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Assessment of Soils Susceptibility to Erosion Menace in Calabar Metropolis, Cross River State, Nigeria

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ABSTRACT This study on the assessment of soils susceptibility to erosion menace was carried out in Calabar Metropolis. Four representative sample sites were randomly selected from where soil samples were collected and subjected to laboratory analysis for the determination of physical properties. The physical measurement of erosion sites was accomplished with the aid of appropriate measuring instruments. The physical properties of soil showed that sand values ranged from 81 – 92% with a mean value of 8.7% and a coefficient of variation of 4.5%. The clay fraction ranged from 2 – 12% with a mean value of 6.5% and a coefficient of variation of 4.7%. The bulk density ranged from 1.35 g/cm^3 to 1.64 g/cm^3 with mean value of 1.55 g/cm^3 and coefficient of variation of 4.04%. Particle density ranged between 2.43 to 2.60 g/cm^3 and a coefficient of variation of 0.071 g/cm^3 were all recorded respectively. Porosity values ranged from 56 to 67% with mean value of 60.83% and coefficient of variation of 11.30%. The coefficient of variation shows that the area has identical soil characteristics hence; there is no marked difference in soil of the selected study locations. The result of this study shows that the soils consisted of huge percentage of sand and because sand lacks cohesion, soil sharing was facilitated giving rise to erosion menace. It is necessary to forestall further degradation scenario by inculcating some important soil protection mechanics among which include the land cover protection and adequate land use planning and management.

INTRODUCTION

Soil degradation has important impact on the functioning of the socio-economic and environmental constituent of any ecosystem. It is associated with important tradeoffs for sustainability, food security, biodiversity and the vulnerability of people and ecosystem to an overall change impact (Lesschen et al. 2005). Put differently, it refers to the reduction in the value and quality of a given soil through alteration in such a way as to render it unsuitable for its best use. As a total expression of an inordinate land - use cover change, a phenomenon that apparently undermines the true potential of a landscape for its immediate or future use. The concept of land or soil degradation are often used interchangeably to represent certain fundamental changes which often manifest as the interplay between socio-economic, institutional and environment factors (Lesschen et al. 2005).

This area of research has continued to gain prime attention, especially since the International Geosphere and Biosphere Programme (IGBP) and the International Human Dimension Programme (IHDP) on global environmental change initiated their core project on this realm of study in the mid 1990s (Turner et al. 1995; Lambin and Geist 1999). Nigeria in general and Calabar in particular has experienced obvious soil degradation problem since the last few decades. The ecological and environmental hazards in Calabar in particular and Nigeria in general include erosion, drought, deforestation, and desertification to mention just a few (Oyeshola 1995). The following factors have been identified as the main causes of soil degradation in the region: improper resource management, logging of forest woods, destruction of wetlands and marshes for infrastructural development, overgrazing, over cropping of arable lands, flooding, erosion menace, strip mining, inordinate use of agrochemicals and landslides (NEST 1991). However, Okali et al. (1997) enumerated other causes to include population growth, population influx and property ownership issues. The effects of human action in the past has started attracting concern from several quarters as erosion concavities, astounding soil wash scenarios, destruction of engineering structures by water erosion and complete loss of soil fertility are now becoming common features.

The ecological issues affecting soil degradation in the region are complex. They range from natural (climatic) to anthropogenic. The climatic or natural dimensions include wind, rainfall and temperature while anthropogenic dimensions include massive deforestation, urbanization, population pressure, improper land use cover change and unwholesome destruction of watersheds. The issue of soil degradation in the area has been viewed as a consequence of inordinate alteration of land cover arising from human activity (Egbai 2002; Egbai and Ndik 2011). Information regarding the extent of damage is scarce, as a result it is necessary to consider and assess the unanticipated possible impact on the overall environment.

The phenomenon of soil degradation is indeed a major constraint to agriculture, urban development, traffic flow and other land related activities in the area as a considerable land mass is implicated. The objective of the study included the assessment of the susceptibility of soil to erosion perturbation. This will help in the understanding of the important soil characteristics (physical properties) that are central to soil coherence and aggregate stability. Hence, the articulation of best management practice(s) as a critical component of soil enhancement process essential in mitigating the phenomena of soil susceptibility and erosion perturbation in the area.

