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# Analysis of some Physical and Chemical Parameters of Domestic Water (Borehole) in Kano Metropolis using Argentometric and Spectrophotometric Techniques

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**ABSTRACT**
The research used the standard argentometric and spectrophotometric techniques to investigate the qualities of domestic water for public consumption. A detailed physical and chemical analysis of water (borehole) samples collected from different parts of Kano metropolis was carried out. Some physical parameters such as pH, electrical conductivity and turbidity, as well as the concentrations of Ca, Cu, $Cl^-$, Pb, Mg, $NO_3^-$ and Zn were analyzed. The results obtained for the physical parameter were found to be in the following ranges: Electrical conductivity (100 to 921.46 µs/cm); pH (6.70 to 7.30) and turbidity (1.05 to 2.07 NTU). While the results of the chemical parameters were as follows: Ca (161.6 to 191.66 mg/L); Cu (3.64 to 10.04 mg/L,); $Cl^-$ (98.0 to 145.4 mg/L); Pb (0.001 to 0.028 mg/L); Mg (86.22 to 100.4 mg/L); $NO_3^-$ (11.8 to 21.1 mg/L) Zn (2.6 to 6.26 mg/L). Most of the results were found to be within World Health Organization and Nigerian Industrial Standard safe limits, except for copper and lead in some areas where the values obtained were found to be higher than the standards limits. Persons correlation coefficient was also ran to establish relationship between the parameters, but in overall, the water from all the locations was found to be safe for human consumption. This research however, suggests that there should be regular monitoring and control of activities especially those leading to ground water contamination.

**Keywords:** Argentometric, Ground water, Kano metropolis, NIS, Spectrophotometric, WHO.

## 1 INTRODUCTION

Water plays a significant role in maintaining both human and animal health, and as such access to safe and clean drinking water is now recognized as a fundamental right of human beings [1], however, around 780 million people do not have access to clean and safe water around 2.5 billion do not have proper sanitation [2], as a result around 6-8 million people die each year due to water related diseases and disasters. Therefore water quality control is a top priority policy agenda in many parts of the world [3]. Water quality and suitability for use are determined by its taste odor, color and concentration of organic and inorganic matters [4]. Contaminants in water can affect the its quality and consequently affect the human health, with the potential sources of water contamination being geological conditions, agricultural and industrial activities, as well as disinfectant, radionuclide, microorganisms, organic and inorganic substances [4].

The major source of drinking water, and the water for agricultural and industrial purposes, is the ground water, whose availability determines the activities and location of humans in an area, with our growing population placing great demand on fresh, clean and natural water [5, 6]. The physico-chemical contaminants that adversely affected the quality of ground water are likely to increase due to variety of sources, ranging from application of agricultural chemicals, municipal wastes, and release of effluents from ternaries and sewage treatment plants, etc, [6]. In addition, human activities also are constantly adding wastes (industrial, agricultural and domestic) to the ground water reservoirs, with both the quantity and quality of water also affected by an increase in anthropogenic activities [7, 8]. As such ground water contamination is one of the most important environmental issues today.

In Nigeria today, the provision of ground water has become an agent of development because government is unable to meet the ever increasing water demand. Thus people have to look for other alternatives to ground water sources such as shallow wells and boreholes. The qualities of these water sources are affected by the characteristics of the media through and/or over which the water passes on its way [9, 10]. Thus the waste discharged from the city; the chemicals released by fertilizers from agricultural purposes; the possible accidental oil spillages from tankers; as well as the heavy metal discharged by the industries, all these can result in an the gradual increase in the contamination of ground water [9, 11]. So there is need to access the quality of these ground water sources, and it is with this in mind that the present study was conducted to assess the physicochemical properties of domestic water (borehole) in Kano Metropolis using argentometric and spectrophotometric techniques.

### 1.1 Study Area

The criteria of choosing this sampling site were based on the population density, areas of commercial and industrial activities. Kano is the state capital of Kano State in North-West Nigeria. It is situated in the Sahelian geographic region, south of the Sahara. Kano is the commercial nerve center of Northern Nigeria and is the second largest city in Nigeria. The Kano metropolis initially covered 137 square kilometers (53 square miles), and comprised six local government areas (LGAs) Kano Municipal, Fagge, Dala, Gwale, Tarauni and Nassarawa; however, it now covers two additional LGAs Ungogo and Kumbotso. The total area of Metropolitan Kano is now 499 square kilometers (193 square miles), with a population of 2,828,861 as of the 2006 Nigerian census; the latest official estimate (for 2016) is 3,931,300 [12].

Four areas were selected due to their population, commercial and industrial activities within the metropolitan, Ja'en is closed proximity to Sharada industrial zone and while Kurna and Madabo are very densely residential areas with some small medium scale commercial activities these areas are very common with uncontrolled and shallow sewers roaming the streets. The last area Hotoro G.R.A. is the government reserve residential area with less population and commercial activities.

