



## Research Article

# Assessment of Water Quality from Shallow Hand-Dug Wells in Dutse Town, North West Nigeria

Ali, Kolomi Yusuf<sup>1\*</sup>, Saleh, Bukar Mustapha<sup>2</sup> and Adam, Kolo Mustapha<sup>2</sup>

<sup>1</sup>Centre for Arid Zone Studies, University of Maiduguri, Borno State, Nigeria

<sup>2</sup>Department of Geography, Faculty of Social Science, University of Maiduguri, Borno State, Nigeria

\*Corresponding author: [kolomiyusuf@gmail.com](mailto:kolomiyusuf@gmail.com), [doi.org/10.55639/607nmlkj](https://doi.org/10.55639/607nmlkj)

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## ABSTRACT

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The inhabitants of Dutse depend predominantly on shallow hand-dug wells for domestic water supply but these are susceptible to contamination from various sources due to the unprotected nature of this water source, the geology of the area and anthropogenic activities. The focus of this paper is to assess the physicochemical and test for coliform of the shallow hand-dug wells in Dutse and compare it to the threshold of WHO and the Nigerian Administration Food and Drugs Agency (NAFDAC). Forty-four shallow unprotected public hand-dug wells were purposively selected and sampled across the town. The physical parameters of pH and Electrical Conductivity were measured using a pH meter and electric conductivity meter on site having mean values of 8.74 and 646.37 mg/L indicating that 90 % of the samples exceeded the set standard limits. The chemical analysis was carried out using Flame photometry, Atomic Absorption Spectrophotometry and Ultra Violet Spectrophotometry methods. The heavy metals Cu, Fe, Mn and Cr have average values of 1.43, 0.11, 3.31 and 0.076 mg/L respectively which complied with the limits. The test for coliform was carried out using the coliform counter and all the samples show positive results for the bacteriological analysis the water should be treated before use.

Corresponding author: Ali, Kolomi Yusuf Email: [kolomiyusuf@gmail.com](mailto:kolomiyusuf@gmail.com)  
Centre for Arid Zone Studies, University of Maiduguri, Borno State, Nigeria

## INTRODUCTION

Groundwater is the water occurring beneath the earth's surface that fills and saturates the void space of rocks or sediments (Todd, 1980). Groundwater is generally considered a safe source of fresh drinking water. But rapid population growth, increasing living standards in urban areas and industrialization have resulted in greater demand for quality on one hand, while the other hand, pollution of water resources is increasing steadily. The availability of safe drinking water is a major problem in the world today. The most widely/accessible and cheapest source of portable water is groundwater. However, this source is unfortunately polluted by anthropogenic and natural episodes (Ocheri and Odoma, 2013).

Groundwater quality is of paramount importance to human life particularly the people of developing countries; where access to safe potable water is generally in deficit and low in per capita supply. This problem is compounded by the increasing population and the ever-increasing dependence on groundwater as the most accessible source of water to communities (David, 1996). Therefore, the groundwater is getting polluted and among which shallow aquifers are generally considered the worst affected in terms of bacteriological and heavy metals pollution (Kumar, 2010). In many parts of the world, both surface and groundwater are fouled mostly by the dumping of domestic wastes, sewage, agricultural waste and industrial effluents, (Agbozu, *et al.*, 2007). Groundwater contaminants might be due to natural and anthropogenic activities; dissolution of minerals from rocks and soil causes high elevation concentration in groundwater (Adekunle *et al.*, 2007), Furthermore, the use of fertilizer, herbicides and pesticides also contributes to its high level of concentration in groundwater (Devendra *et al.*, 2014). Rainfall is the primary source of groundwater; it flows

from higher terrain downslope. As it moves it dissolves minerals/contaminants rocks and artificial sources or suspensions. During the flowing process of water, part of it is leached into the soil reaching the groundwater and polluting it (Iguisi, *et al.*, 2001).

About 80 % of Nigerians lack access to safe drinking water (Ezenwaji *et al.*, 2014). Furthermore, Tasi'u, (2016) have shown that the majority of people living in Dutse urban depend on shallow well water for drinking and daily activities (Tasi'u, 2016). In a similar development Abdullahi and Indabawa (2012), carried out research on the physicochemical and heavy metals (Pb, Fe, Mn) concentrations of tap water in Dutse and found out that all the parameters are within the set threshold except Fe which is a little above the limit. Fe when ingested in excess leads to kidney disease and heart failure. In a related development Amoo, *et. al.*, (2018) assessed the physicochemical and bacteriological quality of water samples from different boreholes on the campus of Federal University, Dutse. It revealed that pH, EC, Turbidity and NO<sub>3</sub> are within the limit and also the bacteriological analysis shows the presence of *Escherichia coli*, in most samples. The elevated concentration of heavy metals might be related to the dissolution of rocks/ minerals containing heavy metals and fertilizer application to farms. This assertion is concomitant with the conclusion of Adebo and Adetoyinbo (2009), which report that the increase in the concentration of trace elements in groundwater is attributed to geological and environmental factors.

