American International Journal of Agricultural Studies
Vol. 3, No. 1; 2020
ISSN 2641-4155 E-ISSN 2641-418X
Published by American Center of Science and Education, USA

Influence of Grasscover in Restoring the Properties of Eroded Soils of Umudike, Southeastern, Nigeria

Onwuchekwa Ojimgba *PhD*
Department of Soil Science
Faculty of Agriculture, Abia State University, Uturu, Nigeria
E-mail: onwuchekwao@yahoo.com

Abstract
The influence of grasscover in restoring the eroded soils was carried out in Umudike, Southestern Nigeria. The use of grass has attracted considerable research attention with respect to forage production and erosion control. Little information is available on the influence of this grasscover management on soil physical and chemical properties. Four different grasses namely: *Paspalum notatum(PN), Panicum maximum(PM), Axonopus compressus(AC)* and *Vetiver* grass(VG)- ***Vetiveria zizanioid/es***) were used in this study and their influence on eroded soil tested in two locations. This study has shown that the soils planted with the grasses gave significantly (p<0.05) higher results of the physical and some chemical properties than their adjacent open bare soil. In all the parameters considered in this study, the values obtained in soils under *Paspalum notatum* was higher than those obtained in PM, AC, VG and their adjacent bare soils(BS). The soils under PN had generally lower bulk density, higher total porosity and hydraulic conductivity than other grasses and adjacent open bare soil in both locations. The soil under PN proved best, outperforming PM, VG,and AC in stabilizing soil aggregates. Planting of PN on eroded soil significantly (p<0.05) increased the mean weight diameter from 0.77mm (BSPN1) to 1.31mm (PN1) and 0.82mm (BSPN2) to 1.48mm (PN2) for Locations 1 and 2, respectively. The relative improvement in Location 1 was in the order : PN1>AC1=VG1>PM1>BSVG1=BSPN1>BSAC1=BSPM1. Also, soils under PN had significantly higher values of pH, organic C and organic matter, total nitrogen and available P more than other grasses and their adjacent open soils. The magnitude of increase in Location 1 was in the order : PN1>AC1>PM1=VG1>BSVG1=BSPN1=BSAC1>BSPM1. Location 2 also increased in the same trend. The organic carbon content of PN increased from 0.73%(BSPN1) to 2.89%(PN1) and 0.88%(BSPN2) to 2.91%(PN2) in Locations 1 and 2, respectively. Also, the organic matter content of the soil increased in the same trend as organic carbon content.

Keywords: Influence, Grasscover, Restoring, Eroded Soils, Umudike, Nigeria.

1. Introduction

1.1 Background Information

Land degradation is becoming one of the severest environmental issues in the world, especially in developing nations. Land degradation, usually accompanied by soil erosion, always results in a decrease or complete loss of land productivity, and produces on-site and off-site pollution to soil and water. Much has been written about the amount of land in the different continents which have succumbed to erosion. It is a major impediment to increased agricultural production in many areas of Nigeria (Ojimgba, 2018). Studies in Nigeria show that damage caused by soil erosion is, manifested in detrimental changes in the physical and chemical properties of the residual eroded soils.

The erosion of soil is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year. Soil erosion may be a slow process that continues relatively unnoticed or it may occur at an alarming rate causing serious loss of topsoil (Ojimgba and Mbagwu, 2007). The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality damage drainage networks (Blanco and Lal, 2010).

.However, erosion is a natural process; human activities have increased by 10-40 times the rate at which erosion is occurring globally. Excessive erosion causes both ‘’on-site’’ and ‘’off-site’’ problem. On-site impacts include decrease in agricultural productivity and ecological collapse, both because of loss of the nutrient-rich upper soil. In some cases, the eventual end result is desertification. Off-site effects include sedimentation of water ways and eutrophication of water bodies, as well as sediment-related damage to roads and houses. Water and wind erosion are the two primary causes of land degradation, they are responsible for about 84% of the global extent of degraded land, making excessive erosion one of the most significant environmental problems world-wide (Blanco and Lal, 2010).

Intensive agriculture, deforestation, roads, anthropogenic climate change and urban sprawl are among the more significant human activities in regard to their effect on stimulating erosion (Julien, 2010). However, there are many remediation practices that can curtail or limit erosion of vulnerable soils and one of such is the use of suitable grasscover.

Grasscover are grasses that are planted primarily to manage soil erosion, improving soil fertility, soil quality, water, weeds, pest, diseases, biodiversity, and wildlife in an agroecosystem (Ojimgba and Mgbeahuru, 2018). Grasscover and perhaps land use are some of the most important factors in erosion management in south eastern- Nigeria. Bahia grass increases soil organic carbon, microbial biomass and potential nitrogen mineralization rate, reducing the bulk density. According to the authors, soils under grass cover have shown better chemical properties than soils under forest cover and also bare soils. Stocking, *et al*., (1988) showed that vegetative cover acts in a variety of ways by intersecting raindrops, encouraging greater infiltration of water and increasing surface organic matter, thereby reducing the erodibility of the soil. Sustainable Agriculture Research and Education opined that grasscover helps to cut fertilizer cost, reduced the need for herbicides and other pesticides, improve yields by enhancing soil health, prevent soil erosion, conserve soil moisture, protects water quality and help safe-guide personal health. The objective of this study was to determine the influence of grasscover in restoring the properties of eroded soils of Umudike, Southeastern, Nigeria

2. Materials and Methods

2.1 General Description of the Location

The study was conducted on the experimental research farm of Abia State University, Umuahia Campus. This study area is located on latitude 0.5^0 -29’N and longitude 07^0-33’E in the rainforest ecological zone of South Eastern Nigeria and lies at a mean elevation of 122meters (400ft) above sea level (climatic data for National Root Crop Research Institute (NRCRI) Station, Umudike).

The soil is classified as Ultisol according to USDA and as an Acrisol according to FAO/UNESCO classification schemes, as summarized by Opara-Nadi (2000). The soil is characterized by inherent constraints such as low organic matter, poor structural stability, low nutrient and water holding capacities, low clay activities and high susceptibility to soil erosion and drought stress (Opara-Nadi 2000; Salau *et al.*, 1992).

