VARIABILITY IN PERSISTENT ORGANIC CARBON POOLS AND ITS RELATIONSHIP WITH SOIL PROPERTIES ON TWO PARENT MATERIALS IN AKWA IBOM STATE, NIGERIA.

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Abstract

Organic matter fractionation revealed different pools of organic carbon sequestration in the soil. Investigation of organic matter pools are important for proper management of soil fertility and stability of soil aggregate. Research was carried out on variability in persistence of organic matter pools and is relationship with soil properties on two parent materials (sandstone/shale and coastal plain sand) in Akwa Ibom State, Nigeria. Soil samples were collected in eighteen locations in each of the parent material giving a total of thirty-six soil samples and were analysed for physical and chemical properties of the soil. Data generated were fitted into empirical models for computation of physical and chemical properties, and organic matter fractions. The result indicates that sand fraction dominant particle size distribution in the two parent materials. Furthermore, among the two parent materials, sandstone/shale had the least mean value in humins and humic acid while coastal plain sand had the least mean value in fulvic acid. Correlation analysis for sandstone/shale parent material shows that total sand correlated positively with humins (0.479) and humic acid (0.536*). Bulk density correlated negatively with total porosity (-0.999*), while hydraulic conductivity correlated positively with potassium (0.516*) and sodium (0.508*). pH correlated negatively with exchangeable acidity (-0.498*). The results for coastal plain sand parent material shows that clay was correlated negatively with calcium (-0.442*) and positively with humins (0.404*), while humins correlated positively with humic acid (0.466*) and fulvic acid (0.903**). pH negatively correlated with calcium (-0.413*). This could be used to develop management frame work practices in the studied soils that would improve soil health*

Keywords: Humins acid, humic acid, fulvic acid, soil properties, sandstone shale, coastal plain sand.

Introduction

Soil organic matter is a complex, heterogeneous and dynamic mixture of organic substances that varies in C and N content, molecular structure, decomposition rate and turn over time (Oades, 1988; Essien *et al*., 2024a). According to Jenkinson (1999); Essien *et al*. (2019) it is considered to be composed of several discrete pools with a negative relationship between pool size and decomposition rate, the smaller pools decompose most rapidly. Chefetz *et al*. (2002); Sam *et al*. (2025a) viewed soil organic matter as consisting of series of substance ranging from undecomposed remains of plants and animals through their intermediate stages called humus. Ceccanti *et al*. (1978) viewed humus as a large undefinable quite variable molecule that is made up of mostly carbon and hydrogen, and is made up of 60 – 70% of the total organic carbon in the soil (Von Lutzow *et al*., 2007). A major source of soil organic matter is plant tissue. Animal residue is secondary source of soil organic matter. According to Donahue *et al.* (1990) total residues produced, crop residue account for about 70 %, animal manure about 23 %, logging and wood manufacturing wastes about 5% and others less than 1 %. These latter consist of plant biopolymer residues materials (e. g polysaccharides, lignin, protein, fat and oil) (Stevenson, 1994). Humus is differentiated into humic and non humic substances. Non-humic substances are polysaccharides, polymer that have sugar-like structures, while humic substances are classified into three chemical groups, namely, fulvic acid, humic acid and humins substances, on the basis of solubility (Donahue *et al.*, 1990). Humic substances are relatively stable in the soil. Because of their complexity and most resistant to microbial attack (decomposes slowly) and are measured in centuries (10 – 50) years. During decomposition of humic, intermolecular bond between phenylproponoid compounds of the humic are severed and oxidized, and phenolic derivatives are released (Stevenson, 1994). Humic fractions maintain soil organic matter levels, and protect associated nitrogen, and other essential nutrients against rapid mineralization and loss from the soil.

