Analysis of Physico-Chemical and Microbiological Properties of Bore Holes and Well Water in Kuje, Kuje Area Council, Abuja, Nigeria

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***Abstract*:-The quality of borehole and well waters from six locations in Kuje area council, (Kuchiyako, Angwar sanyi, Angwar gede, Sauka extension, Bayan town hall and Gudaba) in the Federal Capital Territory Abuja was assessed by undertaking their physical, chemical and microbiological analyses. The risk involved in the everyday uses of these water sources by the residents of these villages was assessed using odour, colour, pH, conductivity, turbidity, alkalinity, acidity, total dissolved solids (TDSs), total suspended solids (TSS), hardness, BOD, elemental composition (manganese, iron, lead and Cadmium), chloride, nitrate, phosphate, Sulphide and total coliform. Results obtained showed that the average values for parameters like colour range, conductivity, TDS, hardness, chloride, nitrate, manganese, Cadmium, though may vary according to water sources and locations, all fall below permissible limits but values for others like iron, lead, pH and alkalinity exceed the permissible limit. The microbial growth for all the samples obtained is below detectable limit; therefore the water samples have minimal potential risk for microbial pathogens. The water sample from these study areas are not suitable for drinking but can be used for other domestic purpose, such as laundry, washing etc.**

Key Words: **pollutants, contaminants, ground water, surface water, drinking**

I. INTRODUCTION

Water is vital to life. This view is not surprising since the need for water, throughout human history, has always been appreciated. The main sources of fresh water are ground and surface water. These sources of freshwater resources are threatened by overexploitation, poor management and pollution. The Greek philosopher Pindar described water as the “best of all things”. Population growth and increasing demands for water, however, coupled with contamination from point and nonpoint sources, threaten the quality and quantity of our water resources (USGS, 2010). The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Metwally *et al* (2006) reported that the implications of lack of clean water are widespread. People died as a result of suffering from diarrhoea, typhoid illnesses and dangerous diseases caused by the contaminated drinking water such as cancer, neurological disorder etc.

Serious ill health can be caused by water contaminated with faeces being passed or washed into river, stream, pool or being allowed to seep into well or borehole. There has been a report of borehole water contamination through much domestic waste water and livestock manure especially if there is a puncture in a layer of soil (Obi and Okacha, 2007). These waste and sewage, when deposited near the boreholes may travel with percolating rain water directly into the boreholes or may travel along the well-wall or surrounding material of the drill-holes (Obi and Okacha, 2007). The high prevalence of diarrhoea among children and infants is associated with the use of unsafe water and unhygienic practice (Oladipo *et al*., 2009; Tortora *et al.*, 2002). Thus, many infectious diseases are transmitted by water through faecal oral contamination. Water may contain toxic inorganic chemicals which may cause either acute or chronic health effect (Tortora *et al.*, 2002).

The quality of groundwater is highly related to local environmental and geological conditions, such as the quality of soil and rock types found in the area. According to Jibrin *et al* (2015) groundwater is the most common source of water in rural communities; it has proved to be the most reliable resource for meeting water demand in rural areas. Also faecal pollution of drinking water causes water born disease which has led to the death of millions of people (Adefemi and Awokunmi, 2010)..

The quality of drinking water has attracted great attention worldwide because of implied public health impacts. Boreholes and wells are the most common drinking water sources in Nigeria. The majority of the population consume it, hence the need to ascertain the qualities of borehole and well water in order to safeguard the health of consumers. Many common and widespread health risks have been found to be associated with drinking water in developing countries, a large percentage of which are of biological origin (Fredrick, 1990). The importance of high quality water cannot be over-emphasized as it sustains human life and maintains health.

Due to the increasingly use of well and borehole waters in the country as a major source of drinking water, there is need to constantly analyze these water sources in order to check the level of contamination and its effects on human health. The results of such a study can be a basis to provide recommendations that could help in controlling and minimizing present and future contaminations of such drinking water sources.

The aim of this work is to ascertain the quality of borehole water from six different locations (Bayan town hall, Angwar gede, Angwar sanyi, Gudaba and Sauka Extension) in Kuje area council of FCT Abuja. The quality indices include physical, and chemical, parameters and some mineral contents of the samples which shall be used to ascertain the safety index and potential risk to the communities.

