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Ionic composition of rainwater from different sampling surfaces across selected locations in Rivers State, Nigeria

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ABSTRACT

This study seeks to assess the impact of pH from an array of ions interactions in rainwater samples across different sampling surfaces (ambient, zinc roof, aluminium roof, asbestos roof and stone-coated roof) and locations (Ogale, Eleme, Rumuodomaya/Rumuodome, Obio-Akpor, Diobu, Port-Harcourt and Chokocho, Etche) in Rivers State, Nigeria. Rainwater were sampled from April, 2019 to October, 2019, prepared and analysed for pH, Cl^-, SO_4^{2-}, NO_3^-, NO_2^-, PO_4^{3-}, HCO_3^-, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+ and Al^{3+}.using standard procedure. Statistical and Factor analysis was estimated to give ionic impacts on rainwater quality. The results showed that pH across different sampling surfaces ranged from 6.26 – 7.02 with decreasing location as Rumuodomaya/Rumuodome > Diobu > Chokocho > Ogale which impacts on different cation and anion interactions. Factor analysis showed cumulative variance of 88.79% for ambient, 87.58% for zinc roof, 86.49% for aluminium roof, 89.57% for asbestos roof and 65.89% for stone-coated roof across all four locations which are due to industrial and biomass emission, agricultural, metabolic and mining activities on chemical composition. Therefore, rainwater is safe for drinking but special treatment is needed to make it safe for human consumption.

***Keywords*:** Cations, Anions, Rainwater quality, Rivers State, Nigeria

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1. INTRODUCTION

One of the biggest problems in Nigeria is getting portable water due to the growing water shortage. Piped-borne water is absent or too expensive, which makes rainwater harvesting a cheap source for domestic use as the availability of good quality water is declining. The inadequate supply of portable and safe water is one of the most basic challenges of rural and urban dwellers in Rivers state, Nigeria for decades is obviously stating the truth as one has to trek few kilometers to rivers and streams to get water which is not palatable or safe for human use. A staggering fifty two percent (52%) of Nigerians have no access to improve drinking water supply [1].

Rainwater is harvested during the rainy season into underground tanks and stored into underground plastic or brick tanks using different surfaces for rainwater collection such as such as land surface, rooftops (zinc, aluminium, asbestos, ceramic tiles etc.), ceramic tiles and other catchments areas, which is stored and used during the dry seasons as succor for rural and urban dwellers in Nigeria.

The ever-increasing population of Rivers state which is an economic hub of the Oil and Gas, Petrochemical, Manufacturing Industries which are high users of groundwater has either not being treating its wastewater before disposal thereby contaminating the groundwater and surface-water quality. Hence, the demand for portable water keeps increasing; thereby people tend to drink untreated water from privately dug underground boreholes with the perception of being pure.

This study seeks to assess the ionic composition of rainwater to establish an alternative to underground water since it is either polluted or unfit for human consumption.

2. MATERIALS AND METHODS

2. 1. Sampling site and Methods

Rivers State is located in southern Nigeria is home to diverse, multi-culture people who speak different languages with a population of over seven million. The climate of rivers state is generally wet with rainfall event that occurs between March to November, 2019; temperature is between 24-28.5 °C, Relative humidity rarely pass below 60%. Rivers state is one of the economic hub of Nigeria with local and international multinational companies engaged in different activities, which release various air pollutant into the environment.

The sampling site was Ogale, Eleme (4.79°N, 7.12°E), Rumuodomaya/Rumuodome, Obio-Akpor (4.88°N, 7.02°E), Diobu, Port-Harcourt (4.77°N, 6.99°E) and Chokocho, Etche (4.99°N, 7.05°E) in Rivers State. The sampling period was from April to October 2019. Rainwater samples were harvested above 1m using a precleared bowl and transferred into four different 500ml pre-treated polyethylene bottle from different sampling surfaces: ambient and different roof materials: zinc, aluminium, asbestos, and stone-coated.

pH were determined on-site. The samples were well labelled, packaged in a black cellophane and taken to the lab within 24 h of collection and kept in a refrigerator until analysed. Sample preparation and handling were carried out according to American Public Health Association procedures (APHA).

