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ASSESSEMENT OF THE BASELINE DISTRIBUTION OF ORGANIC CARBON IN SOILS OF ESAN SOUTH EAST LOCAL GOVERNMENT AREA OF EDO STATE, SOUTHERN NIGERIA

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Abstract
The knowledge of spatial distribution of soil organic carbon is an important requirement for understanding the role of soils in the global carbon system. In this study, soil samples were obtained from the land of different uses in Esan South East Local Government Area, Edo State, South-South Nigeria, in order to determine the forms and spatial distribution of organic carbon content of the soils. The soils were collected from 0 – 15cm (topsoil) and 15 – 30cm (subsoil) depths. The soil samples were physically fractionated into labile organic carbon fraction and recalcitrant organic carbon fraction following standard methods. Selected physiochemical properties of the soils were also determined and the results obtained were subjected to statistical analyses. The result showed that the labile organic carbon fraction accounted for 15 percent of the total organic carbons while the recalcitrant organic carbon fraction accounted for 85 percent indicating that the recalcitrant organic carbon fraction is of a greater proportion than the labile organic carbon fraction. These fractions were found to be decreasing also with the depth. The soil organic carbon is also low. The study also shows that the different land uses contributed to the relatively low levels labile organic carbon in the soil hence appropriate crop and soil management practices are required in maintaining or improving the organic carbon status of the soil.
Key words: Forms, spatial distribution, labile organic carbon fraction, recalcitrant organic carbon fraction.

1. INTRODUCTION

Soil is a natural entity that connects the inorganic minerals of the earth to the organic organisms of life. It's germane to several academic disciplines, but in the presence of climate change, land degradation and biodiversity loss, soil has become one of the most vulnerable resources in the world (FAO and ITPS, 2015). Soil hosts the largest terrestrial carbon pool (Scharlemann, *et. al.* 2014) while land use and land cover change (including agriculture) are the largest anthropogenic source of carbon in the atmosphere after the burning of fossil fuels (IPCC, 2014). Soil plays a crucial role in the global carbon balance by regulating dynamic biogeochemical processes and the exchange of greenhouse gases (GHG) with the atmosphere (Lal, 2013). Soils are key reservoir of global biodiversity which combined with Soil organic carbon (SOC) to sharpen the metabolic capacity of soils. It is also believed to play a crucial role in increasing food production and soil resilience to climate change. Soil organic carbon (SOC) has recently gained prominence in assessment of

soil quality since it compounds affects chemical, physical and biological aspect of the soil (Lehmann, et al., 2015). It is an important parameter to determining soil fertility and sustaining soil health. Soil organic matter is the carbon source of many organisms and it is a build-up in the decayed plant and animal residues. It has been estimated that about one third of Carbon of plant residues is retained in SOM (Tank, 2003). The dynamics of SOC is usually described by dividing. SOM into two or more fractions. SOM is usually divided into different fractions as a function of its physical and chemical stability (FAO and ITPS, 2015, O' Rourke, et al., 2015). Fast Pool (labile or active pool), Intermediate Pool and slow Pool (refractory or stable pool).

2. MATERIALS AND METHODS.

2.1. Study Site description

Study Area: The headquarters Esan South East Local Government Area is located in Ubiaja. Its population was 167,721 at the 2006 census. Towns in the jurisdiction are Ubiaja, Oria, Onog- Holo, Okhu-Esan, Udo, Feku, Illushi, Emu, Eguare-Ewatto, Ewohimi, Ohordua, Orowa, Uroh and Inyenlen.It has an area of 1,305km^2 with coordinated $6^0$35'11.87''N $6^0$28'33.06''E.

2.2. *Data collection*

The study location was based on the heterogeneous distribution of soil organic matter, which strongly dependent on Parent material, Cultivation, Vegetation/Land use, Climate and Topography. (Stevenson, 1982). Soil samples were collected using a Dutch auger and the sampling done randomly at various depth of 0-15cm and 15-30cm. 20 points were sampled at the ecological zone as shown in table 1. The soil samples collected were kept in a sampling bag and then taking to the laboratory for analysis.

Table 1. Description of sampling location

S/N	Sampled Point	Depth [cm]	Easting	Northing	Land Use	Towns/ Villages
1	SP1	0-15	6.411823713	6.65827124	Cassava farm land	Ubiaja
2	SP1	15-30				
3	SP2	0-15	6.466733444	6.652835256	Forest	Udakpa
4	SP2	15-30				
5	SP3	0-15	6.496578356	6.654794839	Forest	Unogholo
6	SP3	15-30				
7	SP4	0-15	6.516109624	6.667727027	Forest	Oria
8	SP4	15-30				
9	SP5	0-15	6.574755851	6.668018889	Grazing Land	Uloshi
10	SP5	15-30				
11	SP6	0-15	6.592325223	6.668782839	Rice Farm land	Illushi
12	SP6	15-30				

13	SP7	0-15	6.455365055	6.643640094	Village settlement	Ahia
14	SP7	15-30				
15	SP8	0-15	6.463130355	6.631027577		Ikeken
16	SP8	15-30				
17	SP9	0-15	6.460090593	6.62100762	Cassava farm land	Eko-Ghenyen
18	SP9	15-30				
19	SP10	0-15	6.456486231	6.576398745	Shrubs Land	Urakhuan
20	SP10	15-30				
21	SP11	0-15	6.476591049	6.55187337	Grassland	Emu 1
22	SP11	15-30				
23	SP12	0-15	6.444242337	6.554881742	Cassava farm land	Urakhuan-Usolo
24	SP12	15-30				
25	SP13	0-15	6.433245063	6.535368416	Forest	Ibhiadan Emu
26	SP13	15-30				
27	SP14	0-15	6.422040015	6.537163731	Rubber Plantation land	Ibhiadan Emu Boundary
28	SP14	15-30				
29	SP15	0-15	6.413743913	6.516218313	Cassava Farm land	Ohordua-Eguare
30	SP15	15-30				
31	SP16	0-15	6.409082039	6.482585495	Forest	Ibhubu-Ohordua
32	SP16	15-30				
33	SP17	0-15	6.376094039	6.488054846	Secondary Forest	Okaigben-Ewohimi
34	SP17	15-30				
35	SP18	0-15	6.333675446	6.476031633	Forest	
36	SP18	15-30				
37	SP19	0-15	6.360256533	6.54834695	Grassland	Abdhuru Ewatto
38	SP19	15-30				
39	SP20	0-15	6.400422179	6.607387391	Teak Forest	Okhuesan-Ubiaja
40	SP20	15-30				

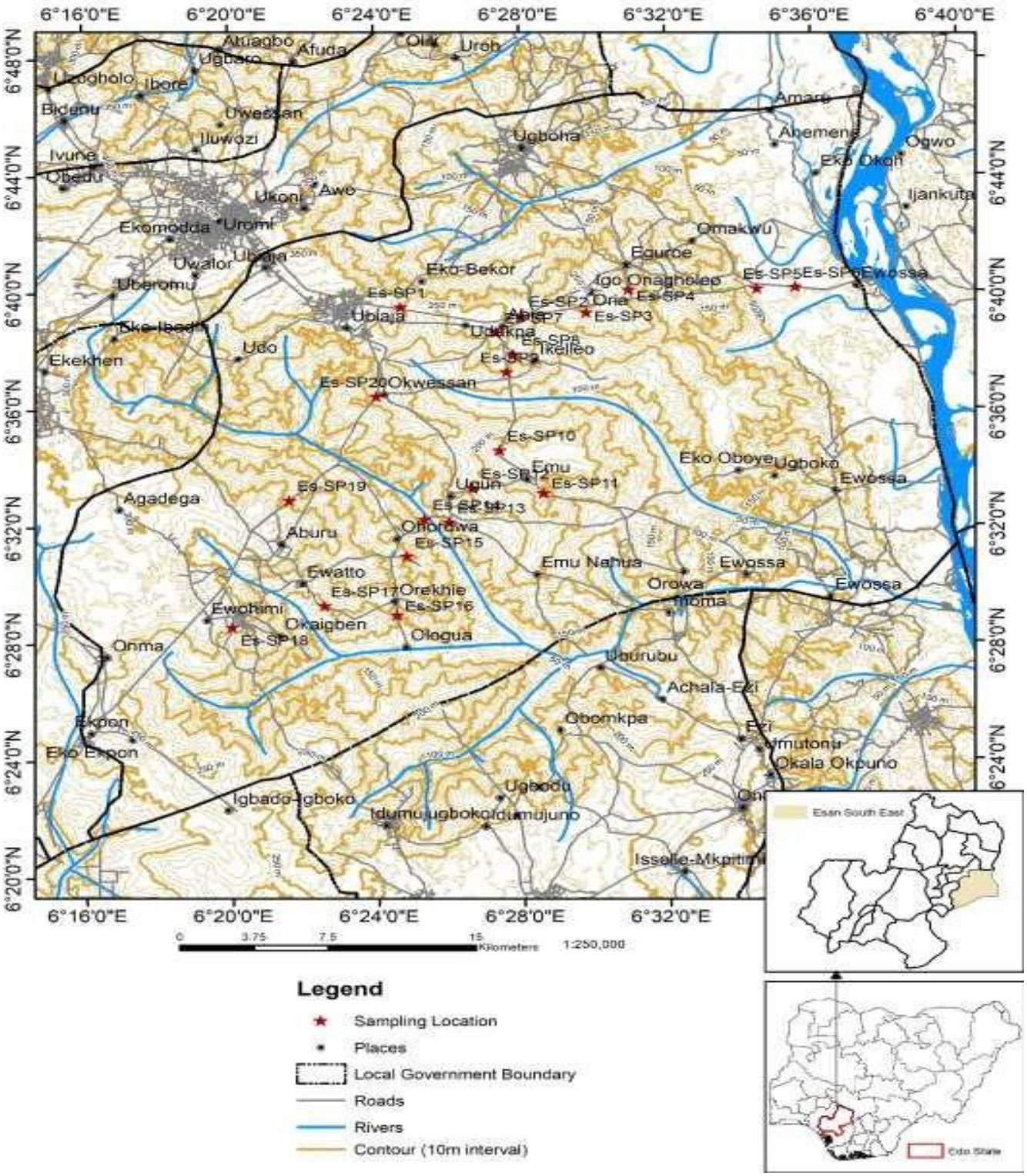

Figure 1.0: Map showing the sampling points
Map was generated using the coordinates of the sampled points.

2.3. Soil Preparation:

In the laboratory, the soils were dried at ambient temperature (22-25°C), crushed in a porcelain mortar and sieved through a 2-mm (10 meshes) stainless sieve, Air dried <2-mm samples were stored in polyethylene bags for subsequent analysis. The <2-mm fractions were used for the determination of selected soil physical and chemical properties and the fractionation of the SOC.

