PRELIMINARY INVESTIGATION OF THE EFFECT OF TECHNOGENIC ACTIVITIES ON SOILS OF THE COASTAL PLAIN SANDS IN CALABAR, CROSS RIVER STATE, NIGERIA

***[1]Kokei Ikpi Ofem, [1]Tambari Kahbari Doneh, [2]Indumunu Glory Akinaka, [3]Benjamin Unuigbe, Patrick Katan Kefas**

[1]Department of Soil Science, Faculty of Agriculture, University of Calabar, Cross River State, Nigeria
[2]Department of Science Laboratory Technology, University of Calabar, Cross River State, Nigeria
[3]Department of Soil Science Technology, Federal College of Land Resources, Kuru – Plateau State, Nigeria
[4]Department of Soil Science and Land Resource Management, Faculty of Agriculture, Taraba State University, Taraba State, Nigeria
Corresponding Author's email: ofem8303@yahoo.com

ABSTRACT

Soils initially considered altered and severely influenced by technogenic and anthropogenic activities are often put into agricultural use without considering the extent to which technological properties have influenced the soils. This study focused on determining the physical and chemical properties of technogenic soils in Calabar Metropolis. Two profile pits were dug at Tinapa Resort in areas thought to have been influenced by construction, and one profile pit was sited at the University of Calabar oil palm estate (UCOP) for comparison. The study revealed that Tinapa's coastal plain soils had been influenced over the years by technogenic activities and differ in some properties from UCOP's coastal plain soils. Among the studied physical properties, bulk density varied between similar horizons, with values exceeding 1.6 Mg/m^3 in Tinapa and values below 1.6 Mg/m^3 in UCOP, while particle size distribution showed little difference. Chemically, soil pH (5.5–7.2) was significantly higher in Tinapa Resort, while organic carbon (4.6–12.1 g/kg) was lower in UCOP. Exchangeable basic cations and cation exchange capacity did not significantly differ between Tinapa and UCOP coastal plain soils. This variation in soil properties, despite similarities in soil formation factors, suggests the influence of technogenic activities such as road and building construction, surface soil removal, and cement's impact on the soils.

Keywords. Technosol; Coastal plain soils; Acid sands; Tinapa Resort

INTRODUCTION

Technogenic soils, significantly transformed by human activities, are rich in artifacts and commonly found in urban and industrial areas (WRB, 2015; Kabała *et al.*, 2019; Schad, 2018). The World Reference Base (WRB, 2022) recognizes Technosols as a distinct Reference Soil Group due to the extensive alteration of many soils. Technosols are characterized by a significant presence of artifacts, sealing by human-made hard materials, or containment of geo-membranes, distinguishing them from natural rock. These soils originate from urban, industrial, mining, and waste areas, including those sealed beneath asphalt and concrete, and soils on urban rooftops. The United States Soil Taxonomy is considering a new order, Artesols, to classify such soils (Galbraith, 2022).

Technosols are more susceptible to contamination due to potential toxic substances from industrial processes (Scalenghe and Ferraris, 2009). Urban soils exhibit unique spatial patterns reflecting historical and current land use, making their heterogeneity a special case (Greinert, 2015; Hulisz *et al.*, 2018). Understanding soil heterogeneity in urbanized areas is crucial for effective management, particularly in identifying changes and threats from urbanization and industrialization.

Despite their unique physicochemical and geochemical properties, transformations in technogenic soils remain understudied (Barnhisel and Massey, 1969; Galbraith, 2022). Restoring ecological functions in post-mine and construction sites stimulates soil formation and biological activities, indirectly affecting soil environment diversity (Grządziel *et al.*, 2019).

Howard's concept (Howard, 2021) addresses urban anthropogenic soil formation through metapedogenesis, technopedogenesis, and ekranopedogenesis. The significant environmental impact of man-made materials, differing from natural origin materials, cannot be overlooked. Technogenic soil development depends on factors such as natural soil properties, time since disturbance, mass transfer of soil material, water input, atmospheric deposition, vegetation, debris, and land management. According to the IUSS Working Group WRB (2015), a soil qualifies as Technosol if it contains technogenic hard material within 5 cm, a geo-membrane, or significant artifacts within 100 cm.

Soils severely altered by technogenic and anthropogenic activities are often repurposed for urban or home agriculture without considering the imposed technological properties. This study investigates the physical and chemical properties of some soils influenced by technic properties, and commonly used for urban and domestic farming, to optimize their use and efficiency. Specifically, this research aims to determine the physical and chemical properties of soils with technic properties in the Tinapa Resort area of Calabar Municipal for post-construction use.

