Effect of Land-use On Groundwater Quality In Nigeria-A Case Study of Ilesa West Local Government Area in Osun State.

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ABSTRACT

This paper assessed the impact of land use on groundwater samples collected in Ilesa West Local Government Area. The impact points within the predominantly residential area are open refuse dump sites, and auto-mechanic workshops. Water samples were collected from residents, and within and around the two impact points for twelve months to cover the two major seasons (dry season and rainy season). The samples were collected from 69 points spreading over the different landuse categories. Parameters analyzed are pH, electrical conductivity, temperature, total dissolved solids, basic anions and cations using standard methods. Analysis of heavy metals (Fe, Pb, As, Cr) was carried out with Atomic Absorption Spectrophotometer and microbiological analysis was conducted using most probable number of counting coliform. The mean pH of water samples at the residential area, dumpsite and mechanic site were 5.61, 6.31 and 4.63 respectively. The maximum concentration of TDS at the residential was 1022mg/L while that at the dumpsite was 733mg/L. Concentration of the heavy metals were higher than the permissible in all the areas and microbial distribution was highest at the dumpsite.There was significant difference among the sources at p<0.05. The impact points have greatly influenced the characteristics of the water and it is suggested that policy makers should re-evaluate the landuse pattern and continue a monitoring program of the study area.

Keywords: ***Land-use*, *groundwater quality, dumpsite area, auto-mechanic area ,physic-chemical parameters, heavy metals***

1.0 INTRODUCTION

Groundwater is part of the precipitation that infiltrates into the soil; so it is a component of the hydrologic cycle. The major ions or electrically charged particles present in rain water are Ca, Mg, Na, Si (as $Si(OH)_4$), SO_4,Cl, nitrogen compounds and the total concentrations of all constituents typically are less than 5 to 10 mg/L. The majority of the remaining ions are typically from airborne particulate matter and gases from industrial emission, automobile exhaust and the evaporation of volatile chemicals. The sustainable development of every country is controlled by the availability of surface and groundwater [24]. In Africa, groundwater is a critical resource playing a vital role in both human life and ecosystem [1]. Currently, groundwater contamination has become a challenging problem, because of its susceptibility to pollution both by natural and anthropogenic processes [12]. [13] reported that there is human activity imprint on the hydro-geochemistry of groundwater in Ilesa shallow wells. [14] concluded that groundwater in Ilesa town should be subjected to further treatment. [16] linked the diarrhea reported in Ilesa with poor quality of drinking water of the children.[7] reported that coliform bacteria occur in high numbers in wells and boreholes in Ilesa. On a national level, it was reported that Nigeria urban groundwater quality is influenced by geology and geochemistry of the environment, landfill/dumpsite leachate, rate of urbanization, industrialization, heavy metals, bacteriological pollution and effect of seasons [15]. [17] reported that the wells located close to dumpsite have high levels of concentration of physico-chemical and heavy metals compared to wells far (>50 m)from the dumpsite. [8] reported that the concentrations of pH, EC, TDS, Mg, NO_3, PO_4 and Fe were higher than the limit and baseline concentration and this was an indication of pollution from dumpsite leachate. The groundwater within 0.55 km radius to municipal solid waste landfill had high concentration of Fe and this resulted in contamination from dumpsite leachate [2]. Several literatures have reported different concentration of groundwater parameters and it was concluded that dumpsite will remain a relevant source of pollution to groundwater in foreseeable future. Studies have also shown that activities in most auto-mechanic villages are a possible threat to groundwater in the future since heavy metals pollution have been reported to be one of the most serious environmental problems nowadays [9]. In Nigeria, the activity of auto-mechanics is one of the major routes for entry of heavy metals into the environment to cause heavy metal contamination of soil and groundwater [22]. When leachates from activities percolate into the ground, they pose threats to the groundwater because they are non-degradable in the soil [18].

Several literatures have reported groundwater contamination from auto-mechanic activities and it was concluded that there is a need to conduct studies in other Nigerian cities so that ground water in contrast to surface water is naturally protected from chemical and biological contamination. The present study aimed at assessing the effects of land use on the groundwater quality. The quality of water is identified as the normal, physical and compound condition of the water, and additionally, any adjustment that may have been initiated by anthropogenic action [6].

2.0 STUDY AREA

This study was conducted in Ilesa West Local Government Area (LGA) in Osun State, Nigeria. The LGA was carved out of the then Ilesa local government in 1996. It is geographically located within coordinates 07^0 36′ N and 004^0 40′E and 07^0 42′N and 004^0 46′E. It has a total area of 63 km^2. The study area belongs to a humid tropical type with humidity throughout the year and a mean annual rainfall of 1600 mm. Geologically, the study area is within the basement complex of the crystalline rocks of Nigeria and it is underlained by mainly biotite-gneisis schist and amphibolites complex [13]. The LGA is made up of 10 wards. The location of the study area is presented Figure 1.

