Evaluation of Water Quality of Domestic Water Sources in Nasarawa Town, Nasarawa Local Government Area, Nasarawa State, Nigeria

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Abstract

This study evaluated water quality of domestic water sources during dry seasons in Nasarawa Local Government Area, Nasarawa State, Nigeria to ascertain the safety of such sources for drinking purposes. A total of fourteen (14) water samples were collected, six (6) samples from boreholes, another six (6) from wells and two (2) 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 average concentrations of pH, EC, BOD, COD and Fe fall short of WHO standard for drinking purpose. Though on average basis other parameters are within the WHO permissible limit for drinking, parameters such as TDS, TSS, turbidity, hardness, chloride, magnesium, calcium, E.Coli and Total Coliform Count had high standard deviation which has indication of high variation in values thus, some samples fall short of WHO permissible limit for drinking in terms of these parameters. It was concluded that majority of the domestic water sources are not safe for drinking purposes. The study recommended that the quality of water sources should be monitored periodically to ascertain further degradation in the domestic water quality, public-private partnership should be encourage in order to increase access to piped borne water networks in the study area via system rehabilitation and expansion and finally awareness programs should be implemented to inform the communities of the status of the water quality and method that can be used to avoid getting ill resulting from water contamination, this method need to be developed.
Keywords: Water, water sources, water quality, domestic water, pollution, well, rivers and boreholes.

Introduction

Worldwide, more people are dying from poor quality of water per year than from all forms of violence including war, it is estimated that about 26% of all deaths are outcome from contagious diseases caused by pathogenic bacteria in water (WHO, 2005). Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grows and demands more water of high quality for domestic purposes and economic activities (UNEP, 2000). The quality of any body of surface or ground water is a function of either or both natural influences and human activities (Stark *et al*., 2001; Kolawole *et al.,* 2008). It is now generally accepted that aquatic environments cannot be perceived simply as holding tanks that supply water for human activities. Rather, these environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future (UNEP, 2000). Both surface and underground water are being polluted by indiscriminate disposal of sewage, industrial waste and other human activities, which affects their physical, chemical and microbiological quality of water (Koshy and Nayar, 1999 cited in Olatunji*et al.,* 2015).

Broadly, the use of water by man can be divided into six (6) major categories; domestic, industrial, agricultural, transportation, recreational and construction (Jidauna et al., 2014). Domestic uses (drinking, cooking, bathing, washing and sanitation) are the fundamental and most important uses of water that must be met sustainably (Mozie, 2010). The supply of water for domestic purposes in good quality greatly improves the health, social and economic facets of human life. In short, safe drinking water supply and basic sanitation are vital to human health and efficiency. The quality of water depends on its physical, chemical, and biological characteristics, which determines its utility for different purposes (Ogunnowo, 2004; Adhikary *et al.*, 2010). The provision of safe water for domestic and other uses in both rural and urban centers is one of the most intractable problems in Nigeria. During the Colonial era, certain measurements were taken to protect and sustain the traditional sources of drinking water. Some of these measures include deepening and concreting of walls of existing wells, fencing of spring head, construction of concrete structure to store and protect spring water.

Water is our most valuable natural resource. This fact though recognized by man has not stopped him from polluting the rivers, lakes and oceans. The cause of water pollution could be municipal, agricultural and industrial. All these major causes have rampantly deteriorated the quality of water the world over. This has resulted in the pollution of surface water for domestic uses including drinking and in the quest to source a safe water many family now rely on ground water for their household uses and the ground water potential and its quality level in both cities and rural areas is getting deteriorated due to population explosion, urbanization, industrialization and also the failure of proper waste management. Ground water quality is normally characterized by different physical, chemical and biological characteristics. These parameters change widely due to the type of pollution/pollutants, seasonal fluctuation, ground water extraction, etc. In an undisturbed river, the chemical composition of water varies with time and space, because of natural factors like climate and topography, water recharge capacity, aquifer level among others. Impairment of a river's water quality because of anthropogenic activities such as disposal of wastewater, transfer of runoff from disturbed land, industrialization can cause major changes in water quality that in turn affect the human benefits and ecosystem services (Singh *et al.,* 2002).Nasarawa Local Area was chosen for this study because of the high rate of population growth and human activities. This resulted to land use changes especially within the Local Government Headquarters (Nasarawa Town), leading 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.