MATERIALS AND METHODS

Location, climate and vegetation of the study area

The current study was conducted in Tinapa Resort, Calabar Municipality, the capital city of Cross River State, Nigeria. Calabar Municipality is situated between latitudes 4˚50'N and 5˚10'N and longitudes 8˚17'E and 8˚20'E, bounded by Odukpani, Akpabuyo, and Calabar South Local Government Areas (Figure 1). Calabar Metropolis lies between the Great Kwa River to the east and the Calabar River to the west, covering an estimated land area of approximately 274.6 km² with a population of about 2,311,297 people.

Geologically, the area's soils are underlain by coastal plain sands belonging to Tertiary Sedimentary deposits. The hydrological province comprises basement and intrusive rocks, sandstone, shale, and alluvial deposits. Coastal plain sands and shales dominate the Calabar formation, extending from Adiabo through Odukpani areas.

Climatically, Calabar features a tropical monsoon climate (Köppen: Am), characterized by a lengthy wet season spanning ten months and a relatively short dry season covering the remaining two months. Temperatures range from 25 to 28 °C, with minimal daytime and nighttime variations. Average annual precipitation exceeds 3,000 mm, peaking in

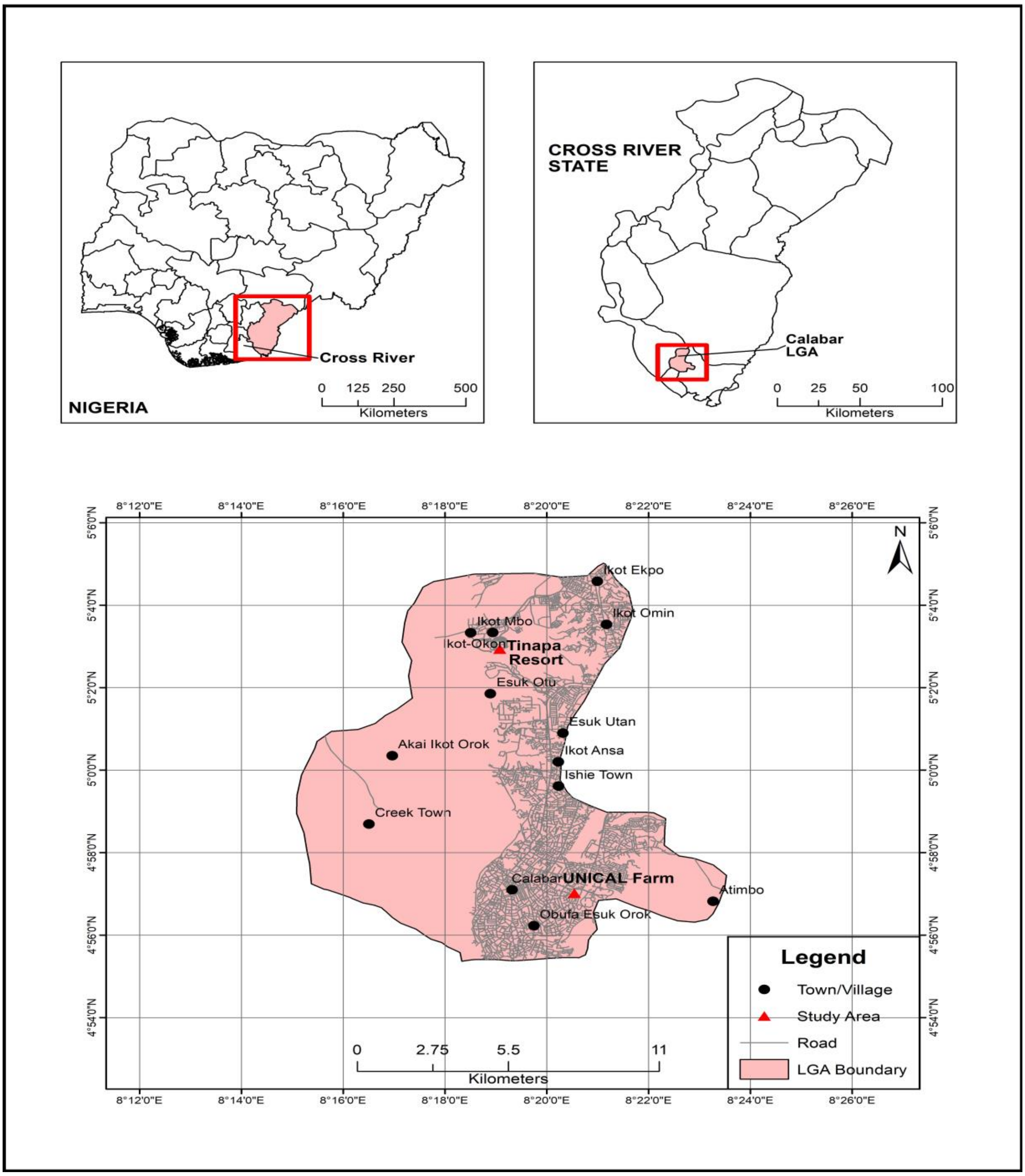

Figure 1: Calabar Municipal showing study locations in Tinapa Resort and UniCal Oil palm Estate

Plate 1: Profile pits (TNP1 and TNP2) at Tinapa Resort, Calabar

August. Relative humidity fluctuates between 87 in June and 70 % in January and December.

