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PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSES OF WELL WATERS IN THE FEDERAL CAPITAL TERRITORY, NIGERIA

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Abstract: Thephysico-chemical and bacteriological analyses of well waters in the six Area Councils of Federal Capital Territory (FCT), Nigeria were conducted. The physico-chemical parameters such as pH, Conductivity, Hardness, Ca2+, Mg2+ and Biological Oxygen Demand (BOD) were assessed with standard methods. The pH recorded was at the range of 6.85-7.85. The Conductivity was recorded highest in Kwali (106.70µs/cm) and lowest in Abaji (99.55µs/cm). The highest value of Hardness was found in Kwali (5.15mg/l) and lowest in Bwari (4.35mg/l).The content of Calcium and Magnesium found in the well water samples ranged from 3.85 to 4.60 (mg/l) and ranged 1.45 to 2.80(mg/l) respectively Wile the BOD was recorded highest in Kwali (6.35mg/l) and lowest in Gwagwalada (2.55mg/l) .The bacteriological quality of the well water in FCT was analysed using spread plate technique for the total aerobic count and the MPN technique for total coliform count. The Total bacterial count in well waters sampled ranged from $2.90x10^6$ to $4.65x10^6$cfu/ml. The total coliform count of the well waters analysed ranged from 29.50 to 6.50mpn /100 ml.The well waters samples were noted to be positive for Escherichia spp, Shigellaspp, Morganellaspp, Acinobacterspp, Aeromonasspp, Salmonella spp, Citrobacterspp, etc. The results of the physico-chemical analyses meet the standard set by World Health Organization (WHO) while bacteriological qualities showed that well waters are not safe for consumption by inhabitants of FCT Area Councils.

Keywords: Physicochemical, Bacteriological, Water and Well.

1.0 Introduction

Water is a combination of hydrogen and oxygen atoms, with a chemical formula H_2O and known to be the most abundant compound (70%) on earth's surface (Osei, 2005). It is vital for all known forms of life. Safe drinking water is essential to humans and other lifeforms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack access to

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adequate sanitation However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability (Kulshreshtha, 1998).

Well water is categorized as groundwater as it is obtained from aquifers (underground layers of water-bearing rock (Singleton 1999). This is because wells are dug deep down into the ground till good clean water is obtained.

Water pollution is a change in the quality of water which renders it unstable or dangerous as regards foods, man and animal health, industry, agriculture, fishing or leisure (Ademorati, 1996). However, before the advent of industrialization, the degree of contamination of water by pollutant was low. Portable water implies that it is free from harmful bacteria and chemical impurities. It is also expected to be clear and bright, colourless and odourless. New age activities like manufacturing process led to pollution of service water source. Typical example is the location of chemical industries at river banks with effluent released into the river.

Safe and clean water is key to healthy life, since 80% of diseases in developing countries are due to lack of good quality water (Cheesbrough, 2006). Drinking quality water helps for the prevention and control of water borne diseases (WHO, 2010). Contaminated water is a global public health threat placing people at risk of a host of diarrhoeal and other illness as well as chemical intoxication (Oladipo *et al*., 2009). Although natural water is never pure, ground water sources are expected to be the purest sources of water. Nevertheless, underground pollution occurs from surface water sources into nearby ground water sources. Water quality parameters taken into consideration include: temperature, pH, conductivity, total dissolved solids, total suspended solids, water hardness, calcium hardness, magnesium hardness, alkalinity, and temperature (Hammer *et al*, 1981). Coliforms are used as indicator organisms because they are common intestinal bacteria; if they are present in water samples, then faecal contamination should be seriously considered (Singleton, 1999)

The population congestion and consequent indiscriminate dumping of polluted water may enhance the infiltration of harmful compound into the ground water (Tortora *et al.,* 2002).

Thus, the possibility of these contaminations may justify the purpose of this research. The objective of the present study was to analyse and determine the overall physical, chemical and bacteriological quality of drinking water from wells in FCT Area councils and the results was compared with the standard guidelines set by WHO and NAFDAC. This research would also provide an insight into the water quality of well waters in FCT Area councils, Nigeria.

2.0 Materials and Methods

2.1 Study Area

The federal Capital Territory is located in the geographical centre of Nigeria for easy accessibility to all parts of the country. It lies between the latitude of 8°30` N and 9° 15` W and longitude 6° 47` S and 7° 20` E. It is bounded to the North by Kaduna and Niger States, to the South by Kogi State, to the East by Nasarawa State and to the West by Niger State. In this study, six Area councils including Abuja Municipal Area Council (AMAC), Abaji, Bwari, Gwagwalada, Kuje and Kwali respectively were used.

