO Standard

Parameter	Range	Mean	Standard Deviation	WHO Permissible Limit
Temp (Oc)	26.52-29	27.697	0.86	20-33
Ph	6.26-7.9	6.973	0.44	6.5-9.2
E.C(µs/cm^3)	40-3280	536.429	582.00	1500
Turbidity (NTU)	0.18-1	0.587	0.20	10
TDS(Mg/l)	20-1590	357.143	389.80	1500
TSS(Mg/l)	1-1.7	1.450	0.10	-
K(Mg/l)	0.04-0.43	0.142	0.10	100
Na (Mg/l)	0.002-0.651	0.179	0.20	60
Cl (Mg/l)	0-7.09	1.321	2.00	200
Mg (Mg/l)	-1.83-40.22	11.303	13.63	30
Ca (Mg/l)	2.41-78.03	23.441		75
No_3(Mg/l)	0.86-2.28	1.533	0.39	45
Po_4(Mg/l)	0.06-0.21	0.124	0.05	100
DO(Mg/l)	2.2-4.2	2.914	0.91	4
BOD(Mg/l)	0-2	1.000	0.96	2
COD(Mg/l)	23.5-70.3	46.693	12.78	30
T. Hardness (Mg/l)	20-560	149.286	139.01	500
Fe (PPM)	1.358-4.367	2.036	0.88	0.1
F(PPM)	0.086-0.086	0.001	0.03	0.9
Zn (PPM)	0-0.002		22.74	5

The properties of domestic water sources in Nasarawa Local Government Area during Rainy Season as presented in Table 2 shows that the concentration of parameters are as follows:

Temperature

The temperature of water samples ranged from 26.52-29**ºC** with mean value of 29.183**ºC** and standard deviation ±0.86**.** The mean value lies within 20-33ºC desirable range set by WHO for drinking purpose. The range and standard deviation show uniformity in temperature. This is because sample sources are within the same geographic setting with same amount of sunshine.

pH

The pH values ranged from 6.26-7.9 with mean value of 6.973 and standard deviation ±0.44. This shows that all the samples of pH lie within the WHO limit safe for domestic water except for the well sampled at Shagari Low cost that is little below the minimum allowable limit. The range and standard deviation 6.26-7.9 and ± 0.44 show little variation in pH values among samples (Figure 1).

Recommended Limit

Electrical Conductivity EC

The E.C ranged from 40-2380 (µs/cm^3) with mean value of 536.429 µs/cm^3 and the standard deviation is ±582.00. The average value of 536.429 µs/cm^3 is below the WHO permissible limit of 1000 µs/cm^3 for drinking purpose. However, the standard deviation being ±582.00 shows wide disparity in the concentration of soluble salts among the samples. The smallest value 40 µs/cm^3 were recorded in the two rivers while the highest value 2380 µs/cm^3 was recorded in a well at Mangoro goma (Fig2).

