Correlation Matrix Between Soil Structural and Chemical Properties as Influenced by Rainfall Patterns in Akwa Ibom State.

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ABSTRACT

This study evaluated the correlation between soil structural indices and soil chemical properties as influenced by rainfall patterns in selected flood-prone areas of Akwa Ibom State, Nigeria. The study was conducted in four locations representing upland and coastal environments namely, Uyo, Eket, Eastern Obolo and Ikot Ekpene. Soil samples were collected at two depths of 0-15cm and 15-30cm and analyzed for selected structural properties such as moisture content (MC), infiltration rate (IR), dispersion ratio (DR) and water stable aggregates (WSA) as well as chemical properties such as soil pH, organic carbon (OC), organic matter (OM), total nitrogen (TN), available phosphorus (Av. P), exchangeable bases, exchangeable acidity (EA), effective cation exchange capacity (ECEC) and base saturation (Bs). Correlation analysis was performed using IBM SPSS. The results showed a strong positive relationship between infiltration rate and organic carbon in Uyo (r= 0.992**), Eket (r= 0.975*), Eastern Obolo (r = 0.473) and Ikot Ekpene (r = 0.404), indicating that increased organic matter improved water movement and soil aggregation. Water stable aggregates (WSA) showed strong positive correlations with total exchangeable bases (TEB) in Uyo (r= 1.000**), Eastern Obolo (r = 0.181) and Ikot Ekpene (r= 0.942) but correlated negatively (r = -0.922) in Eket. Dispersion ratio (DR) shows a negative correlation with organic matter (OM) in Eastern Obolo (r= -0.995**) and Ikot Ekpene (r= -0.927), indicating improved aggregate stability with increased organic matter. Exchangeable acidity (EA) negatively correlated with WSA in Eastern Obolo (r= -0.907) and infiltration rate in Uyo (r= -0.993**), indicating that increasing acidity weakened soil structure under intense rainfall conditions. High rainfall intensity increased soil acidity and nutrient leaching, particularly in coastal locations. It is hereby recommended that sustainable soil management practices that enhance organic matter accumulation and nutrient retention are therefore essential for maintaining soil productivity in Akwa Ibom State.

Keywords: Moisture content, Infiltration rate, organic matter, soil structural and chemical properties, rainfall

INTRODUCTION

Rainfall is one of the major climatic factors controlling soil development and degradation processes in Nigeria. The high intensity rainfall commonly experienced in Akwa Ibom State accelerates aggregate breakdown, nutrient losses, surface sealing and soil erosion, thereby altering both soil structural and chemical properties. (Ibanga *et al.*, 2025). Excessive rainfall promotes the leaching of exchangeable bases such as calcium, magnesium, potassium and sodium resulting in increased soil acidity which is typical of highly weathered tropical soils (Essien *et al.*, 2025). Recent studies have emphasized the importance of evaluating soil structural stability alongside chemical fertility indicators for sustainable management in tropical agroecosystems (Edet *et al.*, 2025). The current climate change phenomenon has necessitated scientific investigations into the effects of hydroclimatic variations on soils (De Jager *et al.*, 2012). The occurrence of soil flooding can be attributed to the retardation of water infiltration after the formation of the

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impermeable soil crust in the relatively lower furrow, and by reduction of RAC (Rainfall Acceptable Capacity) due to the rising of water table and heavy rainfall (Yong *et al*., 2011). The quantity of flooding, in turn, depends on the intensity of rainfall, flood volume, and geological conditions of the watershed (Cheng *et al*., 2020). Rainfall is highly variable over a variety of time and space scales and large areas of the earth experience wide variability as part of a "normal" climate. However, largely due to the current climate change, rainfall in many places have shown distributions that are far from the expected or normal. Hence, understanding the correlation matrix between soil structural and chemical properties as affected by rainfall is essential for developing effective conservation strategies, improving soil productivity and promoting environmental sustainability in Akwa Ibom State.

MATERIALS AND METHODS

Location of the Study Area

The study was conducted in Akwa Ibom State in four (4) different locations; Two each from upland and coastal areas; i.e. coastal areas (Eket, Eastern Obolo) and upland areas (Uyo and Ikot Ekpene), as shown in Fig. 1. Akwa Ibom State lies in the coastal plain of South Eastern Nigeria, where sediments are supplied by Cross River, Qua Iboe River, Imo River and Gulf of Guinea. Generally, landscape of the state comprises of a low-lying plain and riverine area, with elevation of 185.32 meters above sea level (AKSMLS, 2009). Akwa Ibom State lies between latitude 04^{0}56'23.06"N and longitude 07^{0}52'09.71"E. The State is bordered on the East by Cross River State, on the North and Northwest by Abia State, on the Southwest by Rivers State and on the South by the Atlantic Ocean (AKSMLS, 2009).