Dutse is located on the generally undulating terrain of basement rocks (500-600 m asl) with the rainwater flowing downslope (below 400 m asl) and the unprotected shallow hand-dug wells are liable for pollution due to flooding. Some researchers have carried out studies on the

groundwater quality of the area (Abdullahi and Indabawa, 2012, Tasi'u, 2016, Amoo, et. al., 2018). However, they have not related the groundwater quality with the geology and rainfall in the area. Therefore, the present study is aimed to determine the groundwater quality in Dutse, comparing it with WHO and NAFDAC indicating the relation them with groundwater quality within the study area. The set standard for drinking water is biased on uses. The primary focus of the water quality standards is a measure of the portability of water for various uses, and human and environmental factors (Abba, 2018). NAFDAC and SON are the official government organizations controlling the quality standards for drinking water

## **MATERIALS AND METHODS**

### **Study Area**

Dutse town is the Administrative Headquarters of Jigawa State and is situated within Latitudes  $11^{\circ} 38' 31''\text{N}$  to  $11^{\circ} 46' 16''\text{N}$  and Longitudes  $9^{\circ} 18' 33''\text{E}$  to  $9^{\circ} 24' 24''\text{E}$  (Fig.1). It has a population of 138,451 (NPC, 1991). The relief is generally undulating which is about 500-600 m above sea level (asl) with basement complex rocks scattered in the town. While the relief is usually below 400 m (asl) in areas covered by sedimentary rocks of the Chad Formation. The Hadejia River meanders through numerous channels constituting part of the Hadejia / Nguru Wetlands. Many of the water channels dry up during the dry season, and domestic water is obtained by digging holes in the sand-filled river beds. The climate is a tropical wet-dry climate and the temperature is warm to hot throughout the year, even though there is a slightly cool period around November through February. The mean annual temperature is  $26^{\circ}\text{C}$  but, the mean monthly value ranges between  $21^{\circ}\text{C}$  in the coldest months (December -

in Nigeria. There is a yardstick to which drinking water quality can be examined and either considered to be hazardous or suitable for a particular purpose. Substances or parameters that do not exceed the allowable quantity in the water cannot pose danger to human health (WHO, 2011). As Jigawa State is among the states with higher numbers of kidney problems in the North, the problem might likely be connected to water quality in the area (Nuruddeen, *et al.*, 2018). The aim of this research, therefore, was to assess the water qualities of public hand-dug wells (the major source of drinking water) in Dutse Metropolis, Jigawa State and compare them with the NAFDAC and WHO Standards

February) and  $31^{\circ}\text{C}$  in the hottest months (April - May) (Olofin, 1987). Rainfall commences in April and ends in October with about 800 mm recorded annually. Great spatial and temporal variation occurs in the amount of rainfall received in the area each year (Olofin, 1987).

### **Geology**

The northwest and southern parts of the state are underlain by basement complex rocks consisting of granites, schist and gneisses which are separated from the Chad Formation by a hydrological divide. The Chad Formation occupies the northern part of the state; while the Basement Complex rocks undergone weathering forming fairly deep soils covered by a sheet of laterite and exposed by denudation in some places. The Chad sediments are covered by sand dunes with no surface outcrops, the sandy beds overlay the impervious clays layer of the Chad Formation forming the main aquifer in the dry season (Garba, 1998).

