SPATIAL VARIABILITY OF SOIL PROPERTIES IN AKOKO REGION OF ONDO STATE, NIGERIA

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Abstract

Soil erosion is a major form of land degradation that affects the physical and chemical properties of soils resulting in nutrient loss and sedimentation of water resources. This study examined the spatial variability of soil properties in Akoko region of Ondo State, Nigeria.

Observations were carried out largely from sampling points and forty soil samples were collected for laboratory analysis to determine soil pH, organic matter content, exchangeable potassium, calcium, magnesium, sodium, cation exchange capacity (CEC) and particle size distribution. There was spatial variability in soil properties as indicated by the high coefficients of variation in soil pH(6.85 to 15.85), CEC(16.89 to 19.42), organic matter(121 to 127), calcium(27.57 to 29.21), magnesium(37.14 to 50.35), sodium(30.58 to 32.77),

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potassium(43.82 to 45.74), sand(15.16 to 16.50), silt(39.77 to 40.35) and clay(11.96 to 31.78).

These variations suggest differential sensitivity of these properties to change under erosion. There is need to regulate soil loss through the use of preventive measures such as mulching, terracing and planting of cover crops so as to enhance soil productivity.

Introduction

Soil is one of the most precious resources that man depends on for survival. There is no proof yet that man would one day detach his life from the soil. It is on the soil that we have our beings. It sustains us: there we grow our food because soil is the foundation of our worldly goods and it acts as basic wealth upon which our existence, as inhabitant of the earth, depends (Adebayo, 2005).

Soil scientists have been aware of the reality of spatial variation of field soils since the early 1900's. However, it was not until the late 1960's and 1970's that field scientists began to study soil variability in a systematic way. The first studies were independent tests of soil maps in which soil variation was seen as a nuisance that reduced map reliability. Gradually the general nature of soil variation, and its unpredictability, has led researchers to see variability as a key soil attribute rather than a nuisance. In recent years, soil variability has been the subject of a huge research effort (Boone, 1992).

The variability, laterally and vertically, results from the impact of the soil-forming factors, namely, climate, vegetation, topographic setting, parent material, and time (Jenny, l980; Birkeland, 1999). Such attributes exert decisive influence on soil development processes and the way water flow in landscape (Johnson *et al*. 2000; Fu *et al*. 2003; Rezaei and Gilkes 2005). For instance, the concept of catena describes the spatial organization of soil types along the hill slope. Topography is central to the catena concept for soil development (Hook and Burke, 2000), which is characterized by leaching and redistribution of elements and soil material along hill slopes. The effect of topography is more pronounced on young and rolling soils than on old and level ones (Birkeland, 1999; Fisher and Binkley, 2000).

Generally, variance increases with size of area sampled, even for areas regarded as the same sampling unit; forest soils tend to be more variable than agricultural soils; some properties are more variable than others; and data often are not normally distributed. There are no general rules regarding spatial variance of soil properties within horizon and by depth. Temporal variation within a soil horizon or depth interval can be substantial for many soil properties. Temporal changes may reflect seasonal and annual variations in climate and microclimate as well as management regime and alteration of the amounts and chemical quality of organic matter inputs.

According to them, variability in soil properties at the series level is often caused by small changes in topography that affect the transport and storage of water across and within the soil profile. Hunter *et al*. (1982) and Yost *et al*. (1982) reported that soil-forming factors affect different properties differently at different depths. Therefore the aim of this study was to assess the degree of variability of some soil chemical properties at different soil depths in Akoko region. This is necessary because the more variable these properties are the more variable the crop growth and yield. Understanding soil variability is essential in applying location-specific (precision agriculture) management strategies.

Materials and methods

Study area

Akoko region is located north-east of Ondo State and South-West of Nigeria. The region lies within longitude $5^0$31' E to $6^0$06'E and latitude $7^0$18'N to $7^0$45'N. Akoko region covers an areal extent of about 2465.6km^2. Akoko region is situated at an altitude between 270m and 2750m above sea level. Most parts of the region have undulating terrain, which in many cases are almost completely encircled by high rugged rock outcrops, rising to a height of over 2750m in some places.