Soil organic matter is an indicator of soil quality (Lal, 1997; Essien *et al.*, 2024b). It strongly affects soil properties such as infiltration, water-holding capacity, nutrient cycling, Erodibility and pesticide absorption (Ogban and Essien, 2016; Ogban *et al.*, 2022; Ibanga *et al.*, 2025a). It helps to form good soil structure, provides good aeration, and also acts as binding agent (Wu *et al.*, 1990; Essien *et al.*, 2022; Ibanga *et al.*, 2025b). It also enhances the protection of both anions and cations against leaching and accounts for 50 – 90 % of the water and nutrient adsorbing power of soils (Six *et al.*, 2004; Essien *et al.*, 2025a; Essien *et al.*, 2024c)

Soil organic matter content has declined in sandstone/shale and coastal plain sand soils of Akwa Ibom State, Nigeria, due to erosion menace. However, understanding organic matter fractions as sources of soil stability are necessary in developing frame work that would guide the management practices of the soil. Therefore, there is need to evaluate persistence organic matter pools impact and its relationship with soil properties on two parent materials in Akwa Ibom State, Nigeria.

Materials and Methods

Location of the Study Area

The study was conducted on soils formed on sandstone/shale and coastal plain sand parent materials in Akwa Ibom state, Nigeria. Akwa Ibom State is located between latitudes 4^{0}30' and 5^{0}30'N and longitudes 7^{0}27' and 8^{0}27'E. The sandstone/shale parent material situate between latitudes 5^{0}00' and 5^{0}27'N and longitudes 7^{0}27' and 8^{0}03'E and coastal plain sand located between latitudes 4^{0}40' and 5^{0}15'N and longitudes 7^{0}30' and 8^{0}15'E (Essien *et al.*, 2018). The state is characterized by dual seasons, the rainy season, which spans from the month of March through November and dry season which spans from the December through February, accompanied with harmattan. Rainfall varies from 2000 mm on the northern fringes to 3000 mm along the coast. Temperatures are uniformly high averaging 28^{0}C. Relative humidity averaged 95 % (Petters *et al.*, 1989), while evapotranspiration ranges from 4.11 to 4.95 mm, partly because of the high insulation and temperature (Enwezor *et al.*, 1990).

Akwa Ibom State is underlain by a sedimentary geological formation and is made up of the coastal plain sands, beach ridge, sand stone /shale and alluvium deposited. The state generally comprising of a low-lying plain with no portion exceeding 175 m above the sea level. The soil varies in texture from sand to loamy sand and mostly brownish in colour (Mark *et al.*, 2024). The soil has low water retention capacity (Essien *et al.*, 2025b) and low content of organic matter (Simeon and Essien, 2023; Akpan *et al.*, 2025). The coastal plain sands are derived from unconsolidated tertiary sand stones of the Ben formation which associated with shale and limestone (Petters *et al.*, 1989). Due to poor soil fertility in the area and subsequent increment of fertilizer used by farmer to restore the lost fertility, other means adopted by farmers in the remote area include, fallowing, crop rotation, mounding, ridging, slash and allow to decay (Essien *et al.*, 2023a; Essien *et al.*, 2023b).

Akwa Ibom State is located within the humid zone of Nigeria. The climate favours luxuriant tropical rainforest which has been almost completely replaced by secondary forest of predominantly raffia/oil palm forest, woody shrubs and various grass undergrowth. The predominant land use practices in the area includes forest plantation, tree crop plantation, swamp rice and intensive upland cultivation (Sam *et al.*, 2025b; Essien, *et al.*, 2025c), with a great variety of crops grown such as cassava, yam, maize, cocoyams (Akpan *et al.*, 2024). Common crops in the area include Telferia. Okra, pepper, melon, garden egg etc. (Petters *et al.*, 1989).

