



## SHORT TERM ANALYSIS OF QUALITY PARAMETERS OF SELECTED DEEP WELLS: A CASE STUDY OF AN AGRARIAN COMMUNITY IN BOSSO LOCAL GOVERNMENT AREA, NIGER STATE



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**Abstract:** Pollution of groundwater at any level has been linked to industrialization and urbanization which has come to stay over time. This study seeks to establish the effect of age of dugged deep wells and contamination level in Niykangbe community of Niger State, Nigeria. Five sets of samples were collected each from the already identified deep wells for a period of five months during the dry season of the year 2015. The samples were tested for the physical, chemical and bacteriological properties include two years after preliminary study was carried out for the same study location. The results showed that the values recorded for alkalinity ranged between 22 mg/L and 73 mg/L while that of calcium ion ranged between 0.1 mg/L and 0.4 mg/L. It was also observed that for the same study location and same deep wells the values for BH1 and BH5 increased by 75% and 50%, respectively for the calcium ion content. Nitrite values in the borehole water samples ranged between 0.01 and 0.05 mg/L. It was therefore concluded that the various parameters tested for the various boreholes were within the recommended standard of Nigerian Standard for Drinking Water Quality values although some variations exist when compared with the initial study carried out.

**Keywords:** Agrarian, borehole, community, groundwater, physicochemical, water quality

### Introduction

In the last two decades, groundwater resource has become the potential source of domestic water supply in Nigeria and the world at large. Of great interest, many health institutions, surveys and water quality analysis have shown that groundwater is not immune to contaminants such as waterborne pathogens, toxic elements (Boateng *et al.*, 2015; Musa *et al.*, 2011). Thus, the supply of water as regards quality, quantity, when and where it is needed has in the recent times generated great concerns to the public as it plays a significant role in the socio-economic development of human populations (Eniola *et al.*, 2007). Depending on the area under study, groundwater quality in basins are based on various factors such as, influx of liquid industrial effluents, influx of water through rainfall, soil agricultural pattern amongst others.

Water, according to several researchers, has been said to be important to life, without it life cannot go on (Muhammad and Zhonghua, 2014; Sheth & Kalshetty, 2011; Musa *et al.*, 2011; Jeyaruba & Thushyanthy, 2009 Eniola *et al.*, 2007). Human, animal and plants' life depend on water for survival. Groundwater has been identified as the most reliable water resource for human consumption, agriculture and industrial activities for most developing countries like Nigeria (Musa & Ahanonu, 2013; Musa, 2014; Akinbile & Yusoff, 2011). Thus, evaluating the suitability of groundwater for different purposes and understanding the chemical composition of groundwater is necessary (Oluseyi *et al.*, 2014; Tiimub & Adu-Gyamfi, 2013; Versari *et al.*, 2002). As a result, it is important to note that the water required for human need must be fit for consumption and it should not contain contaminants or harmful chemical compounds or bacteria at any particular time (Musa, 2014). In order to ensure availability of sufficient quantity of good quality water, it becomes imperative in a modern society, to plan and build suitable water supply scheme, which may provide potable water to the various sections of the community in accordance to their demands and requirements, and also put in place quality assurance measures that will determine at any particular time the quality of the water (Oluseyiet *al.*, 2014). The effect of drinking

contaminated water results in death of thousands every day, mostly in children below five years in developing countries (WHO, 2004). Thus, access to safe clean water and adequate sanitation is a fundamental right and a condition for basic health (Musa & Ahanonu, 2013).

Groundwater which exists in soils and fissured rocks below the ground surface is considered the purest form of water free from contamination, but its quality can be affected by natural and human factors rendering it unsafe (Musa & Ahanonu, 2013). It is believed that once pollutants, be it natural or industrial enter the subsurface environment; it may remain concealed for some years, becoming scattered over wide areas of groundwater aquifer and rendering its supply unsafe for consumption and other uses. Therefore, understanding the potential influences of human activity on groundwater quality is important for protection and its sustainable use (Jehangir *et al.*, 2011). Groundwater contamination is the result of polluted water percolating through the soil and aquifers and eventually reaching the groundwater. This process might take place at varying distances from various wells and land fill sites where such contaminants are found (Li *et al.*, 2007). Once the ground water is contaminated, it is very difficult to remediate. Thus, the need for constant check on the quality parameters of groundwater supply as new technologies will only reduce the pollution level (Geetha *et al.*, 2008). Human health, agricultural development and the ecosystems are all at risk unless water and land systems are effectively managed (Kehinde *et al.*, 2009).