## 2 Materials and Methods

### 2.1 Sampling

All the sampling procedures were carried out according to NIS [13] guidelines. A total of 24 borehole water samples were randomly collected, the depth of each borehole is 40-50 meters. Collection was done between May and July 2019, for (12 weeks). The samples were collected in triplicate, 100 m apart from different borehole in 1 liter plastic bottles. All the sample containers were washed with detergents then rinsed with deionized water and followed by ethanol. All the samples were placed and maintained at temperature between 4 to $10^{O}$C to avoid contamination. Sample bottles for metal analysis were further rinsed with 0.1 M $HNO_3$ to maintain pH of less than 2.

### 2.3 Analysis of Physical Parameters

The three physical parameters, pH, electrical conductivity and turbidity, were analyzed at the sampling sites using standard procedures of the APHA [14] using different calibrated standard instruments as reported by DeZuane [15] as adopted by Rahmanian *et al.*, [4]. Each analysis was carried out in triplicate. The pH of the four water samples was measured dipping a pre-calibrated and standardized pH meter (model 8000) in each sample for a couple of minutes, and then the pH recorded. The electrical conductivities of the samples were measured using a conductivity meter (model AZ-86P3, Taiwan). The probe was calibrated using a standard solution of known conductivity, and then dipped into the water sample, and the reading recorded accordingly. Before dipping the probe into the next sample, deionized water was used to rinse it, so as to avoid cross-contamination between different samples. The turbidities of the four water samples were determined using a turbidity meter (model 2100P).

### 2.4 Analysis of Chemical Parameters

The concentrations on nitrate in the four water samples were determined using a UV-Visible spectrophotometer type (JASCO V-530), while concentration of chloride was determined using argentometric procedures as mentioned in the Standard Analytical Procedure for Water Analysis [16]. Cations of calcium and magnesium were measured using Flame Photometer, and the concentrations of the heavy metals, copper, lead and zinc, were determined using atomic absorption spectrophotometer (AAS) Agilent Technologies 200 series AA [14].

### 2.5 Statistical Analysis

To test the impact of metals from water coming out from the ground for quality, Statistical Package for Social Scientists (SPPS) version 16.0 was used to express as the results in mean ± SD (standard deviation) the result were collected in triplicate. Also Persons correlation coefficient (r) A significant difference was tested at 95% confidence level ($P<0.05$).

## 3 Results and Discussion

### 3.1 Results

The means and standard deviations of the physical parameters of the water collected from the Kano Metropolitan Areas are presented in Table 1, while the chemical parameters, metals and nitrite, are presented in Figures 1-7, and the Pearson's correlation coefficients of the analyzed parameters are presented in Table 2.

**Table 1: Mean and Standard Deviation of Physical Parameters of Kano Metropolitan Areas**

| Sampling Sites | | Conductivity (µs/cm) | pH | Turbidity NTU |
|---|---|---|---|---|
| Hotoro GRA | Mean | 100.00 | 7.10 | 1.08 |
| | Std. Deviation | 0.00 | 0.00 | 0.00 |
| Madabo Qtrs. | Mean | 921.46 | 6.79 | 1.05 |
| | Std. Deviation | 0.50 | 0.005 | 0.00 |
| Kurna Qtrs. | Mean | 651.00 | 6.70 | 2.07 |
| | Std. Deviation | 0.00 | 0.00 | 0.00 |
| Ja'en Qtrs. | Mean | 541.61 | 7.30 | 1.06 |
| | Std. Deviation | 0.01 | 0.00 | 0.00 |
| WHO | | 1000 | 6.5-8.0 | <5 |
| NIS | | 1000 | 7.0 | 5 |

