EFFECTS OF *Gmelina Arborea* AND *Tectona grandis* VEGETATIVE COVER ON THE WATERSHED SOIL CHARACTERISTICS OF IYADA RIVER FOREST RESERVE IN OGWASHI-UKU, DELTA STATE

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ABSTRACT

This study involved analysis of soil samples of the watershed of the Iyada River in Ogwashi Uku Forest Reserve, Delta State Nigeria. The aim was to determine the effect of the vegetative cover of Tectona grandis (Teak) and Gmelina arborea (Gmelina) on the watershed as potential nutrient and fertility sources for the river while acting as an ecological fort against possible sheeting off of the soil surface to fill the river's water catchment corners, and reshape its channels which could eventually endanger its sustainability. Soil samples were collected at five depth ranges (0-30, 30-59, 59-79, 79-99 and 99-150 cm) in the reserve to determine the particle size distribution, bulk density, porosity, moisture content, organic carbon, total nitrogen, exchangeable acidity and cat ion exchange capacity. Results revealed that soil organic carbon, calcium and phosphorus accumulated most at the 0-30cm and 30-59cm depths. However, the concentrations of these elements decreased significantly ($P < 0.05$) with depth. Hence loss of soil organic carbon and phosphorus can be minimized through less intensive cultivation practices of the watershed.

Keywords: *Watershed, soil samples, Vegetation cover, Tectona grandis and Gmelina arborea*

Introduction

Freshwater body characteristics range from fertile green soups of organisms to pure blue pools, with low productivity, depending on the climate and geology of the watershed. High nutrient concentration in local geologies results in high nutrient concentration in rivers. Usually, such nutrient-rich rivers (eutrophs) appear murky green, with poor under water visibility because the algae are poor at absorbing most of the light entering inside the water. Whereas the nutrient-poor rivers (oligotrophs) are blue due to the fact that the light which leaves the river is in the blue portion of the spectrum since all other light is absorbed by the river (Bush, 2003). The average climatic condition of a river environment is also essential to the sustenance of its life. Thus, in the constitution of forest reserves, river ecosystems and its headwater are critically all inclusive among criteria used in the management of its watershed.

Watershed is described as the entire geographic region that drains water into a river. With the river acting as the drainage feature, most watersheds have been put into multiple land uses that eventually have deleterious impact on the river. Such negative impact is even worse where the river forms a property divide and it suffers from either different types of land use on either side of the bank or opposite ends of the river. Wherefore determining a comprehensive management plan for an entire watershed, especially that which is not within a Community, Local Government Area or State requires cooperation of the various stakeholders for the sustainable use of the river.

Forests and their management in river ecosystem play protective role in conserving soil and maintaining water quality and sustained flow for the purpose of watershed. They bestow important benefit in influencing the conservation as well as supply of water for natural springs and regulation of the flow of water in streams and rivers. Ikojo (2001) noted that the degradation of forest lands in water catchment areas results in erosion and attendant floods with increase in sediment transportation and deposition in rivers, streams and reservoirs. It has been shown that the drying of streams, rivers and even wells in most rural communities is common once the forest cover has been removed (Akinyemi and Ikojo, 1992) because the root pressure established in the roots of trees will not be available to raise the water table neither will the water be cool and free from pollution. Consequently, deforestation alters every element of local ecosystems such as the ecology of local aquatic conditions, micro-climate and soil that could lead to major health, environmental, ecological and socio-economic challenge (Costanza *et. al*, 2012).

The Iyada River watershed in the Government Forest Reserve at Ogwashi Uku has been under various intense land uses of agroforestry and localized sand mining following the deforestation of the original forest cover after its constitution in 1954. This river serves as source of portable drinking water for the Ogwashi community, the Leprosarium at Abboh Ogwashi and for the grazing Fulani community in Ogwashi Uku. It was in recognition of these notable contributions that the Federal Government of Nigeria in 2004 began the construction of an Earth Dam at the downstream as a measure to the perennial water problem associated with the Aniocha edaphic terrain due to extremely low and poor recharging water aquifer. The Delta State Government similarly in 2012 acquired headwater axis, upstream, for the erection of Tourism and Wildlife Park. This study was therefore undertaken on the soils to ascertain the capability and suitability under the present secondary forest as effective watershed management tree species indicator for the on-going land uses around the Iyada River.