II. MATERIAL AND METHODS

Samples Collection

The water samples were collected from six different areas (Bayan town hall, Angwar gede, Angwar sanyi, Gudaba and Sauka Extension) within kuje area council, FCT Abuja. The samples were collected from both the well and bore hole in the polyethylene bottles and were brought to the laboratory for further analysis:

Methods of Analysis

Analysis of the water samples was carried out in THREE different categories namely:

(I) Physical analysis

(ii) Chemical analysis

(iii) Microbiological analysis

Physical analysis

The Color of the samples was determined using hazen disc loved bird model F-BS684**.** The electrical conductivity of the samples was determined using the conductivity meter (Jenway model 4010). pH values were determined using the pH meter (model PBS – 51, EL – Hama instrument)).The turbidity of the water samples was measured by turbidity meter (model HACH 2100Q Colorado); the meter contains a bottle in which the water samples were induced. The bottle was inserted into a cavity hole on the turbidity meter and allows it to read for 30 seconds before the reading was recorded.

Chemical Analysis

Determination of Dissolved Solids

An empty beaker was weighed; 50mls of the water sample was measured and filtered into the beaker. The filtrate was heated to dryness, cooled and reweighed with the beaker, until a constant mass is obtained and the value was recorded.

$$Dissolved\ solids\ (mg/L) = \frac{W1 - W2\ X\ 1000}{Sample\ \ Volume\ \ (ml)} \quad ---- \quad (1)$$

W_1 = weight of dried residue + dish, W_2 = weight of empty dish

Total Hardness

Exactly 50ml of the sample is pipetted into a conical flask, to which 1ml of ammonium buffer and 2-3 drops of Eriochrome black T indicator is added. The mixture is titrated against standard 0.01M EDTA until the wine red color of the solutions turns pale blue at the end point (Apha, 1998).

$$Total\ hardness\ = \frac{volume\ \ of\ EDTA\ x\ N\ x\ 50\ x\ 1000}{Volume\ \ of\ Sample\ \ taken} \quad ------- (2)$$

N= normality

Determination of Alkalinity

Water (10ml) sample was pipette into a conical flask. Three drops of methyl orange indicator were added and titrated with 0.1M NaOH to give an orange color. Alkalinity was calculated using the formula given below;

$$Formula: \frac{TV\ x\ 50{,}000\ x\ N}{Vol\ of\ the\ sample} \quad ---------------------- (3)$$

Determination of dissolved oxygen (DO) (APHA, 1998)

The dissolved oxygen (DO) content of the surface water and underground water samples was measured using the Jenway Model 9070 waterproof meter according to the standard method described by APHA (1998)

Determination of Nitrate, Phosphate and Sulphate (Greenberg et al., 1992)

The HANNA multi parameter logging spectrophotometer (HI83200) was used to digitally determine the nitrate, phosphate and sulphate in the surface water and underground water samples.

Determination of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (Ademoroti, 1996)

Determination of the Biochemical Oxygen Demand and Chemical Oxygen Demand of the surface water and underground water samples was carried out using standard methods described by Ademoroti (1996).

Determination of Lead and Manganese

Water samples were prepared and analysed for Lead and Manganese using spectrometer (ice 3000 aa02134104 v 1.30) at a flame mode at a wavelength of 217.0nm and 279.5nm respectively.

Microbial parameters/ Total Coliform

The membrane filtration technique (Hatch-Company, 2012) was employed in the determination of total coliform using Wagtech field kits.

III. RESULTS

The average values of the determined parameters for the water samples from the different locations alongside with the Standard Organization of Nigeria (SON) values are presented below.

Table 1: Physiochemical and biological properties of Boreholes water from different locations in Kuje, Kuje area council, FCT.