Geologically, Akoko region is a physiographic region characterized by two major crystalline basement rocks of the main African Precambrian shield. These are magmatite and granite gnesis, with quartz and pegmatite veins. These rocks belong to the migmatite-gnesis sub-classification of the basement complex of Nigeria. Akoko region is located within the humid tropical climate of the forest region, which experiences two climatic seasons namely the rainy season (April – October) and the dry season (November – March).

Laboratory analysis

Soil data were collected directly from the field. Soil observations were carried out from twenty (20) sampling points. 40 samples were taken at different depths (0-20cm and 20-50cm) that is 20 samples from each depth were collected for laboratory analysis for particle size, soil organic matter content (OM), soil pH, exchangeable calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), cation exchange capacity (CEC), nitrogen and available phosphorous.

Particle size analysis was carried out by Bouyoucos (1962) hydrometer method. Organic matter content was determined by multiplying the value of soil organic carbon by Van Barnmelen factor of 1724. The soil pH was determined in water (1:1 soil to water ratio) and in potassium chloride (1:1 soil to solution ratio) using a pH probe. Sodium and potassium in the filtered extracts were determined in a flame photometer while calcium and magnesium were determined with atomic absorption spectrophometer. Cation exchangeable capacity was determined by the summation of exchangeable bases and acidity. Available phosphorous was assayed by the Brag P-I method (Olsen and Summers, 1982) while nitrogen was determined using the Micro-Kjeldal method (Bremner and Mulvaney, 1982).

Variation in soil properties was determined by the coefficient of variability. The coefficient of variation, which is the standard deviation expressed as the percentage of the mean (Udofia, 2002) was computed for each soil property in order to ensure that it’s degree of variability can be directly compared with those of other soil properties.

Results and discussion

The results for this study are presented in tables 1 and 2. Tables 1 show the means, standard deviations and coefficients of variation of properties of the top soil while Table 2 indicates the same parameters for the sub soil measurements.

With respect to soil fraction, the soil exhibited little variation from the topsoil to the subsoil as indicated by the coefficient of variation of 15.16% and 16.50%: silt particle exhibited moderate variability (40.35%) at the topsoil than at the subsoil (39.77%), while clay fraction exhibited moderate to little variation from the dubsoil to the topsoil as indicated by the coefficient of variation of 31.78% (subsoil) and 11.96% (topsoil). These results agree with other studies done elsewhere in Nigeria (Phil-Eze, 2010). The soils were classified as sandy clay loam following the USDA textural classification system. The coefficients of variations were comparatively greater at the subsoil soil than at the top soil except silt which is greater at the topsoil than at the subsoil.

Table 1: Mean, Standard Deviation and Coefficient of Variation of the soil properties at 0-20cm layer

Soil Variables	Mean	Standard Deviation	Coefficient of Variation
Sand (%)	58.15	8.82	15.16
Silt (%)	17.30	6.98	40.35
Clay (%)	24.50	2.93	11.96
Soil pH	6.28	0.43	6.85
Cation Exchangeable Capacity	4.50	0.76	16.89
Organic Matter (%)	0.48	0.61	127
Calcium (cmolkg^{-})	1.85	0.51	27.57
Magnesium (cmolkg^{-})	1.41	0.71	50.35
Sodium (cmolkg^{-})	1.19	0.39	32.77
Potassium (cmolkg^{-})	0.94	0.43	45.74
Total Nitrogen (%)	0.37	0.03	8.12
Available Phosphorous (mgkg-1)	10.45	2.80	26.80

Table 2: Mean, Standard Deviation and Coefficient of Variation of the soil properties at 20-50cm layer

