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Research Article

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Assessment of Groundwater Quality Around Sanitation Facilities in Gudum Hausawa, Bauchi, Nigeria

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Abstract In many countries around the world, including Nigeria, access to potable water has become a mirage. Exploitation of groundwater through the construction of hand-dug wells is a major source of drinking water for majority of the populace especially in suburban areas. The need to assess the quality of water from this source to ascertain the role of well water quality has now become imperative because of the health impacts on individuals. Series of samples were collected at Gudum Hausawa province which consists of Angwa Ecwa, Angwa Tala, Angwa Sabongari and Angwa Boreholes located in Bauchi, Nigeria. Twenty (20) hand-dug wells were selected. Results obtained showed that the turbidity varied between 0 to 16 NTU and colour ranged from 0 to 24 Pt- Co. The total suspended and dissolved solids content was high. The conductivity ranged from 110 to 780µs/cm, while pH ranged from 7.0 to 7.9. Calcium and Magnesium ions as well as chloride ion content of the water were within the specified limits. Bacteriological indices showed that the well water was highly contaminated having high total bacterial counts (2 -101 cfu/100ml). The well water showed presence of feacal coliform (E. coli) and had high coliform counts > (0 cfu/100ml). Therefore, the water quality was negatively affected by the surrounding latrines and other sanitation facilities.

Keywords Groundwater, Sanitation Facilities, Quality, WHO, NAFDAC, Hand-dug well

1. Introduction

Some precipitation infiltrates the ground and percolates down ward through voids (pores, fractures, crevices and other spaces) in the soil and rock. The water in these voids is called Ground water. The volume of ground water greatly exceeds that of all fresh water lakes and reservoirs combined. It occurs in several geological formations (aquifers) and at various depths. It is further explained as, that which occupies pores and above layers of impermeable materials [1]. It is free to move gravitationally either downward towards the impermeable layer or by following a gradient.

Ground water generally, has a more constant temperature, less sedimentation and less dissolve materials. They are therefore less prone to pollution when compared to surface waters. However, ground water can be polluted by industrial, domestic (refuse dumps, wastes water seepage, spillage) and other waste that have been buried underground [2, 3 & 4]. Also, agriculture input such as dissolve soluble ions and thereby changes its chemical composition [5]. Many variables in the environment affect chemical processes which lead to wide variation in water quality. Variations in water quality may render its hazardous to human health or pleasant taste low agricultural productivity and unsuitable for some industrial use. Disease causing micro-organisms such as coli form bacteria can be introduced into water supply system during well construction; pit latrine and household waste. Feacal coli form is an indicator of anthropogenic contamination affecting the quality of water to be used for drinking purpose [6]. The presence of these bacterial dictates actual pollution by all pathogens which may be

excreted and which effect the animal and human population of the hydrological catchment areas. Primary drinking water standard regulate organic and inorganic chemicals. Water quality is determined by assessing three classes of attributes, chemical, and biological. There are standards of water quality set for each three classes of attributes. These standards were developed by the world health organization [7]; all public water supplies must be measured against these standards. Some attributes are considered of primary importance to the quality of water, while others are of secondary microbial pathogens and radioactive elements that may affect a set limit. The maximum contaminant level (MCL) on the highest concentration of certain chemicals allowed in the drinking water standards regulate chloride, color, copper corrosives, foaming agents, iron, manganese, odour, pH , total dissolved solids etc. all of which may affect qualities of drinking water, like taste, odour, colour and appearance.

Dug wells are essentially shafts sunk by manual labour from the land surface to a surface to a depth some distance below the water table or ground water level. If they are dug through hard rock, a wall is commonly built around the mouth of the well in order to limit the entrance of water from land surface during storm and to prevent soil from sloughing into the well. However, if they are dug through materials such as sand and clay, the walls most be shored up as the digging processes in order to prevent caving in. Generally the water is raised from the wells by a rope attached to a bucket made of skin, or, later of such materials as wood and steel. Although dug wells are good sources of water for rural communities, researches on potentially toxic elements and pathogens are is crucial so as to protect human health [8].

2. Materials and Methods

The method of study involves collection of water samples from twenty (20) different points (hand dug wells). All samples used in this research work were collected from four different Areas of Gudum Hausawa with at least five samples from each of the areas taken for quality test. Standard method of collection and laboratory analysis were used because, the interpretation of laboratory analysis depends on condition of sampling. Average results was taken and compared with National Food and Drugs Administration and Control (NAFDAC) standard for drinking water.