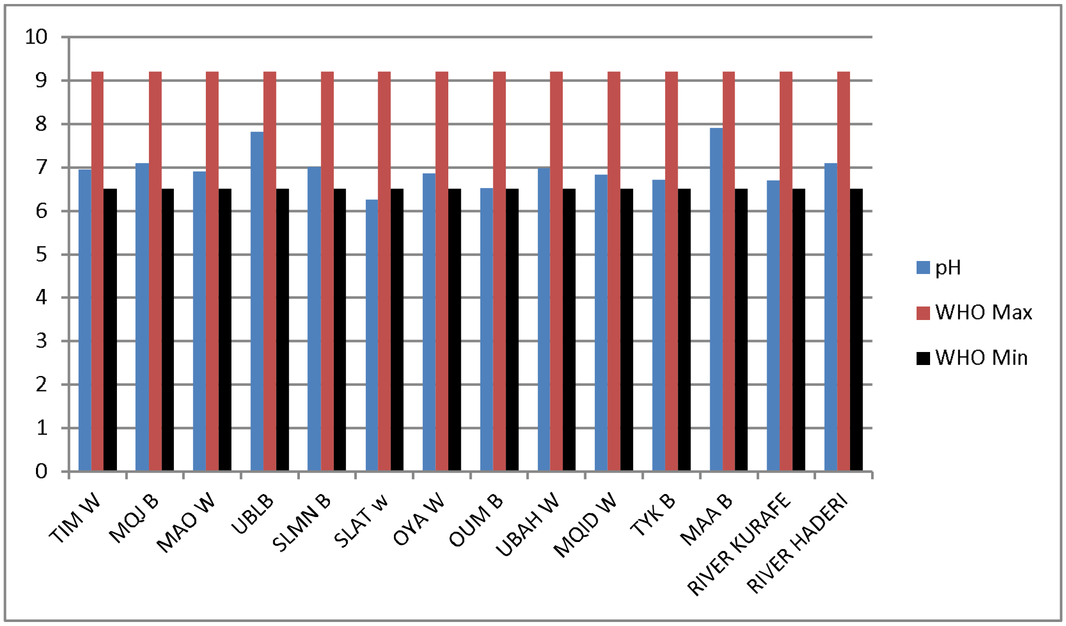

Figure 1: The Concentration of pH in the Samples and WHO

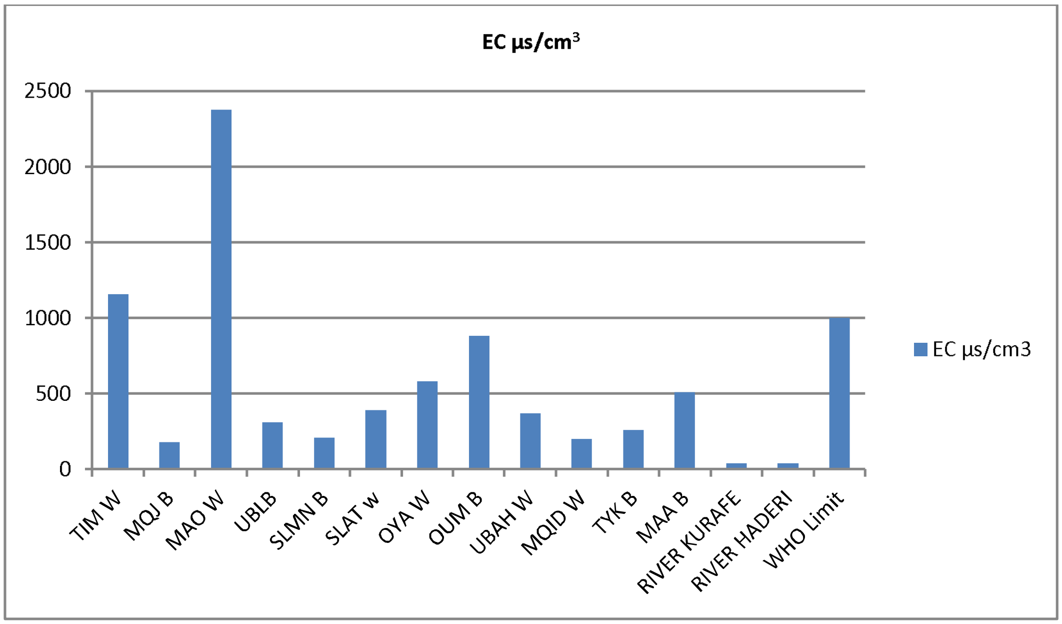

Figure 2: The Concentration of EC in the Samples and WHO

Recommended Limit

Figure 2 revealed that only samples from wells in Tammah and Mangoro goma were above the permissible limit of 1000 µS/cm set by WHO in 1985. Therefore, in terms of EC, all the sampled sources met the WHO standard for drinking purposes except well samples from Tammah and Mangoro goma.

Turbidity and Solids

Turbidity measures number of particles in the water it ranged from 0.18-1NTUwith average value of 0.587NTU and standard deviation was ±0.20. The mean value is within the desirable limit of 5NTU set by WHO for drinking purpose. The standard deviation being ±0.20 shows close proximity in turbidity record of all the samples.