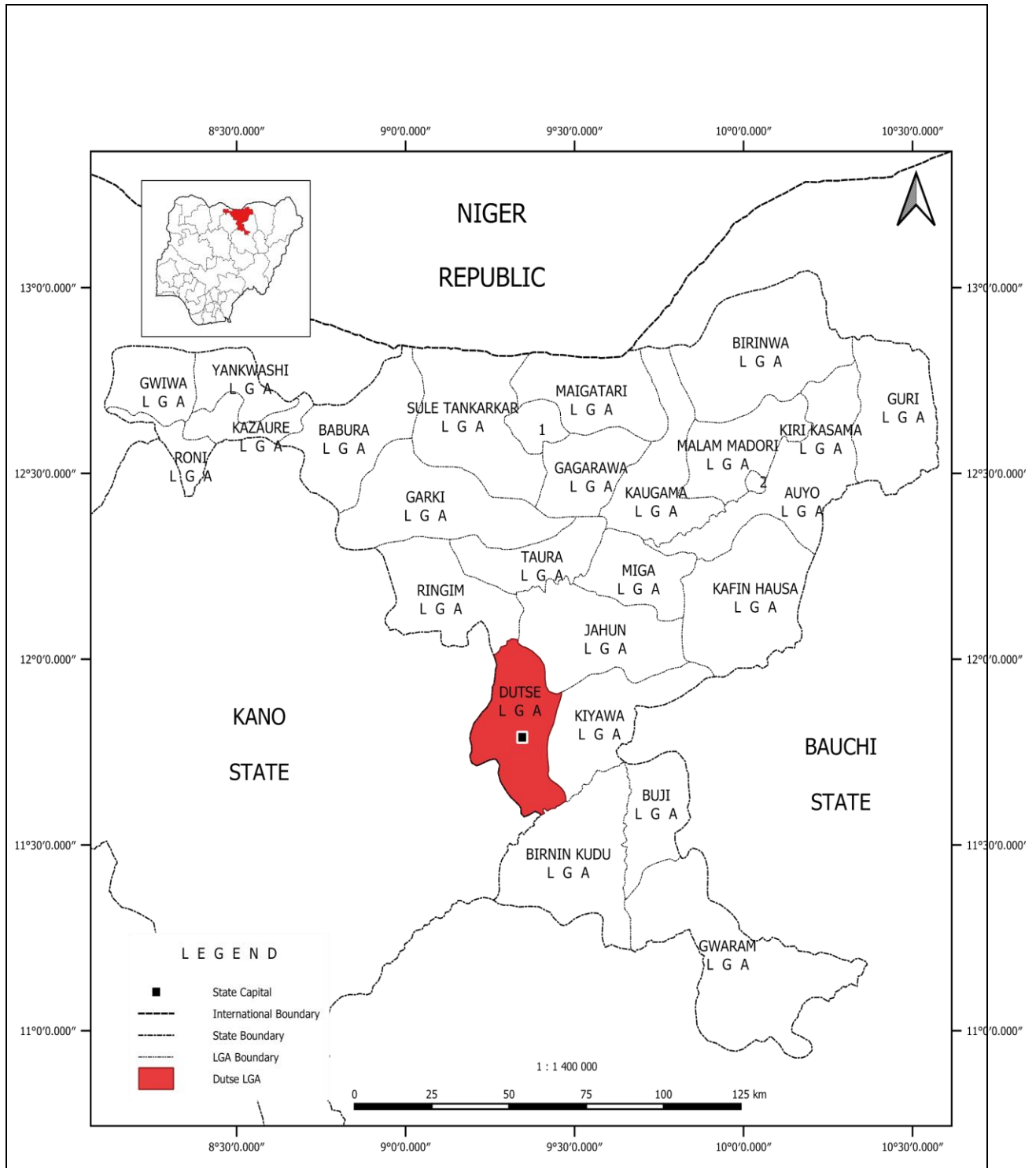


Figure 1: Map showing the study area

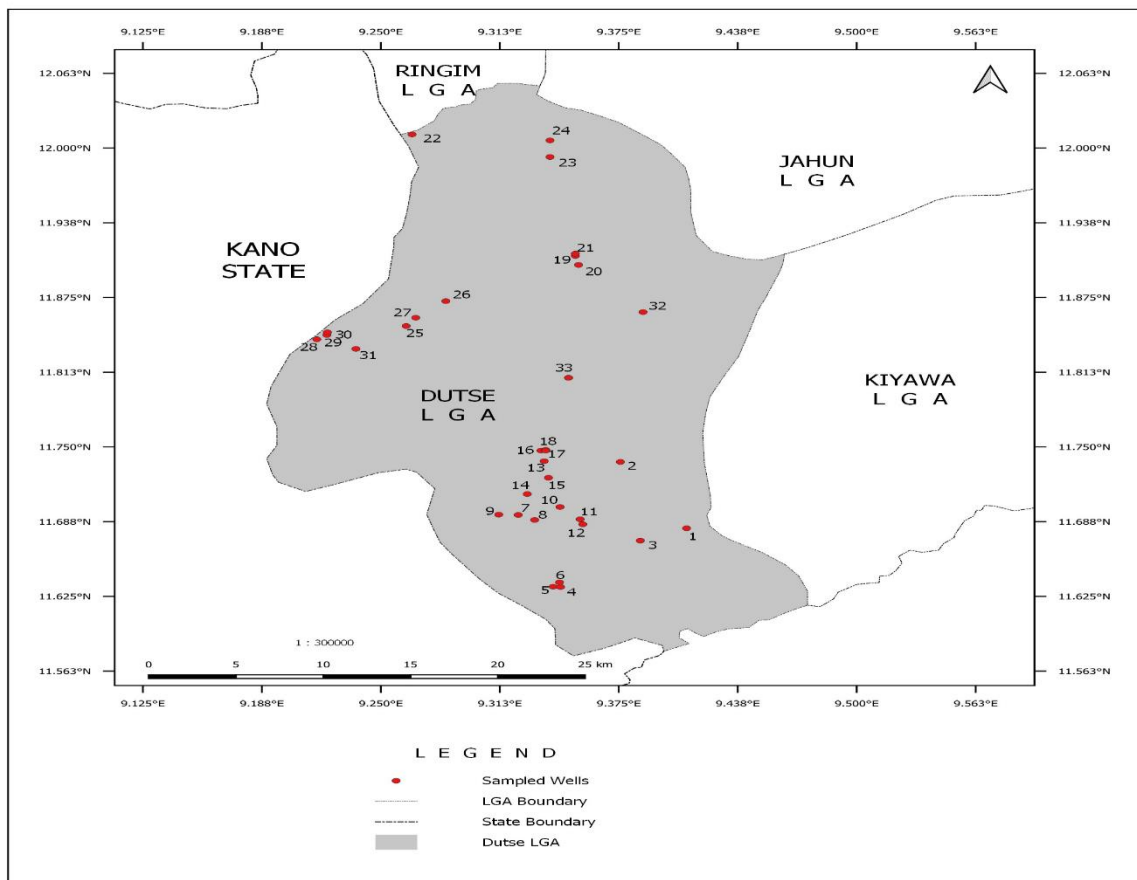
**METHODOLOGY**

**Sampling Technique**

Forty-four (44) water samples were purposively collected (Fig.2) from all the existing 84 public hand-dug wells for water quality analysis in the study area. Thirty-three (33) samples were collected for a physicochemical test while eleven (11) samples were bacteriologically tested. The samples were analyzed using APHA techniques (2017). A 750 ml plastic bottle container was used to collect water samples for laboratory analysis for physical-chemical parameters. The container was thoroughly washed with distilled water before the samples were collected. The physicochemical parameters analyses were carried out in Borno State Water Treatment Plant Maiduguri. The physical parameters measured include pH, Colour, Total

Dissolve Solid, Electrical Conductivity and Turbidity. While the chemical parameters analysed are Calcium, Chlorides, Nitrates, Sulphate, Manganese, Copper, Magnesium, Iron, fluoride and Chromium.

For the test for coliform, the water samples were obtained in a 200 ml sterile bottle and kept in an ice-parked cooler and transported to the NAFDAC office in Kano for analysis within 6 hours of collection. *Total Coliform Count* was obtained using a Coliform counter (WINCOM) and recorded and presented as colony-forming units (cfu). Also, the standard procedure for culturing, isolations and identification of the organisms as described by the American Public Health Association (2017) was employed. The bacteriological parameters tested include *Total coliform*, *Faecal coliform* and *Escherichia coli*.