The climate of Umuahia is typical of the humid tropics, with fairly even and uniform temperature throughout the two seasons (dry and rainy) each year. The rainy season which usually starts from March and ends in October is characterized by clouds driven by light winds from the ocean relatively constant temperatures. Frequent rain and high humidity from May to October, rainfall is quite high with peaks in July and September. The rainfall distribution pattern of the area is bimodal with a total annual mean of 1830mm in the Northern parts to 2188mm in the Delta region (Odurukwe *et al.*, 1995). The mean annual minimum temperature ranges from 30^0C to 33^0C and mean annual minimum temperature ranges from 21^0C to29^oC (Enwezor *et al*., 1990).

Grasscover Species Used for the Study

Carpet grass/Root (*Axonopus compressus)*

Bahia grass/Root (*Paspalum notatum*)

Guinea grass/Root (*Panicum maximum*)

Vetiver grass/Root (*Vetiveria zizanioides*)

2.2 Laboratory Studies

Under each of the grasscover and the adjacent bare soil, disturbed samples were collected from the 0 -30 cm in two locations within the campus. Each location represented a replicate. The samples were collected from the grasscover (*Paspalum notatum, Panicum maximum, Axonopus compressus* and *Vetiver* grass- ***Vetiveria zizanioides***) already established to monitor runoff and soil loss, and their adjacent open bare soil ten (10) meters away. The grasses had been there for over 8 years. These are perennial grasses and could be widely accepted as a better alternative for land reclamation due to their excellent features: 1) strong resistance to adverse conditions, which adapts it to various harsh weather and environmental conditions; 2) strong ability to remove pollutants, which makes it rehabilitate the polluted land rapidly; and 3) huge biomass, including shoots and roots, which makes it effectively ameliorate the degraded soil and cover barren land rapidly.

Also, undisturbed core samples were collected randomly near points where the disturbed samples were taken. The dimensions of the core were 5.0 cm (height) and 5.7cm (internal diameter). The disturbed samples were air-dried, sieved through a 2-mm sieve and used to determine particle size distribution, pH, organic carbon, total nitrogen, available phosphorus and moisture retained at 1.5 MPa. The core samples were used to measure soil moisture retained at 0.01 MPa, saturated hydraulic conductivity, bulk density and total porosity. The unsieved, disturbed samples were used to determine aggregate stability.

The procedures that were used for the determination of the physico-chemical properties of the soil were outlined below:

Soil reaction (pH)

Soil pH was determined in 0.1N Potassium chloride (KCl) solution using a soil: liquid ratio of 1:2.5. After 20g of soil sample was weighed into plastic beakers, distilled water of KCl was added and stirred for 30 minutes, then the pH values was read off using a glass electrode pH meter (McLean. 1982).

Organic carbon (OC)

This was determined by the Walkley and Black method in which the soil organic matter was oxidized using 1N $K_2Cr_20_7$ solution and conc.H_2SO_4, and the percentage organic carbon found by titrating with IN ferrous ammonium sulphate solution (Nelson and Sommers, 1982).

Organic Matter (OM)

This was determined from Walkley and Black method. The organic matter content was determined by multiplying the percentage organic carbon by the conventional ''Van Bemmelen factor'' of 1.724. The use of this factor is based on the assumption that soil organic matter contains 58% carbon.

Total Nitrogen (N)

This was determined by the micro-Kjaldahl method using $CuSO_4/Na_2SO_4$ catalyst mixture. The ammonia (NH_3) from the digestion was distilled with 45% NaOH into 2.5% boric acid and determined by titrating with 0.5N HCl

Available phosphorus

Available phosphorus was determined by the extractant method-Bray's method II (0.03N ammonium fluoride x O.IN HCl). The ppm phosphorus were determined using a photo-electric calorimeter (Page *et al.*, 1982).

Particle Size Analysis

Particle size analysis was determined on the soil sample using the principles of Bouyoucos hydrometer method described by Day (1965). The technique used was the dispersion of sample with calgon (sodium hexameta-phosphate). In this method, soil samples were soaked in calgon for 24 hours and later transferred to mechanical stirrer for mechanical agitation before the hydrometer test (Gee and Bauder, 1986).

Soil Moisture Retention Characteristics

Disturbed soil samples were collected from the plots and 30 g of each weighed into robber bands (rings). These were used to determine the water content of the soil at 1.5 MPa (15 bar) and 0.01 MPa (0.1 bar), using the pressure – plate apparatus (Stolte, 1997). In each case, the samples were placed on ceramic plate – sand soaked with water for 24 hours. The plates with the samples were placed in the pressure chamber and subjected to the different suctions until water ceased to drain out from the soil samples. The samples were then weighed and oven dried at 105°C for 24 hours.

Calculation

Field capacity that is 0.01 MPa suction is the maximum amount of water the soil can hold after it has freely drained for 2 – 3 days following saturation and without evapotranspiration occurring during the period (Klute, 1986). **Wilting point:** This value is sometimes known as lower limit of plant available water. It is often equated to the soil water content at 1.5 MPa (15 bar) water potential.

Available Water Capacity (AWC)

The amount of water which a given soil can store for plant use is estimated from the difference between the field capacity (FC) and the Wilting point (WP). It was calculated as follows.

AWC = FC - WP

Where:

FC = gravimetric water content at field capacity (%)

WP = gravimetric water content at wilting point (%)

Saturated Hydraulic Conductivity

Undisturbed soil samples were collected from each plot using cylindrical metal cores of size 5.0 x 5.7 cm for the length and internal diameter, respectively. Soil loss was prevented by a muslin gauze at the bottom of the column. After saturating the samples with water for 24 hours, saturated hydraulic conductivity $K(\theta)$ was determined using a constant head permeameter. The transposed Darcy's formula for vertical flows of liquid was used to calculate $K(\theta)$ thus:

$$K(\theta) = \frac{\theta}{At} \cdot \frac{L}{\Delta H}$$

Where:

θ	=	Steady state volume of flow (cm^3)
A	=	Cross sectional area of core sample (cm^2)
t	=	Time elapsed (hr)
L	=	Length of core sample (cm)
ΔH	=	Change in hydraulic head (cm)
$\frac{H}{L}$	=	The hydraulic gradient (i.e., space rate of change of hydraulic head in the direction flow).

