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Biosequence in Relic Forest of Michael Okpara University of Agriculture, Umudike, Nigeria.

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ABSRACT

Biosequence describes a dominant influence of living organism (vegetation) in pedogenesis and silt/clay ratio is a simple weathering ratio to estimate it. Three forestry plantations (Irvingia gabonensis, Dacryodes edulis and Treculia africana) were established to expand the relic of natural forest at Michael Okpara University of Agriculture, Umudike (MOUAU). The forestry plantations and the natural forest constituted four treatments. They were divided into subplots where duplicate composite soil samples were collected at 0 - 15 and 15 - 30 cm depths, and analysed. All the treatments had strong acidity pH (4.1 - 4.2) except Dacryodes edulis plantation that was slightly acid pH (6.00). Mean organic matter (1.12 %) and total N (0.08%) were low in all the treatments. Results showed that vegetation influenced pedogenesis. Dacryodes edulis plantation had the highest silt/clay ratio (1.15) while Treculia africana plantation had the least (0.66). Higher mean silt/clay ratio (1.11) at 0 - 15 cm depth than 0.70 at 15 - 30 cm depth, is indicative that weathering, a process of pedogenesis, was higher in the subsoil than at the topsoil. In biosequence, Treculia africana plantation exacerbated weathering process (silt/clay of 0.66) more than natural vegetation (0.90), Irvingia gabonensis (0.92) and Dacryodes edulis (1.15) plantations. It is concluded that biosequence was evident in the relic forest of MOUAU. Natural forest fallow, Dacryodes edulis and Irvingia gabonensis plantations are recommended in forestry soil resources management.

Keywords: Biosequence, natural forest, relic forest, silt/clay ratio, tree plantations.

INTRODUCTION: Forest is a community of trees, associated plants and animals. Forestry Commission (2011) defined a forest as land under stands of trees with a canopy cover of at least 20 %, whether in large tracts or smaller areas, known by a variety of terms such as, forests, woods, copses, spinneys or shelterbelts. Similarly, EUROSTAT (2024) defined a forest as land with tree crown cover (meaning all parts of the tree above ground level including its leaves, branches etc.), or equivalent stocking level, of more than 10 % and with an area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of 5 metres at maturity *in situ*. A pedosite, according to Costantini (2000), refers to a geo-referenced soil having cultural heritage, that is, a soil exposure or a soil-scape where an extraordinary cultural interest has been recognized. Costantini and Dazzi (2013), explained that it can take the form of an exposure or a trait of land, and it could be either vertical dimension (soil profiles) or horizontal dimension (soilscapes). Forest pedosite, as a term comprising forest and pedosite, refers to any forest site that has scientific, ancient, historic and cultural heritage of interest with respect to peoples' culture (Costantini and Dazzi (2013) and Giovanni, 2010). They are fundamental natural resources playing vital roles in environmental stability and ecosystem functions.

