ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2521-0912 (Print)
ISSN: 2521-0513 (Online)
CODEN : JCOLBF

Journal Clean WAS (JCleanWAS)
DOI : *http://doi.org/10.26480/jcleanwas.02.2019.20.24*

RESEARCH ARTICLE

HYDROGEOCHEMISTRY OF LEKKI, AJAH AND IKORODU WATER RESOURCES, SOUTHWESTERN NIGERIA

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ARTICLE DETAILS

Article History:

Received 30 August 2019
Accepted 5 September 2019
Available online 19 September 2019

ABSTRACT

Water resources are essential drinking water resource in developing cities, especially where no public water supply exists because of an insufficient infrastructure. Hydrogeochemistry of Lagos state was carried out to evaluate the ionic composition of the water. Coordinates was taken during sampling of water samples from Lekki, Ajah and Ikorodu areas. Atomic Absorption Spectrometer (AAS) was used for the geochemical analysis. The results revealed that (Ajah 1 -5) to be: mixed, magnesium bicarbonate, between calcium and sodium, sodium chloride and mixed type water respectively. Lekki axis from (1-5): mixed -calcium sulphate and sodium chloride, Sodium chloride, mixed - between Sodium chloride and magnesium bicarbonate, mixed- sodium chloride and calcium sulphate and mixed type waters respectively. The dominance of cations like Na, Ca, Mg and anion SO_{4^-} as well as lower K indicates the significance of silicate weathering and agricultural sources, resistance of potassium minerals to weathering in the study area. The source for HCO_{3^-} might have been attributed from sources like atmospheric CO^{2+} and soil organic materials while Cl^- and NO_{3^-} suggested anthropogenic activities like agricultural influences. Lekki and Ikorodu surface water bodies falls within the mixed (saline and calcium sulphate) -permanently hard while Ajah falls into temporary hard water.

KEYWORDS

Weathering, hard water, anthropogenic, lithounits, concentration.

1. INTRODUCTION

Water resources are essential drinking water resource in developing cities, particularly in places where no public water supply exists because of an insufficient infrastructure or a poor economic situation. Shortage of water is one of the main problems that many societies face due to the unequal distribution of resources, in addition to man-induced pollution (agricultural and urbanization activities), and unsustainable or improper management of the water resources. Groundwater is the chief source of fresh water supply in many countries and it makes up about ninety percent of the world's readily available freshwater resource. Therefore, assessment of its occurrence, distribution, potentiality and quality is of a great concern to public and local authorities. According to Botkin and Keller [1], more than 97% of earth's water is in the oceans and ice caps, and glaciers account for another 2%. Also, the ocean comprises 97%, while 3% of the earth's water is fresh [2]. Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life [3]. Man requires a regular and accessible supply of water which forms a major component of the protoplasm and provides an essential requirement for vital physiological and biochemical processes. Man can go without food for twenty-eight days, but only three days without water, and two third of a person's water consumption per day is through food while one third is obtained through drinking [4].

Water resources are of critical importance to both natural ecosystem and human development. It is essential for agriculture, industry and human existence. The healthy aquatic ecosystem depends on the physico-chemical and biological characteristics [5]. The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem. Good quality of water resources depends on a large number of physico-chemical parameters and biological characteristics. Natural surface water is mostly prone to contamination due to anthropogenic activities. Various methods have been developed for the visual understanding of hydrochemical data of surface water in order to look for discernible patterns and trends. The simplest methods include plotting distribution diagrams, bar charts, and pie charts, radial and stiff diagrams. Although these methods are easy to construct, they are not convenient for graphical presentation of large number of analyses and hence, other techniques such as ternary, piper, and Durov diagrams have been widely used [6]. One of the limitations of the graphical methods is that, limited number of parameters can be used. Unlike the statistical methods such as cluster and factor analyses, these methods provide a powerful tool for analyzing groundwater data for grouping into distinct hydrochemical zones. This work is aimed at evaluating the hydrogeochemistry of water resources of Lagos State, Southwestern Nigeria.