Bulk Density

Bulk density (D_b) is the apparent density of the field soil and was calculated by dividing the mass of the oven – dried soil by its volume. After drying the soil samples used for the hydraulic conductivity measurements for 48 hours at 105°C, bulk density was determined by the core method (Blake and Hartge, 1986) using the formula.

$$D_b = \frac{M_s}{V} \ g/cm^3$$

Where:

D_b	=	bulk density
M_s	=	mass of soil sample
V	=	volume of soil sample (equals volume of core)

Total Porosity

Total porosity is the volume of the sample not occupied by solid materials and is usually expressed as percentage of the sample volume. It is assumed to be the volume available to air and/or water. It was calculated from the values of bulk density using the method described by Vomocile (1965). The calculation was based on the relationship between bulk density and particle density and on the assumption of particle density of 2.65 mg m^{-3} for mineral soils.

$$S_t = \frac{(1 - D_b)}{D_p} \times 100$$

Where:

S_t	=	total porosity (%)
D_b	=	bulk density (mg m^{-3})
D_p	=	particle density (mg m^{-3})

Water Stable Aggregates (WSA)

A nest of sieves, 2 mm, 1 mm 0.5 mm as described by Kemper and Chepil (1965) were used to sieve wet aggregates of between 4 and 2 mm diameter size. The operation was carried out for 2 minutes at one oscillation per second after which the sieves were removed from water and oven – dry weight of the materials on each determined. Mean weight diameter : This was determined using the method of Van Bavel (1950) as modified by Kemper and Chepil (1965). The materials used for water stable aggregates determination were used in the following relationship:

MWD = $\sum \overline{X_1} W_1 \ldots$

MWD = mean weight diameter

$\overline{X}$ = mean diameter of each size fraction (mm)

W = the proportion of the total sample weight occurring in the corresponding size fraction.

2.3 Statistical Analysis

The data collected were analyzed statistically and significant differences between treatment means of various experiments were tested at P<0.05 using the Fisher's least-significant differences (F-LSD), standard errors and student's "t"-test, according to the procedures of Steel and Terrie (1980). In all statistical analysis, P<0.05 were used to test for significant differences between the treatment means of the various experiments.

3. Results and Discussion

Physico-chemical properties of the eroded surrounding topsoil of the study site at Umudike, Nigeria.

Tables 1 and 2 summarize the physico-chemical properties of the bare topsoil of the study site at Umudike, Nigeria. The sandy clay loam topsoil had 1.70 mg gm^{-3} bulk density, 25.50% total porosity and 10.02 cm hr^{-1} hydraulic conductivity. However, the topsoil of the study site had low pH, N, Organic C. and consequently organic matter, available P, exchangeable cations (K, Na, Ca, and Mg) and percentage base saturation. However the percentage Al. saturation, effective cation exchange capacity (ECEC) and exchangeable acidity (EA) were high.

The very high bulk density , decrease in total porosity and hydraulic conductivity observed in the surrounding soils of the study site according to Ojimgba and Mbagwu (2007), was due to translocation of clay from eluvial horizon with simultaneous loss of structure and close parking of sand grains in the eluvial horizon. Lowery *et al*., (1995) also associated increase bulk density and decrease saturated hydraulic conductivity of eroded soils to loss of organic matter and other colloidal particles. Ojimgba and Mbagwu (2007) also concluded that increase in bulk density generally resulted in decrease porosity and poor aeration which physically restrict root growth.

Also, the soil pH value (4.42) was acidic. Ojimgba and Mbagwu (2007) observed that there was a problem of exposure of very acidic subsoil due to erosion. They attributed this low value partly because the soils were heavily leached of the basic cations due to very heavy rainfall associated with the rainforest zone. The organic matter content (0.72%) was low which is typical of most tropical soils which have been exposed to hot weather and constant cultivation. As erosion increased, Organic C is reduced (Ojimgba and Mbagwu, 2007). Opara-Nadi (2000) concluded that, these soils being an Ultisol constitutes the bulk of the upland soils of southeastern Nigeria. He added that these soils are rich in free iron but have a lower mineral reserve and lower fertility than the Ferruginous Tropical Soils. Their cation exchange capacity and base saturation are very low.

Table 1. Physical properties of unprotected topsoil at Umudike, Nigeria.

Attributes /Statistics	Units of measurement	Mean values
Sand	%	51.80
Silt	%	12.80
Clay	%	35.40
Textural class		Sand clay loam
Bulk density	mg mg^{-3}	1.70
Total porosity	%	26.50
Hydraulic conductivity	cm hr^{-1}	10.02

Table 2. Chemical properties of unprotected topsoil at Umudike, Nigeria.

Attributes /Statistics	Units of measurement	Mean values
pH		**4.42**
Nitrogen	**%**	**0.03**
Organic C	**%**	**0.42**
Organic matter	**%**	**0.72**
Available P	**Ppm**	**3.40**
Exchangeable K	**C mol (+) kg^{-1}**	**0.06**
" Na	**"**	**0.12**
" Ca	**"**	**0.70**
" Mg	**"**	**0.50**
" Al	**"**	**2.20**
Exchangeable H	**"**	**0.60**
Exchangeable Acidity (EA)	**"**	**2.80**
Effective cation exchange capacity (ECEC)	**"**	**4.18**
Al Saturation	**%**	**62.90**
Base saturation	**%**	**39.00**
C:N		**14:1**

Influence of grasscover management in improving the physical properties of eroded soils of Umudike, Nigeria

Table 3 summarizes the influence of grasscover (*Paspalum notatum*, *Panicum maximum*, *Axonopus compressus* and *Vetiver* grass- ***Vetiveria zizanioides***), and their adjacent open soils on the textures, bulk density, total porosity and hydraulic conductivity of the soils of Umudike. The grasscover management significantly ($P<0.05$) improved the soil physical properties. There were also significant changes in the physical properties of the various grasscover management as shown in Tables 3, 4 and 5. Therefore, the grasscover management improved the physical properties of the degraded soil.

Particle size distribution

Generally, the values obtained from Table 3 show that the textures of the soils were not affected significantly at $P<0.05$ by the various grasses. Clay values obtained from the grasses (PM, PN, AC AND VG) were significantly similar and ranged between 33 and 35% for PN1 and BSPM1 in Location 1 as well as 34 and 35% for PN2 and BSVG2 in Location 2, respectively. Also, Table 3 shows the values of the silt which were significantly similar in both Locations 1 and 2, and ranged between 10 and 11% for BSPN1 and PN1 (Location 1), and 10 and 12% for BSAC2 and PN2 (Location 2), respectively. However, total sand content with statistically similar values ranged between 54 and 56% in Location1 for BSVG1 and PN1, and 54 and 55% in Location 2 for PN2 and BSAC2, respectively.