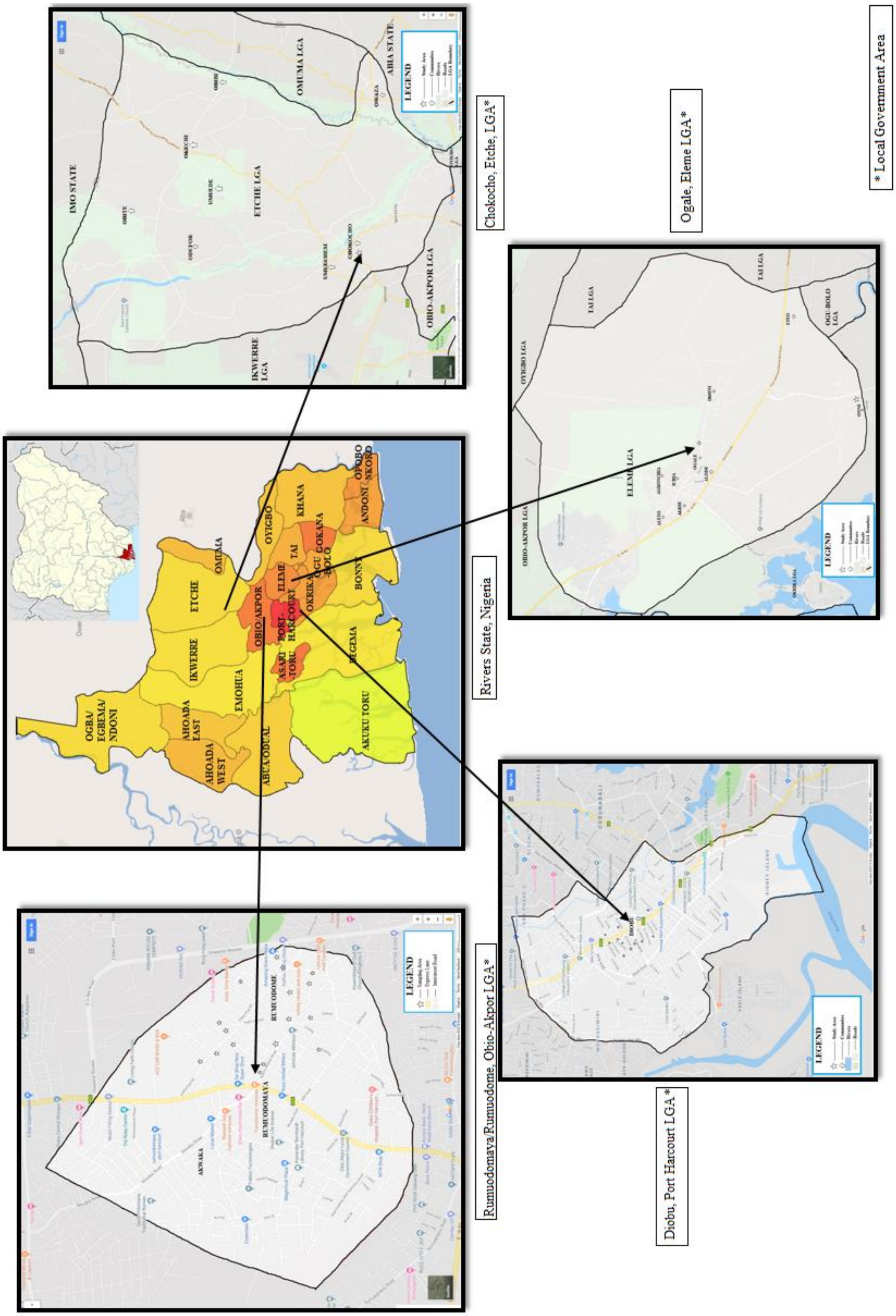

Figure 1. Site maps indicating sampling sites

2. 2. Analytical method

Light metals were analysed by digesting 50 ml rainwater samples with 5 ml of concentrated nitric acid (HNO_3) for 10 minutes at 165 – 170 °C. The samples were cooled and made up 100 ml deionized water in a volumetric flask. Five metals (Sodium - Na^+, Potassium - K^+, Magnesium - Mg^{2+}, Calcium - Ca^{2+}, Aluminium-Al^{3+}) were determined in triplicate using Agilient Inductively Coupled Plasma – Optical Emission Spectrophotometer 280FS AA Instrument with plasma touch using air–acetylene flame and auto sampler. Selected ions (Sulphate - SO_4^{2-}, Ammonium - NH_4^+, Nitrate - NO_3^-, Nitrite - NO_2^-, Phosphate - PO_4^{3-}) were determined using D5000 Ultraviolet–Visible spectrophotometer with standard powder pellets Chloride - Cl^- and Hydrogen carbonate - HCO_3^- were determined in rainwater samples using titrimetry

2. 3. Statistical analysis

Microsoft Excel Package 2019 for Windows was used to execute several statistical analysis using different preinstalled Add-ins such as Data Analysis (mean and standard deviation concentration) and XRealStats (Factor Analysis) Graphical presentations were prepared using line plot using Excel Charts.

3. RESULT AND DISCUSSION

3. 1. pH value of rainwater

The pH mean value of rainwater collected from different sampling surface are shown in **Table 1** and **Figure 2** ranged from 6.26 to 7.02 respectively. This showed steady increase from acidity to alkalinity by dilution from more rainfall event throughout the sampling months. The pH values for stone-coated roof indicate the impact of limestone ($CaCO_3$) in increasing pH value than other roofing materials [2-4].

The pH of the rainwater plays a more prominent role across different roofing surfaces by an array of anionic releases from industrial and automobile emissions into the atmosphere which reacts atmospheric gases then interacts with water vapour before rainwater deposition on different roofing arrays. This continuous deposition cycle leads to an increase in reactivity, dissolution and solubility of cations from roofing surface or vice versa which leaches and dissolves into rainwater causing negative aesthetic, health and economic impact on consumption or other human activity [5-7]

Table 1. pH mean value for different sampling location.

