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RESEARCH ARTICLE

GROUND WATER QUALITY ASSESSMENT: a case study of ground water from hand dug wells in Hawul Local Government Area of Borno State

Kwari Williams Joshua,

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***Corresponding Author**

Kwari Williams Joshua

Abstract

One of the greatest environmental challenges that confront rural communities in north eastern Nigeria especially Borno state is scarcity of water supply. In most rural communities in northern Nigeria, hand dug wells are the major source of water for both domestic and livestock use. However, the qualities of water in these wells are not known. In Hawul local government area of Borno state, there are limited information on the quality of ground water. Therefore, this study was conducted to analyse the Physical, chemical and bacteriological quality of water in hand dug wells and to compare the result obtained with the stipulated guideline given by both the World Health Organisation (WHO) and the National Agency for Food and Drug Administration and Control (NAFDAC) with a view to balance needs and resources.

Water samples were collected from eleven wells in five different villages and assessed. From the analysis conducted and result obtained, 36% of the wells are slightly coloured, 45% have high level of turbidity, 18% contain high level of chloride, 9% contain high manganese, 18% have high concentration of nitrates, 45% have high fluoride, 36% have high magnesium, 27% have high potassium and 45% are bacteriologically contaminated. This implies that only 9% of the total wells are free from contamination while the remaining 91% are contaminated. These results pose a high level of risk to the health of people living in those communities and therefore, treatment of water before use as well as proper sanitary awareness is highly recommended for the safety of the local people.

INTRODUCTION

Next to oxygen, water is about the most essential element needed for all forms of biological activity. Human beings, animals as well as plants depend absolutely on water for survival. Almost three-forth (72%) of the earth's surface is covered with water (Venugopala 2004). Approximately 1.4cubic kilometres of water exist on earth in the form of oceans, seas, rivers, lakes, ice etc but only 3% of the total quantity of water on earth is in the form of fresh water (Shiklomanov 1993). This further corresponds with the United Geological survey which presented that 97% of the water on earth is salt water and only 3% is fresh water of which slightly over two third is frozen in glaciers and polar ice caps, the remaining unfrozen fresh water is found as ground water with only a small fraction present above ground or in the air. This fact notwithstanding, it is interesting to note that there is hardly enough water to drink and meet other basic requirements such as cooking, washing, bathing among other usage in most rural communities of developing nations (Hassan et al. 2013)

Fresh water is a renewable resource, yet the world supply of clean fresh water is steadily decreasing (Hoekstra 2006). Pure/clean water does not occur in its natural state due to the presence of dissolved or suspended impurities.

The degree of impurities varies and are contributed to the water either naturally or as acidification of rain water, surface run off, dissolution underground and/or artificially by mans activities such as sewage, farming, mining, industrial discharge etc (shiklomanov 2000). The demand for fresh water is steadily rising and as it is, water demand already exceeds supply in many parts of the world and as the world population continues to rise, so too does water demand. Fresh water availability and water use have been recognised as global issues and their consistent quantification is required to provide an integral view of the water situation on earth. Lucas and Alejandra 2010 pointed out that the challenge and possible threats related to global change, including climate change also affect hydrological research which currently undergoes a change in focus, driven by increasing global and complex water problems. According to Evan et al., 2011, the demand for fresh water is rising but a variety of factors including population growth, water pollution, economic progress; land use change and climate change render its availability into the future uncertain. Alcamo et al., 2003 went further to add that the awareness of growing water scarcity has led to increasing interest in global modelling of water resources, both in terms of supply and demand, with the aim of developing and implementing appropriate water resources infrastructure and management strategies

Water use has almost tripled over the past 50 years and in some regions the water demand already exceeds supply (Hassan et al. 2013 and Vorosmarty et al., 2000). The world is facing a 'global water crises'; in many countries, current levels of water use are unsustainable, with systems vulnerable to collapse from even small changes in water availability. The need for scientifically-based assessment of the potential impact on water resource of future changes, as a basis for society to adapt to such changes, is strong for most parts of the world. Although the focus of such assessment has tendered to be climate change, socio-economic changes can have a significant impact on water availability across the four main use sectors, i.e. domestic, agricultural, industrial (including energy) and environmental. Withdrawal and consumption of water is expected to continue to grow substantially over the next 20-50 years (Cosgrove and Rijberman 2002) and constant changes in availability may drastically affect society and economic growth.