Field Methods

Soils samples were collected in eighteen location each, in two parent materials. These are; sandstone/shale parent material (Odoro Ikpe I, Odoro Ikpe II, Odoro Ikpe III, Ikpe Ikot Nkon I, Ikpe Ikot Nkon II, Ikpe Ikot Nkon III, Nna Enin Ikpe I, Nna Enin Ikpe II, Nna Enin Ikpe III, Itak Ikot Akpandem I, Itak Ikot Akpandem II, Itak Ikot Akpandem III, Nung Ukim I, Nung Ukim II, Nung Ukim III, Oduk I, Oduk II, Oduk and Oduk III) and Coastal plain sand parent material (Oruk Anam I, Oruk Anam II, Oruk Anam II, Oruk Anam III, Abak I, Abak II, Abak III, Etinan I, Etinan II, Etinan III, Mkpat I, Mkpat II, Mkpat III, Nsit Ibom I, Nsit Ibom II, Nsit III, Obot Akara I, Obot Akara II and Obot Akara III). At each sampling point three random soil samples were collected, bulked, bagged, labelled giving a total of 36 samples and stored for physical and chemical analyses. Core samples were collected using core cylinders measuring 7.5 cm long and 6.5 cm internal diameter. The core samples taken were for the determination of saturated hydraulic conductivity and bulk density.

Laboratory Analysis

The bulked samples were air – dried, crushed and sieved through a 2mm sieve for particle size distribution and some chemical analyses.

Physical Properties of the Studied Soil

Particle size analysis was determination using Bouyoucos Hydrometer method after dispersing the soil with sodium hexametaphosphate solution, as described by Dane and Topp (2002). The soil textural classes were determined using the textural triangle. Saturated hydraulic conductivity (K_{sat}) was determined using the laboratory constant head permeameter method as described by Dane and Topp (2002). The saturated hydraulic conductivity was calculated using the equation below:

$$K_{sat} = \frac{QL}{\Delta hAt}$$

Where;

K_{sat} = saturated hydraulic conductivity (cm/hr^{-1}), Q = discharge rate (cm^3), L = length of soil column (cm), Δh = change in hydraulic head (cm) (L + h) (L = length of soil containing cylinder, h = height of water above soil containing cylinder

A = cross – sectional area through which the flow takes place, t = time taken to collect Q (min)

Bulk density was determined by the method described by Dane and Topp (2002). Soil samples were oven – dried at a temperature of 105°C to a constant mass and bulk density was calculated using the equation below:

$$Lb = \frac{MS}{vt}$$

Where;

Lb = bulk density (Mgm^{-3}), Ms = dry soil mass (Kg), Vt = total volume of soil (m^{-3}); this was calculated from the internal dimensions of the cylinder. Total porosity was calculated from particle size and bulk density relationship as follows;

$$Tp = \left[1 - \left(\frac{Bd}{Pd} \right) \right] x\ 100$$

Where;
Tp = total porosity (m^{-3}/m^{-3}), Bd = Bulk density (Mgm^{-3}), Pd = particle density, which is assumed to be $2.65m^{-3}/m^{-3}$

Chemical Properties of the Studied Soil
Soil pH was determined using a glass electrode PH meter and INKCI at 1:2.5 soil water ratio (Udo *et al.,* (2009). Organic carbon was determined by Walkley and Black wet digestion method (Nelson and Sommers, 1996), which organic matter was obtained by multiplying the result from organic carbon with Van Bemmelen of 1.724. The amount of Potassium (K) and Sodium (Na) were determined using flame photometer with appropriate filters while magnesium (Mg) and Calcium (Ca) were determined by atomic absorption spectrometer (AAS) (Thomas, 1982). Effect cation exchangeable capacity (ECEC) was obtained by summation of exchangeable acidity and exchangeable bases (Udo *et al.,* 2009).

Base saturation was calculated by the summation of exchangeable basic cations divided by ECEC and multiplied by 100% (Udo *et al.,* 2009).

$$\%\ BS = \frac{TEB}{ECEC}$$

Where;
TEB = Total exchangeable bases, BS = Base Saturation, ECEC= Effective cation exchange capacity.

Exchangeable acidity was determined by titration using KCI extraction method (Peech *et al.,* 1962).