Materials and Methods

Site Description

The study was conducted at the Government Forest Reserve in Ogwashi-Uku, Aniocha South LGA of Delta State. Geographic limits are set by latitude 6^o 00”-6^o 25”N and longitude 6^o15”-6^o 25”East. It occupies a total area of 258ha, with less than 27ha (10.5%) occupied by natural lowland rainforest while the deforested areas have been regenerated with exotic tree species (FORMECU, 2000). The rainfall pattern is bimodal, with peak periods in July and September, and an annual average between 1600-2000mm. Mean annual temperatures is between 25-29^{o}C and a relative humidity of 75% (Metrological Service Station, 2013). The geology of the study area reveals that the location is overlaid by various degrees of granites, gensis, shits and isolated deposition of amphibolite (Perekeme, 2000). The vegetation is significantly of humid forest (NEST, 1991) that is exclusively secondary forest, made up of Teak and Gmelina, with incursing taungya farming practice at its fringes since 1963. The plantation was heavily thinned with 50% of the tree species removed between 1995 and 1996. The Iyada River runs through the forest reserve with 70% of its length.

Data Collection and Analysis

Soil samples were collected from the Teak and Gmelina plantations within the watershed on either side of the Iyada River. Each of the species plantations was divided into four compartments. Two profile pits measuring 200 X 200 X 150 cm per compartment were dug and four soil samples per depth of 0-30, 30-59, 59-79, 79-99 and 99-150 cm were collected from four sides of the pits. Samples were air dried at room temperature and passed through 2mm sieve before physico-chemical analysis.

Particle size distribution was analyzed using the hydrometer method in which 0.5N sodium hexameta-phosphate was used as dispersant (Bouyoucos, 1957), soil pH by soil-water suspension using the glass electrode pH meter (McClean, 1982), total nitrogen by the micro-Kjedahl method (Juo, 1979), organic matter by the Walkley Black method (Nelson and Sommers, 1982), exchangeable cations (K, Ca, Mg and Na) were extracted with 1M NH_4OAc and the amounts in extracts were then determined using the atomic absorption spectrophotometer (Thomas, 1982) while exchangeable acidity was measured from 0.1M KCl extract and titrated with 0.1M NaOH (Juo, 1979). The effective cation exchange capacity was taken as the sum total of exchangeable cations and exchangeable acidity.

Data collected were subjected to analysis of variance using SAS (2010) at 5% level of probability and significant treatment means were separated using Duncan multiple range test. The relationships between evaluated properties were tested by the Pearson correlation coefficient.

Results

The effect of depth on soil properties under the Teak and Gmelina watersheds respectively is shown in Tables 1 and 2. Under the Teak watershed, there was no significant difference in Ca at 0-30cm and 30-59cm depth. But there was significant difference in the CEC and pH at these sampling depths. Similar relationship was shown by the *Gmelina arborea* at these depths for Ca, exchangeable acidity, pH and CEC.

TABLE 1: Effect of sampling depth on soil physical and chemical properties under *Tectona grandis* watershed

	%			g/cm^{3}	%			%		EXCH.CATIONS (Meg/100g soil)				(ppm)	EXCH.ACIDITY (Meg/100g soil)				%	(Mol/Kg)
Sampling Depth (cm)	Sand	Silt	Clay	Bulk Density	Porosity	Moisture Content	pH (H_2O)	OC	OM	Na^{+}	Mg^{2+}	K^{+}	Ca^{2+}	P	Al^{3+}	H^{+}	EA	CEC	TN	TEB
0-30	76.66^{e}	9.03^{b}	14.31^{a}	1.47^{b}	44.40^{d}	23.30^{c}	5.80^{a}	1.70^{a}	2.93^{a}	0.15^{a}	1.09^{a}	0.83^{a}	2.11^{a}	26.87^{a}	0.82^{a}	0.52^{a}	1.34^{a}	5.50^{a}	0.76^{a}	4.18^{a}
30-59	81.43^{d}	9.49^{a}	9.08^{b}	1.52^{a}	42.76^{e}	22.24^{d}	5.60^{b}	1.60^{b}	2.79^{b}	0.14^{b}	1.02^{b}	0.78^{b}	2.02^{a}	25.91^{b}	0.85^{a}	0.49^{b}	1.33^{a}	5.28^{b}	0.70^{b}	3.96^{b}
59-79	89.82^{b}	5.78^{d}	4.30^{c}	1.45^{b}	44.99^{c}	28.27^{b}	5.30^{c}	1.50^{c}	2.61^{c}	0.13^{b}	0.95^{c}	0.72^{c}	1.86^{b}	24.18^{c}	0.78^{b}	0.48^{b}	1.26^{b}	4.93^{c}	0.65^{c}	3.66^{c}
79-99	90.02^{a}	5.91^{d}	4.07^{e}	1.44^{c}	45.55^{b}	29.74^{a}	5.17^{d}	1.49^{c}	2.57^{c}	0.12^{b}	0.90^{c}	0.67^{c}	1.70^{c}	23.04^{c}	0.76^{b}	0.46^{b}	1.22^{c}	4.60^{d}	0.55^{d}	3.38^{d}
99-150	89.16^{c}	6.57^{c}	4.27^{d}	1.41^{c}	47.96^{a}	19.30^{e}	5.06^{e}	1.50^{c}	2.59^{c}	0.10^{b}	0.81^{d}	0.64^{c}	1.56^{d}	22.18^{e}	0.72^{c}	0.44^{c}	1.16^{d}	4.28^{e}	0.53^{d}	3.12^{e}