2. SITE DESCRIPTION AND GEOLOGICAL SETTING

Figure 1 show the accessibility map of Lagos State is located in the south-western coast of Nigeria approximately between latitudes 6°22'N and 6°52'N and longitudes 2°42'E and 3°42'E [7]. It is bounded on the west by the Republic of Benin while the southern boundary of the state is formed by the 180km long Atlantic coastline. Its northern and eastern boundaries are shared with Ogun State [7]. It has a total area of 3,577 km2 about 22 percent of which is water. It is the smallest state in the Federation in terms of land mass. About a century ago, Lagos was a small port comprising several villages or settlements, developed on the higher ground within the swamp lands that dominated the area [8]. Lagos grew from a farming and fishing village of the 15th century to a world class megacity. It has grown spatially from a traditional core settlement of about 3.8 sq. km. to a huge metropolis of over 1,183sq.km. Metropolitan Lagos constitutes about 33% of Lagos State with 455sq.km of the metropolis being water bodies, wetlands and mangrove swamps

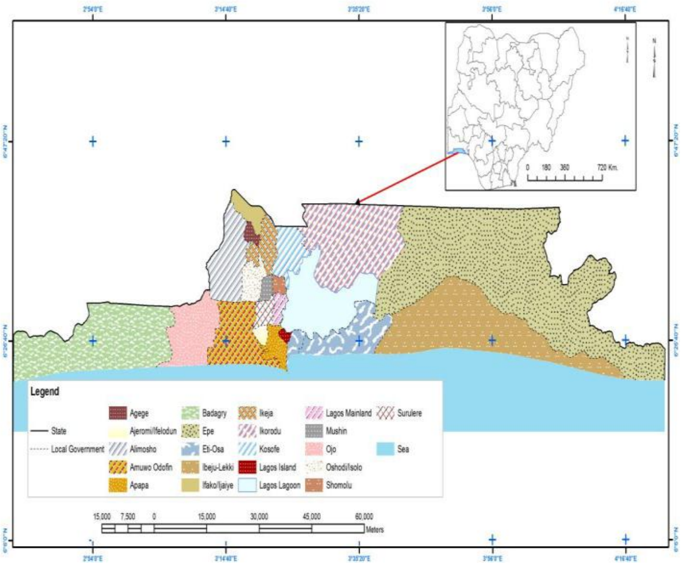

Figure 1: Accessibility map of Lagos state

Generally, the pattern of relief in Lagos reflects the coastal location of the state. Water is the most significant topographical feature in Lagos State. Water and wetlands cover over 40% of the total land area within the state and an additional 12% is subject to seasonal flooding [9].

Factors affecting ions distribution of water include: Nature of rain, minerals present in the pathways from rain to the water body, solubilities of minerals present in these pathways, acidity of rain, as acid rain increases concentrations of certain ions (such as calcium, magnesium and iron) in the water body because it is better able to leach these from its pathway, rate at which rainwater enters the water body (high rate dilutes water), rate of evaporation from the water body, extent of human activities, extent of agricultural practices, such as the use of fertilisers, in areas near the water body, extent of discharge of waste from industry into the water body, extent of discharge of effluent into the water body, extent of leaching from rubbish dumps into the water body, due to their smaller volumes, rivers and dams are more susceptible than oceans to changes in ion concentrations, however, ion concentration in coastal ocean water can be significantly affected, particularly by: Discharge of sewerage, run-off from rivers that flow through agricultural land.