Bulk density

Table 3 also shows that the grasscover management significantly decreased the soil bulk density relative to the adjacent open soils in Locations 1 and 2. The results indicated that *Paspalum notatum* (PN) gave significantly higher bulk density values in Location 1 than those of the other grasses and their open adjacent soils. For example in Location 1, the PN1 reduced the bulk density from 1.43 (BSPN1) to 1.10 mg m^{-3}(PN1), while in Location 2, the reduction was from 1.49(BSPN2) to 1.13 mg m^{-3} (PN2). The differences among the treatment means were in the order : PN1<PM1=AC1=VG1<BSPM1=BSPN1=BSVG1=BSAC1. The results showed that the adjacent open soils produced no significant changes in bulk densities probably due to low organic matter content.

Total porosity

Table 3 also shows that the various grasscover management significantly increased the total porosity when compared with the adjacent open soils in Locations 1 and 2. The *Paspalum notatum (68.23%)* had statistically similar total porosity values with those of *Axonopus compressus (68%)* and *Panicum maximum (65%)* which were significantly higher than the values of Vetiver grass (48%) and their adjacent open soils. The differences between the treatment means in Location 1 were in the order : PN1=AC1=PM1>VG1=BSPN1>BSPM1>BSVG1=BSAC1. Also in Location 2 PN1 gave significantly ($P<0.05$) the highest total porosity values than the rest of the treatments. The values ranged between 71.00 and 35.00% for PN2 and BSVG2, respectively.

Hydraulic conductivity

Table 3 also shows that *Paspalum notatum (PN1)* and *Axonopus compressus (AC1)* significantly increased the soil hydraulic conductivity relative to the statistically similar values of PM1 and VG1 as well as their adjacent open soils. However, the grasscover *Paspalum notatum (PN)* gave significantly higher soil hydraulic conductivity values of 75.00 and 79.00 cm hr^{-1} than other treatments, while the least values of 25.00 and 27.00 cm hr^{-1} in both Locations 1 and 2 study periods, respectively were the results for BSVG1 and BSAC2. Also, the relative improvement in the hydraulic conductivity of the eroded soils by the grasses was in the order : PN1(75 cm hr^{-1}) =AC1 (75 cm hr^{-1}) >PM1 (63 cm hr^{-1}) =VG1 (60 cm hr^{-1}) >BSPM1(45 cm hr^{-1}) =BSPN1(43 cm hr^{-1}) >BSAC1(26 cm hr^{-1}) =BSVG1(25 cm hr^{-1}) . *Paspalum notatum (PN1) grass*, therefore, greatly improved water movement into the eroded soils more than the other grasses.

Water-stable aggregates (WSA)

Table 4 shows the influence of grasscover on water-stable aggregates as well as the mean weight diameter of the study soils. Introduction of grasscover on the eroded soil greatly improved the stability of the soils. Aggregate stability was determined at five different diameter : 4.00 – 2.00 mm, 2.00 – 1.00 mm, 1.00 – 0.5 mm, 0.5 – 0.2 mm, and <0.2 mm. The eroded soil planted with *Paspalum notatum* in Locations 1 and 2 proved best, outperforming other treatments in stabilizing aggregates. For example, relative to the adjacent open soil, in size range of 4.00 -2.00 mm, PN increased from 13.10 to 31.80, and 14.67 to 40.70% in Locations 1 and 2, for BSPN and PN, respectively. Also, in size range between 0.5 and 0.2 mm, *Paspalum notatum* significantly ($P<0.05$) reduced the soil size range from 49.37 to 35.00%, and 49.10 to 30.50% in Locations 1 and 2 for BSPN and PN, respectively. Similar trends were observed with the < 0.2 mm fraction. However, relative to the adjacent open sites whose effects were not statistically noticed, the establishment of *Paspalum notatum* in the eroded soils significantly increased mean weight diameter (MWD). The relative improvement in Location 1 was in the order : PN1>AC1=VG1>PM1>BSVG1=BSPN1>BSAC1=BSPM1. All the grasses significantly improved the eroded soils more than their adjacent open soils, while PN was the best in improving the soil aggregates. Planting of PN on eroded soil significantly ($p<0.05$) increased the mean weight diameter from 0.77mm (BSPN1) to 1.31mm (PN1) and 0.82mm (BSPN2) to 1.48mm (PN2) for Locations 1 and 2, respectively.

Moisture retention characteristics

Table 5 summarises the influence of grasscover management on volumetric soil moisture content (0.01 and 1.5 MPa suctions) and available water capacity of the eroded soils of Umudike, Nigeria. As with the saturated hydraulic conductivity and total porosity, the establishment of grasscover into the eroded soils significantly increased the soil moisture contents measured for the 0.01 and 1.5 MPa matric potentials. Among the treatments, PN gave significantly the highest moisture content. However, the magnitude of increase was more pronounced at field capacity (0.01 MPa) than at wilting point (1.5 MPa). The volumetric moisture content of the soils ranged between 23.00 and 40.00% at 0.01 MPa in Location 1, and 24.90 and 40.90% in Location 2, for BSVG and PN, respectively. At these suction levels, higher values were obtained for soils with PN, while the corresponding adjacent open soils had lower values. However, the relative order of improvements in available water capacity (AWC) obtained due to these grasses was : PN1>AC1> PM1>VG1> >BSPM1>BSPN1>BSAC1=BSVG1. Generally, the adjacent open soils gave significantly lower values than the grasses.

Table 3. Influence of grasscover on the physical properties of eroded soils of Umudike, Nigeria.