3.0 MATERIALS AND METHODS

The land-sat imagery was used to classify the different land cover of the study area. A field study was then conducted to identify the different categories of land use. For ease of assessing the effect of landuse on the quality of groundwater, a physical features classification was done; fully residential area, areas close to dumpsite and close to mechanic workshop. A total of 69 wells points were surveyed and imported into the study area map using ArcGIS 10.1 as presented in Figure 2.Water sampling was done for rainy and dry seasons to represent the two seasons adequately. Well depths were measured at the beginning of each sampling exercise using a water level meter. Basic anions, cations and heavy metals were analysed using standard methods [5] and microbiological analysis was carried out using most probable number (MPN) of counting coliforms. The results obtained were subjected to different types of statistical analysis: descriptive statististics, Analysis of Variance (ANOVA), Pearson correlation, factor analysis and cluster analysis. The hydro-chemical phases of the groundwater was developed using PAST (Paleontological Statistics) software.

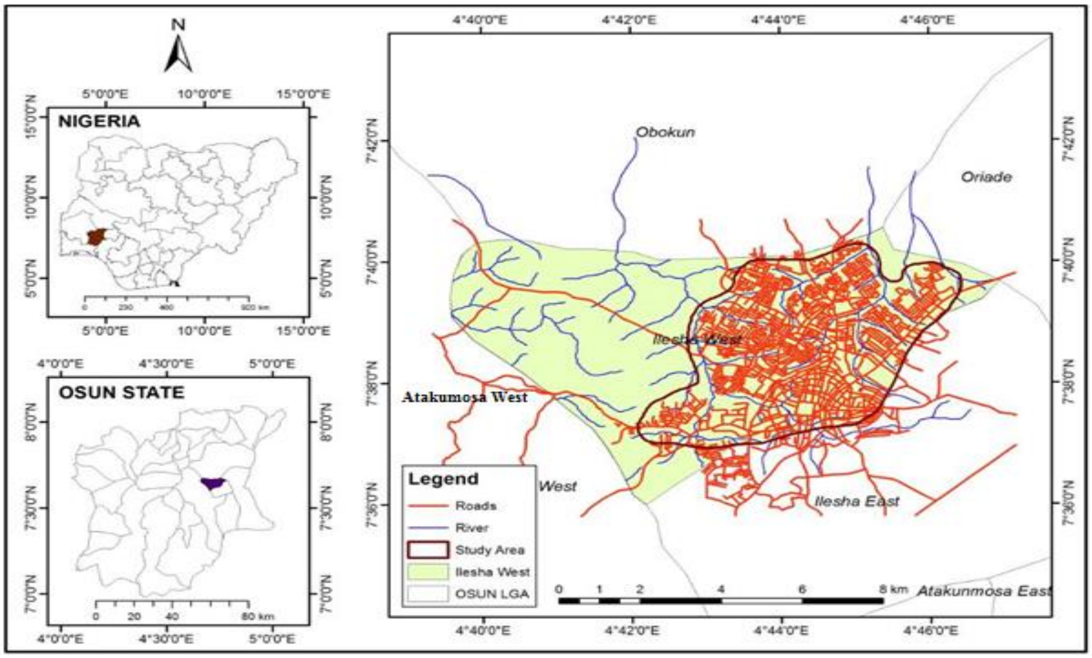


Figure 1: Map of the study area

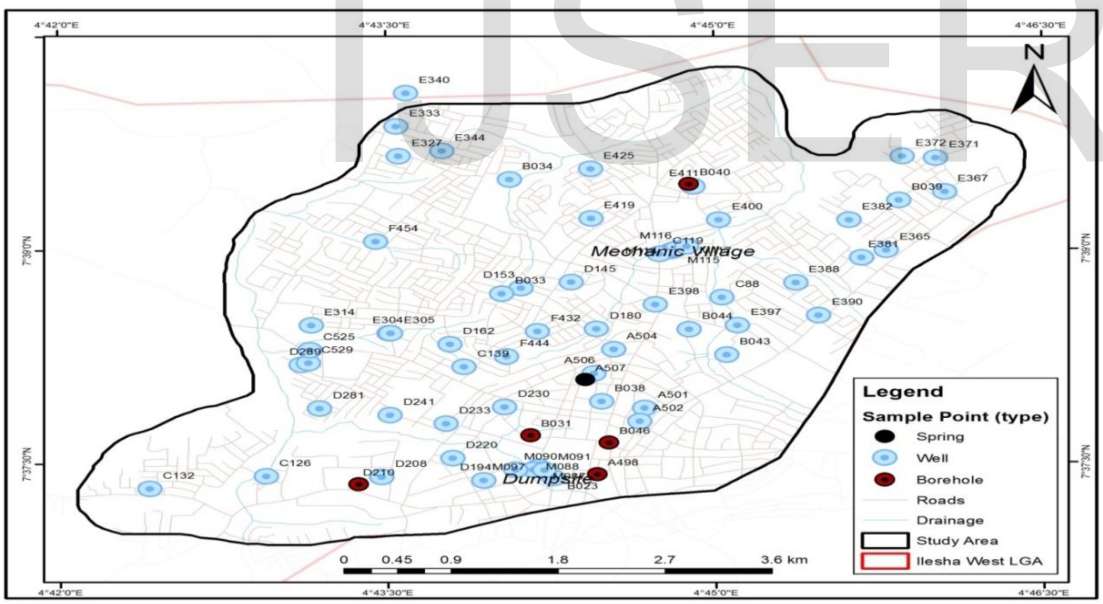


Figure 2: Location of sampling points on the study area

4.0 RESULTS AND DISCUSSION

The descriptive statistics (Table 1) of all parameters investigated in the study area (wells in fully residential areas, wells around dumpsites and wells around mechanical area) revealed that most of the parameters were within WHO standards except for pH, TDS, EC, K and the heavy metals.

4.1 Wells in fully residential areas

The mean pH (5.61±0.73) around the fully residential area showed an acidic groundwater but the range (4.1-7.3) revealed alkaline situation in some of the wells. The temporal variation of pH fluctuated during the period of sampling and the variation was entirely different from that at the dumpsite and mechanic. Most times, low pH in groundwater is connected with very little or no dissolved carbonate and hydroxyl ions or when the hydrogen ions are high. Most acid rain have pH values near 5.6 [10] and once on the ground, some of the acidic precipitation infiltrates downward to mix with groundwater and can affect the groundwater pH. The pH did not correlate with any other parameters but the values of the pH obtained in this study agreed with[13] and [7]. This shows that acidity around the study area has not changed over time. Acidity in water is not in itself harmful to health, but it can be naturally soft and corrosive. Water with a low pH could contain elevated levels of toxic metals, cause premature damage to metal piping, and have associated aesthetic problems such as a metallic or sour taste. The mean concentration of TDS 147.29±201.11 (Table 1) and the range (8.3-1022) revealed high dissolved solids in some of the wells. When TDS levels exceed 1000 