



Groundwater Quality Assessment of Hand-Dug Wells Using Atomic Absorption Spectroscopy, Titrimetry, and Spectrophotometric Analysis

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Abstract

The study seeks to investigate the quality of groundwater from Hand-Dug wells around Kipi-Nari Kaukau, Rido, and Ungwan-Barde villages in Chikun local government Area of Kaduna State Using Atomic Absorption Spectroscopy (AAS), Titrimetry and Spectrophotometric, analyses, a total of seven (7) water samples from seven different Hand Dug wells collected and 19 Parameters were analyzed which includes; PH level, colour, odour, conductivity, Total Dissolved Solid (TDS), turbidity, Chloride, Hardness, Sodium, Nitrate, Calcium, Chromium, Lithium, Cadmium, Beryllium, phosphate, temperature, lead and Total Petroleum Hydrocarbon. Comparing the water Analyses result with WHO, NSDQW (Nigerian standard for drinking water quality) and NAFDAC recommended standard values for drinking water, it was revealed that the water is generally colourless, odourless, slightly acidic due to low PH level, hardness, conductivity calcium, sodium, nitrate, cadmium, lithium, beryllium, turbidity, chloride, total dissolved solid, chromium and total petroleum hydrocarbon concentration is within the recommended standard limit at room temperature. But Phosphate and Lead has high concentration of 30mg/l and 2.00mg/l respectively at against recommended standard of 0.03mg/l and 0.1mg/l, excessive consumption could be poisonous also low PH level of between 5 to 6.2 at against recommended standard of 7.5 to 8.5, the water may not be safe for drinking. Borehole siting in the study area is recommended with further Geo-chemical analysis of the water to ascertain causes of the lead poisoning, high level of phosphate and low level of PH in the drinking water.

Keywords: Groundwater, AAS, Titrimetry, spectrophotometric, Lead and Investigation

Introduction

The population of the globe is largely reliant on ground water either directly or indirectly (Sanjay, 2010). It is estimated that ground water constitutes 0.06 percent of total water resources in the planet among which 98 percent is fresh water (Bashir et al., 2014). With the increase in population, there is an increase in water demand and this promotes the exploration of underground water sources. Accessible surface water available to industries, agriculture, and domestic purposes is often less than the current water demand (Abdullahi & Iheakanwa, 2013). The absence of clean water supply has increased the prevalence of water-borne diseases such as cholera, typhoid fever, guinea worm among others (Aboh, 2009). The quality of water is impacted by many factors, such as the atmosphere, chemicals, the underlying geology, human activity, and climate change (Tahir et al., 2015). The water quality must comply with requirements set by the World Health Organization (WHO), National Agency of Food and Drug Administration Control (NAFDAC) and other standards agencies as regards to specific applications, such as drinking, household, industrial, recreational and agricultural. The pore spaces of soil or rock contain the ground water in the form of the aquifer.

The layers above the aquifer units are a major source of the pollutants that find their way into the groundwater (Obiora et al., 2015; Ibuot et al., 2019). The leakages of chemical and petrochemical distribution facilities, including pipelines and waste-water collection systems, could form part of contaminants; septic tanks, urban sewage channels, and pipelines are some of the real examples of unknown contamination (World Health Organization, 2006). Moreover,

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the application of manure, the disposal wastes of pharmaceutical companies in unlined evaporation pond, and veterinary drugs of land applied manure could pollute ground water (Campagnolo et al., 2002). It is on this basis that the current study was done to employ the use of Atomic Absorption Spectroscopy (AAS), Titrimetry and Spectrophotometric analyses to test the quality of groundwater of hand-dug wells that would be used in the area of Kipi-NariKaukau, Rido and Ungwan-Barde villages in the Chikun local government area of Kaduna State.

The Study Area

KipiNari-Kaukau, Rido, and Ungwan-Barde are the villages located in the Chikun Local Government Area of Kaduna State near the Kaduna Refining and Petrochemical Company (KRPC). The southern region of Kaduna State is home to Chikun Local Government. Latitudes $10^{\circ}38' 47.78''N$ and $10^{\circ}41' 07.50''N$ and longitudes $7^{\circ}43' 96.39''E$ and $7^{\circ}50'34.417''E$ define the boundaries of the study area. The area of this operation is approximately 615 m above sea level and 8 kilometres.