Means in the same column with same superscript(s) are not significantly different ($P > 0.05$) using DMRT

TABLE 2: Effect of sampling depth on soil physical and chemical properties under *Gmelina arborea* watershed

	%			gcm^{-3}	%			%		EXCH. CATIONS (Meg/100g soil)				(ppm)	EXCH. ACIDITY (Meg/100g soil)				%	MolKg^{-3}
Sampling Depth(cm)	Sand	Silt	Clay	Bulk Density	Porosity	Moisture Content	pH (H_2O)	OC	OM	Na^{+}	Mg^{2+}	K^{+}	Ca^{2+}	P	Al^{3+}	H^{+}	EA	CEC	TN	TEB
0-30	72.59^{d}	11.18^{a}	16.23^{a}	1.59^{a}	39.38^{e}	21.28^{c}	5.69^{a}	1.66^{a}	2.86^{a}	0.17^{a}	0.98^{a}	0.62^{a}	1.99^{a}	25.53^{a}	0.77^{b}	0.52^{a}	1.29^{a}	5.05^{a}	0.64^{a}	3.76^{a}
30-59	85.20^{b}	7.74^{c}	7.06^{c}	1.58^{a}	40.38^{d}	21.77^{c}	5.27^{b}	1.64^{a}	2.83^{a}	0.15^{a}	0.97^{a}	0.61^{a}	1.91^{a}	24.48^{b}	0.74^{c}	0.50^{a}	1.25^{a}	4.89^{b}	0.63^{a}	3.64^{b}
59-79	84.77^{c}	8.87^{b}	6.36^{d}	1.54^{b}	41.59^{c}	23.87^{b}	5.29^{b}	1.60^{a}	2.76^{a}	0.14^{b}	0.92^{a}	0.59^{a}	1.78^{b}	22.74^{c}	0.73^{c}	0.49^{a}	1.23^{b}	4.69^{b}	0.55^{a}	3.44^{c}
79-99	88.56^{a}	6.55^{d}	4.89^{e}	1.52^{b}	42.77^{b}	25.56^{a}	4.79^{c}	1.53^{b}	2.64^{b}	0.13^{b}	0.89^{a}	0.57^{a}	1.73^{c}	21.58^{d}	0.72^{c}	0.49^{a}	1.23^{b}	4.55^{c}	0.41^{b}	3.32^{c}
99-150	85.13^{b}	5.57^{e}	9.30^{b}	1.50^{b}	44.62^{a}	25.76^{a}	4.82^{c}	1.50^{b}	2.59^{b}	0.11^{b}	0.87^{a}	0.55^{a}	1.71^{c}	20.45^{e}	1.02^{a}	0.49^{a}	1.20^{b}	4.46^{c}	0.40^{b}	3.26^{c}

Means in the same column with same superscript (s) are not significantly different ($P > 0.05$) using DMRT

With respect to the exchangeable cations, there were significant differences in the Mg across the five depths under the *Gmelina arborea* watershed unlike the *Tectona grandis* where no significant difference existed between depths 59-79cm and 79-99cm. Result also showed that the top layer (0-30cm) had highest clay content 16.23% and 14.31% for *Gmelina arborea* and *Tectona grandis*, this relationship differed at 99-150cm depth. Soil acidity and percentage clay content varied with depth. Soil planted to the *Gmelina arborea* had significantly lower porosity, percent silt and clay contents. The individual tree species showed no significant influence on the bulk density, pH and organic matter contents but on the moisture content. Result showed that moisture content (19.30%) was least at depth 99-150 cm with the highest porosity (47.96%) under the Teak plantation. Whereas, under the Gmelina the highest moisture content (25.76%) was recorded at depth 99-150 cm though not significantly different ($P > 0.05$) from depth 79-99 cm.

Although the interaction between soil depth and forested tree species under the watershed had no significant effect except for moisture content, these however showed proportionately favourable soil index factor for the evaluated soil properties. Pearson correlation matrix between evaluated soil physical and chemical characters showed significant ($P < 0.01$) relationship between bulk density and organic carbon, pH and Al, porosity and organic matter, bulk density and porosity, bulk density and moisture content, porosity and organic carbon (Table 3).