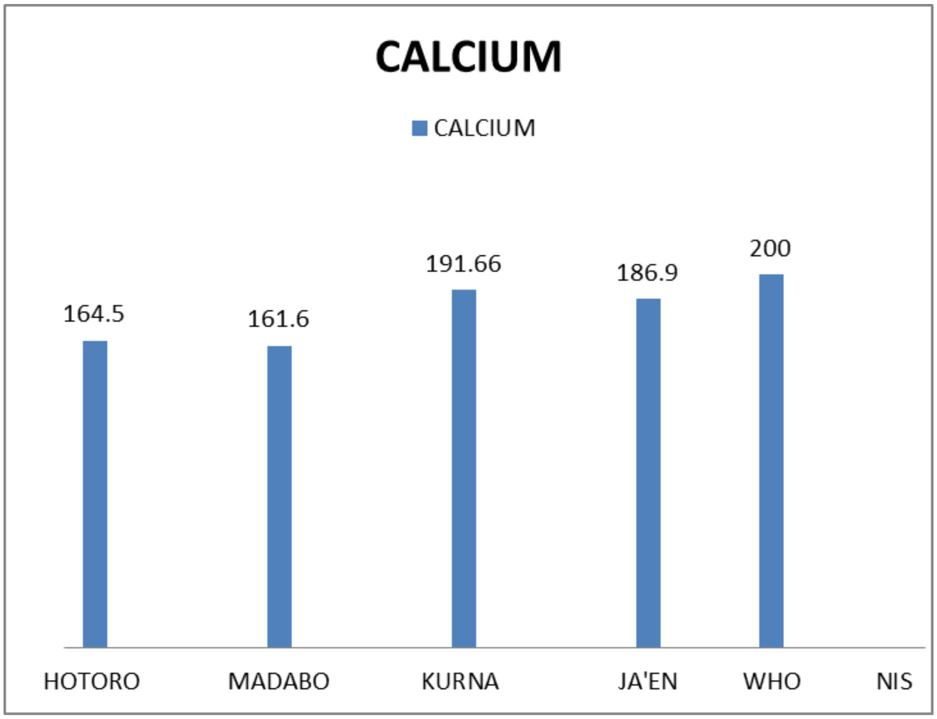


**Fig. 1: Concentration of Calcium in the Analyzed Water Samples**

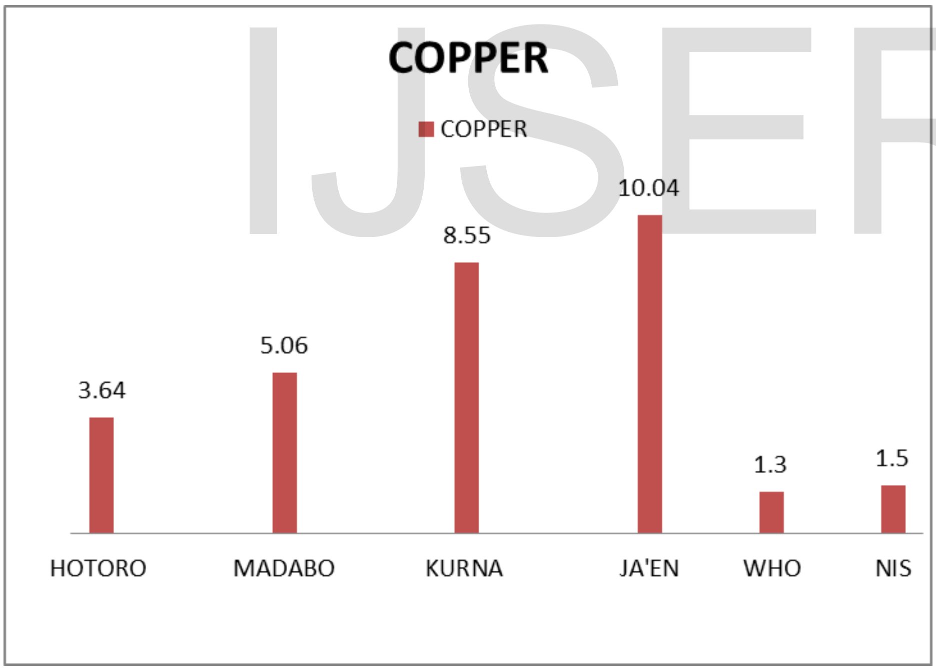


**Fig. 2: Concentration of Copper in the Analyzed Water Samples**

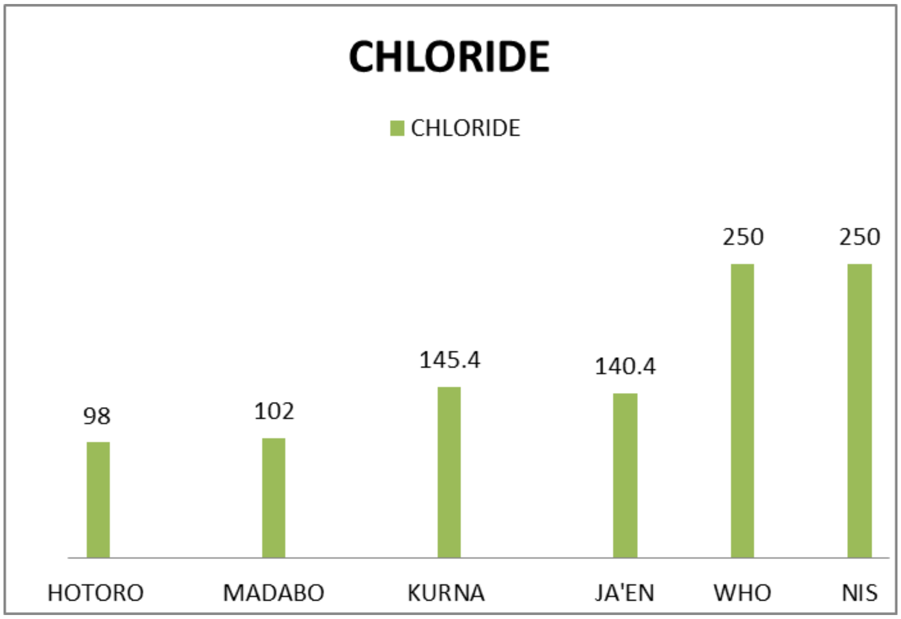


**Fig. 3: Concentration of Chloride in the Analyzed Water Samples**

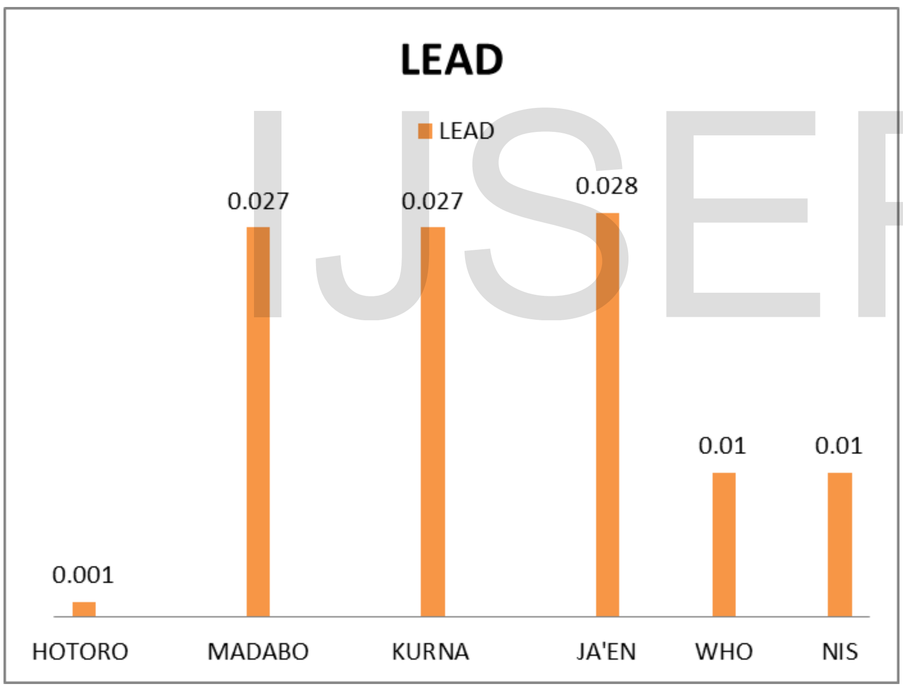


**Fig. 4: Concentration of Lead in the Analyzed Water Samples**

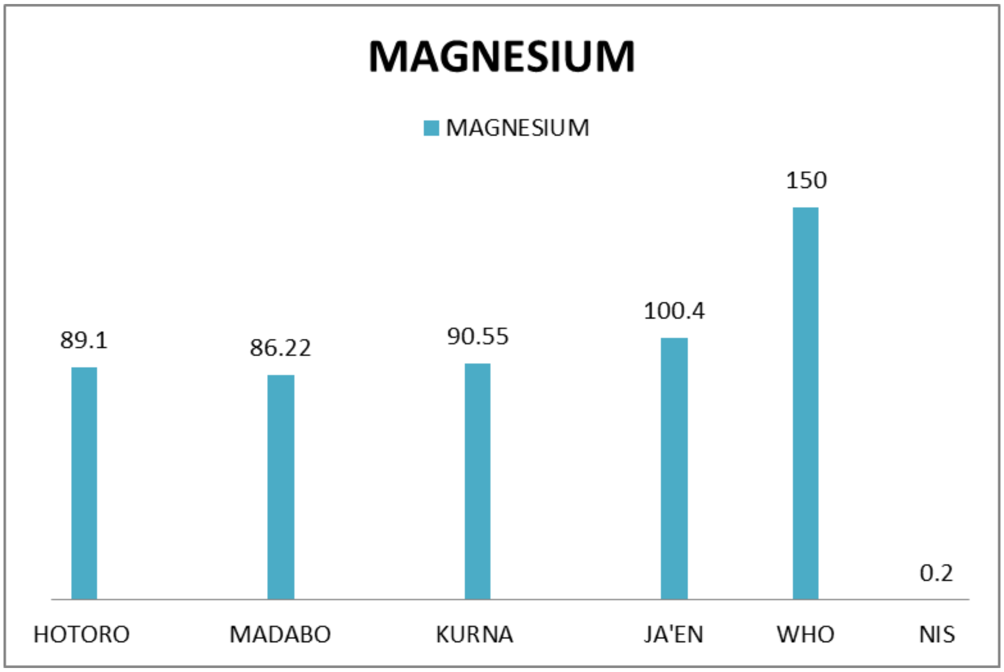


**Fig. 5: Concentration of Magnesium in the Analyzed Water Samples**

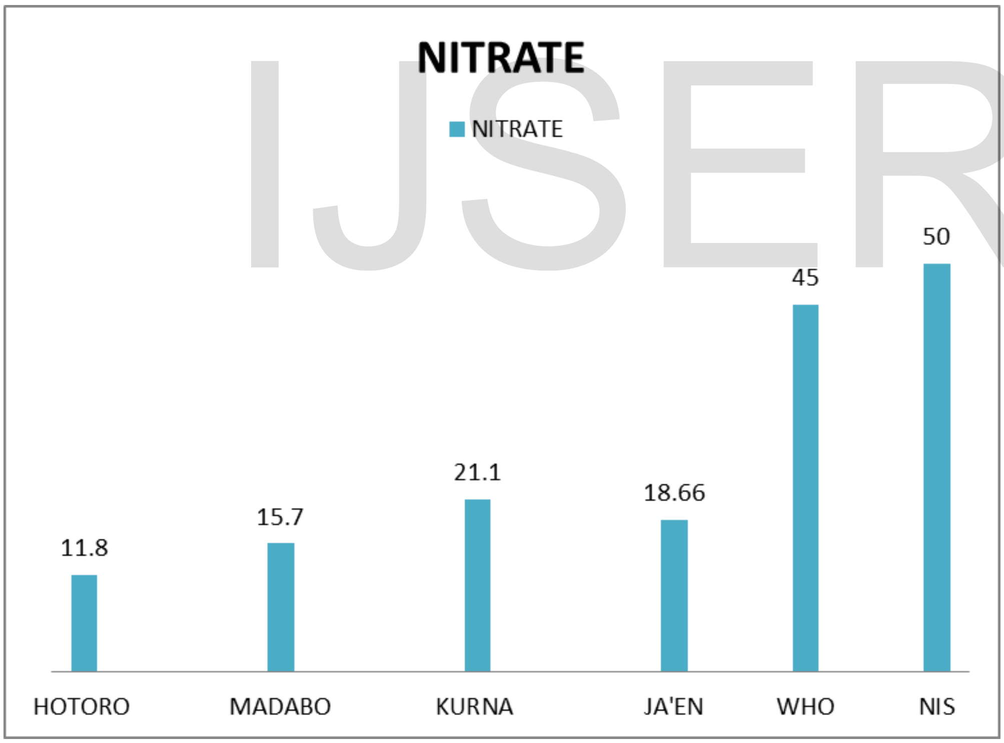


**Fig. 6: Concentration of Nitrite in the Analyzed Water Samples**

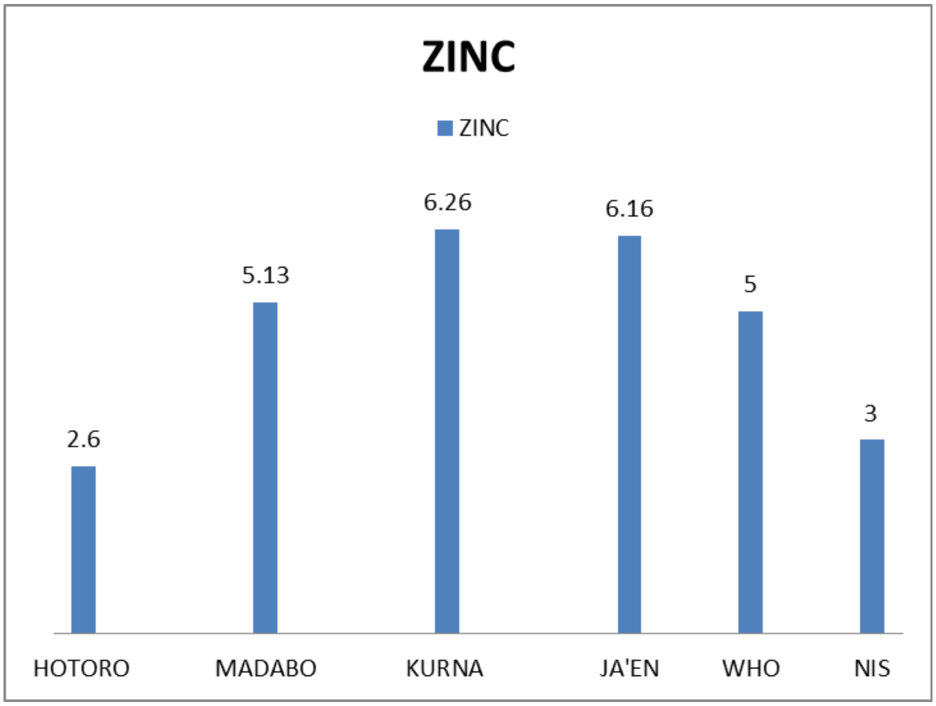


**Fig. 7: Concentration of Zinc in the Analyzed Water Samples**



**Table 2: Pearson's Correlation Coefficient**

| | | Ca | Cu | Cl | Pb | Mg | $NO_3^-$ | Zn | Conductivity | pH | Turbidity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | Pearson Correlation | | | | | | | | | | |
| | Sig. (2-tailed) | | | | | | | | | | |
| Ca | Pearson Correlation | | | | | | | | | | |
| | Sig. (2-tailed) | | | | | | | | | | |
| Cu | Pearson Correlation | 0.890** | | | | | | | | | |
| | Sig. (2-tailed) | 0.000 | | | | | | | | | |
| Cl | Pearson Correlation | 0.973** | 0.949** | | | | | | | | |
| | Sig. (2-tailed) | 0.000 | 0.000 | | | | | | | | |
| Pb | Pearson Correlation | 0.544 | 0.738** | 0.660* | | | | | | | |
| | Sig. (2-tailed) | 0.067 | 0.006 | 0.019 | | | | | | | |