Study Area

The study is Gudum Hausawa in Bauchi town of Bauchi state, Nigeria. Bauchi is located in the North-East of Nigeria on latitudes 90 30'N of the equator and longitudinally lies between longitude 80 50' and 110 E of Greenwich meridian with two tropical climates marked by two seasons; rainy and dry seasons. The natures of the activities that will cause alarm in terms of water quality are as follows; presence of sanitation facilities near water source, Runoffs as a result of washing, rainwater and Chemical content of the soil. The main source of water in the study area is groundwater obtain from hand dug wells. The water is mainly used for drinking and other domestic activities like cooking, laundry, car wash, bathing, watering garden, processing of local product e.t.c. The depths of latrines and septic tank in the study area are within the range of 2.0m - 2.4m and the depths of hand dug wells are within the range of 9m - 11m. Majority of the hand dug wells are not lined with concrete.

Sample Collection

Five samples were collected from each location, in which physical, chemical and bacteriological parameters were determined on each one. Samples for physical and chemical test were collected in new plastic bottles. The bottles were first washed with 10% of HCL, rinsed with tap water and finally rinsed with distilled water. At the sample collection point, the bottle was rinsed twice with the water to be collected before collection. Each sample was acidified with conc. Nitric acid in order to preserve the ions in solution and to prevent the growth of bacteria and fungi. Samples for bacteriological analysis were collected in a glass ware container that were sterilized and properly cap and covered with aluminum foil. The samples were immediately stored in an ice packed cooler. All samples were collected were properly taken to laboratory for quality tests and analysis.

Laboratory Test

Three categories of tests were carried out, these were

Physical Test

Five physical parameters were determined; turbidity, colour, odour, taste and total dissolved solids. Turbidity and colour were automatically measured using DR 890 (HACH) colorimeter which was programmed at number

35 and 19 respectively. The water samples were tested by smelling to detect if odour and taste was objectionable. Total Dissolved Solids was measured by automatic digital TDS meter.

Chemical Test

PH, Dissolved Oxygen, Chloride Concentration and Trace Metals were measured for each sample. pH was measured by automatic digital ph meter which was first calibrated with a standard buffer solution. Dissolved Oxygen was measured using Potassium Permanganate Consumption Method. Chloride Concentration was measured using DR 890 (HACH) colorimeter programmed at number 58. Atomic Absorption Spectrophotometer was used for the determination of metal ion concentration in the samples.

Bacteriological Test

The Preparation of ager (culture media): 28grammes of auger powder was weighed and dispersed in 1 liter di-ionized water. The solution was allowed soak for 1 minute. It was then mixed properly and sterilized by autoclaving for 15 minutes at 1200oC. It was then allowed to cool to 450c then poured into Petri dish and allow to gel. About 10 ml of distill of distill water was measured and poured into each test tube and serial dilution was made in 1.0 ml of diluted sample was then measured from the culture media. The calories formed in each dish were counted.

3. Results and Discussion

Twenty (20) samples of water collected from four different areas in Gudum Hausawa province are tagged as follows: Anguwan Ecwa (samples A1 to A5), Anguwan Tala (samples B1 to B5), Anguwan sabon Gari (samples C1 to C5), Anguwa Boful (samples D1 to D5). The mean value of each parameter was considered in this research.

Table -1: Sampling Location Details

Sample ID	Mode of on-site sanitation	Distance of Well from sanitation facility (m)	Depth of Well (m)	Depth of sanitation facility (m)
A1	Soak away	21	9	2.0
A2	Latrine Toilet	23	10	2.4
A3	Soak away	15	10	2.3
A4	Latrine Toilet	10	11	2.2
A5	Latrine Toilet	12	10	2.2
B1	Latrine Toilet	5	9	2.4
B2	Latrine Toilet	25	11	2.4
B3	Latrine Toilet	10	11	2.4
B4	Latrine Toilet	13	10	2.3
B5	Latrine Toilet	17	11	2.2
C1	Latrine Toilet	23	9	2.2
C2	Latrine Toilet	25	10	2.3
C3	Latrine Toilet	15	11	2.3
C4	Soak away	13	10	2.0
C5	Latrine Toilet	6	9	2.4
D1	Latrine Toilet	11	10	2.3
D2	Latrine Toilet	8	11	2.2
D3	Soak away	13	11	2.4
D4	Latrine Toilet	7	9	2.2
D5	Soak away	23	10	2.3