2.0 WATER QUALITY

When we talk of quality we refer to as pure, therefore quality water is termed water free from impurities (pure). We know that all forms of life is dependent upon water and that water exist in nature in many forms- clouds, rain, snow, ice and fogs; however strictly speaking, chemically pure water does not exist for any appreciable length of time in nature. Even while falling as rain, water picks up small amount of gasses, ions, dust and particle matter from the atmosphere. Also, as it flows over or through the surface layers of the earth, it dissolves and carries with it some of almost everything it touches including that which is dumped into it by man (Shelton 2007). Horwitz et al 2012 added that these added substances may be arbitrarily classified as physical, chemical, bacteriological and radiological impurities. They include industrial and commercial solvents, metals and acid salts, sediments, pesticides, herbicides, plant nutrients, radioactive materials, decaying animals and vegetable matter, and living micro organisms such as algae, bacteria, and viruses. These impurities may give water bad taste, colour, odour and turbidity and cause hardness, corrosiveness, staining or frothing (Venugopala 2010).

2.1 GROUND WATER QUALITY

The quality of water underground can be said to be acceptable in most cases, however, the quality of particularly shallow ground water is changing as a result of human activities. Ground water is less susceptible to bacteriological contamination than surface water due to the soil and rocks through which water flows. These strata tend to serve as a filter medium thereby filtering bacteriological impurities. Bacteria however occasionally find their way into ground water in dangerously high concentrations. Freedom from bacteriological contamination however does not mean water is pure and fit to consume, many unseen minerals and organic constituents are present in ground water in various concentrations. Some are harmless or even beneficial; though occurring infrequently, while others are harmful and a few may be highly toxic (Krantz and Kifferstein 2007). Water is a solvent and dissolves minerals from the rocks with which it comes in contact with. According to WHO 1984, ground water contains dissolved minerals and gasses which affect its taste. Among such mineral substance are sodium, calcium, magnesium, potassium, chloride, bicarbonate and sulphate. Water typically is not considered desirable for drinking if the quantity of dissolved minerals exceeds 1.000mg/l (milligrams per litre) (WHO 1984). Well water (ground water) may sometimes contain very large concentrations of dissolved minerals and cannot be tolerated by humans and other animals or plants. For example, too much dissolved sodium in water may be harmful to people who have heart problems. Boron is a mineral that is good for plants in small amount but is toxic to some plants in slightly higher concentrations (Shelton 2007).

In recent years, the quality of ground water has degraded. Municipal and industrial waste and chemical fertilizers, herbicides and pesticides not properly contained and or disposed have entered the soil, infiltrated some aquifers and contaminated the water thereby degrading ground water quality (Horwitz et al 2012). Other pollution problems include sewer leakages, faulty septic tanks operation and landfill leachates (Venugopala 2010). In recognition for the potentials for pollution, biological and chemical analysis is made routinely on both municipal and industrial water supplies. Federal, state and local agencies are all taking steps to increase water quality monitoring, Analytical technique have been refined and plans are being implemented to mitigate and prevent water quality hazards (Horwitz et al 2012).

2.2 GROUND WATER QUALITY REQUIREMENT

Because of the essential role played by water in supporting human, animal and plant life, it also has if contaminated; great potential for transmitting a wide range of diseases and illness. In developed world, water related diseases are rare due essentially to the presence of efficient water supply systems and waste water disposal systems. However, this is not so with developing countries were over 200 million people still leave without safe water supply and adequate sanitation (E.P.A 2009 and Tebutt 1971). Ground water quality requirement should as it may, be free from all forms of contamination. Generally because of the nature of the source of ground water, it is mostly free from most of the contamination present in surface water. However, chemical contaminants are however the major problem associated with ground water.