Study Area

The study area located in Calabar, Nigeria lies between latitude $04^{0}45$ and $05^{0}30$ N and longitude $8^{0}5$ and $8^{0}20$ E. The study sites are those of Ikot Awatim, MCC, Ikot Effanga and Edim Otop all in Calabar (Fig. 1). The whole area is bounded to the north by the great Qua River, to the south and east by the University of Calabar, CRUTECH and to the west by Cross River.

The area experiences maximum rainfall, which starts from late February through October. The annual average rainfall is between 2000-3500 mm. The annual relative humidity is between 80 and 100 percent and vapour pressure in the air has an average of 29 millibar throughout the year (CRADP 1992). The relief is regarded as low lying land which washes its sediments into the Great Qua River. The most significant feature in the area is the great Qua river and the entire area has similar geology. The sediment deposits are mainly sand, clay and alluvial materials. Vegetation is of the low land or humid tropical rainforest. Species of mangrove are the dominant vegetation of coastal and riverine area. The original natural humid virgin rainforest characterized by a large number of woody and non-woody plants including massive trees, shrubs, herbs, climbers and abundant biological diversity and resources amongst others has for the past years disappeared or become extinct due to human activities, particularly, logging, farming, urbanization and construction work.

MATERIALS AND METHODS

The collection of soil samples was accomplished with the aid of soil auger. Composite soil samples were randomly collected at a depth of 0-20cm from the four locations. These soil samples were air dried into a polythene bag for the laboratory analysis for particle size distribution, particle density, bulk density, and porosity, as key indicators of soil degradation. Logsdon and Karten (2004) opined that these characteristics can serve as indicators of soil degradation.

The physical measurement of erosion sites was accomplished with the following materials. A 30m measuring tap,100 m Gunter chain, ranging poles, twain rope and an anchor (weight) were used to measure the length, breadth and depth of each erosion sites. The anchor (a heavy metal) and rope were tied to a ranging pole and were used to measure the depth of gullies that could not be reached. Ranging poles and Gunter chains and survey pins were used in measuring large erosion site. The Global Positioning System (GPS) devise was used to obtain slope and the geo-coordinate dimensions. The use of physical measurement of erosion sites to elucidate the actual extent of soil degradation has apparently gained recognition in the work of (Commeraat and Imeson 1998; Mackel and Walter 1994). However, small scale interview was conducted at the time of reconnaissance survey to gather information regarding when soil erosion was initiated, duration and the possible cause(s).

RESULTS AND DISCUSSION

Physical Surface Measurement of Erosion Sites

Brief description of erosion sites was made by way of presentation of physical measurement of sites. These results are presented in Table 1.

Soil Analysis

Physical characteristics of soils from the different locations are presented as physical properties of soils in Table 2 as follows:

The results of soil analyses and the small scale oral interview revealed that soil degradation is a consequence of human activity. These activities

