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# Comparative Study of Ground Water Quality Around Selected Filling Stations in Ogbomoso North and South Metropolis, Nigeria

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***Abstract***

***Introduction***
*Groundwater which is the last assumed resort for safe and potable water is now at great risk to contamination due to anthropogenic activities that aids industrialization. In Nigeria, the endless dependent on petroleum products for automobiles, fuel, power generation and the nation's economy has geometrically proliferated the siting of filling stations all over the countrywhere products sold are stored and channeled through underground storage tanks and pipe networks into the dispenser which lies above the water level. Hence, this study compared the ground water quality in Ogbomoso north and south metropolis.*

***Methods***
*A purposive descriptive study was conducted where a total number of 35 stations above the age of 15 were involved in the study. A total number of 50 samples was collected across those stations and its environment and this samples were subjected into physiochemical and heavy metals using standard techniques.*

***Results***
*The result of the physical parameter show that the alkalinity and hardness are the only parameters that are above standard level. All other average means of the physical parameter across the two geographical location are within the WHO recommended standard. Majority of the heavy metals of the two local government fall within the recommended standard limit givens by WHO expect for iron with the mean of 0.863 for Ogbomosho north and 0.461 for Ogbomosho south which is above WHO standard level of 0.3. The result shows that both geographical point and element are statistically significant.*

***Conclusion***
*Based on the data obtained, it can be concluded that water from the various different locations have different level of quality. Most of the samples were safe for human consumption and other domestic, industrial and agricultural proposes. They were soft, and with other quality parameters well within the permissible range*

***Keywords****: Water quality, Heavy metals, Filling Stations, Physicochemical.*

## INTRODUCTION

In Nigeria, Filling stations operations started prior to independence; the production and distribution of petroleum products which did not gain much popularity until independence in 1960 as a result of the fact that the mileage of motor able roads rarely increased and are few vehicles plying these roads. However with the independence in1960, Construction of more roads, schools, and factories started and consumption of Petroleum Products increased. Demands for all grades of Petroleum Products started to overtake the supply and this became more manifested after the civil war leading to opening of many filling stations across the country (Udoh, 2013).

Globally, various researches and publications has revealed that the surface water sources though easily accessible are limited in quantity and susceptible to external pollutants, hereby increasing the demand on groundwater resources (Simeonov *et al.*, 2003). Groundwater resources are mostly termed non-renewable when used up or polluted because naturally in their aquifer where found; i.e. protected from external contact by the overburden thickness, it can take up to 100s or more years to naturally replenish itself (which is a very long time in relation to the age of humans) (UNESCO, 2006). Hence, proper care should be taken to maintain the quality of such resource. According to Badu (2015), Groundwater pollution has been traced to an unending list of possible sources, the most common are reported cases of accidental spills of chemicals, improper waste disposal (liquid and solid), pesticides applications, fertilizers application, runoffs from agricultural sites, waste ponds (sewerage and its likes), septic tanks, salt water intrusion, acid mine drainage, leakages of underground storage tanks, pipeline and injection wells etc.

Underground storage tanks (USTs) is defined by the United States Code of Federal Regulations (2002) as “tanks and any underground piping connected to the tank that has at least 10 percent of its combined volume underground”. Generally, these tanks are used to store varieties of chemicals or hazardous substances especially gasoline and other notable petroleum derived products, at both urban and rural areas (Reynolds, 2005). Reports showed that globally USTs has increasing been used as storage facilities in retail filling stations for all kinds of products since the end of World War II ( Lenz, 2014; Groundwater Pollution, 2015) These USTs when leaking are pollution sources to the environment as the contained substances such as petroleum products and other chemicals finds their way into the environmental media i.e. soil and water. The indiscriminate setting up and construction of Filling Stations across Nigeria has increased geometrically over the years as a result of the dependency of the country’s economy on crude oil and other petroleum resources, other factors such as increase in population growth yielding a higher demand on automobile use, lack of stable electricity aiding a generalized use of fuel generators, and also petroleum products like kerosene and liquefied gas for cooking has also promoted the construction of dispensing filling stations at every corner of the country and at close proximities to the end users (Marxsen, 1999; Arokoyu, Mark, & Jochebed, 2015; Oloko-Oba *et al*., 2016; Olukoya, Ana, & Oloruntoba, 2016).

One of the major privately owned establishment that is  widely spread all-over the city is the

Petrol stations where petroleum products such as kerosene, diesel, natural liquefied gas and gasoline (petrol) is commercially dispensed at close proximities to residential settlements.Petrol stations are called by different names such as service stations, fuelling station, filling station, petrol station, petrol bunk, garage, gas station etc. in different countries all over the world (Mshelia, John, & Emmanuel, 2015). These petroleum products are been stored and channeled through underground storage tanks and pipe networks into the dispenser which lies above the water level. According to a research by Baghebo and Atima (2013), the petroleum industry in Nigeria is the largest industry which provides approximately 90 percent of foreign exchange earnings and about 80 percent of Federal revenue and subscribe to the rate of growth of Gross domestic product (GDP). The continuous dependency on petroleum products for fuel, automobiles and power generation has led to the increase of siting of petrol stations all over the country and these products are been stored and channeled through underground storage tanks and pipe networks into the dispenser which lies above the water level.