The vegetation in Calabar Municipality primarily consists of tropical rainforests and swamp or mangrove forests in areas with poorly drained soil conditions. However, there has been significant depletion of the rainforest.

Field studies

Field reconnaissance visit was made to Tinapa in Adiabo where soil profile pits; TNP1 (N0423506, E0558072) and TNP2 (N0424126, E0558572) were sited (Plate 1), and the University of Calabar Oil palm estate (UCOP) (N0427722, E0546197) was sited (Plate 2). The soils in Tinapa have been influenced by heavy construction and exhibit technic properties. Also, soil profile pit was sited at UCOP which acted as a control to check the technic extent of the Tinapa soils. Both soils are of the Coastal plain sands.

The locations of the pits were georeferenced with the aid of a global positioning system and soil profiles sited in an East-West direction and dug to specification. Soil samples were collected from identified horizons starting from the deepest horizons to the top. The soil samples were transported to the laboratory in labelled polythene bags and air-dried under laboratory conditions. Soil samples were grinded with a wooden pestle to break crumbs of peds to pass through a 2mm mesh to separate the fine fraction from the coarse component. However, samples meant for total nitrogen determination were sieved through a 0.5 mm mesh. The fine fractions were then subjected to physical and chemical analyses. Furthermore, samples meant for soil bulk density determination were collected vertically with metal rings with known volume.

Laboratory analyses

Particle size distribution was determined using the Bouyoucos hydrometer method with sodium hexametaphosphate as a dispersant. Meanwhile, core soil samples for bulk density analysis were oven-dried at 105 °C to constant weight. Total porosity was calculated from the bulk density and an estimated particle density of 2.65 Mg/m^3. Gravimetric water content was obtained by expressing soil moisture content as a percentage of soil wet-weight.

Plate 2: Profile pit (UCOP) at the University of Calabar Oil palm Estate

Soil pH was determined using a glass electrode pH meter with a water: soil mixture ratio of 2.5:1. Soil organic carbon was determined by the Walkley-Black wet oxidation method, employing diphenylamine as an indicator and potassium dichromate as an oxidizing agent in the presence of concentrated sulfuric acid.

Total nitrogen was determined through total macro-Kjeldahl digestion. Available phosphorus (P) was extracted with Bray No. 1 solution, which extracts adsorbed forms of phosphate, and measured colorimetrically. Exchangeable bases were extracted with NH_4OAc at pH 7, exchangeable K^+ and Na^+ were determined by flame photometry, whereas Mg^{2+} and Ca^{2+} were determined by atomic absorption spectrometry. Exchangeable hydrogen (H^+) and aluminum (Al^{3+}) were determined by extracting with KCl using phenolphthalein as an indicator. Cation exchange capacity (CEC) was measured at pH 7.0 using ammonium acetate as the extractant. Base saturation was calculated by expressing the sum of exchangeable basic cations as a percentage of CEC. All analyses were carried out following the procedures of Soil Survey Staff (2014).

Statistical analysis

Laboratory data were analyzed statistically using the unpaired t-test in Statview software (version 2.1) at a significance level of 5%.

RESULTS AND DISCUSSION

Physical properties of the soils

The physical properties of the soils are presented in Table 1, while the results of statistical analyses are shown in Tables 2 and 3.

Sand content in the soils ranged from 727 to 907 g/kg in Tinapa, compared to 777 - 907 g/kg in the University of Calabar Oil Palm (UCOP) estate. These values are similar with sand content that exceeds 700 g/kg, suggesting soil development from similar parent materials. Previous studies by Akpa *et al*. (2019), Ofem and Esu (2015), and Essoka and Esu (2002) reported sand contents of 769, 533-633, and 304-598 g/kg, respectively, for coastal plain soils of Calabar, coastal sediments of Calabar South, and inland valleys of Central Cross River State. These findings suggest that coastal plain soils typically have sand content exceeding 700 g/kg and are relatively unaffected by technological processes. However, the sand content in pedon UCOP was significantly higher than in TNP1 ($p < 0.05$; Table 3).