| Mg | Pearson Correlation | 0.641* | 0.798** | 0.659* | 0.292 | | | | | | |
| | Sig. (2-tailed) | 0.025 | 0.002 | 0.020 | 0.357 | | | | | | |
| $NO_3^-$ | Pearson Correlation | 0.862** | 0.870** | 0.923** | 0.849** | 0.404 | | | | | |
| | Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | 0.193 | | | | | |
| Zn | Pearson Correlation | 0.729** | 0.875** | 0.831** | 0.963** | 0.448 | 0.945** | | | | |
| | Sig. (2-tailed) | 0.007 | 0.000 | 0.001 | 0.000 | 0.144 | 0.000 | | | | |
| Conductivity | Pearson Correlation | 0.083 | 0.301 | 0.219 | 0.860** | -.172 | .548 | 0.713** | | | |
| | Sig. (2-tailed) | 0.797 | 0.342 | 0.494 | 0.000 | 0.593 | 0.065 | 0.009 | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| pH | Pearson Correlation | 0.035 | 0.205 | 0.010 | -.284 | 0.751** | -.298 | 0-.201 | -.541 | |
| | Sig. (2-tailed) | 0.915 | 0.522 | 0.974 | 0.371 | 0.005 | 0.348 | 0.532 | 0.070 | |
| Turbidity | Pearson Correlation | 0.658* | 0.374 | 0.634* | 0.330 | 0-.115 | 0.697* | 0.456 | 0.166 | -.651* |
| | Sig. (2-tailed) | 0.020 | 0.231 | 0.027 | 0.295 | 0.722 | 0.012 | 0.136 | 0.607 | 0.022 |

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

## Discussion

### Physical Properties

**pH:** pH is believed to be one of the most important operational water quality parameters [13]. All the samples analysed in this study were found to be within World Health Organization [3] and NIS [13] safe permissible limits for drinking water, with Kurna sample recording the lowest pH of 6.70, and Ja'en sample recording the highest (7.30). Similar findings by previous researchers were all within this current research findings, with Sadiq *et al.,* [17] reporting a pH of ground water within Kano metropolis between the range of 7.1 to 8.3; Emmanuel and Nuruddeen [18] reporting a pH range between 6.3 to 8.2; Muhammad *et al.,* [19] reporting a pH ranging from 7.00 to 7.40 for ground water samples.

**Conductivity:** Electric conductivity is the ability of any medium (in this case water) to carry an electric current. The presence of dissolved solids such as calcium, chloride, and magnesium in water samples carries the electric current through water [4]. In this current study all the above mentioned dissolved ions were detected therefore this make conductivity one of the important parameters to be checked for water quality parameter. Pure water is not a good conductor of electricity because the current is transported by the ions in solution, but the conductivity increases as the concentration of ions increases. In this current study lowest conductivity (100.00) was recorded in the Hotoro GRA sampling site, and this led to the lower metal ions detected in that area. On the other hand, the highest conductivity (921.46) was recorded in the Madabo sample. All the findings in this study were within the World Health Organization [3] and NIS [13] safe permissible limits of conductivity in water. However, the values reported in this study were above what was reported by Emmanuel and Nuruddeen [18], who reported conductivity ranging from 126 to 143 µs/cm. Similarly, the results from this study were found to be lower than 405 to 1939 µs/cm range reported by Sadiq *et al.,* [17], and 113 to 2540 µs/cm range reported by Sa'eed and Amira [20]. Conductivity does not have direct impact on human health, however higher conductivity may lead to lowering the aesthetic value of the water giving it mineral-like taste [4].

**Turbidity:** Turbidity is the measure of water clarity, and how much the materials suspended in the water decreases the passage of light through the water [14, 21]. Such suspended materials may include, among others, soil particles (sand, silt and clay), microbes, plankton, algae and other substances [21]. The values of turbidity of the borehole water samples within Kano metropolis collected range from 1.05 NTU (Madabo sample) to 2.87 NTU (Kurna sample). Increase in turbidity is mainly due to presence of colloidal matter or very finely divided suspended matter, which settles only with great difficulty, sewage and industrial wastes [22]. The results of this study were found to be within the permissible limit of both WHO [3] and NIS [13] of less than 5 NTU. The current study findings are within the ranges of similar results reported by Musa [11] who reported a range of 1 to 3 NTU; Muhammad *et al.,* [19] who reported a range of 0 to 53 NTU; and Sadiq *et al.,* [17] who reported turbidity range of 2 to 13 NTU. However, the results are below that reported by Ezeribe *et al.,* [8] who reported a range of 3.60 to 13.50 NTU.