The Study Area

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 to the South. Tropical wet and dry climate characterized by two distinct seasons is experienced in the area. The wet (rainy) season lasts from about the beginning of April and ends in October. The dry season is experienced between November and April. Annual rainfall figures of the area range from 1100mm to about 2000mm and about 90% of the rain falls between May and September.

Sampling and Analytical Procedures

A total of fourteen (14) water samples were collected in dry six (6) samples from boreholes another six (6) from wells and two (2) samples from Kurafe and Haderi rivers. The water samples were collected at the peak of dry season in the month of February. Water samples were collected in one 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 as follows: Temperature, Potential of Hydrogen (pH), Electrical Conductivity (EC), turbidity, Total Dissolve Solid (TDS), Total Suspended Solid (TSS), Potassium (K), Sodium (Na), Chlorides (Cl), Magnesium (Mg), Calcium (Ca), Nitrate (NO_3), Phosphate (PO_4), Oxygen Demand (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), hardness, Iron (Fe), Fluoride (F), Zinc (Zn) , Lead (Pb), Chromium (Cr), Cadmium (Cd), Copper (Cu), Manganese (Mn) and Coliforms.

Results and Discussions

The domestic water sources in Nasarawa Local Government Area were tested for physicochemical properties and biological properties during dry season in the month of February, 2018 (Table 1). The results were compared with WHO standard for drinking purpose (Table 2).

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

Temperature

The temperature of water samples ranged from 26.9-30.78 ^{o}**C** with mean value of 29.183 ^{o}**C** and standard deviation ±i.156**.** The mean value lies within 20-33 ^{o}**C** desirable range set by WHO for drinking purposes. 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 5.17-7.02 with mean value of 6.2.11 and standard deviation ±0.43. The mean value of 6.2.11 is below the WHO minimum permissible limit of 6.5. However, some samples are within permissible range of 6.5-9. The range and standard deviation 6.26-7.9 and ±0.44 -shows similarity in pH values among samples (Figure 1).

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

Parameters	W3	B2	W5	B6	B4	W4	W1	B1	B6	W2	B3	B5	R2	R1
Temp. .(^{0}C)	29.8	29.7	27.9	29.7	29.5	29.6	27.8	28.86	27.52	29.97	29.8 3	26.9	30.7	30.78
Ph	6.12	6.61	6.01	7.02	6.41	6.09	6.13	5.82	5.17	6.61	6.11	6.7	6.07	6.09
E.C(µs/cm3)	120	140	1317	218	218	400	592	970	408	318	322	600	120	110
Turbidity	2.82	3.18	2.67	1.23	0.94	2.61	3.72	0.83	5.46	7.54	0.68	0.79	10.9	11.1
TDS	985	265	2643	230	170	540	530	240	550	430	180	290	420	632
TSS	2.4	2	2.04	1.08	1.5	2.05	2.6	0.3	2.8	2.9	2.7	1.12	2.6	20.2
K	2.2	1.06	1.01	1.05	1.08	1.02	1.33	1.29	1.2	1.09	1.6	1.32	1.27	1.9
Na	0.11	0.621	0.036	0.067	0.014	0.651	0.043	0.092	0.86	1.371	0.76	0.32	0.74	0.234
Cl-	3.54	1.42	0	0	2.3	3.2	3.2	1.49	2	3	4.1	3.42	12.1 9	0.3.54
Mg	3.05	-1.73	26.66	7.23	36.22	7.09	10.09	24.32	5.43	3.86	-1.2	8.39	2.76	3.91
Ca	68.43	4.75	32.96	54.85	-2.04	14.08	22.11	68.49	10.92	4.11	- 3.76	11.16	1.2	2.26