mg/L it is generally considered unfit for human consumption because some of the individual mineral salts that make up TDS pose a variety of health hazards. The TDS around the residential area correlated strongly with EC (r = 0.99), Cl(r=0.91), Ca (r = 0.84) hardness (r = 0.84) , Na (r = 0.88) and K (r = 0.91). The strong correlation with Cl may be anthropogenic but it was not established. If water has a moderate to high total dissolved solids content, it can affect taste or may have unpleasant odours. The temporal variation did not vary significantly for the sampling periods. Generally, most of the values of EC at the residential areas were far below the WHO limit of 1000 μS/cm except for some wells. The temporal variation of EC followed a definite trend with month of June having the highest. The range of potassium in the residential areas was high (Table 1) and the variation was entirely different from that at the dumpsite and auto-mechanic area. Potassium is commonly found in soils and rocks and because it is released slowly upon dissolution of rocks, concentration increases as residence time in ground water increases. [20] reported that Na_2O and K_2O were high in Ilesa basement complex thus the high value of potassium may be a geological issue.

The mean concentration of Fe was 1.37 mg/L in wells around the residential area (Table 1) and it was present in almost all the water samples at concentration higher than permissible limit (0.3 mg/L). Though Fe can be found in most hydro-geological environments, they are only dissolved in groundwater under reducing (anaerobic) conditions. The pH in the study area is low and solubility of metals increases in acidic groundwater. Generally, the value did not agree with values of [13] but [7] reported higher values in some boreholes. This implied that over the years, dissolution of iron has increased and the pattern of iron concentration over the season varied. The concentration of Pb at the residential areas was higher than 0.01 mg/L permissible limit. Lead could enter water from household plumbing systems containing lead in pipes, solder and fittings. The amount of lead. dissolved from the plumbing system depends on several factors, including pH, temperature, water hardness and standing time of the water, with soft, acidic water being the most plumbo-solvent [23]**.** The solubility of lead near pH 6.5 can approach or exceed 100 µg/l. Thus, dissolution from pipes and distribution system may most likely influence the concentration at the residential area. Excessive lead in water can cause serious health problems especially for infants, children and pregnant women [19]. The concentration agreed with the findings of Ayoade and Ibitoye (2012). The temporal variation of arsenic in residential areas showed the concentration was higher than the permissible limit (0.01 mg/L).

Table 1. Mean, standard error and range of water quality parameters for wells around classified physical features of the study area