Sampling Surface Type	**Ogale, Eleme**	**Rumudomaya/ Rumuodome, Obio-Akpor**	**Diobu, Port-Harcourt**	**Chokocho, Etche**
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Ambient	6.54 ± 0.89	6.91 ± 0.62	6.78 ± 0.51	6.78 ± 0.75

Zinc Roof	6.36 ± 1.05	6.77 ± 0.55	6.50 ± 0.47	6.26 ± 1.07
Aluminium Roof	6.38 ± 0.98	6.59 ± 0.64	6.53 ± 0.62	6.43 ± 0.92
Asbestos Roof	6.60 ± 0.80	6.86 ± 0.48	6.68 ± 0.58	6.59 ± 1.14
Stone-Coated Roof	–	7.02 ± 0.25	–	6.77 ± 0.63

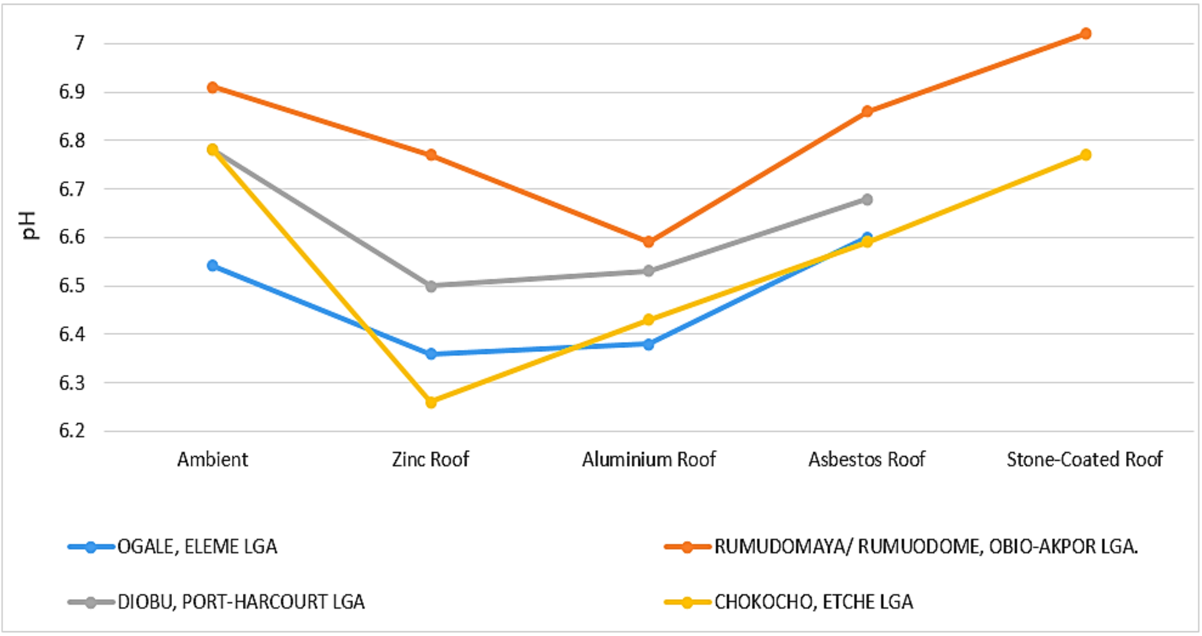

Figure 2. pH variation due to different locations and sampling surface

3. 2. Anionic composition of rainwater

Table 2 shows the anionic concentration level of rainwater collected from different sampling surface. Chokocho showed high proportion of chloride compared to Diobu, Rumuodomaya/Rumuodome, and Ogale. Chloride is found in large amount from industrial brine which increases the corrosiveness of water is due to variation in climatic, marine contribution and geological conditions with anthropogenic activities in the environment [8-9]. Sulphate concentration showed that Chokocho was high compared to other locations which can be attributed to industrial emission that lead to decrease in pH range, increase in corrosion in pipes and also causes gastrointestinal effect in humans [10-11].

The nitrate concentration level in decreasing order based on locations are Chokocho > Rumuodomaya/Rumuodome > Ogale > Diobu which can be attributed to fertilizer, agro-allied industries which is a precursor for decrease in pH and eutrophication in water bodies and cause methaemoglominaemia in bottle-fed babies [11-12]. The nitrite concentration in terms of decreasing level based on locations are Rumuodomaya/Rumuodome > Ogale > Chookocho>

Diobu. This could be attributed to elevated temperature and long residence time from industrial emission and microbial reduction of dissolved oxygen in aquatic waterbodies, which can influence drinking water quality and cause corrosion to metallic pipes [11].

The phosphate concentration in terms of decreasing level based on locations are Rumuodomaya/Rumuodome > Ogale > Diobu > Chokocho. This can be attributed to fertilizer, agro-allied and other anthropogenic industries that lead to eutrophication and reduction in acidity in water bodies [12]. Hydrogen carbonate concentration showed that chokocho was highest while Rumuodomaya/Rumuodome was least, which can be attributed to geographical locations, meerological conditions and anthrophenic activities (agriculture, chemical industry, vehicular emission etc.) that influences acidity, increase in sediment, turbidity and taste in waterbodies [13-14]

Table 2. Anion concentration of rainwater.