2.4. Data analysis

2.4.1. Physical fractionation of the soil sample

The soil sample was physically fractionated following the procedure described by Camberdella, et al., 1992.

Sub sample was sieved and 20 g of the sieved sub sample was placed in 250 ml plastic bottle and same was done to the remaining 39 soil sub samples. 105 ml of distilled water was added and the mixture shaken for 1 hour on an end to end mechanical shaker. The content was passed through 53 µm sieve. The sample above the 53 µm and the sample that passed through the sieve were collected and oven dried at 70 °C so as not to destroy Carbon contained in the samples. The sample above the sieve was considered as the Particulate SOM (Labile fraction) while the sample that passed through the sieve as the Recalcitrant SOM (Stable fraction) The oven dried samples were reduced into powder form using mortar and pestle and then analyzed for organic carbon content using the wet-oxidation method. The organic carbon was determined by Walkley and Black method.

2.4.2. Determination of Organic Carbon

About 1 gm of soil sample will be weighed and transferred to a dried 500 ml conical flask. Add 10 mL of 1N $K_2Cr_2O_7$ and 20 mL of concentrated sulphuric acid (H_2SO_4) added and mixed by gentle swirling. The flask will be allowed for the mixture to react and kept for about 30 minutes. After the reaction is over, the content is diluted with 200 ml of distilled water and then 10 ml o-phosphoric acid is added followed by 1 ml of diphenylamine indicator. The sample is then titrated with 0.4N Ferrous Ammonium Sulphate (FAS) till the colour changed to brilliant green at the end point. The process was repeated for blank with same quantity of the chemicals but without soil.

Calculation:

a. % Carbon = (1-T/S) (3.951/g)

b. % Organic Matter = % Carbon × 1.724

Where,

g = wt. of sample in g

S = ml of FAS with blank titration

T = ml of FAS with sample titration

The factor 1.724 is based on the assumption that carbon is only 58 % of the organic matter (Pribyl, 2010).

The average oxidation number for organic carbon is assumed as zero and the reaction involved is as follows: -

$$2C_rO_7^{2-} + 3C^0 + 16H^+ \rightarrow 4C_r^{3+} + 3CO_2 + 8H_2O$$

And

$$6\,Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 6\,Fe^{3+} + 7\,H_2O$$

2.5. Statistical Analysis

Variability among soils in the different location point was analyzed using completely randomized designed of Analysis of Variance (ANOVA) comparisons were made using the least significant different (LSD) method at

$p<0.05$ levels (Wahua 1999). Coefficient of variation as used by Wilding, et al. (1994) was used to estimate the degree of variability existing among the studied parameters. However, correlation was used to determine the relationship among the forms of organic carbon and the soil properties.

2.6. Geospatial Distribution Map

Geographic Information System (GIS) software was used to generate geospatial distribution map to express the distribution pattern of the forms of organic carbon at various sampling points.

3.0. RESULT AND DISCUSSION

Table 2: Result of selected physical and chemical properties for 0-15cm and 15 30cm depths.

S/N	pH	EC µS/cm	OM (%)	OC (%)	Total N (%)	C:N	P (mg/kg)	Ex. K ($cmolkg^{-1}$)	Ex. Na ($cmolkg^{-1}$)
1	5.5	225	3.20	1.86	0.132	14.20	2.04	0.17	0.07
2	5.6	143	1.88	1.09	0.041	26.59	0.94	0.13	0.07
3	5.4	541	4.14	2.40	0.071	33.80	2.59	0.26	0.07
4	4.2	71	1.05	0.61	0.321	1.90	0.34	0.15	0.07
5	4.9	431	2.79	1.62	0.704	2.30	1.39	0.16	0.07
6	5.0	146	1.60	0.93	0.272	3.42	0.68	0.13	0.07
7	5.3	548	2.48	1.44	0.329	4.38	2.45	0.18	0.07
8	4.0	191	1.43	0.83	0.337	2.46	2.00	0.15	0.07
9	5.0	512	3.00	1.74	0.288	6.04	4.70	0.23	0.07
10	5.2	86	1.99	1.16	0.268	4.37	1.00	0.20	0.08
11	4.3	364	3.97	2.30	0.700	3.29	21.06	0.22	0.07
12	3.7	110	2.31	1.34	0.313	4.28	11.26	0.17	0.07
13	6.6	1193	6.72	3.90	0.576	6.77	20.83	0.31	0.08
14	6.8	252	2.65	1.54	0.304	5.07	2.45	0.25	0.08
15	5.8	427	3.78	2.19	0.304	7.21	2.41	0.16	0.59
16	5.9	179	1.55	0.90	0.364	2.49	0.88	0.13	0.06
17	5.4	524	4.09	2.37	0.494	4.80	2.71	0.28	0.07
18	5.6	206	2.31	1.34	0.617	2.17	1.14	0.14	0.06
19	5.3	395	3.03	1.76	0.568	3.10	2.08	0.22	0.07
20	5.0	154	0.28	0.35	0.494	0.71	0.85	0.13	0.07
21	5.4	348	3.26	1.89	0.625	3.02	2.11	0.19	0.07
22	5.2	196	2.26	1.31	0.527	2.49	1.00	0.14	0.07
23	4.3	587	2.86	1.66	0.362	4.59	6.38	0.20	0.08
24	4.0	129	2.10	1.22	0.346	3.53	1.68	0.13	0.06
25	6.4	456	3.73	2.16	0.737	2.94	3.62	0.23	0.06
26	6.7	173	1.48	0.86	0.346	2.49	6.24	0.19	0.07
27	4.4	345	3.03	1.76	0.521	5.48	4.82	0.17	0.08
28	5.4	142	1.75	1.02	0.370	2.76	0.68	0.11	0.07
29	4.8	266	3.59	2.08	0.560	3.71	3.88	0.19	0.07
30	4.3	142	2.59	1.51	0.266	5.66	1.50	0.16	0.10
31	4.6	146	2.53	1.47	1.284	1.14	2.79	0.19	0.08
32	4.3	200	1.38	0.80	0.502	1.59	1.17	0.12	0.08
33	4.7	817	2.98	1.73	0.905	1.91	1.65	0.13	0.08
34	4.7	101	2.59	1.50	0.469	3.20	1.00	0.11	0.08
35	6.4	666	5.97	3.46	0.157	22.04	4.73	0.23	0.09
36	7.3	306	2.81	1.63	1.029	1.58	6.64	0.17	0.08
37	5.9	361	2.71	1.57	0.477	3.29	1.62	0.13	0.08
38	5.9	150	1.93	1.12	0.658	1.70	1.03	0.12	0.08

39	6.2	451	2.68	1.56	0.243	7.80	11.04	0.22	0.08
40	6.4	124	2.21	1.28	0.101	12..67	0.94	0.13	0.08

Table 2. Result of selected physical and chemical properties for 0-15cm and 15-30cm depths,

S/N	Ex. Ca ($cmolkg^{-1}$)	Ex. Mg ($cmolkg^{-1}$)	CEC ($cmolkg^{-1}$)	Ex. H^+ ($cmolkg^{-1}$)	Al^{3+} ($cmolkg^{-1}$)	ECEC ($cmolkg^{-1)}$	Clay (%)	Silt (%)	Sand (%)
1	5.84	1.48	7.56	0.005	0.006	7.565	3.4	4.8	91.9
2	2.16	0.80	3.15	0.004	0.006	3.154	3.5	4.1	92.4
3	4.72	1.68	6.73	0.004	0.006	6.734	6.5	6.1	87.4
4	1.36	0.88	2.46	0.007	0.006	2.473	23.5	4.1	72.4
5	2.96	1.56	4.74	0.005	0.006	4.745	3.4	4.2	92.4
6	1.76	0.80	2.76	0.005	0.006	2.765	5.5	8.1	86.4
7	6.16	2.40	8.81	0.005	0.006	8.815	3.5	2.1	94.4
8	0.72	0.48	1.42	0.011	0.003	1.434	10.5	4.1	85.4
9	3.44	0.80	4.54	0.004	0.003	4.544	3.5	6.1	90.4
10	2.32	0.56	3.16	0.005	0.003	3.158	7.9	5.7	86.4
11	3.36	1.12	4.77	0.007	0.003	4.780	4.5	8.1	87.4
12	0.96	1.04	2.24	0.007	0.006	2.253	9.5	5.1	85.4
13	16.96	1.20	18.55	0.006	0.006	18.556	3.5	2.1	94.4
14	4.08	1.04	5.45	0.005	0.006	5.455	5.5	6.1	84.4
15	5.12	1.40	5.93	0.005	0.006	5.930	3.4	3.2	93.4
16	2.16	1.48	3.83	0.005	0.006	3.835	5.5	4.4	90.1
17	5.44	1.04	6.83	0.005	0.006	6.835	3.5	5.4	91.1
18	4.40	0.48	5.08	0.006	0.006	5.086	3.5	6.4	90.1
19	3.12	1.36	4.77	0.002	0.006	4.772	3.5	7.4	89.1
20	2.24	1.12	3.55	0.005	0.006	3.555	12.3	5.0	82.8
21	3.52	1.76	5.54	0.006	0.006	5.546	3.5	5.4	91.1
22	1.84	0.64	2.69	0.004	0.006	2.694	5.5	5.4	89.1
23	2.00	0.80	3.08	0.008	0.006	3.088	6.5	2.4	91.1
24	0.40	0.40	0.99	0.007	0.012	1.009	8.5	3.4	88.1
25	6.24	0.92	7.45	0.005	0.012	7.455	3.4	1.4	95.3
26	2.08	0.64	2.98	0.004	0.012	2.984	5.5	4.4	90.1
27	1.84	1.12	3.21	0.004	0.012	3.214	9.5	8.4	82.1
28	1.68	3.72	5.58	0.004	0.012	5.584	4.5	4.4	91.1
29	0.96	0.48	1.70	0.004	0.012	1.704	4.5	6.4	89.1
30	0.96	0.80	2.01	0.008	0.014	2.031	18.4	6.4	75.3
31	2.88	1.12	4.27	0.006	0.014	4.276	3.5	5.4	91.1
32	0.64	0.48	1.32	0.012	0.014	1.332	10.5	4.4	85.1
33	2.00	0.96	3.17	0.007	0.014	3.177	3.5	1.4	95.1
34	0.80	0.40	1.39	0.008	0.006	1.404	1.3	2.4	96.4
35	12.52	1.40	14.24	0.008	0.006	14.241	2.8	0.9	93.9
36	6.64	1.52	8.41	0.008	0.006	8.418	6.3	2.4	91.3
37	3.92	1.44	5.57	0.005	0.006	5.575	3.3	2.4	94.3
38	3.04	0.64	3.88	0.005	0.006	3.885	3.3	4.4	92.3
39	6.72	0.60	7.62	0.006	0.006	7.626	3.3	1.9	94.9
40	1.44	0.24	1.89	0.005	0.006	1.895	3.0	2.7	94.3