Cation exchange capacity was determined by the summation of all the exchangeable bases Mg, Ca, K and Na.

Organic Matter Fractionation
Organic matter fractionation was done with the method of Belchikova-Kononova with the modifications described in detail in Santos (1984). Soil samples were treated with o-phosphoric acid (2 mol L^{-1}) to separate the free fulvic acid fraction (FFA). Humic materials were then extracted by adding 100 mL of 0.1 mol L^{-1} NaOH + NaP_2O_7 to 10 g of soil subsamples. Air was displaced by N_2 from the flask was closed and then shaken for 24 h at room temperature. The dark-colored supernatant solution was separated from the residual soil by centrifugation at 3500 g for 30 min and decanting. Soil residue was resuspended in 50 mL of 0.1 mol L^{-1} NaOH + $Na_4P_2O_7$, then shaken for 4h. The solution was centrifuged again and the supernatant was added to the supernatant collected previously. The alkaline extraction solution containing dissolved humic acids (HA) and fulvic acids (FA) was acidified to pH 1 .0 with 6 mol L^{-1} HCI. After fractionation, the content of organic carbon in the soluble humified organic matter (FFA, FA and HA) and in the insoluble residues (humins) was determined by a Walkley Black procedure (Anderson and Ingram, 1996).
Humic acid (HA) extraction was performed with a 0.5 mol L^{-1} NaOH solution (1:10 soil/solvent ratio) under N_2 atmosphere. To improve the NMR-^{13}C spectra resolution, KCI was added to the extraction solution under continuous stirring to reach concentrations of 0.03 mol L^{-1}. After precipitation and further centrifugation, the residues were discarded. To isolate the HA, the system was then acidified with HCI 6 mol L^{-1} to pH 1. The redissolution and reprecipitation of the HA was repeated three times. The HA purification was performed by using a diluted mixture of HF – HCI solution and dialyzing against deionized water. Finally, the HA was dried by lyophilization.

Statistical Analysis
The data generated for physical and chemical properties of the soil were summarized using the mean, standard deviation and coefficient of variation using analysis of variance (ANOVA). Pearson correlation analysis was used to establish relationships between organic matter fractions and soil physical properties on coastal plain sand and sandstone/shale parent materials.

RESULTS AND DISCUSSION

Comparative Evaluation of Soil Physical Properties on Sandstone/Shale and Coastal Plain Sand Parent Material

The result of the physical properties of sandstone/shale and coastal plain sand parent materials are presented in Tables 1. The mean values of sand, silt and clay were 779.21 ± 174.54 gkg^{-1} (CV = 22.40 %), 71.56 ± 19.83 gkg^{-1} (CV = 27.71 %) and 105.33 ± 20.30 gkg^{-1} (CV = 19.27 %) for sandstone/shale parent material while the mean value of sand, silt and clay in coastal plain sand parent material were 845.61 ± 31.56 gkg^{-1} (CV = 3.73%), 46.78 ± 12.54 gkg^{-1} (CV = 26.80 %) and 102.56 gkg^{-1} (CV = 23.90 %). The result of sand, silt and clay (Tables 1), indicated that the dominant particle size fraction for sandstone/shale and coastal plain sand parent material was sand while the least size fraction was silt; which reflects the sandy nature of the parent materials on which the soil was formed (Mark *et al*., 2024; Ben *et al*., 2024). The result of bulk density mean values were 1.84 ± 0.18 mg m^{-3} (CV – 9.78 %) for sandstone/shale parent material and 1.50 mg m^{-3} (CV = 66.00 %) for coastal plain sand parent material, indicated the mean value of 1.50 mg m^{-3} in coastal plain sand while the highest mean value of 1.84 Mg m^{-3} in sandstone/shale parent material. The values of the bulk densities showed the mechanical resistance to root penetration, decrease in air filled porosity and permeability as observed by Eyong *et al.* (2008).