The size or magnitude of pollution problem depends on the size of the affected area, the amount of the pollutant involved, the solubility, toxicity and the density of the pollutant, the mineral composition and the hydraulic characteristics of the soils, the rocks through which the pollutant moves, and the effect or potential effect on ground water use (Saxena & Saxena, 2013). Due to the outburst in population and increased standard of living coupled with the ever increasing demands for clean water around the world, more water is required for the growing environmental concerns such as aquatic life, wildlife refuges, scenic values, riparian habitats (Li, *et al.*, 2007). The increase in population and

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establishment of industries involved in the manufacture of various agrochemicals, petrochemicals and household products have resulted in the increase in the production of disastrous substances including heavy metals in some countries (Oguzie & Okhagbuzo, 2010; Jeyaruba & Thushyanthy, 2009).

Application of herbicides and fertilizers for improved and increased agricultural yield can release contaminants of various categories such as bacteria, nitrate and harmful household chemicals to the subsurface, posing potential threats to nearby wells and surface water (Jeyaruba & Thushyanthy, 2009). The effect of human activities in and around agricultural farmlands is felt on the physical and chemical properties of water on which sustenance of the various forms depend (Mustapha, 2008). Past and present pollution of land with heavy metals as a result of atmospheric disposition and the application of fertilizers have led to an upsurge in the level of heavy metals in the soil of farmland and uncultivated area. These heavy metals of human origin together with amounts that are naturally occurring in the soil cause emissions into ground and surface waters (Bonten & Groenenberg, 2008).

The objective of this study, therefore, is to re-evaluate the physical and chemical properties of water from already identified locations in Nyikangbe agrarian community, Minna, Nigeria and to clarify the concerns about the quality and safety of water used as drinking water within the locality after an initial quality test carried out in the year 2013.

### Materials and Method

#### Study site

Nyikangbe community is one of the rapidly growing twenty-five (25) neighborhoods of Minna, Niger State. Niger State is located in the North Central area of Nigeria with an estimated population of over one million. Minna having an average temperature of 31°C and wind speed at 10 km/h, lies on the geographical coordinates of latitude 9°36'50" north and longitude 6°33'24" east. The average elevation of Minna is 272 m and altitude 1007 feet above the sea level (Musa *et al.*, 2013).

#### Sample collection

**Table 2: Physico-chemical analysis of water samples for deep wells**

N/S	Parameter	BH1	BH2	BH3	BH4	BH5	NSDQW
1	Colour (pt. Co)	ND	ND	ND	ND	ND	15
2	Turbidity (NTU)	ND	ND	ND	ND	ND	5
3	Total Suspended Solid (mg/L)	ND	ND	ND	ND	ND	N.S
4	Electrical Conductivity (µS/cm)	160	170	170	190	220	1000
5	Total Dissolved Solid (mg/L)	80	90	90	90	110	500
6	Temperature (°C)	28.1	28.3	28.3	28.3	28.3	Ambient
7	pH	7.2	6.9	6.9	7.1	7.2	6.5-8.5
8	Nitrate (Mg/L)	0.85	0.41	0.41	0.48	0.53	50
9	Aluminium (Mg/L)	ND	ND	ND	ND	ND	0.2
10	Nitrite (Mg/L)	0.05	0.03	0.03	0.03	0.05	0.2
11	Chromium (Mg/L)	ND	ND	ND	ND	ND	0.05
12	Copper (Mg/L)	0.00	0.02	0.02	0.04	0.05	1.0
13	Iron (Mg/L)	0.12	0.10	0.10	0.14	0.11	0.3
14	Cyanide (Mg/L)	ND	ND	ND	ND	ND	0.01
15	Fluoride (Mg/L)	0.00	0.00	0.00	0.03	0.01	1.5
16	Sulphate (Mg/L)	2.8	1.2	1.2	2.3	1.5	100
17	Magnesium (Mg/L)	0.03	0.01	0.01	0.04	0.02	0.20
18	Calcium (Mg/L)	0.4	0.2	0.2	0.4	0.2	N.S
19	Total Hardness (Mg/L)	52	58	56	122	76	150
20	Total Alkalinity (Mg/L)	18	14	14	52	20	N.S
21	Phosphate (Mg/L)	0.07	0.17	0.17	0.24	0.19	N.S
22	Manganese (Mg/L)	ND	ND	ND	ND	ND	0.2
23	Ammonia (Mg/L)	0.10	0.21	0.21	0.42	0.21	N.S
24	Sodium (Mg/L)	2.3	3.1	3.1	6.0	3.9	200

ND = Not Detected; BH = Borehole

The same process of sample collection was followed as identified by Musa *et al.* (2013) for the same study location and points. A total of five samples each from the various already identified boreholes in the community over a period of five months were collected for analysis. The water quality of the boreholes had earlier being carried in the year 2013; thus, the same set of boreholes were again considered to be observed if there could be any change in the physical and chemical parameters over a period of two years. Samples from these sources of underground water were collected during pick period of the dry season. The various points where the various samples were collected are presented in Table 1.