NO3	1.93	0.86	2.67	2.18	2.69	1.23	0.89	0.97	0.85	0.73	0.06	0.88	2.78	2.74
PO4	0.12	0.09	0.13	0.08	0.06	0.09	2.1	0.07	0.31	0.18	0.16	0.21	0.08	0.019
DO	0.2	4.2	1.2	1.2	4.8	2.2	1.2	4.2	3.2	2.2	3.2	4.2	2.2	2.2
BOD	5	2.1	1	0	0	6	7	0	3	4	0	0	6	8
COD	38.5	37.5	41.2	35.1	30.1	44.3	43.9	25.2	52.7	32.1	38.7	39.2	30.3	33.3
T.Hardnes	292	146	590	184	170	281	190	430	128	714	70	212	228	127
Fe	2.358	1.963	2.862	2.08	1.873	2.916	1.896	1.783	1.477	1.367	1.896	1.962	6.7223	6.567
F	0	0	0.001	0.002	0	0.003	-0.097	0	0.002	-0.003	0	0	0.036	0.001
Zn	0	0.005	0	0	0.006	0	0	0.007	0	0	0	0	0	0
Lead	0.009	0.097	0	0.066	0	0.092	0.09	0	0	0.006	0.0086	0.0048	0.096	0.05
Cr	0.048	0.047	0.021	0.012	0.031	0.061	0.025	0.008	0.071	0.097	0.073	0.066	0.305	0.201
Cd	0.089	0.0053	0.0219	0.0181	0.0672	-0.0099	0.0207	0.0266	0.0689	0.0145	0.02778	0.0064	-0.0032	0.00088
Cu	0.0003	0.002	0.007	0	0.005	0.001	0.004	0.003	0.001	0.007	0.001	0	0.007	0.008
Mn	0.0896	0.3484	0.0988	-0.0881	0.0821	-0.0002	0.0261	0.0357	0.1819	0.2207	0.938	-0.0239	0.0997	0.0842
B	0.083	0.068	0.045	0.075	0.081	0.071	0.043	0.083	0.09	0.066	0.085	0.08	0.6	0.7
M/E Coli	98	36	23	4	1	97	28	117	0.9	9	22	0	242	348
T.Coliform C	60	63	50	50	34	2	0	0	0	5	95	75	64	40

Note: W = well, B= Bore hole, R1 = River Haderi and R2 = River Kurafe

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

Parameters	Range	®	Standard Deviation(±)	WHO Permissible Limit for Drinking
Ph	5.17-7.02	6.211	0.431175	20-33
E.C(µs/cm3)	110-2490	489.500	557.5539	6.5-9.2
Turbidity(NUT)	0.68-11.1	3.891	3.451419	1500
TDS	170-2643	578.929	610.9306	10
TSS	0.3-2.4	3.306	4.742892	1500
K	1.01-2.2	1.316	0.342673	-
Na	0.014-1.771	0.423	0.399729	100
Cl-	0-12.19	3.066	2.914469	60
Mg	1.73-36.22	9.720	10.84691	200
Ca	3.76-68.43	20.680	24.60596	30
NO_3	0.06-2.78	1.533	0.89451	75
PO_4	0.019-0.13	0.264	0.51409	45
DO	0.2-4.8	2.600	1.350132	100
BOD	0-8	3.007	2.851181	4

COD	25.2-41.2	37.293	6.798683	2
T.Hardnes	70-714	268.714	179.4099	30
Fe	1.367-2.862	2.694	1.666573	500
Fe	**0.097-0.036**	-0.004	0.027408	0.1
Zn	0-0.007	0.001	0.002491	0.9
Lead	0-0.097	0.037	0.040523	5
Cr	0.008-0.048	0.076	0.078768	0.05
Cd	**0.0099-0.008**	0.025	0.028446	0.05
Cu	0-0.008	0.003	0.002866	0.01
Mn	0.0881-0.3484	0.150	0.242306	1.0
B	0.043-0.7	0.155	0.203406	0.5
M/E Coli	0-98	73.279	100.1375	-
T.Coliform C	0-95	38.429	30.96707	-