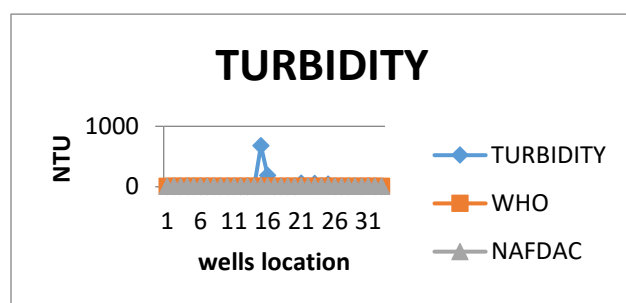
**Figure 2:** Showing all the Sampled points

## RESULTS AND DISCUSSIONS

### Physicochemical Parameters

#### Turbidity

This refers to cloudiness or haziness cause by suspended solid particles in water. It is measured in NTU (Nephelometric Turbidity Units). Turbidity maximum permissible level of 5 NTU within the WHO and NAFDAC recommended limit. The result shows that the samples have a mean value of 6.50 and range of 0.17- 60.9. This is in contrasts to the findings of Amoo, *et al* (2018) who gave a range of 0.01- 41.2 NTU.

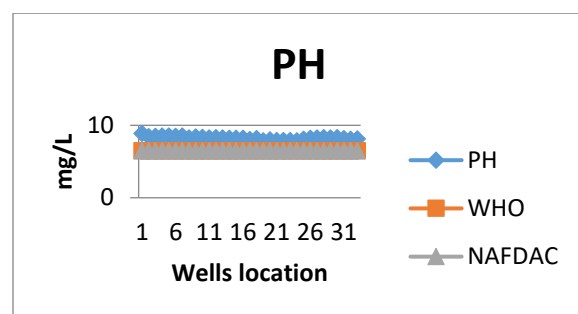


**Figure 4:** Shows a plot of Turbidity (NTU) with location in the study area

#### pH

The pH in groundwater is the product of the soil and the underlying bedrock which the water infiltrates and percolates to the water table. The mean pH of the samples is 8.74 and has a range of 7.87- 8.88. The recommended limits of WHO and NAFDAC pH values in groundwater ranged from 6.5-8.5. Wells Locations 19, 21, 22, 23 and 24 have values above the set limit. These samples are neutral with a little inclination to basicity as shown in figure 5. Lower pH is acidic in nature and caused by geological and environmental factors leading to debilitating for children, vomiting, diarrhoea, kidney disease, liver diseases, stomach cramps and nausea (WHO, 2007). While extreme pH is basic in water causes irritation to skin, eye and mucus membrane.

Wells Locations 20 - 24 and 28 have values elevated above the set threshold as indicated in figure 4. The high turbidity levels in these wells may be associated with nature of the groundwater. Considering the location of the study area, it is prone to flood and over use by the residents, so a lot of suspended materials and dissolved organic particles could be present in the water. Excessive turbidity may constitute health risk because it protects pathogenic micro-organisms from the effect of disinfectants and therefore stimulates growth of bacteria.

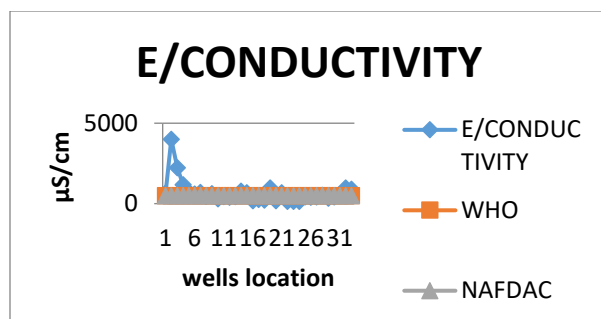


**Figure 5:** Shows a graph of pH verses the wells' wells locations in Dutse town.

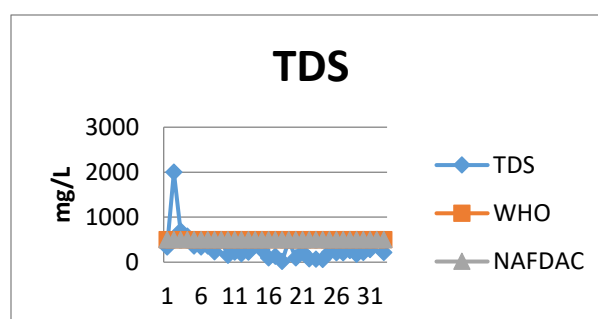
#### EC

EC of water samples is an indicator of how salt-free, ion-free, or impurity-free the water sample is. The maximum value of EC by the WHO and NAFDAC is 1000  $\mu\text{S}/\text{cm}$ . So the sources in Well locations 2, 3 and 4 are found to have values of 3999, 2223 and 1168  $\mu\text{S}/\text{cm}$  exceeding the recommended threshold as observed in figure 6 and the average is 666.55  $\mu\text{S}/\text{cm}$ . This finding is concomitant with the results of Amoo, *et al*. (2018). The increase in EC might be due to farmland around the water source and due to fertilizer application in the area.