The primary topographical characteristic of the study area based on Aboh (2009) is the alluvial plain of the small tributaries of the Kaduna River, which are distributed all over the area and up to the northern flank. These plains gently climb into the consolidated lateritic hills and inselbergs. The vegetation of the area is characteristic of the Guinea Savannah type with the temperature mean of $29^{\circ}C$ and the rainfall mean of 300mm/year (Udo, 1982). Most of the rivers and streams of the research area are controlled by the superior River Kaduna. The primary contributors to the recharge of the aquifers in the Basement Complex are rainfall and neighboring rivers and streams.

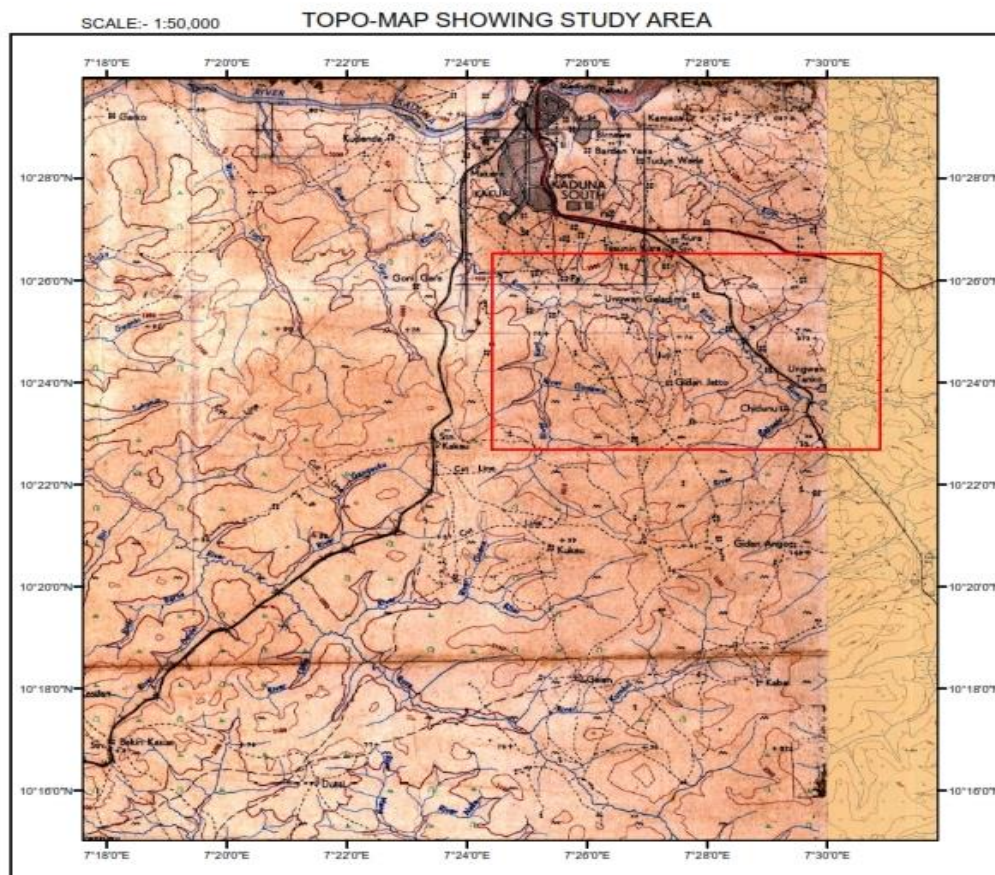


Figure 1. Study area showing the geographical coordinates

Materials and Methods

According to the principle of atomic absorption spectroscopy, Atomic Absorption Spectrophotometer is an excellent analysis instrument to establish the content of metal ions in drinking water samples (Sharma & Tyagi, 2013). When a sample solution is inhaled into a flame, the sample element is turned into atomic vapour. Atoms of elements are found in flames. Also, although most of the atoms remain in their ground state, others are thermally excited by flame. The radiation of a particular wavelength produced by the source a hollow cathode lamp of that particular metal is subsequently absorbed by the ground state atoms. At this point, the wavelength of the radiation that is emitted by the lamp or source is similar to the wavelength of radiation that the atoms of the flame absorb.

