International Journal of Plant & Soil Science
11(6): 1-16, 2016; Article no.IJPSS.27182
ISSN: 2320-7035

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The Role of Organic Matter in Conservation and Restoration of Soils in Southeastern Nigeria: A Review

Edeh Ifeoma Gloria[1*] and Kefas Patrick Katan[2]

[1]Department of Soil Science, University of Nigeria, Nsukka 410001, Nigeria.
[2]Taraba State University, Jalingo, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author EIG designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author KPK managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2016/27182
Editor(s):
(1) Dionisios Gasparatos, Soil Science Laboratory, Faculty of Agriculture, Aristotle University of Thessaloniki, Greece.
Reviewers:
(1) Lawrence Tanner, Le Moyne College, USA.
(2) Temgoua Emile, University of Dschang, Cameroon.
Complete Peer review History: http://sciencedomain.org/review-history/15321

Review Article

Received 23rd May 2016
Accepted 28th June 2016
Published 9th July 2016

ABSTRACT

The threat and subsequent destruction of land by soil erosion and other land degradation agent has been the subject for intensive debate. The main focus of the paper is providing a critical scientific review of the current state of knowledge regarding the role of organic matter to soil conservation and restoration of degraded lands in southeastern Nigeria. These are put into context to provide a sound scientific basis for policy development, to identify gaps in current knowledge and to recommend further research relating to organic matter usage. Causes and impact of land degradation as well as soil conservation and the role organic matter play in conserving soil and restoring degraded lands were examined.

Keywords: Soil erosion; land degradation; organic matter; gully.

**Corresponding author: E-mail: ifeoma.edeh@unn.edu.ng;*

1. INTRODUCTION

Nigeria has a total of 92.4 million hectares of land out of which about 57% (52.668 million hectares) is under crop and pasture production [1]. Although the aggregate production from these lands has sustained the population and the economy in the time past, the rapid increase in population and the need to diversify the economy in other non-agricultural sectors, has necessitated much pressure on the resources [2]. Population growth has been a detrimental dynamic to the use and cultivation of land, leading to changes in cropping patterns; basically continuous cropping. This poses serious problems due to the fragile nature of soils in the humid tropics as well as high dependency on vegetative cover for moisture and stability [3].

The land in South East Nigeria has been considered as low lying in nature that exposes the surface areas to flooding and erosion [4]. Soil fertility in this area is traditionally maintained through shifting cultivation and fallow. The inhabitants of southeast Nigeria are predominantly farmers and crop production is centered on food crops such as cassava, yam, maize, rice, beans and cash crops such as oil palm, groundnut, cocoa and bananas. Over 80% of the area allotted to agricultural production is occupied by food crops [5]. The rapid growth of population in the area over the past three decades results in more demands on arable land, which has adversely affected its resource base. Consequently, there is a breakdown of the old traditional land management practices, causing pressure on land and agricultural intensification with reduced fallow periods. In the absence of adequate soil management practices or the economic use of fertilizer and other additives (inputs), declining fallow periods result in accelerated leaching of nutrients, increased weed production, erosion and decreased moisture [6,7,8].

The threats and subsequent destruction of land by soil erosion and other forms of land degradation has been the subject for intensive debate in literatures [9,10,11,12]. Over the years the destructive process has continued with increased intensity, quantum and rate, such that its devastating effects had subjected the communities to high risks of loss of lives, properties and the natural land that supports their livelihood including extreme difficulties in marketing their products.

Now that we are facing the greatest challenges of food insecurity resulting from the recent flooding that devastated some parts of the country coupled with the fast declining productivity of our soils, the need to increase soil productivity and also to conserve the soil has prompted the use of various approaches. The use of chemical fertilizers to sustain cropping systems on a long term basis has not been very effective. It usually leads to a decline in soil organic matter content, soil acidification and soil physical degradation, which, consequently leads to increased soil erosion [13,14]. The inorganic fertilizers are usually not available and are always rather expensive for the low – income, small - scale farmers. Organic manures can be used as an alternative for the inorganic fertilizers. They release nutrients rather slowly and steadily over a longer period and also improve the soil fertility status by activating the soil microbial biomass [15]. Organic manure application sustains cropping system and conserves the soil for future use through better nutrient recycling, improved soil structure and increased soil water – holding capacity [16]. The objective of this paper is to clearly outline the role of organic manure in the conservation of soil and improvement of crop yields in South Eastern Nigeria.

