Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.1, 2013

A Comparative Study of the Physical and Chemical Properties of Soils under Different Vegetation Types

Olatunde Ogunkunle
Department Of Geography, University Of Lagos, Lagos, Nigeria
jogunkunle@unilag.edu.ng

Abstract
Soils under three different vegetation types- the forest, the savanna and swamp forest within the forest zone in the coastal area of Badagry were analysed and compared. Significant differences were found in the soils in respect of sand and silt particles, pH, organic carbon and organic matter. The soils are sandy, slightly acidic and generally poor in exchangeable bases.
The suggestion is made that the use of the soils for sustained cropping would require the judicious use of inorganic chemical fertilizers.
Keywords: Badagry, swamp forest, secondary forest, savanna, exchangeable bases

1.0: Introduction

Vegetation and soils are not only interdependent but are also functionally inseparable. Vegetation is not only an essential factor of soil formation, the nature of vegetation in an area also gives an insight into soil and geomorphic conditions. Vegetation adds humus to the soil and it is this component that distinguishes soil from weathered materials. The humus/organic matter give life to the soil. The nature of vegetation and the quality of litter supplied can therefore differentiate soils in terms of their nutrient contents. Any change in vegetal cover is also bound to affect soil and vice versa.

Most previous studies on soil-vegetation interrelationships have tended to concentrate on soil characteristics under single vegetation units while others have compared characteristics of soils under natural vegetation particularly forests with those of lands cultivated for various food crops or soils under tree crop vegetation (Aweto, 1981b; Ojanuga, 1975; Ayodele and Agboola, 1983; Ekanade, 1985). Little consideration has been given to the study of soil characteristics under different natural or semi-natural vegetation units particularly within the same climatic zones. Badagry area of Lagos State therefore provides a unique situation where a study can be carried out. The area which is relatively small and within the same climatic zone (equatorial), displays the zonation of vegetation types which are characteristic of West Africa and Nigeria. Within the relatively small area of study are the swamp forest, secondary forest and savanna vegetation.

It is therefore the objective of this paper to analyze and compare some physical and chemical properties of soils under these different vegetation types. It is hoped that the study will provide useful knowledge of the physico-chemical properties of these soils which may guide the uses to which these soils can be put and future studies in the area.

2.0 The Study Area

The study area was conducted in the Badagry Local Government Area of Lagos State, Nigeria. The study area, which is situated in a low-lying coastal region with a general elevation of less than 20m, lies within the tropical rainforest zone of south-western Nigeria. Mean daily temperatures remain characteristically high throughout the year at about 26^0-28^0C. Mean annual rainfall is about 2000mm with rainfall in all the months of the year.

The natural vegetation of the area is the evergreen tropical forest but the poor anaerobic conditions of the soil in many places have prevented the tropical rainforest from fully developing in many parts. The Badagry creeks however constitute part of the few remaining pockets of natural swamp forest in southern Nigeria.

The soils are mainly regosols with poorly developed profiles below a thin surface humic layer. The soils in some places are excessively drained and may be susceptible to drought during the dry season.

3.0 Methodology and Data Collection

This study was carried out using a vegetation map of the study area, produced from the interpretation of black and white aerial photographs on a scale of 1:25,000 and quickbird 2005 imageries. Three vegetation types viz: swamp forest, secondary forest and savanna were identified on the photographs.

Grids were imposed on the map so produced and random numbers were used in selecting the sample plots with consideration for accessibility and adequate representation of area units covered by the vegetation types. Ten sample plots were randomly selected from each of the three vegetation types. There were thus a total of 30 plots. Each plot was 20m x 20m. Soil samples were collected from five randomly located points in each plot, using a core sampler. Soil sampling in each plot was restricted to the top 10cm of the soil because the greatest effects of tree vegetation usually occur in the top soil especially the top 10cm of the soil profile (Billings, 1938; Aweto, 1981a).

The soil samples were air-dried and sieved with 2mm mesh sieve. Samples for total elemental analysis and for total carbon were further ground to pass through a 100 micron mesh sieve. Care was taken to avoid differential loss of fine dust.

The samples were then analysed for 12 soil parameters listed in Table 1 using standard laboratory procedures.

Simple statistical analyses were used to compare the oil properties under the three vegetation types. The statistical mean and the analysis of variance were used to ascertain whether the differences in these soil properties were significantly different. The null hypothesis in this case is that there are no differences in the soil properties while the alternative is that the soil properties under the different vegetation types differ significantly.