Silt content in Tinapa ranged from 10 to 60 g/kg, while UCOP had a narrower range of 30-50 g/kg. The similar ranges across locations suggest that silt content is relatively unaffected by technic activities in the Tinapa area. In contrast, previous studies reported higher silt contents: 84 g/kg in Akani Esuk Orok

Community, Calabar (Akpa *et al*., 2019); 87-837 g/kg in Calabar South, Nigeria (Ofem and Esu, 2015); and 120-460 g/kg in inland valley soils of Central Cross River State (Essoka and Esu, 2002).

TABLE 1: Physical properties of the studied soils

Horizons	BD (Mg/m^3)	%TP	g/kg Sand	g/kg Silt	g/kg Clay	Textural class
TNPI						
0-22 (A)	1.52	42.64	737	40	223	Sandy clay loam
22-67 (B)	1.58	40.37	737	30	233	Sandy clay loam
67-155 (C)	1.55	41.5	727	10	263	Sandy clay loam
155-200 (D)	1.55	41.5	727	10	263	Sandy clay loam
TNP2						
0-17 (A)	1.7	35.84	907	60	33	Sand
17-56 (B)	1.7	35.84	877	20	103	Loamy sand
56-102 (C)	1.81	31.69	857	30	113	Loamy sand
102-187 (D)	1.75	33.96	877	20	103	Loamy sand
UCOP						
0-13 (A)	1.32	50.18	907	50	43	Sand
13-67 (B)	1.52	42.64	827	40	133	Loamy sand
67-107 (C)	1.56	41.13	787	30	183	Sandy loam
107-200 (D)	1.56	41.13	777	30	193	Sandy loam

TABLE 2: Mean Effect of Horizons on physical properties of UCOP, TNP1 and TNP2

Source of Variance	BD	TP	Sand	Silt	Clay
A-Horizon	1.513	42.887	840.33	36.67	123.00
$LSD_{(0.05)}$	0.036*	51.455	82.333	2.533	84.000
B-Horizon	1.600	39.617	813.67	30.00	156.33
$LSD_{(0.05)}$	0.008*	11.986	50.333	1.000	46.333
C-Horizon	1.640	38.107	790.33	23.33	186.33
D-Horizon	1.620	38.863	793.67	20.00	186.33
$LSD_{(0.05)}$	0.013*	18.066	58.333	1.000	64.333

TABLE 3: Mean Effect of profiles UCOP, TNP1 and TNP2 on soil physical properties.

Source of Variance	BD	TP	Sand	Silt	Clay
UCOP	1.490	43.770	824.50	37.50	138.00
$LSD_{(0.05)}$	0.013*	18.768	34.917	0.917	47.000
TNP1	1.550	41.502	732.00	22.50	245.50
$LSD_{(0.05)}$	0.001**	0.859	0.333	2.250	4.250
TNP2	1.740	34.333	872.00	22.50	105.50
$LSD_{(0.05)}$	0.003*	3.889	1.000	0.250	0.250
UCOP*TP1	0.346	0.045*	0.021*	0.142	0.024*
TNP2*UCOP	0.007*	0.007*	0.164	0.032*	0.381
TNP1*TNP2	0.006*	0.001**	<0.001**	0.000	<0.001**

In Tinapa, clay content ranged from 33 to 263 g/kg, while in UCOP, it ranged from 43 to 193 g/kg. The similarity in these values suggests minimal alteration in clay content despite heavy construction activities in the Tinapa area. However, the lower limits of values in this study were lower than those reported by other researchers. For instance, clay content in coastal plain soils of Akani Esuk Orok Community, Calabar, ranged from 140 to 180 g/kg (Akpa *et al*., 2019), 128 to 191 g/kg in soils derived from coastal sediments (Ofem and Esu, 2015), and 142 to 502 g/kg in inland valley soils of Central Cross River State (Essoka and Esu, 2002). The clay content in TNP1 significantly exceeded that in UCOP at $p < 0.05$. However, the respective horizons did not differ significantly.

The bulk density of Tinapa soils ranged from 1.52 to 1.81 Mg/m³, whereas UCOP soils had a range of 1.32 to 1.56 Mg/m³. Bulk density values exceeding 1.60 Mg/m³ in Tinapa imply reduced soil aeration and water movement (Esu, 2010), as well as potential impairment of plant root growth. The irregular distribution of bulk density values in Tinapa may have resulted from periodic soil disturbance due to heavy-duty equipment. These values exceed those reported by Akpa *et al*. (2019) and Ahn (1993), who presented 1.3 and 1.5-1.6 Mg/m³, respectively, for coastal plain soils. The bulk density of pedon TNP2 significantly exceeded values in UCOP and TNP1 at $p < 0.05$, both horizon-wise and pedon-wise.