Analysis with respect to location

Physical Tests Results

Turbidity in water results from the presence of suspended solids. Turbidity is known to have effects on taste, odour and colour of water [9]. It also serves as a transport medium of giardia and cryptosporidium cystsin drinking water system [10]. The results of analysis shows that Gudum Hausawa province was observed to have turbidity ranges from (6.3-12.5) NTU respectively. These values are however still within the recommended

values by WHO and NAFDAC standard. The results obtained for colour in table 1 shows that the samples colour were within a range of (10.8-15.7) Pt-Co. which is less than 50 Pt-Co. and therefore conform to WHO standard for drinking water. Therefore the samples do not contain organic and mineral matter in excessive quantities which may impact an unpleasant taste. The temperature values are less than 35oC as stipulated in WHO for temperatures. The ranges of temperature for samples are (27.1-27.6) which is in conformity with WHO standard which is ambient. The results obtained for total dissolved solid (TDS) of the samples were in range of (128-330.8) mg/L which is less than 500 mg/L and therefore conform to WHO standard as regard to TDS. Total dissolved solids above the WHO upper limit of 500 mg/L may affect the taste of drinking water negatively and not considered fit for drinking purpose. The results of this clearly shows that the salinity of the potable water analyzed is within the limit recommended for consumption. The total suspended solid value in the well water of the study areas ranges from 0.1-0.12mg/l, which is very low as compared to WHO standard. The values of the suspended solid in the water are within the standard and require no treatment. The presence of clay or clay material suspended particles in drinking water may not adversely affect health but rather water containing such particle may require treatment to make it suitable for use.

Table -2: Physical, Chemical and Biological Parameters

	Anguwan ECWA	Anguwan Tala	Anguwan Sabon Gari	Anguwan Boful
Turbidity (NTU)	7.2	7.8	12.5	6.3
Colour (Pt-Co)	15.7	10.8	13.8	11.6
Temperature (^{0}C)	27.2	27.1	27.6	27.4
TDS (mg/L)	184.2	379.6	128	330.8
TSS (mg/L)	0.12	0.12	0.1	0.1
pH	7.3	7.7	7.2	7.5
EC (µS/cm)	404	586	214	458
Chloride (mg/L)	0.1	0.1	0.1	0.1
Calcium (mg/L)	26.4	38.43	25.36	35.66
Sodium (mg/L)	30.41	36.26	30.54	20.75
Iron (mg/L)	1.88	4.06	3.27	3.51
Copper (mg/L)	0.05	0.05	0.04	0.03
Magnesium (mg/L)	1.31	1.91	2.21	2.13
Potassium (mg/L)	12.5	14.8	11.34	22.6
BOD (mg/L)	3.19	1.39	0.12	1.21
Total Coliform Count (cfu/100ml)	27.4	10.8	25.8	56.8

Chemical Test Results

pH ranges from (7.2-7.7). All the water samples analyzed are within the range as recommended by WHO. It is very important to state that the well water samples with pH within the regulatory guideline values do not have any probability of posing health issues like acidosis [11]. The sample values for electrical conductivity (EC) ranges from (214-586) which is very high as compared to WHO standard for drinking water. This makes the sample waters less conductive. All the water samples analyzed had a chloride content of 0.1 mg/L. The result is appreciably within the NAFDAC guideline value of maximum permissible concentration of 250 mg/L desirable for drinking water. This limit has been laid down primarily based on taste considerations. However, no adverse health effects on humans have been reported from intake of water containing even higher concentrations of

chloride [9] but higher concentration of chloride ions in drinking water can add its taste to the water. The concentration of calcium in the samples analysed varied from (25.36 –38.43) mg/L. The observed values in all the analyzed water samples are satisfactorily below 72mg/l as recommended by WHO. Excess calcium may impact a salty taste in water. Results obtained in table 2 showed that the amount of sodium in the well water of the study area ranges from 20.75-36.26mg/l. For a healthy person, the sodium content of water is not a concern because the intake from table sale in ordinary diet is greater, but for those on low-sodium diet. Sodium water must be considered and the usual low sodium diets allowed is 20mg/l in drinking water [7].

The level of concentration of Iron is within the ranges of 1.88 - 4.06mg/l and the WHO maximum value is 1.0mg/l. Therefore, the iron content of the water is not within the WHO range. A possible source of iron in some sample wells is the ferruginization of aquifer materials which give way for extraneous fluids and oxygen to feed in to the well. The copper content of the sample well water in the study area is within the range of 0.03 – 0.05 mg/L. The WHO standard for cupper in drinking water is 0.5mg/l. According to [7], copper is rarely found in natural waters. Presence of cupper is an index of pollution from runoff effluence that comes from leachate deposited nearby areas. Magnesium concentration ranges from (1.31-2.21)mg/l, when these values are compared with WHO limit of 30 mg/l, it shows that there exist an appreciable concentration of the metallic ion, whose presence were due to the type of material deposited, rock type and soil material in the area. Potassium is necessity for the sustenance of a biological system. It is an essential nutrient in intracellular fluid, acid-alkaline balance, osmotic, pressure regulation, muscular contraction and nerve impulse conduction [12 & 13]. This mineral element was detected in all the locations. The concentrations of potassium from table 2 are within the range of 11.34-22.6 mg/l which is beyond the guidelines set by WHO. The values of BOD ranges from 0.12-3.19mg/L and are appreciably within the W.H.O guideline of 25mglL.