Ogbomosho is a city in Oyo State, south-western region in Nigeria with a population of approximately 245,000 in 2006 census (federal republic of Nigeria, 2006). The major economy of this land is Agriculture known for its wide distribution of cashew plantations and as well as Mango plantations. Although there is inadequate government investment in infrastructural facilities and policy guidelines for local initiatives have undermined economic growth and development of the town. Ogbomosho like every other city in Nigeria is also flooded with retail filling stations. Hence, the location of filling stations poses great threat to the groundwater system in Ogbomosho town because over 98% of filling stations uses underground storage tanks as the storage facility for their petroleum products which utilizes underground piping networks in distributing and channeling these products to the dispensers on the surface. The chemicals leaked from these USTs can seep and migrate through soil and pollute groundwater due to their composition. Therefore, a study to compare the ground water quality in Ogbomosho north and south metropolis is to be carried out.

## Material and Methods

### Study Area

The study was carried out across Ogbomosho Metropolis, which is the urban centre of the ancient Oyo State, South west, Nigeria. It lies within coordinates of Latitude 8° 30'N and Longitude 4° 30'E respectively and it covers an approximated area of 180 sq km. Ogbomosho is a fast growing town that is geographically divided into two Local government areas namely Ogbomosho North, Ogbomosho South, with populations at 354,690 respectively as at the 2006 Nationwide census totally 551,474 (NPC, 2006), and geopolitically subdivided into 10 wards.

### Population of the Study

The population of the study is the population of community members of Ogbomosho North and South, including the 10 Ward Local Government Area of Oyo state.

**Table 1: List of Geopolitical Wards in Ogbomoso**

| S/No | Ogbomoso North (Ward No) | Ogbomoso South (Ward No) |
|---|---|---|
| **1** | Aaje/Ogunbado/Oke Agbede-1 | Akata- 1 |
| **2** | Abogunde-2 | Alapata -2 |
| **3** | Aguodo/Masifa-3 | Arowomole- 3 |
| **4** | Isale Afon-4 | Ibapon – 4 |
| **5** | Isale Alaasa-5 | Ijeru i- 5 |
| **6** | Isale Ora/Saja-6 | Ijeru II 6 |
| **7** | Jagun-8 | Ilogbo- 7 |
| **8** | Okelerin-9 | Isoko- 8 |
| **9** | Osupa-10 | Lagbedu- 9 |
| **10** | Sabo/Tara-7 | Oke ola/Farm settlement- 10 |

**Research Design**

A purposive descriptive study was conducted where a total number of 35 stations above the age of 15 years were involved in the study.

- Inclusion Criteria
- Petrol stations in less than 100m distance to the nearest residential home in accordance to Department of Petroleum Resources (DPR) guidelines for approval of petrol stations construction;
- Petrol stations with water sources within its vicinity i.e. wells, boreholes etc.
- Petrol stations with more than 1 underground storage tanks of petroleum products i.e. above 100 metric tonnes in its vicinity
- Exclusion Criteria
- Petrol stations outside 100m in distance to the nearest residential settlement;
- Petrol stations with water source outside its vicinity
- Petrol stations with less than 3 underground storage tanks for petroleum products.

**Data collection procedure**

While conducting the research, the method of approach towards the collection of data for the study is:

- The Quantitative method: This involves ground water samples collection from these categories of petrol stations with nearest residential buildings, which will be assessed for concentration of physicochemical parameters and heavy metals using the standard techniques such as, APHA (2002). All parameters gotten will then be compared to the WHO threshold for drinking water to determine the deviation from norm.

**Sampling Techniques**

The sample size was purposively chosen based on some criteria. A purposive descriptive study was conducted where a total number of 35 stations above the age of 15 were involved in the study. A total number of 50 samples was collected across those stations and its environment and this samples were subjected into physiochemical and heavy metals using standard techniques. Data obtained from the quantitative aspect of the research were analyzed using two way anova, mean, standard deviation and range. The qualitative data obtained from the interviews were transcribed and analyzed thematically. The qualitative data were coded and processed using Statistical Package for Social Sciences (SPSS) version 25.0 for Windows (IBM SPSS, 2017). All data analyses were performed using version 3.6.3 of the R software for statistical computing and graphics (R Core Team, 2020) and reports were written using Rmarkdown (Allaire *et al*., 2019; Xie *et al*., 2018) and knitr (Xie, 2014, 2015 & 2019) packages of the R software via R Studio (R Studio Team, 2019) integrated development environment (IDE).