Parameters	/Location	Angwar sanyi	Gudaba	Sauka Extension	Kuchiyako	Angwar gede	Bayan town hall	SON
Odour	-	odourless	Odourless	Odourless	Odourless	Odourless	Agreeable	Unobjectionable
Colour	-	Colourless	Turbid	colourless	colourless	Colourles s	Colorless	5
pH	-	6.49	6.62	6.82	6.55	6.54	6.08	6.5-8.5
Conductivity	μS/cm	109.7	313.85	373.9	200	346.2	358.5	1000
Turbidity	NTU	0.9	1.6	0.9	0.9	0.8	1.2	5
Alkalinity	mg/ml	680	280	480	240	360	340	-
TDS	mg/ml	79	204	243	130	225	233	500
Total hardness	mg/ml	2	2.8	2	1.6	2.4	3.4	150
Chloride	mg/ml	0.58308	1.6034	4.227	1.3119	2.1876	2.187	250
TSS	mg/ml	0.03	0.01	0.001	0.01	0.001	15	-
Phosphate	mg/ml	Nil	Nil	Nil	0.22	0.04	0.2	-
Sulphide	mg/ml	Nil	5	Nil	Nil	-	25	3
BOD	mg/ml	7.3	8.3	6	8.1	7.8	6.6	-
Manganese	mg/ml	-0.0951	-03755	-0.6806	-0.4978	-0.5685	-0.4104	0.2
Iron	mg/ml	5.59	1.01	2.54	3.23	2.8	0.75	0.3
Lead	mg/ml	0.4321	0.9907	1.7617	1.3969	0.1995	0.1608	0.01
Cadmium	mg/ml	0.1964	0.2095	0.1840	0.1818	0.1940	0.5132	0.003
Total coliform	cfu/ml	Nil	Nil	Nil	Nil	nil	ND	10

Table 2: Physiochemical and biological properties of well water from different locations in Kuje, Kuje area council, FCT.

Parameters	/Location	Angwar sanyi	Gudaba	Sauka Extension	Kuchiyako	Angwar gede	Bayan town hall	SON
Odour	-	Odourless	Odourless	odourless	Odourless	Odourless	Agreeable	Unobjectionable
Colour	-	Colourless	Colourless	colourless	Colourless	Colourless	turbid	5
pH	-	6.59	6.18	6.67	6.98	6.22	6.65	6.5-8.5
Conductivity	μS/cm	349.2	892.3	669.2	183.07	530.77	604.6	1000
Turbidity	NTU	1.6	1.5	0.9	1.9	1.12	1.8	5
Alkalinity	mg/ml	140	580.05	280	160	400	440	-
TDS	mg/ml	227	580	435	119	345	393	500
Total hardness	mg/ml	3.2	2.001	2	1.2	3.6	3.2	150
Chloride	mg/ml	2.624	6.997	1.6035	1.6035	3.498	3.644	250
TSS	mg/ml	0.1	0.05	0.01	0.02	0.01	11	-
Phosphate	mg/ml	Nil	0.01	0.01	0.29	0.08	0.01	-
Sulphide	mg/ml	Nil	Nil	Nil	Nil	5	ND	3
BOD	mg/ml	7.9	4.5	8.7	7.5	6	0.75	-
Manganese	mg/ml	-0.5773	-0.4881	-0.2593	-0.1298	0.2608	-0.1951	0.2
Iron	mg/ml	3.11	Nil	2.94	3.18	3.44	1.85	0.3
Lead	mg/ml	1.3462	2.0678	2.0396	1.6813	0.3624	1.9655	0.01
Cadmium	mg/ml	0.2194	0.2647	0.1378	0.2194	0.1753	0.3254	0.003
Total coliform	cfu/ml	Nil	Nil	Nil	Nil	Nil	ND	10

SON = Standard Organisation of Nigeria ND = Not Detected TDS = Total dissolved solid

Odour

The odor of the well and borehole water samples from all the locations were found to be agreeable, and odorless. This signifies low concentration of dissolved solid since high concentration in water could be responsible for odour (ASTM, 2004). Similar results of odour were obtained from similar analysis conducted in different part of Abuja (Gidado, et al, 2017) where all of the locations the odour of the samples was found to be agreeable.