Total porosity mean values are 0.31 ± 0.07 m^3 m^{-3} (CV = 22.58 %) on sandstone/shale parent material and 0.43 ± 0.04 m^3 m^{-3} (CV = 9.30 %) for coastal plain sand parent material. This result indicated that sandstone/shale parent material had the least mean value while coastal plain sand parent material had the highest mean value. The variation in matrix pore space observed may...

Table 1: Soil Physical Properties on Sandstone/Shale and Coastal Plain Sand Parent M

Location	Ts	Si	Cl	Bd	Tp	Ksat
	gkg^{-1}	gkg^{-1}	gkg^{-1}	Mgm^{-3}	m^{3}m^{-3}	cmhr^{-1}
Sandstone/Shale Parent Material						
x	79.21	71.56	105.33	1.84	0.31	0.34
Std (±)	174.54	19.83	20.30	0.18	0.07	0.23
CV (%)	22.40	27.71	19.27	9.78	22.58	67.65
Coastal Plain Sand Parent Material						
x	845.61	46.78	102.56	1.50	0.43	0.46
Std (±)	31.56	12.54	24.51	0.99	0.04	0.26
CV (%)	3.73	26.80	23.90	66.00	9.30	56.52

Ts – Total sand, Si – silt, Cl – clay, Bd – bulk density, Tp – total porosity, Ksat – saturated hydraulic conductivity be trend to reverse in bulk density, and it is affected by particle-size distribution (Lal and Shukla, 2004). Saturated hydraulic conductivity (Ksat) averaged 0.34 ± 0.23 cm hr^{-1} (CV = 67.65 %) on sandstone/shale parent material and 0.46 ± 0.26 cm hr^{-1} (CV = 56.52 %) on coastal plain sand parent material. The result indicated that sandstone/shale parent material had moderate hydraulic conductivity while coastal plain sand parent material had high hydraulic conductivity.

Comparative Evaluation of Soil Chemical Properties on Sandstone/Shale and Coastal Plain Sand Parent Materials.

The results of soil chemical properties (Table 2) indicated that pH in sandstone/shale parent material recorded 3.23 ± o38 (11.76), while coastal plain sand parent material recorded 6.20 ± o.34 (5.48). The result shows that sandstone/shale parent material is more acidic than coastal plain sand, as observed by Myers (2010).

The organic matter mean value on sandstone/shale parent material had 2.32 ± 0.90 (38.79 %), while coastal plain sand parent material had 2.26 ± 1.40 (61.95 %), indicating that there is an average organic matter content related to particle size, as observed by Troeh *et al.* (2005). The mean value of total exchangeable bases was 17.45 cmol kg^{-1} for sandstone/shale parent material and 6.55 cmol kg^{-1} for coastal plain sand parent material. The result indicated that coastal plain sand had the least total exchangeable bases while sandstone/shale had the highest. The result of exchangeable acidity indicated the highest mean value of 2.46 ± 1.10cmol kg^{-1} (44.72 %) for coastal plain sand, while sandstone/Shale parent material had the lowest mean value of 0.52 ± 0.18cmolkg^{-1} (34.61 %). This would be attributed to the high rainfall in the region as observed by Essien *et al.* (2024a). Base saturation had mean value of 96.69 ± 2.02 % (2.09 %) for sandstone/shale parent material and 73.13 ± 10. 79 % (14.75 %) for coastal plain sand parent material. The result indicated that sandstone/shale parent material had the highest mean base saturation, while coastal plain sand had the least mean value. Soil with high base saturation contain greater amount of essential nutrient (cation) for plant growth (Etukudoh *et al.*, 2021; Etukudoh, *et al.*, 2013).

Table 2: Soil Chemical Properties on Sandstone/ Shale and Coastal plain Sand Parent Materials.