**Figure 6:** Indicates the graph of EC and well's locations



**Figure 7:** Graphical Representation of TDS and well's locations.

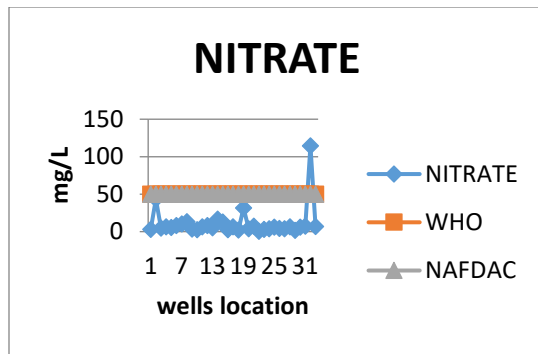
### Total dissolves Solid (TDS)

The TDS in the study area ranged from 64.3 to 1006 mg/L with a mean value of 689.7 mg/L. The values of wells locations 2, 3 and 4 have values of 2000, 687 and 573 mg/L respectively exceeding the permissible limit of WHO and NAFDAC of 500 mg/L (figure 7). The high total dissolved solids values can be attributed to the high degree of mineralization of the groundwater, dumpsites, geology and excessive withdrawal from sources. Also, TDS in groundwater increases due to improper waste disposal and fertilizer application (Shridar, 2014). Elevated concentration of TDS in groundwater leads to gastrointestinal irritation and is not good for use in industries (Abdullahi, 2017). Excessive TDS usually affects the taste of water and can lead to coronary heart disease and cancer.

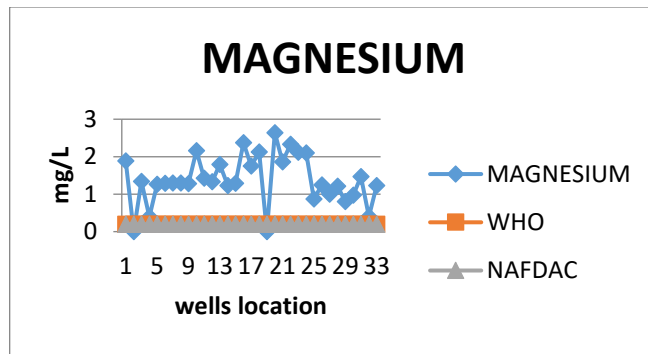
### Nitrate (NO<sub>3</sub>)

According to Lenntect (2015), nitrate in groundwater is increasing despite being one of the most ubiquitous chemical contaminants in all aquifers globally. Nitrate is naturally injected into the groundwater through the chemical weathering of rock minerals and other organic constituents in

the soil environment. Nitrate is also an indicator of pollution from human faeces. Widespread pollution in groundwater where NPK fertilizers and animal manure are used. A high dose of nitrates in humans is capable of causing various diseases in infants less than six months, a health condition is known as Blue-baby syndrome (methemoglobinemia) (Nicole, 2018). Gastrointestinal disorders, carcinogenic diseases, neurological cases, hypertension, and certain stomach cancers are linked to nitrates ingestion from groundwater sources (Mary *et al.*, 2018). The safe concentration of nitrate for drinking water is 50 mg/L (WHO 2011). Nitrate concentration in the shallow wells in Dutse ranged from 0.5 to 114.4 mg/L and a mean of 11.13 mg/L This is in line with the findings of Amoo, *et al* (2018), based on this analysis only well location 32 has a value of 114.4 mg/L above the recommended limit of WHO and NAFDAC as shown in figure 8. The high level of NO<sub>3</sub> in location 32 is due to its proximity to residential areas with poor methods of waste disposal and other anthropogenic activities.



**Figure 8:** This plot indicates a Nitrate Concentration against wells location



**Figure 9:** Plot of Magnesium concentration against hand dug well's location

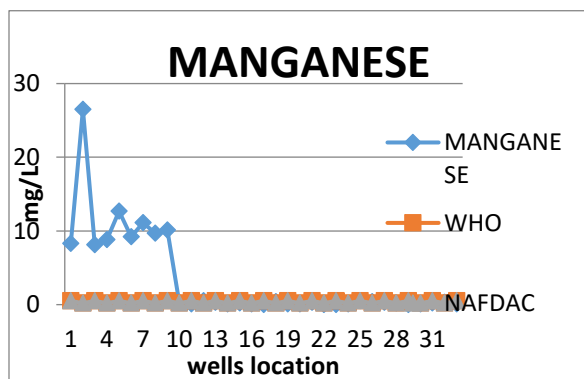
**Magnesium (Mg)**

Mg concentration was found to have exceeded the recommended limit of WHO and NAFDAC across all the locations of sampled point sources except in Wells locations 2 and 19. Mg has an average concentration value of 1.39 mg/L and a range of 0 to 2.64 mg/L. While the WHO and NAFDAC threshold value is 0.2 mg/L and it has no or less health implications but it only has consumer acceptability in consuming the water as seen in figure 9.

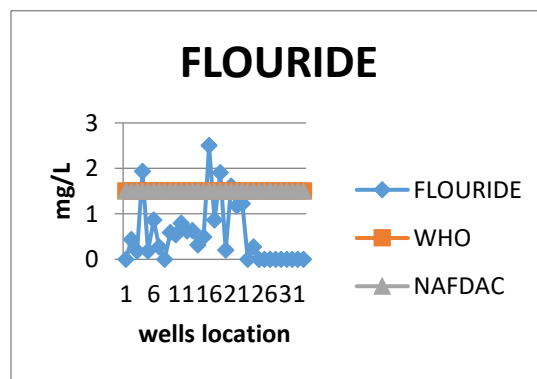
**Manganese (Mn)**

Mn is a widespread mineral in the Earth's crust and coexists with iron. High concentrations occur in deep wells from dissolved oxygen concentrations decrease with good depth (WHO, 2011 British Geological Survey, 2003). Mn concentration in groundwater has a slight change

between the WHO and NAFDAC maximum permissible limit. For the WHO is 0.5 mg/L while for the NAFDAC is 0.2mg/L Which shows that there is some source that exceeds in WHO limit but are within the permissible limit of NAFDAC. The average concentration of Mn in the area is 3.31 mg/L with a range from 0 to 26.5 mg/L. This result is far above the results of Abdullahi and Indabawa, 2018. The source that exceeded both permissible limits are well's locations 1- 9. (Fig.10). The high concentration of Mn is attributed to anthropogenic activities in densely populated areas. Therefore, excess consumption of Manganese that exceeded the WHO and NAFDAC recommended limit will lead to Neurological disorders in human health, particularly diseases relating to nerves or neurons, kidneys, liver and lungs.