Cont'd

Table 3. Result of Total Organic Carbon and its fractions for depth 0-15cm and 15-30cm

S/N	TOC (%)	LOC (%)	MAOC (%)	ROC (%)	% LOC (%)	%ROC (%)
1	1.86	0.55	1.31	7.56	7.00	93.00
2	1.09	0.27	0.82	3.62	7.00	93.00
3	2.40	1.49	0.91	3.12	32.00	68.00
4	0.61	0.19	0.42	0.51	27.00	73.00
5	1.62	0.75	0.87	5.40	12.00	88.00
6	0.93	0.31	0.62	2.15	13.00	87.00
7	1.44	0.61	0.83	6.12	9.00	91.00
8	0.83	0.13	0.70	1.79	7.00	93.00
9	1.74	0.55	1.19	3.54	13.00	87.00
10	1.16	0.17	0.99	1.94	8.00	92.00
11	2.30	0.85	1.45	5.35	14.00	86.00
12	1.34	0.31	1.03	3.03	9.00	91.00
13	3.90	2.24	1.66	7.96	22.00	78.00
14	1.54	0.34	1.20	3.03	10.00	90.00
15	2.19	0.77	1.42	7.31	10.00	90.00
16	0.90	0.19	0.71	2.44	7.00	93.00
17	2.37	1.20	1.17	6.51	17.00	84.00
18	1.34	0.48	0.86	3.76	11.00	89.00
19	1.76	0.45	1.31	3.84	11.00	90.00
20	0.35	0.30	0.05	1.54	16.00	84.00
21	1.89	1.33	0.56	5.21	20.00	80.00
22	1.31	0.72	0.59	3.05	19.00	81.00
23	1.66	0.89	0.77	7.94	10.00	90.00
24	1.22	0.36	0.86	3.25	10.00	90.00
25	2.15	1.05	1.10	7.32	13.00	87.00
26	0.86	0.29	0.57	2.11	12.00	88.00
27	1.76	1.55	0.21	5.54	22.00	78.00
28	1.02	0.28	0.74	2.23	11.00	89.00
29	2.08	1.40	0.68	5.78	20.00	81.00
30	1.51	0.79	1.02	2.55	24.00	76.00
31	1.47	1.11	0.36	5.27	17.00	83.00
32	0.80	0.35	0.45	1.90	16.00	84.00
33	1.73	0.87	0.86	8.11	10.00	91.00
34	1.50	0.62	0.88	3.87	14.00	86.00
35	3.46	2.40	1.06	8.26	23.00	77.00
36	1.63	0.76	0.87	4.02	16.00	84.00
37	1.57	0.83	0.74	5.97	12.00	88.00
38	1.12	0.56	0.56	3.59	14.00	87.00
39	2.02	1.07	0.95	7.91	12.00	88.00
40	1.19	0.24	0.95	1.72	12.00	90.00

According to table 3, the results show the concentration of organic carbon of the top soil is higher than the subsoil, this is due to the high concentration of dead organic matter on the surface of the top soil. P1 with land use as village settlement has the highest concentration of Total Organic Carbon also with highest concentration of Labile Organic Carbon and Mineral Associated Organic Carbon of 3.90%, 2.24% and 1.66% respectively. P18 with land use as forest has the highest concentration of Recalcitrant Organic carbon of 8.26%.

The summation of Labile Organic Carbon and Mineral Associated Organic Carbon gives Total Organic Carbon of a particular sampling point.

The percentage of Recalcitrant Organic Carbon is higher than the percentages of Labile Organic Carbon and Mineral Associated Organic Carbon.

Table 4: Descriptive Statistical Analysis of selected chemical properties for depth 0-15cm.

S/N	Sampled Point	Soil Ph	EC (µS/cm)	Org. M (%)	Org. C (%)	Total N (%)	C:N	Av.P (mg/ kg)	CEC (cmol kg^{-1})	Ex.K (cmol kg^{-1})	Ex. Na (cmol kg^{-1})	Ex. Ca (cmol kg^{-1})	Ex Mg (cmolkg^{-1})	Ex. H^+ (cmol kg^{-1})	Ex. Al^{3+} (cmol kg^{-1})	ECEC (cmol kg^{-1})
1	P1	5.5	225	3.2	1.86	0.132	14.2	2.04	7.56	0.17	0.07	5.84	1.48	0.005	0.000	7.565
2	P2	5.4	541	4.14	2.4	0.071	33.8	2.59	6.73	0.26	0.07	4.72	1.68	0.004	0.000	6.734
3	P3	4.9	431	2.79	1.62	0.704	2.30	1.39	4.74	0.16	0.07	1.36	0.88	0.005	0.000	4.745
4	P4	5.3	548	2.48	1.44	0.329	4.38	2.48	8.81	0.18	0.07	6.16	2.40	0.005	0.000	8.815
5	P5	5.0	512	3.00	1.74	0.288	6.04	4.70	4.54	0.23	0.07	3.44	0.80	0.004	0.000	4.544
6	P6	4.3	364	3.97	2.30	0.700	3.29	21.06	4.77	0.22	0.07	3.36	1.12	0.007	0.003	4.780
7	P7	6.6	1193	6.72	3.90	0.576	6.77	20.83	18.55	0.31	0.08	16.96	1.20	0.006	0.000	18.556
8	P8	5.8	427	3.78	2.19	0.304	7.21	2.41	5.93	0.16	0.59	5.12	1.40	0.005	0.000	5.930
9	P9	5.4	524	4.09	2.37	0.494	4.80	2.71	6.83	0.28	0.07	5.44	1.04	0.005	0.000	6.835
10	P10	5.3	395	3.03	1.76	0.568	3.10	2.08	4.77	0.22	0.07	2.24	1.12	0.002	0.000	4.772
11	P11	5.4	348	3.26	1.89	0.625	3.02	2.11	5.54	0.19	0.07	3.52	1.76	0.006	0.000	5.546
12	P12	4.3	587	2.86	1.66	0.362	4.59	6.38	3.08	0.20	0.08	2.00	0.80	0.008	0.000	3.088
13	P13	6.4	456	3.73	2.16	0.737	2.94	3.62	7.46	0.23	0.06	6.24	0.92	0.005	0.000	7.455
14	P14	4.4	345	3.03	1.76	0.521	5.48	4.82	3.21	0.17	0.08	1.84	1.12	0.004	0.000	3.214
15	P15	4.8	266	3.59	2.08	0.560	3.71	3.88	1.70	0.19	0.07	0.96	0.48	0.004	0.000	1.704
16	P16	4.6	146	2.53	1.47	1.284	1.14	2.79	4.27	0.19	0.08	2.88	1.12	0.006	0.000	4.276
17	P17	4.7	817	2.98	1.73	0.905	1.91	1.65	3.17	0.13	0.08	2.00	0.96	0.007	0.000	3.177
18	P18	6.4	666	5.97	3.46	0.157	22.04	4.73	14.24	0.23	0.09	12.52	1.40	0.008	0.000	14.241
19	P19	5.9	361	2.71	1.57	0.477	3.29	1.62	5.57	0.13	0.08	3.92	1.44	0.005	0.000	5.575
20	P20	6.2	451	2.68	1.56	0.243	7.80	11.04	7.62	0.22	0.08	6.72	0.60	0.006	0.000	7.626
	Mean	**5.3**	**480**	**3.53**	**2.04**	**0.502**	**7.09**	**5.25**	**6.45**	**0.20**	**0.10**	**4.86**	**1.19**	**0.005**	**0.000**	**6.460**
	Std. Dev	**0.7**	**227**	**1.10**	**0.64**	**0.289**	**7.90**	**5.80**	**3.910**	**0.05**	**0.12**	**3.87**	**0.44**	**0.001**	**0.000**	**3.910**
	Max	**6.6**	**119**	**6.72**	**3.90**	**1.280**	**33.80**	**21.06**	**18.55**	**0.31**	**0.59**	**16.96**	**2.40**	**0.010**	**0.000**	**18.560**
	Min	**4.3**	**146**	**2.48**	**1.44**	**0.070**	**1.14**	**1.39**	**1.70**	**0.13**	**0.06**	**0.96**	**0.48**	**0.000**	**0.000**	**1.700**
	Range	**2.3**	**105**	**4.24**	**2.46**	**1.210**	**32.66**	**19.67**	**16.85**	**0.18**	**0.53**	**16.0**	**1.92**	**0.010**	**0.000**	**16.850**

Table 5: Descriptive Statistical Analysis of selected chemical properties for depth 15-30cm.