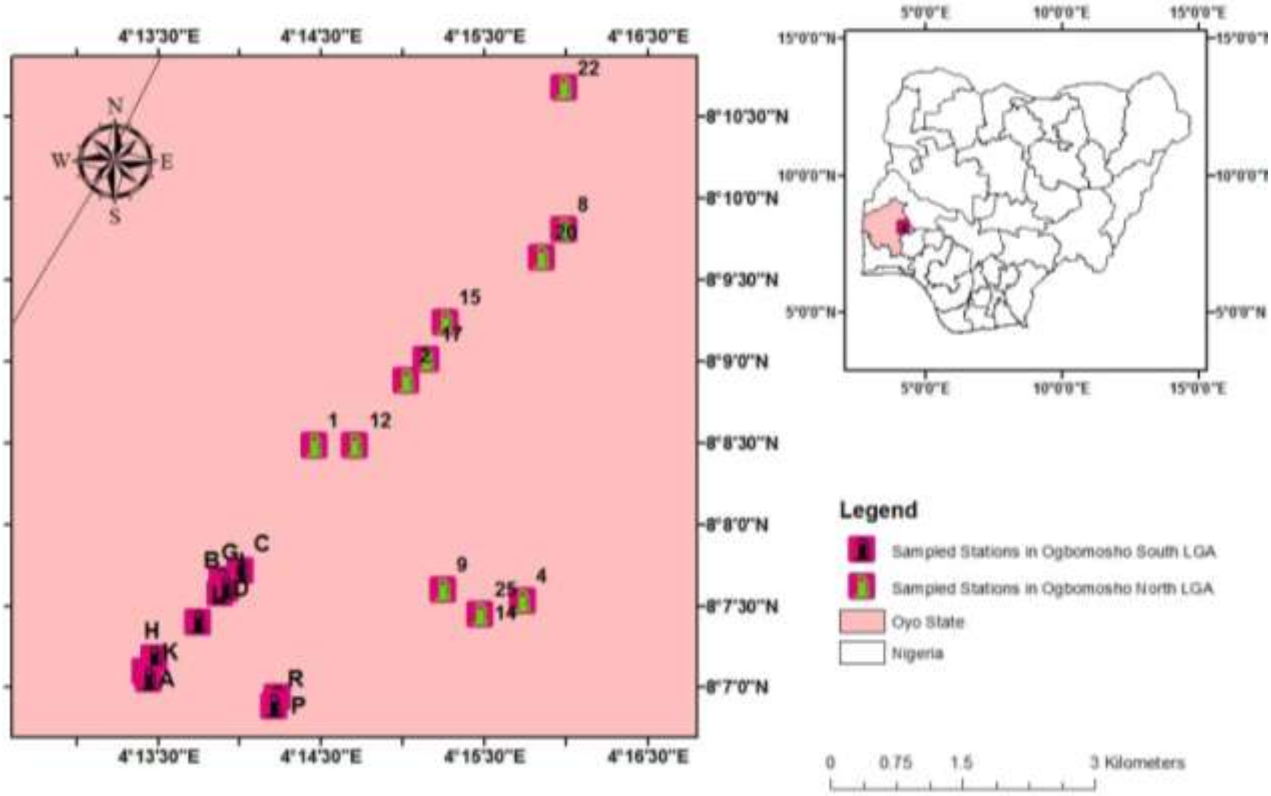


**Figure 1:** Map showing the sampled station

**Water Sample Collection and Analysis**

Groundwater samples were collected from hand dug wells within and around the premises of 35 filling stations that were above 15years of age and functioning. The distance of the well (sample points) to the underground storage tanks were measured. The method of sampling was the grab/spot sampling. The water samples were collected into 28ml glass bottles, which were labelled at the point of collection and transported immediately for laboratory analysis. Duplicate were also taken from sampled wells for precision.

While collecting water samples, some physical measurements were taken at the sample location to give more scientific details of the surrounding environment before further analysis were carried out to categorize the possible heavy metals present in the samples.

**Measurement of Distance from Groundwater Sources to Fuel Storage Tanks (USTs)**

The distances of the well water sampled from the respective fuel storage facilities in the selected filling stations were measured using the surveyor's measuring tape when water samples were taken.

**Measurement of the Groundwater level**

The depth to groundwater level from the earth surface was also obtained while collecting the water samples at all locations.

**Data Analysis**

Spatial analysis using Geographical Information System in modelling and creating maps for obtaining suitable information was done with software such as ArcGIS 10.4, SURFER-12 etc.While, the physicochemical and heavy metals parameters across all samples were modelled to create a pollution vulnerability map using the ArcGIS 10.4 software by the geostatistical approach called Kriging. Kriging a commonly used geostatistical procedure in spatial processes, has been succesfully applied in pollution mapping, hydrology, environmental monitoring, geology etc. (Nas, 2009; Baalousha, 2010; Sheikhy Narany *et al.*, 2014; Kumar *et al.*, 2015)

**Ethical Consideration**

Certification for ethical consideration in undertaking the research was sought for and obtained from the required ministries, departments and agencies who are stakeholders in the field of study

**Results**

**Physical properties of groundwater parameters:**
**Table 2:** Physiochemical Characteristics of Groundwater Samples from Ogbomoso North

LGA

| Parameter | Range | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **Alkalinity (mg/l)** | 168 – 1128 | 278.44 | 363.640 | 218.44 |
| **Hardness** | 96.00 – 556 | 198 | 214.560 | 97.594 |
| **Dissolved** | 6.00-30.000 | 18.20 | 18.240 | 6.194 |
| **Turbidity (NTU)** | 0.10 - 1.000 | 0.100 | 0.244 | 0.337 |
| **Chloride (mg/l)** | 0.002 - 0.007 | 0.004 | 0.005 | 0.002 |
| **Conductivity (ms/cm)** | 0.000 - 0.009 | 0.003 | 0.003 | 0.002 |
| **Total Dissolved Solid** | 1.180 - 8.60 | 3.190 | 3.691 | 2.223 |
| **Total Dissolved** | 0.000 - 8.00 | 0.020 | 1.360 | 1.976 |
| **Volatile Organic** | 0.000 -16.20 | 0.000 | 4.756 | 5.443 |