### Chemical Properties

Presence of trace metals and some anions in drinking water in concentrations higher than their permissible limits can cause serious impacts on human health; therefore the analysis of such substances in drinking water is an important parameter for water quality. In this study, the results of trace metals such as Ca, Cu, Mg, Pb and Zn, as well as that of Cl and $NO_2$ were compared with the safe limits set by WHO [3] and NIS [13].

**Calcium:** Calcium ions, alongside magnesium ions, are good for healthy bone and teeth, excess of which may cause unpleasant tastes in water [23]. In this study Kurna sample showed the highest mean calcium concentration of 191 mg/L followed closely by Ja'en sample with 186.9 mg/L, while the least concentration (161.6 mg/L) was recorded by the Madabo sample. These finding were found to be within World Health Organization [3] permissible limit of 200 mg/L, while the Nigerian Industrial Standard [13] did not specify any value for calcium concentration in water. The findings from the present study were found to be far above 36 to 72.10 mg/L range reported by Sadiq *et al.*, [17] for calcium concentration in Kano metropolis; and also above 44.39 to 50.01 mg/L range reported by Gorthi and Mohan [24] for calcium concentration in some ground water samples. However, the results of the present study were found to be within 24.2 to 303 mg/L range reported by Emmanuel and Nuruddeen [18] for calcium concentration in ground water. Variations in calcium contents may be due to the types of rocks and soils within different study areas [24].

**Copper:** Some people who drink water containing copper in excess of the permissible level may with short exposure experience gastrointestinal distress and with long term exposure may experience liver or kidney damage [25]. The mean concentrations of copper in this study were found to be above WHO [3] limit of 1.3 mg/L, and the Nigerian Industrial Standard [13] limit of 1.5 mg/L, with the highest concentration of copper found in Ja'en (10.5 mg/L) followed closely Kurna with 8.55 mg/L, with the least mean concentration recorded in the Hotoro GRA sample. The results are found to be far above 0 to 0.002 mg/L range reported by Rahmanian *et al.*, [4] for ground water samples from Perek state, Malaysia. The results are also above that reported by Dogara *et al.*, 26 for water samples from selected areas of Kauru Local Government Area of Kaduna State, Nigeria. Copper is an essential trace element, with the recommended daily allowance (RDA) for copper in normal healthy adult is between 0.97 to 3.0 mg/day range. It is absorbed in gut, and then transported to the liver bound to albumin, where it is processed and then distributed to other tissue [27]. Copper in the body normally undergoes enterohepatic circulation, where the body is able to excrete large excess of copper in the body [27]. This implies that the concentrations obtained in this research for copper will not be considered dangerous since many grams can be excreted daily.

**Chloride:** Chlorides in natural waters such as ground and well waters result from the leaching of chloride-containing rocks and soils with which the water comes in contact [8]. The mean concentrations of chloride in this study showed that Kurna sample has the highest concentration of 145.4 mg/L, followed by Jaen sample with 140.4 mg/L, while the least concentration was found in the Hotoro GRA sample. All the results from this study were found to be within World Health Organization [3] and Nigerian Industrial Standard [13] limits of 250 mg/L for chloride in drinking water. These findings are in line with similar results from Sadiq *et al.*, [18] who reported a range 106.57 to 2961 mg/L. The results are also in agreement to similar results by Pathak and Limaye [6] who reported a range of 38.97 to 153.97 mg/L range for chloride concentrations for groundwater in rural area nearby Sagar city, India. However, the results were far above 18.40 to 82.10 mg/L range reported by Ezeribe *et al.*, [8]; and 7.10 to 8.45 mg/L range reported by Emmanuel and Nuruddeen [18]. On another hand, the results from this study are far below 394.99 to 408.99 mg/L range reported by Gorth and Mohan [24] for some groundwater samples.

**Lead:** Lead is a highly poisonous metal regardless of weither it is inhaled or swallowed, and it affects almost every organ and system of the body [28]. Infant and children who drink water containing lead in excess of the action level could experience delay in their physical or mental development, while adults who drink this water over many years could develop kidney problems [25]. The concentrations of lead in the ground waters of the sample areas differ range from 0.001 mg/L for Hotoro GRA sample, to 0.028 mg/L for Jaen sample, with Kurna and Madabo samples all recorded mean concentrations of 0.027 mg/L. All the findings of this study (except the Hotoro GRA sample) were above World Health Organization [3] and Nigerian Industrial Standard [13] safe limits of lead in drinking water (0.01mg/L). The high concentration of lead in these samples may be attributed to the fact that lead containing substances can be found in household and plumbing materials, as well as lead batteries, ceramics glazes, paint and PVCs, all of which may corrode later and sink down to contaminate ground water through leaching [29]. Previous researchers like Sa'eed and Amira [20] have reported lead concentration (0.14 to 0.18 mg/L) higher than the current study, while Momodu and Anyakora [10] reported lead in ground water between 0.001 to 0.021 mg/L. The difference in lead concentrations between different sampling sites may be attributed degree of contamination and the location of the sample site.