**Table 1: Geographical locations of various deep wells**

Deep well sampling points	Longitude	Latitude
BH6	N 09° 35 629'	E 006° 30 596'
BH7	N 09° 35 618'	E 006° 30 612'
BH8	N 09° 35 591'	E 006 30 568'
BH9	N 09° 35 614'	E 006° 30 523'
BH10	N 09° 35 578'	E 006° 30 800'

The samples were collected in a 1 liter sterilized bottle with each carefully labeled and kept in an iced box. The physiochemical properties for the various samples collected were carried out in the laboratory. The temperature was measured *in-situ* in the field with a capillary filled thermometer which was first suspended in the air to know the temperature of the environment before it was inserted in all the samples to know their various temperatures. Total dissolved solids, pH and conductivity were analyzed immediately using electrodes including pH probe and electrical conductivity meter. Titrimetric analysis was performed for chemical parameters of total hardness, alkalinity, total acidity, calcium and magnesium within 24 to 48 h after collection. Nitrate was analyzed by spectrophotometer. This is in accordance with the works of Musa *et al.* (2013); Tiimub & Adu-Gyamfi (2013); Musa & Ahanonu (2013).

### Results and Discussion

Results for the physical and chemical parameters of the water sample analysis for the physical and chemical parameters for the five boreholes in Nyikangbe agrarian community are presented in Table 2.

### pH

The recommended standard as provided by Nigerian Standard for Drinking Water Quality (NSDWQ, 2007) for pH is given as 6.5 – 8.5. The samples for all the boreholes were observed to be within the same range of an initial study carried out in the same area. The maximum and minimum values that were recorded for borehole ranged between 6.8 and 7.2. This present result obtained is similar to the earlier work carried out within the same community by Musa *et al.* (2013). pH is a measure of the acidity or alkalinity of water. The results obtained were found to be within the range as reported by Musa & Ahanonu (2013), Al Sabahi *et al.* (2012); Adejuwon & Mbuk (2011), Krishnan *et al.* (2007) and Usha *et al.* (2008).

### Alkalinity

There is no recommended standard stated for total alkalinity for the NSDWQ (2007) standard. The borehole values recorded for the agrarian community of Nyikangbe ranged between 22 and 73 mg/L. These results were similar to the works of Al Sabahi *et al.* (2012); Adejuwon & Mbuk (2011) Krishnan *et al.* (2007) and Usha *et al.* (2008). It is important to note that high values of alkalinity are usually observed in groundwater because of the various contents of carbonates and bicarbonates. This is in line with the works of Saxena & Saxena (2013) and Nirmala *et al.* (2012).

### Calcium Ion

Calcium ions if consumed in moderate quantity, is beneficial to human and animal system; the NSDWQ (2007) did not state any value either at the minimum or maximum level for calcium. The values obtained from the analysis for the borehole water ranged between 0.1 and 0.4 mg/L. These values when compared with the initial study carried out by Musa *et al.*, (2013) for the same study location and same deep wells indicated that the values of BH1 and BH5 increased by 75% and 50%, respectively. The other boreholes had reduced values. Adverse effects of calcium can be observed only if there is intake of extremely large quantities of it into the human or animal system. The combination of calcium and magnesium according to Nirmala *et al.* (2012) with biocarbonate, carbonate, sulphate and other species contributes to the hardness of natural waters. The recommended standard by NSDWQ (2007) for total hardness of water is 150 mg/L. The values obtained from the borehole sample ranged between 32 and 122 mg/L which when compared with the recommended values of NSDWQ (2007), the values were found to be below 150 mg/L which signify that the water met the required standard. When these results were further compared with the works of Musa *et al.* (2013), Musa & Ahanonu (2013), Oludare & Sikiru (2012) and Saharanb *et al.* (2009), they were similar to the results obtained from Nyikangbe agrarian community in Niger State, Nigeria. Water hardness is described as a measure of polyvalent cations (ions with a charge greater than +1) in water which generally represents the concentration of calcium ( $\text{Ca}^{2+}$ ) and magnesium ( $\text{Mg}^{2+}$ ) ions, because these are the most common polyvalent cations. Other ions, such as  $\text{Fe}^{2+}$  and  $\text{Mn}^{2+}$ , may also contribute to the hardness of water as they are generally present in much lower concentrations, particularly in surface water. Water with high hardness values are referred to as hard, while those with low hardness values are soft.