Sampling Surface Type	**Locations:** / **Type of Parameter**	**Ogale, Eleme**	**Rumudomaya/ Rumuodome, Obio-Akpor**	**Diobu, Port-Harcourt**	**Chokocho, Etche**
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Ambient	Chloride (Cl^{-})	2.22 ± 2.21	2.71 ± 2.55	5.73 ± 6.32	9.95 ± 11.55
	Sulphate (SO_4^{2-})	1.42 ± 0.92	1.89 ± 1.00	2.75 ± 2.50	4.50 ± 3.87
	Nitrate (NO_3^{-})	2.69 ± 2.60	2.79 ± 2.77	2.03 ± 1.58	2.96 ± 2.61
	Nitrite (NO_2^{-})	0.87 ± 0.77	1.08 ± 0.91	0.34 ± 0.18	0.74 ± 0.40
	Phosphate (PO_4^{3-})	0.46 ± 0.26	0.70 ± 0.17	0.49 ± 0.25	0.45 ± 0.37
	Hydrogen Carbonate (HCO_3^{-})	1.66 ± 1.45	1.24 ± 0.88	1.67 ± 1.62	2.09 ± 1.74
Zinc Roof	Chloride (Cl^{-})	2.90 ± 2.80	4.65 ± 4.70	10.21 ± 12.61	11.51 ± 14.88
	Sulphate (SO_4^{2-})	2.75 ± 2.09	3.23 ± 2.68	3.36 ± 2.58	6.48 ± 6.76
	Nitrate (NO_3^{-})	4.28 ± 3.75	4.77 ± 5.35	1.69 ± 1.18	4.38 ± 4.46
	Nitrite (NO_2^{-})	1.18 ± 0.96	1.32 ± 1.09	0.54 ± 0.28	0.98 ± 0.33
	Phosphate (PO_4^{3-})	0.80 ± 0.18	1.15 ± 0.26	0.60 ± 0.29	0.56 ± 0.46

	Hydrogen Carbonate (HCO_3^-)	2.39 ± 2.03	1.51 ± 1.43	2.56 ± 2.72	3.44 ± 3.64
Aluminium Roof	Chloride (Cl^-)	4.43 ± 4.84	2.81 ± 2.13	10.33 ± 12.01	8.58 ± 8.76
	Sulphate (SO_4^{2-})	3.12 ± 2.71	2.62 ± 1.36	3.95 ± 3.65	4.44 ± 2.82
	Nitrate (NO_3^-)	4.54 ± 5.46	4.08 ± 4.79	1.74 ± 1.08	5.06 ± 4.30
	Nitrite (NO_2^-)	1.18 ± 0.93	1.15 ± 1.08	0.56 ± 0.40	1.12 ± 0.62
	Phosphate (PO_4^{3-})	0.73 ± 0.17	1.13 ± 0.31	0.74 ± 0.44	0.44 ± 0.29
	Hydrogen Carbonate (HCO_3^-)	2.46 ± 2.03	1.66 ± 1.01	2.72 ± 3.20	3.60 ± 4.34
Asbestos Roof	Chloride (Cl^-)	3.04 ± 3.11	3.88 ± 3.65	8.60 ± 10.53	10.78 ± 13.18
	Sulphate (SO_4^{2-})	2.64 ± 2.35	2.99 ± 1.71	3.57 ± 2.81	5.76 ± 5.36
	Nitrate (NO_3^-)	2.94 ± 3.56	3.82 ± 4.28	2.37 ± 2.16	4.05 ± 4.36
	Nitrite (NO_2^-)	0.90 ± 0.86	1.11 ± 0.73	0.53 ± 0.35	0.85 ± 0.34
	Phosphate (PO_4^{3-})	0.84 ± 0.10	1.26 ± 0.30	1.05 ± 0.62	0.49 ± 0.45
	Hydrogen Carbonate (HCO_3^-)	2.06 ± 1.59	2.70 ± 3.15	3.10 ± 3.71	4.09 ± 4.79
Stone - Coated Roof	Chloride (Cl^-)	–	2.76 ± 2.63	–	8.68 ± 10.08
	Sulphate (SO_4^{2-})	–	2.86 ± 1.76	–	2.69 ± 1.27
	Nitrate (NO_3^-)	–	2.96 ± 2.43	–	4.98 ± 3.72
	Nitrite (NO_2^-)	–	0.91 ± 0.61	–	0.97 ± 0.43
	Phosphate (PO_4^{3-})	–	0.78 ± 0.17	–	0.30 ± 0.22
	Hydrogen Carbonate (HCO_3^-)	–	1.39 ± 0.73	–	2.27 ± 1.82