Soil Variables	Mean	Standard Deviation	Coefficient of Variation	
Sand (%)	58.25	9.61	16.50	
Silt (%)	17.65	7.02	39.77	
Clay (%)	24.10	7.66	31.78	
Soil pH	6.33	1.00	15.85	
Cation Exchangeable Capacity	4.48	0.87	19.42	
Organic Matter (%)	0.39	0.47	121	
Calcium (cmolkg$^-$)	1.78	0.70	29.24	
Magnesium (cmolkg$^-$)	1.40	0.52	37.14	
Sodium (cmolkg$^-$)	1.21	0.37	30.58	
Potassium (cmolkg$^-$)	0.89	0.39	43.82	
Total Nitrogen (%)	0.54	0.05	9.26	
Available Phosphorous (mgkg-1)	10.70	3.10	28.97	

The pH was the least variable at the topsoil while nitrogen has the least at the subsoil. Organic matter, magnesium and potassium were highly variable at the topsoil (CV>35%). Cation Exchangeable Capacity, calcium, sodium and available phosphorous were moderately variable (CV between 15 and 35%) at the topsoil.

Soil pH and nitrogen were least variable at the topsoil. For the subsoil, organic matter, magnesium and potassium were highly variable while soil pH, cation exchangeable capacity, calcium, sodium and available phosphorous were moderately variable. Nitrogen was least variable. Soil properties differ in their degree of variability with depth. In order to compare the variability of the soil properties among themselves across the study area, the coefficient of variability was categorized into four classes in a modified version after Aweto (1982). Less than 20% CV was regarded as low variability; between 21 and 50% was regarded as moderate variability; while between 51 and 100% CV was regarded as high variability. Any CV above 100% was regarded as very high variability. In the topsoil, CEC, nitrogen and soil pH have low CV of 16.89%,8.12% and 6.85% respectively, soil calcium, sodium, potassium and available phosphorous varied moderately at 27.57%, 32.77%, 45.74% and 26.80%. High CV was recorded for magnesium, 50.35% and very high for organic matter (127%) at the topsoil. In the subsoil, CEC, nitrogen and soil pH have low CV of 19.42%, 9.26% and 15.85% respectively, sodium, calcium, magnesium, potassium and available phosporous varied moderately at 29.21%, 30.58%, 37.14%, 43.82% and 28.97% respectively. Very high CV was recorded for organic matter (121%).

This study confirms the fact that soil processes controlling variability of the characteristics may be different at different scales. The observed differences in soil properties were attributed to pedogenetic-geomorphic factors like eluviation and illuviation (Olorunlana, 2014). Salako et al. (2006) observed that geomorphic processes and parent materials do have different influences on the concentrations of chemical properties. Olowolafe (2002) also established some variation in soil properties due to the influence of soil parent materials in a study of two separate catchment areas of Jos, Nigeria. The results of this study indicate that the variability of soil properties can be attributed to the inherent heterogeneity in the parent material, soil depth and location. Since soils formed from the parent material have the same amount and concentration of soil properties, it is only logical to conclude that by ensuring the protection of parent material could guarantee the quality of the soils. The formation of organic matter are more intense at the topsoil with dense vegetation cover than sparse vegetation cover. This was probably true for the study area due to higher moisture content and the vegetation cover. Area under dense vegetation cover is sure to have high level of organic matter for soil enrichment. Organic matter plays a significant role in aggregating the soil particles and makes it more resistant to soil erosion.

Conclusion

Soil variability is inherent in nature due to geologic and pedologic soil forming factors but some of the variability may be induced by tillage and other management practices. These factors interact with each other across spatial and temporal scales, and are further modified locally by erosion and deposition processes. Spatial variation of soil properties in Akoko region had been examined. It was concluded that due to variability of soil properties, soil erosion rate varied from one location to another in the region.

There is need to regulate soil loss through preventive measures such as mulching, terrace and planting of cover crops so as to reduce the existing rate of soil loss and enhance agricultural productivity. If long term preventive measures such as re-vegetation with trees and perennial grasses, introduction of agro-forestry programme that is compatible with crop, livestock and forestry development and short term soil and water conservation measures are put in place, these will reduce soil loss in Akoko region.

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