The AAS method obeys the law of beer that the absorbance and the concentration are directly proportional (Tyson, 1988). Each atomic absorption spectrophotometer consists of a light source, which could be a lamp, sample cell, monochromator, detector and output. The schematic diagram of an atomic absorption spectrophotometer is indicated in figure 2. The most popular kind of burner is a premix, which removes bigger depletes by introducing the spray into a condensing chamber.

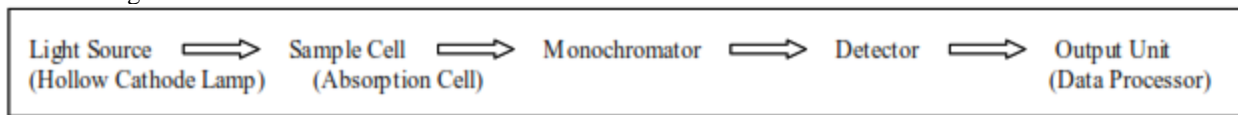


Figure 2. Schematic diagram of an Atomic Absorption Spectroscopy (Sharma and Tyagi, 2013)

Water samples were collected in plastic bottles in different hand-dug wells of different settlements behind the refinery. The plastic bottles were first washed and rinsed using distilled water to avoid the contamination or absorption of materials in the sample. To make sure that fresh samples were obtained, the stagnant water in the wells would first be purged by simply pumping it out, and then letting the well refill. This was repeated several times and with the assistance of a bailer. The samples were collected and immediately taken to the laboratory of the Kaduna State Environment Protection Authority where they were analysed in three days. The examination of the water samples was done in order to attain the highest level of accuracy and prevent the sample's composition from changing.