Color

The analysis of the samples from the six locations showed that they were colorless, except for borehole water in Gudaba and well water in Bayan town hall. The areas were the water samples are colorless may be as a result of low dissolved and suspended solids in the water samples, and high level of dissolved and suspended solids in the areas where the water samples were found turbid. Color is a critical quality parameter and the Color in drinking water can be caused by dissolved and suspended materials, which may be due to natural causes or human activity (mahananda, et al 2010)

pH

The mean results of pH obtained for BWGD, WWGD, BWAS, WWAG, and BWBT, were below 6.5 which indicate they are slightly acidic and are fairly comparable with the standard value of the SON (6.5 – 8.5). pH results obtained in this study suggest that isolates identified may tend to thrive in slightly acidic environments which are consistent with the report of Jideani (2003). The PH values of (WWSE, BWAG, WWBT, WWKY, WWAS, BWKY, BWSE), Are all within the permissible limit specified by the SON. Drinking water with an elevated pH above 11 can cause skin, eye and mucous membrane irritation. On the opposite end of the scale, pH values below 6.5 cause ulcer and irritation due to the corrosive effect of the low pH level (Wikipedia-pH, 2010). The pH range in this study is close to neutrality and would allow the growth of most bacterial species. Eniola et al., (2007) obtained similar pH ranges of 6.54 – 7.80 and 6.54 to 7.90 for borehole water.

Conductivity

The conductivity of the bore hole water samples in all the six locations ranged from 109.2 us/cm to 669.2 us/cm while that of the well water samples have the lowest to be 183.07 us/cm and the highest to be 892.3us/cm. Both categories of conductivity values fall below the permissible limit (1000us/cm) and are in agreement with Nigeria Standard of Drinking Water Quality (NSDWQ, 2007). The obtained values ,however are similar to the result obtained from similar analysis of the water samples by Bundela et al, 2012 which ranged between 571us/cm to 959us/cm indicating the presence of high amount of dissolved inorganic substances in ionized form.

Turbidity

The turbidity mean results of the well and bore hole water from the six locations shows that, they are all below the permissible limit given by the SON (5 NTU). This is due to little or no presence of colloidal solids presents in the water that causes water to have cloudy appearance and reduction in transparency. Turbidity in waters results from colloidal clay particles and Colloidal organic matter originating from decay vegetation. The higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases (Gidado *et al*, 2017). This is especially problematic for immune-compromised people, because contaminants like viruses or bacteria can become attached to the suspended solids (Gidado *et al*, 2017).

Alkalinity

Alkalinity is defined by (Ademorati, 1996) as a measure of the ability of water samples to neutralize strong acids to an arbitrary pH or an indicator end-point. The measure of the capacity of natural water to neutralize acid is alkalinity. The alkalinity of well water samples from the six locations ranged from 140mg/l to 580.05mg/l while that for the borehole water samples were found to ranged from 240mg/l to 680mg/l. These values show that the borehole water samples from Bayan town hall (440mg/l), Angwar Gede(360mg/l), Agwar sanyi (680mg/l), Sauka extension(480mg/l) and well water samples from Angwar Gede(400mg/l), Gudaba (580.05mg/l), and Bayan town hall (340mg/l) contains high presence of hydroxides, carbonate and bicarbonate making them more alkaline than others. High concentration of dissolved solid which are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles in water is responsible for hardness, alkalinity (ASTM, 2004).

Total dissolved solids

The TDS in well water samples in the six locations ranged between 119m/l to 580mg/l while that for borehole water samples ranged from 79mg/l to 435mg/l, which shows that the well water in the six locations contain higher content of TDS than the bore hole water samples but they are all below the standard value for drinking water (500mg/l) except for Gudaba well water having (580mg/l) which is above the permissible limit. All water sources in the study area are classified as fresh based on the proportion of TDS which fall between 0 to 1000 mg/L (Elueze, 2004). The TDS values observed are also within the range of the values (60 to 455 mg/L) observed by Oni (2000)

Hardness

Hardness is caused by metallic salt (ion) of Calcium and Magnesium and sometimes Fe. These salts are usually in the form of bicarbonate, sulphates and chlorides (Apha, 1999). From the result obtained, the mean value for hardness in well water samples from the six locations ranged between 1.2mg/l to 3.6mg/l, while for borehole water samples, the mean values ranged between 1.6mg/l to 3.4mg/l, but they are all below the SON permissible limit (150mg/l) and FEPA(1991) standards for water quality: Drinking water (200mg/l)

Chloride

Chloride content in the water quality serves as an indicator of pollution by sewage. People accustomed to higher chloride in water are subjected to laxative effects. In the present analysis, chloride content in well water samples from the three locations was found in the range of 1.6035mg/l to 6.997mg/l, and 1.3119mg/l to 4.227mg/l for boreholes, for all the three locations. All the mean values are below the standard value (250mg/l).