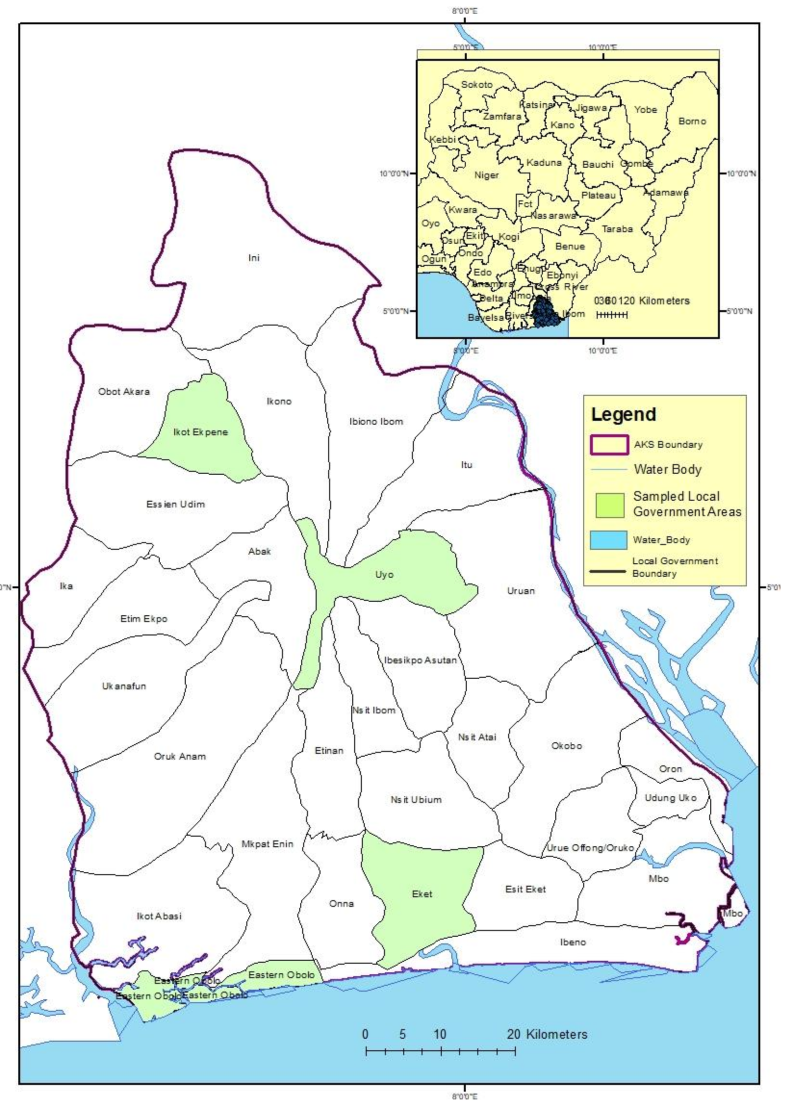

Fig. 1: A Map of Akwa Ibom State showing locations of the Study Area

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Climate of the Study Area

Akwa Ibom State has a humid tropical climate, characterized by distinct wet and dry seasons. In the South and Central parts of the State (nearer the coast), wet season lasts for about 10 -11 months (February/March – mid November), but towards the far north, it reduces to about nine months (i.e. March - October). The dry season =begins in mid – November and ends in February or March (Petters *et al*., 1989). Annual rainfall amount varies from 3,200 mm along the coast to 2,250 mm in the northern fringe. Temperature values are relatively high in Akwa Ibom State throughout the year with mean annual values varying between 26 and 280C. The months with highest temperatures include February and March (the period just before heavy rains), while July – September have lowest temperatures (when heavy rains and cloud cover reduces insulation reaching the surface (NiMet, 2018). Also, relative humidity remains at average of 70 – 80 percent throughout the year. Average sunshine circulates to 1,450 hours per year and the annual evaporation rate range from 1,500 – 1800 mm (Ekpeyong, 2013).

Field Methods

Four (4) flood prone location was identified and samples were collected on a dry soil of the flooded site using soil auger in each location at 4 different points (Control, Upper, Middle and Lower) each for Oku (Uyo), Ikot Ibiok (Eket), Emeroke (Eastern Obolo), and Ikot Udoma (Ikot Ekpene) across the State. Disturbed and undisturbed samples was collected for physical and chemical laboratory analysis.

Climate Data collection

A reconnaissance survey was carried out in Akwa Ibom State in order to familiarize the researcher with the communities that always experience flooding. Mean monthly rainfall data from the State Meteorological Stations between 1995-2024 was collected. The data was grouped into decades, such as D1 (1995-2004), D2 (2005-2014), and D3 (2015-2024).