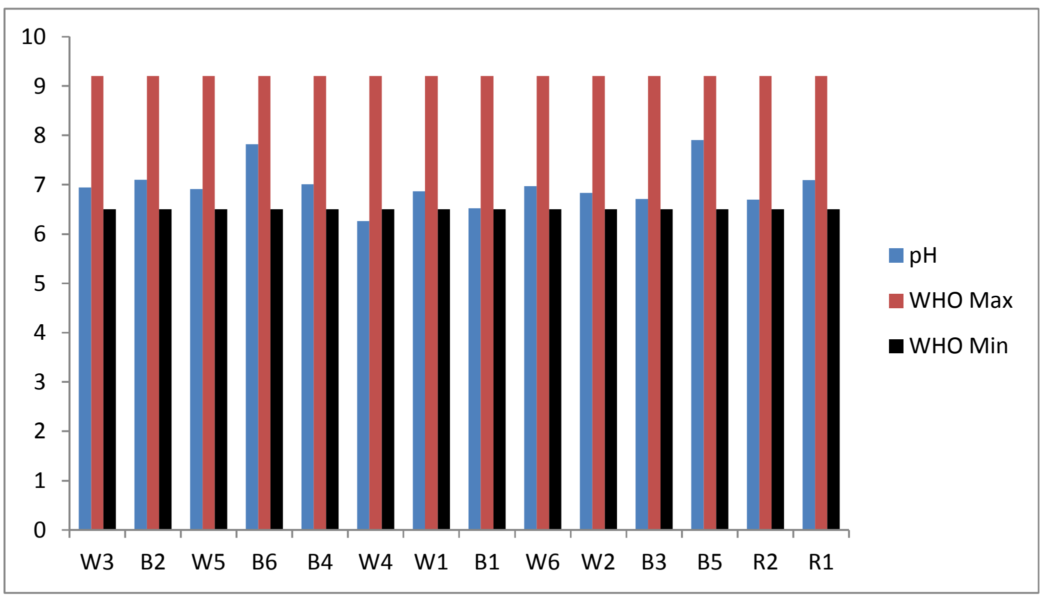

Figure1: The Concentration of pH in the Samples and WHO Recommended Limit

Electrical Conductivity (EC)

The electrical conductivity (E.C) ranged from 110-1317 (µs/cm^3) with mean value of 489.500µs/cm^3 and the standard is ± 557.55. The average value of 489.500µsµs/cm^3 is below the WHO permissible limit of 1000 µs/cm^3 for drinking purpose. However, the standard being ± 557.55, shows wide disparity in the concentration of soluble salts among the samples. The smallest values were recorded in the two rivers while the highest value 1317 µs/cm^3 was recorded in a well at Mangoro Goma (MAO W), (Figure 2).