2.1 Geology of Dahomey basin

The Benin (Dahomey) Basin forms one of a series of West African Atlantic Margin basins that were initiated during the period of rifting in the late Jurassic to early Cretaceous [10, 11]. The basin stretches along the coast of Nigeria, Benin Republic, Togo and Ghana in the margin of the Gulf of Guinea (Fig.2). It is separated from Niger Delta in the Eastern section by Benin Hinge Line and Okitipupa Ridge and marks the continental extension of the chain fracture zone. It is bounded on the west by Ghana Ridge, and has been interpreted as the Romanche fracture zone [12, 13]. The basin fill covers a broad arc–shaped profile, attaining about 13 km maximum width in the onshore at the basin axis along Nigerian and Republic of Benin boundary. This narrows westwards and eastwards to about 5 km [14]. Detailed geology, evolution, stratigraphy and hydrocarbon occurrence of the basin have been described in literatures [10, 14, 15]. Most of these authors have recognized two structural elements, which comprise the Benin basin proper and the Okitipupa structure. Coker and Ejedawe, [14]identified three structural domains; namely, the onshore (Bodashe, Ileppa – Ojo), the Okitipupa structure (Union – Gbekebo) and offshore. They emphasized that these three structural domains have gone through three main stages of basin evolution. These stages are initial graben (predrift) phase, prolonged transitional stage and open marine (drift) phase. Early study on the basin stratigraphy by Jones and Hockey [16] recognized both Cretaceous and Tertiary sediments (Fig.2.2). Other subsequent workers recognized three chronostratigraphic units:
(i) pre-lower Cretaceous folded sequence, (ii) Cretaceous sequence and (iii) Tertiary sequence [10, 15] (Fig. 2.2). The Cretaceous stratigraphy as compiled from outcrop and borehole records consists Abeokuta Group sub-divided into three informal formational units namely Ise, Afowo [10].

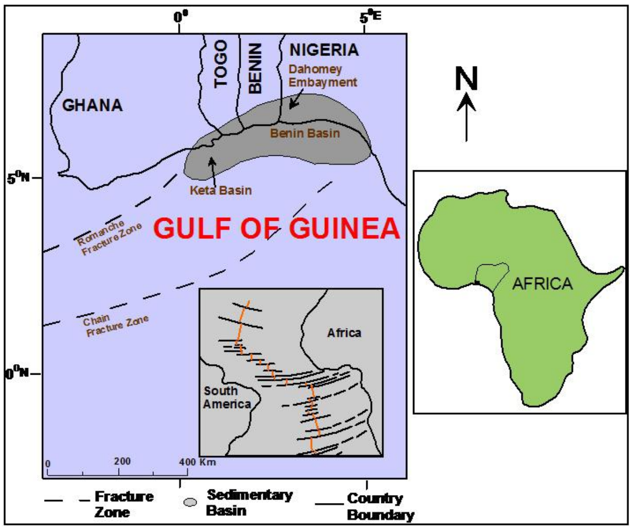

Figure 2: Regional map of four countries showing the location of the Benin (Dahomey) Basin in the Gulf of Guinea

2.1.1 Ise Formation

Ise Formation unconformably overlies the basement complex and comprises coarse conglomeratic sediments and grits.

2.1.2 Afowo Formation

Afowo Formation is composed of transitional to marine sands and sandstone with variable but thick interbedded shales and siltstone. Araromi is the uppermost formation and is made up of shales and siltstone with interbeds of limestone and sands (Fig. 2). The Tertiary sediments consist of Ewekoro, Akinbo, Oshosun, Ilaro and Benin (Coastal Plain Sands) Formations (Fig.3).

2.1.3 Ewekoro Formation

The Ewekoro Formation is made up of fossiliferous well-bedded limestone while Akinbo and Oshosun Formations are made up of flaggy grey and black shales. Glauconitic rock bands and phosphatic beds define the boundary between Ewekoro and Akinbo Formations. Ilaro and Benin Formations are predominantly coarse sandy estuarine, deltaic and continental beds. The stratigraphy of the Cretaceous and Tertiary Formations in the Nigerian sector of the basin is controversial. This is due primarily to different stratigraphic names that have been proposed for the same Formation in different localities in the basin [15,14]. This situation can be partly blamed on the lack of good borehole coverage and adequate outcrops for detailed stratigraphic studies.

Overlying the Ewekoro Formation is the Akinbo Formation, which is made up of shale and clayey sequence. The claystones are concretionary and are predominantly kaolinite. Oshosun Formation overlies the Akinbo Formation and consists of greenish - grey clay and shale with interbeds of sandstones. The Ilaro Formation overlies conformably the Oshosun Formation and consists of massive, yellowish, poorly consolidated, cross-bedded sandstones. Capping the sequence is the Coastal Plain Sands [16] and consists of poorly sorted sands with lenses of clays.