**Table 3:** Physiochemical Characteristics of Groundwater Samples from Ogbomoso South LGA

| Parameter | Range | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **Alkalinity (mg/l)** | 168 – 784 | 280.00 | 329.680 | 159.89 |
| **Hardness (mg/l)** | 14 – 172 | 90.00 | 83.680 | 40.721 |
| **Dissolved (mg/l)** | 6.000 - 44.00 | 17.30 | 19.652 | 10.199 |
| **Turbidity (NTU)** | 0.040 - 1.000 | 0.100 | 0.0896 | 0.021 |
| **Chloride (mg/l)** | 0.001 - 0.009 | 0.006 | 0.006 | 0.002 |
| **Conductivity (Uscm-1)** | 0.000- 1.000 | 0.004 | 0.045 | 0.199 |
| **Total Dissolved Solid (ppm)** | 1.230 - 5.750 | 3.310 | 3.417 | 1.402 |
| **Total Dissolved (mg/l)** | 0.000 - 6.000 | 2.000 | 1.360 | 1.705 |
| **Volatile Organic (mg/l)** | 0.000 -16.200 | 8.200 | 4.864 | 5.015 |

**Comparing the physiochemical of the water sampled with WHO standard**

**Table 4:** Physiochemical of Groundwater Samples Compared with Standard (WHO, 1993)

| | Ground Water | | Standard |
|---|---|---|---|
| **Parameter** | **ONLGA** | **OSLGA** | **Level** |
| **Alkalinity (mg/l)** | 363.640 | 329.680 | 200 |
| **Hardness** | 214.560 | 83.680 | 150 |
| **Dissolved** | 18.240 | 19.652 | - |
| **Turbidity (NTU)** | 0.244 | 0.0896 | 5 |
| **Chloride (mg/l)** | 0.005 | 0.006 | 200 |
| **Conductivity(ms/cm)** | 0.003 | 0.045 | 1000 |
| **Total Dissolved Solid** | 3.691 | 3.417 | 500 |
| **Total Dissolved** | 1.360 | 1.360 | - |
| **Volatile Organic** | 4.756 | 4.864 | - |

