Impact of erosion on selected soil structural indices of four Local Government Areas of Abia State, Nigeria

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ABSTRACT
Soil erosion is a major problem in several parts of South East Nigeria, and this study evaluated the effect of erosion on soil structure in Isuikwuato, Ohafia, Ukwa and Ikwuano in Abia state. In each location, topsoil samples of 0 – 20 cm depth were collected from eroded and non eroded sites and then compared for their physical properties. Soil structural indices were adversely affected by erosion, being significantly lower in eroded soils within each location and across all four locations under study. Total porosity in eroded and non eroded soils were 50.95% and 52.95% respectively, hydraulic conductivity (2.02 and 2.64 cm min⁻¹ respectively) and aggregate stability (3.54 and 5.66 m s⁻¹). In eroded soils, both initial infiltration (167.7 mm h⁻¹) and steady infiltration rate (35.4 mm h⁻¹) were significantly lower than in non eroded soil which was 554 mm h⁻¹ initial and 77.2 mm h⁻¹ steady infiltration after 3 hours. There was no significant effect of erosion on bulk density.

**Key words:**

Introduction

Soil degradation relates to any process which reduces the ability of soils to produce, be it physical, chemical or ecological processes, affecting the ability of man to produce much needed food for himself, feed for his animals and raw materials for his industries (FAO, 1995). Soils of South Eastern Nigeria have high erodibility and are classed as structurally unstable (Idowu and Oluwatosin, 2008), therefore erosion forms a major type of soil degradation in the area. Erosion affects areas which have been subjected to bush burning, continuous cultivation, and mining on hill side slopes, all of which are common and long term traditional practices in South East Nigeria (Nwachukwu and Onwuka, 2011). Erosion also affects development because infrastructures such as houses, roads, and many others are being destroyed yearly (Idah et. al., 2008).

Soil structure relates to the physical state of the soil complex, and the indices which of soil structure comprises are properties such as bulk density, soil texture, aggregate stability, infiltration, clay dispersion and porosity (DEFRA, 2006; USDA, 1996). Erosion directly affects the structure of a soil because when erosion occurs it washes away the topsoil, resulting in a rearrangement of soil particles, soil moisture and aeration status and compaction (Brady and Weil, 2004). Soil structure therefore
influences all processes that take place in the soil including water and nutrient movement within the soil (Eneje and Mbagwu, 2005).

The organic constituents of the soil are very important because of their influence on stability of soil aggregates (Agbede, 2009). Organic matter is vital for the physical, chemical and biological functioning of soils (DEFRA, 2006), and burning of farmlands leads to direct loss of organic matter, consequently facilitating erosion. Burning of natural vegetation causes the pH of the topmost soil layer to rise and facilitates its disaggregation. This, in turn results in clay illuviation to subsurface horizons as well as the erosion of fine sand which has major implications on soil morphology (Onwuka et al., 2009).

In South East Nigeria, the soils are naturally prone to erosion due to their fragile nature and ease of leaching, being mainly ultisols and alfisols (Oguike and Mbagwu, 2009). The situation is further aggravated due to practices like bush burning and indiscriminate excavations (Igwe and Ejiofor, 2005). This study sought to evaluate the impact of erosion on selected soil structural indices in Abia State, Nigeria.

Materials and Method

The experiment was designed as a split plot Factorial in Completely Randomized Design with location being the Main Plot (4 locations) and soil status as the subplot i.e. eroded soils and non eroded soils (2 status), with five replications (within the subplots five samples were collected each for either eroded or non eroded soil). The local Government Areas used were Isuikwato, Ohafia, Ikwuano and Ukwa East (Plate 1), with each sampling point being one kilometer apart, taken radially from a singly starting point.

Plate 1. Map of Abia State showing sampling locations
Approximately 1kg soil was collected from each location and taken to the greenhouse at Michael Okpara University of Agriculture greenhouse where they were air dried for 48 hours. Soils for physical analyses were not sieved. The selected soil physical (structural) characteristics studied were bulk density (Campbell and Henshall, 1991); mean weight diameter/aggregate stability (Kemper and Chepil, 1965); saturated hydraulic conductivity (Young, 2001); particle size analysis using calgon as a dispersion agent (Bouyocos, 1962); micro porosity and total porosity (Marsily, 1988). Analysis of Variance was done on the results of the experiments using Gen Stat 7.2 DE and where significant, the LSD of 5% means was used in order to separate the means of the variables.

Results and Discussion

The particle size analysis of soils is presented in Table 1, and it shows that erosion has impact on soil texture by disrupting its natural composition.