To test for normality of the time series data, Microsoft Excel was used to calculate for the following: maximum, minimum, mean, standard deviation, coefficient of variation, standard coefficient of skewness (Z_1) and the standard coefficient of kurtosis (Z_2).

Sample size

Samples were collected at four (4) different points at each location each of the following flood prone areas (Eket, Eastern Obolo, Uyo, Ikot Ekpene) of Akwa Ibom State giving 12 samples in each depth and 24 in each location and a total of 96 samples

Soil Data Collection

Samples were collected using soil auger at a depth of 0-15cm and 15-30cm at four different points at the same location. Soil samples was properly labelled and taken to the laboratory for analysis.

Laboratory Procedures

Disturbed and undisturbed soil samples were collected from the experimental field air dried, sieved with 2mm mesh, and used to determine some properties of the soil as described by Udo *et al.,* (2009). Gravimetric moisture content was determined by Cater method (1993). A cylinder (flooding) infiltrometer described by Hills (1970) was used to determine infiltration rate. Dispersion ratio was determined by dividing the suspension percentage by the total percentage of silt and clay of the soil and multiplying by 100 (Middleton, 1980). The stability of aggregates to water or percent wet aggregate stability (%WSA) was determined with the 0.25mm sieve (Nimmo and Perkins, 2002). Soil pH was determined in a 1:2.5 soil: water ratio with a pH meter. Organic carbon was determined by the Walkley Black Dichromate Oxidation Method. Organic matter was obtained by multiplying %OC values with a factor of 1.72. Total nitrogen (N) was determined by the microkjeldahl method. Available phosphorous (P) was extracted by the Bray 1 extraction method, and the content of P was determined colorimetrically using a TechnicoAAll auto analyzer. Exchangeable bases K, Na, Ca, and Mg) were extracted with O. I. N ammonium acetate; K and Na were read with a flame photometer while Ca and Mg were determined through the EDTA titration method. Exchangeable acidity was determined by leaching the soils with I N KCl and titrating the aliquots with 0.01 NaOH. Effective cation exchange capacity (ECEC) was calculated as the sum of exchangeable bases and exchangeable acidity. Base saturation was calculated by dividing the sum of exchangeable bases by ECEC and multiplying by 100.

Statistical Analysis

Correlation analysis on the relationship between the soil structural and chemical properties were carried out using IBM SPSS 12th Edition.

Summary of Descriptive Statistics of a 30 years (1994-2024) monthly Rainfall Data of the Study Area

Table 1 shows the descriptive statistical analysis of monthly rainfall data for Uyo, Eket, Ikot Ekpene and Eastern Obolo over a 30 years period. The parameters analyzed includes, mean rainfall, standard deviation (STD) and coefficient of variation (CV). These statistical indices provide insight into rainfall variability, distribution patterns, and climatic stability within the study area.

For Uyo, the mean monthly rainfall ranged from 20.08mm in January to 322.00mm in September, confirming the dominance of the rainy season between March and October. The standard deviation values were generally high during the peak rainy months, especially June (165.13) and September (135.81), indicating substantial interannual rainfall variability. High rainfall variability is often associated with climate instability and changing atmospheric circulation patterns (Trenberth *et al.*, 2022). The coefficient of variation (CV) ranged from 0.20 in January to 0.77 in December. According to Hare (2020), CV values above 0.30 indicate high variability, suggesting that rainfall in Uyo is highly inconsistent during several months of the year. The skewness values were predominantly positive, indicating that rainfall distributions were skewed toward extremely wet events. December showed a very high skewness value (5.24), implying occasional extreme rainfall occurrences during the normally dry season. Similarly, the kurtosis value of 28.18 in December indicates a leptokurtic distribution characterized by extreme rainfall outliers and high rainfall concentration.

In Eket, the rainfall statistics showed relatively higher mean rainfall values compared to Uyo, with August (414.70mm) and September (411.14mm) recording the highest means. The coefficient of variation ranged from 0.13 to 0.50, indicating moderate rainfall variability. Lower CV values observed in July and August suggest relatively stable rainfall during the peak wet season. Stable rainfall conditions are common in coastal humid regions due to persistent moisture availability from the Atlantic Ocean (Ayoade, 2021). The skewness values in Eket were generally low, indicating near-normal rainfall distribution in most months. Negative skewness observed in January (-1.40) suggests that rainfall distribution was dominated by lower rainfall events. Kurtosis values were mostly negative or close to zero, indicating playkurtic rainfall distributions with fewer extreme rainfall events compared to Uyo.