Soil total porosity in Tinapa ranged from 31.69 to 42.64%, compared to 41.13 to 50.18% in UCOP, which was comparatively higher, possibly due to soil compaction during construction in Tinapa. Values of total porosity in Tinapa are lower than those reported by Essoka and Esu (2002) and Kaczmarek *et al*. (2021), who presented 40.8-64.7 and 62.20-63.68%, respectively, for surface soils. Total porosity of UCOP significantly exceeded values in Tinapa at $p < 0.05$, pedon-wise.

Chemical Properties of the Soils

The chemical properties of the soils are presented in Table 4. Soil pH in Tinapa ranged from 5.5 to 7.2, compared to 5.2-5.4 in UCOP. According to Holland *et al*. (1989), Tinapa soils were strongly acid to neutral, while UCOP soils were strongly acid. Higher soil pH values in Tinapa suggest the impact of $CaCO_3$ from cement used for construction, even after long periods. These values exceed those reported by Akpa *et al*. (2019), Akpan-Idiok and Ukwang (2006), and Akpan-Idiok and Esu (2001), who presented values below 5.4 for coastal plain soils in Calabar.

Soil organic carbon in Tinapa ranged from 4.68 to 12.06 g/kg, whereas in UCOP, values ranged from 9.07 to 16.85 g/kg. According to Holland *et al*. (1989), UCOP soils had medium to high organic carbon levels. These values appear similar for both locations, possibly due to agricultural land use in UCOP, which may have depleted soil organic carbon. Comparatively higher values of 68.2 and 16.6 - 70.6 g/kg have been reported by Akpa *et al*. (2019) and Ofem and Esu (2015) in the soils of Calabar area, and 14.5 g/kg in the coastal plain soils of Akwa Ibom (Udo, 1977). The organic carbon of UCOP significantly exceeded values in TNP1 and suggests the impact of Technic activities on the soils of Tinapa, particularly the removal of surface soils during construction. Organic carbon is an important soil quality indicator for agronomic purpose (Onweremadu *et al*., 2008).

The total nitrogen content of Tinapa soils ranged from 1.0 to 1.61 g/kg, compared to 1.08 to 1.63 g/kg in UCOP, earning a low rating on the Holland *et al*. (1989) scale. Similar results have been reported for coastal plain soils in Calabar, with values of 1.04 g/kg (Akpa *et al*., 2019) and 0.80-1.00 g/kg (Akpan-Idiok and Ukwang, 2006). The low total nitrogen levels may be attributed to active microbial activities, leaching of nitrates, and removal of vegetations from the environment.

TABLE 4: Chemical properties of the studied soils

Source of Variance	pH	SOC	TN	Avail.P	K	Na	Ca	Mg	H	Al	CEC	BS
A-Horizon	5.433*	11.60	1.45**	29.053	0.115	0.361	4.267	2.133	0.733	0.573	43.500	15.760
$LSD_{(0.05)}$	**0.043**	**0.302**	**0.001**	**10.715**	**1.403**	**0.202**	**2.013**	**1.724**	**0.071**	**0.295**	**284.440**	**0.109**
B-Horizon	5.567	0.681*	1.24	27.913	0.115	0.399	4.000*	2.267	1.053*	0.353	43.667	15.848
$LSD_{(0.05)}$	**0.093**	**0.039**	**0.029***	**3.759**	**1.423**	**0.253**	**0.040**	**1.453**	**0.026**	**0.099**	**95.103**	**5.652**
C-Horizon	5.967	0.668	1.14	28.963	0.124	0,110	3.533	3.200	1.187	0.533	49.267	14.094
D-Horizon	6.100	0.701*	11.00	26.690	0.128**	0.091	3.500	1.733	1.053	0.347	57.600	15.224
$LSD_{(0.05)}$	**0.930**	**0.053**	**1.030**	**20.280**	**0.001**	**1.003**	**3.720**	**0.853**	**0.266**	**0.169**	**57.990**	**2.826**