Solids: Total Dissolved Solids (TDS) and Total Suspended Solids

The total dissolved solids (TDS) ranged from 20- 1590 with mean value of

357.143Mg/l and standard deviation was ±389.80. The mean value 357.143Mg/l is within the WHO permissible limit 1500Mg/l for drinking purpose. However, the standard deviation being ±389.80 shows wide disparity in recorded TDS. All samples are within the permissible limit except well sampled at Mangoro goma (Figure 3). The total suspended solids were also relatively low as values ranged from 1.-1.7 Mg/l with mean value of 1.450 Mg/l.

Recommended Limit
Mineral Nutrients (K, Na, Cl-, Mg, Ca, NO_3 and PO_4)

The concentrations of these minerals in the water samples are generally low, the concentrations are as follows: Potassium ranged from 0.04-0.43 Mg/l mean 0.142 Mg/l, Sodium ranged from 0.002-0.651 Mg/l mean 0.179 Mg/l, Chlorine ranged from 0-7.09Mg/l mean1.321 Mg/l, Magnesium ranged from -1.83-40.22 Mg/l mean11.303 Mg/l, Calcium ranged from2.41-78.03 Mg/l mean 23.4 Mg/l, Nitrate ranged from 0.86-2.3 Mg/l mean 1.5 Mg/l, and phosphate ranged from 0.06-0.21 Mg/l mean 0.124 Mg/l. On average, all the mineral nutrients were below their desirable limits for drinking purpose set by WHO in 2010. The mean Concentrations of K, Na, Cl-, Mg, Ca, NO_3 and PO_4 in Mg/l are 0.142,0.179, 1.321, 1.321, 11.303, 23.441, 1.533 and 0.124 respectively compared to their permissible limits of100mg/l, 60Mg/l, 200 Mg/l, 30 Mg/l, 75 Mg/l and 45 Mg/l and 400Mg/l. The standard deviations of these mineral nutrients are low indicating close ranges expect for magnesium and calcium that had standard deviation ±13.63 and ±22.74 respectively (Figure 4).