Ikot Ekpene exhibited high rainfall variability with CV values ranging from 0.10 to 0.56. the highest variability occurred in November (0.56), suggesting unpredictable rainfall conditions during the transition from wet to dry season. The high standard deviations recorded during recorded during June (136.25) and August (128.28) indicate considerable fluctuations in rainfall amounts over the years. . Positive skewness values in most months indicate the dominance of extreme rainfall events and occasional heavy storms, which may increase flood risks and soil erosion (IPCC, 2021). The kurtosis values were mostly positive, indicating peaked rainfall distribution and concentration of rainfall around the mean. Such rainfall characteristics are often linked to convective storm activity in tropical environments (Nicholson, 2018).

Eastern Obolo showed consistently high rainfall means, especially from June to September, with August recording 385.08mm. the coefficient of variation values were generally moderate, ranging from 0.17 to 0.48, suggesting relatively stable rainfall patterns despite the high rainfall stable rainfall patterns despite the high rainfall totals. The positive skewness values in most months indicate the occurrence of heavy rainfall episodes. December recorded a skewness value of 1.49 and kurtosis value of 5.82, suggesting occasional intense rainfall events during the dry season. Coastal regions are increasingly experiencing rainfall extremes due to warming sea surface temperatures and enhanced atmospheric moisture content (WMO, 2023).

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Table 1: Summary of Descriptive Statistics of a 30 years (1995-2024) monthly Rainfall Data of the Study Area (Uyo, Eket, Ikot Ekpene and Eastern Obolo)

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN
Uyo													
Maximum	28.06	74.31	288.10	338.60	429.60	656.30	546.30	593.80	593.80	359.08	316.50	134.30	363.23
Minimum	10.08	32.08	118.09	118.27	118.97	89.07	116.13	118.38	118.38	112.16	82.00	18.16	87.65
Mean	20.08	43.07	149.49	196.56	240.61	235.54	273.68	284.21	322.00	228.60	164.66	26.50	182.08
STD	4.01	11.02	40.30	72.93	92.20	165.13	132.16	120.10	135.81	70.79	53.68	20.30	76.54
CV	0.20	0.26	0.27	0.37	0.38	0.70	0.48	0.42	0.42	0.31	0.33	0.77	0.41
skewness	0.18	1.70	2.35	0.70	0.44	1.41	0.64	1.11	0.26	-0.22	1.01	5.24	1.24
Kurtosis	0.46	2.32	5.08	-0.70	-0.52	0.70	-0.76	1.06	-0.85	-1.12	0.80	28.18	2.89
Eket													
Maximum	24.08	89.47	381.10	425.16	418.48	483.10	518.76	522.18	541.29	522.89	218.21	30.47	347.93
Minimum	10.42	22.84	112.25	114.23	113.48	112.49	178.38	316.67	220.97	114.03	112.43	18.15	120.53
Mean	19.98	52.58	184.58	236.79	250.41	262.79	365.52	414.70	411.14	312.66	162.87	21.76	224.65
STD	2.62	16.70	63.72	117.72	84.21	108.14	77.10	66.33	90.47	124.90	40.73	3.82	66.37
CV	0.13	0.32	0.35	0.50	0.34	0.41	0.21	0.16	0.22	0.40	0.25	0.18	0.29
skewness	-1.40	0.06	1.15	0.52	-0.16	0.26	-0.35	0.03	-0.27	0.16	-0.04	1.18	0.10
Kurtosis	4.95	-0.55	1.94	-1.29	-0.81	-0.96	0.15	-0.62	-1.06	-0.96	-1.71	0.06	-0.07
Ikot Ekpene													
Maximum	21.57	62.85	311.19	424.67	476.08	612.48	488.94	623.28	438.48	482.82	322.49	21.06	357.16
Minimum	12.01	16.71	89.14	89.03	104.48	103.44	117.83	119.20	114.62	112.83	36.27	14.03	77.47
Mean	17.02	34.25	149.86	203.21	216.21	250.81	283.54	332.24	257.00	275.54	114.99	18.26	179.41
STD	1.99	12.47	53.24	99.57	97.76	136.25	104.94	128.28	89.99	102.86	64.34	1.85	74.46
CV	0.12	0.36	0.36	0.49	0.45	0.54	0.37	0.39	0.35	0.37	0.56	0.10	0.37
skewness	-0.53	0.34	1.20	0.98	1.09	1.31	0.34	0.28	0.68	0.32	1.22	-0.89	0.53
Kurtosis	0.47	-0.65	1.13	0.02	1.14	0.96	-0.49	-0.65	-0.22	-0.96	2.37	0.57	0.31
Eastern Obolo													
Maximum	29.91	54.01	310.35	422.41	447.27	631.34	628.47	622.38	611.87	513.29	217.34	30.33	376.58
Minimum	16.18	20.31	110.29	116.73	111.39	115.71	117.02	188.42	124.26	116.18	38.14	12.04	90.56
Mean	21.18	39.17	179.38	248.86	255.23	358.14	358.54	385.08	346.52	288.94	138.56	18.82	219.87
STD	3.56	8.50	55.83	85.37	122.50	127.71	130.22	105.04	111.82	109.93	52.45	3.13	76.34
CV	0.17	0.22	0.31	0.34	0.48	0.36	0.36	0.27	0.32	0.38	0.38	0.17	0.31
skewness	0.95	-0.24	0.02	0.23	0.33	0.40	0.40	0.41	0.21	0.13	0.26	1.49	0.38
Kurtosis	0.24	0.07	-0.98	-0.66	-1.36	-0.28	-0.47	0.15	-0.20	-0.86	-0.67	5.82	0.07