Location	Treatment	% Clay	% Silt	% Sand	T C	BD (Mg m^{-1})	TP (%)	HC (cm hr^{-1})
	-----	Particle Size Analysis	---------					
Location 1	BSPM1	35.00	11.00	54.00	SCL	1.43	40.21	45.00
	PM1	35.00	10.00	55.00	SCL	1.26	65.00	63.00
	BSVG1	35.00	11.00	54.00	SCL	1.55	32.19	25.00
	VG1	35.00	11.00	55.00	SCL	1.30	48.00	60.00
	AC1	35.00	11.00	54.00	SCL	1.28	68.00	75.00
	BSAC1	34.00	10.00	56.00	SCL	1.56	30.50	26.00
	BSPN1	34.00	10.00	56.00	SCL	1.43	45.00	43.00
	PN1	33.00	11.00	56.00	SCL	1.10	68.23	75.00
	F-LSD$_{0.05}$	2.18^{NS}	3.75^{NS}	2.06^{NS}		0.13*	4.45*	8.38*
Location 2	BSPM2	35.00	11.00	54.00	SCL	1.40	39.22	50.00
	PM2	34.00	11.00	55.00	SCL	1.19	57.99	73.00
	BSVG2	35.00	11.00	54.00	SCL	1.53	35.00	28.00
	VG2	35.00	11.00	54.00	SCL	1.30	48.05	62.00
	AC2	35.00	10.00	55.00	SCL	1.20	62.00	69.00
	BSAC2	35.00	10.00	55.00	SCL	1.50	36.01	27.00
	BSPN2	35.00	10.00	54.00	SCL	1.49	48.91	53.00
	PN2	34.00	12.00	54.00	SCL	1.13	71.00	79.00
	F-LSD$_{0.05}$	1.89^{NS}	2.06^{NS}	1.73^{NS}		0.12*	4.64*	4.58*

TC = Textural class, BD = Bulk density, TC = Total porosity, HC = Hydraulic conductivity, SCL = Sandy clay loam
NS = Not significant, * = Significant at P = 0.05, PN=*Paspalum notatum*,PM=*Panicum maximum*, AC=*Axonopus compressus*, VG= *Vetiver* grass- ***Vetiveria zizanioides***), BSPN=Bare soil PN, BSPM=Bare soil PM, BSAC=Bare soil AC, BSVG=Bare soil VG

Table 4. Influence of grasscover on water-stable aggregates (WSA) and mean weight diameter (MWD) of the eroded soil of Umudike, Nigeria.

		WSA%					
Location (mm)	**Treatment**	**4.00 - 2.00 mm**	**2.00 - 1.00 mm**	**1.00 - 0.5 mm**	**0.5 - 0.2 mm**	**< 0.2 mm**	**MWD**
Location 1	**PM1**	**24.40**	**3.90**	**17.00**	**39.90**	**14.80**	**1.09**
	BSPM1	**8.10**	**2.20**	**14.90**	**46.00**	**28.80**	**0.61**
	BSVG1	**14.10**	**2.90**	**14.10**	**43.80**	**25.20**	**0.77**
	VG1	**27.00**	**4.00**	**22.10**	**35.70**	**11.20**	**1.18**
	AC1	**27.80**	**3.50**	**18.80**	**36.80**	**13.10**	**1.18**
	BSAC1	**9.80**	**2.00**	**13.10**	**42.70**	**32.40**	**0.64**
	BSPN1	**13.10**	**2.70**	**17.50**	**49.37**	**17.00**	**0.77**
	PN1	**31.80**	**4.50**	**20.10**	**35.00**	**8.60**	**1.31**
	$F\text{-}LSD_{0.05}$	**0.68***	**0.34***	**0.27***	**0.59***	**0.39***	**0.04***
Location 2	**PM2**	**31.10**	**3.20**	**13.20**	**35.50**	**17.00**	**1.24**
	BSPM2	**12.00**	**3.50**	**24.50**	**43.50**	**15.60**	**0.78**
	BSVG2	**21.50**	**3.60**	**19.50**	**42.10**	**13.30**	**1.02**
	VG2	**28.00**	**3.40**	**19.20**	**38.50**	**10.90**	**1.16**
	AC2	**31.80**	**4.50**	**20.10**	**35.00**	**8.60**	**1.31**
	BSAC2	**10.80**	**2.10**	**17.30**	**48.40**	**21.40**	**0.70**
	BSPN2	**14.67**	**2.60**	**17.60**	**49.10**	**15.70**	**0.82**
	PN2	**40.70**	**4.00**	**11.70**	**30.50**	**15.10**	**1.48**
	$F\text{-}LSD_{0.05}$	**0.91***	**0.38***	**0.34***	**0.85***	**0.36***	**0.05***

*** = Significant at P = 0.05 , MWD = Mean weight diameter, WSA=Water- stable aggregate, PN=***Paspalum notatum*,PM=*Panicum maximum*, AC=*Axonopus compressus,* VG= *Vetiver* grass- ***Vetiveria zizanioides***), BSPN=Bare soil PN, BSPM=Bare soil PM, BSAC=Bare soil AC, BSVG=Bare soil VG

Table 5. Influence of grasscover management on volumetric soil moisture content (0.01 and 1.5 MPa suctions) and available water capacity of eroded soils of Umudike, Nigeria.

Location	Treatment	0.01 MPa	1.5 MPa	AWC
Location 1	**PM1**	**25.60**	**10.90**	**24.70**
	BSPM1	**30.00**	**10.10**	**19.90**
	BSVG1	**23.00**	**7.40**	**15.60**
	VG1	**32.40**	**9.90**	**22.50**
	AC1	**39.70**	**13.30**	**26.50**
	BSAC1	**26.70**	**8.20**	**18.50**
	BSPN1	**29.30**	**10.20**	**19.10**
	PN1	**40.00**	**13.10**	**26.90**
	F-LSD$_{0.05}$	**10.07***	**0.53***	**0.37***
Location 2	**PM2**	**38.00**	**11.90**	**26.10**
	BSPM2	**31.80**	**10.20**	**21.60**
	BSVG2	**24.90**	**8.70**	**16.20**
	VG2	**33.40**	**10.50**	**22.90**
	AC2	**39.93**	**12.90**	**28.53**
	BSAC2	**29.80**	**9.00**	**20.80**
	BSPN2	**34.30**	**10.60**	**23.70**
	PN2	**40.90**	**13.80**	**28.60**
	F-LSD$_{0.05}$	**0.88***	**0.65***	**0.44***

AWC = Available water capacity; * = Significant at P = 0.05, PN=*Paspalum notatum*,PM=*Panicum maximum*, AC=*Axonopus compressus*, VG= *Vetiver* grass- ***Vetiveria zizanioides***), BSPN=Bare soil PN, BSPM=Bare soil PM, BSAC=Bare soil AC, BSVG=Bare soil VG