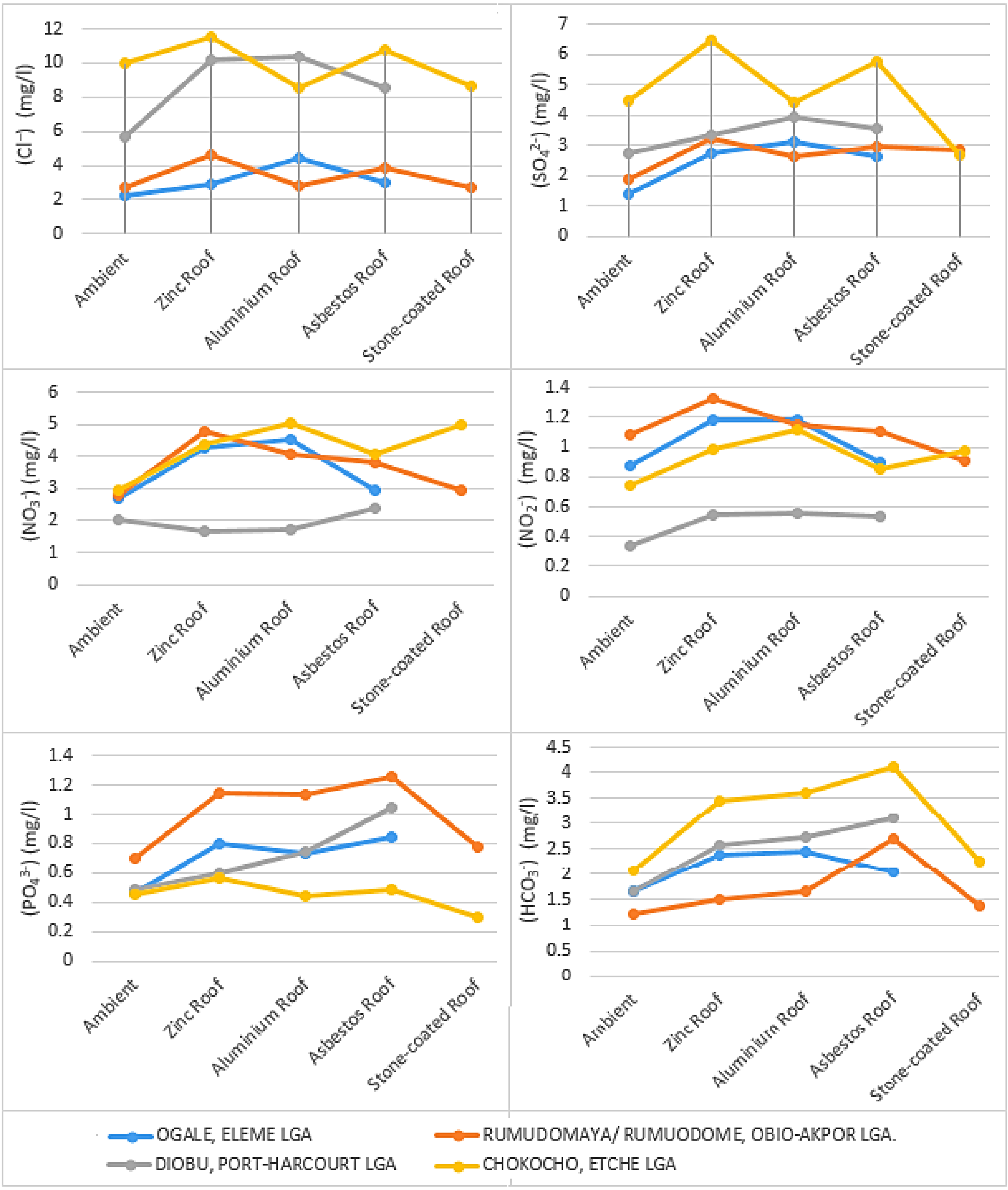

Figure 3. Line graph indicating mean anion concentrations in different location

3. 3. Cationic composition of rainwater

Table 3 shows the cationic concentration level of rainwater collecting from different sampling surface. Sodium concentration showed that Chokocho was highest while Diobu was least. Presence of sodium in water influence taste, as level above 20 mg/l can cause hypertension and increase blood pressure in humans. Sodium plays a role in nutrition as it contributes to electrolyte regulation by kidney, affect muscle contraction in the body maintains and ionic and water balance [15]. In the environment, sodium is toxic to plants in high concentration as it reduces permeation, produces foams in industrial boilers, and causes corrosion in metal tubing [16]. Potassium concentration for Rumudomaya/Rumuodome showed variations based on zinc roof and asbestos roof compared to Ogale, Chokocho and Diobu. There is no health risk associated to potassium in drinking water, but it can interfere with drug interactions in medical illness [17].

Ogale had relatively high magnesium content across different sampling surfaces compared to Rumuodomaya/Rumudome, Chokocho and Diobu. Magnesium influences hardness, taste and colour of water [18]. Ogale showed high calcium content from different sampling surface compared to Rumuodomaya/Rumuodmome, Diobu and Chokocho. Calcium impacts on hardness, taste and turbidity content in water that can be attributed to limestone dust from industries and construction work.

The ammonium concentration level in decreasing order based on locations are Ogale > Rumuodomaya/Rumuodome > Chokocho > Diobu which can be attributed to increase in pH in rainwater. At low pH, ammonia combines with rain droplet to produce ammonium ion (NH_4^+) and hydroxide ion (OH^-) is produced by metabolic, agricultural and industrial processes and from disinfection with chloramine which causes taste and odour problem [19]. Aluminium content was high in Rumuodomaya/Rumuodome compared to Ogale, Diobu and Chokocho. Aluminium contributes to increase in colour, turbidity, coagulation, hardness and has been hypothesized to cause Alzheimer disease in human [20-21].

Table 3. Cation concentration of rainwater.