**ONLGA**: Ogbomoso north Local Government Area; **OSLGA:** Ogbomoso south Local Government Area

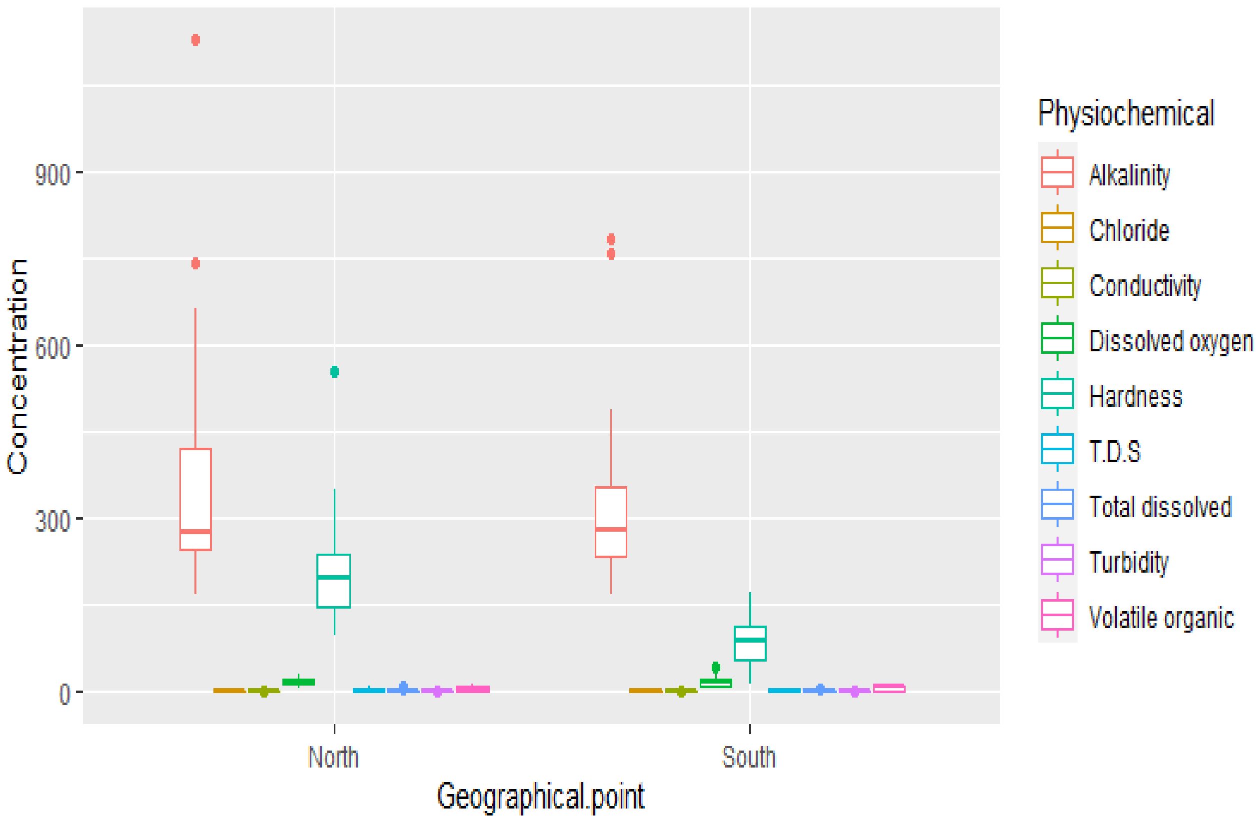


**Figure 2:** Boxplot showing Measurements by geographical point

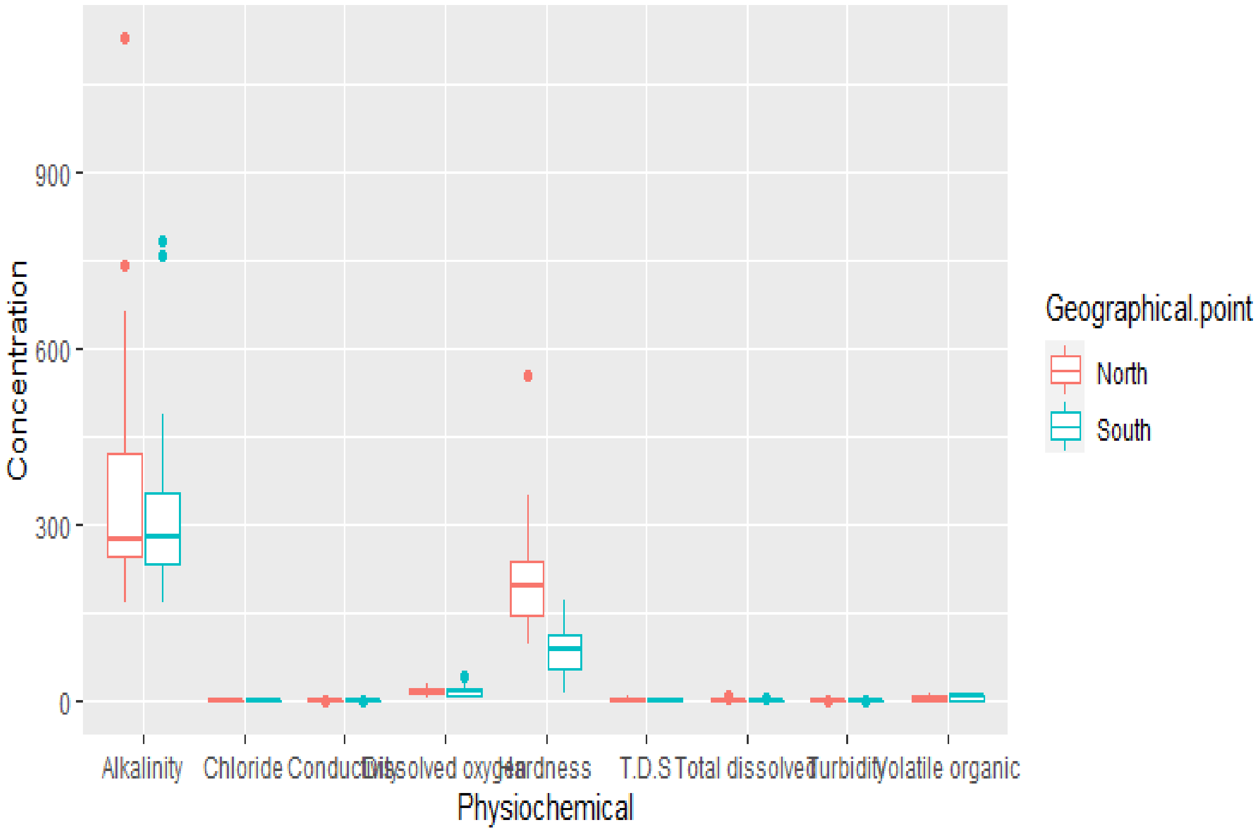


**Figure 3:** Boxplot showing Measurements by physiochemical

**Chemical properties of groundwater parameters:**

**Table 5:** Metal Contents of Groundwater Samples from Ogbomoso North LGA

| Parameter | Range | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **Magnesium (Mg/l)** | 1.158 - 15.987 | 3.854 | 5.074 | 4.147 |
| **Sodium (mg/l)** | 0.000 - 45.110 | 7.000 | 10.224 | 9.353 |
| **Manganese (mg/l)** | 0.000 - 0.900 | 0.310 | 0.109 | 0.231 |
| **Iron (mg/l)** | 0.042 - 2.501 | 0.701 | 0.863 | 0.550 |
| **Copper (mg/l)** | 0.012 - 0.750 | 0.039 | 0.078 | 0.157 |
| **Zinc (mg/l)** | 0.030- 0.426 | 0.204 | 0.197 | 0.099 |
| **Chromium (mg/l)** | 0.000 - 0.008 | 0.002 | 0.003 | 0.002 |
| **Cad (mg/l)** | 0.000 - 0.007 | 0.002 | 0.002 | 0.001 |
| **Lead (mg/l)** | 0.000 - 0.004 | 0.001 | 0.002 | 0.001 |
| **Nickel (mg/l)** | 0.000 -0.022 | 0.001 | 0.002 | 0.004 |