Location	PH	OM	K	Ca	Mg	Na	EA	ECEC	Bsat
	Kcl	%	?	----------------------cmolkg^{-1}-------------------------				?	%
Sandstone/Shale Parent Material									
X	3.23	2.32	0.12	9.58	7.67	0.08	0.52	17.92	96.69
Std (±)	0.38	0.90	0.05	2.96	2.97	0.04	0.18	5.85	2.02
CV (%)	11.76	38.79	41.67	30.90	38.72	50.00	34.61	32.65	2.09
Coastal Plain Sand Parent Material									
X	6.20	2.26	0.18	4.75	1.56	0.06	2.46	9.01	73.13
Std (±)	0.34	1.40	0.15	0.75	0.24	0.02	1.10	0.98	10.79
CV (%)	5.48	61.95	83.33	15.79	15 38	33.33	44.72	10.88	14.75

OM = Organic Matter; K = Potassium; Ca = Calcium; Mg = Magnesium; Na = Sodium; EA = Exchangeable Acidity; ECEC = Effective Cation Exchange Capacity; Bsat = Base Saturation.

Table 3: Organic Matter Fractions on Sandstone/Shale and Coastal Plain Sand Parent Materials

Location	OM (%)	HN (%)	HA (%)	FA (%)
Sandstone/Shale Parent Material				
X	2.32	0.49	0.29	0.20
Std (±)	0.90	0.32	0.12	0.28
CV (%)	38.79	65.31	41.38	140.00
Coastal Plain Sand Parent material				
X	2.34	0.51	0.35	0.17
Std (%)	1.30	0.16	0.10	0.04
CV (%)	55.56	31.37	28.57	23.53

OM – Organic matter, HN – Humin, HA – Humic acid, FA – Fulvic acid.

Relationship between Soil Physical and Chemical Properties with Organic Matter Fractions on Sandstone/shale Parent Materia

The relationship between physical and chemical properties with organic matter fractions on sandstone/shale parent material (Table 4) shows that total sand correlated positively with humin (0.479*) and humic acid (0.536*). The positive relationship between total sand, humin and humic acid, provides that there was an increase in water holding capacity, significantly reducing water evaporation and increasing its availability for use by plants. Silt correlated positively with sodium (0.542*). Clay correlated negatively with bulk density (-0.488*). The negative relationship between clay and bulk density shows that as clay increases, bulk density decreases.

Bulk density correlated negatively with total porosity (-0.999**). The negative relationship shows that as bulk density increases, total porosity decreases. Hydraulic conductivity correlated positively with potassium (0.516*) and sodium (0.508*). The positive relationship between hydraulic conductivity and sodium indicates great soil structural stability. pH correlated negatively with

Table 4: Correlation Matrix of Soil Properties and Organic Matter Fractions on Sandstone/Shale Parent material

	Ts	Si	Cl	Bd	Tp	Ksat	pH	K	Ca	Mg	Na	EA	ECEC	Bsat	OM	HN	HA	FA
Ts	1.000																	
Si	0.216	1.000																
Cl	0.258	0.090	1.000															
Bd	-0.230	-0.244	-0.488*	1.000														
Tp	0.235	0.265	0.490	-0.999**	1.000													
Ksat	0.112	0.046	0.185	-0.186	0.178	1.000												
PH	-0.036	0.154	-0.276	0.087	-0.099	0.342	1.000											
K	0.284	0.343	0.447	-0.127	0.120	0.516*	-0.463	1.000										
Ca	-0.202	-0.189	0.430	-0.037	0.050	0.249	-0369	-0.264	1.000									
Mg	-0.173	-0.092	0.087	-0.050	0.065	0.262	-0.416	-0.187	0.980**	1.000								
Na	0.239	0.542*	0.349	-0.087	0.082	0.508*	-0.371	0.936**	-0.241	-0.126	1.000							
EA	0.192	0.194	-0.067	-0.034	0.024	-0.024	-0.498*	0.363	-0.258	-0.224	0..290	1.000						
ECEC	-0.181	-0.130	0.070	-0.047	0.060	0.267	-0.420	-0.203	0.993**	0.996**	-0.163	-0.209	1.000					
Bsat	-0.228	-0.128	0.263	-0.092	0.104	0.301	0.022	-0.250	0.726**	0.707**	-0.201	-0.757**	0.701**	1.000				
OM	0.105	-0.008	0.306	-0.323	0.329	-0.067	-0.259	0.135	-0.121	-0.066	0.113	0.258	-0.085	-0.126	1.000			
HN	0.479*	0.186	-0.268	-0.060	0.056	-0.073	0.071	0.224	-0.146	-0.091	0.297	0.127	-0.113	-0.345	0.205	1.000		
HA	0.536*	0.013	0.080	0.044	-0.054	-0.072	0.076	0.262	-0.222	-0.180	0.205	0.190	-0.194	-0.301	0.306	0.744**	1.000	
FA	0.454	0.180	0.101	0.026	-0.032	-0.216	0.142	0.062	-0.286	-0.208	0.043	0.133	-0.246	-0.261	0.290	0.525*	0.851**	1.000