S/N	Sampled points	Soil Ph	EC (µS/cm)	Org. M (%)	Org. C (%)	Total N (%)	C:N	Av. P (mg/kg)	CEC (cmol kg^{-1})	Ex. K (cmol kg^{-1})	Ex. Na (cmol kg^{-1})	Ex. Ca. (cmol kg^{-1})	Ex Mg (cmol kg^{-1})	Ex. $_{H}+$ (cmol kg^{-1})	Ex. $_{Al}3+$ (cmol kg^{-1})	ECEC (cmol kg^{-1})
1	P1	5.6	143.0	1.88	1.09	0.041	26.59	0.94	3.15	0.13	0.06	2.16	0.80	0.004	0.000	3.154
2	P2	4.2	71.0	1.05	0.61	0.321	1.90	0.34	2.46	0.15	0.07	1.36	0.80	0.007	0.006	2.473
3	P3	5.0	146.0	1.6	0.93	0.277	3.42	0.68	2.76	0.13	0.07	1.76	0.80	0.005	0.000	2.765
4	P4	4.0	191.0	1.43	0.88	0.337	2.46	2.00	1.42	0.15	0.07	0.72	0.48	0.011	0.003	1.434
5	P5	5.2	86.0	1.99	1.16	0.268	4.37	1.00	3.16	0.20	0.08	2.32	0.56	0.005	0.000	3.158
6	P6	3.7	110.0	2.31	1.34	0.333	4.28	11.26	2.24	0.17	0.07	0.96	1.04	0.007	0.006	2.253
7	P7	6.8	252.0	2.65	1.54	0.304	5.07	2.45	5.45	0.25	0.08	4.08	1.04	0.005	0.000	5.455
8	P8	5.9	179.0	1.55	0.9	0.364	2.49	0.88	3.83	0.13	0.06	2.16	1.48	0.005	0.000	3.835
9	P9	5.6	206.0	2.31	1.34	0.617	2.17	1.14	5.08	0.14	0.06	4.40	0.48	0.006	0.000	5.086
10	P10	5.0	154.0	0.28	0.35	0.499	0.71	0.85	3.55	0.13	0.07	2.24	1.12	0.005	0.000	3.555
11	P11	5.2	196	2.26	1.31	0.527	2.49	1.00	2.69	0.14	0.07	1.84	0.64	0.004	0.000	2.694
12	P12	4.0	129	2.1	1.22	0.346	3.53	1.68	0.99	0.19	0.06	0.40	0.40	0.007	0.012	1.009
13	P13	6.7	173	1.48	0.86	0.346	2.49	6.24	2.98	0.19	0.07	2.08	0.64	0.004	0.000	2.984
14	P14	5.4	142	1.75	1.02	0.37	2.76	0.68	5.58	0.11	0.07	1.68	3.72	0.004	0.000	5.584
15	P15	4.3	142	2.59	1.51	0.266	5.66	1.50	2.01	0.16	0.10	0.96	0.80	0.008	0.014	2.031
16	P16	4.3	200	1.38	0.80	0.502	1.59	1.17	1.32	0.12	0.08	0.64	0.48	0.012	0.000	1.332
17	P17	4.7	101	2.59	1.50	0.469	3.20	1.00	1.39	0.11	0.08	0.80	0.40	0.008	0.006	1.404
18	P18	7.3	306	2.81	1.63	1.029	1.58	6.64	8.41	0.17	0.08	6.64	1.52	0.008	0.000	8.418
19	P19	5.9	150	1.93	1.12	0.659	1.70	1.03	3.88	0.12	0.08	3.04	0.64	0.005	0.000	3.885
20	P20	6.4	124	2.21	1.28	0.101	12.67	0.94	1.89	0.13	0.08	1.44	0.24	0.005	0.000	1.895
	Mean	**5.3**	**160**	**1.91**	**1.12**	**0.399**	**4.56**	**2.17**	**3.21**	**0.15**	**0.07**	**2.08**	**0.90**	**0.006**	**0.002**	**3.220**
	Std. Dev.	**1.0**	**560**	**0.62**	**0.33**	**0.212**	**5.76**	**2.73**	**1.81**	**0.04**	**0.01**	**1.51**	**0.75**	**0.002**	**0.004**	**1.809**
	Max.	**7.3**	**306**	**2.81**	**1.63**	**1.030**	**26.60**	**11.26**	**8.41**	**0.25**	**0.10**	**6.64**	**3.72**	**0.010**	**0.01**	**8.420**
	Min.	**3.7**	**710**	**0.28**	**0.35**	**0.040**	**0.71**	**0.34**	**0.99**	**0.11**	**0.06**	**0.40**	**0.24**	**0.000**	**0.000**	**1.010**
	Range	**3.6**	**235**	**2.53**	**1.28**	**0.990**	**25.88**	**10.92**	**7.42**	**0.14**	**0.04**	**6.24**	**3.48**	**0.010**	**0.010**	**7.410**

Soil pH varied across the location varying from 4.30 to 6.60 on the top soil of depth 0-15cm with range of 2.30 and standard of 0.72 while the sub soil of depth 15-30cm varied between 3.70 and 7.30 with range of 3.60 and standard deviation of 1.03.Total Nitrogen varied across the location from 0.07 to 1.28 on the top soil of depth 0-15cm with range of 1.21 and standard deviation of 0.28 while the sub soil of depth 15-30cm is between 0.04 to 1.03 with range of 0.99 and a standard deviation of 0.21.Carbon to Nitrogen ratio varied between 1.14 to33.80 on the top soil of depth 0-15cm with range of 32.66 with a standard deviation of 7.90 while the sub soil of depth 15-30cm is between 0.71 to 26.6 with range of 25.88 and a standard deviation of 5.76.

Table 6: Descriptive Statistical Analysis of selected physical properties for depths 0-15cm and 15-30cm.

S/N	Sampled point	Sampled Depth	Clay (%)	Silt (%)	Sand (%)	Sampled Depth	Clay (%)	Silt (%)	Sand (%)
1	P1	0-15cm	3.4	4.8	91.9	15-30cm	3.5	4.1	92.4
2	P2	0-15cm	6.5	6.1	87.4	15-30cm	23.5	4.1	72.4
3	P3	0-15cm	3.4	4.2	92.4	15-30cm	5.5	8.1	86.4
4	P4	0-15cm	3.5	2.1	94.4	15-30cm	10.5	4.1	85.4
5	P5	0-15cm	3.5	6.1	90.4	15-30cm	7.9	5.7	86.4
6	P6	0-15cm	4.5	8.1	87.4	15-30cm	9.5	5.1	85.4
7	P7	0-15cm	3.5	2.1	54.4	15-30cm	5.5	6.1	84.4
8	P8	0-15cm	3.4	3.2	93.4	15-30cm	5.5	4.4	90.1
9	P9	0-15cm	3.5	5.4	91.1	15-30cm	3.5	6.4	90.1
10	P10	0-15cm	3.5	7.4	89.1	15-30cm	12.3	5.0	82.8
11	P11	0-15cm	3.5	5.4	91.1	15-30cm	5.5	5.4	89.1
12	P12	0-15cm	6.5	2.4	91.1	15-30cm	8.5	3.4	88.1
13	P13	0-15cm	3.4	1.4	95.3	15-30cm	5.5	4.4	90.1
14	P14	0-15cm	9.5	8.4	82.1	15-30cm	4.5	4.4	91.1
15	P15	0-15cm	4.5	6.4	89.1	15-30cm	18.4	6.4	75.3
16	P16	0-15cm	3.5	5.4	91.1	15-30cm	10.5	4.4	85.1
17	P17	0-15cm	3.5	1.4	95.1	15-30cm	1.3	2.4	96.4
18	P18	0-15cm	2.8	0.9	93.9	15-30cm	6.3	2.4	91.3
19	P19	0-15cm	3.3	2.4	94.3	15-30cm	3.3	4.4	92.3
20	P20	0-15cm	3.3	1.9	94.9	15-30cm	3.0	2.7	94.3
		Mean	**4.1**	**4.3**	**89.5**	**Mean**	**7.7**	**4.7**	**87.4**
		Std. Dev	**1.6**	**2.4**	**8.9**	**Std. Dev**	**5.4**	**1.4**	**5.8**
		Max	**9.5**	**8.4**	**95.3**	**Max**	**23.5**	**8.1**	**96.4**
		Min	**2.8**	**0.9**	**54.4**	**Min**	**1.3**	**2.4**	**72.4**
		Range	**6.7**	**7.5**	**40.9**	**Range**	**22.2**	**5.7**	**24.0**

Clay varied between 2.80 to 9.50 on the top soil of depth 0-15cm with range of 6.70 and a standard deviation of 1.60 while the sub soil of depth 15-30cm varied between 1.30 to 23.50 with range of 22.20 and a standard deviation of 5.42. Sand varied between 54.40 to 95.30 on the top soil of depth 0-15cm with range of 40.90 with a standard deviation of 8.88 while the sub soil of depth 15-30cm varied between 72.40 to 96.40 with range of 24.00 and a standard deviation of 5.84.

Table 7: Descriptive Statistical Analysis of TOC and its forms for depth 0-15cm.

S/N	Sampled point	Sampled Depth	TOC (%)	LOC (%)	MAOC (%)	ROC (%)	%LOC (%)	%ROC (%)
1	P1	0-15cm	1.86	0.55	1.31	7.56	7.0	93
2	P2	0-15cm	2.40	1.49	0.91	3.12	32	68
3	P3	0-15cm	1.62	0.75	0.87	5.40	12	88
4	P4	0-15cm	1.44	0.61	0.83	6.12	9.0	91
5	P5	0-15cm	1.74	0.55	1.19	3.54	13	87
6	P6	0-15cm	2.30	0.85	1.45	5.35	14	86
7	P7	0-15cm	3.90	2.24	1.66	7.96	22	78
8	P8	0-15cm	2.19	0.77	1.42	7.31	10	90
9	P9	0-15cm	2.37	1.20	1.17	6.51	17	84
10	P10	0-15cm	1.76	0.45	1.31	3.84	11	90
11	P11	0-15cm	1.89	1.33	0.56	5.21	20	80
12	P12	0-15cm	1.66	0.89	0.77	7.94	10	90
13	P13	0-15cm	2.15	1.05	1.10	7.32	13	87
14	P14	0-15cm	1.76	1.55	0.21	5.54	22	78
15	P15	0-15cm	2.08	1.40	0.68	5.78	20	81
16	P16	0-15cm	1.47	1.11	0.36	5.27	17	83
17	P17	0-15cm	1.73	0.87	0.86	8.11	10	91
18	P18	0-15cm	3.46	2.40	1.06	8.26	23	77
19	P19	0-15cm	1.57	0.83	0.74	5.97	12	88
20	P20	0-15cm	2.02	1.07	0.95	7.91	12	88
		Mean	**2.07**	**1.10**	**0.97**	**6.20**	**15**	**85**
		Std. Dev	**0.63**	**0.52**	**0.37**	**1.58**	**6**	**6**
		Max	**3.90**	**2.40**	**1.66**	**8.26**	**32**	**93**
		Min	**1.44**	**0.45**	**0.21**	**3.12**	**7**	**68**
		Range	**2.46**	**1.95**	**1.45**	**5.14**	**25**	**25**

Table 8: Descriptive Statistical Analysis of TOC and its forms for depth 15-30cm.