### Total dissolved solids (TDS)

The analyzed value for the Total Dissolved Solids (TDS) for the borehole water ranged between 100 and 160 mg/L. These values when compared with NSDWQ (2007) were found to be below the maximum permissible limit of 500 mg/L. This

shows that there is a low concentration of dissolved solid in the various water samples, thus making it very safe for domestic use. The obtained values were also compared with the values of the initial study carried out by Musa *et al.* (2013) and it was discovered that the values for all the boreholes reduced. The values obtained were further compared with the works of Musa & Ahanonu (2013), Oludare & Sikiru (2012) and Gupta *et al.* (2009) and they were found to be similar. The effects of total dissolved solids on drinking water depend on the level of individual elements, compounds and components. Common properties of such water include taste, colour, and turbidity and so on. High concentration may affect taste adversely and deteriorate plumbing appliances. Treatment for household uses is reverse osmosis.

### Total suspended solids

Standard values for Total Suspended Solids in Nigeria are not available in NSDWQ (2007). The maximum and minimum values obtained during the analysis for borehole was zero. This implies that no suspended solid was observed from the various water samples collected. This similar to earlier work carried out by Musa *et al.* (2013). This could be linked to the geological formation of the area as it is known to have hard rocks from the depth of 50 meters and above. The results of Adejuwon & Mbuk (2011), Birhanu (2007) and Pritchard *et al.* (2010) were compared to these results which show a clear similarity. Total suspended solids (TSS) are solids in water that can be trapped by a filter. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial and sewage wastes.

### Nitrite

The maximum permissible limit of nitrite for NSDWQ (2007) is stated as 0.2mg/L. Nitrite values in the borehole water samples ranged between 0.01 and 0.05mg/L. It was observed that the values were all within the range of the recommended values. These results are in conformity with the works of Musa & Ahanonu (2013), Al Sabahi *et al.* (2012); Adejuwon & Mbuk (2011) Krishnan *et al.* (2007) and Usha *et al.* (2008); that is, they show distinct similarity to the results obtained from the analysis. The results were also comparable with the initial works carried out by Musa *et al.* (2013) and it was observed that the values of nitrite reduced greatly by almost 50% with only BH1 and BH2 retaining the same values. Nitrite ( $\text{NO}_2$ ) is relatively short-lived in water because it is quickly converted to nitrate by bacteria. Excessive concentrations of nitrite can be harmful to humans and animals that depend on such water for drinking.

### Nitrate

The minimum and maximum values obtained for borehole were 0.38 and 0.85 mg/L and when compared with the previous work carried out by Musa *et al.*, (2013), it was observed that the concentration reduced. When further compared with the recommended values of NSDWQ (2007) of 500 mg/L, the values were almost negligible. The results were found to be similar to the works of Adejuwon & Mbuk (2011) and Geetha *et al.* (2008) which showed similar correspondence. However, the presence of excess nitrate in water may adversely affect the health of infants.

### Sulphate

Sulphate is a substance that occurs naturally in drinking water at various concentrations. The NSDWQ (2007) standard for sulphate ( $\text{SO}_4^{2-}$ ) is 100 mg/L. The values for the various water samples for deep wells in Nyikangbe agrarian community ranged between 1.0 and 2.8 mg/L. The observed values from the study area were compared with the initial study of Musa *et al.*, (2013) and the values for BH1 and BH5 were observed to be higher while the others were lower. However, all the values were noticed to be within the recommended range of NSDWQ

(2007). The results obtained were further compared with the works of Musa & Ahanonu (2013) for another agrarian community where the sulphate content ranged between 0.3 and 2.9 mg/L. The current study shows that the sulphate was found to be lower. Health concerns regarding high sulphate concentrations in drinking water have been raised because of reports that link it with an increased occurrence of diarrhoea.

#### **Electrical conductivity**

The minimum and maximum determined values of the various samples were between 160 and 220 $\mu$ s/cm, respectively. All the values were observed to be below the recommended maximum permissible limits of 1000  $\mu$ s/cm as recommended by NSDWQ (2007). The results as compared with the values obtained in an initial study by Musa *et al.* (2013) showed that the values were much lower an indication that some level of purifications had been carried out in the various water samples. The values obtained were also compared to the previous works of Reddy & Reddy (2011); Musa *et al.* (2011) which were observed to be lower when compared with the NSDWQ permissible level.