Correlation matrix between soil structural indices and soil chemical properties as affected by rainfall patterns in Uyo, Eket, Eastern Obolo and Ikot Ekpene

In Uyo, the result shows that Infiltration rate (IR) showed strong positive relationships with OC (r = 0.992**), OM (r = 0.983*), Ca (r = 0.993**), TEB (r = 0.642), and base saturation (BS) (r = 0.913). This implies that higher concentrations of organic matter and exchangeable bases promoted aggregate formation and reduced structural degradation. Organic matter contributes to soil aggregation through microbial polysaccharides and humic substances that bind soil particles together (Sani *et al*., 2025). Dispersion ratio (DR) exhibited strong negative relationships with OC (r = -0.867), OM (r = -0.851), Ca (r = -0.985), and WSA (r = -0.439), indicating that soils rich in organic matter and divalent cations were less dispersive and structurally more stable. This agrees with findings by Nweke and Nnabude (2015), who reported that increased exchangeable calcium and magnesium reduced clay dispersion and enhanced soil aggregation in southeastern Nigerian soils. Water stable aggregates (WSA) correlated negatively with TN (r = - 0.949), Mg (r = -0.970*), and ECEC (r = -0.998*), while showing a positive correlation with TEB (r = 1.000**). The correlation value of (r = 1.000**) indicate that there is a perfect positive relationship between water stable aggregates and total exchangeable bases. Hence increase in water stable aggregates increases total exchangeable bases. This demonstrates that nutrient retention and exchangeable bases are critical determinants of aggregate stability in humid tropical soils. The presence of calcium and magnesium improves flocculation, thereby enhancing stable aggregate formation and reducing erosion risk under intense rainfall (Igwe *et al.,* 1999).

In Eket, moisture content (MC) showed a strong positive relationship with infiltration rate (IR) (r = 0.999**) and WSA (r = 0.862), but negative correlations with OC (r = -0.935*), OM (r = -0.938*), Mg (r = -0.962*), and TEB (r = -0.598). This suggests that increasing organic matter and exchangeable bases reduced soil structural instability and improved aggregation. Organic matter acts as a binding agent that improves aggregate cohesion and reduces susceptibility to erosion (Sani *et al*., 2025). Infiltration rate (IR) correlated positively with OC (r = 0.975*), OM (r = 0.994**), Mg (r = 0.980*), and K (r = 0.995**). This indicates that soils rich in organic constituents and basic cations exhibited stronger structural development. Similar findings were reported by Edem (2013), who observed that organic matter and exchangeable bases significantly improved aggregate stability and crop productivity in southeastern Nigerian Ultisols. Water stable aggregates (WSA) correlated positively with TN (r = 0.962*), Mg (r = 0.961*), and BS (r = 0.993*), indicating that nutrient-rich soils possessed better aggregation and structural resistance. Stable aggregates improve infiltration, aeration, and resistance to raindrop impact, which are critical in humid tropical environments (Agim *et al*., 2026).