Ts = Total nitrogen, Si = Silt, Cl = Clay, Bd -= Bulk density, Tp = Total porosity, Ksat = Saturated hydraulic conductivity, OM = Organic matter, K = Potassium, Ca = Calcium, Mg = Magnesium, Na = Sodium, EA = Exchangeable acidity, ECEC = Effective cation exchange capacity, Bsat = Base saturation, HN = Humin acid, HA = Humic acid, FA = Fulvic acid.

Exchangeable acidity (-0.498*). The negative relationship shows that exchangeable acidity of the soil was high with a resultant low pH, this probably may affect the soil condition and many other soil processes. Potassium correlated positively with sodium (0.936**). The positive relationship between potassium and sodium shows an inverse relationship, meaning when sodium level rise, potassium level fall and vice versa. Calcium correlated positively with magnesium (0.980**), effective cation exchange capacity (0.996**) and base saturation (0.707**).

Exchangeable acidity negatively correlated with base saturation (-0.757**). Effective cation exchange capacity correlated positively with base saturation (0.701**). Humin correlated positively with humic acid (0.744**) and fuivic acid (0.525*). Humic acid correlated positively with FA (0.851**). The positive relationship between humic and fulvic acid shows that these acids work together synergically. Humic acid naturally improves soil health and growth, fulvic acid helps plants take up nutrients more effectively.

Relationship between Soil physical and Chemical Properties with organic Matter Fractions on Coastal Plain Sand Parent Material

The relationship between soil physical and chemical properties with organic matter fractions on coastal plain sand parent material (Table 5) results revealed that total sand correlated negatively with silt (-0.754*) and clay (-0.931**). The negative relation between total sand with silt and clay shows that as total sand increases, silt and clay decreases. Silt positively correlated with clay (0.705**) and exchangeable acidity (0.561**) and negatively correlated with calcium (-0.402*) and base saturation (-0.536*). Clay correlated negatively with calcium (-0.442*) and positively correlated with humin (0.404*). Bulk density correlated with total porosity (-0.941**). This negative relationship between bulk density and total porosity shows that as bulk density increases total porosity decreases.

Total porosity negatively correlated with potassium (-0.452*). The negative relationship between total porosity and potassium shows that potassium can cause dispersion of soil. Hydraulic conductivity correlated positively with magnesium (0.522*). pH negatively correlated with calcium (-0.413*). The negative relationship between pH and calcium shows that higher calcium carbonate in the soils increases pH making many nutrients less available. Organic matter positively correlated with calcium (0.591**) and base saturation (0.703**) and negatively correlated with exchangeable acidity (-0.632**). Calcium negatively correlated with exchangeable acidity (-0.541*) and positively correlated with base saturation (0.646**) and negatively correlated with base saturation (-0.959**). Effective cation exchange capacity negatively correlated with base saturation (-0.410*). Humin positively correlated with humic (0.466*) and fulvic acid (0.930**). The positive relationship between humin with humic and fulvic acids indicated that the organic matter materials been persistence are not transient in nature, not easily decompose and can stay in the soil for a longer period of time, as such the soil of the area cannot be easily degraded, which also will help the soil aggregate to be stable.