**Figure 10:** Is a plot of Manganese against locations.



**Figure 11:** Flouride concentration with well locations.

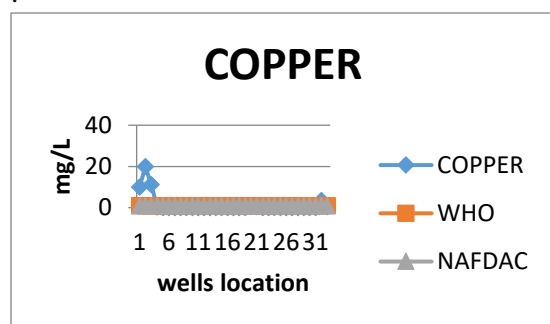


### Fluoride (F)

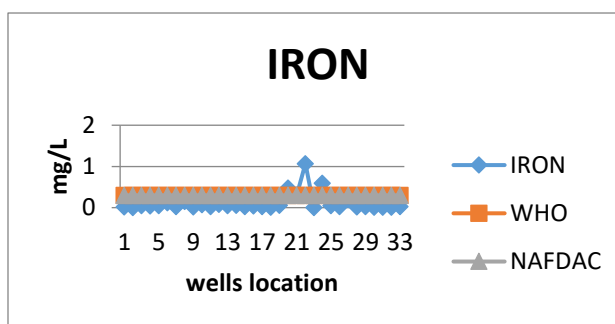
Fluoride is an element in the water-quality investigation; it affects the dental health of children. Its ingestion at a lower concentration can reduce dental cavities in young children but excessive fluoride dose is capable of causing bone-related diseases. The fluoride concentration in groundwater is mainly due to geological formation in the area. Fluoride concentration found in groundwater with the maximum permissible limit of both WHO and NAFDAC is 1.5 mg/L. The source that exceeded the recommended limit is well's locations 4, 16, 18 and 20 having fluoride mean concentration in the area is 0.52 mg/L with a range from 0 – 2.30 mg/L. But remaining sources of water are within recommended threshold as indicated in figure 11.

### Copper

The concentration of Cu in groundwater ranged from 0 to 19.9 mg/L and an average value of 1.43 mg/L. But recommended WHO and NAFDAC are found to be 1.0 mg/L. The result shows the sources that exceeded the WHO and NAFDAC permissible limit in wells locations 1, 2, 3 and 32 with values of 9.96, 19.91, 11.2 and 3.46 mg/L respectively as observed in figure 12. Copper has a health impact on humans taking water with excess Cu will lead to gastrointestinal bleeding, haematuria, intravascular haemolysis, methaemoglobinaemia, hepatocellular toxicity, acute renal failure and oliguria. At a lower dose, copper ions can cause symptoms such as headache, nausea, vomiting and diarrhoea (US EPA, 2010)



**Figure 12:** Is a graph of Copper (Cu) and well's location in study area.



**Figure 13:** Is a plot Iron (Fe) and well's location in study area.

### Iron (Fe)

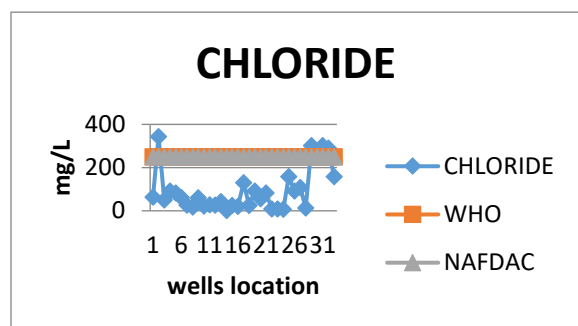
Fe concentration limit in groundwater is 0.3 mg/L by WHO and NAFDAC recommended limit. Fe changes the colour of the water from colourless to brownish-black by oxidation of the Fe from ferrous oxide ( $Fe^{2+}$ ) to ferric oxide ( $Fe^{3+}$ ) and is objectionable to users (Bello, 2011). It promotes undesirable bacterial growth in water works and distribution systems. Iron has little effect on human health but excessive ingestion can be inimical to human health, leading to carcinogenic diseases in animals (WHO, 2003), causing damage to blood vessels, liver and kidneys, bloody vomitus/stool and even causing death in

humans (Saskatchewan, 2007). Fe was recorded in excess values in samples 20 and 24 with concentrations values of .48 and .59 while the average is .11 and ranged from 0 -1.07 (Fig. 13). This result is in disagreement with Abdullahi and Indabawa, (2018) who gave a range of .25- .32.