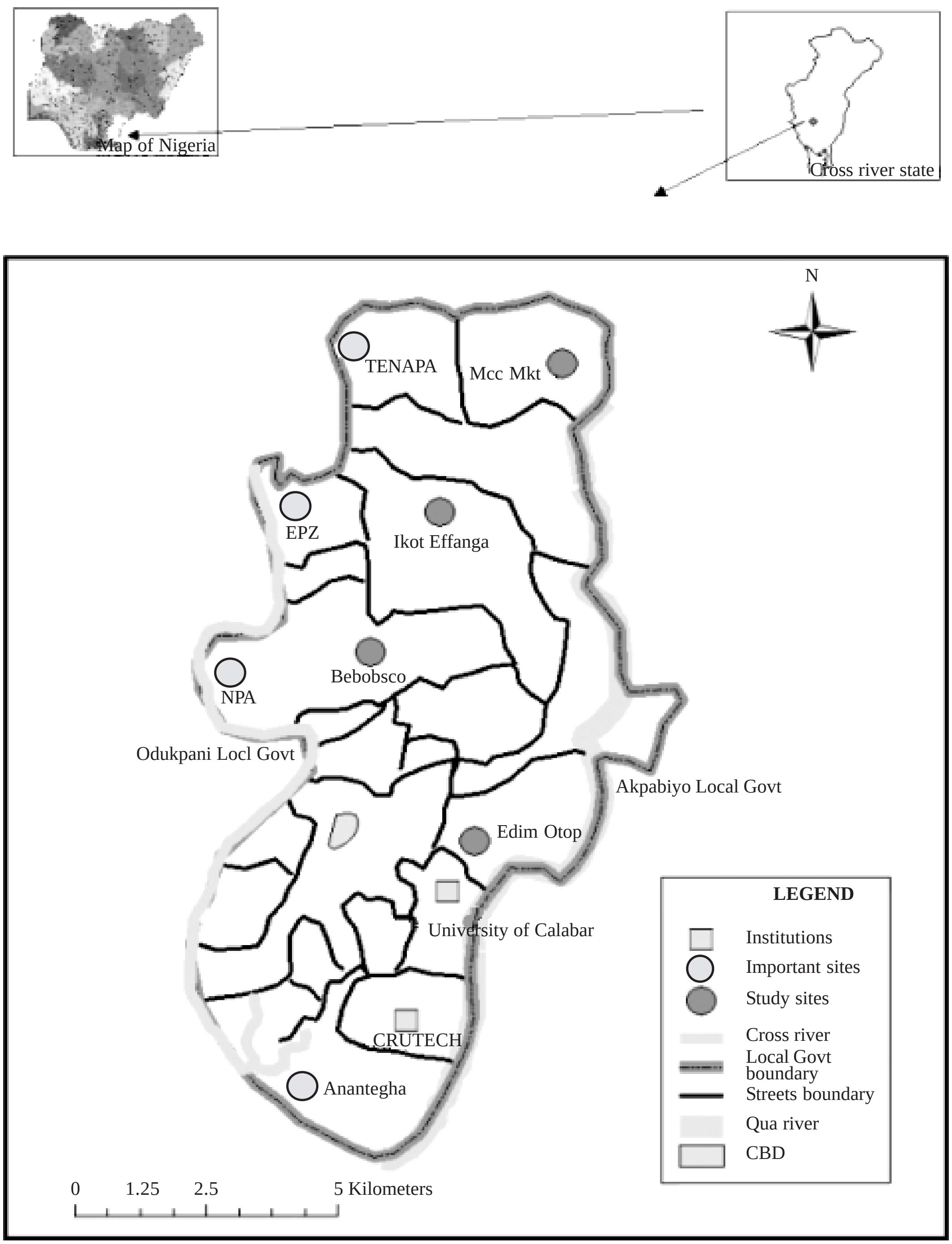

Fig. 1. Map of Calabar showing study sites

Table 1: Physical measurement of sites

Erosion site	*Parameter*	*Measurement (Dimension)*	*Year of initiation*	*Duration*	*Sources of degradation*
Ikot Awatim or Beebobsco	a) Length b) Width c) Depth	250m 10m 15m	1986	24 yr	Lumbering and agriculture activity
MCC Timber Market	a) Length b) Width c) Depth	5000m 50m 56m	1982	28 yr	Human activities and poor channelization.
Ikot Effanga	a) Length b) Width c) Depth	600m 65m 13m	1990	20 yr	Sand excavation and farming
Edim Otop	a) Length b) Width c) Depth	3000m 40m 52m	1997	13 yr	Improper channelization.

Source: Authors Field Report 2010

Table 2: Physical properties of soil in the study locations

Location	*Bd (g/cm³)*	*Pd (g/cm³)*	*Porosity %*	*Sand %*	*Silt %*	*Clay %*
MCC market	1.55	2.58	60.0	88.3	7.0	4.7
Edim Otop	1.64	2.69	60.9	81.3	7.0	111.7
Bebobsco	1.64	2.45	66.9	87.3	6.0	6.7
Ikot Effanga	1.35	2.34	55.5	92.3	6.0	11.7

Bd= Bulk density, Pd= Particle density
Source: Authors Field Work 2010

Table 3: Range, mean (M), Standard Deviation (SD) and Coefficient of Variation (CV) of soil particles