S/N	Sampled Points	Sampled Depths	TOC (%)	LOC (%)	MAOC (%)	ROC (%)	%LOC (%)	%ROC (%)
1	P1	15-30cm	1.09	0.27	0.82	3.62	7.0	93
2	P2	15-30cm	0.61	0.19	0.42	0.51	27	73
3	P3	15-30cm	0.99	0.31	0.62	2.15	13	87
4	P4	15-30cm	0.83	0.13	0.7	1.79	7.0	93
5	P5	15-30cm	1.16	0.17	0.99	1.94	8	92
6	P6	15-30cm	1.43	0.31	1.03	3.03	9	91
7	P7	15-30cm	1.54	0.34	1.2	3.03	10	90
8	P8	15-30cm	0.9	0.19	0.71	2.44	7	93
9	P9	15-30cm	1.34	0.48	0.86	3.76	11	89
10	P10	15-30cm	0.35	0.3	0.05	1.54	16	84
11	P11	15-30cm	1.31	0.72	0.59	3.05	19	81
12	P12	15-30cm	1.22	0.36	0.86	3.25	10	88
13	P13	15-30cm	0.86	0.29	0.57	2.11	12	90
14	P14	15-30cm	1.02	0.28	0.74	2.23	11	88
15	P15	15-30cm	1.51	0.79	1.02	2.55	24	89
16	P16	15-30cm	0.8	0.35	0.45	1.9	16	76
17	P17	15-30cm	1.5	0.62	0.88	3.87	14	84
18	P18	15-30cm	1.63	0.76	0.87	4.02	16	86
19	P19	15-30cm	1.12	0.56	0.56	3.59	14	84
20	P20	15-30cm	1.19	0.24	0.95	1.72	12	87
		Mean	**1.12**	**0.38**	**0.74**	**2.61**	**13**	**87**
		Std. Dev	**0.33**	**0.20**	**0.26**	**0.93**	**5**	**5**
		Max	**1.63**	**0.79**	**1.20**	**4.02**	**27**	**93**
		Min	**0.35**	**0.13**	**0.05**	**0.51**	**7**	**73**
		Range	**1.28**	**0.66**	**1.15**	**3.51**	**20**	**20**

Labile organic carbon varied between 0.45 to 2.40 on the top soil of depth 0-15cm with range of 1.95 with a standard deviation of 0.52 while the sub soil of depth 15-30cm is between 0.13 to 0.79 with range of 0.66 and a standard deviation of 0.20. Recalcitrant organic carbon varied between 3.12 to 8.26 on the top soil of depth 0-15cm with range of 5.14 with a standard deviation of 1.58 while the sub soil of depth 15-30cm is between 0.51 to 4.02 with range of 3.51 and a standard deviation of 0.93. Soil pH has a positive correlation with LOC by 39.3 %, (r = 0.393) though it is not significant at depth 0-15cm.Total Nitrogen has a negative correlation with LOC by 7.8%, (r = -0.078) though is not significant at depth 0-15.Carbon to Nitrogen ratio has a positive correlation with LOC by 41.4%, (r = 0.414) though is not significant at depth 0-15cm.Clay correlated positively with LOC by 16.2%, (r = 0.162) though is not significant at depth 0-15cm. Soil pH has a positive correlation with ROC by 38.0 %, (r = 0.380) though it is not significant at depth 0-15cm.Total Nitrogen has a negative correlation with ROC by 4.8%, (r = -0.048) and it is not significant at depth 0-15cm.

Table 9: Co Efficient of Correlation of forms organic carbon with selected Physical and Chemical Properties

Parameters	Sampled Depth	TOC (%)	LOC (%)	MAOC (%)	ROC (%)	Sampled Depth	TOC (%).	LOC (%)	MAOC (%)	ROC (%)
Soil Ph	15-30cm	0.237ns	0.148	0.161	0.288	0-15cm	0.596	0.393	0.450	0.380
EC (µS/cm)	15-30cm	0.287ns	0.365	0.082	0.402	0-15cm	0.659	0.471	0.446	0.398
Org. M (%)	15-30cm	0.991s	0.594	0.860	0.714	0-15cm	0.986	0.796	0.539	0.301
Org. C (%)	15-30cm	0.995s	0.619	0.851	0.728	0-15cm	0.987	0.796	0.539	0.302
Total N (%)	15-30cm	0.205ns	0.583	-0.213	0.420	0-15cm	-0.249	-0.078	-0.311	-0.048
C:N ratio	15-30cm	0.126	-0.167	0.303	0.180	0-15cm	0.432	0.414	0.142	-0.119
Av. P (mg/kg)	15-30cm	0.335	0.096	0.283	0.246	0-15cm	0.567	0.341	0.475	0.203
CEC($cmolkg^{-1}$)	15-30cm	0.272	0.247	0.127	0.352	0-15cm	0.825	0.619	0.517	0.404
Ex. K($cmolkg^{-1}$)	15-30cm	0.329	-0.084	0.494	0.036	0-15cm	0.695	0.493	0.476	-0.076
Ex.Na($cmolkg^{-1}$)	15-30cm	0.355	0.482	0.254	-0.057	0-15cm	0.063	-0.117	0.273	0.190
Ex.Ca ($cmolkg^{-1}$)	15-30cm	0.347	0.329	0.158	0.447	0-15cm	0.857	0.651	0.526	0.470
Ex.Mg($cmolkg^{-1}$)	15-30cm	-.053ns	-0.062	-0.030	-0.035	0-15cm	-0.004	0.002	-0.010	-0.129
Ex.H^{+}($cmolkg^{-1}$)	15-30cm	0.006	0.092	-0.017	-0.086	0-15cm	0.286	0.346	-0.007	0.661
Ex Al^{3+}($cmolkg^{-1}$)	15-30cm	0.254	0.274	0.266	0.028	0-15cm	0.087	-0.111	0.305	-0.127
ECEC($cmolkg^{-1}$)	15-30cm	0.273	0.249	0.128	0.353	0-15cm	0.825	0.619	0.517	0.404
Clay (%)	15-30cm	-0.362	-0.081	-0.280	-0.619	0-15cm	-0.140	0.162	-0.467	-0.235
Silt (%)	15-30cm	-0.033	-0.031	0.020	-0.137	0-15cm	-0.241	-0.183	-0.149	-0.744
Sand (%)	15-30cm	0.299	0.093	0.191	0.592	0-15cm	-0.637	-0.532	-0.321	-0.039

EC=Electrical Conductivity, OM=Organic Matter, OC=Organic Carbon, Total N=Total Nitrogen, C:N=Carbon-Nitrogen Ratio, Av. P=Phosphorus, Ex K=Exchangeable Potassium. Ex.Na=Exchangeable Sodium, Ex.Ca=Exchangeable Calcium, Ex Mg=Exchangeable Magnesium, CEC=Cation Exchange Capacity, Ex. H^{+}=Exchangeable Hydrogen ion,Al^{3+}=Aluminum ion, ECEC=Effective Cation Exchange Capacity. Correlation coefficient = r, $p < 0.05$: $r < 0.005$ not significant, $r > 0.007$ highly significant.

Table 10: Mean Separation of selected chemical properties for depth 0-15cm

S/N	Sampled point	Sampled Depth	Soil pH	EC (µS/cm)	Org. M (%)	Org. C (%)	Total N (%)	C:N	Av.P (mg kg^{-1})	CEC (cmol kg^{-1})	E.K (cmol kg^{-1})	Ex. Na (cmol kg^{-1})	Ex. Ca (cmol kg^{-1})	Ex Mg (cmol kg^{-1})	Ex. H^+ (cmol kg^{-1})	Ex. Al^{3+} (cmol kg^{-1})	ECEC (cmol kg^{-1})
1	P1	0-15cm	5.5	225	3.2	1.86	0.132	14.2	2.04	7.56	0.17	0.07	5.84	1.48	0.005	0.000	7.565
2	P2	0-15cm	5.4	541	4.14	2.4	0.071	33.8	2.59	6.73	0.26	0.07	4.72	1.68	0.004	0.000	6.734
3	P3	0-15cm	4.9	431	2.79	1.62	0.704	2.30	1.39	4.74	0.16	0.07	1.36	0.88	0.005	0.000	4.745
4	P4	0-15cm	5.3	548	2.48	1.44	0.329	4.38	2.48	8.81	0.18	0.07	6.16	2.40	0.005	0.000	8.815
5	P5	0-15cm	5.0	512	3.00	1.74	0.288	6.04	4.70	4.54	0.23	0.07	3.44	0.80	0.004	0.000	4.544
6	P6	0-15cm	4.3	364	3.97	2.30	0.700	3.29	21.06	4.77	0.22	0.07	3.36	1.12	0.007	0.003	4.780
7	P7	0-15cm	6.6	1193	6.72	3.90	0.576	6.77	20.83	18.55	0.31	0.08	16.96	1.20	0.006	0.000	18.556
8	P8	0-15cm	5.8	427	3.78	2.19	0.304	7.21	2.41	5.93	0.16	0.59	5.12	1.40	0.005	0.000	5.930
9	P9	0-15cm	5.4	524	4.09	2.37	0.494	4.80	2.71	6.83	0.28	0.07	5.44	1.04	0.005	0.000	6.835
10	P10	0-15cm	5.3	395	3.03	1.76	0.568	3.10	2.08	4.77	0.22	0.07	2.24	1.12	0.002	0.000	4.772
11	P11	0-15cm	5.4	348	3.26	1.89	0.625	3.02	2.11	5.54	0.19	0.07	3.52	1.76	0.006	0.000	5.546
12	P12	0-15cm	4.3	587	2.86	1.66	0.362	4.59	6.38	3.08	0.20	0.08	2.00	0.80	0.008	0.000	3.088
13	P13	0-15cm	6.4	456	3.73	2.16	0.737	2.94	3.62	7.46	0.23	0.06	6.24	0.92	0.005	0.000	7.455
14	P14	0-15cm	4.4	345	3.03	1.76	0.521	5.48	4.82	3.21	0.17	0.08	1.84	1.12	0.004	0.000	3.214
15	P15	0-15cm	4.8	266	3.59	2.08	0.560	3.71	3.88	1.70	0.19	0.07	0.96	0.48	0.004	0.000	1.704
16	P16	0-15cm	4.6	146	2.53	1.47	1.284	1.14	2.79	4.27	0.19	0.08	2.88	1.12	0.006	0.000	4.276
17	P17	0-15cm	4.7	817	2.98	1.73	0.905	1.91	1.65	3.17	0.13	0.08	2.00	0.96	0.007	0.000	3.177
18	P18	0-15cm	6.4	666	5.97	3.46	0.157	22.04	4.73	14.24	0.23	0.09	12.52	1.40	0.008	0.000	14.241
19	P19	0-15cm	5.9	361	2.71	1.57	0.477	3.29	1.62	5.57	0.13	0.08	3.92	1.44	0.005	0.000	5.575
20	P20	0-15cm	6.2	451	2.68	1.56	0.243	7.80	11.04	7.62	0.22	0.08	6.72	0.60	0.006	0.000	7.626
		Mean	**5.3**	**480**	**3.53**	**2.04**	**0.502**	**7.09**	**5.25**	**6.45**	**0.20**	**0.10**	**4.86**	**1.19**	**0.005**	**0.000**	**6.460**
		Std. Dev	**0.7**	**227**	**1.10**	**0.636**	**0.289**	**7.900**	**5.80**	**3.910**	**0.047**	**0.12**	**3.87**	**0.44**	**0.001**	**0.000**	**3.910**
		Lsd (p< 0.05)	**1.2**	**391**	**1.90**	**1.095**	**0.498**	**13.6**	**9.993**	**6.74**	**0.08**	**0.199**	**6.67**	**0.758**	**0.0017**	**0.000**	**6.740**

EC=Electrical Conductivity, OM=Organic Matter, OC=Organic Carbon, Total N=Total Nitrogen, C:N=Carbon-Nitrogen Ratio, P=Phosphorus, Ex K=Exchangeable Potassium. Ex.Na=Exchangeable Sodium, Ex.Ca=Exchangeable Calcium, Ex Mg=Exchangeable Magnesium, CEC=Cation Exchange Capacity, Ex. H^+=Exchangeable Hydrogen ion,Al^{3+}=Aluminum ion, ECEC=Effective Cation Exchange Capacity.