The Dahomey Basin is a combination of inland / coastal / offshore basin that stretches from southeastern Ghana through Togo and the Republic of Benin to southwestern Nigeria. It is separated from the Niger Delta by a subsurface basement high referred to as the Okitipupa Ridge. Its offshore extent is poorly defined. Sediment deposition follows an east-west trend. In the Republic of Benin, the geology is fairly well known [15]. In the onshore, Cretaceous strata are about 200 m thick. A non-fossiliferous basal sequence rests on the Precambrian basement. This is succeeded by coal cycles, clays and marls which contain fossiliferous horizons. Offshore, a 1,000 m thick sequence consisting of sandstones followed by black fossiliferous shales towards the top has been reported. This was dated by Billman [15] as being pre-Albian to Maastrichtian. The Cretaceous is divisible into two geographic zones, north and south. The sequence in the northern zone consists of a basal sand that progressively grades into clay beds with intercalations of lignite and shales. The uppermost beds of the Maastrichtian are almost entirely argillaceous. The southern zone has a more complicated stratigraphy with limestone and marl beds constituting the major facies.

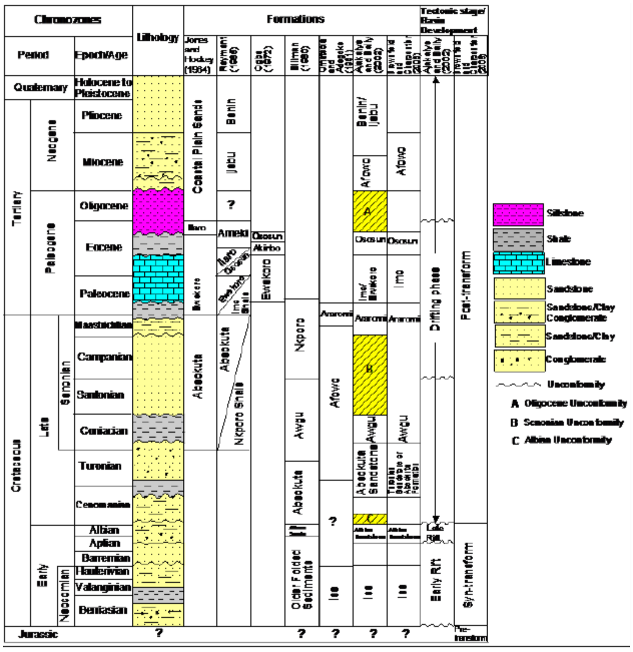

Figure 3: Stratigraphy of the Nigerian sector of the Benin (Dahomey) Basin

3. MATERIALS AND METHODS

3.1 Materials

The reconnaissance survey of the study area was thoroughly carried out to affirm the accessibility of the study area. GPS is used for taking the coordinates, plastic bottle is used for canning the water sample, masking tape and marker for labelling the samples, sampling bag for collection of samples, Fresh water samples were collected and immediately canned in water can. To enhance accurate result such as decayed debris, plant residues and ion concentration are kept in check.

3.2 Methods of Sampling

Three locations (15 water samples) were collected for analysis. five samples were taken from each location. All the samples were collected in Lagos starting from Ibeshe lagoon in Ikorodu and Lekki. The collected water samples from each location were analyzed at the National Agency for Science and Engineering Infrastructure, Akure, Nigeria. Using Atomic Absorption Spectrometer AAS.

3.2.1 Atomic Absorption Spectrometer

Figure 4 illustrate the picture of the atomic absorption spectrophotometer (AAS) used for the analysis is made of hollow cathode lamp to provide the emission of the element an induction system, the burner and aspirator, a deflection stem consisting of length setting slit and an electronic computing system. For the determination of element standard solutions of each of the elements were prepared in flasks. Each standard solution was aspirated with the aspirator. The AAS and a range of values were obtained. These were then used as records for the determination of the unknown concentrations of the elements in sample solutions. Before analyzing for the elements in the sample solutions, appropriate length settings, slit setting, acetylene flames and adjustments were done. Also, appropriate hollow cathode lamp for each element used. After these measurements, the simplest were aspirated with a capillary tube and after three seconds, thread switch was pressed and released at once. The readings appeared on the ray indicator and values were recorded. The aspiration tube was always put in a bottle containing distilled water after treating each sample. This was done to prevent contamination.