Five pedogenetic factors (parent material, climate, topography, living organisms and time) and processes influence soil formation (pedogenesis). A sequence of soils can contain distinctly different soil horizons because of the influence that vegetation had on the soils during their development. The influence of living organisms (vegetations, man and animals) on pedogenesis is collectively described as biosequence (Chukwu, 2016). The stage of soil development, soil age and some relic properties of soils are usually estimated using a simple weathering ratio. The most commonly calculated ratio is silt/clay ratio, acclaimed to be an important physical criterion to ascertain if the soil is highly weathered or not (Fasina, A. S., Raji, A., Oluwatosin, G. A., Omoju, O. J and Oluwadare, D. A. (2015). Van Wambeke (2006) established that silt /clay ratio of < 0.50, > 0.50 and 0.50, signify soils derived from "old" parent materials, "young" parent materials and "moderately weathered" parent materials, respectively. In their investigation of wrong pedogenetic assumptions in southern guinea savanna of Nigeria, Ajiboye, G. A. Ogunwale, J. A., Talbot, J and Mesele, I. (2017) confirmed that silt/clay ratio was a suitable index of stage of soil development. In their study in southwestern Nigeria, Fasina *et al.* (2015) found a silt/clay ratio ranging from 0.11 – 2.25. The study showed that most of the soils had silt/clay ratio > 0.15, indicating that the soils are relatively young with a high degree of weathering potential. Ajiboye *et al.* (2017) observed a rage of silt/clay ratio of 0.30 – 2.23 in all the profiles they studied in Southern guinea savanna. Pedogenesis is exacerbated where the yearly temperature is continuously high and precipitation is higher than evapotranspiration. Ojanuga (1979) remarked that warm soil temperature causes a marked dissolution of soil water, leading to a build-up of hydrogen ions to accelerate pedogenetic processes like leaching, erosion and lessivation. In the South-western Nigeria, Fasina *et al,* (2015) reported higher silt/clay ratio at the upper soil horizons than lower horizons. Their interpretation showed that weathering was higher in the lower than the upper horizons. Working on lateritic soils in Minna, Niger State, Lawal *et al.* (2012) reported that pedons that had silt/clay ratio ranging from 0.33 – 0.35 still had weatherable minerals. They also reported that silt/clay ratios of 0.33 and 0.35 respectively, observed in the pedons they studied suggested that the soils might still have weatherable minerals in them. Ashaye (1969) reported that a low silt/clay ratio of < 1 could mean that the soil had undergone ferralitic pedogenesis.

MATERIALS AND METHODS: The study was carried out at in a forest pedosite located at MOUA, Umudike, in Ikwuano Local Government Area (LGA) of Abia State, Nigeria. A forest pedosite (natural forest) representing a relic of the original humid forest vegetation, preserved when the National Root Crops Research Institute, Umudike (NRCRI) started in 1923, as a Provincial Experimental Farm still exists. When Michael Okpara University of Agriculture Umudike (MOUAU), formerly Federal University of Agriculture, Umudike, was established in November 1992. Three forestry plantations (*Irvingia gabonensis, Dacryodes edulis* and *Treculia africana)* which were established by MOUAU, to expand the relic forest.

The area lies between latitudes 05° 28′ 41.5″ N to 05° 28′ 46.2″ N and longitudes 07°32′ 24.7″ E to 07° 32′ 29.1″ E, with an elevation ranging from 100 - 103 m above sea level, in the rainforest area of

South-eastern Nigeria. The forest pedosite falls within Ahiara soil series (normal) in soils of Ikwuano, underlain by Coastal Plain Sands as the geology and parent material (Chukwu, 2013). The climatic regime is characterized by erosive tropical bimodal high rainfall (> 2,000 mm) that starts appreciably from April and ends in November, with peaks in June and October. The relative humidity of Umudike ranged from 52.5 % in the dry season to 90.3 % in the wet season, with mean annual temperature ranging from 23 to 32 ◦C and the soil temperature is isohyperthermic (28.8 ◦C) (Chukwu, 2007). The vegetation is characterized with heavy liners (climbers) and several tropical rainforest woody perennials, among which are *Ceiba petandra*, *Monodora myristica*, *Gmelina arborea*, *Irvingia gabonensis*, *Dacryodes edulis*, *Treculia africana*, *Funtumia elastica*, *Pterocarpus osun*, *Albizia ferruginea*, and *Elaeis guineensis*.