Results

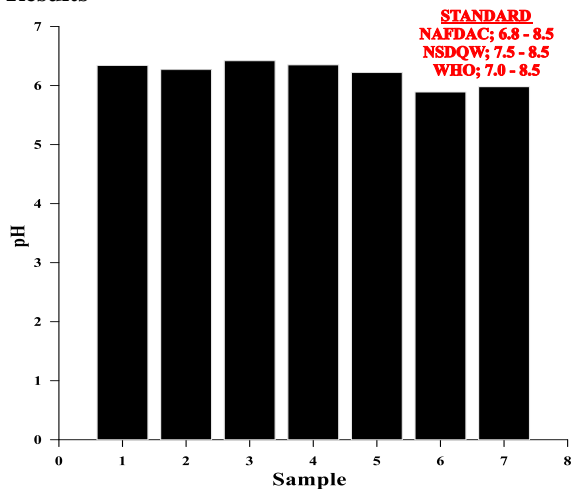


Figure 3. pH level of samples

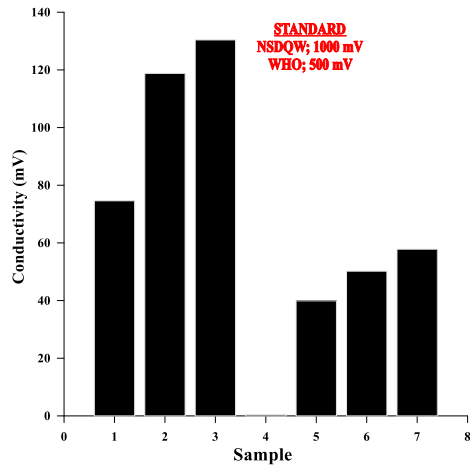


Figure 4. Conductivity level in samples

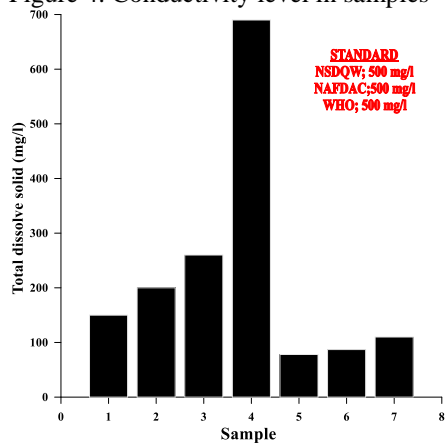


Figure 5; Total dissolved solids level in the samples

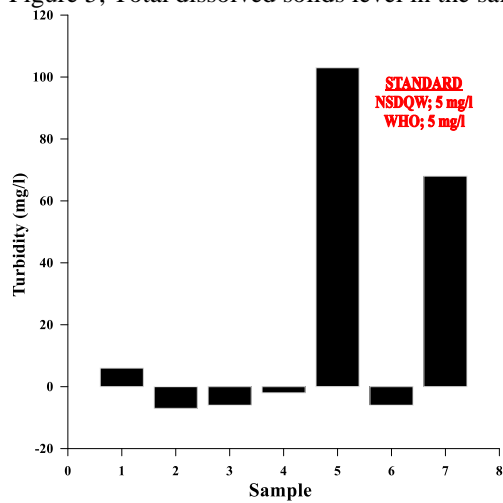


Figure 6: Turbidity level in the samples

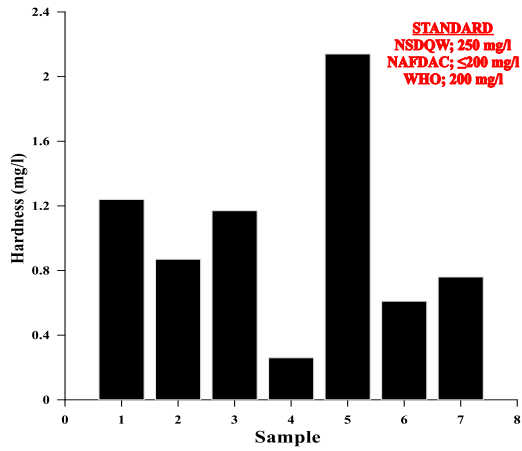