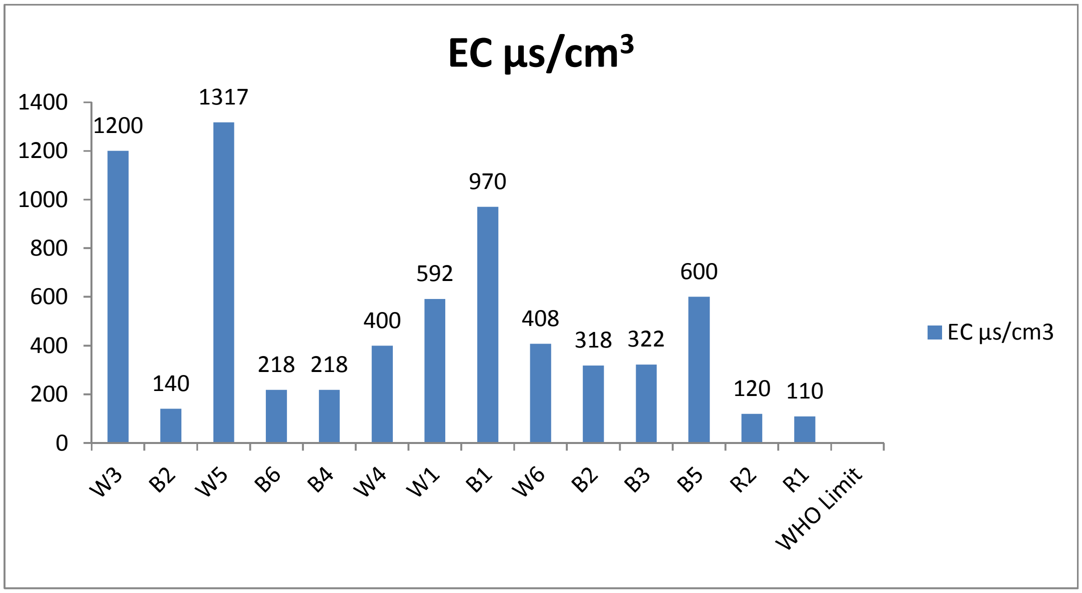

Figure 2: The Concentration of EC in the Samples and WHO Recommended Limit

Figure 2 revealed that only samples from wells in Tamal (TIM W) and Mangoro Goma (MAO W) are above the permissible limit of 1000 µs/cm3 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 Tamal and Mangoro Goma.

Turbidity and Solids

Turbidity measures amount of particles in the water, it ranged from 0.68-11.1NTUwith average value of 3.891NTU and standard deviation was ± 3.45. The mean value is within the desirable limit of 5NTU set by WHO for drinking purpose. The range being 0.68-11.1 and standard deviation being ± 3.45 shows a disparity in turbidity record of all the samples. Thus, some samples have turbidity level above 10NTU permissible limit for drinking purposes.

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

The total dissolved solids (TDS) ranged from 170-2643 with mean value of 578.929Mg/l and standard deviation was ±610.93. The mean value of 578.929Mg /l is within the WHO permissible limit of 1500Mg/l for drinking purpose. However, the standard deviation being ±610.93 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 0.3-2.4Mg/l with mean value of 3.306 Mg/l.