Field and laboratory work: A reconnaissance visit to the forest pedosite was made by a team of scientists to ascertain the nature of the terrain. Subsequently, the forest was surveyed using ground survey equipment to generate a map of the study area (Figure 1). The area comprised four treatments: natural forest (subdivided into three to ensure adequate soil sampling) and the three forestry tree plantations ((*Irvingia gabonensis*, *Dacryodes edulis* and *Treculia africana)* (Figure 2). This guided soil sampling exercise. Composite soil samples were collected in duplicate, from each treatment at 0 -15 and 15 - 30 cm depths, respectively. The soil samples were taken to laboratory for particle size distribution analysis following the procedure of Gee and Or (2002). Textural class was interpreted by estimating the percentage soil separates using textural triangle. The study lasted for three months. Biosequence was estimated based on silt/clay ratio (Van Wambekee, 2006) as applied by Fasina *et al.* (2015) and Ajiboye *et al.* (2018), was adopted in this study. In the above procedure, where silt/clay ratio is > 0.5 in young soils, < 0.50 in old soils, and 0.50 in moderately weathered soils. It is the degree of weathering that determines how fast pedogenesis occurs, and how easily degraded the soils can be (Fasina *et al.*, 2015). Soil pH was determined using 1:2.5 soil: liquid (water) ratio (Thomas, 1996). Wet digestion method of Nelson and Sommers, (1996) was used for organic carbon determination. Organic matter was obtained by multiplying values of organic carbon by 1.724 (Bemmelen's factor). Total N was determined by Kjeldahl digestion method (Bremner, 1996). Data collected were subjected to descriptive statistics.

Particle Size Distribution: The particle size distribution is shown in Table 1. At 0 - 15 cm, the textural classes were coarse loam (sandy loam) in all the tree plantations but except natural forest that was medium loam (sandy clay loam). Consequently, there was no significant difference in the means of soil separates (sand and silt) among the treatments except the clay contents, in the natural forest, which was significantly higher than in the tree plantations. This accounted for the sandy clay loam textural class observed in the natural forest. There was low coefficient of variation (2.71 - 17. 5 %) in the sand, silt and clay contents. However, at 15 - 30 cm depth, all the textural classes were sandy clay loam except in *Dacryodes edulis* plantation, where the textural class did not change from sandy loam obtained at 0 - 15 cm depth. The mean values of sand, silt and clay particles were 58.4, 16.5 and 25.1 %, respectively. The coefficients of variation of sand, silt and clay particles varied in the magnitude: sand < silt < clay. Mean sand contents among the tree plantations (*Irvingia gabonensis*, *Dacryodes edulis* and *Treculia africana*) was not statistically different but they were significantly higher than in the natural forest.

Silt/clay ratio: Table 2 shows that at 0 - 15 cm depth, the mean silt/clay ratio was very high (1.11) with a low coefficient of variation (13.5 %). The silt/clay ratio varied from 0.90, 1.11, 1.15 to 1.128 in *Treculia africana,* natural forest, *Irvingia gabonensis* to *Dacryodes edulis* plantations, respectively (Table 2). All the treatments had silt/clay ratio > 1, except *Treculia africana* that had lower significant (p ≤ 0.05) silt/clay ratio than other treatments. The magnitude of variation of the silt/clay ration was: *Dacryodes edulis* > *Irvingia gabonensis* > natural forest > *Treculia africana* at the topsoil (0 - 15 cm). Similar trend was maintained at the subsoil (15 - 30 cm). At 15 - 30 cm depth, the mean silt/clay ratio (0.78) was generally lower than in the topsoil with a coefficient variation of 35.7 %. *Dacryodes edulis* plantation had the highest silt/clay ratio (1.04) while *Treculia africana* plantation had the least (0.68).