Figure 7: Hardness of samples

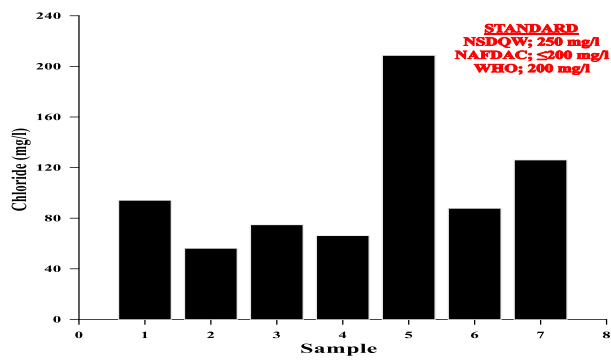


Figure 8: Chloride level in the samples

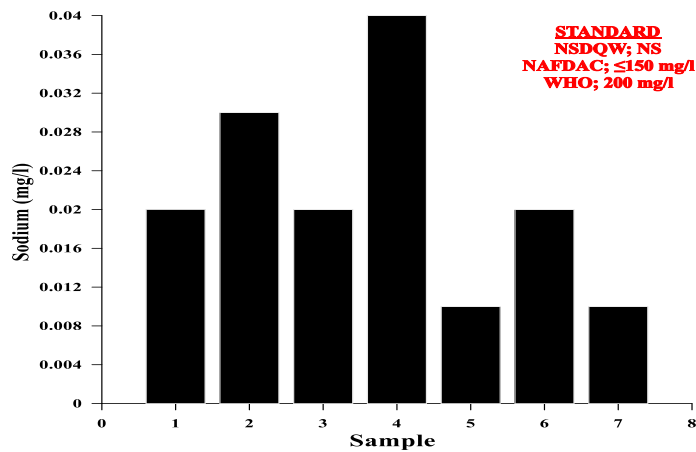


Figure 9: Sodium level in the samples

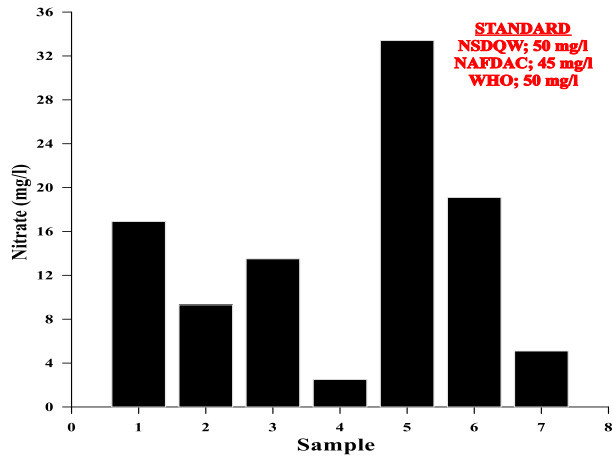


Figure 10: Nitrate level of the samples.

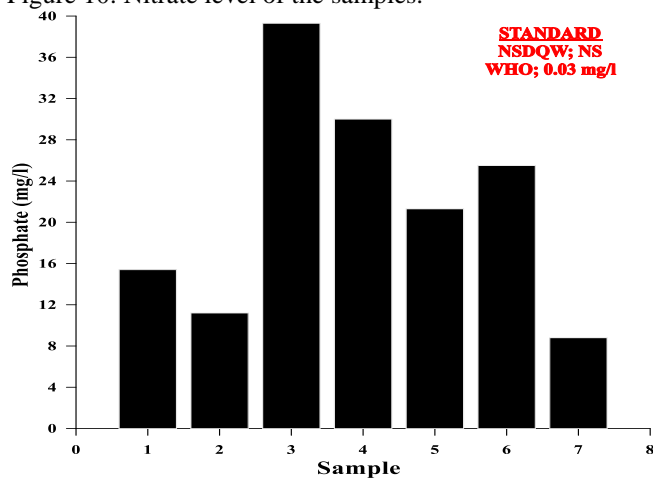


Figure 11: Phosphate level of the sample.