#### **Iron**

The analyzed values of iron content in borehole ranged between 0.0 and 0.14 mg/L which were observed to be within the recommended value of NSDWQ (2007) of 0.30 mg/L. The obtained values were also compared with the initial study carried out for the same points by Musa *et al.*, (2013) and it was observed that BH1 had same value while others reduced by varying values. These results were similar to the works of Reddy & Reddy, (2011) and Krishnan *et al.*, (2007). Most iron concentrations are absorbed in the duodenum and upper jejunum of either human or animals. Absorption depends on the individual's iron status and its rate of intake. Total body iron in adult males and females is usually about 50 and 34-42 mg/kg of body weight, respectively.

#### **Total dissolved solids**

The recommended standard by NSDWQ (2007) is 500 mg/L. The minimum and maximum values of the Total Dissolved Solid (TDS) ranged between 60 and 110 mg/L. These values were compared with the predetermined values of Musa *et al.* (2013) for the same study area and points and it was discovered that the values reduced by varying degrees and within the recommended values of NSDWQ. The values obtained were also observed to be similar to the results from previous works of Birhanu (2007) and Pritchard *et al.* (2010). The effects of total dissolved solids on drinking water depend on the level of individual elements, compounds, and components. Common properties of such water include taste, colour, and turbidity and so on. High concentration may affect taste adversely and deteriorate plumbing appliances.

#### **Sodium**

Sodium occurs as a major cation in water samples. The concentration of sodium in the various boreholes for the study area ranged between 2.3 to 6.2 mg/L which when compared with the works of Musa *et al.* (2013) for the same study location showed a decline in the values of BH1 and BH2 while the others increased. This may be as a result of the geological formation of the area and the filtration processes through the medium that the water passes through to get the storage point before being pumped out. The values obtained were observed to be within the recommended NSDWQ (2007) value of 200 mg/L and also similar to the studies carried out by Musa *et al.* (2011), Reddy and Reddy (2011) and Krishnan *et al.* (2007).

#### **Fluoride**

The recommended maximum permissible limit by WHO/UNICEF (2004) for fluoride in drinking water is 1.5 mg/L. Groundwater containing values higher than 1.5 mg/L

are found in area or terrains of metamorphic rocks and granite and occasionally in sedimentary basins. They are also more likely to be found in arid regions than regions with high rates of groundwater recharge. Granitic rocks and sedimentary basins in the arid northern parts of the country are therefore potentially most vulnerable to development of high groundwater-fluoride concentrations. As noted above, granitic rocks occur extensively in Nigeria. Fluoride is beneficial when present in small concentrations (0.8 to 1.0 mg/L) in drinking water for calcification of dental enamel. However, it causes dental and skeletal fluorosis if high. The fluoride concentration in the study area is found to be negligible. The minimum and maximum values recorded for borehole water samples ranged between 0.0 and 0.03 mg/L while that of well water sample ranges between 0.00 and 0.08 mg/L, respectively. The results obtained were compared with the maximum permissible limit of NSDWQ (2007) and it was observed to be within the recommended range. The values obtained were compared with the initial works of Musa *et al.* (2013) that carried out an initial study within the area and it was observed that the values were found to be lower with only BH5 retaining the same value. The values obtained were also compared with the works of Geetha *et al.* (2008); Oludare & Sikiru (2012), they showed high level of similarity.

#### **Magnesium**

The desirable permissible limit of magnesium in drinking water is 0.2 mg/L as recommended by NSDWQ (2007). From the study, the minimum and maximum values obtained ranged between 0.01 and 0.04 mg/L respectively. These results were compared with the work of Musa *et al.*, (2013) for the same study location and points showed that there was an increase in the values of magnesium obtained from the various points. This can be linked to the kind of activities being carried within the community which is basically farming. These results were compared with the results of Musa & Ahanonu (2013); Geetha *et al.* (2008) and were found to be similar as much difference were not observed in the values obtained from the previous work done within the study area. When the results were also compared with the recommended maximum and minimum permissible limit of NSDWQ (2007), they were found to be lower. High concentration of magnesium adversely affects domestic use of water as it constitutes to water hardness which in turn increase soap consumption in laundry.

#### **Conclusions**

The safety status of the various waters consumed by the public requires constant checking to make it fit for consumption for the public. It was therefore concluded that the various parameters tested for the various deep wells in Niykangbe agrarian community were within the recommended standard values of NSDWQ though some slight differences were observed when the values were compared with the initial study carried out by Musa *et al.* (2013). This is a strong indication that over time the various levels of water parameters can change either positively for some of the parameters such as electrical conductivity, total dissolved solid, temperature, copper. Thus, standard sanitation measures should be put in place to secure the safety of water collection points in the area used for both domestic uses and human consumption.

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