<table>
<thead>
<tr>
<th>Non eroded soils</th>
<th>Eroded Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand</td>
</tr>
<tr>
<td>Isuikwuato</td>
<td>90.56</td>
</tr>
<tr>
<td>Ohafia</td>
<td>94.34</td>
</tr>
<tr>
<td>Ukwa</td>
<td>92.34</td>
</tr>
<tr>
<td>Ikwuano</td>
<td>72.00</td>
</tr>
<tr>
<td>Soil status mean</td>
<td>87.31</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>2.3</td>
</tr>
</tbody>
</table>

T. class- textural class; row comparisons (eroded vs non eroded); column comparisons (locations)

There was significantly more sand in eroded soils than non eroded soils. This would be as a result of the loss of organic binding agents by rain action, leading to the loss of finer soil particles carried away by the force of erosion and flood water (Olusegun et al., 2011). The aggregate stability of soils was reduced by erosion (Table 2), especially at 2.0mm. Generally, silt and clay content in eroded soils was reduced while sand content was increased, suggesting great influences on surface water flow which have eroded the lighter silt and clay in the soils tested.
Table 2 Effect of erosion on Aggregate Stability in Soils of Abia State

<table>
<thead>
<tr>
<th>Location</th>
<th>0.6mm</th>
<th>1mm</th>
<th>2mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E</td>
<td>NE</td>
<td>E</td>
</tr>
<tr>
<td>Isuikwuato</td>
<td>5.8</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Ohafia</td>
<td>7.2</td>
<td>6.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Ukwa</td>
<td>6.9</td>
<td>7.6</td>
<td>5.6</td>
</tr>
<tr>
<td>Ikwuano</td>
<td>4.1</td>
<td>4.3</td>
<td>4.1</td>
</tr>
<tr>
<td>LSD</td>
<td>1.9</td>
<td>1.4</td>
<td>0.9</td>
</tr>
</tbody>
</table>

E- eroded; NE- non eroded

In comparing aggregate stability of eroded and non eroded soils, there was no statistical difference at 0.6 mm and 1.0 mm, but there was a highly significant reduction of aggregate stability in eroded soils at 2mm aggregate size (Table 2). Bulk density did not show any significant difference due to erosion (Table 3).

There was no significant difference in the electrical conductivity between eroded and non eroded soils except at Isuikwuato. However, erosion had a highly significant effect on total porosity between eroded and non eroded soils being a lower average of 50.95% in eroded soils and 52.96% in non eroded soils (Table 3).

Table 3 Effect of Erosion on Bulk density, Porosity, Hydraulic cond. and Electrical conductivity

<table>
<thead>
<tr>
<th>Location</th>
<th>Bulk density</th>
<th>Porosity</th>
<th>Hydraulic cond.</th>
<th>Electrical Cond.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E</td>
<td>NE</td>
<td>E</td>
<td>NE</td>
</tr>
<tr>
<td>Isuikwuato</td>
<td>1.18 (1.24)</td>
<td>53.5 (51.5)</td>
<td>3.12 (2.20)</td>
<td>2.30 (3.30)</td>
</tr>
<tr>
<td>Ohafia</td>
<td>1.32 (1.20)</td>
<td>49.0 (52.8)</td>
<td>1.46 (4.29)</td>
<td>3.06 (3.22)</td>
</tr>
<tr>
<td>Ukwa</td>
<td>1.30 (1.22)</td>
<td>49.5 (53.1)</td>
<td>2.75 (3.04)</td>
<td>3.06 (2.82)</td>
</tr>
<tr>
<td>Ikwuano</td>
<td>1.22 (1.60)</td>
<td>51.7 (54.4)</td>
<td>0.75 (1.03)</td>
<td>2.42 (2.58)</td>
</tr>
<tr>
<td>LSD</td>
<td>0.56</td>
<td>1.8</td>
<td>0.86</td>
<td>0.34</td>
</tr>
</tbody>
</table>

E- eroded, NE- non eroded

Micro porosity and Macro porosity tests of eroded soils were significantly lower than non eroded soils across all locations. Porosity influences rate of infiltration and percolation and both are factors which affect the disposition of a soil to erosion (Idah et. al., 2008). Hydraulic conductivity showed significant difference among locations only, and not between eroded and non eroded soils (Table 3).
Infiltration

Initial Infiltration rate of less than 30 minutes showed statistical difference between eroded and non eroded soils and at different locations, being lower in eroded soil (Figure 1).

![Figure 1 Effect of Erosion on Infiltration in Soils of Four LGA’s of Abia state](image)

Steady Infiltration rates also showed statistical difference between eroded and non eroded soils, being lower in eroded areas (Figure 1). The implication of this is more noteworthy given that such a significant impact is already made at early stages of erosion in the areas under study. It has been shown that soil aggregate breakdown due to dispersion results in pore collapse which reduces infiltration rate, leading to runoff and erosion and finally, soil degradation (Tekwa and Usman, 2006). There was no difference in soil status to the mean weight diameter of the soils.

Conclusions

From the study, soil structural indices were adversely affected by erosion as total porosity, hydraulic conductivity, infiltration and aggregate stability were all significantly lower in eroded soil. Reduced water infiltration tends to increase run-off which can lead to further erosion, and lower soil porosity has implications for reduced aeration and consequently, productivity. A reduction in the silt and clay fractions of the soil tends to also cause lower chemical reactions and exchangeable cations, thereby leading to loss of top soil which reduces the capacity of soil to function and restricts its
ability to sustain future uses. Destruction of the physical character of the soil through erosion will limit the other uses of the land like urban and rural infrastructural developments. It is recommended that safe cultural practices like crop rotation, mulching and adoption of organic farming techniques be incorporated into farming communities of Abia state in order to stem the advance of erosion in the study areas.

References


Marsily G. de., 1986 Quantitative Hydrogeology Academic Press Orlando Flo. USA