Table 11: Mean Separation of selected chemical properties for depth 15-30cm

S/N	Sampled point	Sampled Depth	Ph	EC (µS/cm)	Org. M (%)	Org. C (%)	Total N (%)	C:N	Av.P (mg kg^{-1})	CEC (cmol $_{kg}^{-1}$)	Ex. K (cmol kg^{-1})	Ex. Na (cmolkg^{-1})	Ex.Ca (cmol kg^{-1})	Ex Mg (cmol $_{kg}^{-1}$)	Ex_H+ (cmol Kg^{-1})	Ex. $_{Al}3+$ (cmol kg^{-1})	ECEC (cmol kg^{-1})
1	P1	15-30cm	5.6	143	1.88	1.09	0.041	26.59	0.94	3.15	0.13	0.06	2.16	0.80	0.004	0.00	3.154
2	P2	15-30cm	4.2	71	1.05	0.61	0.321	1.90	0.34	2.46	0.15	0.07	1.36	0.80	0.007	0.01	2.473
3	P3	15-30cm	5.0	146	1.60	0.93	0.277	3.42	0.68	2.76	0.13	0.07	1.76	0.80	0.005	0.00	2.765
4	P4	15-30cm	4.0	191	1.43	0.88	0.337	2.46	2.00	1.42	0.15	0.07	0.72	0.48	0.011	0.00	1.434
5	P5	15=30cm	5.2	86	1.99	1.16	0.268	4.37	1.00	3.16	0.20	0.08	2.32	0.56	0.005	0.00	3.158
6	P6	15-30cm	3.7	110	2.31	1.34	0.333	4.28	11.26	2.24	0.17	0.07	0.96	1.04	0.007	0.01	2.253
7	P7	15-30cm	6.8	252	2.65	1.54	0.304	5.07	2.45	5.45	0.25	0.08	4.08	1.04	0.005	0.00	5.455
8	P8	15-30cm	5.9	179	1.55	0.9	0.364	2.49	0.88	3.83	0.13	0.06	2.16	1.48	0.005	0.00	3.835
9	P9	15-30cm	5.6	206	2.31	1.34	0.617	2.17	1.14	5.08	0.14	0.06	4.40	0.48	0.006	0.00	5.086
10	P10	15-30cm	5.0	154	0.28	0.35	0.499	0.71	0.85	3.55	0.13	0.07	2.24	1.12	0.005	0.00	3.555
11	P11	15-30cm	5.2	196	2.26	1.31	0.527	2.49	1.00	2.69	0.14	0.07	1.84	0.64	0.004	0.00	2.694
12	P12	15-30cm	4.0	129	2.10	1.22	0.346	3.53	1.68	0.99	0.19	0.06	0.40	0.40	0.007	0.01	1.009
13	P13	15-30cm	6.7	173	1.48	0.86	0.346	2.49	6.24	2.98	0.19	0.07	2.08	0.64	0.004	0.00	2.984
14	P14	15-30cm	5.4	142	1.75	1.02	0.37	2.76	0.68	5.58	0.11	0.07	1.68	3.72	0.004	0.00	5.584
15	P15	15-30cm	4.3	142	2.59	1.51	0.266	5.66	1.50	2.01	0.16	0.10	0.96	0.80	0.008	0.01	2.031
16	P16	15-30cm	4.3	200	1.38	0.80	0.502	1.59	1.17	1.32	0.12	0.08	0.64	0.48	0.012	0.00	1.332
17	P17	15-30cm	4.7	101	2.59	1.50	0.469	3.20	1.00	1.39	0.11	0.08	0.80	0.40	0.008	0.01	1.404
18	P18	15-30cm	7.3	306	2.81	1.63	1.029	1.58	6.64	8.41	0.17	0.08	6.64	1.52	0.008	0.00	8.418
19	P19	15-30cm	5.9	150	1.93	1.12	0.659	1.70	1.03	3.88	0.12	0.08	3.04	0.64	0.005	0.00	3.885
20	P20	15-30cm	6.4	124	2.21	1.28	0.101	12.67	0.94	1.89	0.13	0.08	1.44	0.24	0.005	0.00	1.895
		Mean	**5.3**	**160**	**1.91**	**1.12**	**0.399**	**4.56**	**2.17**	**3.21**	**0.15**	**0.07**	**2.08**	**0.90**	**0.006**	**0.00**	**3.220**
		Std. Dev	**1.0**	**56**	**0.62**	**0.33**	**0.212**	**5.76**	**2.73**	**1.81**	**0.04**	**0.01**	**1.51**	**0.75**	**0.002**	**0.00**	**1.809**
		Lsd (p<0.05)	**1.8**	**96**	**1.06**	**0.57**	**0.3653**	**9.93**	**4.71**	**3.12**	**0.06**	**0.17**	**2.60**	**1.29**	**0.034**	**0.00**	**3.117**

EC=Electrical Conductivity, OM=Organic Matter, OC=Organic Carbon, Total N=Total Nitrogen, C:N=Carbon-Nitrogen Ratio, P=Phosphorus, Ex K=Exchangeable Potassium. Ex.Na=Exchangeable Sodium, Ex.Ca=Exchangeable Calcium, Ex Mg=Exchangeable Magnesium, CEC=Cation Exchange Capacity, Ex. H^+=Exchangeable Hydrogen ion,Al^{3+}=Aluminum ion, ECEC=Effective Cation Exchange Capacity.Std.Dev.=Standard Deviation,LSD=Least Significant Difference.

Table 12: Mean Separation of physical properties for depth 0-15cm and 15-30cm

S/N	Sampled Point	Sampled Depth(cm)	Clay (%)	Silt (%)	Sand (%)	Sampled Depth(cm)	Clay (%)	Silt (%)	Sand (%)
1	P1	15-30cm	3.4	4.8	91.9	0-15cm	3.5	4.1	92.4
2	P2	15-30cm	6.5	6.1	87.4	0-15cm	23.5	4.1	72.4
3	P3	15-30cm	3.4	4.2	92.4	0-15cm	5.5	8.1	86.4
4	P4	15-30cm	3.5	2.1	94.4	0-15cm	10.5	4.1	85.4
5	P5	15-30cm	3.5	6.1	90.4	0-15cm	7.9	5.7	86.4
6	P6	15-30cm	4.5	8.1	87.4	0-15cm	9.5	5.1	85.4
7	P7	15-30cm	3.5	2.1	54.4	0-15cm	5.5	6.1	84.4
8	P8	15-30cm	3.4	3.2	93.4	0-15cm	5.5	4.4	90.1
9	P9	15-30cm	3.5	5.4	91.1	0-15cm	3.5	6.4	90.1
10	P10	15-30cm	3.5	7.4	89.1	0-15cm	12.3	5.0	82.8
11	P11	15-30cm	3.5	5.4	91.1	0-15cm	5.5	5.4	89.1
12	P12	15-30cm	6.5	2.4	91.1	0-15cm	8.5	3.4	88.1
13	P13	15-30cm	3.4	1.4	95.3	0-15cm	5.5	4.4	90.1
14	P14	15-30cm	9.5	8.4	82.1	0-15cm	4.5	4.4	91.1
15	P15	15-30cm	4.5	6.4	89.1	0-15cm	18.4	6.4	75.3
16	P16	15-30cm	3.5	5.4	91.1	0-15cm	10.5	4.4	85.1
17	P17	15-30cm	3.5	1.4	95.1	0-15cm	1.3	2.4	96.4
18	P18	15-30cm	2.8	0.9	93.9	0-15cm	6.3	2.4	91.3
19	P19	15-30cm	3.3	2.4	94.3	0-15cm	3.3	4.4	92.3
20	P20	15-30cm	3.3	1.9	94.9	0-15cm	3.0	2.7	94.3
		Mean	**4.1**	**4.3**	**89.5**	**Mean**	**7.7**	**4.7**	**87.4**
		Std. Dev.	**1.6**	**2.4**	**8.9**	**Std. Dev.**	**5.4**	**1.4**	**5.8**
		Lsd (P<0.05)	**0.620**	**0.921**	**3.432**	**Lsd (P<0.05)**	**2.1**	**0.553**	**2.259**

. Std. Dev. = Standard Deviation, LSD=Least Significant Difference

Table 13: Mean Separation of forms of organic carbon for depth 0-15cm

S/N	Sampled point	Sampled Depth	TOC (%)	LOC (%)	MAOC (%)	ROC (%)	%LOC (%)	%ROC (%)
1	P1	0-15cm	1.86	0.55	1.31	7.56	7.0	93
2	P2	0-15cm	2.40	1.49	0.91	3.12	32	68
3	P3	0-15cm	1.62	0.75	0.87	5.40	12	88
4	P4	0-15cm	1.44	0.61	0.83	6.12	9.0	91
5	P5	0-15cm	1.74	0.55	1.19	3.54	13	87
6	P6	0-15cm	2.30	0.85	1.45	5.35	14	86
7	P7	0-15cm	3.90	2.24	1.66	7.96	22	78
8	P8	0-15cm	2.19	0.77	1.42	7.31	10	90
9	P9	0-15cm	2.37	1.20	1.17	6.51	17	84
10	P10	0-15cm	1.76	0.45	1.31	3.84	11	90
11	P11	0-15cm	1.89	1.33	0.56	5.21	20	80
12	12	0-15cm	1.66	0.89	0.77	7.94	10	90
13	P13	0-15cm	2.15	1.05	1.10	7.32	13	87
14	P14	0-15cm	1.76	1.55	0.21	5.54	22	78
15	P15	0-15cm	2.08	1.40	0.68	5.78	20	81
16	P16	0-15cm	1.47	1.11	0.36	5.27	17	83
17	P17	0-15cm	1.73	0.87	0.86	8.11	10	91
18	P18	0-15cm	3.46	2.40	1.06	8.26	23	77
19	P19	0-15cm	1.57	0.83	0.74	5.97	12	88
20	P20	0-15cm	2.02	1.07	0.95	7.91	12	88
		Mean	**2.07**	**1.10**	**0.97**	**6.20**	**15**	**85**
		Std. Dev.	**0.63**	**0.53**	**0.37**	**1.58**	**6**	**6**
		Lsd (P<0.05)	**0.2386**	**0.2029**	**0.1428**	**0.6105**	**2.7204**	**2.4189**

TOC=Total Organic Carbon, LOC=Labile Organic Carbon, MAOC=Mineral Associated Organic Carbon. Recalcitrant Organic Carbon, %LOC=Percentage Labile Organic Carbon, Percentage Recalcitrant Organic Carbon, Lsd=Least Significant Difference, Std. Dev.=Standard Deviation.