Results presented in Table 3 showed that the adjacent bare soils gave the highest bulk density values for the two Locations than the grasses. Ojimgba and Mbagwu (2007) observed that the increase in bulk density may be due to the lower organic matter contents of the eroded soils. High bulk density according to Mbagwu *et al*., (1984) is also attributed to translocation of clay from eluvial horizon with simultaneous loss of structure and close packing of sand grains in the eluvial horizon. Also, bulk densities of all soils increased over time with cultivation. Dry bulk density is a soil physical parameter used extensively to quantify soil compactness and has a very influential effect on root growth and proliferation which are both indicators of soil productivity (Alvaro *et al*., 1998). Anikwe *et al*., (2003) noted that a 0.1 Mg m^{-3} decrease in dry bulk density had a significant beneficial effect on root development and yield of sorghum and groundnut. Soil compatibility is influenced by soil organic matter content, soil water content during trafficking, initial dry bulk intensity, soil strength (cone index) and soil texture (Gysi, 2001).

The planting of grasses on the eroded soils resulted in a decrease in bulk densities. The lowest bulk density obtained with *Paspalum notatum* may be due to its high organic matter contents and its constituents. Anikwe *et al*., (2003) noted that it is logical that soil and crop management factors like tillage, crop type, incorporation of organic matter and mulching could influence soil compactability. They observed that the lowest (P<0.05) soil dry bulk density was recorded in groundnut plots amended with manure + NPK than in plots with NPK alone or control.

Decrease in total porosity and hydraulic conductivity was observed in all bare soils and was more evident on BSAC. Mbagwu *et al*., (1984) who made similar observation stated that reduced saturated hydraulic conductivities were due to structure degradations as reflected in increased bulk densities and decreased total porosities of the exposed soils. Also, this reduction may be directly related to increased compaction, reduced micro-porosity and a higher incidence of soil crusting observed on the eroded soils. Ojimgba and Mbagwu (2007) concluded that increase in bulk density generally resulted in decrease porosity and poor aeration which physically restrict root growth. Mbagwu (1992) had emphasized that expected high crop yields were not obtained on many tropical soils even after optimizing the chemical fertility. This had led to the conclusion that, on most soils in the tropics, for soil-management practices to be effective and reduce the fertilizer demand, they should aim at ameliorating the degraded physical properties. He concluded that the major physical constraint to high level crop production on degraded tropical soils is high bulk density resulting from continuous cultivation. That the consequences of this is reduced porosity, infiltration rates and saturated hydraulic conductivity, and low available water capacity within the rhizosphere. He also stressed that since high bulk density of these soils is directly related to low organic matter contents, all ameliorative treatments should logically aim at improving the soil organic matter status. High organic matter content of the grasses might have contributed to the reduction in soil bulk densities, increased porosity and hydraulic conductivity of the study soils.

In terms of water-stable aggregates (WSA) at five different diameters, the soil planted with *Paspalum notatum* proved best, outperforming other treatments in stabilizing aggregates and increasing mean weight diameter (MWD). This may be attributed to the increase in organic matter content of the soils which seemed to contribute to aggregation. However, from the result in Table 4, with grasses, aggregate size distribution of whole soils was shifted to larger sizes, whereas percent content of micro-aggregates (<0.2 and 0.5 – 0.2 mm) decreased indicating improvement in aggregates >2 mm in size. Piccolo and Mbagwu (1990) made similar observations. Bewick (1980) concluded that adding crop residues along side with manure increases soil aggregation, water movement and roots penetration.

Also, the incorporation of amendments into the soils significantly increased the soil moisture contents measured for the 0.01 (field capacity) and 1.5 MPa (wilting point) as well as the available water capacity (AWC) relative to the unamended control and the fertilizer rates (Table 4.6.3). Ojimgba and Mbagwu (2007) observed that it is possible that a reduction in the organic matter contents of the soils might have caused the lowering of water retained at these various suctions in the adjacent open soils. The increase in soil moisture contents and available water capacity (AWC) may be due to the increase in organic matter contents of the soil as a result of the grasses. Mbagwu (1992) had emphasized that the incorporation of organic manure into the soil significantly increased the soil moisture content.

Influence of various grasscover management on some chemical properties of soils of Umudike, Nigeria.

Tables 6 and 7 summarize the influence of grasses (Vetiver grass- ***Vetiveria zizanioides,*** *Axonopus compressus, Paspalum notatum* and *Panicum maximum*) on some chemical properties of soils in the two locations in Umudike, Nigeria. The soils under the grasses generally had higher pH, organic carbon and organic matter, as well as higher nitrogen and available phosphorus than the soils of the open adjacent soils. . The Tables also show significant (P<0.05) differences existing among the various grasscover management. The grasses significantly improved the chemical properties of the soils more than their open adjacent bare soils.

Some increase in pH of the soils under the grasses was observed. For example, the pH of the soil under *Paspalum notatum(PN1)* in Location 1 was raised slightly from 4.5(H_2O) and 4.0(KCl) for BSPN1 to 6.3(H_2O) and 5.2(KCl) for PN1, respectively. Also, Location 2 followed same trend. However, the soils under PN gave significantly higher values of pH than the values of other grasses and their open adjacent soils in Locations 1 and 2. The relative improvement in pH in Location 1 was in the order : PN1>AC1>VG1=PM1>BSPM1=BSVG1>BSAC1=BSPN1 (Table 6).

Also, the results obtained from Tables 6 and 7 show that the percentage organic carbon content was significantly higher in the grasses than the adjacent open soils in Locations 1 and 2. Generally, all the grasses significantly increased the organic carbon concentration of the soil, but the magnitude of increase was more for PN than the other grasses and their adjacent open soils. The magnitude of increase in Location 1 was in the order : PN1>AC1>PM1=VG1>BSVG1=BSPN1=BSAC1>BSPM1. Location 2 also increased in the same trend. The organic carbon content of PN increased from 0.73%(BSPN1) to 2.89%(PN1) and 0.88%(BSPN2) to 2.91%(PN2) in Locations 1 and 2, respectively. Also, the organic matter content of the soil increased in the same trend as organic matter content.