Discussion

Total organic carbon and porosity were significantly enhanced at 0-30cm, 30-59cm and 59-79cm soil depths respectively. This could be as a result of the deposition of leaf litters on the soil surface of the watershed since the soil are not cultivated their incorporation will be minimal as reported in Rasmussen and Collins (1991). This is an indication that the loss of soil organic carbon can be minimized through less intensive cultivation practices on the watershed. The potential of Teak and Gmelina to improve soil quality of the watershed for the sustainability of the river could be attributed to the dense foliage that are periodically shed off in large quantities to increase the organic matter and the ability of its tissues to decompose rapidly, thus releasing plant nutrients into the underlying soil (Keay, 1995). Such cover crops which have been reported to increase carbon inputs, cation exchange capacity and enhance microbial biomass (Nwoboshi and Amakiri, 1987; Bronick and Lai, 2005) could equally have increased the potential biological and biochemical activities, especially soil aggregate stability to forestall leaching, losses of nutrients and erosion that are harmful to the river.

TABLE 3: Summary of the Pearson product moment correlation coefficient under the Teak and Gmelina watershed

Site	Correlated Variable	R	R^2
Tectona grandis	Sand vs Silt	-0.923	-0.8519
	Sand vs Clay	-0.985	-0.9712
	Sand vs Organic matter	0.9675	0.9360
	Sand vs Ca	0.9904	0.9808
	Silt vs Clay	-0.985	0.9702
	Silt vs Organic matter	0.9674	0.9358
	Silt vs K	0.9442	0.8915
	Silt vs Al	0.9665	0.9341
	Clay vs pH	0.9997	0.9952
	Clay vs Organic matter	0.9982	0.9994
	Bulk Density *vs* Porosity	0.9568	0.9964
	Bulk Density vs Moisture content	0.9978	0.9154
	Bulk Density vs pH	0.9998	0.9956
	Bulk Density vs Organic matter	0.9411	0.9996
	Moisture content vs pH	0.9864	0.8856
	Moisture content vs EA	0.9970	0.9729
Gmelina arborea	pH vs Al	0.9992	0.9940
	pH vs N	0.9938	0.9980
	Organic matter vs Al	0.9995	0.9876
	Organic matter vs EA	0.9980	0.9990
	Na vs EA	0.9944	0.9888
	Sand vs Silt	-0.9966	0.9331
	Sand vs Clay	-0.9879	0.9759
	Silt vs Clay	-0.9789	0.9795
	Bulk Density vs pH	0.9997	0.9974
	Bulk Density vs Organic carbon	0.9980	0.9960
	Porosity vs pH	0.9248	08552
	Porosity vs Organic carbon	0.9980	0.9960
	Porosity vs Organic matter	0.9192	0.8449
	Porosity vs H	0.9463	0.8954
	Na vs Ca	0.9925	0.9850
	Na vs Al	0.9966	0.9932
	Na vs TEB	0.9943	0.9886
	Ca vs TEB	0.9978	0.9956

Na= Sodium, Ca= Calcium, Al= Aluminum, N= Nitrogen, H= Hydrogen, K= Potassium, EA= Exchangeable acidity, TEB= Total exchangeable base

The effect of individual tree species on the moisture content of the last two sampling depths, 77-99 cm and 99-150 cm is also very suggestive of the more likely tree species for water availability through effective root pressure. Gmelina seems to demonstrate such greater potential on the water holding capacity of the Iyada watershed. This may not be unrelated with its ability to reach out for moisture through the more sprawling roots and branches than the Teak species.

However, the stability of calcium in the first two sampling depths, 0-30cm and 30-59cm, under the two tree species, could be taken as probable edaphic insurance in the management of the Iyada river watershed because calcium is a critical element for the stabilization of soil organic matter and soil aggregate through its role in the formation of clay-polyvalent cation-organic matter complexes (Clough and Skjemstad, 2000). This relative stability, as indicated by the soil particle size distribution of the watershed under the Teak and Gmelina vegetation, can be employed in assessing the likely sustainability vis-à-vis fertility status of the river for either or both of the intending socio-economic purpose.

Conclusion

The study suggests that vegetation cover with tree species such as *Gmelina arborea* and *Tectona grandis* is essential for the effective protection of the Iyada River watershed and for its sustainability. This is on account of its capability to influence soil organic matter that is crucial to maintaining soil structural stability, promote water retention and reduce erosion which is detrimental to river channels and catchment corners. Furthermore, the study stresses the urgent need to de-emphasize the fast-growing "taungya" farming system at the fringes of the watershed in the forest reserve, because the system was observed to be an unsustainable management practice as it leads to loss of soil carbon that could consequently set up a whole course of action that can impair the potential of the river as a tourism center given the present development effort at its headwater site and the envisaged earth dam establishment at its tail-water axis.

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