Parameters	Wells around residential area	Wells around dumpsites area	Wells around mechanic site
pH (no units)	5.61±0.04(4.1-7.3)	6.31±0.09(5.0-7.4)	4.63±0.06(4.1-5.1)
DW(m)	8.64±3.42(2.45-15.40)	4.98±0.57(1.83-9.8)	1.99±0.08(1.20-2.90)
TDS (mg/L)	147.29±11.17(8.3-1022)	420.07±24.93(268.00-733)	89.81±4.48(30.1-132.7)
EC(µS/cm)	233.86±18.64(12.34-1625.0)	671.33±44.01(35.80-1277)	145.95±7.04(93.1-221.0)
Cl (mg/L)	25.88±2.14(1.40-298.43)	68.66±8.29(8.54-212.70)	18.4±1.21(7.8-27.5)
SO_4 (mg/L)	10.5±0.42(1.28-33.76)	13.82±1.42(2.68-27.82)	13.08±1.82(2.33-27.82)
NO_3 (mg/L)	1.28±1.55(0.07-8.68)	1.88±0.31(0.10-6.26)	1.60±0.25(0.1-3.85)
Ca (mg/L)	15.05±1.0(1.66-132.29)	44.50±2.65(21.50-79.15)	5.42±0.41(1.66-10.52)
Mg (mg/L)	1.79±1.0(0.00-10.84)	2.96±0.42(0.13-9.91)	1.33±0.25(0.13-4.55)
TH (mg/L)	45.87±2.50(6.5-330.15)	123.5±6.37(71.69-210.85)	19.67±1.62(6.52-37.59)
TA (mg/L)	34.36±1.78(4.00-196.00)	153.00±13.16(16.00-260.00)	19.63±1.54(8.00-34.00)
HCO_3 (mg/L)	41.23±2.133(4.80-235.20)	183.60±15.79(19.20-312.00)	23.55±1.85(9.60-40.80)
CO_3 (mg/L)	20.61±19.20(2.40-117.60)	91.80±43.25(9.60-156.00)	11.78±4.52(4.80-20.40)
Na (mg/L)	21.77±1.45(0.98-107.5)	42.21±4,21(13.24-91.42)	23.65±1.28(1.80-33.01)
K (mg/L)	13.12±1.58(0.22-176.01)	58.73±4.21(35.00-108.30)	2.35±0.18(1.01-4.01)
Fe (mg/L)	1.32±0.070 (ND-9.25)	2.00±0.24 (0.38-5.04)	1.18±0.14 (0.38-2.40)
Pb (mg/L)	0.08±0.10 (ND-0.73)	0.03±0.03 (ND-0.10)	0.05±0.14 (ND-0.15)
As (mg/L)	0.16±0.03 (ND-3.88)	0.033±0.25 (ND-3.73)	0.16±0.08 (ND-0.56)
Cr (mg/L)	0.19±0.18 (ND-0.73)	-0.17±0.19 (ND-0.78)	0.15±0.17 (ND-0.45)

DW-Depth of wells: TH-Total hardness : TA- Total Alkalinity

Arsenic is a characteristic of most groundwater but could also result from human activities which migrate into the soil and because groundwater moves slowly, it may continue to dissolve and concentrate in the aquifer. [3] reported high arsenic content of 0.12 -8.60 mg/L at the mining site in a peri-urban Ilesa. It is therefore necessary to investigate the study area for gold tailings. Long term ingestion of high concentrations of arsenic from drinking water can give rise to various health problems; internal cancer, particularly of the lung, bladder, liver and kidney had been linked with arsenic in drinking water [4]. Long term ingestion of high concentrations of arsenic from drinking water can give rise to various health problems; internal cancer, particularly of the lung, bladder, liver and kidney had been linked with arsenic in drinking water [4]. The highest mean concentration of chromium was detected in the water samples around the residential areas and it was higher than the permissible limit of 0.05 mg/L. Cr (VI) anions can be absorbed on positively charged surfaces such as oxides and hydroxides of Fe, Mn, and Al. Adsorption of Cr (VI) on these adsorbents is usually limited and decreases with increasing pH . The values agreed with the result of [7]. Low levels exposure of Cr can irritate the skin and cause ulteration. Long term exposure can cause kidney and liver problem and damage to circulatory and nerve tissue