3.0 MATERIALS AND METHODS

3.1 THE STUDY AREA

Borno state has a total with land mass of 69,435 sq·km lies between latitude 10˚N to 13˚N and longitude 12˚E to 15˚E. The greater part of the state lies on the Chad basin. It is bounded to the west by Yobe state, to the north by Niger and Chad republics and to the east by Cameroun republic while the southern part is bounded by Adamawa and Gombe states (NPC 2006). Hawul is one of the twenty seven local government areas of Borno state located in the southern part of the state. It shares boundaries with Biu, Shani, Kwaya Kusar and Bayo local government area as well as Gombi local government area of Adamawa state. Hawul lies generally at an altitude of about 600m above sea level even though some areas might be lower. Temperatures are as would be expected, generally high in the town with mean daily maximum temperatures ranging from 29.2˚c in July and August to 37.6˚c in March and April. The mean daily minimum temperature ranges from about 11.7˚c in December and January to about 24.7˚c in April and May. The rainy season months are from May to September with humidity ranging from about 37% to 68% respectively. Rainfall ranges from 1mm in February and November to about 343mm in July and August (Hassan et al 2013).

3.2 GROUND WATER RESOURCE OF THE AREA

Hawul local government is regarded as a basement complex area with crystalline rocks. Only secondary aquifers occur in rock fractures, joints or weathering profile. Ground water is the major sources of water for both domestic and livestock usages. Ground water is mostly tapped through hand dug wells, open wells with very few boreholes. Ground water in Hawul is susceptible to problems and these problems are more of quality and distribution than of quantity. Problems of water quality are associated with pollution and most of the pollutants find their way into the water source either through the soil strata, infiltration of fertilizer through runoff or through collection and use of water from the source (Hassan et al 2013).

3.3 METHOD

The assessment of water quality was achieved after thorough laboratory examination. Perhaps field testing can also be made using field testing kits for faster and emergency analysis. Nevertheless, test for physical, chemical and bacteriological qualities are the most important types of analysis to be carried out for both rural and urban water supplies. Hence these tests reveal the type as well as the extent of contamination present in a particular sample.

4.0 PRESENTATION OF RESULTS

Table 1: Tabula summary on method of analysis and instrumentation

PROPERTIES	METHODS/INSTRUMENTATION
Temperature	Use of a thermometer directly inserting into the sample and taking the reading.
Total dissolved solids	Use of a TDS meter, by inserting the probe into the sample and taking the reading.

PH	Use of a PH colour scale and a universal indicator
Turbidity	Use of a turbid meter by placing the sample into the turbid meter and taking the reading.
Conductivity	Use of a conductivity meter by immersing the electrode into the sample and taking the reading
Total Hardness	By titration, and the result obtained computed
Chloride	Titration with silver nitrate standard solution and observing the colour change.
Sulphate	By the use of sulpha ver 4 sulphate reagent (powder pillow)
Nitrate	By precipitation of nitrate ver 5 nitrate powder reagent.
Fluoride	By titrating 5.00ml of SPADNS reagent.
Iron	By use of one ferror ver iron powder pillow reagent
Manganese	By the use of a buffer powder reagent and sodium periodic powder pillow for manganese
Phosphate	By the use of phospha ver 4 phosphate powder pillow reagent.
E-Coli	Incubation of colonies to produce acid using macconkey broth for a period of 24 hours at 45˚c
Coli form	Incubation of colonies in a broth solution for a period of 24 hours at 30˚c
Colony count	Mixing samples with molten agar and incubating the solid on a plate at 37˚c for a period of 24hours.