Table 1: List of Soil Variables Used in the Analysis

Soil Variable	Method of Determination
1. % Sand)	
2. % Silt)	Hydrometer method (Buoyoucos (1951)
3. % Clay)	
4. % Organic matter	Walkey-Black (1934) method
5. % Total nitrogen	Kjeldahl method (Brenner 1960)
6. Av. Phosphorus (ppm)	Bray & Kurtz (1945)
7. Exchangeable Na+) (meq/100 dry soil))	
8. Exchangeable Ca++) (meq /100 dry soil))	Flame Photometry method
9. Exchangeable K) (meq /100 dry soil))	Residual carbonate method
10. Exchangeable Acidity (meq /100 dry soil))	
11. P^H	Determined Potentiometrically in 0.01 $CaCl_2$ solution

3.0 RESULTS AND DISCUSSION

3.1 Soil physical Properties

Table 2: Summary Results of Physical Properties of Soils

SOIL PROPERTIES	**SAVANNA**	**FOREST**	**SWAMP**	**ANOVA at 5% CONFIDENCE LEVEL**
	-x	- x	- x	
SAND (%)	93.6	93.6	86.6	SIGNIFICANT
SILT (%)	2.8	3.2	9.6	SIGNIFICANT
CLAY	3.6	3.6	3.6	NO SIGNIFICANT DIFFERENCE

Table 2 shows the summary of the physical properties of the soils. Sand accounts for over 80% of the inorganic fragments of the soils. The soils are quite homogeneous texturally, being mainly sandy. The high proportion of sand in the soils may be attributed to the fact most of the soils in the area are developed on sandy ridges and deposits.

The amount of silt is small being usually under 10% for swamp and as low 2.8% in the savanna soils. The clay content of 3.6% for the soils in the three communities sampled indicates that the amount of clay present in the soil is relatively small compared to the values of 4.7% reported by Aweto (1987) for savanna enclaves of Urhobo plains and 21% reported by Ekanade (1985) for forest soils both in south-western Nigeria. Analysis of variance tests revealed significant differences in the sand and silt particles of the soils. Significant differences were found in the sand and silt compositions of the swamp soils on one hand and that of the secondary forest and savanna on the other. Sand and silt composition of the secondary forest and the savanna were not statistically different.

The predominance of sand and the low proportions of silt and clay in the soils may be due to erosion and leaching to which sand soils are susceptible. These lead to the removal, translocation and loss of minerals especially clay minerals from the soil profile (Faniran & Areola, 1987).

3.2: Soil Chemical Properties

Table 3:Summary Results of Chemical Properties of Soils

SOIL PROPERTIES	SAVANNA	FOREST	SWAMP	AT5% CONFIDENCE LEVEL
	-x	-x	-x	DIFFERENCE
SOIL pH	6.65	6.09	5.29	SIGNIFICANT
ORGANIC MATTER (%)	1.31	1.21	1.91	SIGNIFICANT
TOTAL NITROGEN (%)	0.080	0.075	0.091	NO SIGNIFICANT DIFFERENCE
SODIUM (Me./100g)	0.23	0.23	0.29	NO SIGNIFICANT DIFFERENCE
CALCIUM (Me./100g)	0.17	0.17	0.59	NO SIGNIFICANT DIFFERENCE
POTASSIUM (Me./100g)	0.17	0.17	0.21	NO SIGNIFICANT DIFFERENCE
AVAILABLE PHOSPHORUS (PPM)	7.13	9.09	4.83	NO SIGNIFICANT DIFFERENCE
EXCHANGE ACIDITY	0.77	1.70	0.83	NO SIGNIFICANT DIFFERENCE
ORGANIC (%) CARBON	0.76	0.70	1.11	SIGNIFICANT

Table 3 shows the chemical properties of the soils studied. The soils are generally weakly acidic with mean values ranging from 5.29 to 6.65 (in water). The mean pH in water of swamp soil was significantly lower than that of the other two being 5.29 and therefore relatively more acidic. Swamp soils recorded the lowest actual pH value of 4.6 while savanna soils had the highest actual pH value of 7.4. The relatively more acidic nature of the swamp soils can be readily attributed to the relatively poor drainage condition of the soil and possibly the release of organic acids as a result of slow decomposition of organic compounds. The poor drainage of the swamp soils may be attributed to a combination of low relief, high water table and high rainfall amounts.

The mean value of 1.91for soil organic matter recorded for the swamp forest is the highest and was found to be significantly higher at 5% confidence level. The mean values of 1.31 and 1.21 recorded by the savanna and the secondary forest respectively were not statistically different from one another. The relatively high level of organic matter in the soils under the swamp forest might be due to slow decomposition of litter under anaerobic conditions.

There were no significant differences in the exchange acidity of the soils under savanna, secondary forest and swamp forest. However, the soil under secondary forest and swamp forest recorded the highest mean value of 1.07 while the lowest mean value of 0.77 was recorded for soil under savanna. The generally low level of exchange acidity in the soils may be attributed to the sandy nature of the soils and the low clay contents of the soils.

Although there were no significant differences in the total nitrogen (%) contents of the soils, the swamp soil recorded the highest value of 0.091 followed by the savanna with 0.081(Table 3). The pattern of total Nitrogen (%) contents observed could be related to the soil organic matter content. Thus, the highest value of 0.091 recorded by the swamp soil was not surprising since it recorded a significantly higher value of 1.91 for organic matter which is the main source and store of soil Nitrogen.