Table 14: Mean Separation of forms of organic carbon for depth `5-30cm

S/N	Sampled point	Sampled Depth	TOC (%)	LOCF (%)	MAOCF (%)	ROCF (%)	%LOCF (%)	%ROCF (%)
1	P1	15-30cm	1.09	0.27	0.82	3.62	7.0	93
2	P2	15-30cm	0.61	0.19	0.42	0.51	27	73
3	P3	15-30cm	0.99	0.31	0.62	2.15	13	87
4	P4	15-30cm	0.83	0.13	0.7	1.79	7.0	93
5	P5	15-30cm	1.16	0.17	0.99	1.94	8	92
6	P6	15-30cm	1.43	0.31	1.03	3.03	9	91
7	P7	15-30cm	1.54	0.34	1.2	3.03	10	90
8	P8	15-30cm	0.9	0.19	0.71	2.44	7	93
9	P9	15-30cm	1.34	0.48	0.86	3.76	11	89
10	P10	15-30cm	0.35	0.3	0.05	1.54	16	84
11	P11	15-30cm	1.31	0.72	0.59	3.05	19	81
12	P12	15-30cm	1.22	0.36	0.86	3.25	10	88
13	P13	15-30cm	0.86	0.29	0.57	2.11	12	90
14	P14	15-30cm	1.02	0.28	0.74	2.23	11	88
15	P15	15-30cm	1.51	0.79	1.02	2.55	24	89
16	P16	15-30cm	0.8	0.35	0.45	1.9	16	76
17	P17	15-30cm	1.5	0.62	0.88	3.87	14	84
18	P18	15-30cm	1.63	0.76	0.87	4.02	16	86
19	P19	15-30cm	1.12	0.56	0.56	3.59	14	84
20	P20	15-30cm	1.19	0.24	0.95	1.72	12	87
		Mean	**1.12**	**0.38**	**0.74**	**2.61**	**13**	**86**
		Std.Dev	**0.33**	**0.20**	**0.26**	**0.93**	**5**	**5**
		Lsd(p<0.05)	**0.13**	**0.35**	**0.10**	**0.36**	**2**	**2**

TOC=Total Organic Carbon, LOC=Labile Organic Carbon Fraction, MAOC=Mineral Associated Organic Carbon Fraction. Recalcitrant Organic Carbon Fraction, %LOC=Percentage Labile Organic Carbon Fraction, Percentage Recalcitrant Organic Carbon Fraction. Lsd =Least Significant Difference, Std. Dev.=Standard Deviation

3.2 Geospatial Distribution Map

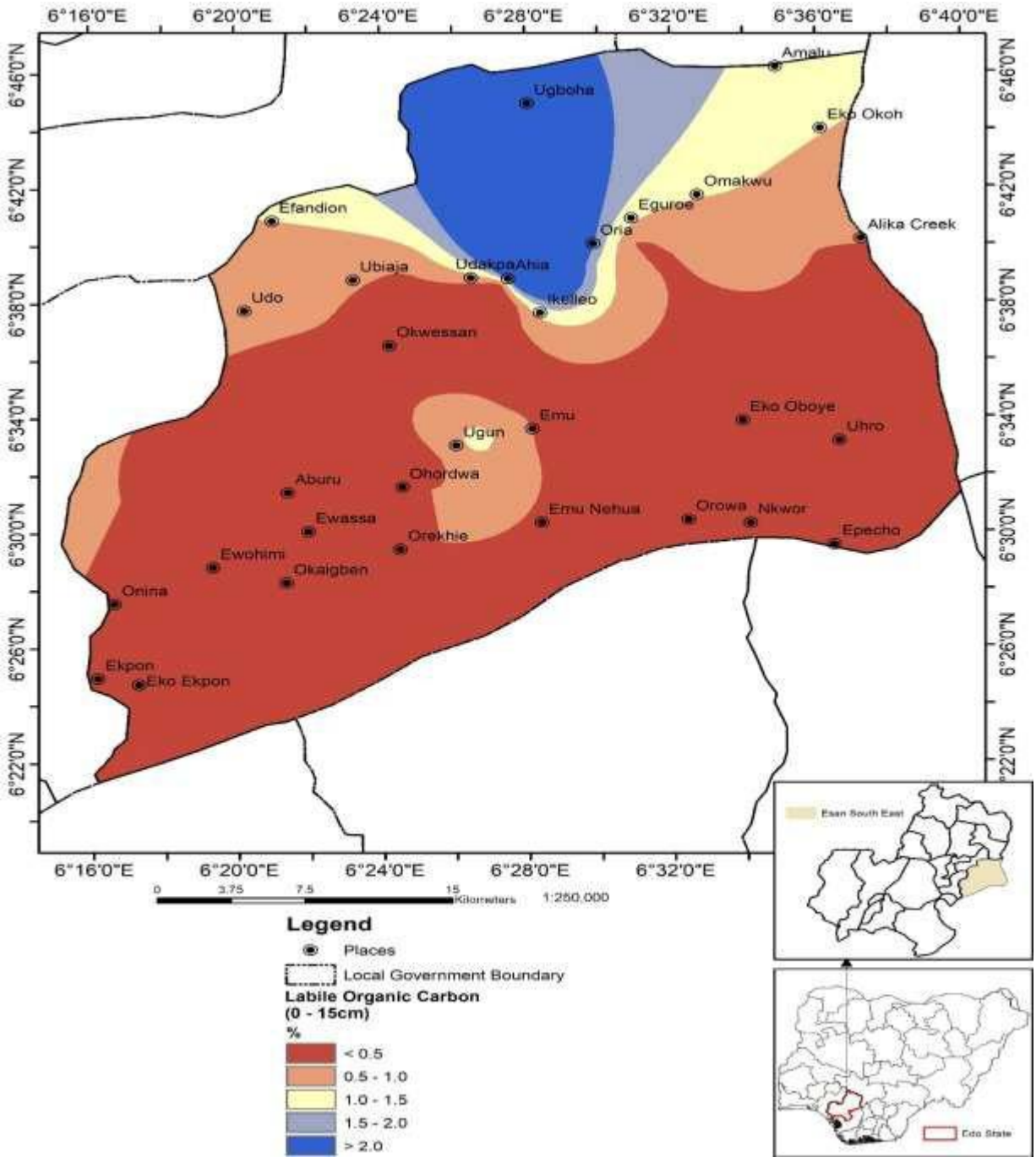

Figure 2: Esan South East Local Government Area map showing the geospatial distribution of Labile Organic Carbon contents for depth 0-15cm.

Figure 2 shows the geospatial distribution map of communities in Esan South East Local Government Area soils with high percentage content of LOC for depth 0-15cm as Ugboha, Eko-Ghenyen, Ahia and Oria while the communities with low LOC for the same depth include Onina, Orowa, Nkwor, Uloshi, Ekpon, Eko-Ekpon, Ekpecho, Ewohimi,Uhro, Eko-Oboye.

Figure 3 shows the communities with high percentage content of LOC for depth 15-30cm Ugun while the low percentage content communities for LOC for depth 15-30cm include Epecho, Uloshi, Illushi, Ikeken, Eko-Ghenyen, Urakhuan and Ahia.

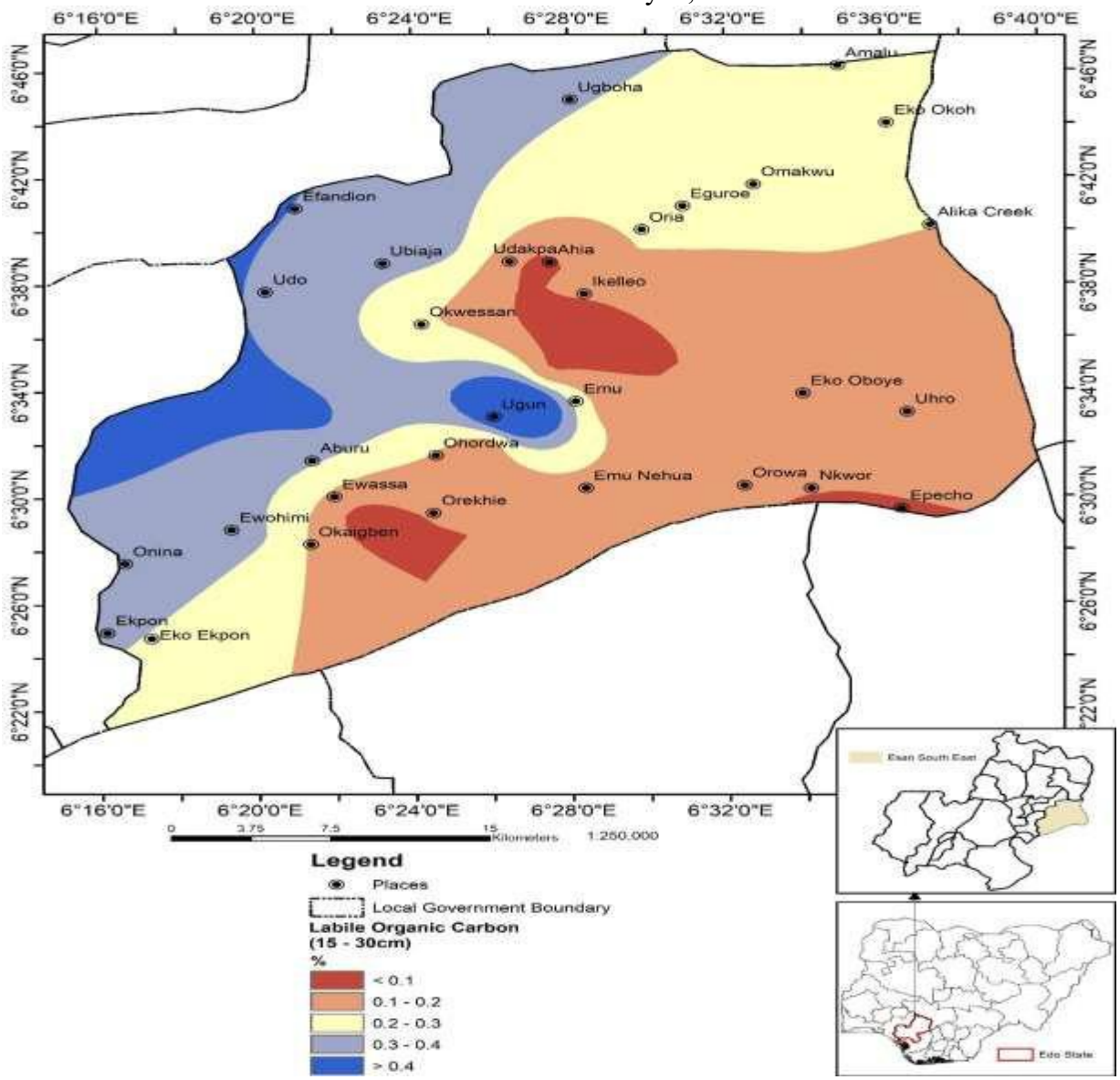

Figure 3: Esan South East Local Government Area map showing the geospatial distribution of Labile Organic Carbon contents for depth 15-30cm.