4.2 Wells around the dumpsite.

The mean concentration of pH of wells around the dumpsite (Table 1) indicated a slightly acidic to alkaline groundwater. The pH did not have any strong correlation with any parameter at the dumpsite. But from the ANOVA analysis, water samples from the three classes of land use were statistically significant ($p<0.05$) which suggested that a clear difference existed between the different landuse categories. The mean pH at the dumpsite agreed with the values reported by [2], [8] and [17]. Landfill exploited for a long period of time gives rise to alkaline leachate [11]. The dumpsite was used for all forms of solid wastes most of which were biodegradable. The mean concentration of TDS was moderate as majority of the wells were within the acceptable limit of WHO except for a well around the dumpsite (M090) which on physical assessment was on the uphill side of the dumpsite and had the highest depth. At the dumpsite, TDS has a moderate correlation ($r = 0.65, 0.53$) with Cl and K, respectively. It however has a strong correlation with EC ($r=0.89$) and Na ($r= 0.73$). This was supported by the ANOVA analysis where there was statistical significance ($p<0.05$) between wells around the dumpsite and around the residential area. The mean depth of wells around the dumpsite was 4.55 m (Table 1) and this shows that the water level in this area is high. Its correlation ($r = 0.76$, $r = 0.87$ and $r = 0.78$) with TDS, Na and K respectively may be expected. The concentration of 176.01 mg/L of potassium recorded in some of the wells was higher than 10 mg/L recommended. The values obtained in this study agreed with the findings of [13] and [8] but some literatures reported a much lower range of the parameters in a basement complex of southwestern Nigeria. The values of potassium and sodium in the study area have not changed over time. The mean concentration of Fe at the dumpsite area was higher than the residential area but the range (Table 1) was lower. At the dumpsite areas, all forms of wastes including metal scraps were equally dumped along other wastes. The temporal distribution of Fe showed a fluctuating trend in the residential, dumpsite and mechanic areas but high concentration above permissible was continuously observed at the dumpsite area. The correlation ($r = 0.71$, $r = 0.75$ and $r = 0.98$) with the depth of well, depth of well to water level and TDS was high while the pH ($r=0.60$) was fair. Mean concentration of Pb in wells around the dumpsite area was 0.03 mg/L and it was higher than permissible limit (0.01 mg/L). Open air incineration of waste material at dumpsites can increase Pb concentration [19]. The presence of Pb in the groundwater samples around the dumpsite area did not follow a definite trend but it was constantly present in two dugwells (M090 and M091) in Figure 2 and it did not have any correlation with any other parameter. The mean concentration of As and Cr in water samples around the dumpsites (Table 1) was higher than the permissible limit (0.01 mg/L) and (0.05 mg/L) respectively. The correlation of Cr to other parameters was similar to that of Fe but As has a very strong correlation (r=0.97, r=0.76) with pH and the temperature of the water samples

4.3 Wells around mechanic area

The parameter that was not within the permissible range around the mechanic area was pH (no correlation with any other parameter) and the heavy metals. The mean concentration and the range of the pH values indicated an acidic groundwater (Table 1). The ranges of Fe, Pb, As and Cr values (Table 1) were higher than the permissible values. The activities at the mechanic area involved stockpiling of metals and engine parts and leachates were seen infiltrating into the bare floor.

4.4 Principal component analysis (PCA), cluster analysis and hydro-geochemical facies

For the physico-chemical parameters, 5 principal components (PCs) were obtained which explained 82.937%, 81.92% and 79.001% of the total variance for residential, dumpsite and auto-mechanic areas respectively. The first PC in the residential area (Figure 3a) was described by Na, TDS, EC, K, Cl, Ca and hardness. The PC (Figure 3b and 3c) showed that hardness was absent at the dumpsites and at the mechanic area indicating that the PCs were entirely different. The dendogram produced from the cluster analysis (Figures 4a) allowed identification of three clusters of associated characteristics in the water samples around the residential areas (Figure 4a), three around the dumpsite (Figure 4b) and four around the mechanical area (Figure 4c). The different hydro-chemical phases in the study area revealed that the dominant anions in the residential area are HCO_3 (100%) >Cl (92%) > SO_4 (70%) while the cations are in the order of Na +K (100%) > Ca (100%) > Mg (80%). The tenary map for the dumpsite revealed a different trend as the anions are in the order of HCO_3 (100%) > Cl (89%) > SO_4 (22%) and the cations are in the order of Na + K (100%) > Ca (62%) > 14%. At the mechanic area, the anions are in the order of Cl (70%) > HCO_3 (59%) > SO_4 (50%) and the cations are Na +K (100%) > Ca (50%) > Mg (29%).

4.5 Microbiological analysis

The occurrence and percentage distribution of the microbes revealed the highest in wells around the dumpsite and the mechanic area but the period of occurrence is different. Wells around the residential area reported 52% for *E.coli* while other organisms varied within the months. Bacteria could enter groundwater and water supply wells through many interacting variables related to land use, soil types, depth to water, types of geologic strata and method of well construction [21] , thus the existence of the microbes occurring singly and in combination in the water samples may be anthropogenic influenced.

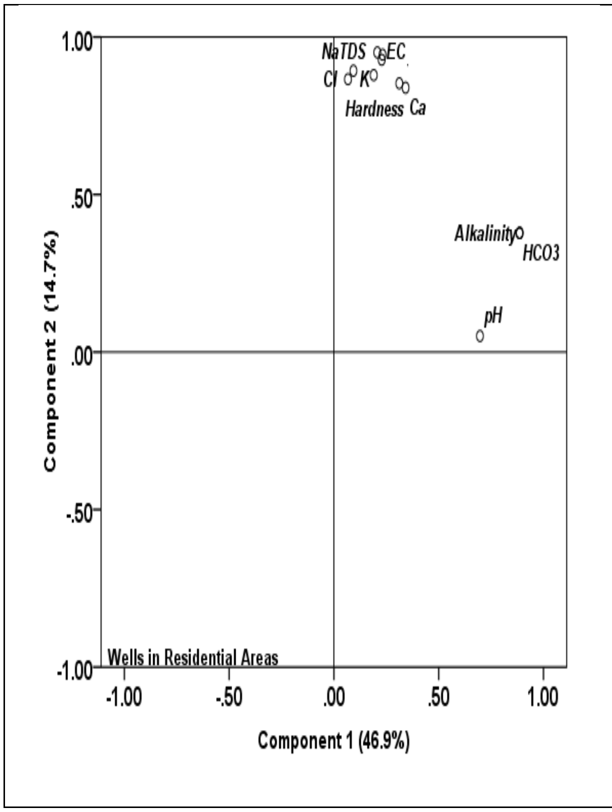
5.0 CONCLUSION AND RECOMMENDATION

The different statistical analysis has revealed different water chemistry for the different land use in the study area, thus the location of the dumpsite is a contributing factor to the poor water quality. The activities of the auto- mechanic area has not affected the groundwater reasonably but the present practices of discharging oil and petroleum products on cemented floor cannot be sustained. It is recommended the present land use in this area be reviewed and a routine monitoring of wells be conducted.