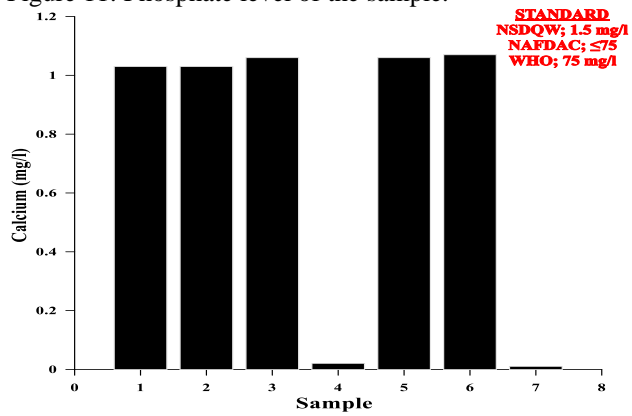


Figure 12: Calcium level of the samples

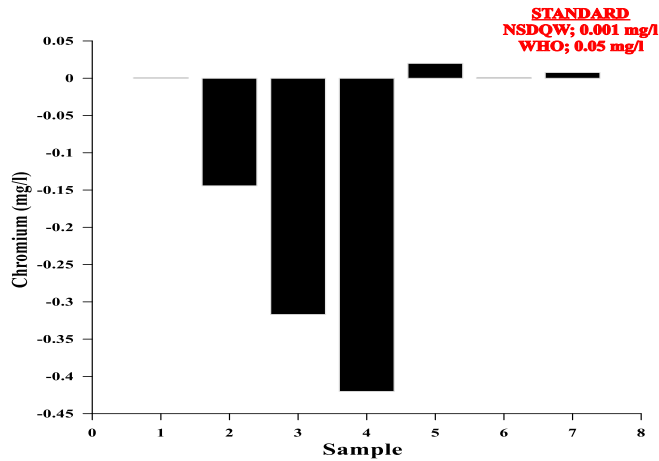


Figure 13: Chromium level of the samples

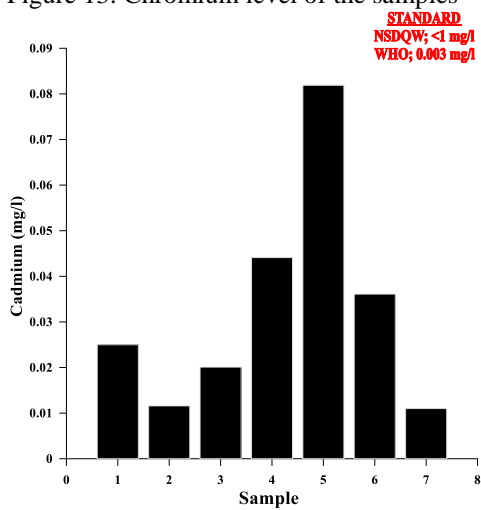


Figure 14: Cadmium level of the sample

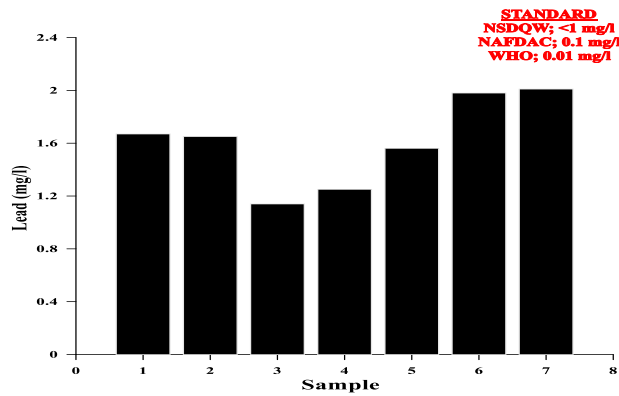


Figure 15: Lead level of the sample

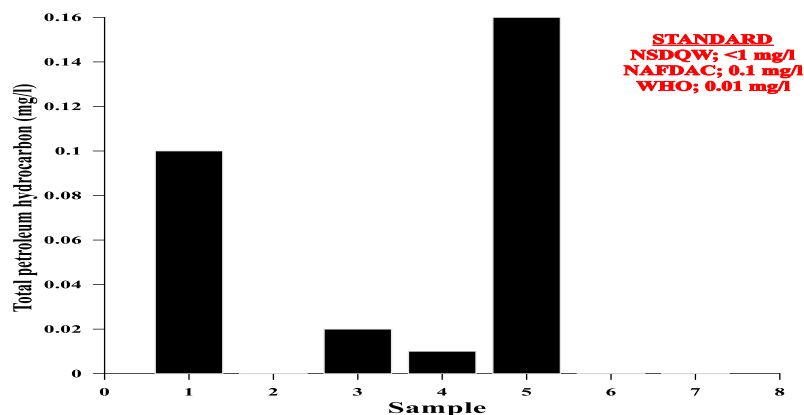


Figure 16: Total petroleum hydrocarbon level in the sample

Well 1, Kipinari-kaukau.

The result of the analysis of the water sample collected from well 1 shows that it is colourless, odourless, slightly acidic (because the PH values is less than 7) and has a temperature 30 °C. The conductivity, Total Dissolved Solid, Chloride, Hardness, Sodium, Nitrate and Calcium levels in the water sample is less than the standards recommended by NSDQW, NAFDAC and WHO for drinking water. The Cadmium, Lithium, Berylium Total Petroleum Hydrocarbon and Chromium values all falls within the recommended standard while Turbidity, phosphate and lead levels is higher than the recommended standards for drinking water.

Well 2, Rido village.

The result of the analysis of the water sample collected from well 2 shows that it is colourless, odourless, slightly acidic, and has a temperature 30 °C. The conductivity, Total Dissolved Solid, turbidity, Chloride, Hardness, Sodium, Nitrate and Calcium levels in the water sample is less than the recommended standards. Chromium, Lithium, Berylium, cadmium and Total Petroleum Hydrocarbon levels in the water sample are within the recommended standard by NSDQW, NAFDAC and WHO for drinking water. while phosphate and lead levels is higher than the recommended standards.

Table 4: Result of the analysis of water samples from hand dug wells in the study area.