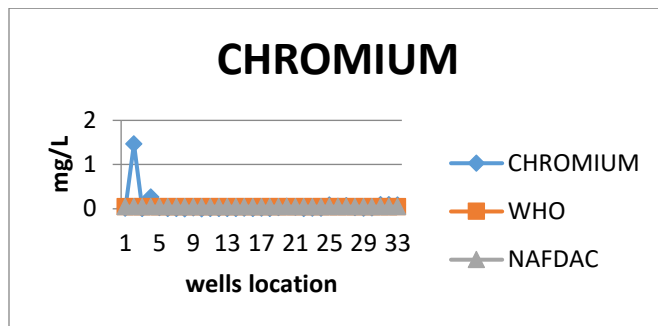
### Chloride (Cl)

Cl in groundwater has a permissible concentration of 250 for the WHO and NAFDAC recommended limit. The sources that exceeded the permissible limit are 2, 29, 30, 31 and 32 with concentrations values of 343, 302.1, 277.4, 302.1 and 289.8 mg/L (Fig.14). Cl concentration in the

area is 93.26 mg/L and ranged between 1.8 -343.4 mg/L. Cl in water in the area is from crystalline aquifers and meteoric origin.



**Figure 14:** Is a plot of Chloride (Cl) against well’s locations



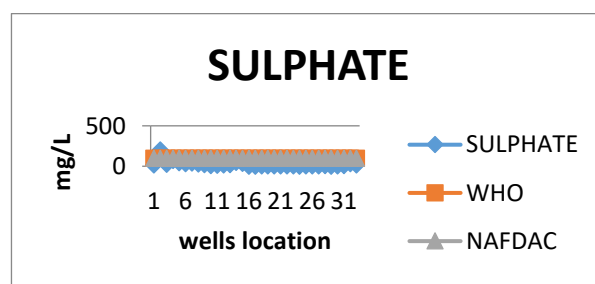
**Figure 16:** Cr concentration in the study area.

**Chromium (Cr)**

Chromium concentration in groundwater found in both WHO and NAFDAC recommended limit is 0.05 mg/L and it exceeded in samples 2, 25, 26, 27, 31, 32 and 33 with concentrations values of 1.47, .083, .054, .067, .092, .089 and .086 mg/L as depicted in figure 16. Cr has an average value of .076 and a range from 0 – 1.47. According to the United States Environmental Protection Agency (US EPA 2010) when swallowed, Chromium can upset the gastrointestinal tract and has also been linked to certain types of cancer.

**Sulphate (SO<sub>4</sub>)**

Sulphate concentration found in the groundwater has the maximum limit of WHO and NAFDAC recommended limit is 100 mg/L. Sulphate in the result shows that they are all found within the recommended limit of WHO and NAFDAC except in samples location 2 with a concentration value of 202 each as indicated in figure 17. It has a range from 0.0- 202 and an average of 21.37. The sulphate ion is a common constituent of unpolluted water, leached from most sedimentary rocks like gypsum. High SO<sub>4</sub> concentration in groundwater when ingested causes gastrointestinal irritation and purgative effects.



**Figure 17:** Sulphate concentration in the study area

**Microbial Parameters**

Assessment of microbial contaminants is necessary for any water quality investigation, as stated by Amadi (2009) “Physicochemical analyses of water samples and the exclusion of microbial/bacteriological analysis is

unacceptable”. According to Bryan, *et al.*, (2015), microbial contaminants are determined by the presence of the family of bacteria called *coliform* which is found in the soil, plants and animals.

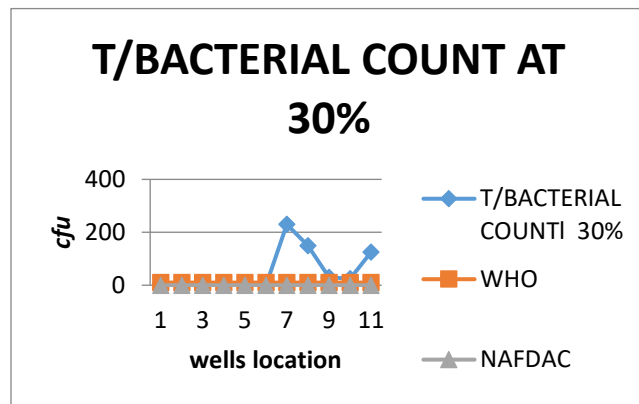
In water quality assessment the family constitutes *total coliform*, *Escherichia-coli*, *faecal coliform* and *faecal streptococcus*. It is believed that they are very dangerous because of their ability to cause diseases instantly or within a very short time after consumption, unlike most chemical contaminants that cause diseases after a long time.

**Total Coliform**

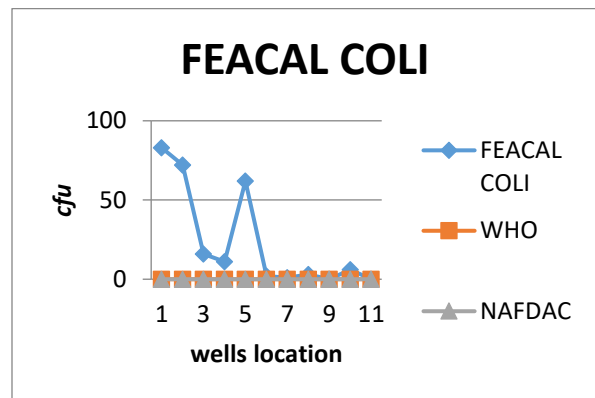
The total coliform count is mostly considered the only microbial parameter used in determining the quality of water. However, it must be noted that it does not normally differentiate the types and

their concentration in the water (Cliff, 2009; João, 2010; Groundwater Association, 2007).