**Table 6:** Metal Contents of Groundwater Samples from Ogbomoso South LGA

| Parameter | Range | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **Magnesium (Mg/l)** | 1.567 - 15.736 | 7.526 | 8.073 | 3.869 |
| **Sodium (mg/l)** | 6.420 – 55.050 | 20.130 | 21.464 | 11.209 |
| **Manganese (Mn)** | 0.000 - 0.101 | 0.010 | 0.024 | 0.028 |
| **Iron (mg/l)** | 0.030 – 0.698 | 0.469 | 0.461 | 0.153 |
| **Copper (mg/l)** | 0.000 - 0.062 | 0.035 | 0.037 | 0.013 |
| **Zinc (mg/l)** | 0.083- 0.603 | 0.283 | 0.284 | 0.117 |
| **Chromium (mg/l)** | 0.000 - 0.004 | 0.002 | 0.002 | 0.001 |
| **Cad (mg/l)** | 0.000 - 0.003 | 0.001 | 0.002 | 0.001 |
| **Lead (mg/l)** | 0.000 - 0.002 | 0.000 | 0.001 | 0.001 |
| **Nickel (mg/l)** | 0.000 - 0.002 | 0.000 | 0.000 | 0.001 |

**Comparing heavy metal from Ogbomosho north and south with WHO standard:**

**Table 7:** Metal Contents of Groundwater Samples Compared with Standard (WHO, 1993)

| | Ground Water | | Standard |
|---|---|---|---|
| Parameter | ONLGA | OSLGA | Level |
| **Magnesium (Mg/l)** | 5.074 | 8.073 | 150.0 |
| **Sodium (Mg/l)** | 10.224 | 21.464 | 200 |
| **Manganese (Mn)** | 0.109 | 0.024 | - |
| **Iron (Mg/l)** | 0.863 | 0.461 | 0.3 |
| **Copper (Mg/l)** | 0.078 | 0.037 | 1.0 |
| **Zinc (mg/l)** | 0.197 | 0.284 | 5 |
| **Chromium (Mg/l)** | 0.003 | 0.002 | 0.05 |
| **Cad (mg/l)** | 0.002 | 0.002 | 0.005 |
| **Lead (mg/l)** | 0.002 | 0.001 | 0.05 |
| **Nitrate (Mg/l)** | 0.002 | 0.000 | 0.02 |