**Magnesium:** Magnesium is also an abundant mineral that is naturally present in many foods, and is an activator of more than 300 enzyme systems [30, 31]. Deficiency of magnesium leads to body weakness, fatigue, nausea, vomiting and loss of appetite, or to some extent poor bone growth, fertility problems and abnormal heart rhythms can occur in severe deficiency [24, 30, 32]. On the contrary, high concentration of magnesium is reported to have laxative effect [24]. Magnesium and calcium concentration are the major causes of hardness in water [33]. The magnesium contents of the four ground water samples analyzed in this study fall between 86.22 mg/L (Madabo sample) to 100.40 mg/L (Ja'en sample) range. These findings are within the World Health Organization [3] safe limit of 150 mg/L, but above the Nigerian Industrial Standard [13] safe limit of 0.2 mg/L. The results from the present study are in agreement with similar results (91.30 to 93.54 mg/L) reported by Gorthi and Mohan [24]. The results also compare with that (78.1 to 149.6 mg/L) reported by Behailu *et al.*, [34] for some ground water samples collected around Konso Area, Southwestern Ethiopia. However, the results from the present study are above 4.56 to 18.29 mg/L range reported by Pathak and Limaye [6].

**Nitrates:** The major sources of nitrates in drinking water are runoff from fertilizer, manure, decay vegetable, municipal waste water, individual discharge sewage, and erosion of natural deposite [35]. Nitrate is used mainly in inorganic fertilizers. Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater treatment and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks. An excess nitrate in water is highly carcinogenic [35, 36]. All the mean values for nitrate in the water sample analyzed in this study were within the World Health Organisation [3] and the Nigerian Industrail Standard [13] safe limits, with Hotoro GRA sample recording the lowest value of 11.8 mg/L, while Kurna sample recorded the highest (21.1 mg/L). These results are in agreement with similar findings (9.78 to 24.2 mg/L) reported by Ezeribe *et al.*, [8], with Musa [11] reporting a much higher results of 25.96 to 43.23 mg/L range. However, Pathak and Limaye [6] reported a much lower results (1.06 to 6.69 mg/L) compared with that of the present study. Emmanuel and Nurudden [18] also recorded an average mean concentration of nitrate (0.52-1.67 mg/L) that is much lower than that of the current study. The variations in the concentrations of the samples might be attributed to the source of the water, soil type and geological location [35].

**Zinc:** Zinc is a trace element necessary for a healthy immune system, deficiency of which may lead to disease and illness [37]. Its main functions include helping in stimulating the activities of many enzymes in the body; playing a role in healing of wound, as well as in the treatment to diarrhea [38, 39]. Of all the four samples analyzed in this study, only Hotoro sample recorded a mean concentration of zinc within the World Health Organisation [3] and the Nigerian Industrail Standard [13] permissible limits of 5 and 3 mg/L respectively. Madabo sample (5.13 mg/L), Kurna sample (6.26 mg/L) and Ja'en sample (6.16 mg/L) were all found to be above the standards. Thes findings from Madabo, Kurna and Ja'en were far above the 0.3 to 3.0 mg/L range reported by [40], as well as 0.59 to 1.73 mg/L range reported by [41]. Rahmanian *et al.*, [4]; Behailu *et al.*, [34]; Samuel *et al.*, [42] have all reported a very low zinc concentration in ground water that compares to that reported for Hotoro GRA sample in this study. Even though zinc is one of the important trace metal that plays a vital role in the physiological and metabolic process of many organisms, higher concentration of zinc can be toxic. Zinc in water can be originated from many sources which includes; corroded zinc roofing sheets, corrosion of household plumbing system, foil paper, dry cell batteries and erosion of natural deposites [43].

**Pearson's Correlation Coefficient:** The correlation matrices of borehole water samples physicochemical parameters and trace metals contents were analyzed using Pearson's correlation coefficient. A correlation matrix for trace metals in the borehole water of different sites as shown in Table: 2.0 were run to see if some metals themselves, and physicochemical parameters were interrelated with each other. In general, most notable positive correlations were between metals themselves; magnesium calcium and chloride the correlation is strong and positive at 0.05 levels. Others were positive but at 0.01 level such as; chloride calcium and copper, Lead copper and chloride, calcium have positive correlation with nitrate, copper and chloride at

0.01 level. A negative correlation was most notably found between pH, lead, nitrate and zinc.

## 4 Conclusion

Some physical and chemical properties of domestic water in some parts of Kano Metropolis were determined using argentometric and spectrophotometric techniques. The values of water quality parameters such as pH, conductivity, turbidity of all the samples were found to be within the recommended limits of WHO and NIS safe limits. Similarly, the concentrations of almost all chemical parameters analyzed were found to be within safe limits, except for copper (Cu) and lead (Pb) in some areas where the values obtained were found to be higher than the standards limits, however if these concentrations continue for long time the public are susceptible to metal toxicity. With this development we suggested that other scientific procedures should be employed to checkmate the quality of domestic water as they contained reasonable amount of these metals. Human activities leading to ground water contamination by toxic metal such as lead (Pb) should be given a priority.

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