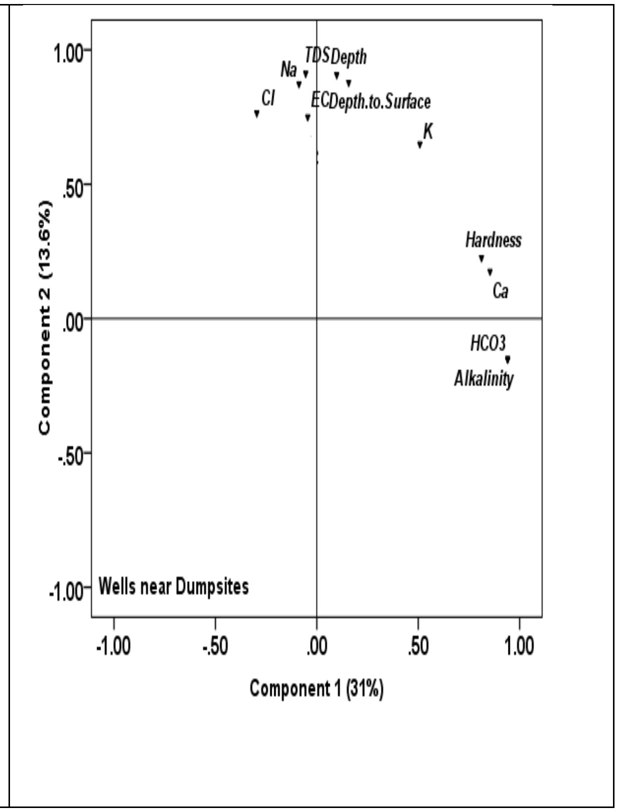
REFERENCES

[1] Adelana, S., Fatong, W., Nedaw, D., and Duah, A.(2011). Groundwater and Health: Meeting Unmet Needs in Sub-Sahara Africa. *Sustaining Groundwater Resources, International Year of Planet Earth*. 21-28

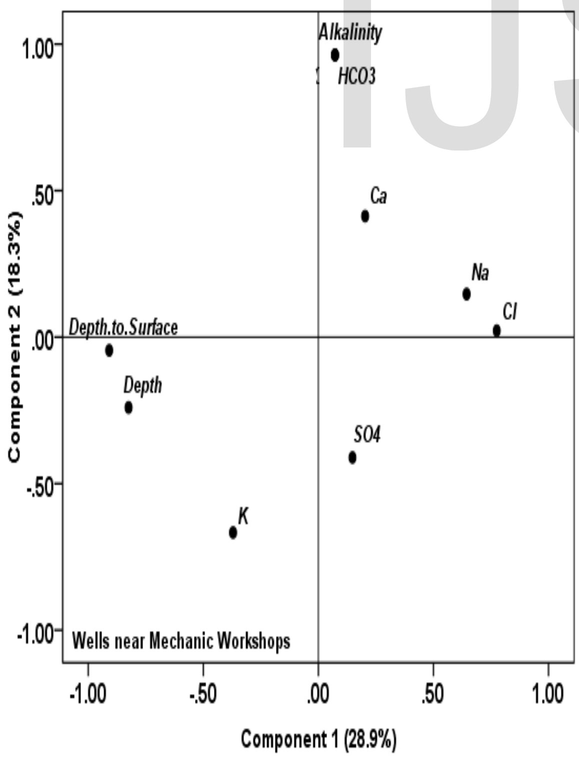
[2] Aderemi, A. O., Oriaku, A. V., Adewumi, G. A and Otitoloju, A. A.(2011). Asessessment of Groundwater Contamination by Leachate near a Municipal Solid Waste Landfill. *African Journal of Environmental Science and Technology*. 5(11): 933-940