Table 2: Drinking water quality standard

GUIDELINE FOR DRINKING WATER

TEST	**WHO(guidelines)**	**NAFDAC**	**NPDWR (US)**
Temperature	No Limit	-	-
Colour	Colourless	Colourless	Colourless
Odour	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable	Flat (tasteless)
Conductivity	No limit	-	-
T.D.S	1000mg/l	500mg/l	500mg/l
Turbidity	5 (NTU)	-	5 (NTU)
PH	7.0-8.5	6.5-8.5	6.5-8.5
Alkalinity	100mg/l	100mg/l	100mg/l
Total Hardness	250mg/l	-	-
Iron	0.05-0.3mg/l	-	Not exceeding 0.3mg/l
Sulphate	200mg/l	200mg/l	Not exceeding 250mg/l
Magnesium	150mg/l	30mg/l	50mg/l
Calcium	75-200mg/l	75mg/l	200mg/l
Chloride	200mg/l	200mg/l	Not exceeding 250mg/l
Fluoride	1.5mg/l	-	4mg/l
Copper	2.0mg/l	-	1.3mg/l
Zinc	5.0mg/l	5.0mg/l	5.0mg/l
Aluminium	0.5mg/l	-	0.05-0.2mg/l
Manganese	0.5mg/l	-	0.05mg/l
Nitrate	50mg/l	-	10mg/l
Nitrite	3mg/l	-	1mg/l
Potassium	1-2mg/l	1.0mg/l	1.0mg/l
Arsenic	0.01mg/l	-	0.05mg/l
Barium	0.7mg/l	-	2.0mg/l

Cadmium	0.003mg/l	-	0.005mg/l
Chromium	0.05mg/l	-	0.1mg/l
Cyanide	0.07mg/l	-	0.2mg/l
Lead	0.01mg/l	-	0.015mg/l
Selenium	0.01mg/l	-	0.08mg/l
Mercury	0.001mg/l	-	0.002mg/l
Carbon dioxide	50mg/l	-	50mg/l
Vinyl Chloride	0.005mg/l	0.0mg/l	0.02mg/l
Methoxy Chlor	0.02mg/l	-	0.04mg/l
Toxaphene	-	-	0.03mg/l
Chlorophenoxy	-	-	0.003mg/l
2-4dichlorophenoxy	0.03mg/l	-	0.07mg/l
2,4,5-trichlorophenoxy acetic acid	0.009mg/l	-	0.05mg/l
Aerobic mesophilic count	-		-
Coli form count	Must not be detected in any 100ml per sample	1 (max)	Not more than 5% sample total coli form-positive in a month
E-coli	Must not be detected in any 100ml per sample	0 (max)	Not more than 5% sample total E-coli- positive in a month

SOURCE: *WHO surveyance for drinking water quality (SFDWQ) 1993*
NAFDAC FACT FILE; consumer safety bulletin 2001

Table 3: Result for physical parameters

Sample Location	B.Kutiki	B.Kutiki	T.Alede	T.Alede	Ndragina	Ndragina	Durkwa	Durkwa	Shaffa	Shaffa	Shaffa
Parameters	A1	A2	B1	B2	C1	C2	D1	D2	E1	F1	G1
Temperature (˚C)	28	28	26.3	25.8	25.5	25.4	24.8	25.0	23	26	27.8
TDS (mg/l)	22.53	13.73	81.38	74.40	59.89	34.74	21.73	41.67	126.90	63.98	48.3
PH	7.6	7.8	8.1	8.2	8.0	7.2	8.1	8.0	7.7	7.9	8.0
Colour	Slightly coloured	Slightly coloured	-	-	-	-	-	Slightly coloured	-	Slightly coloured	-
Turbidity	2.50	2.48	8.50	8.51	2.50	2.50	3.10	8.75	5.20	2.03	8.41
Conductivity	4.99	6.47	2.83	3.53	14.02	21.10	33.80	3.49	5.46	4.38	9.96
Water source	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL

Table 4: Result for chemical parameters

Sample Location	B.Kutiki	B.Kutiki	T.Alede	T.Alede	Ndragina	Ndragina	Durkwa	Durkwa	Shaffa	Shaffa	Shaffa
Parameters	A1	A2	B1	B2	C1	C2	D1	D2	E1	F1	G1
Total Hardness (mg/l)	6.8	17.6	35.4	41.6	17.8	23.0	34.6	31.0	52.6	42.8	52.1
Chloride (mg/l)	121.5	112.3	49.7	49.7	14.2	38.4	47.7	28.4	203.5	63.9	210.0
Sulphate (mg/l)	164.0	98.3	71.4	72.02	122.3	111.1	74.98	78.21	60.04	103.0	90.3
Nitrate (mg/l)	11.30	14.74	12.70	14.67	38.20	20.14	10.76	9.41	51.60	54.00	21.02
Fluoride (mg/l)	1.72	1.65	0.85	0.76	1.02	0.94	1.32	1.54	1.55	1.12	1.0
Iron (mg/l)	0.001	0.013	0.020	0.01	0	0.003	0	0	0.007	0	0
Manganese (mg/l)	0.04	0.22	0.47	0.004	0.032	0.43	0.005	0.004	0.232	0.63	0.61
Calcium (mg/l)	32.06	56.11	180.56	141.60	68.13	152.9	136.47	128.51	233.06	188.57	211.0
Magnesium (mg/l)	94.56	48.64	60.22	139.13	175.10	147.26	117.24	238.33	116.16	245.34	264.4

Table 5: Result for bacteriological parameter

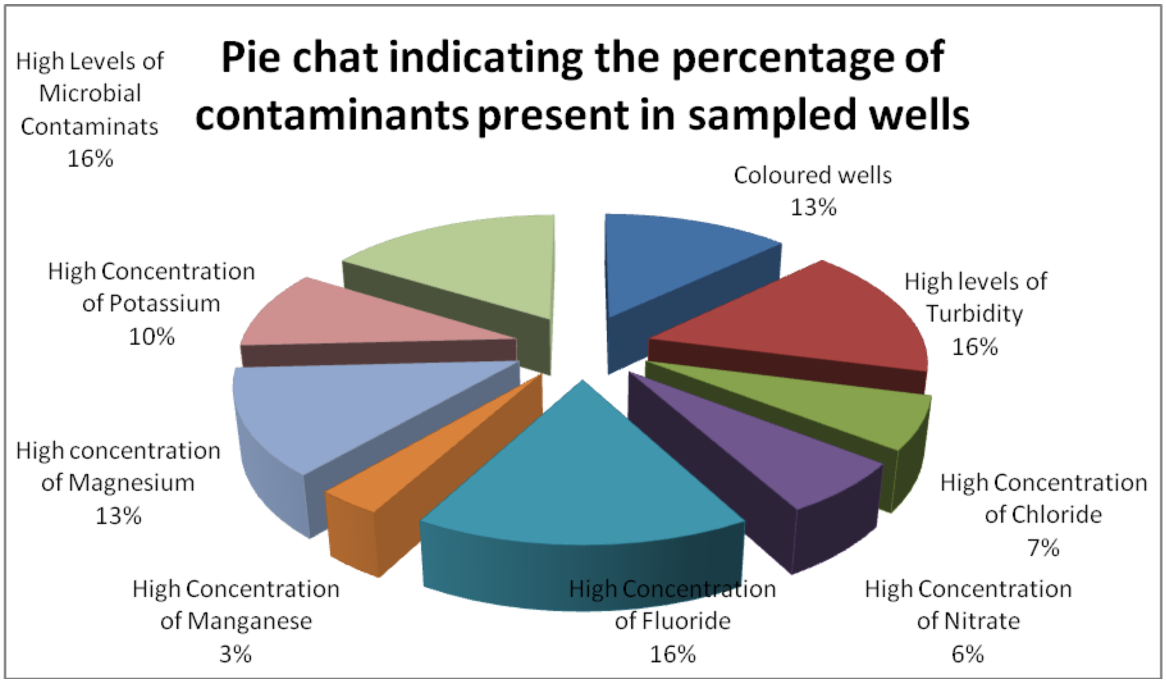
Sample Location	B.Kutiki	B.Kutiki	T.Alede	T.Alede	Ndragina	Ndragina	Durkwa	Durkwa	Shaffa	Shaffa	Shaffa
Parameters	A1	A2	B1	B2	C1	C2	D1	D2	E1	F1	G1
Coli Form	2.1	0	0	0	1.0	0	0	1.4	2.0	1.0	0
E Coli	-	-	-	-	-	-	-	-	-	-	-
Distance to Pollution Source	5.2	21.4	30.03	37.08	6.7	18.9	22.60	6.08	5.92	8.60	45.30