3.2.2 Methodology for AAS Analysis

Solutions were introduced into the plasma by a number of devices such as the nebulizer and the flow injector which is the commonest and its main function is to turn the sample solution into tiny droplets (aerosol). The aerosol is then carried via a spray chamber in a stream of acetylene gas through a plasma torch to the plasma. The geometry of the torch ensures that vertical funnel is blown through the flat base of the plasma by the central flow acetylene gas that carries the sample material. The sample material passes through the funnel and reaches a temperature of about 7500K. At this temperature, the sample becomes completely atomized. The result of the chemical analysis is displayed.

Figure 4: Perkins Elmer Atomic Absorption spectrometer equipment

4. RESULTS DISCUSSION

Results are presented and discussed. The geochemical analysis of the water samples from the study area: Lagos, Nigeria. Table 1 depict the hydrogeochemistry of the study areas within Lagos metropolis.

Table 1: Summary of the geochemical analysis result

Ions	Ajah					Lekki					Ikorodu				
Na^+	2.3	2.7	10.2	2.1	2	2.3	2.1	2.1	1.5	9.3	2.2	2.2	3.8	9.2	4.2
K^+	0.5	0.5	3.9	0.7	0.7	0.3	1	0.6	0.3	4	0.3	0.3	0.9	2.4	1.3
Ca^{2+}	1.9	2.6	7.8	1.9	1.7	2	1.5	2.8	1.2	8.1	2.4	2.6	1.2	7.4	4.2
Mg^{2+}	0.2	0.4	1	0.3	0.2	1.3	0.6	0.6	0.7	0.9	0.2	1.8	0.5	1.3	0.2
Fe^{2+}	0.18	0.1	0.15	0.12	0.1	0.08	0.1	0.08	0.1	0.17	0.1	0.1	0.1	0.24	0.1
Zn^{2+}	0.47	0.34	0.83	0.28	0.4	0.15	0.17	0.14	0.12	0.45	0.16	0.18	0.6	0.5	0.5
Cd	0.7	0.1	0.73	0.5	0.4	0.7	0.44	0.49	0.29	0.33	0.31	0.12	0.1	0.7	0.55
Cu	3.5	2	2.5	5.4	8.6	8	12	4.1	7.2	8.2	9.5	8	6.4	8.8	12.5
Ni	2.2	2.1	2.4	2.2	2.3	2.2	2.3	2	3.4	2.6	2.1	3.2	2	1.9	2.2
Cr	1.7	1	2.2	1	1.7	2.2	2.4	2.1	1.6	2	2.2	3.1	2.2	2.4	2.2
Pb	0.3	0.3	0.5	0.3	0.2	0.4	0.3	0.4	0.3	0.2	0.4	0.2	0.2	0.3	0.3
Hg	0.21	0.12	0.18	0.15	1.8	0.8	0.16	0.12	0.16	0.88	0.11	0.25	0.2	0.14	0.15
Sr	0.23	0.74	0.16	0.23	0.21	0.42	0.21	0.14	0.2	0.23	0.21	0.28	0.22	0.24	0.22
Br	0.14	0.16	0.12	0.12	0.15	0.12	0.22	0.15	0.18	0.13	0.12	0.21	0.22	0.12	0.14
As	0.02	0.05	0.05	0.06	0.08	0.04	0.05	0.04	0.04	0.2	0.04	0.02	0.02	0.03	0.02
Cl^-	3.8	5	8.2	3.5	8.5	8	4.2	4.9	4.5	12	8.2	7.4	4.1	3.2	3.8
SO_4^{2-}	0.2	0.1	0.3	0.2	0.2	0.1	0.1	0.1	0.2	1.8	0.1	0.2	0.6	0.3	0.1
HCO^{3-}	2	8	1	1	1	2	2	4	1	2	2	2	4	2	1