TABLE 5: Mean Effect Horizons of UCOP, TNP1 and TNP2 on Soil Properties

Horizons	pH	SOC g/kg	TN	Avail. P mg/kg	K+	Na+	Ca2+	Mg2+ cmol/kg	H+	*Al3+*	CEC	BS %
TNP1												
0-22 (A)	5.6	5.88	1.11	25.87	0.121	0.10	5.8	1.8	0.96	0.64	48.5	16.1
22-67 (B)	5.5	5.48	1.09	30.14	0.123	0.11	4.0	3.4	1.08	0.46	53.3	14.3
67-155 (C)	5.7	4.68	1.21	26.89	0.131	0.101	2.4	2.8	1.2	0.8	39.9	13.6
155-200 (D)	5.7	4.68	1.21	26.89	0.131	0.101	2.4	2.8	1.2	0.8	39.9	13.6
TNP2												
0-17 (A)	5.5	12.06	1.61	28.88	0.122	0.102	3.0	0.6	0.8	0	24.7	15.5
17-56 (B)	5.9	5.88	1.21	26.60	0.12	0.108	3.8	2.4	0.88	0	43.9	14.6
56-102 (C)	6.9	4.68	1.00	25.66	0.14	0.128	5.0	4.4	1.28	0	67.4	14.3
102-187 (D)	7.2	6.88	1.01	31.09	0.151	0.081	6.0	1.2	0.48	0	43.8	16.9
UCOP												
0-13 (A)	5.2	16.85	1.63	32.41	0.101	0.88	4.0	4.0	0.44	1.08	57.3	15.7
13-67 (B)	5.3	9.07	1.41	27.0	0.101	0.98	4.2	1.0	1.2	0.6	33.8	18.6
67-107 (C)	5.3	10.67	1.52	34.34	0.101	0.10	3.2	2.4	1.08	0.8	40.5	14.3
107-200 (D)	5.4	9.47	1.08	22.09	0.101	0.09	3.0	1.2	1.48	0.24	29.1	15.1

TABLE 6: Mean Effect of Profile UCOP, TNP1 and TNP2 on Soil Properties

Source of Variance	pH	SOC	TN	Avail. P	K	Na	Ca	Mg	H	Al	CEC	BS
UCOP	5.300	11.52	1.41	28.960	0.101	0.512	3.600	2.150	1.050	0.680	40.175	15.917
$LSD_{(0.05)}$	**0.007***	**0.131**	**0.001****	**30.628**	**0.000**	**0.234**	**0.347**	**1.903**	**0.193**	**0.125**	**152.22**	**3.463**
TNP1	5.625	5.18	1.15	27.448	0.127	0.103	3.650	2.700	1.110	0.675	45.400	14.418
$LSD_{(0.05)}$	**0.009***	**0.004***	**4.100**	**3.453**	**2.767**	**2.200**	**2.623**	**0.440**	**0.013***	**0.026***	**44.173**	**1.405**
TNP2	6.375	7.38	1.21	28.058	0.133	0.105	4.450	2.150	0.860	0.000	55.95	15.359
$LSD_{(0.05)}$	**0.649**	**0.106**	**0.001****	**5.915**	**2.209**	**3.743**	**1.743**	**2.510**	**0.108**	**0.000**	**305.50**	**1.383**
						Interaction						
UCOP*TP1	0.002*	0.013*	0.083	0.622	<0.001**	0.1415	0.955	0.994	0.801	0.980	0.484	0.223
TNP2*UCOP	0.037*	0.139	0.317	0.775	0.005*	0.1431	0.284	0.564	0.515	0.008*	0.671	0.303
TNP1*TNP2	0.114	0.232	0.731	0.704	0.425	0.8662	0.472	0.000	0.201	0.001**	0.963	0.630

* = significant at $P<0.05$; ** = significant at $p< 0.01$. SOC: Soil organic carbon, TN: Total nitrogen, CEC: cation exchange capacity, BS: Base saturation

However, total nitrogen in the B and C horizons of UCOP significantly exceeded that in TNP1 and TNP2 at $p < 0.05$.

Available phosphorus had range of 25.66 – 31.09 mg/kg in Tinapa and 22.09 - 34.34 mg/kg in UCOP and was rated high on the scale of Holland *et al.* (1989) as values exceeded 20 mg/kg. In the Calabar area, similar soils had 24.7 mg/kg (Akpa *et al.*, 2019) and 32.79 - 73.06 mg/kg (Akpan-Idiok and Ukwang, 2006) for available P, whereas Udo (1994) and Ogban *et al.* (1998) published values within the range of 19.2 – 103.2 mg/kg for similar soils in Akwa Ibom State. Available P did not vary by the horizon and pedons in UCOP and Tinapa at $p < 0.05$. High available P as obtained in the current study is required for cell division and development of growing plant tips.

Exchangeable Ca^{2+} dominated the soils' exchange complex, but its concentration was less than 6.0 cmol/kg in both UCOP and Tinapa areas, rating low to moderate on the Holland *et al.* (1989) scale. The relatively higher values in Tinapa can be attributed to cement concretionary materials, as coastal plain soils are often leached of exchangeable Ca^{2+}. The obtained values for exchangeable Ca^{2+} (1.0–8.2 cmol/kg) align with those reported by Akpan-Idiok and Ukwang (2006). Although exchangeable Ca concentrations did not vary significantly between pedons UCOP, TNP1, and TNP2, the B horizon of UCOP had significantly higher values than TNP1 and TNP2 ($p < 0.05$).