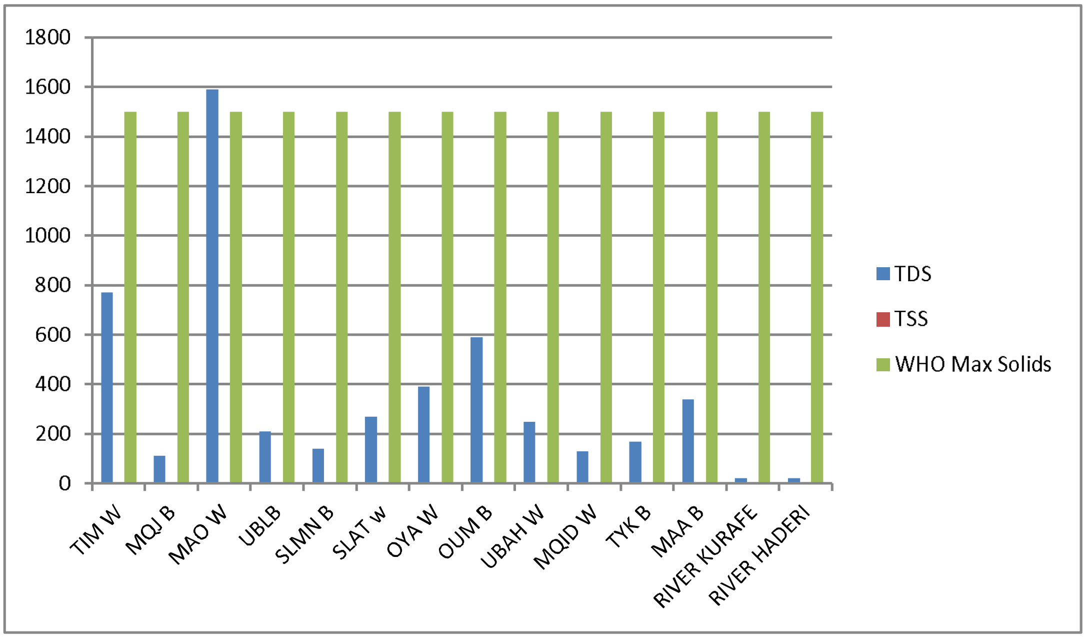

Figure 3: The Concentration of Solids in the Samples and WHO

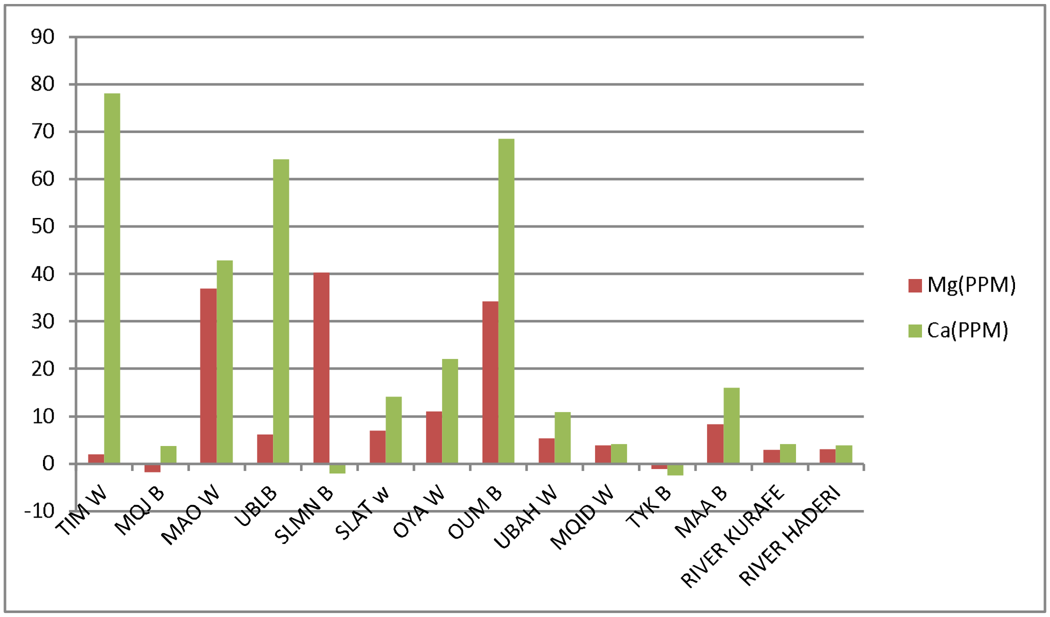

Figure4: Disparity in the Concentration of Magnesium and Calcium

DO, BOD and COD

The dissolved oxygen (DO) ranged from 2.2-4.230Mg/l with mean value of 2.91430Mg/l, and standard deviation was ±0.91. The mean value is below maximum permissible limit of 4.030Mg/l. The standard variation being ±0.91shows that there is close range in the record of DO among the samples. The Biological Oxygen Demand (BOD) ranged from 0-2 with mean value of 1.030Mg/l this is within the permissible limit for drinking. Unpolluted waters typically have a BOD of 2 mg/l O2 or less, while those receiving wastewaters or other organic residues can have up to 10 mg/l O2 or more (WHO, 2010). The Chemical Oxygen Demand ranged from 23.5-70.330Mg/l with mean value of 46.693PPM and standard deviation ± 12.78. The mean value is above the safety limit of 30Mg/l. However, the standard deviation being ± 12.78 shows disparities in values as it ranged from 23.5-70.330Mg/l.

Hardness

The total hardness ranged from 20-560 Mg/l with mean value of 149.286Mg/ l and standard deviation was ±139.01. Though the mean value of 149.286Mg/l lies below the maximum limit of 500Mg/l for drinking purpose as set by WHO, sample from Mangoro Goma have higher value than the allowable limit in order words, there is disparity in the values of total hardness. These correspond with the high value of the standard deviation±139.01. This is a consequence of high concentration of Ca and Mg in some samples and stagnation of well water.

Heavy Metals (Fe, F, Zn, Pb, Cr, Cu, Mn and B)

Heavy metals have human and environmental toxicity even at very low concentrations. Concern over metals relate to their toxicity, bio-accumulation and hazards to human health. Elevated concentration of metals may result in toxic consequences.

The mean concentration of heavy metals in Part Per Million is in the order of Fe>Mn> B>Cr>Pb>Cd >Cu>F (Figure 5).