4.1 DISCUSSION OF VALUES/RESULTS

The results are discussed under its quality and portability for human consumption and compared with the World Health Organisation (WHO) standards/guidelines. From the results obtained, it was found that some of the parameters do not conform to the stipulated guidelines of most health authorities. General analysis of drinking water quality has become imperative with a view to know the final product made for consumption, conforming to be pure and wholesome. In the case of this research work, eleven selected wells from five different villages were analysed within Hawul local government area of Borno state with the objective of assessing their quality and determining the source of contaminant.

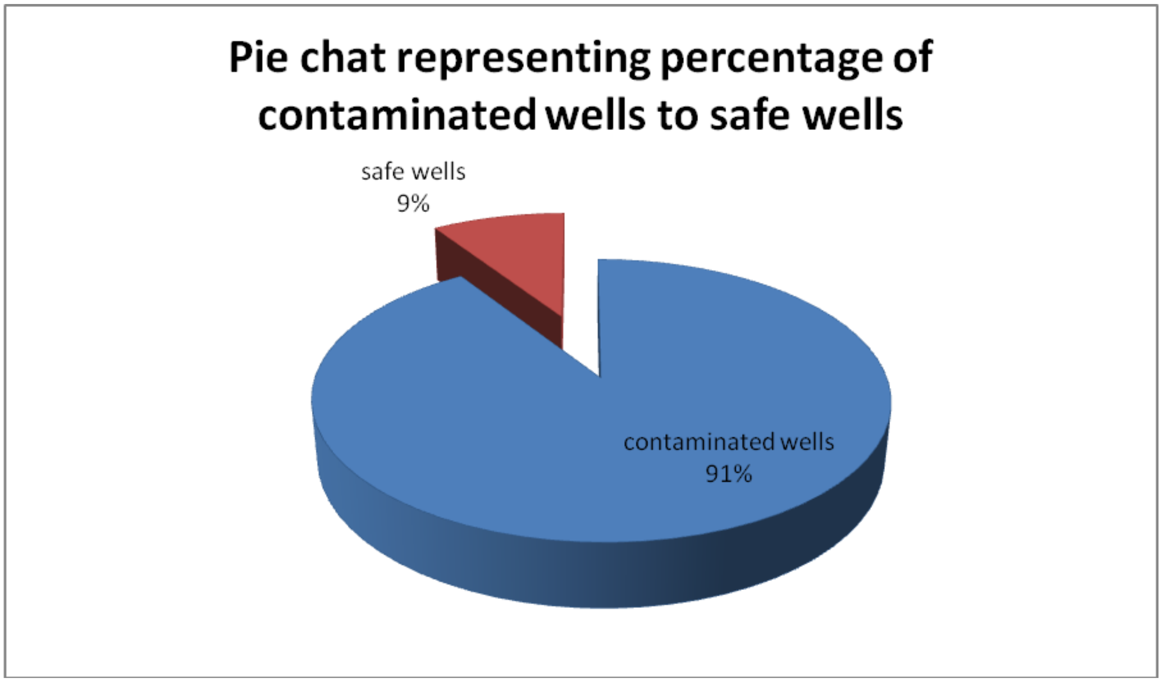
The outcome of the physical, chemical and microbial analysis reveals the following; temperatures were within the range of 23˚c and 28.2˚c hence adequate. However, wells A1, A2, D2 and F1 representing 36.3% of the total wells are coloured. Samples B1, B2, D2, E1 and G1 having values of 8.50NTU, 8.51NTU, 8.75NTU, 5.20NTU and 8.41NTU respectively as against WHO value of 5NTU amounts to 45.4% of wells with high level of turbidity. Wells E1 and G1 with values of 203.5mg/l and 210mg/l as against WHO value of 200mg/l amounts to 18.1% of wells with high concentration of chloride while wells E1 and F1 with values of 51.60mg/l and 54.00mg/l respectively as against WHO value of 50mg/l amounts to 18.1% of wells contaminated with nitrate. Wells A1, A2, D2, E1 and G1 amounts to 45.4% of wells containing high concentration of fluoride while well F1 with a value of 0.63mg/l as against WHO value of 0.5mg/l amounts to 9% of well contaminated with manganese. Wells C1, D2, F1 and G1 with values of 175.10mg/l, 238.33mg/l, 245.34mg/l, 260.21mg/l respectively as against WHO value of 150mg/l amounts to 36.3% of wells with high magnesium while E1, F1 and G1 with values of 2.03mg/l, 2.01mg/l and 2.09mg/l respectively as against WHO value of 1-2mg/l amounts to 27.2% of wells contaminated with potassium. Finally, wells A1, C1, D2, E1 and F1 with values of 2.1, 1.0, 1.4, 2.0 and 1.0 MPN/100ML respectively as against WHO guideline (Coli form count/ E-coli must not be detected in 100ml per sample) reveals that 45.4% of wells are contaminated by microbial contaminants.