Exchangeable Mg^{2+} in Tinapa ranged from 0.6 to 4.4 cmol/kg, while UCOP values ranged from 1.0 to 4.0 cmol/kg, rating moderate to high on the Holland *et al*. (1989) scale. These values are lower than the 1.0–12.0 cmol/kg reported by Akpan-Idiok and Ukwang (2006) for similar soils. Exchangeable Mg^{2+} was significantly affected by technogenic characteristics in the area ($p < 0.05$).

Exchangeable K^+ in Tinapa ranged from 0.12 to 0.15 cmol/kg, while UCOP values ranged from 0.101 to 0.101 cmol/kg. These values are below 0.20 cmol/kg, indicating low K concentration on the Holland *et al.* (1989) scale. The low concentration is likely due to leaching by high rainfall in the tropical rainforest area. These values are similar to those reported by Akpan-Idiok and Ukwang (2006) in the Calabar area (0.09–0.14 cmol/kg). Exchangeable K^+ in Tinapa significantly exceeded UCOP values ($p < 0.05$). Exchangeable Na^+ was below 0.2 cmol/kg in the studied soils, rating low on the Holland *et al.* (1989) scale. These values are similar to those reported by Akpan-Idiok and Ukwang (2006) for coastal plain soils in Calabar (0.08–0.11 cmol/kg).

Exchangeable H^+ was less than 1.5 cmol/kg in both locations, while exchangeable Al^{3+} ranged from 0.00 to 0.8 cmol/kg, appearing lower than H^+ concentrations. The relatively low exchangeable acidity may be due to cement influences in the Tinapa area, which raised soil pH. Akpan-Idiok and Ukwang (2006) reported total acidity ranges of 4.32–9.12 cmol/kg in Calabar, while Ofem and Esu (2015) reported exchangeable H^+ values up to 7.4 cmol/kg in coastal plain sediments.

The cation exchange capacity (CEC) of Tinapa soils ranged from 24.75 to 56.74 cmol/kg, while UCOP values ranged from 29.1 to 57.3 cmol/kg, rating high on the Holland *et al*. (1989) scale. These values are similar to 14.0–83.0 and 18.5–27.2 cmol/kg reported by Ofem and Esu (2015) and Pal *et al*. (1990), respectively. The similarity indicates minimal influence of technic activities on CEC. High CEC suggests support for most crops' growth. All soil horizons in both locations had relatively similar CEC values ($p < 0.05$).

Base saturation was less than 35% in both Tinapa and UCOP, rating low on the Holland *et al.* (1989) scale, indicating minimal influence of technic activities. Despite moderate to high exchangeable Mg and Ca levels, these ions may not be available for plant root uptake. The obtained values were lower than those reported by Akpa *et al*. (2019), Akpan-Idiok and Ukwang (2006), and Ofem and Esu (2015) for coastal plain soils and coastal sediments.

Summary and conclusion

The soils were dominated by sand-sized grains, with values exceeding 700 g/kg at all depths. Meanwhile, soil bulk density was significantly higher in the Tinapa Resort area, with values exceeding 1.6 Mg/m^3, whereas UCOP had values below 1.6 Mg/m^3. Soil pH and exchangeable Ca^{2+} were significantly higher in Tinapa soils compared to UCOP. Furthermore, the cation exchange capacity, exchangeable Ca^{2+}, and Mg^{2+} were rated high in these soils. Despite similarities in lithology, climate, living organisms, and local relief, the soils differed in bulk density, soil pH, and organic carbon. Therefore, there is a need to conduct soil tests on technogenically altered soils before engaging in agronomic activities, regardless of similarities in soil formation factors.

REFERENCES

Akpa, E. A., Eyong, M. O., Afu, S. M., & Olim, D. M. (2019). Hydraulic Properties of Soils of Akani Esuk Orok in Calabar, Cross River State, Nigeria. Department of Soil Science,

Ahn, P. M. (1993) Tropical Soils and Fertilizer Use. Longman Scientific Technical, U.K.264pp.

Akpan - Idiok, A. U. & Esu, I. E. (2001). Morphological Characteristics and Classification of Mangrove Swamp Soils in Cross River State Estuary, Southeast - Nigeria. In Management of Wetland Soils for Sustainable Agriculture and environments proceedings of the 27th Annual soils Sciences Society of Nigeria conference. 60 – 80.

Akpan-Idiok, A. U. & Ukwang, E. E. (2006). Characterization and Classification of Coastal Plain Soils in Calabar, Nigeria. Department of Soil Science, University of Calabar, Nigeria, Department of Geology, University of Calabar, Nigeria.