In Eastern Obolo, the results show that the strong positive relationship between MC and soil pH (r = 0.999**) indicates that wetter conditions may have moderated soil acidity through enhanced nutrient dissolution and ion mobility. However, IR had a strong positive relationship with magnesium (Mg) (r = 0.984*) and potassium (K) (r = 0.646), suggesting that exchangeable basic cations improved pore continuity and enhanced water movement within the soil matrix. Dispersion ratio (DR) showed strong negative correlations with organic carbon (OC) (-0.989*) and organic matter (OM) (-0.995**). This implies that higher organic matter content reduced soil dispersion and enhanced aggregate stability. Organic matter acts as a binding agent that promotes microaggregate formation and protects soil particles from disintegration under intense rainfall conditions. This agrees with findings of Agim *et al*., (2026), who reported that organic amendments significantly improved structural stability and reduced susceptibility to deformation in degraded Ultisols of southeastern Nigeria. Similarly, Igwe (2004) reported that soils with higher organic carbon content exhibited lower dispersion and better structural resilience. Water stable aggregates (WSA) correlated positively with available phosphorus (Av.P) (r = 0.996**) and soil pH (r = 0.995**), indicating that stable aggregates improved nutrient retention and availability. Stable soil aggregates protect nutrients against leaching and erosion losses during heavy rainfall. This observation agrees with studies showing that aggregate stability enhances nutrient conservation and improves soil fertility in highly weathered tropical soils. Base saturation (BS) showed positive relationships with WSA (0.729), pH (0.659), and Ca (0.825), suggesting that soils with higher base saturation possessed better structural conditions and nutrient balance. Higher BS reflects increased availability of basic cations which enhance aggregate stability and reduce dispersion. This agrees with findings that base-rich soils generally exhibit improved physical resilience and better resistance to rainfall-induced degradation in tropical environments.

In Ikot Ekpene, Moisture content (MC) showed strong positive correlations with dispersion ratio (DR) (r = 0.914), water stable aggregates (WSA) (r = 0.860), organic carbon (OC) (r = 1.000**), and base saturation (BS) (r = 0.994**). These relationships suggest that increased moisture enhanced organic matter decomposition and aggregate stabilization. Soil moisture is important in promoting microbial activities and improving aggregation through the formation of organo-mineral complexes. Infiltration rate (IR) had strong negative correlations with DR (-0.756), WSA (-0.828), and pH (-0.830), indicating that rainfall-induced surface sealing and compaction reduced infiltration and destabilized soil structure. However, IR correlated positively with TN (0.891), Mg (0.968*), and Na (0.926), suggesting that soils with better nutrient status maintained improved pore continuity and water transmission. Igwe *et al*., (2013) reported that infiltration characteristics in southeastern Nigerian soils are strongly influenced by exchangeable cations and aggregate stability. Water stable aggregates (WSA) correlated positively with Ca (0.893), TEB (0.942), ECEC (0.865), and BS (0.910), this demonstrates critical role of exchangeable bases in aggregate stabilization. Calcium and magnesium facilitate flocculation and strengthen inter-particle bonding, leading to improved structural stability. Effective cation exchange capacity (ECEC) exhibited strong positive relationships with DR (0.900), WSA (0.865), and Ca (0.998**), confirming that soils with higher exchange capacity possessed greater aggregate stability and nutrient retention. Base saturation (BS) showed strong positive correlations with MC (0.994**), DR (0.952*), and WSA (0.910), indicating that soils with higher base saturation maintained better structural quality under rainfall conditions.

Table 2: Correlation matrix between soil structural indices and soil chemical properties as affected by rainfall in Uyo

	MC	IR	DR	WSA	**pH**	**OC**	**OM**	**TN**	**AV.P**	**Ca**	**Mg**	**K**	**Na**	**TEB**	**EA**	**ECEC**	**Bs**
MC	1																
IR	-0.677	1															
DR	0.462	-0.920	1														
WSA	1.000**	-0.656	0.439	1													
pH	0.021	-0.750	0.827	-0.008	1												
OC	-0.747	0.992**	-0.867	-0.728	-0.678	1											
OM	-0.796	0.983*	-0.851	-0.778	-0.621	0.997**	1										
TN	-0.940	0.405	-0.132	-0.949	0.293	0.503	0.564	1									
Av.P	-0.527	-0.268	0.454	-0.552	0.838	-0.168	-0.093	0.763	1								
Ca	-0.761	0.993**	-0.885	-0.742	-0.665	0.998**	0.998**	0.511	-0.150	1							
Mg	-0.962*	0.452	-0.218	-0.970*	0.251	0.540	0.602	0.992**	0.739	0.556	1						
K	-0.593	-0.189	0.372	-0.616	0.791	-0.091	-0.015	0.805	0.996**	-0.070	0.789	1					
Na	0.479	0.270	-0.333	0.504	-0.805	0.200	0.122	-0.662	-0.943	0.161	-0.678	-0.951*	1				
TEB	-0.999**	0.642	-0.420	1.000**	0.026	0.715	0.767	0.955*	0.567	0.729	0.974*	0.631	-0.516	1			
EA	0.587	-0.993**	0.937	0.564	0.822	-0.974*	-0.956*	-0.298	0.378	-0.972*	-0.345	0.302	-0.375	-0.548	1		
ECEC	-0.983*	0.531	-0.307	-0.988*	0.162	0.613	0.671	0.980*	0.674	0.629	0.996**	0.731	-0.623	0.991**	-0.429	1	
Bs	-0.912	0.919	-0.758	-0.900	-0.429	0.953*	0.674*	0.729	0.133	0.960*	0.767	0.212	-0.105	0.892	-0.867	0.822	1

MC=Moisture Content, IR=Infiltration Rate, DR=Dispersion Ratio, WSA=Water Stable Aggregate, OC= Organic Carbon, OM= Organic matter, EC= Electrical conductivity, TN= Total nitrogen, Av. P= Available Phosphorus, K= Potassium, Ca= Calcium, Mg=Magnesium, Na= Sodium, EA= Exchangeable Acidity, TEB=Total Exchangeable Bases, EA=Exchangeable Acidity, ECEC= Effective Cation Exchange Capacity, BS= Base saturation.