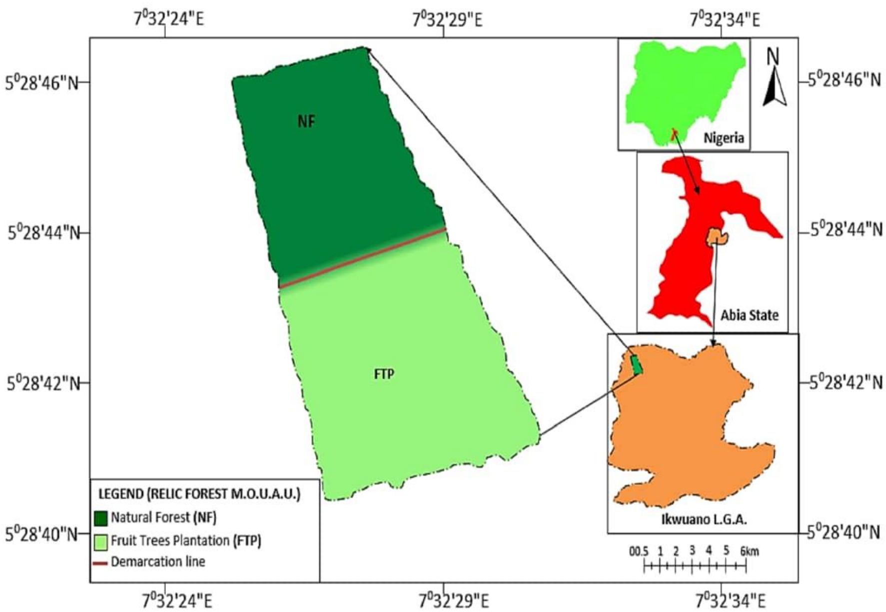

Figure 1. Map of the Study Area.

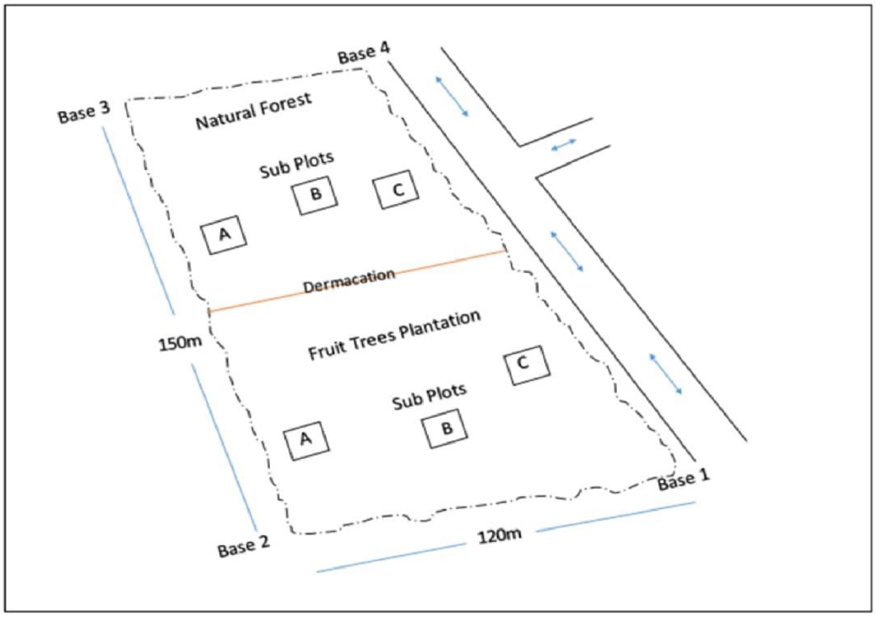

Fig. 2. Aerial view of experimental site showing the sub plots of the natural forest and man-made (fruit tree) plantations.

Where: In natural forest A, B and C under are subplots for soil sampling.

In fruit tree plantations, A = *Irvingia gabonensis*, B = *Dacryodes edulis* and C = *Treculia africana*

RESULTS AND DISCUSSION

Table 1. Particle Size Distribution of the Soils.

	0 - 15 cm			
Tree species and forest	**Sand**	**Silt**	**Clay**	**Textural class**
Irvingia gabonensis	66.4	18.0	15.6	Sandy loam
Dacryodes edulis	64.4	20.0	15.6	Sandy loam
Treculia africana	66.4	16.0	17.6	Sandy loam
Natural forest	54.4	24.0	21.6	Sandy clay loam
Mean	62.9	19.5	17.6	Sandy loam
Cv (%)	2.75	17.5	8.89	
SE	28.6	1.71	0.79	
	15 - 30			
Irvingia gabonensis	60.4	16.0	23.6	Sandy clay loam
Dacryodes edulis	64.4	18.0	17.6	Sandy loam
Treculia africana	58.4	12.0	29.6	Sandy clay loam
Natural forest	10.1	20.0	29.6	Sandy clay loam
Mean	58.4	16.5	25.1	Sandy clay loam
Cv (%)	2.95	20.7	22.9	
SE	2.95	1.71	2.87	