Barnhisel & Massey, (1969) R.I. Barnhisel, H.F. Massey Chemical, mineralogical and physical properties of eastern Kentucky acid-forming coal spoil materials Soil Sci., 108 (5) (1969), pp. 367-372, 10.1097/00010694-196911000-00010

Essoka, A. N. & Esu, I. F. (2002). Physical properties of Inland Valley Soils of Central Cross River State, Nigeria. (Received 26 July 2002; Revision accepted 25 November, 2002).

Esu, I. E. (2010). Soil characterization, classification and survey. Hinneman Educational Book Publishers Plc. Nigeria. Pp. 232

Galbraith, J., (2022). Explaining the new Soil Order in Soil Taxonomy. Proceeding of the VI International Soil Classification Conference ISCC2020+2. https://youtu.be/O8 CW1eM53ik.

Greinert, A. (2015) The heterogeneity of urban soils in the light of their properties J. Soils Sediments.

Grządziel, K.J. Furtak, A. Gałązka (2019) Community-level physiological profiles of microorganisms from different types of soils that are characteristic to Poland-a long term microplot experiment Sustainability,11(1), Pp. 1-17

Holland, M.D.G; Barton, A.D and Morph, S.T (1989). Land Evaluation for Agricultural Recommendation of Cross River National Park. Oban Division. Prepared by Odwki in Collaboration with INNF.

Howard, J. L. (2021). Urban anthropogenic soils: A Review. *Advances in Agronomy*, 165: 1 - 57

Hulisz, P. (2018) Technogenic layers in organic soils as a result of the impact of the soda industry Eurasian Soil Sci.

IUSS Working Group WRB, 2022. World Reference Base for Soil Resources: International Soil Classification System for Naming Soils and Creating Legends for Soil Maps, 4th edn. International Union of Soil Sciences (IUSS), Vienna, Austria.

IUSS Working Group WRB, 2015.World Reference Base for Soil Resources 2014, update 2015. World Soil Resources Reports.

Kabała, C., Charzyński, P., Chodorowski, J., Drewnik, M., Glina, B., Greinert, A., Hulisz, P., Jankowski, M., Jonczak, J., Łabaz, B., Łachacz, A., Marzec, M., Mendyk, Ł., Musiał, P., Musielok, Ł., Smre-czak, B., Sowiński, P., Świtoniak, M., Uzarowicz, Ł., Waroszewski, J., 2019. Polish Soil Classification, 6th edition – principles, classification. Soil Science Annual 70(2), 71–97.

Kaczmarek, Z., Mocek-plo'ciniak, A., Gajewski, p., Mendyk, L., Bocianowski, J. (2021). Physical and soil water properties of technosols developed from lignite fly ash. Poznań University of Life Sciences, Poznań, Poland.

Ofem K. I. & Esu I. E. (2015). Characterisation and classification of four soil profiles developed on coastal sediments in Calabar South, Nigeria Department of Soil Science, University of Calabar, Cross River State, Nigeria. *Nigerian Journal of Soil and Tillage Research (ISTRO-NG*), (2), 198 - 208.

Ogban, P. I., T. P. Ekanem, E. A. Etim & Effiong, G. S. (1998). Mulching practices on a tropical soil physical properties. Proceedings of 25th Annual Conference, Soil Science Society of Nigeria. November 21-25, 1998, Benin, Nigeria.

Onweremadu, E.U., F. O. R. Akamigbo & C. A. Igwe (2008). Soil Quality Morphological Index in Relation to Organic Carbon Content of Soils in Southeastern Nigeria. *Trends in Applied Sci. Res.* 3 (1), 76-82.

Pal, S; Laskar, B.K; De, G. K. & Debnath, N.S (1990). Nature of some Acid Sulfate Soils in the Coastal Area of west Bengal. *J. Indian Soc. Soil sci;* 39: 56 – 62.

Scalenghe, R. & Ferraris, S. (2009). "The first forty years of a Technosol". Pedosphere. 19: 40–52. doi:10.1016/S1002-0160(08)60082-X.

Schad, P. (2018). Technosols in the World Reference Base for Soil Resources–history and definitions. *Soil Science and Plant Nutrition* 64(2), 138–144.

Udo, E. A. (1994). Soils and Crop Production. In: Akwa Ibom State: The Land of Promise.a Compendium Edited by Peters, S.W., E.R. Iwoke and O.E. Uya. Gabumo Publishing Co. Ltd., P. O. Box, 50874, Lagos, Nigeria. pp 263 - 270.

Udo, E. J. (1977). Clay mineralogy of five surface soils under different drainage conditions. *Nig. J. Sci.* 11, 315-337.