Table 3: Correlation matrix between soil structural indices and soil chemical properties as affected by rainfall in Eket

	MC	IR	DR	WSA	**pH**	**OC**	**OM**	**TN**	**AV.P**	**Ca**	**Mg**	**K**	**Na**	**TEB**	**EA**	**ECEC**	**Bs**
MC	1																
IR	-0.999**	1															
DR	0.714	-0.745	1														
WSA	0.862	-0.886	0.927	1													
pH	-0.030	-0.020	0.570	0.479	1												
OC	-0.985*	0.975*	-0.607	-0.763	0.201	1											
OM	-0.988*	0.994**	-0.814	-0.923	-0.107	0.951*	1										
TN	-0.747	0.778	-0.870	-0.969*	-0.629	0.622	0.818	1									
Av.P	0.186	-0.136	-0.471	-0.338	-0.986*	-0.350	-0.044	0.492	1								

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Ca	-0.418	0.463	-0.857	-0.821	-0.894	0.257	0.541	0.895	0.815	1							
Mg	-0.969*	0.980*	-0.845	-0.961*	-0.218	0.912	0.992**	0.883	0.064	0.630	1						
K	-0.994**	0.995**	-0.704	-0.879	-0.019	0.970*	0.982*	0.787	-0.142	0.455	0.974*	1					
Na	-0.152	0.111	0.577	0.275	0.768	0.273	0.000	-0.302	-0.816	-0.666	-0.052	0.174	1				
TEB	-0.598	0.637	-0.920	-0.922	-0.781	0.453	0.704	0.961*	0.677	0.978*	0.778	0.629	-0.553	1			
EA	-0.785	0.763	-0.453	-0.462	0.474	0.856	0.745	0.237	-0.560	-0.055	0.656	0.717	0.196	0.131	1		
ECEC	-0.595	0.635	-0.920	-0.920	-0.783	0.450	0.702	0.960*	0.679	0.979*	0.776	0.626	-0.554	1.000**	0.128	1	
Bs	-0.681	0.717	-0.938	-0.958*	-0.710	0.547	0.777	0.978*	0.593	0.950	0.841	0.708	-0.486	0.994**	0.227	0.994**	1

MC=Moisture Content, IR=Infiltration Rate, DR=Dispersion Ratio, WSA=Water Stable Aggregate, OC= Organic Carbon, OM= Organic matter, EC= Electrical conductivity, TN= Total nitrogen, Av. P= Available Phosphorus, K= Potassium, Ca= Calcium, Mg=Magnesium, Na= Sodium, EA= Exchangeable Acidity, TEB=Total Exchangeable Bases, EA=Exchangeable Acidity, ECEC= Effective Cation Exchange Capacity, BS= Base saturation.

Table 4: Correlation matrix between soil structural indices and soil chemical properties as affected by rainfall in Eastern Obolo

	MC	IR	DR	WSA	**pH**	**OC**	**OM**	**TN**	**AV. P**	**Ca**	**Mg**	**K**	**Na**	**TEB**	**EA**	**ECEC**	**Bs**
MC	1																
IR	-0.598	1															
DR	0.956*	-0.338	1														
WSA	0.990*	-0.706	0.905	1													
pH	0.999**	-0.635	0.942	0.995**	1												
OC	-0.989*	0.473	-0.989*	-0.958*	-0.981*	1											
OM	-0.980	0.427	-0.995**	-0.942	-0.970*	0.999**	1										
TN	-0.288	0.924	0.000	-0.419	-0.335	0.145	0.095	1									
Av.P	0.974*	-0.763	0.866	0.996**	0.984	-0.930	-0.910	-0.492	1								
Ca	0.073	-0.843	-0.222	0.214	0.119	0.076	0.127	-0.960*	0.295	1							
Mg	-0.731	0.984*	-0.500	-0.821	-0.762	0.622	0.581	0.853	-0.866	-0.734	1						
K	0.225	0.646	0.500	0.084	0.179	-0.367	-0.415	0.853	0.000	-0.955*	0.500	1					
Na	-0.643	-0.163	-0.816	-0.538	-0.604	0.738	0.765	-0.522	-0.471	0.641	0.000	-0.816	1				
TEB	0.039	-0.824	-0.255	0.181	0.085	0.110	0.161	-0.951*	0.263	0.999**	-0.710	-0.965*	0.661	1			
EA	-0.838	0.938	-0.642	-0.907	-0.863	0.748	0.713	0.758	-0.939	-0.605	0.985*	0.343	0.157	-0.577	1		
ECEC	-0.368	-0.525	-0.623	-0.232	-0.324	0.502	0.546	-0.770	-0.149	0.901	-0.365	-0.989*	0.878	0.915	-0.199	1	
Bs	0.623	-0.999**	0.368	0.728	0.659	-0.500	-0.455	-0.916	0.783	0.825	-0.989*	-0.621	0.138	0.805	-0.949	0.498	1