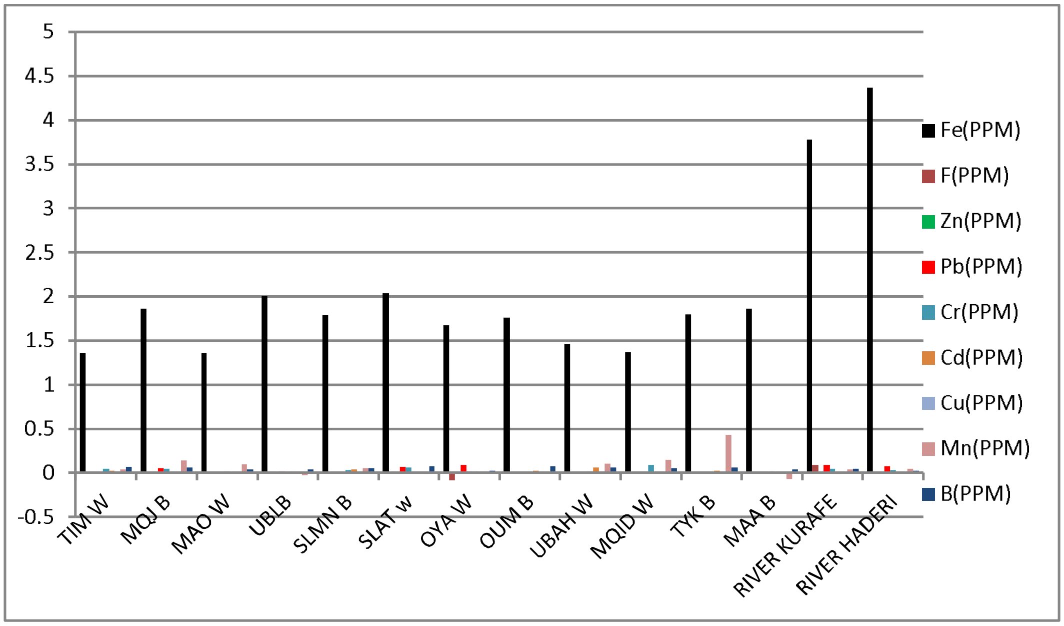

Figure 5: Concentration of Heavy Metals

Figure 5 shows that Iron (Fe) was the most abundant heavy metals in the samples and it is more abundant in rivers than other sources. Its concentrations ranged from 1.358-4.367 with mean value of 2.036PPMand standard deviation±0.88. All the heavy metals were within their permissible limit set by WHO for drinking purpose except iron.
According to Kumar and Puri (2012), "Iron is the most abundant element, by weight, in the earth's crust. Iron is the second most abundant metal in earth's crust. Natural water contains variable amounts of iron despite its universal distribution and abundance".

Biological Properties
Microbial analysis of the water sampled showed the presence of faecal coliform including E-coli in all samples. The Faecal coliform and E. coli are often used as water quality indicators for the health status of potable water. The high bacteria count indicates the presence of pathogenic organisms whose presence in water is likely to be accompanied with water borne diseases when used for domestic purposes.

Conclusion
The study has shown that not all the domestic water sources are safe for domestic purposes. Though most of the parameters were within the WHO permissible limit for domestic water use however other parameters such as pH, TDS, COD, EC, BOD, Cl-, Ca, Mg, hardness, are below the WHO permissible limit for domestic water use. While, concentration of parameters such as Fe, E-Coli and Total Coliform Count are above the WHO permissible limit for domestic water use. Since some of the parameters such as iron, E-coli and Total Coliform Count covered by this study are high this implies contamination of some of the sources which make them unsafe for domestic water purpose.

Recommendations
The study therefore recommends that there is the need to treat water especially from the rivers in the area to avoid any possible damage to human health likely to occur from the use of the water. Pipe borne water should be made available to the inhabitants of the community; there is need for public enlightenment campaign to reduce human activities that are likely to pollute the water sources. Open wells should be lined with cement with level of cover above ground level to avoid surface runoff of pollutant especially during the rains. Finally, communal water treatment plants and filter

system could be set up for ground water sources in the study area.

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