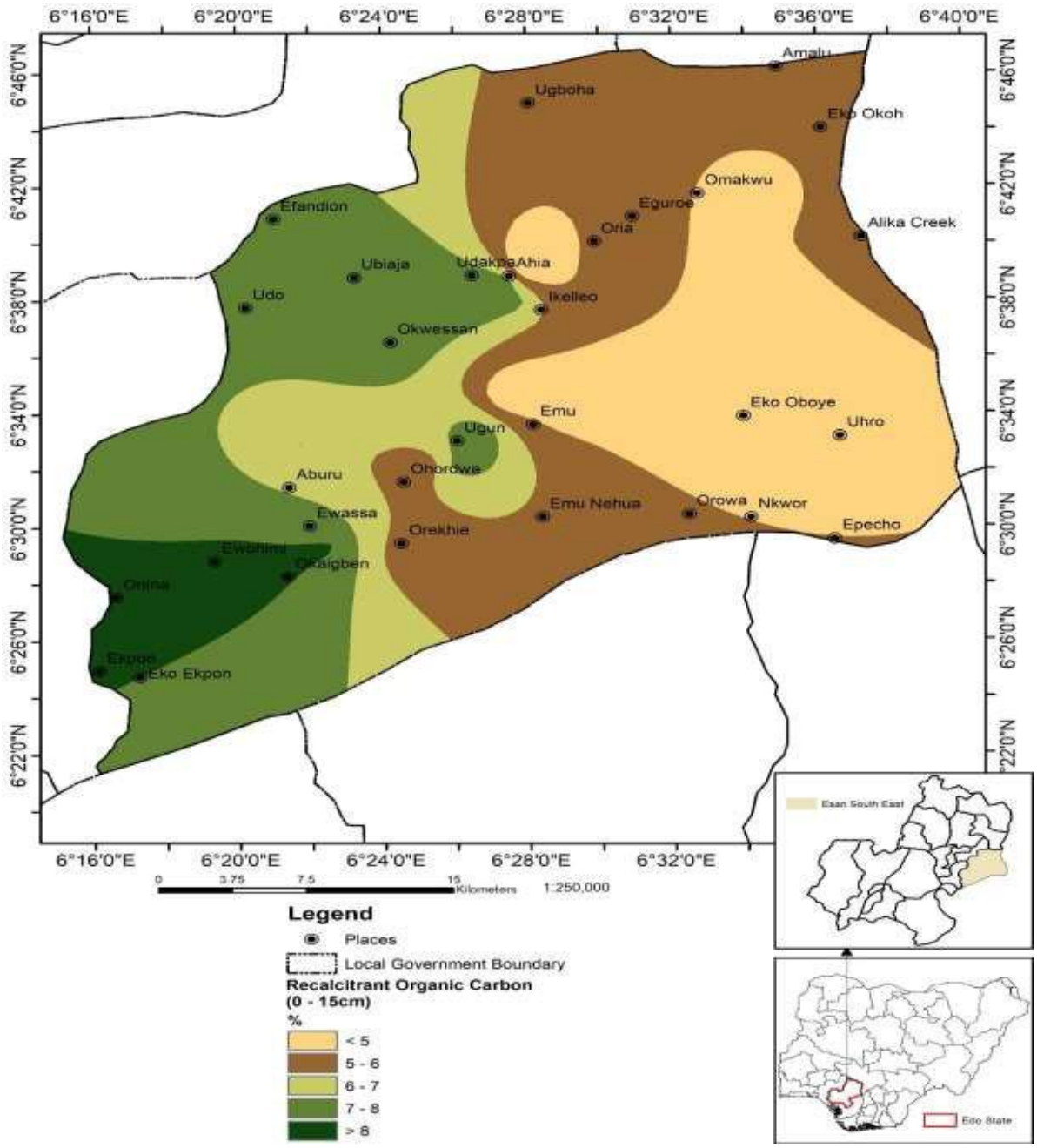

Figure 4: Esan South East Local Government Area map showing the geospatial distribution of Recalcitrant Organic Carbon contents for depth 0-15cm.

Figure 4 shows communities with high percentage content of ROC for depth 0-15cm as onina, Ewohimi, Okaigben, Ekpon, Eko-Ekpon and Eko-Ghenyen while Omakwu, Eko-Ooye, Uhro and Nkeor communities has low percentage content of ROC for depth 0-15cm

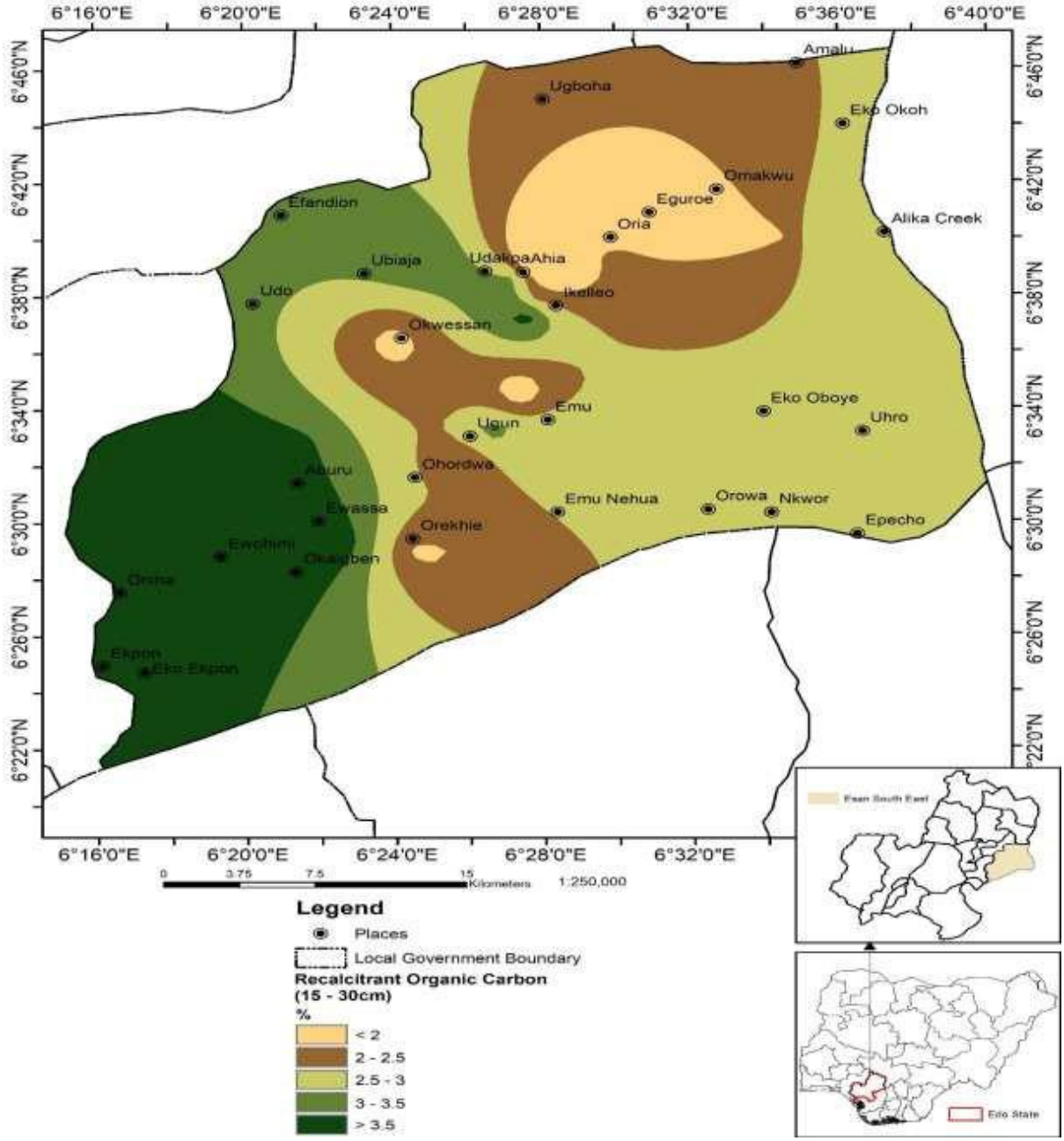

Figure 5: Esan South East Local Government Area map showing the geospatial distribution of Recalcitrant Organic Carbon contents for depth 15-30cm.

Figure 5 shows the communities with high percentage content of ROC for depth 15-30cm which include Ekpon, Eko Ekpon, Okaigben, Aburu, Ewasse, Ewohimi, Eko-Ghenyen, Urahhuan and Onina while the communities with low percentage content for ROC are Owessan, Oria.

3.3: Conclusion

Total Organic carbon fractions (labile and recalcitrant fraction) and distribution in the soils varied according to locations, topsoil depth and the land use options. In both cultivated and uncultivated soils, TOC pool decreased with topsoil depth, uncultivated soils stored higher TOC than the cultivated soils at 0–15 cm, and 15–30 cm depth. The lowest percentage mean value of LOC in Esan South East Local Government Area soils was 1.03 and the land use is grassland while the highest percentage mean value was 1.58 and the land use is forest. . In addition, percentage clay content, soil pH and C:N ratio are important determinants of TOC in these soils. The percentage of LOC in the total land area of Esan South East Local Government Area is 11.4%.

Reference

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