2.2 Materials

The materials used include Thermometer, pH meter (AGS-75), conductivity meter (LF90), sterilized petri dishes, hand lens, absorbent pads, water samples, membrane filtration apparatus, marker, Bunsen flame, hot plate, forcep, distilled water, incubator, autoclave, filter paper (0.45µm), wire loop, membrane lauryl sulpahte broth, eosin methylene blue, nutrient agar, microscope, clean grease free glass slides spatula, weighing balance, bijoux bottles, incubator, autoclave, porcelain evaporating dish 100cm capacity, desiccators, drying over for operation at 103 C to 105 C, Analytical balance, durham tubes.

2.3 Collection Samples

This study was carried out between the months of February and May. Two well water samples were randomly collected from six different wells in the Area councils and used for both physicochemical and bacteriological analyses.

2.4 Procedure for Physico-chemical Analysis

The physico-chemical tests included the determination of pH, conductivity, temperature, calcium, Magnesium, Cadmium, Lead, Zinc and total hardness, using the methods of FAO (1997).

2.4. 1 pH Value; The pH readings of the well water samples in FCT were determined using pH meter (AGS-75). The pH meter was standardized with buffer solutions of different pH values of 4 before being used according to (Ademoroti, 1996).

2.4.2 Electrical Conductivity; Electrical conductivity was estimated with conductivity meter (LF90 model). The conductivity meter was first standardized with buffer water and temperature of different water samples before the steady readings were noted (Ademoroti, 1996).

2.4.3 Temperature; Temperature of each sample was determined with mercury-bulb thermometer by immersing the bulb vertically into the water samples and allowed to stand till the temperature reading was steady according to (Ademoroti, 1996).

2.4.4 Preparation for Cations Standards;

Calcium (Ca): A 1000 ppm of calcium was prepared by dissolving 0.92g of calcium chloride ($CaCl_2$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Magnesium (Mg): A 1000 ppm of magnesium was prepared by dissolving 2.59g of magnesium sulphate ($MgSO_4$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Cadmium (Cd): A 1000 ppm of cadmium was prepared by dissolving 0.79g of cadmium sulphate ($CdSO_4.8H_2O$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Lead (Pb): A 1000 ppm of lead was prepared by dissolving 0.4g of lead nitrate ($Pb(NO_3)_2$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Zinc (Zn): A 1000 ppm of zinc was prepared by dissolving 1.02g of zinc pentahydrate ($ZnSO_4.7H_2O$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

All the cations as mentioned above were determined by the concentration of the element in the unknown sample and calculated by reading the sample concentration from the calibration curve and multiplying it by the dilution factor (Adams, 1995).

2.5 Determination of Total Hardness: Total Hardness was determined using EDTA Trimetric method (Apha, 1995).

2.6 Procedure for Bacteriological Analysis

2.6.1 Total Aerobic Count; using the Spread Plate Technique: This was done by preparing tenfold serial dilution of the samples and later, 0.05ml from chosen dilutions (10^3 and 10^4) were dispensed onto dry, sterile surfaces of nutrient agar plates, and spread out using a sterile hockey-stick shaped glass rod. They were allowed undisturbed for 30 minutes on the bench and later incubated upside down (to avoid possible contamination from the water vapours) at 37°C for 24 hours till consistent colony forming units (CFU) were obtained. The CFU were counted and recorded for each sample (Agbu*et al*., 1988).

2.6.2 Most Probable Numbers (MPN) Technique:

The technique was carried out in three stages of Presumption, Confirmatory and Completed Tests as adopted by Isu and Onyeagba (1998).

2.6.3 Biological Oxygen Demand (BOD):

This was done using Winkler's method as reported by Ademoroti (1996). The BOD is a test to measure the amount of biodegradable organic materials present in a sample of water. The results are expressed in terms of mg/l of dissolved oxygen (D.O) which microorganisms, principal bacteria will consume while degrading these materials (Ademoroti, 1996).

2.7 Biochemical Test

The biochemical test such as catalase, gelatin hydrolysis, oxidase, imvic, indole, methyl red, voges-proskauer, simmon citrate and gram staining were carried out and each plate was confirmed and given a positive or negative scores. However, isolates were confirmed by biochemical test according to (Isu and Onyeagba, 1998).