Parameter	*Range*	*Mean*	*Standard Deviation (SD)*	*Coefficient of Variation (CV)*
Sand %	81-92	87	3.94	4.53
Clay%	2-12	6.5	0.01	4.7
Silt %	6-7	6.5	0.5	7.70
Bd (g/cm^3)	1.35-1.64	1.55	0.25	4.04
Pd(g/cm^3)	2.43-2.60	2.52	0.071	2.82
Porosity %	56-67	60.83	4.38	11.30

Bd= Bulk density, Pd= Particle density
Source: Authors Field Work 2010

expose the soil entity to the vagaries of weather elements. Human activities include farming, deforestation, quarrying, channelization and road construction. Very frequently, various activities that people initiate can worsen soil erosion just as sea waves, rainfall or wind action. The impact of this menace is utterly devastating in extreme circumstances.

The physical properties of the soil showed that the sand values ranged from 81 to 92% with a mean value of 6.5% and a coefficient of variation of 7.7%. The clay fraction ranged from 2 to 12% with a mean of 6.5% and a coefficient of variation of 4.7% percent. The particle size distribution showed little variability by the coefficient of variation thus, suggesting identical textural classes of the soils. The dominant particle size is the sand fraction and from the classes obtained from the textural triangle, the soils are predominantly sandy soils. This is in consonance with the observation of Bulk Trade Investment Limited (1981) which shows that soils derived from coastal plan sand parent materials which the area represents have sandy surface soils. The different textural fractions impact certain unique characteristic on soil. This is because soil dominated by sand particles fraction enhance susceptibility to leaching and erosion, while those with dominant clay fraction can impede hydraulic conductivity, infiltration or percolation of water down the soil layers. The small surface contributes little to the water and nutrient retention capacity. Lack of cohesion has conspicuously facilitated soil sharing phenomenon. Thus, soils that are predominantly sandy are prone to leaching and erosion perturbations. Hence, the proliferation of gully sites in Calabar metropolis.

One of the major causes of soil degradation in the tropics is water erosion. The bulk density values ranged from 1.35 to 1.64 g/cm^3 with a mean value of 1.55 g/cm^3 and coefficient of variation of 4.04 $^0/_0$ were all obtained as corresponding values from the area. According to Obi (2000), loamy sand ranges from 1.1 to 1.4 g/cm^3 while that of sandy soil ranges from 1.6 to 1.84 g/cm^3, the values for the present study areas fall within these ranges. Obi (2000) had earlier stressed that such values are low and they indicate that such soils are in a loose state leading to high erosion, leaching of valuable nutrients and low water retention capacity. These factors clearly indicate that degradation has set in (Lal 1988). The particle density ranged from 2.43 to 2.60 g/cm^3 with a coefficient of variation of 0.071 indicating similar values for the four sites. Porosity values ranged from 56 to $67^0/_0$ with a mean value of $60.83^0/_0$ and coefficient of variation of $11.30^0/_0$ suggesting that the soils have identical levels of porosity. However, it is important to stress that the primary determinant of soil degradation is the particle size distribution while the other parameters are secondary and passive factors (Obi 2000). The study revealed that humans are the key players in soil degradation vis a vis the large scale susceptibility scenarios in the area. Resulting in, accelerated erosion, sediment deposits in low land areas and loss of watersheds to mention just a few. Severe accelerated erosion has been associated with tropical ecosystem which the area represents (Lal 1988).

CONCLUSION

The issues of soil susceptibility and erosion menace in Calabar Metropolis are central to the overall degradation scenarios. The apparent lack of vegetation cover, sandy nature of soil, high rainfall regimes, which is a consequence of the geographical location of Calabar are indeed not unconnected with the vulnerability of soil to rain wash. Consequently, it is necessary to evolve a holistic land use planning mechanism tailored towards ensuring aggregate stability. Through soil treatment mechanics, the use of organic manure can be captured as a veritable means of facilitating soil coherence and reduced soil sharing to a considerable level. The aspect of land cover perspective will help prevent undue exposure of soil surface to adverse effect of weather elements thereby forestalling excessive cascade of soil particulate sediment down the slope preventing the phenomenon of gully formation and ensuring sufficient land area for urban development.

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