Sampling Surface Type	**Location:** / **Type of Parameter**	**Ogale, Eleme**	**Rumudomaya/ Rumuodome, Obio-Akpor**	**Diobu, Port-Harcourt**	**Chokocho, Etche**
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Ambient	Sodium (Na^+)	0.91 ± 1.12	0.68 ± 0.86	0.65 ± 0.60	0.78 ± 1.15
	Potassium (K^+)	0.10 ± 0.07	0.14 ± 0.19	0.14 ± 0.11	0.15 ± 0.20
	Magnesium (Mg^{2+})	0.31 ± 0.25	0.29 ± 0.41	0.07 ± 0.05	0.09 ± 0.01
	Calcium (Ca^{2+})	0.72 ± 0.52	0.42 ± 0.63	0.18 ± 0.04	0.23 ± 0.04
	Ammonium (NH_4^+)	4.15 ± 3.45	3.41 ± 1.90	3.63 ± 2.56	4.93 ± 3.71
	Aluminium (Al^{3+})	0.04 ± 0.04	0.07 ± 0.06	0.02 ± 0.02	0.02 ± 0.01
Zinc Roof	Sodium (Na^+)	1.19 ± 1.50	0.94 ± 1.20	0.77 ± 0.72	1.81 ± 2.89

	Potassium (K^+)	0.29 ± 0.35	0.46 ± 0.59	0.23 ± 0.20	0.14 ± 0.16
	Magnesium (Mg^{2+})	0.48 ± 0.30	0.34 ± 0.35	0.12 ± 0.02	0.21 ± 0.15
	Calcium (Ca^{2+})	1.13 ± 0.76	0.55 ± 0.74	0.43 ± 0.15	0.30 ± 0.13
	Ammonium (NH_4^+)	6.29 ± 5.25	7.59 ± 7.27	5.07 ± 4.49	5.26 ± 3.51
	Aluminium (Al^{3+})	0.07 ± 0.06	0.18 ± 0.16	0.04 ± 0.03	0.04 ± 0.01
Aluminium Roof	Sodium (Na^+)	1.27 ± 1.68	0.72 ± 0.78	0.85 ± 0.67	1.83 ± 2.85
	Potassium (K^+)	0.42 ± 0.50	0.32 ± 0.32	0.17 ± 0.04	0.25 ± 0.34
	Magnesium (Mg^{2+})	0.43 ± 0.26	0.38 ± 0.30	0.16 ± 0.08	0.37 ± 0.34
	Calcium (Ca^{2+})	1.07 ± 0.76	1.14 ± 1.24	0.45 ± 0.11	0.46 ± 0.32
	Ammonium (NH_4^+)	6.58 ± 7.09	6.13 ± 5.67	4.52 ± 3.14	6.03 ± 2.31
	Aluminium (Al^{3+})	0.11 ± 0.12	0.24 ± 0.20	0.08 ± 0.02	0.06 ± 0.04
Asbestos Roof	Sodium (Na^+)	1.23 ± 1.66	1.04 ± 1.51	0.94 ± 0.92	2.00 ± 3.15
	Potassium (K^+)	0.35 ± 0.45	0.51 ± 0.57	0.32 ± 0.35	0.34 ± 0.45
	Magnesium (Mg^{2+})	0.44 ± 0.35	0.48 ± 0.45	0.33 ± 0.22	0.26 ± 0.25
	Calcium (Ca^{2+})	1.22 ± 1.31	1.01 ± 1.32	0.52 ± 0.38	0.45 ± 0.27
	Ammonium (NH_4^+)	5.27 ± 5.77	6.20 ± 5.68	4.34 ± 3.47	4.35 ± 2.07
	Aluminium (Al^{3+})	0.16 ± 0.20	0.23 ± 0.25	0.05 ± 0.01	0.07 ± 0.04
Stone - Coated Roof	Sodium (Na^+)	–	0.55 ± 0.78	–	0.99 ± 1.53
	Potassium (K^+)	–	0.23 ± 0.29	–	0.18 ± 0.21
	Magnesium (Mg^{2+})	–	0.60 ± 0.83	–	0.34 ± 0.17
	Calcium (Ca^{2+})	–	1.28 ± 1.80	–	0.46 ± 0.19
	Ammonium (NH_4^+)	–	5.02 ± 3.30	–	5.89 ± 2.73
	Aluminium (Al^{3+})	–	0.22 ± 0.16	–	0.04 0.02