3.0 RESULTS

The results obtained from the physico-chemical and bacteriological analysis of well water in FCT, Nigeria as shown in table 1, 2 and 3 respectively. These results were compared with that of the World Health Organization (WHO) and National Agency for Food and Drug Administration and Control (NAFDAC). From the physico-chemical analysis (pH, Conductivity, Calcium, Magnesium, lead, Cadmium, Zinc and Hardness) as presented in Table 1. The pH of the well water sampled in all the area councils in FCT ranged from 6.85 to 7.85. Well water sample from Bwari has the highest pH (7.85) while Kwali has the lowest pH (6.85). All the well water samples pH are within the range of WHO and NAFDAC standards.

The conductivity of the well water samples ranged from 99.55 to 106.70 (μs/cm) and the highest was recorded in Kwali (106.70 μs/cm) followed by Gwagwalada (106.00μs/cm) while Abaji (99.55 μs/cm) was the lowest. The quantity of Calcium found in the well water samples also ranged from 3.85 to 4.60 (mg/l) and the highest was in Kwali (4.60mg/l) as well Magnesium measured at (2.80mg/l) with the ranged 1.45 to 2.80(mg/l) while there was no trace of lead, Cadmium and Zinc found. The Highest value for hardness (5.15mg/l) was observed in Kwali well water sample while well water sample from Bwari had the least hardness of (4.35mg/l).

Table 1: Physioco-Chemical Parameters of Different Well Water Samples in FCT.

Source	PARAMETERS	GWAGWALADA	AMAC	ABAJI	BWARI	KUJE	KWALI	WHO	NAFDAC
Well	**pH**	7.10	6.90	6.90	7.85	7.00	6.85	7.0-8.5	6.5-8.5
Well	**Conductivity (µs/cm)**	106.00	104.85	99.55	100.75	102.35	106.70	-	-
Well	**Calcium (mg/l)**	4.55	4.40	3.95	3.85	4.10	4.60	-	-
Well	**Magnesium (mg/l)**	1.30	1.45	2.50	2.05	1.75	2.80	-	-
Well	**Lead(mg/l)**	NT	NT	NT	NT	NT	NT	-	-
Well	**Cadmium (mg/l)**	NT	NT	NT	NT	NT	NT	-	-
Well	**Zinc(mg/l)**	NT	NT	NT	NT	NT	NT	-	-
Well	**Hardness (mg/l)**	5.10	5.00	4.70	4.35	4.60	5.15	-	-

NT-Not Traceable.

The result of the bacteriological analysis of the well water in the FCT area councils exceeded the WHO set standard as seen in Table 2. The total aerobic count in Kwali ($4.65x10^6$cfu/100ml) was the highest value recorded while Bwari ($2.90x10^6$cfu/100ml) was the lowest. The total coliform count and BOD were recorded highest in Kwali as well, at (29.50 MPN per 100ml) and (6.35mg/l) respectively**.**

Table 2: Bacteriological analysis of Different Well Water Samples in FCT

SOURCE	SAMPLE LOCATION	TOTAL AEROBIC COUNT (cfu/100ml)	TOTAL COLIFORM COUNT (MPN per 100ml)	BOD (mg/l)
WELL	GWAGWALADA	$4.10x10^5$	6.50	2.55
WELL	AMAC	$3.15x10^6$	19.00	4.55
WELL	ABAJI	$3.75x10^6$	8.00	2.80
WELL	BWARI	$2.90x10^6$	22.00	5.05
WELL	KUJE	$3.22x10^6$	17.50	4.75
WELL	KWALI	$4.65x10^6$	29.50	6.35
WELL	WHO	Zero per 100ml	Zero per 100ml	

BOD-Biological Oxygen Demand

The result of biochemical analysis of the well water in FCT area council have shown that some microorganisms as seen in the Table 3 below are present. The occurrence of these microorganisms may be as a result of the nature of soil, or process of handling during digging of the wells.