However, the grasses significantly ($p<0.05$) increased the total nitrogen of the soil more than their adjacent open soils. For example, *Paspalum notatum*(PN) increased the total nitrogen from 0.061%(BSPN1) to 0.231%(PN1) and 0.036%(BSPN2) to 0.241%(PN2) in Locations 1 and 2, respectively. The relative improvement was in the order : PN1>AC1>PM1=VG1>BSVG1>BSPN1>BSAC1>BSPM1 in Location 1. Also, Location 2 followed the same trend, while BSPM1 gave the least total nitrogen values in both locations (Tables 6 and 7). The grasses also increased the available phosphorus (P) values.

Table 6. Influence of various grass cover management on Organic carbon, Total nitrogen, pH and Available phosphorus of Umudike soils (Location 1)

Treatment Location 1	pH (H_2O)	pH (KCl)	OC (%)	OM (%)	N (%)	AV.P (mg/kg)
VG1	5.8	4.7	1.68	2.89	0.148	18.6
BSVG1	4.8	4.3	0.76	1.31	0.068	13.4
AC1	6.1	4.9	2.62	4.52	0.209	21.3
BSAC1	4.5	3.7	0.67	1.16	0.059	14.0
PN1	6.3	5.2	2.89	5.01	0.231	41.8
BSPN1	4.5	4.0	0.73	1.26	0.061	16.5
PM1	5.7	4.8	1.81	3.12	0.149	18.5
BSPM1	4.8	3.6	0.29	0.50	0.029	12.1
LSD $_{(0.05)}$	0.18*	0.08*	0.20*	0.34*	0.01*	1.5*

AC = *Axonopus Compressus*, OC = Organic carbon , PN = *Paspalum notatum* ,OM = Organic Matter, PM = *Panicum maximum*, VG = Vetiver Grass, TN = Total Nitrogen , AV.P = Available Phosphorus,), BSPN=Bare soil PN, BSPM=Bare soil PM, BSAC=Bare soil AC, BSVG=Bare soil VG

Table 7. Influence of various grass cover management on Organic carbon, Total nitrogen, pH and Available phosphorus of Umudike soils (Location 2)

Treatment Location 2	pH (H_2O)	pH (KCl)	OC (%)	OM (%)	N (%)	AV.P (mg/kg)
VG2	6.0	4.9	1.87	3.22	0.171	20.1
BSVG2	4.6	4.3	0.69	1.81	0.090	14.8
AC2	5.9	4.8	2.44	4.21	0.211	19.2
BSAC2	4.8	3.8	0.48	0.83	0.033	12.8
PN2	6.4	5.2	2.91	5.04	0.241	22.6
BSPN2	4.9	4.3	0.88	1.52	0.036	13.0
PM2	5.9	4.9	1.60	2.76	0.136	19.0
BSPM2	4.5	4.0	0.36	0.62	0.030	11.3
LSD $_{(0.05)}$	0.12*	0.07*	0.19*	0.35*	0.01*	1.0*

AC = *Axonopus Compressus,* OC = Organic carbon , PN = *Paspalum notatum* ,OM = Organic Matter, PM = *Panicum maximum,* VG = Vetiver Grass, TN = Total Nitrogen , AV.P = Available Phosphorus,), BSPN=Bare soil PN, BSPM=Bare soil PM, BSAC=Bare soil AC, BSVG=Bare soil VG

Ojimgba and Mgbeahuru, (2018) observed increase in pH due to *Paspalum notatum*. They added that grass increases soil organic carbon, microbial biomass and potential nitrogen mineralization rate, reducing the soil bulk density. They also stated that soils under grass cover have shown better chemical properties than soils under forest cover and bare soils. Similar observation was made by Ojimgba (2018). The high pH values of the adjacent bare soil according the Ojimgba and Mbagwu, (2007) may be attributed to the exposure of the acidic subsoil due to soil erosion. The attributed this low values partly because the soils are heavily leached of the basic cations due to very heavy rainfall associated with the rainforest zone. Grasscover management have contributed to the sustainable management of land through replenishing soil nutrients (Tizita, 2015).

4. Conclusion and Recommendations

- The study had basic information on the influence of grasscover management on the physical and some chemical properties of soil under P*anicum maximum*, *Paspulum notatum*, *Axonopus compressus and vertiver grass* and their adjacent bare soils in Umudike. This study has shown that the soils planted with the grasses gave significantly ($p<0.05$) higher results of the physical and some chemical properties than their adjacent open bare soil. In all the parameters considered in this study, the values obtained in soils under *Paspalum notatum* was higher than those obtained in PM, AC, VG and their adjacent bare soils(BS). The soils under PN had generally lower bulk density, higher total porosity and hydraulic conductivity than other grasses and adjacent open bare soil in both locations. Also, soils under PN had significantly higher values of pH, organic C and organic matter, total nitrogen and available P more than other grasses and their adjacent open soils The result, therefore, pointed to the fact that grasscover management especially *Paspulum notatum(PN)* improved the physical and some chemical properties of the soils better than other grasses and their adjacent open soils.
    - From the study, ***Paspalum notatum*** which proved best is a perennial grass with huge biomass and accepted as a better alternative for land reclamation. The shoots and roots, make it effective for use to ameliorate the degraded soil and cover barren land
    - It is hoped that grasscover if established on soils that are prone to erosion, would help improve the soil aggregate, reduce direct impact of raindrop and runoff and encourage infiltration. People should

not weed and expose the topsoil to avoid erosion hazards, rather plant ***Paspalum notatum*** and trim continually.

References

Alvaro, P.S., Kay, B.D. and Perfect, E. (1998). Management versus inherent soil properties: effects on bulk density and relative compaction. Soil Tillage Res. **44**: 81-93

Anikwe, M.A.N., Obi, M.E. and Agbim, N.N. (2003). Effect of crop and soil management practices on soil compatibility in maize and groundnut plots in a Paleustult in Southeastern Nigeria. Netherlands. *Plant and soil* **253:** 457-465.

Bewick, M.W.M. (1980). Handbook of organic waste conversion. New York. N.Y. Nostrand Reinhold Co. 418 p.

Blanco, and Lal,R. (2010) "Soil and water conservation". Principles of soil conservation and management. Springer.p.2. ISBN 978-90-481-8529-0.