Manganese

The maximum mean value of manganese of well water samples from the six locations was found in Angwan Gede (0.2608mg/l) with the minimum obtained in Angwar sanyi (-0.5773mg/l). In case of the borehole water samples, the maximum mean value was found in Angwar sanyi (-0.0951mg/l) while the minimum was recorded in Sauka Extension (-0.6806mg/l). The mean values for both well and borehole water samples from five locations fall below the standard value (0.2mg/l), except for well water Angwar Gede (0.2608mg/l) which is above the permissible limit. Drinking water containing high levels of manganese can lead to Neurological disorder (SON, 2007).

Iron

The mean value of iron in well water samples from the six areas ranged between 0.92mg/l to 3.44mg/l, except for well water sample in Gudaba where it was not detected. While that of borehole water samples was found to range between 1.01mg/l to 3.59mg/l. It was found that the mean values of both well water and borehole water samples from all the six locations are above the standard value (0.3mg/l) except for Gudaba. However the mean values for borehole water samples shows they have higher values when compared to that of well water. Presence of high iron in drinking water may be due to the use of various iron salts as coagulating agents in water-treatment plants and where cast iron, steel, and galvanized iron pipes are used for water distribution.

High presence of iron in water promotes undesirable bacterial growth ("iron bacteria") within a waterworks and distribution system, resulting in the deposition of a slimy coating on the piping. Aeration of iron-containing layers in the soil can affect the quality of groundwater if the nitrate leaching takes place.

Lead

The maximum mean value of lead in well water samples was found in Gudaba (2.0678mg/l) which is above the standard value (0.01mg/l). The minimum value for lead in well water samples was found in Angwar Gede (0.3624mg/l) which is also above the permissible limit, while in borehole water samples the maximum mean values was found in Sauka extension (1.7617mg/l), while the minimum mean value is Bayan town hall (0.1608) and are also above the permissible limit.

The presence of high lead concentration in water samples for the six locations might be due to the pesticides used decades ago or industrial activities that contaminated the soil and groundwater. Additionally, this could also result from household plumbing activities around the sampling sites. Excessive amount of lead in water can cause cancer, kidney disease, memory problems, high blood pressure, brain damage, hearing loss and behavioral problems (SON, 2007).

Total coliform

The concentration of the total coliform in well water and borehole water samples from the six areas was found to be (Nil). Therefore, there is no potential health risk that exists for the communities due to the presence of microbial pathogens in water.

IV. CONCLUSION

From the overall results obtained, it is clear that Pb and Fe concentration of samples obtained from all the location are above SON standard value for drinking water and are attributed to the usage of iron salt for water treatment, steel and galvanizing iron for water distribution, pesticides and insecticides and plumbing activities. Most of the physicochemical parameters determined were within the SON permissible limit for drinking water. High level of dissolved and suspended matter were observed in Gudaba bore hole water and Bayan town hall well water which made them colorful. Bayan town hall bore hole, Angwar Gede bore hole, Agwar sanyi bore hole, Sauka extension bore hole, Angwar Gede well water, Gudaba well water, and Bayan town hall well water contains high presence of hydroxides, carbonate and bicarbonate making them more alkaline than others. The microbial growth for all the samples obtained is below detectable limit; therefore the water samples have minimal potential risk for microbial pathogens. The water sample from these study areas are not suitable for drinking but can be used for other domestic purpose, such as laundry, washing etc.

V. RECOMMENDATIONS

I. Domestic waste and effluents generated should be treated, re-processed for reuse purposes rather than being carelessly discharge into the water bodies.
II. Villagers should be regularly enlighten on how to defend their sources of drinking water from contamination and pollution
III. Government should enact laws that guarantee safe drinking water and minimize indiscriminate dumping of wastes on environment.
IV. Regular monitoring of water sources to ensure conformity to the SON and or WHO standards and to assure the public of the portability of their water is necessary. In fact simple tests carried out regularly at

short intervals are of more valued than detailed test mode occasionally.

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