Bacteriological Tests Results

The result for bacteriological tests shows that the samples have a total coliform ranging from 27.4 cfu/100ml to 56.8 cfu/100ml while the recommended standard is 0 cfu/100ml. The high levels of faecal bacteria contamination are strongly attributed to poor quality of water source. Water sources with coliform greater than 3 cfu/100ml are unsuitable for consumption as they do not meet the [7 & 14] standard for drinking water. This level of contamination can lead to various water borne diseases such as typhoid, Amoebic dysentery, bilharzias and cholera, if the water is consumed untreated.

Analysis with respect to distance of water source from the sanitation facilities

This is to analyze the quality of ground water based on the distance of water source to the sanitation facilities. For this analysis, the physical parameters are considered and two of the chemical parameters in order to ascertain the water quality with respect to distance between water source and sanitation facility. Having established that the water is already contaminated with bacteria, there is need to relate the coliform count with distance between sanitation facility and water source.

Table 3 shows that the turbidity of the water samples are within the range of (7-8.8) NTU for all range of distance. This is within the standard recommended by NAFDAC which is (5-50) NTU. It was observed that the colours of the water samples were within the range of (9-15) Pt.Co which is less than the permissible standard for drinking water by W.H.O which is 50 Pt.Co. The water samples are within the range of (27.1-31) which is within the range of drinking water standard as stipulated by W.H.O (less than 35). The total dissolved solid of the water sample is within the range of (266-394) mg/l which is falls within the drinking water standard as stipulated by NAFDAC (less than 500) mg/l. The total suspended solids for water samples ranges from (0.1-0.13) which are less than 1000 as stipulated by NAFDAC.

Table -3: Distance vs Physical Parameters

Distance (m)	**Mean Value of Physical Parameters**							
	Turbidity (NTU)	**Colour** (Pt-Co)	**Temperature** (^{0}C)	**TDS (mg/l)**	**TSS (mg/l)**	**pH**	**EC** (µS/cm)	**Total Coliform Count** (cfu/100ml)
5 to 10	8.3	15	27.4	305.8	0.12	7.5	472	50.3

10 to 15	6.5	11.9	31	266	0.13	7.4	366	27.9
15 to 20	7	9	27.1	394	0.1	7.6	550	21.0
20 to 25	8.8	10.7	27.4	174.8	0.13	7.3	307	12.8

Table 3 shows that the water sample analysis carried out for PH is within the range of (7.3-7.6) which is also within the drinking water standard stipulated by W.H.O (6.5-8.5). The sample values for electrical conductivity (EC) ranges from (307-550) which is very high as compared to WHO standard for drinking water. The result for bacteriological tests shows that the samples have a total coliform ranging from 12.8 cfu/100ml to 50.3 cfu/100ml while the recommended standard is 0 cfu/100ml. These high levels of faecal bacteria contamination are strong indications that the water is of poor quality.

4. Conclusion

The result of the study carried out were to ascertain the physico-chemical and bacteriological quality of water from selected hand-dug well in the study area suspected to have been polluted. The outcome of the study has revealed a lot of things. Some physical and chemical quality parameters of water from the sampled hand-dug wells are in accordance with WHO and NAFDAC prescribed limit for drinking water quality. The conductivity appeared to be far above the standard limit, which indicates that the water from these wells contains dissolved elements and it is a clear indication of the extent of pollution in the environment. Based on high availability of some parameters, the water when consume by human will cause adverse health and physiological effects. Therefore, water from these wells needs a standard method of treatment to reduce the pollutant to a permissible value.

On average, water samples from the study area has been strongly polluted by bacterial irrespective of location or distance between water source and sanitation facility. In conclusion, the well water from these locations is not recommended for drinking due to high bacteriological contamination. These contaminations may be due to following factors; -

i. Closure of latrines and soak away pits at the surrounding wells.
ii. Indiscriminate human defecation and other wastes, which are disposed of nearness to the source of water.
iii. Irrespective of the method of analysis, microbial evaluation revealed that the sample well waters had total bacteria coliform count exceeding limits compared by all standards especially those who are much closer to the sanitation facilities
iv. Ingression of contaminants into wells, which have not been well constructed, lined or left uncovered.
v. The nearness of the static water level to the surface in area where porous and permeable rocks/soil overlies the water table.

Based on the outcome of the study, the following recommendations are made:

i. Latrines and soak away pits should be constructed far away from existing wells to avoid contaminations.
ii. An effective government legislature regarding the dumping of refuge in areas where there is tendency of contamination of underground water should be imposed.
iii. Community should be educated on the choice of siting their hand-dug well, so that they should not be cited near source of contamination like refuse dumps, pit, runoff drainage and motorable roads.
iv. There should be regular sampling and analysis of water from hand-dug wells in a community in the state by concerned authority in order to monitor the amount of physio-chemical and bacteriological concentration of well and ensure public health safety.

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