Figure 1: A Pie Chat representing the level of contaminants in samples wells



Other parameters such as TDS, EC, PH, Hardness, sulphate, Iron, calcium, and sodium all complied with the maximum contaminant levels stipulated by WHO and NAFDAC as a guide in ascertaining pure, safe and portable drinking water to both urban and rural communities.

Figure 2: A Pie Chat representing the percentage of contaminated wells to safe wells



5.0 CONCLUSION

Water is essential to people and the large available source of fresh water lies under ground. Increase in demand for ground water in the rural areas has lead to contamination and the outbreak of diseases. Experience has shown that the major risks to contamination is not from source but between collection and use as the people of those communities have developed resistance to some extent of the chemical contaminants but that does not ascertain that it is safe for everyone since we don't have the same immune systems. The peculiar climate and terrain of Hawul local government has made ground water the major source of water supply as well as the most important means of rural water supply. From both the physic-chemical and bacteriological analysis, result shows that open or poorly covered well heads pose the commonest risk to well water quality. The presence of faecal coli form however is due to a pollution source (pit latrine and cattle ranch). These are mostly observed to be at a distance between 5 and 8 meters which makes it possible for pathogens to travel easily to the water source. Most pathogenic bacteria found in water are indigenous to the intestinal tract of humans and animals and with the presence of a pit latrine or a cattle ranch close to a well, there is a high risk of contamination.

6.0 RECOMMENDATIONS

Hawul being one of the fastest growing local government areas of Borno state is entitled to safe and portable drinking water to its communities. Measures to improve water quality are so many depending on the body responsible. In respect to the result obtained from this study however, the following recommendations are made;

- Water from open wells should be monitored regularly by health care supervisors or appropriate authorities who are responsible for safe drinking water.
- Bore holes should be recommended in place of wells.
- Wells should be covered with metal or proper wooden lids to avoid contamination.
- Educate well users on personal safety and hygiene.
- Pit latrines and cattle ranch should be located within a minimum distance of 20meters away from water source.
- The ambient area of the well should be sealed with concrete to make the well impervious to surface water infiltrating to ground water.
- The wells should be disinfected and/or chlorinated regularly against bacteria.
- Political reasons must not be allowed to prevail over the needs of the people in the society, hence proper funds should be made available by the government for improving ground water supply as well as providing pipe network within the township to provide treated and protected water from open dug wells at various location to be supplied to the consumer with serious concern.

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