MC=Moisture Content, IR=Infiltration Rate, DR=Dispersion Ratio, WSA=Water Stable Aggregate, OC= Organic Carbon, OM= Organic matter, EC= Electrical conductivity, TN= Total nitrogen, Av. P= Available Phosphorus, K= Potassium, Ca= Calcium, Mg=Magnesium, Na= Sodium, EA= Exchangeable Acidity, TEB=Total Exchangeable Bases, EA=Exchangeable Acidity, ECEC=

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Effective Cation Exchange Capacity, BS= Base saturation.

Table 5: Correlation matrix between soil structural indices and soil chemical properties as affected by rainfall in Ikot Ekpene

	MC	IR	DR	WSA	**pH**	**OC**	**OM**	**TN**	**AV. P**	**Ca**	**Mg**	**K**	**Na**	**TEB**	**EA**	**ECEC**	**Bs**
MC	1																
IR	-0.425	1															
DR	0.914	-0.756	1														
WSA	0.860	-0.828	0.993**	1													
pH	-0.151	-0.830	0.264	0.375	1												
OC	1.000**	0.404	-0.904	0.848	0.173	1											
OM	-0.999**	0.455	-0.927	-0.877	0.116	0.998**	1										
TN	-0.751	0.891	-0.943	-0.968*	-0.518	0.736	0.776	1									
Av.P	-0.644	-0.419	-0.277	-0.163	0.853	0.661	0.617	0.000	1								
Ca	0.538	-0.992**	0.834	0.893	0.752	-0.519	-0.567	-0.937	0.299	1							
Mg	-0.635	0.968*	-0.893	-0.940	-0.665	0.617	0.660	0.954*	-0.182	-0.992**	1						
K	0.683	0.371	0.327	0.214	-0.825	-0.700	-0.657	-0.051	-0.999**	-0.248	0.130	1					
Na	-0.554	0.926	-0.816	-0.866	-0.682	0.537	0.587	0.962*	-0.226	-0.941	0.924	0.178	1				
TEB	0.639	-0.968*	0.896	0.942	0.664	-0.621	-0.665	-0.966*	0.178	0.992**	0.999**	-0.126	-0.941	1			
EA	-0.655	-0.405	-0.292	-0.178	0.843	0.672	0.629	0.023	0.999**	0.283	-0.168	-0.999**	-0.199	0.162	1		
ECEC	0.487	-0.997**	0.800	0.865	0.789	-0.467	-0.516	-0.914	0.355	0.998**	-0.983*	-0.305	-0.930	0.983*	0.341	1	
Bs	0.994**	-0.520	0.952*	0.910	-0.043	-0.991**	-0.997**	-0.815	-0.558	0.626	-0.714	0.600	-0.634	0.718	-0.570	0.578	1

MC=Moisture Content, IR=Infiltration Rate, DR=Dispersion Ratio, WSA=Water Stable Aggregate, OC= Organic Carbon, OM= Organic matter, EC= Electrical conductivity, TN= Total nitrogen, Av. P= Available Phosphorus, K= Potassium, Ca= Calcium, Mg=Magnesium, Na= Sodium, EA= Exchangeable Acidity, TEB=Total Exchangeable Bases, EA=Exchangeable Acidity, ECEC= Effective Cation Exchange Capacity, BS= Base saturation.

CONCLUSION AND RECOMMENDATIONS

The study shows that rainfall patterns significantly influenced the relationships between soil structural indices and soil chemical properties across the selected locations in Akwa Ibom State. Coastal areas subjected to intense rainfall experienced greater nutrient leaching, acidity and structural degradation compared to upland locations.

It is hereby recommended that conservation practices such as mulching, cover cropping, reduced tillage, integrated soil fertility management should be adopted to minimize erosion and structural degradation caused by rainfall.

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