The result shows that well’s locations 4, 19, 25 and 31 exceeded the recommended limit of NAFDAC but within the recommended limit of WHO. Well’s locations 1, 7, 16, 22 and 28 exceeded both WHO and NAFDAC recommended limits respectively (Fig.18). This increase in the coliform count is not unconnected to the open defecation and poor method of waste disposal



**Figure 18:** Total bacterial count in samples



**Figure 19:** Plot indicating Faecal Coliform

**Faecal Coliform**

A *faecal coliform* is a group of bacteria that are passed through the faecal excrement of animals and humans. *Faecal coliform* indicated the presence of recent faecal contamination in water. *Faecal coliform* is usually a product of point sources of pollution to the groundwater, e.g., latrines and livestock feeds lot (João, 2010; Brian, 2014). The recommended distance from the latrine to a water source is at least 30 meters (WHO 2011). The contaminants level allowed by the SON for drinking water is 0 CFU/ 100 ml. The *faecal coliform* level has exceeded the limit of HDW 28, HDW 7 and HDW 16. However, HDW 1 and HDW 22 were found within WHO and NAFDAC recommended limit (Fig.19). This high number of *faecal coliforms* is not

unconnected with their proximity to pit latrines and soaking away from nearby residential areas.

**Escherichia coli**

*Escherichia-coli (E-coli)* are a gram-negative rod-shaped bacterium that is found in the colon of animals and humans. The concentration of *E-Coli* in the groundwater was found with the maximum permissible limit of 0 CFU in both WHO and NAFDAC recommended limits. The concentration was found within the recommended limit of WHO and NAFDAC at HDW 31, HDW 4, HDW 25, HDW13, HDW 19 and HDW 10. But exceeded the WHO and NAFDAC recommended limit in HDW 28, HDW 7, HDW 1, HDW 16 and HDW 22 (Fig.20). this

high E-coli is caused by the latrines and animal dungs in close distance to the source of the water.

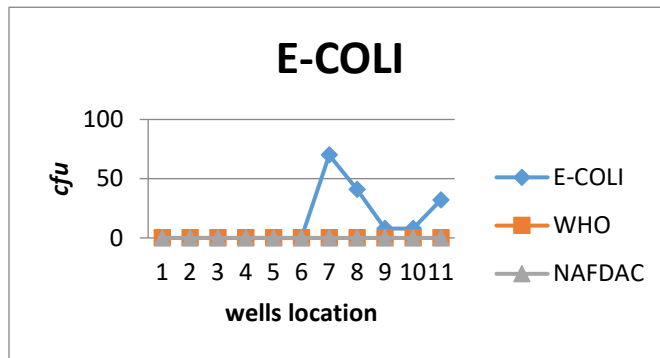


Figure 20: E coli in the study area

A graphical comparison of the bacterial analysis of *total coliform*, *faecal coliform* and *Escherichia coli* for quick visual expression shows that the total bacterial count has 250, *faecal coliform* has 83 while *Escherichia coli* has 70 in that order of decreasing (Fig.21).

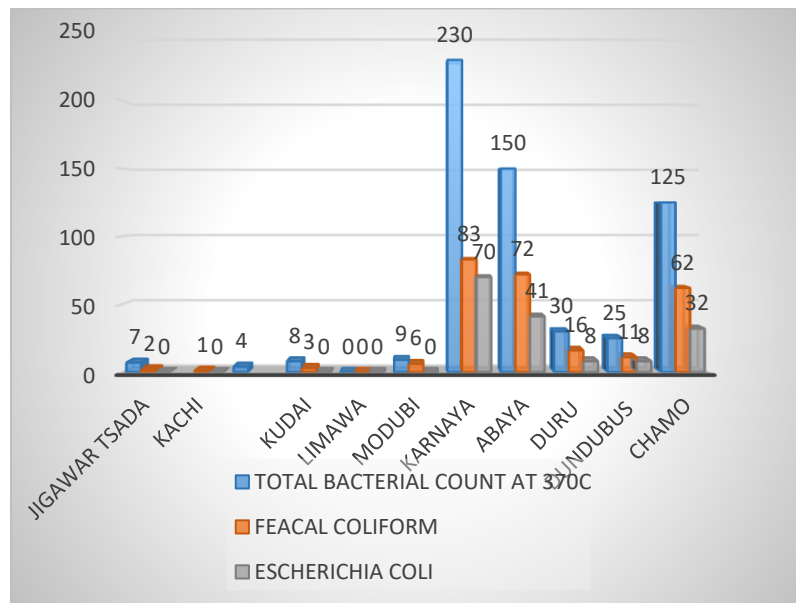


Figure 21: Bacteriological Parameters of Public hand Dug Well in Dutse

**CONCLUSION**

The assessment of 44 water samples from shallow hand-dug wells indicates a negative impact on groundwater resources and is above the threshold of WHO/NAFDAC. There were no significant differences in water quality from well water in Dutse town irrespective of location. All parameters measured shows compliance with the

set standard of WHO/NAFDAC except Fe and microbial analysis. The presence of coliform and high Fe concentration makes the water not safe for drinking unless treated for such parameters. Consuming contaminated water that exceeds the allowable limits of WHO and NAFDAC standards has direct adverse effects on human health resulting in certain types of waterborne

diseases such as fluorosis, carcinogenic, cholera, dysentery, typhoid etc. The causes of pollution in the shallow groundwater resources of Dutse in caused mainly by the geology of the area and anthropogenic activities of man, hygienically approved methods for waste disposal (both solid and liquid) should be explored and adopted to check the possibilities of indiscriminate land dumping of potentially hazardous waste materials.

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## Conflict of Interest

The authors of this manuscript declare that they have no conflict of interest in writing the manuscript.

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