Blake, G. R. and Hartge, K. H. (1986). Bulk density. Methods of Soil Analysis, Part 1.Physical and Mineralogical Methods. Ed. A. Klute. American Society of Agron. , Madison, WI, USA. Pp. 365 – 375.

Day, P. R. (1965). Particle fraction and particle size analysis . In: C. A. Black (ed) Methods of Soil Analysis. Part I. *Am. Agron*. **9**: 545 – 567.

Enwezor, W.O, Ohiri, A.C, Opuwaribo, E.E. and Udo, E.J. (1990). A Review of soil fertility investigation in southeastern Nigeria Vol. II. Federal Department of Agriculture (FDA) Lagos, Nigeria.

Gee, G. W. and Bauder, J. W. (1986). Particle size analysis. In: Methods of Soil Analysis. Part II. Agronomy 9. Ed. A. Klute. Am. Soc. Agron., Madison, WI, USA, pp. 383 – 411.

Gysi, M. (2001). Compaction of a Eutric Cambisol under heavy wheel traffic in Switzerland: Field data and a critical state soil mechanics model approach. Soil Tillage Res. 61, 133-142.

Julien, P.Y.(2010). Erosion and sedimentation. Cambridge university press. p.I. IBSN 978-0-521-53737-7.

Kemper, W O. and Chepil, W. S. (1965). Water-stable aggregates. In: Methods of Soil Analysis, Part 1. C. A. Black (ed) , *Amer. Soc. Of Agron*. Madison, Wisconsin.

Klute, A. (1986). Water Retention : Laboratory methods . In: A. Klute (ed) . Methods of Soil Analysis, Part 1. Second Edition. *Amer. Soc. of Agronomy*, Inc., Madison.

Lowery, B., Swan, J. Schumacher, T. and Jones, A. 1995. Physical properties of selected soils by erosion class. *J. Soil and Water Cons*. **50** : 306-311.

Mbagwu, J.S.C. (1992). Improving the productivity of a degraded ultisol in Nigeria using organic and inorganic amendments. Part 1. Effects on the chemical properties and maize yield. *Bioresource Technol.* **42**, 149-154.

Mbagwu, J.S.C., Lal, R. and Scott, T.W. (1984). Effects of desurfacing Alfisols and Ultisols in Southern Nigeria. II. Changes in soil physical properties. *Soil Sci. Soc. Am. J.* **48**: 834-838.

McLean, E.O. (1982). Soil pH and lime requirement. In: methods of soil analysis, part II. Agronomy 9.Ed.A.L. Page. Pp. 199-234. Am. Soc. Agron., Madison, WI, USA.

Nelson, D. W. and Sommers, L. E. (1982). Total carbon, organic carbon and organic matter. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. ASA, Madison, WI. Pp.359 – 380.

Odurukwe, S. O. , Anuebunwa, F. O., Iloka, A. W., Udealor, A. and Ibedu, M. A. (1995). Physical environment of south-eastern Nigeria. In: Indigenous fallow and multi-purpose tree and shrub species in the farming systems of southeast zone of Nigeria. A Report of Diagnostic Survey. N.R.C.R.I., Umudike Publications.

Ojimgba, O. (2018). Effectiveness of soil amendments in restoring the chemical properties of soils subjected to different intensities of erosion in Nsukka, southeastern Nigeria. Scientific Paper Series management, Economic Engineering in Agriculture and Rural Development. Vol. 18, **Issue 4.** Pp 193-200. PRINT ISSN 2284-7995, E-ISSN 2285-3952

Ojimgba, O and Mbagwu, J. S. C. (2007). Evaluation of the physical and chemical properties of an eroded Ultisol and their effects on maize yield. *Journ. Sc. Agric. , Food Tech. and the Env.* Vol. **7**. No. **1**. pp. 57 – 64. Fac. of Agric., Ebonyi State Uni. , Abakaliki, Nigeria.

Ojimgba, O. and Mgbeahuru, C. (2018). Effect of bahia grass cover on the chemical properties of ultisol at different levels of slope in Umudike, Nigeria. Scientific Paper Series management, Economic Engineering in Agriculture and Rural Development. Vol. 18, **Issue 3.** Pp 287-296. PRINT ISSN 284-7995, E-ISSN 2285-3952

Opera-Nadi, O.A.,(2000). Soil resources and agricultural productivity in Nigeria. In: food and fiber production in the 21th century. Nwaigbo, L.C., Ukpabi, U.H. and Anene, A. (Eds). Proceeding of the first Annual conference of the college of Agriculture and Veterinary Medicine, Abia State University held on the 10^{th}-13^{th} September, 2000.

Page, A.L,, Miller, R.H and Keeney, D.R. (1982). Methods of soil analysis. Part 2 chemical and microbiological properties. ASA, Madison.

Piccolo, A. and Mbagwu, J.S.C. 1990. Effects of different organic waste amendments on soil micro-aggregates stability and molecular sizes of humic substances. *Plant and Soil* **123**: 27-37.

Salau, O.A., Opara-Nadi, O.A. and Swennen, R. (1992). Effect of mulching on the properties, growth and yield of plantain on a tropical Ultisol in southeastern Nigeria. Soil tillage Res. 23:73-93.

Steel, R.G.D. and Torrie, J.H. (1980). Principles, procedures of statistics. A biometric approach. Mc Graw Hill publication, New York, 633 pp.

Stocking, M.A., Chakela, Q. and Elwell, H. (1988). An improved methodology for erosion hazard mapping. Part 1. The technique Geogr. Amn. 7OA(3):169-180.

Stolte, J. (1997). Manual of Soil Physical Measurements. Version 3 . Wageningen, D. L. O. Staring Centre. Tech. Doc. 37.

Tizita Endale (2015) Dynamics of Soil Physico-Chemical Properties in Area Closures at Hirna Watershed of West Hararghe Zone of Oromia Region, Ethiopia. International Journal of Soil Science., 11(1);1-8,2016.

Van Bavel, C. H. M. (1950). Mean weight diameter of soil aggregates as a statistical index of aggregation. *Soil Sci. Soc. Am. Proc.* **14** : 20 – 23.

Vomicil , J. A. (1965). Porosity. In: C. A. Black (ed), Methods of Soil Analysis. Part 1. *Am. Soc. Agron.* **9** : 299 – 314.