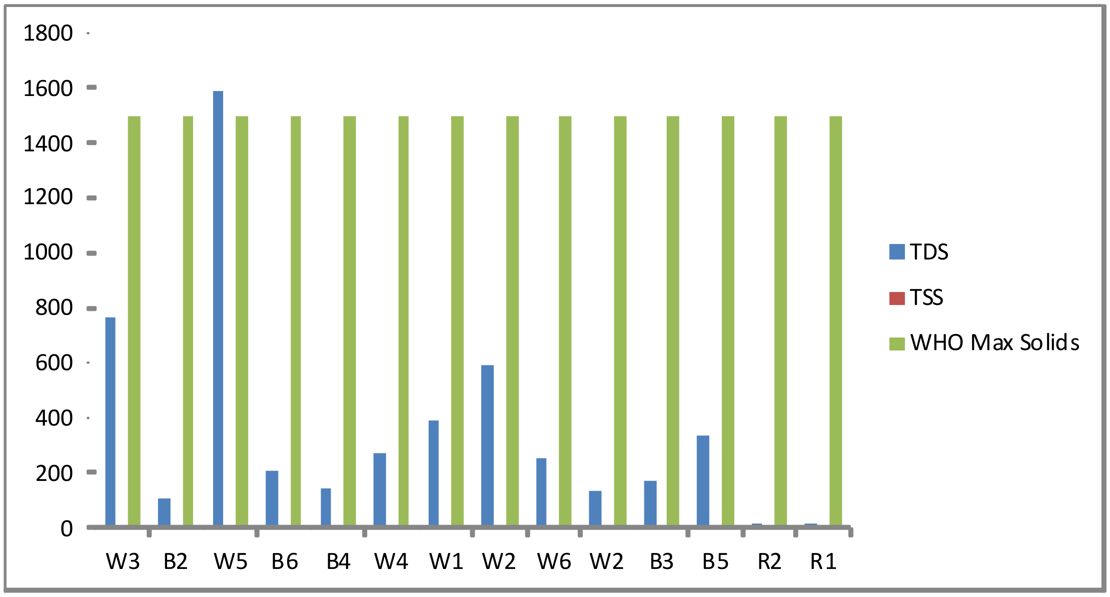

Figure 3: The Concentration of Solids in the Samples and WHO Recommended Limit

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 1.01-2.2Mg/l mean 1.316Mg/l, Sodium ranged from Mg/l0.014-1.771 mean 0.423 Mg/l, Chlorine ranged from 0-12.19Mg/l, mean 3.066Mg/l, Magnesium ranged from **1.73-36.22**Mg/l mean 9.720Mg/l, Calcium ranged from **3.76-68.43**Mg/l mean 20.680Mg/l, Nitrate ranged from 0.06-2.78Mg/l mean 20.680 Mg/l, and phosphate ranged from 0.019-0.13Mg/l mean 0.264 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 1.316, 0.423, 3.066, 9.720, 20.680, 1.533 and 0.264 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 expected for chloride, magnesium and calcium that had standard deviations of ±2.914, ±13.63 and ±22.74 respectively (Figure 4).

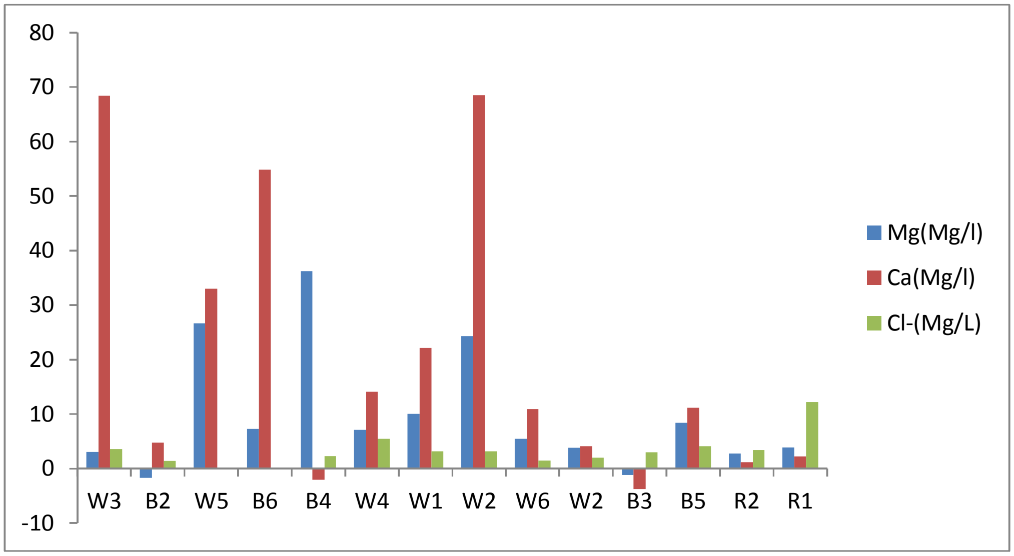

Figure4: Disparity in the Concentration of Chloride, Magnesium and Calcium

DO, BOD and COD

The dissolved oxygen (DO) ranged from 0.2-4.8Mg/l with mean value of 2.600Mg/l, and standard deviation was ±1.35. The mean value is below maximum permissible limit of 4.030Mg/l. The standard variation being ±1.35 shows that there is close range in the record of DO among the samples. The Biological Oxygen Demand (BOD) ranged from 0-8 with mean value of 3.007Mg/l, this is above the permissible limit for drinking. Unpolluted waters typically have a BOD of 2 mg/l O_2 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 25.2-41.2Mg/l with mean value of 37.293 Mg/l and standard deviation ± 6.798. The mean value is above the safety limit of 30Mg/l. However, the standard deviation being ±6.798 shows slight disparities in values as it ranged from 25.2-41.2Mg/l.