PARAMETER	SPL ₁	SPL ₂	SPL ₃	SPL ₄	SPL ₅	SPL ₆	SPL ₇	NSDQW	NAFDAC	WHO
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Unobjectionable	Colourless liquid	Colourless liquid
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Unobjectionable	Odourless	Odourless
Ph	6.36	6.27	6.42	6.35	6.22	5.89	5.95	7.5 – 8.5	6.8 – 8.5	7.0 – 8.5
Conductivity (mV)	74.6	118.8	130.4	0.471	39.90	50.2	50.8	1000		500
Temperature (°C)	30	30	30	30	30	30	30	Ambient	Ambient	Ambient
TDS (mg/l)	150	200	260	690	78	87	110	500	500	500
Turbidity (mg/l)	6	-7	-6	-2	103	-6	68	5		5
Hardness (mg/l)	1.24	0.87	1.17	0.26	2.14	0.61	0.76	250	≤200	200
Chloride (mg/l)	94.1	56.1	74.8	66.2	208.7	87.61	126	250	≤200	200
Sodium (mg/l)	0.02	0.03	0.02	0.04	0.01	0.02	0.01	NS	≤150	200
Nitrate (mg/l)	16.9	9.3	13.5	2.5	33.4	19.1	5.1	50	45	50
Phosphate (mg/l)	15.4	11.2	39.3	30	21.3	25.5	8.8	NS		0.03
Calcium (mg/l)	1.03	1.03	1.06	0.02	1.06	1.07	0.01	1.5	≤75	75
Chromium (mg/l)	0.001	-0.1444	-0.3170	-0.4201	0.02	0.00116	0.0076	0.001		0.05
Cadmium (mg/l)	0.025	0.0116	0.0201	0.0441	0.0819	0.0361	0.011	<1		0.003
Lead (mg/l)	1.67	1.65	1.14	1.25	1.56	1.98	2.01	<1	0.1	0.10
Lithium (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1		0.7
Beryllium (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1		0.1
TPH (mg/l)	0.01	0.0	0.02	0.01	0.16	0.0	0.0	2.0		0.2

Note: SPL = Sample, mg/l = milligram per litre, mV = millivolt, WHO = World health organization TDS = Total dissolved solid, TPH = Total petroleum hydrocarbon NSDQW = Nigerian standard for drinking water quality NAFDAC = Nigerian agency for food and drug administration and control Well 3, Rido village.

Discussion

The result of the analysis of the water sample collected from well 3 shows that it is colourless, odourless, slightly acidic, and has a temperature 30 °C. The conductivity, Total Dissolved Solid, turbidity, Chloride, Hardness, Sodium, Nitrate and Calcium levels in the water sample is less than the recommended standards for drinking water. Chromium, Lithium, Cadmium, Beryllium, and Total Petroleum Hydrocarbon levels in the water sample falls within the recommended standard values by NSDQW, NAFDAC and WHO for drinking water while phosphate and lead levels is higher than the recommended standards.

Well 4, Rido village.

The result of the analysis of the water sample collected from well 4 shows that it is colourless, odourless, slightly acidic (Figure 4.4), and has a temperature 30 °C. The conductivity, turbidity, Chloride, Hardness, Sodium, Nitrate and Calcium levels in the water sample is less than the recommended standards for drinking water. Chromium, Lithium, Cadmium, Beryllium, and Total Petroleum Hydrocarbon levels in the water sample falls within the recommended standards values, while The Total Dissolved Solid, phosphate and lead levels is higher than the recommended standard for drinking water.

Well 5, Juji village.

The result of the analysis of the water sample collected from well 5 shows that it is colourless, odourless, slightly acidic, and has a temperature 30 °C. The conductivity, Total Dissolved Solid, Hardness, Sodium, Nitrate and Calcium levels in the water sample is less than the standard recommended by NSDQW, NAFDAC and WHO for drinking water. Chromium, Lithium, Chloride, Cadmium, Beryllium, and Total Petroleum Hydrocarbon levels in the water

sample falls within the recommended standards values while the turbidity, phosphate and lead levels is higher than the standards recommended for drinking water.

Well 6, Unguwan-barde.