a) Residential area

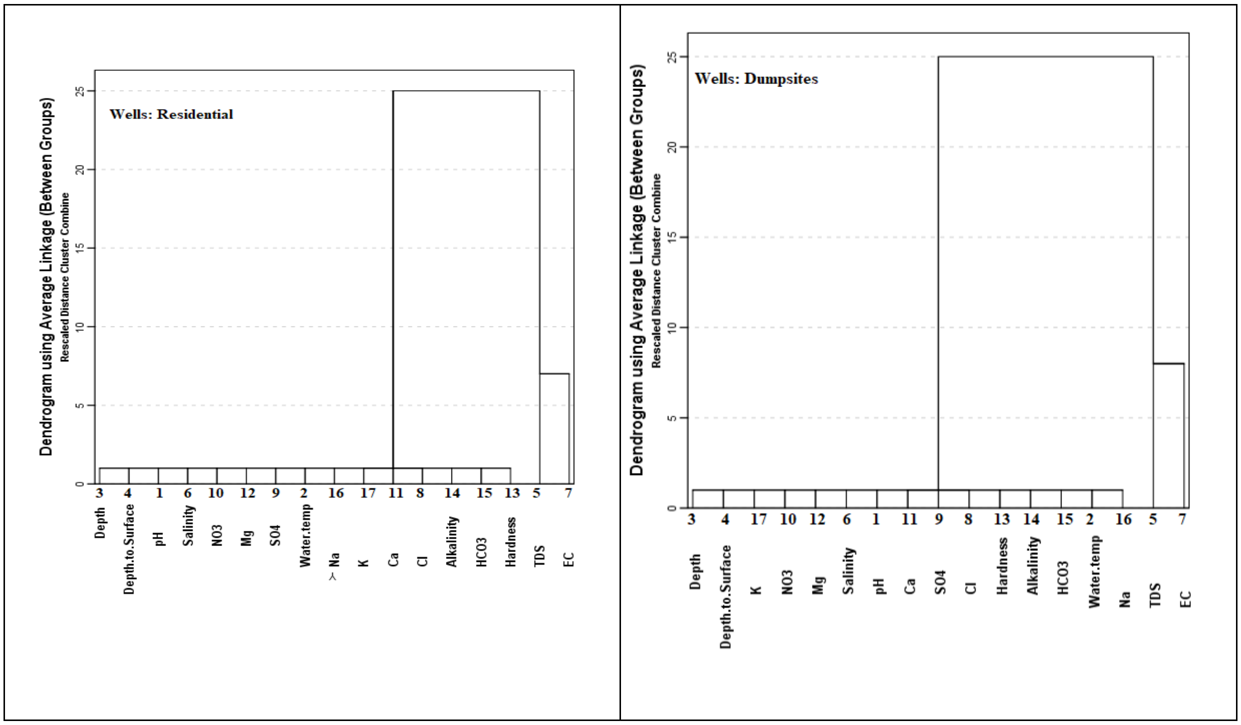


b) Dumpsite area

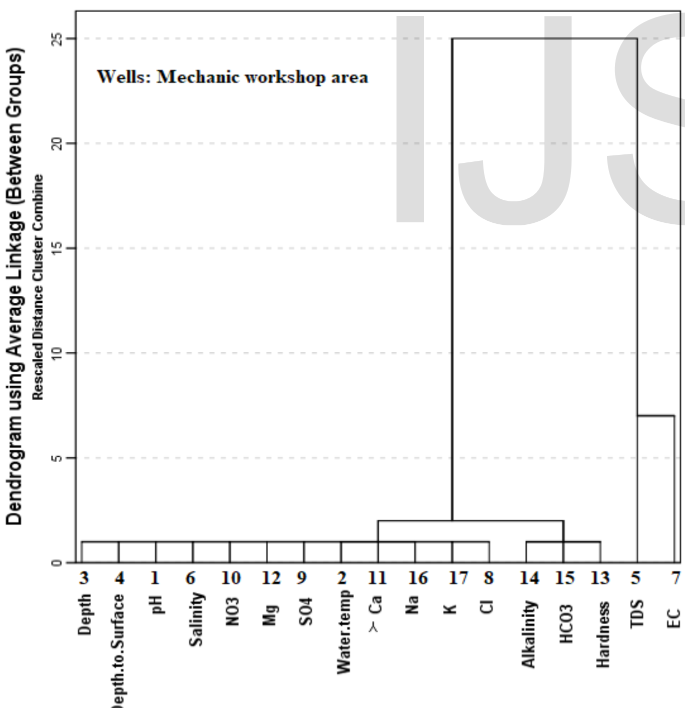


c)Auto-mechanite area

Figure 3: Principal components for water quality parameters of wells in residential area, dumpsite and around auto-mechanic site



a)Dendogram of clusters in wells in residential area   b) Dendogram of clusters around dumpsites



c)Dendogram of clusters of wells around auto-mechanic area

Figure 4: Dendogram of clusters for wells around residential , dumpsite and auto-mechanic areas.

[3] Adetoyinbo, A. A., Adelegan, F. T., and Bello A. K.(2015). Environmental Impact Assessment of the Potability of Water from Bore-hole, Hand -dug well and Stream at Itagunmodi Gold Deposits of South Western, Nigeria Using FORTRAN Algorithm for Monitoring Leachates and Interpreting Physicochemical Data of Contaminants in Groundwater. *International Journal of Water Resources and Environmental Engineering.* 7(1):1-6

[4] Ajayi, S. O and Osibanjo, O.(1981). Pollution Studies on Nigeria Rivers II: Water Quality of Some Nigerian Rivers. *Journal of Environmental Pollution.* 2: 87- 95

[5] APHA. (1998). Standard Methods for the Examination of Water and Wastewater, 20th Edn. Washington D.C.