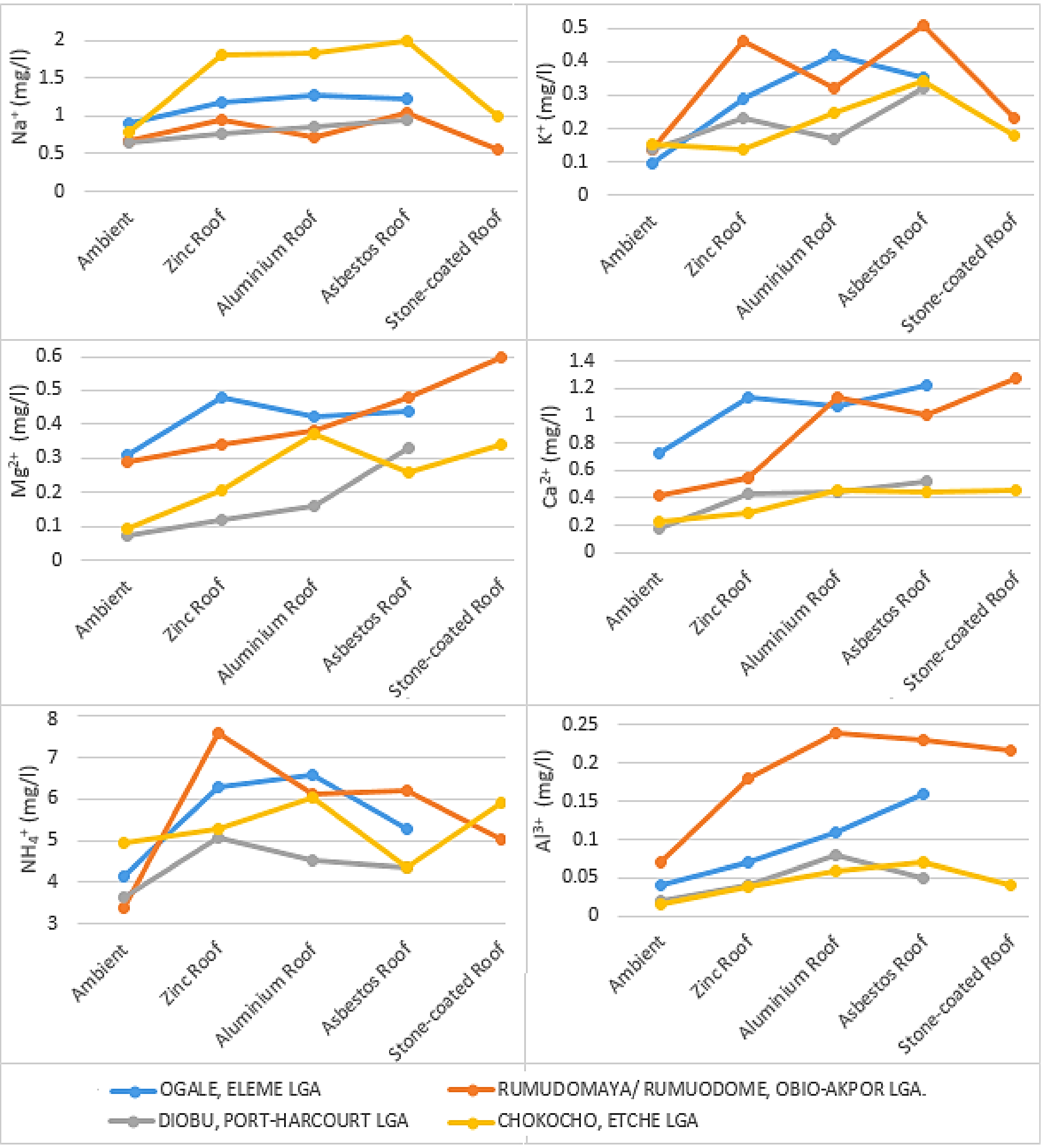

Figure 4. Line graph indicating mean cations concentrations in different location

3. 4. Comparison of ions in rainwater samples based on sampling surfaces

Factor analysis (Principal component analysis) has being widely used in different studies Principal component analysis is based on mathematical model used to analyse multidimensional data with a goal to correlate variables thereby extracting salient information. Factor analysis were carried out by the principal component method using Microsoft Excel, 2016 – XRealStats Package for windows.

It was carried out to determine factor underlying the inter-correlation between measured species. According to Kovacs *et al.* and Thepanondh *et al.* absolute values of factor loading higher than 0.71. The major ionic species (Cl^{-}, SO_4^{2-}, NO_3^{-}, NO_2^{-}, PO_4^{3-}, HCO_3^{-}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, NH_4^{+}, Al^{3+}) were taken into considerations in the factor analysis. Initial factors were extracted for sampling surfaces from different study area in rivers state. Factor with eigenvalue greater than 1 were consider for verimax rotation to obtain final matrix for possible interpretation of possible sources [21-28].

Table 4a, b shows the factor analysis of selected ions across different sampling surfaces. For ambient surface, it identified three factors having 88.79% cumulative variance. Factor 1 showed 41.51% of PO_4^{3-}, HCO_3^{-}, Al^{3+} indicating influence of industrial emission and automobile combustion process. Factor 2 shows the influence of 35.13% of SO_4^{2-}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}. Na^{+}, K^{+}, is due to marine contribution from long-range transportation of sea salts; Mg^{2+}, Ca^{2+} limestone mining from quarries while SO_4^{2-} is due to petrochemical emissions.

Factor 3 shows influence level of 12.15% of Cl^{-}, NO_3^{-}, NH_4^{+} from agro-allied fertilizers and industrial activities which are from dissolution of aerosol in the atmosphere and interacts with rainwater e.g. (NH_4NO_3, NH_4Cl). For zinc roof, the results of factor analysis identified three factors indicates 87.58% of total variance. Factor 1 showed influence of 26.37% of NO_3^{-}, NO_2^{-}, Na^{+}, K^{+}, Mg^{2+}, NH_4^{+} which is influenced by marine contribution, metabolic by microbial organisms and agricultural activities.