Hardness

The total hardness ranged from70-714 Mg/l with mean value of 268.714Mg/l and standard deviation was ±179.41. Though the mean value of 268.71 Mg/l lies below the maximum limit of 500Mg/l for drinking purpose as set by WHO, some samples have higher values than the allowable limits, in order words, there is disparity in the values of total hardness, this correspond with the high value of the standard deviation±179.41. 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)

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

Table 3: The Order of Concentration of Heavy Metals

Heavy metals	®	Rank
Fe	2.694	1
F	-0.004	9
Zn	0.001	8
Lead	0.037	5
Cr	0.076	4
Cd	0.025	6
Cu	0.003	7
Mn	0.15	3
B	0.155	2

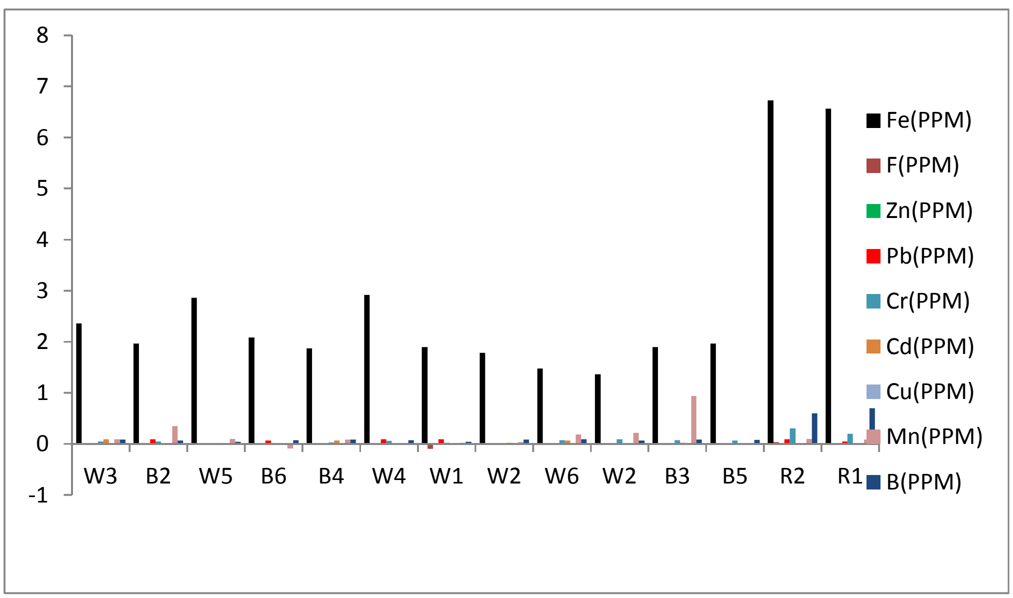

Figure 5: Concentration of Heavy Metals

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 1.367-6.72 with mean value of 2.694PPM and standard deviation± 1.67. All the heavy metals were within their permissible limit set by WHO for drinking purpose except iron.

"Iron is the most abundant element, by weight, in the earth's crust. Iron is the second most abundant metal in the earth's crust. Natural water contains variable amounts of iron despite its universal distribution and abundance"(Kumar and Puri, 2012).

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 markers for the health status of potable water. The high bacteria count indicates the presence of microbial contamination of the samples.

Conclusion

It was concluded that majority of the domestic water sources are not safe for drinking purpose. This is because some of the samples contains E. coli and the average concentrations of pH, EC, BOD, COD and Fe fall short of WHO standard for drinking purpose and even though on average basis other parameters are within the WHO permissible limit for drinking, parameters such as TDS, TSS, turbidity, hardness, chloride, magnesium, calcium, E.Coli and Total Coliform Count had high standard deviation which has indication of high variation in values. This suggested contamination of some of the sources and make them unsafe for drinking purpose.

Recommendation

The study recommends that the quality of water sources should be monitored periodically to ascertain further degradation in the domestic water quality, private partnership should be encourage in order to increase access to piped borne water network in the study area via system rehabilitation and expansion and finally awareness programs should be implemented to inform the communities of the status of the water quality and method that can be used to avoid getting ill resulting from water contamination.

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