**ONLGA**: Ogbomoso north Local Government Area; **OSLGA:** Ogbomoso south Local Government Area

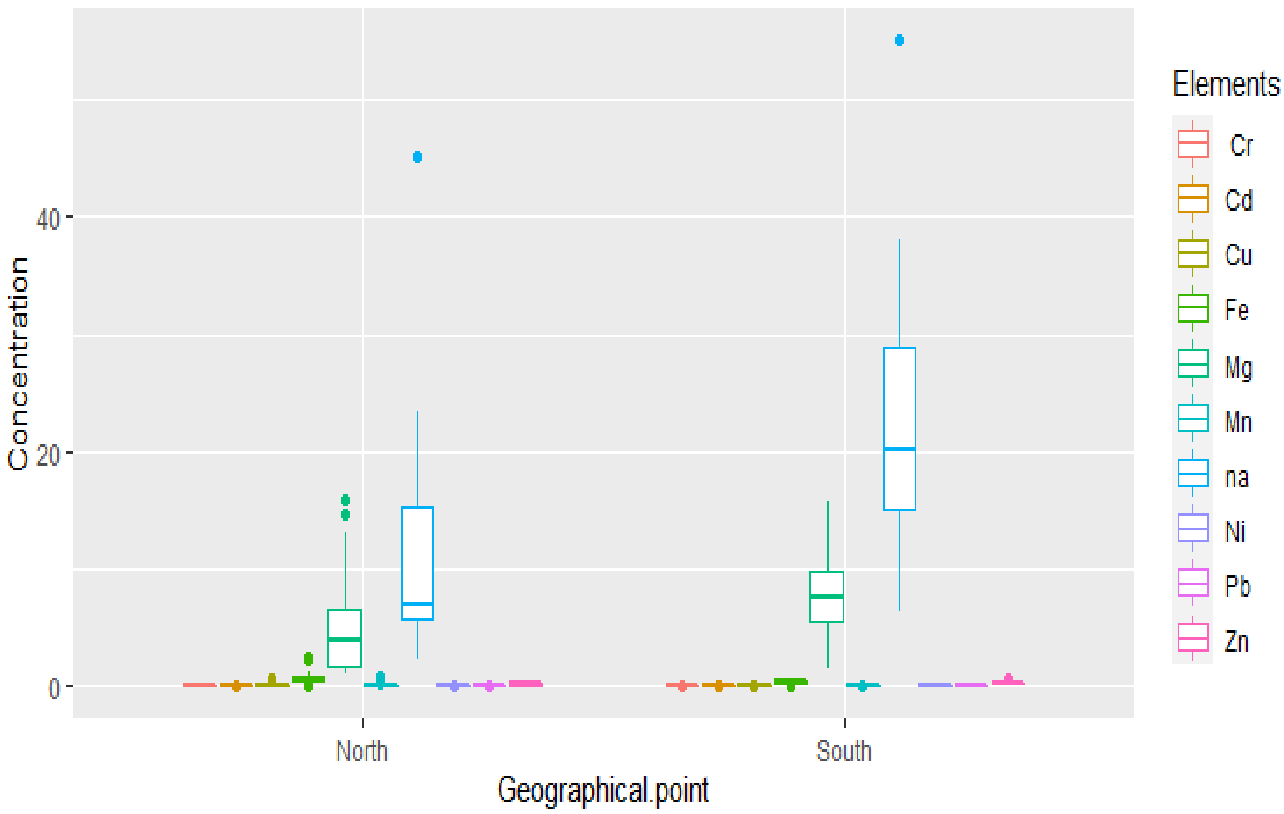


**Figure 4:** Boxplot showing Measurements by geographical point

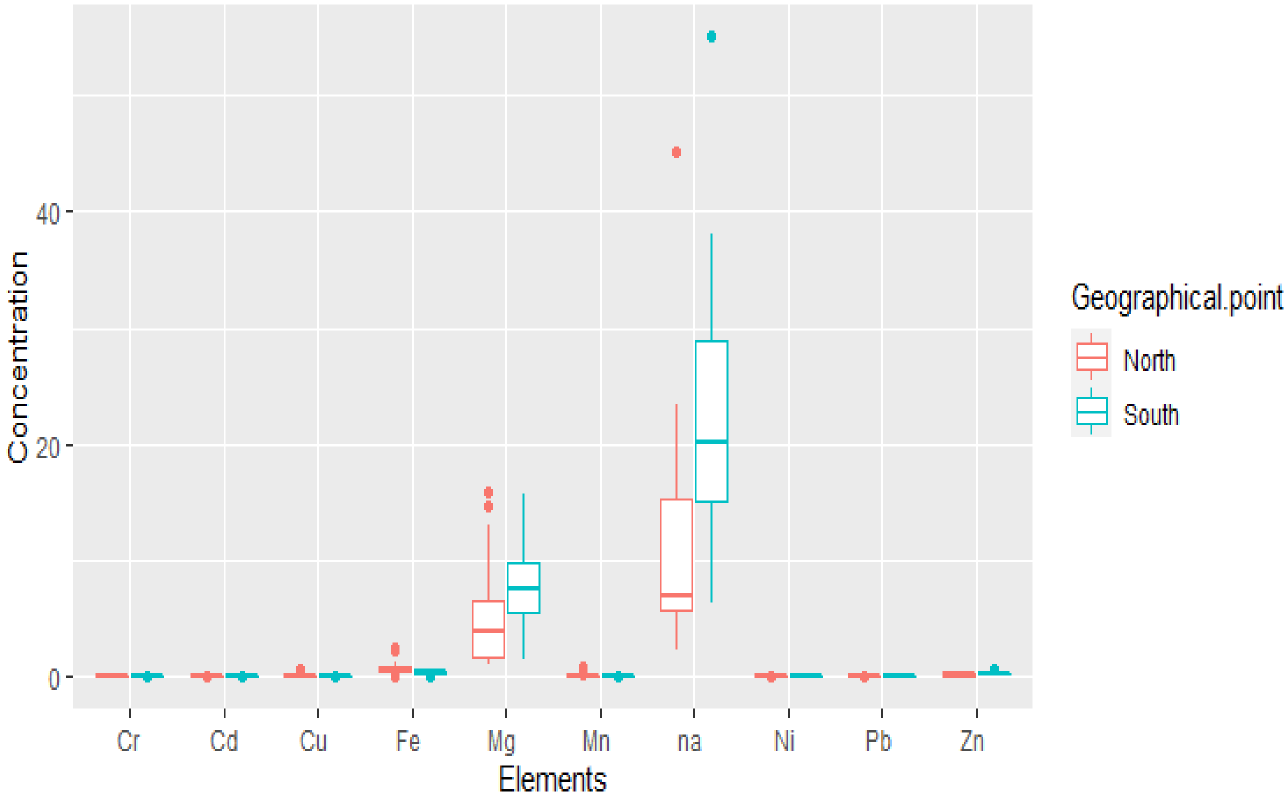


**Figure 5:** Boxplot showing Measurements by elements

**Relationship between location of filling station and water quality**

**Table 8:** Two-way ANOVA

| | DF | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| **Geographical Point** | 1 | 210 | 209.7 | 14.35 | 0.000171 |
| **Element** | 9 | 12563 | 1395.9 | 95.49 | 2e-16 |
| **Residuals** | 489 | 7148 | 14.6 | | |

$$Y_{ij} = \mu + \text{ Geographical Point}_i + \text{ Element}_j +$$

**Table 9:** Two-way ANOVA

| | DF | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| **Geographical Point** | 1 | 37222 | 37222 | 7.365 | 0.00691 |
| **Physiochemical** | 8 | 5611136 | 701392 | 138.786 | 2e-16 |
| **Residuals** | 440 | 2223654 | 5054 | | |

$$Y_{ij} = \mu + \ Geographical\ Point_i + \ Physiochemical_j + \varepsilon$$

**Table 10:** Two-way ANOVA with Interaction

| | DF | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| **Geographical Point** | 1 | 37222 | 37222 | 7.912 | 0.00513 |
| **Physiochemical** | 8 | 5611136 | 701392 | 149.092 | 2e-16 |
| **Geographical Point * physiochemical** | 8 | 191340 | 23918 | 5.084 | 4.64e-06 |
| **Residuals** | 432 | 2032314 | 4704 | | |

$$Y_{ijk} = \mu + \text{ Geographical Point}_i + \text{ Physiochemical}_j + \text{Geographical Point} * \text{Physiochemical}_{ij} + \varepsilon_{(ij)k}$$

**Table 11:** Tukey Multiple Pairwise- Comparisons

| Geographical Point | Differ | Lwr | Upr | P adj |
|---|---|---|---|---|
| **South-North** | -18.1895 | -31.36222 | -5.016784 | 0.0069 |

**Discussion**

**General Information on Filling Stations across the Metropolis**

The clustered pattern and high volume of stations within the metropolis as shown in **Fig.1** indicated an increased rate of setting up filling stations in urban centres and the proliferation showed how the dependency on petroleum products sold are required by all in every corner and zones. Studies such as Samuel (2011) in Kaduna; Abdullahi (2012) in Lagos; Mohammed, Musa & Jeb (2014) in Kano; Mshelia, John & Emmanuel (2015) in Borno, and Oloko-Oba *et al*., (2016) in Kwara; Olufayo (2018) in Ondo like similar researches in Nigeria identified that filling stations are unevenly sited and distributed along major roads in respective study areas which were most likely triggered by increasing population, urbanization, higher demands on petroleum products and the underlining economic benefit in the oil business.