Figure 5 depicts the piper plot for Ajah axis depicts that the sample taken from location 1 (Ajah 1) is of mixed type water and Ajah 2 sample falls into Magnesium bicarbonate type water. Sample taken from Ajah 3 indicate that it falls within a mixed type water between calcium and sodium type. Ajah 4 sample falls between the Sodium chloride type water while sample taken from Ajah 5 falls within mixed water between the Calcium and sodium type water.

Sample taken from Ajah axis exclusively falls in the mixed type water between Sodium and calcium water type except for sample 2 which is Magnesium bicarbonate type water.

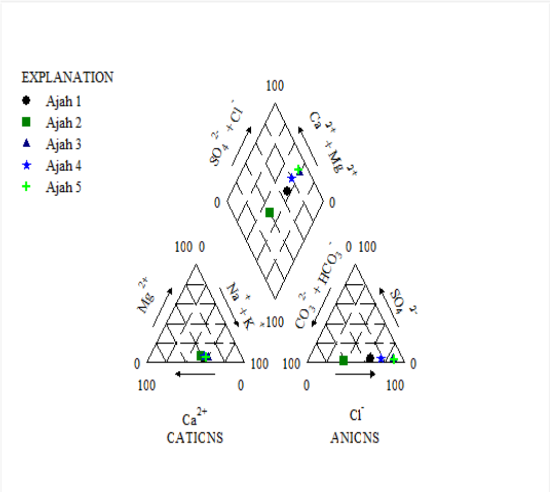

Figure 5: Piper diagram for sample taken from Ajah axis

In Lekki axis (Fig.6), the first sample falls within the mixed type water of calcium sulphate and sodium chloride type waters, sample 2 falls within Sodium chloride type waters, sample 3 falls in the mixed type between Sodium chloride water and Magnesium bicarbonate type waters, sample 4 from Lekki axis falls within the mixed type of sodium chloride and calcium sulphate type water, sample 5 also falls measurably on the mixed type waters (Fig. 7).

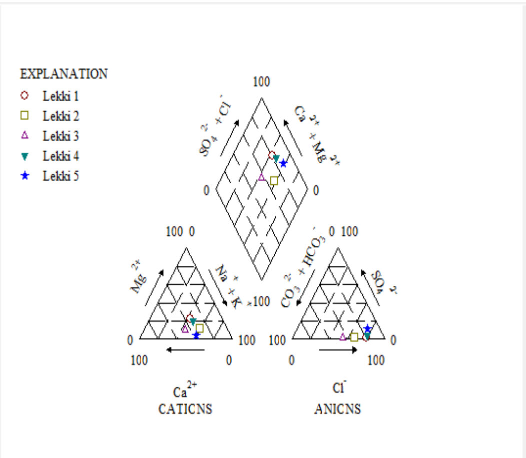

Figure 6: Piper diagram for sample taken from Lekki axis

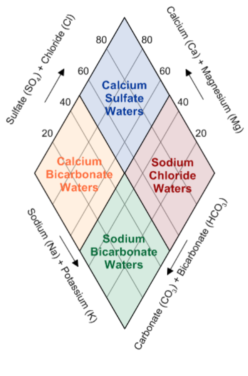

Figure 7: Standard for classification water type

Figure 8 illusttrate the piper plot of Ikorodu axis water sample fall considerable in the mixed water type between the calcium sulphate and sodium chloride except for sampls taken from point 2 and 3 which falls in the calcium sulfate and sodium chloride type waters respectively (Fig. 9)