Where CV = Coefficient of variation and SE = Standard error

Table 2. Silt/clay ratio of soils in the relic forest

Tree species and forest	Silt-clay ratio 0 - 15 cm	15 - 30 cm	Mean
Irvingia gabonensis	1.15	0.68	0.92
Dacryodes edulis	1.28	1.02	1.15
Treculia Africana	0.91	0.41	0.66
Natural forest	1.11	0.68	0.90
Mean	1.11	0.70	0.91
CV (%)	13.5	35.7	22.0
SE	0.08	0.12	0.10

Where CV = Coefficient of variation, and SE = Standard error

Soil pH, Organic Matter and Total N: The mean soil pH, organic matter status and total N of the treatments at 0 - 15 and 15 - 30 cm depths are shown in Tables 3. All the treatments had strong acidity pH (4.1 - 4.2) except *Dacryodes edulis* plantation that was slightly acid pH (6.00). Consequently, *Dacryodes edulis* had a higher significant ($p \leq 0.05$) soil pH than *Treculia africana* plantation, natural forest, *Irvingia gabonensis* plantations, respectively. Soil organic matter contents were generally low in all the treatments. The mean values were 0.62, 0.80, 1.46 and 1.63 % for *Irvingia gabonensis*, *Treculia africana*, *Dacryodes edulis* plantations and natural forest respectively. The total N was generally low among the treatments, ranging from 0.04 - 0.11 % (Table 3). Both the organic matter contents and total N were below critical levels of 2 % organic matter and of 0.15 % N, established by Enwezor *et al*. (1989). The results confirmed that the forest pedosite falls into medium soil fertility class, in soil fertility map of Ikwuano Local Government Area, Abia State, produced by Chukwu *et al*. (2013).

Table 3. Influence of Natural Vegetation and Tree Plantations on mean pH, Organic matter and Total N at 0 - 15 and 15 - 30 cm depths.

Tree species and Natural forest	pH (H_2O)	Organic C (%)	OM	Total N (%)
Irvingia gabonensis	4.10	0.34	0.62	0.04
Dacryodes edulis	6.00	0.84	1.46	0.10
Treculia africana	4.20	0.46	0.80	0.06
Natural forest	4.20	0.95	1.63	0.11
Mean	4.62	0.65	1.12	0.08
Cv (%)	20.2	18.5	51.8	23.9
LSD (0.05)	0.92	0.12	0.58	0.02

Where C = Carbon and OM = Organic matter

Pedogenetic processes of eluviation, lessivage and illuviation, which account for the translocation of materials in the soil solum, most likely, explained the different concentrations of silt/clay ratio in the two sampling depths. The results suggest that soils under the forest pedosite are pedologically young soils and very lowly degraded, contradicting the generalization by Chukwu (2013) who delineated the forest pedosite within Ahiara soil series (normal), in soils of Ikwuano, adjudged to be mature soils (Ultisols). The results further suggest that in biosequence, *Treculia africana* plantation can exacerbate pedogenesis and soil degradation faster than *Irvingia gabonensis* and *Dacryodes edulis* plantations and natural vegetation. The higher silt/clay ratio at 0 - 15 cm than at 15 - 30 cm showed that weathering was higher in the lower than the upper soil depth and confirmed similar observations in Nigeria by Fasina *et al.* (2015) in soils of South-west and Ajiboye *et al.* (2017) in the southern guinea savanna.

CONCLUSIONS AND RECOMMENDATION: It is concluded that biosequence was evident in the relic forest of MOUAU. *Treculia africana* plantation exacerbated pedogenetic process to degrade forest soils more than natural vegetation, *Dacryodes edulis* and *Irvingia gabonensis* plantations. Natural forest fallow, *Dacryodes edulis* and *Irvingia gabonensis* plantations are recommended in forestry soil resources management.

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