The result of the analysis of the water sample collected from well 6 shows that it is colourless, odourless, acidic, and has a temperature 30 °C. The conductivity, Total Dissolved Solid, turbidity, Chloride, Hardness, Sodium, Nitrate and Calcium levels in the water sample is less than the recommended standards. Chromium, Lithium, Cadmium, Beryllium, and Total Petroleum Hydrocarbon levels in the water sample falls within the recommended standards values by NSDQW, NAFDAC and WHO for drinking water while the phosphate and lead levels is higher than the standards recommended.

Well 7, Unguwan-barde.

The result of the analysis of the water sample collected from well 7 shows that it is colourless, odourless, acidic, and has a temperature 30 °C. The conductivity, Total Dissolved Solid, Chloride, Hardness, Sodium, Nitrate and Calcium levels in the water sample is less than the recommended standards by NSDQW, NAFDAC and WHO for drinking water. Chromium, Lithium, Cadmium, Beryllium, and Total Petroleum Hydrocarbon levels in the water sample falls within the recommended standards values by NSDQW, NAFDAC and WHO for drinking water while The turbidity, phosphate and lead levels is higher than the standards.

The analysis of the water sample from hand-dug wells shows that the samples are generally colourless, odourless, slightly acidic, of less hardness and conductivity compared to the standard, and at room temperature. The result shows that the concentration of the following elements is less than the NSDQW and other standards in all samples; calcium, sodium, nitrate, cadmium, lithium, beryllium, and total petroleum hydrocarbon (Figures 12, 9, 10, 14, 16, 11, and 15). The concentration of phosphate and lead (Figures 11 and 15) is higher than the standards in all samples, excessive consumption could be poisonous. The level of turbidity, chloride, total dissolved solid, and chromium are less than the standard except in some in some samples (Figures 6, 8, 5, and 13),The quality of water is impacted by many factors, such as the atmosphere, chemicals, the underlying geology, human activity, and climate change (Tahir et al., 2015).

Although there is a very good potential for water within the study area, the slightly acidic nature, high level of lead and phosphate in the water suggest that the water is not safe for consumption in accordance with the standard provided by NSDQW, NAFDAC and WHO.The leakages of chemical and petrochemical distribution facilities, including pipelines and waste-water collection systems, could form part of contaminants; septic tanks, urban sewage channels, and pipelines are some of the real examples of unknown contamination (World Health Organization, 2006).

Conclusion

The water sample from hand-dug wells are generally colourless, odourless, slightly acidic, of less hardness and conductivity at room temperature and the concentration of phosphate and lead is higher than the recommended standards. The absence of clean water supply has increased the prevalence of water-borne diseases such as cholera, typhoid fever, guinea worm among others (Aboh, 2009), Phosphate and Lead has high concentration of 30mg/l and 2.00mg/l respectively at against recommended standard of 0.03mg/l and 0.1mg/l, excessive consumption could be poisonous also low PH level of between 5 to 6.2 at against recommended standard of 7.5 to 8.5. The test outcome of the water sample indicates that the water, which the residents are drinking, is probably not safe. The role of normal PH value in drinking water cannot be over stressed, they maintain the body in balance and metabolism. Acidic water retards the immune system and leads to weight gain. Lead in high amounts of portable devices makes individuals susceptible to health issues such as cancer, stroke, kidney disease, memory issues, high blood pressure and reproductive issues in both men and women. Turbidity of portable water can shield bacteria and other living things rendering chlorine useless in sanitizing the water leading to symptoms such as headaches, cramps and nausea. Hence, although the water in the study area has good potential, the high-water content of lead and phosphate and slightly acidic properties of the water imply that the water might not be safe to drink.

Recommendations

1. This study succeeded in identifying the quality of Groundwater from hand-dug wells in the study Area as being possibly unsafe for drinking.
2. The Groundwater contains high concentration of lead and phosphate also it is slightly acidic in nature as a result of low level of PH value.
3. The layers above the aquifer units are a major source of the pollutants that find their way into the groundwater (Obiora et al., 2015; Ibuot et al., 2019).due to limitation of methodology and resources this study couldn't link the proximity of the refinery to study area as the sources of the pollutants (high concentration of lead, phosphate and slightly acidic in nature of the Groundwater).
4. Hence further geophysical investigation of the study area to find out the causes of the lead poisoning, high level of phosphate and low level of PH in the drinking water is recommended.

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