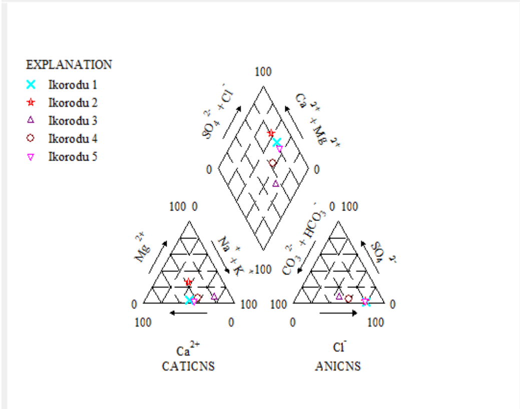

Figure 8: Piper plot of sampled water in Ikorodu

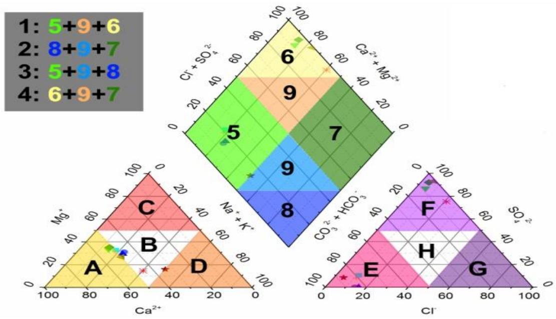

Figure 9: Piper diagram interpretation chart A: Calcium type; B: No dominant type; C: Magnesium type; D: Sodium and potassium type; E: Bicarbonate type; F: Sulphate type; G: Chloride type; 1: Alkaline earths exceed alkalis; 2: Alkalis exceed alkaline earths; 3: Weak acids exceed; strong acids; 4: Strong acids exceed weak acids; 5: Magnesium bicarbonate type; 6: Calcium chloride type; 7: Sodium chloride type; 8: Sodium bicarbonate type; 9: Mixed type

Figure 10 demonstrate the radial plot of cations and anions is the direct comparison of various ionic samples values is against each other, according to standard measurement. The circular plot permit comparative analysis based on geometry of each section of the plot in terms of wind speed and velocity of ionic concentration and transportation due to their mineral availability.

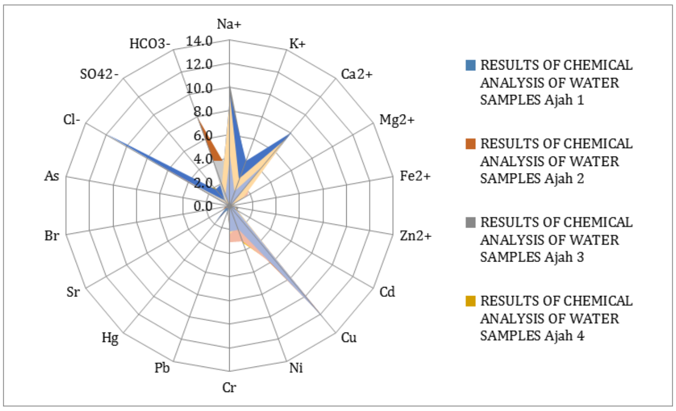

Figure 10: Radar plot for geochemical results of Ajah axis

5. CONCLUSION

Silicate weathering is one of the key hydrogeochemical processes controlling the major ions chemistry of the water resources. The dominance of cations like Na, Ca, Mg and lower K indicates the significance of silicate weathering and the resistance of potassium minerals to weathering and the concentrations of SO4 might have been derived from sources like agricultural influences since no dominant litho units for the contribution of the same have been identified in the study area. The source for HCO3- might have been attributed from sources like atmospheric CO2 and soil organic materials. The sources for ions like Cl- and NO3- might have been derived from anthropogenic activities like agricultural influences. The result of the piper plot shows that almost all the water sample falls in the mixed type between the sodium chloride type (saline) water and the calcium sulphate water (permanent hard type) only a few falls into the category of sodium bicarbonate (temporary hard water) and its mixed type. The study area surface water bodies fall within the mixed type which is saline and calcium sulphate which is permanently hard. The parts of water in Ajah falls into the category of temporary hard water, in this water type, it is possible for the hardness to be removed. We recommend that detail baseline hydrogeochemical analyses should be carried out in Lagos metropolis to ascertain the water types, treatment methods and its potability in meeting international standards.

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