[6] Asadi, E., Isazadeh, M., Samadianfard, S., Ramli, M.R., Amir, M., Shahaboddin Chau,K. (2019). Groundwater Quality Assessment for Drinking and Agricultural Purposes in Tabriz Aquifer, Iran preprints (www.preprint .org)

[7] Ayoade, P. A., and Ibitoye, T. A. (2012). Appraisal of Water Quality Status Within Ilesa Environs, South Western Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences.* 3(6):969-976

[8]Bayode, S., Olurunfemi, M. O., and Ojo. J. C. (2012). Assessment of Impact of Some Waste Dumpsite on Groundwater Quality in Some Parts of Akure Metropolis Southwestern Nigeria. *Pacific Journal of Technology.* 13(2):528-536.

[9] Karnib, M., Kabbani A., Holail H., Olama Z. (2014). Heavy Metals Removal Using Activated Carbon, Silica ,and Silica Activated Carbon Composite. *Journal of Science Direct, Energy Procedia* 50:113-120

[10] Knutsson G. (1994). Acidification Effects on Groundwater - Prognosis of the Risks for the Future. (Proceedings of the Helsinki Conference). IAHS Publ. no. 222, 1994.

[11] Longe, E. O., and Balogun, M. R. (2010). Ground Water Quality Assessment Near a Municipal Landfill Lagos, Nigeria. *Research Journal of Applied Science* 2(1): 3944

[12] Malik M.S and Shukla, J.P (2019). Assessment of Groundwater Vulnerability Risk in Shallow Aquifers of Kandaihimmat Watershed, Hoshangabad, Madhya Pradesh. *Journal Geological Society Of India*. 93: 199-206

[13] Malomo, S., Okufarasin, V. A., Olorunnio, M. A. and Omode, A. A. (1990). Groundwater Chemistry of Weathered Zone Aquifers of an Area Underlain by Basement Complex Rocks. *Journal of African Earth Sciences.* II(3/4):357-371

[14] Odebunmi, E.O., Olutona, G.O Akintunde, E.A., Faboro, E.O., Balogun,O.S.,(2014). Trace Metals Levels of Drinking Water in parts of Osun State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*. 7(6):635-644

[15] Ocheri, M.I., Odoma, L.A.,and Umar. N.D. (2014). Groundwater Quality in Nigeria Urban Areas: A Review. *Global Journal of Science Frontier Research: Environment and Earth Sciences.* 14(3):35-44

[16] Ogunlesi, T. J.,Okeniyi.O., Oyedeji S., Oseni O, Oyelami, O., and Sokanma,O. (2004). Childhood Dysentery in Ilesa, Nigeria: The Unusual role of Entamoeba Histolytica. *The International Journal of Tropical Medicine.* 2(2).

[17] Okpanachi, A. S. (2015). Effects of Solid Waste Dumpsites on Groundwater Quality in Samaru, Zaria, Kaduna State, Nigeria. An Unpublished M.Sc Thesis, Ahmadu Bello University, Zaria, Nigeria.

[18] Ololade, I. A. (2014). An Assessment of Heavy-Metal Contamination in Soils within Auto-Mechanic Workshops Using Enrichment and Contamination Factors with Geo-accumulation Indexes. *Journal of Environmental Protection.* 5:970-982

[19] Oyekunle, J.A.O., Okpu, R.C., Ogunfowokan, A.O., Olutona, G.O., and Durosinmi, L.M. (2012). Total and Exchangeable Metals in Groundwater of Ile-Ife, Southwestern Nigeria. *Hydrology for Disaster Management Special Publication of the Nigeria , Association of Hydrological Sciences.* 208-

223

[20] Oyinloye, A. O. (2011). Geology and Geotechnic Setting of the Basement Complex Rocks in South Western Nigeria. Implications on Provenanace and Evolution. *Earth and Environmental Sciences.* ISBN: 978-953-307-468-9.

[21] Somaratne, G., and Hallas G. (2015). Review of Risk Status of Groundwater Wells by Tracing the Source of Coliform Contamination. *Water*. 7:3878-3905. www.mdpi.com/journal/water.

[22] Usman, A. A., Odoma A. N., Ozulu G. U. (2013). Impact of Automobile Workshop Activities on Heavy Metal in Some Ground Water of North Central Nigeria. *International Journal of Water Research* 2(1):1-4

[23] WHO. (2006). Guidelines for Drinking Water Quality and Criteria, 2 (2):281-308, World Health Organization, Geneva, Switzerland.

[24] Zaki, S.R., Redwan, M., Masoud, A.M., and Abdel Moneim, A.A. (2019). Chemical Characteristics and Assessment of Groundwater Quality in Halayieb area, Southeastern part of the Eastern Desert, Egypt. *Geosciences Journal* . 23(1):149-164