Table 3: Biochemical Characterization of Bacteria Isolated From Well Water in FCT

ISOLATE NO.	GRAM REACTION	IND	MR	VP	S.C	GH	OX	CAT	PROBABLE ORGANISM
A(1-5)	GR	+	+	_	_	_	_	_	*Escherratia spp., Shigella spp., Morganella spp., Acinobacter spp., Aeromonas spp.*
B(1-4)	GR	_	+	_	+	_	_	_	*Salmonella spp., Citrobacter spp., Paracolobactrum spp., Edwardsiella spp.*
C(1-2)	GR	_	_	_	+	_	_	_	*Aerobacterspp and Capnocytophage spp.*
D(1-3)	GR	+	+	_	+	_	_	_	*Serratia spp., Kelebiesella spp., providencia spp.*
E(1)	GR	_	_	_	_	+	+	_	*Pseudomonas spp.*
F(1)	GR	+	+	+	+	_	_	_	*Enterobacter spp.*
G(1)	GR	+	+	+	+	+	_	_	*Proteus spp.*

GR-Gram Reaction, IND-Indole, MR-Methyl Red, VP-Voges-Proskauer, S.C-Simmon Citrate, GH-Gelatin Hydrolysis, OX-Oxidase, CAT- Catalase

4.0 DISCUSSION

From the results of physicochemical analyses of well water obtained in this study, the pH values of the water samples fell within the range of 7.85 to 6.85 which do comply with standard requirements by WHO, WHO (1984). The 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 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 water analyses. Lower conductivity of range of 99.55 to 106.70 μs/cm was observed in the water sample collected from all the area councils and this is in agreement with Nigeria Standard of Drinking Water Quality (NSDWQ, 2007). These results correspond to the similar study in Gwagwalada Area Council by Etu-Effeotor (1998). The cations determined in this study were Ca^{2+} and $Mg^{2+,}$ while Cd^{2+}, Zn^{2+} and pb^{2+} some

were not detected in the samples and this may not necessarily mean that there was an absolute absence of these cations in water samples but that they could be occurring in minute quantities that may not have been detected by the AAS SP9 model. The range values of well water noted Ca^{2+} (3.85-4.60mg/l) and Mg^{2+} (1.30-2.80mg/l) were within the (WHO 1984) tolerable values of 500mg/l and 150mg/l for Calcium and Magnesium respectively and also agree with the results of Etu-Effeotor, (1998). The total hardness for well water in FCT is 28.95mg/l which fall within the WHO (1984) set standard of ≤ 500mg/l and the result agrees with the range of 61-120mg/l according to (Udom *et al*., 2002)

The results of the bacteriological study shows the total aerobic bacteria and total coliform counts in the well waters showed highest in Kwali ($4.65x10^6$cfu/100ml and 29.5MPN per 100ml).The total aerobic bacteria and total coliform counts of all the water samples were generally high. They exceeded the standard requirement of zero total aerobic bacteria and total coliform counts per 100 ml for WHO (WHO, 2001). High total coliform counts showed that the water from the well may have been contaminated. It could be suggested that the container used in drawing water from the well may have been contaminated, too the pipeline may become corroded with random cracks and in most cases clogged with sediment (Onemano and Otun, 2003).

The BOD showed highest value of (6.35mg/l) in Kwali and the lowest value in Gwagwalada (2.55mg/l) and these values showed that the well water oxygen demand is in agreement with the WHO (1984) standard of 6mg/l as well as that of EtuEffeotor (1998) recorded range of 1.9-4.21mg/l in Gwagwalada Area Council too.

Finally, the samples from the well waters in FCT were positive for some isolates as shown in Table 3 above. About Seventeen genera of bacteria which include *Escherichia spp, Shigellaspp, Morganellaspp, Acinobacterspp, Aeromonasspp, Salmonella spp, Citrobacterspp*, Paracolobactrumspp,Edwardsiellaspp, Aerobacterspp, Capnocytophagespp, Serratiaspp, *Klebsiella*spp*, Providenciaspp, Pseudomonas spp, Enterobacterspp*and *Proteus* spp, were isolated from the well water and these organisms could be pathogenic.

5.0 Conclusion

From the result of the well water analyses in all the area councils in FCT, Nigeria, It has been established that all the well water analysed did not meet the standard set by World Health Organization (WHO) on the total number of aerobic count, total coliform count and biological oxygen demand (BOD) even though the physic-chemical analyses results

conformed with the standard of World Health Organization (WHO) and National Agency for Drug Administration and Control (NAFDAC).

6.0 Recommendation

From the results, this research has shown that there is urgent need to enlighten the populace more on the best way to protect their water sources from contamination hence, well diggers as well as their owners should be enlightened by environmental protection experts to ensure that they dug their wells at least 30 m away from septic tanks or toilets. Well owners need to be advised to hang their buckets to avoid contact with any possible contaminant. The entire public is also encouraged to boil and filter their drinking water especially if it is not treated. Finally, it would be desirable to make properly treated pipe-borne water available to the entire populace.

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