The levels of exchangeable sodium in the soils under savanna, secondary forest and swamp forest are comparable and the observed differences among the soils with regard to the sodium content were not statistically significant at the 5% confidence level. The soil under swamp forest records the highest mean values of 1.59 and 0.21 for calcium and potassium respectively. These values were however not proven to be statistically different at the 5% confidence levels from the mean values of 1.15 and 0.17 (savanna); 1.36 and 0.17 (secondary forest) for calcium and potassium respectively. The highest values recorded by swamp soils for calcium and potassium may be related to the highest values of organic matter recorded for the swamp soil, since it is organic matter that makes exchangeable cations available to plants.

The relative proportions of nitrogen and phosphorus in the soils are important in determining whether the amount of potassium in the soils will be adequate for plant needs or not. Analysis of variance test shows that there were no significant differences in the levels of available phosphorus in the three soil types at 5% confidence level. The highest mean value of 9.09 was however recorded by the secondary forest.

4.0 Conclusion

The soils of the study area are sandy, slightly acidic and poor in mineral nutrients. There were significant differences in the sand and silt compositions of the soils under swamp on one hand and the soils under secondary forest and savanna. The swamp forest soils recorded significantly higher amount of silt and lower sand content presumably due to greater earthworm activity in the swamp soils.

The null hypothesis which states that there are no differences in the soil properties is therefore rejected in respect of sand and silt contents while it is accepted in respect of the clay content. The soils were generally found to be poor in exchangeable bases. No significant differences were found among the soils with respect to total nitrogen, sodium, calcium, potassium and available phosphorus. The low level of exchangeable bases in the soils may be attributed to the fact that these soils are developed on base-deficient sandy ridges and deposits and the high rainfall amount which results in high rate of leaching of the soils. There were however significant differences in the pH and organic matter contents of the swamp soils and those of the secondary forests and savanna. This situation is attributable to the poor drainage conditions of the swamps and the large number of tree species in the swamp forest.

The soils of the study area can thus be regarded as being poor in chemical nutrients and therefore of low fertility. The use of these soils, particularly the secondary forest and savanna soils, for any sustained cropping would therefore require the use of fertilizers, which may only slightly improve crop yields in the area.

References

Adejuwon, J.O. (1973): Soils and the Derivatives of the Tropical Rainforest in Nigeria, *Nig. Geog. Journal*, Vol. 16, pp. 39-50.

Adejuwon, J.O. (1975): Soil Mapping in the Coastal Zone of Western Nigeria, *Nig. Geog. Journal*, Vol. 18, No. 1, pp. 57-68.

Ahn, P.M. (1970): *West African Soils*, 3rd Edn. Oxford University Press, London.

Areola, O. (1977): "Aerial Photo-Interpretation of Land Types and Terrain Conditions in the Lagos Coastal Region", *Nig. Geog. Journal*, Vol. 20, No. , pp. 70-81.

Areola, O. (1978): "Soil and Vegetal Resources", in Oguntoyinbo et al (1978): *A Geography of Nigerian Development*, Heinemann, pp. 105-126.

Aweto, A. O. (1981): "Secondary Succession and Soil Fertility Restoration in South-western Nigeria", *Journal of Ecology*, Vol. 69, pp. 601-607.

Aweto, A. O. (1985): Soil Cation Exchange Capacity Dynamics under Bush Fallow in South-western Nigeria,

GeoForum, Vol. 16, No. 1, pp. 85-92.
Aweto, A. O. (1987): Vegetation and Soils of the Savanna Enclaves of Urhobo Plains, South-western Nigeria, *Catena*, Vol. 14, No. 3.
Aweto, A.O. & Iyanda, A.O. (2002): Effects of *Newboulda Laevis* on Soil Subjected to Shifting Cultivation in the Ibadan Area, South-western Nigeria, *Land Deregulation & Development*, 14, Pp 51-56.
Aweto, A.O, & Dikinya, O. (2003): The beneficial effects of two tree species on soil properties on a semi arid savanna rangeland in Botswana, *Land Contamination & Reclamation*, Vol. 11, Parts 3.
Ayodele & Agboola (1987): Evaluation of phosphorus in savanna soils of western Nigeria under bush fallow systems, *Journal of Agricultural Science*, Cambridge, 101 part 2, 283-289.
Boughey, A.S. (1975): "Ecological Studies of Tropical Coastlines", *Journal of Ecology*, Vol. 45.
Brady, N.C. (1974): The Nature and Properties of Soils, Macmillan, N. York.
Ekanade, O. (1985): The effects of cocoa cultivation on some physical properties of soil in South-western Nigeria, *The International Tree Crops Journal*, 3 (1958), 113-124.
Faniran, A. & Areola, O. (1978): *Essentials of Soil Study*, Heinemann Educational Books, Ibadan.
Lawson, G. W. (1986): 'Vegetation and Environment in West Africa' in *Plant Ecology in West Africa*, edited G.W. Lawson.
Mabogunje, A.L. (2007):"Developing Megacities in Developing Countries", Lecture delivered at the Dept. of Geography, University of Lagos Colloquium.
Odun, E.P. (1959): Fundamentals and Ecology, Saunders.
Ojanuga (1975): Clay mineralogy of soils in the Nigerian tropical savanna regions, *Soil Science Society of America Journal* 43, 1237-1242.
Sanchez, P.A. (1976): *Properties and Management of Soils in the Tropics*, John Wiley, New York.