Factor 2 shows 32.83% of Ca^{2+}, Al^{3+} from limestone mining, dust particles from construction activities and industrial emission. Factor 3 show 28.38% of Cl^{-}, SO_4^{2-}, PO_4^{3-}, HCO_3^{-} from marine interaction, industrial emission, biomass burning and combustion activities from dissolution with rain droplet thereby reducing the pH of water.

Aluminium roof assessment had two factors at 86.49% of cumulative variance. Factor 1 showed high load level of 52.68% of Cl^{-}, SO_4^{2-},PO_4^{3-}, HCO_3^{-}, Na^{+}, Ca^{2+}, Al^{3+} which is influenced by marine contribution, combustion process, automobile and industrial emissions that can increase acidity content, reactivity of water quality. Factor 2 shows 33.81% of NO_3^{-}, NO_2^{-}, K^{+}, Mg^{2+}, NH_4^{+} from microbial breakdown of biomass; agricultural activities industrial emission and marine contribution that can impact on eutrophication of water bodies thereby reducing dissolved oxygen.

For asbestos roof, identified three factors indicates 89.57% of data variation. Factor 1 showed influence of 39.02% of Cl^{-}, SO_4^{2-}, HCO_3^{-}, Ca^{2+} that is influenced by marine contribution, industrial emission and automobile combustions. Factor 2 shows 18.36% of NO_3^{-}, NO_2^{-}, K^{+}, NH_4^{+}, Al^{3+} from agro-allied activities, industrial emission and metabolic process by microbes. Factor 3 show 32.19% of PO_4^{3-}, Na^{+} from agricultural and industrial process that can influence eutrophication in water bodies.

For stone-coated roof, four factors were identified at 65.89% total variance. Factor 1 showed impacts of Cl^{-}, NO_3^{-}, HCO_3^{-}, and Na^{+}, which can be attributed to marine contribution, NO_3^{-} can be from industrial and agricultural activities and metabolic process in the soil. Factor 2 showed influence from Mg^{2+} and Ca^{2+} due to limestone quarry, construction activity and dust re-suspension from weathering processes.

Factor 3 showed SO_4^{2-}, NO_2^{-} and NH_4^{+} which could be from metabolic process, industrial emissions. Factor 4 showed impact of PO_4^{3-} from industrial and agricultural activities, which can impacts on dissolved oxygen by eutrophication process.

Table 4a. Factor analysis (rotated varimax) of ionic species across sampling surfaces.

Component	**Ambient**			**Zinc Roof**			**Aluminium Roof**	
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2
$\mathbf{Cl^-}$			0.95			0.82	0.72	
$\mathbf{SO_4^{2-}}$		0.72				0.97	0.94	
$\mathbf{NO_3^-}$			0.96	0.89				0.95
$\mathbf{NO_2^-}$				0.84				0.98
$\mathbf{PO_4^{3-}}$	0.98					0.71	0.99	
$\mathbf{HCO_3^-}$	0.89					0.90	0.99	
$\mathbf{Na^+}$		0.82		0.76			0.88	
$\mathbf{K^+}$		0.97		0.87				0.85
$\mathbf{Mg^{2+}}$		0.78		0.97				0.99
$\mathbf{Ca^{2+}}$		0.97			0.99		0.79	
$\mathbf{NH_4^+}$			0.73	0.87				0.99
$\mathbf{Al^{3+}}$	0.97				0.99		0.91	
Eigenvalue	4.66	3.97	3.37	4.95	3.87	3.18	5.81	5.77
Variance (%)	41.51	35.13	12.15	26.37	32.83	28.38	52.68	33.81
Cumulative (%)	41.51	76.64	88.79	26.37	59.20	87.58	52.68	86.49

Table 4b. Factor analysis (rotated varimax) of ionic species across sampling surfaces.

Component	**Asbestos Roof**			**Stone-coated Roof**			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 4
$\mathbf{Cl^-}$	0.86			0.99			
$\mathbf{SO_4^{2-}}$	0.74					0.98	

NO_3^-		0.82		0.92			
NO_2^-		0.93				0.94	
PO_4^{3-}			0.95				0.91
HCO_3^-	0.89			0.99			
Na^+			-0.94	0.96			
K^+		0.90					
Mg^{2+}					0.99		
Ca^{2+}	0.93				0.99		
NH_4^+		0.79				0.80	
Al^{3+}		0.79					
Eigenvalue	4.30	4.15	3.55	4.57	2.3	3.38	1.36
Variance (%)	39.02	18.36	32.19	21.88	16.63	16.82	10.56
Cumulative (%)	39.02	57.38	89.57	21.88	38.51	55.33	65.89

4. CONCLUSION

The study has assessed the impact of ions on pH potential of rainwater quality by a number of variables in selected locations in Rivers State. The pH range of rainwater ranged from 6.20 – 7.02 with gradual increased over sampling period. The analysed ions indicate the influence of anions to cations on acid deposition at the across different roofing surfaces.

The application of factor analysis shows that industrial emission, agricultural activities, microbial influence with marine contribution from transport activities plays an important role in neutralizing acidity to alkalinity from contributing ionic species in rainfall event. Therefore, rainwater across different sampling surfaces is fit for drinking but special care must be taken into consideration.

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