The age distribution of the stations across the metropolis revealed a growth pattern of increase in construction of filling station in recent years, this is similar to reports from literatures concerning filling stations across the nation caused by the increase on the demand of petroleum products (Afolabi, Olajide & Omotayo, 2011). Based on statistics, Ogundahunsi, (2014) in Ilesa, Osun State revealed that 60% of filling station in the study area were constructed within a space of 12 years (2000 – 2012) which also corresponded with this findings that over 60% of the stations in Ogbomosho metropolis are less than 15 years.

**Physiochemical concentration of the groundwater sampled**

Results obtained for the selected physical parameters (Alkalinity, hardness, dissolved, turbidity, TDS, TS, chlorine, volatile and conductivity measured in the ground water samples from the two local government areas were presented in tables 2–4.
The mean, standard deviation and range of alkalinity from Ogbomoso North Local Government area were 363.640 ± 218.44mg/l and 168 -1128 mg/l respectively (Table 2), while for Ogbomoso South Local Government area the mean alkalinity of the water samples was 329.680 ± 159.89, with the range of 168 - 784 mg/l(Table 3). The Alkalinity values were higher than the standard value (200mg/l) recommended by the World Health Organization (WHO, 1984). Out of the two local government area, ONLGA have the highest physiochemical (**Alkalinity, Hardness, Turbidity** and **TSD**) than OSLGA.

**Heavy Metals Concentration across the Samples**

Results obtained for the selected stations based on the required criteria were for possible heavy metal constituents where the water quality was examined by monitoring the following parameters: lead (Pb), cadmium (Cd), copper (Cu), chromium (Cr), nickel (Ni), zinc (Zn), magnesium (Mg), Manganese (Mn) and Iron (Fe).

The health risk impacts of heavy metals even at low concentrations make it a required assessment for water quality determination (Patil, Sawant & Deshmuhk, 2012; Gautam *et al*., 2014; Raimi *et al*., 2018). Hence the exact idea of water quality was determined when concentrations of these elements were compared to the World Health Organization (WHO, 1993). Across all samples as shown in table (5-7) Ogbomoso North Local Governent has higer concentration of the following heavy metals (Mn, Fe, Cu, Cr, Pb and Ni ) than that of Ogbomoso South Local Government. While Ogbomoso South Local Government has higher concentration of the following heavy metals (Mg, Na., Zn) than that of Ogbomoso North Local Government. All of the samples obtained fall within the (WHO,1993) Standard, thereby safe for consumption.

**Determining the Relationship between location of the filling station and water quality using Two way Anova and Post Hoc Testing.**

**TWO – WAY ANOVA**

Analysis of variance (ANOVA) was used to examine the relationship between the hypotheses. From **Tab.9**, the result shows that both geographical point and element are statistically significant making the null hypothesis acceptable and the alternative hypothesis to be rejected of hypothesis 1. The result from **Tab.10** show that there is statistical relationship between the geographical point and the physiochemical, which makes the alternative hypothesis to be acceptable of Hypothesis 2. This result also prove that the geographical point and physiochemical, will impact significantly the mean value of concentration.

**Tab.10** show that the main effects (Geographical Point * physiochemical) are statistically significant, as well as their interaction. The p-value of geographical point is 0.00513 (significant), indicates that the levels of geographical point are associated with significant different value of concentration. The p-value of physiochemical is <2e-16 (significant), indicates that the levels of physiochemical are associated with significant different value of concentration and lastly the p-value for the interaction between Geographical Point * physiochemical is 4.64e-06 (significant), which indicates that the relationships between physiochemical and the value of concentration depends on the Geographical Point.

## POST – HOC TESTING

Tukey Multiple Pairwise- Comparisons was used to test for relationship between the two geographical point, **Tab.11** shows that the pairwise differences between the two geographical point with the average difference (diff), the lower and the upper bounds of the 95% confidence interval (‘lwr’ and ‘upr’) and the p-value of the difference (‘p-adj’), the result revealed that there is significant differences ($p < 0.05$) between south and north region.

## Conclusion

Based on the data obtained, it can be concluded that water from the various different locations have different level of quality. Most of the samples were safe for human consumption and other domestic, industrial and agricultural proposes. There slight direct influence of the filling station location on the concentration of physiochemical quality of the groundwater sited around the area.

## Recommendation

The study suggest the following recommendations:

- There should be proper environmental health impact assessment prior to the construction of filling station due to the capacity of stored product in affecting the quality of groundwater.
- The location of filling stations especially the citing of underground storage tanks should not be at a close distance to groundwater sources.
- Private and public water sources in the country are not registered and guided by regulations which makes the location and accessibility of some wells and boreholes not feasible, therefore let the appropriate ministries, department and agency take up the responsibility.
- Further studies should be carried out to look at the properties of the groundwater sited around filling station