Table 5: Correlation Matrix of Soil Properties and Organic Matter Fractions on C0astal Plain Sand Parent material

	Ts	Si	Cl	Bd	Tp	Ksat	pH	K	Ca	Mg	Na	EA	ECEC	Bsat	OM	HN	HA	FA
Ts	1.000																	
Si	-0.754**	1.000																
Cl	-0.931**	0.705**	1.000															
Bd	-0.162	0.037	0.188	1.000														
Tp	0.296	-0.129	-0.329	-0.941**	1.000													
Ksat	-0.111	0.119	0.265	-0.317	0.194	1.000												
PH	-0.030	0.126	0.235	-0.196	0.077	0.393	1.000											
OM	0.174	-0.368	-0.202	0.293	-0.218	-0.340	-0.128	1.000										
K	-0.043	0.030	0.122	0.398	-0.452*	0.127	0.384	0.373	1.000									
Ca	0.313	-0.402*	-0.442*	0.186	-0.046	-0.309	-0.413*	0.591**	0.127	1.000								
Mg	-0.051	-0.035	0.156	0.024	-0.053	0.522*	0.000	-0.166	-0.090	- 0.015	1.000							
Na	-0.025	0.240	-0.013	0.019	-0.095	- 0.271	-0.064	0.086	0.013	-0.079	-0.241	1.000						
EA	-0.211	0.561**	0.246	-0.176	0.147	0.267	0.043	-0.363**	-0.223	-0.541*	0.196	0.159	1.000					
ECEC	0.028	0.329	-0.081	-0.027	0.111	0.092	-0.284	-0.161	- 0.068	0.259	0.229	0.201	0.646**	1.000				
Bsat	0.235	-0.536*	-0.310	0.170	-0.105	-0.285	-0.162	0.703**	0.226	0.742**	-0.153	-0.129	- 0.959**	-0.410*	1.000			
HN	-0.321	0.053	0.404*	0.262	-0.256	-0.161	0.256	0.088	0.030	0.063	-0.180	-0.158	-0.030	-0.094	0.004	1.000		
HA	-0.168	0.097	0.150	0.008	-0.033	0.353	0.220	-0.304	-0.109	-0.111	-0.128	-0.235	0.148	0.006	-0.161	0.466*	1.000	
FA	-0.290	0.019	0.391	0.291	-0.275	-0.328	0.196	0.225	0.079	0.117	-0.149	-0.080	-0.095	-0.108	0.071	0.930**	0.109	1.000

Ts = Total nitrogen, Si = Silt, Cl = Clay, Bd -= Bulk density, Tp = Total porosity, Ksat = Saturated hydraulic conductivity, OM = Organic matter, K = Potassium, Ca = Calcium, Mg = Magnesium, Na = Sodium, EA = Exchangeable acidity, ECEC = Effective cation exchange capacity, Bsat = Base saturation, HN = Humin acid, HA = Humic acid, FA = Fulvic acid

CONCLUSION

Organic matter fractionation allows the assessment of different organic fractions available in the soil. Organic matter influences the physical conditions of the soil in several ways, such as soil structure, aggregation, water retention, soil biodiversity, absorption and retention of pollutants, buffering capacity and the cycling and storage of plant nutrients. The amount of persistent organic carbon pools in the soil determines if the soil is transient or stable in nature and can resist external forces that causes soil degradation.

RECOMMENDATION

It is recommended that proper attention should be given to soil management practices that will promote or increase organic carbon pools that are resistance to easily organic matter decomposition/degradation and not transient in nature, which weathered away for a moment, due to high temperature. Furthermore, quality and quantity of organic matter pools should be taken into consideration to enhance soil stability in the study area.

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