2. LAND DEGRADATION

2.1 Perspective on Land Degradation

Land degradation has been defined by many but it revolves around soil surface removal, destruction of various components of soils, reduction in the natural component of the soil and the reduction in the productivity of the soil. Few of such definitions are outlined here;

- The United Nations Convention to Combat Desertification [17] considers land degradation as a reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigations cropland or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes including processes, arising from human activities and habitation patterns such as, soil erosion caused by wind/or water; deterioration of the physical, chemical, and biological or economic properties of soil and long term loss of natural vegetation.
- Global Environmental Fund [18] explained land degradation to be any form of

deterioration of the natural potential of land that affects ecosystems integrity either in terms of reducing sustainable ecological productivity or in terms of reducing its sustainable and resilience.

- Land Degradation Assessment in Dry land [19] considered it as the reduction in the capacity of the land to perform ecosystems functions and services (including those of agro ecosystems and urban systems) that support society and development.

  In addition to the usual types of land degradation that have been known for centuries (water, wind and mechanical erosion, physical, chemical and biological degradation), four other types have emerged in the last 50 years [20]: pollution (often chemical) due to agricultural, industrial, mining or commercial activities; loss of arable land due to urban construction; artificial radioactivity, sometimes accidental; land-use constraints associated with armed conflicts. Overall, 36 types of land degradation can be assessed. All are induced or aggravated by human activities, e.g. sheet erosion, silting, aridification, salinization, urbanization, etc. Fig. 1 shows the various types of land degradation;

2.2 Land Degradation in South Eastern Nigeria

Geopolitical speaking, the south eastern region of Nigeria is comprised of five states namely, Imo, Anambra, Abia, Enugu and Ebonyi States (Fig. 2). It is the home of the Igbo speaking people of Nigeria. It is located within latitudes 4°47 ' 35""N and 7°7 ' 44""N, and longitudes 7°54 ' 26"E and 8°27 ' 10"E in the tropical rain forest zone of Nigeria, with mean maximum temperature of 27ºC, and total annual rainfall exceeding 2500 mm [21]. The region is largely agrarian and there is thus much dependence on land resources, due to its dense population averaged to about 1000 people/Km2. This dependence on land has led to the over use of the land resources in the region, leading to the farming of agricultural lands annually.

[22] records showed that soils in Africa are generally shallow, acidic and carbon poor when compared with the types in Europe. Decomposition of biomass is a rapid process in consistently warm temperatures, leaving little time for accumulation of humus. As a result, extensive layers of deep top soil are rare in Africa. The nature of soil in the south east is the red earth with sand stones loose surface that is easily prone to damages by torrential rain and flood [22] also steep slopes occurs at some locations which reinforces the rapid flow of rain water to wash away the soil including the vegetation and other nutrients. The soil structure has been a major factor in the use of land in the south east and any threat to such structure renders the land unproductive and vulnerable to destruction.

The major kind of land degradation experienced in southeastern Nigeria is soil erosion. Gully erosion is particularly severe in Abia, Imo, Anambra and Enugu States. Anambra and Enugu States alone have over 50 active gully complexes, with some extending over 100 meters, 20 meters wide and 15 meters deep [23]. This has largely been attributed to extensive use of land for agricultural purposes due to high population density [24]. Conservative assessment shows that a total of 2300 gully sites (Table 1) are found in Southeastern Nigeria [25,26].

These statistics are not exhaustive as new gullies keep forming every rainy season due to flooding and torrential rainfall. Figs. 3 – 5 show pictures of gullies in various parts of South East Nigeria.

2.3 Causes of Land Degradation

The causes of threats to land cannot be isolated from the natural and human activities. The natural factors in land degradation includes wind and water soil erosion, torrential rainfall, floods, landslides, desertification, drought, acid rain, acid and salt accumulation, retreating forests, climatic vagaries and sand dunes accumulation. It is pertinent to note that these natural factors are intensified by the anthropogenic factors. Igwe [27] noted that the anthropogenic factors are mainly technical factors comprising mainly of land use and tillage methods, the choice and distribution of cultures and the nature of agro-technology. Land has been subjected to intensive pressure from human uses that induce degradation. Since soil erosion is the major form of land degradation in Southeastern Nigeria a brief description of what causes erosion in the area will be discussed.

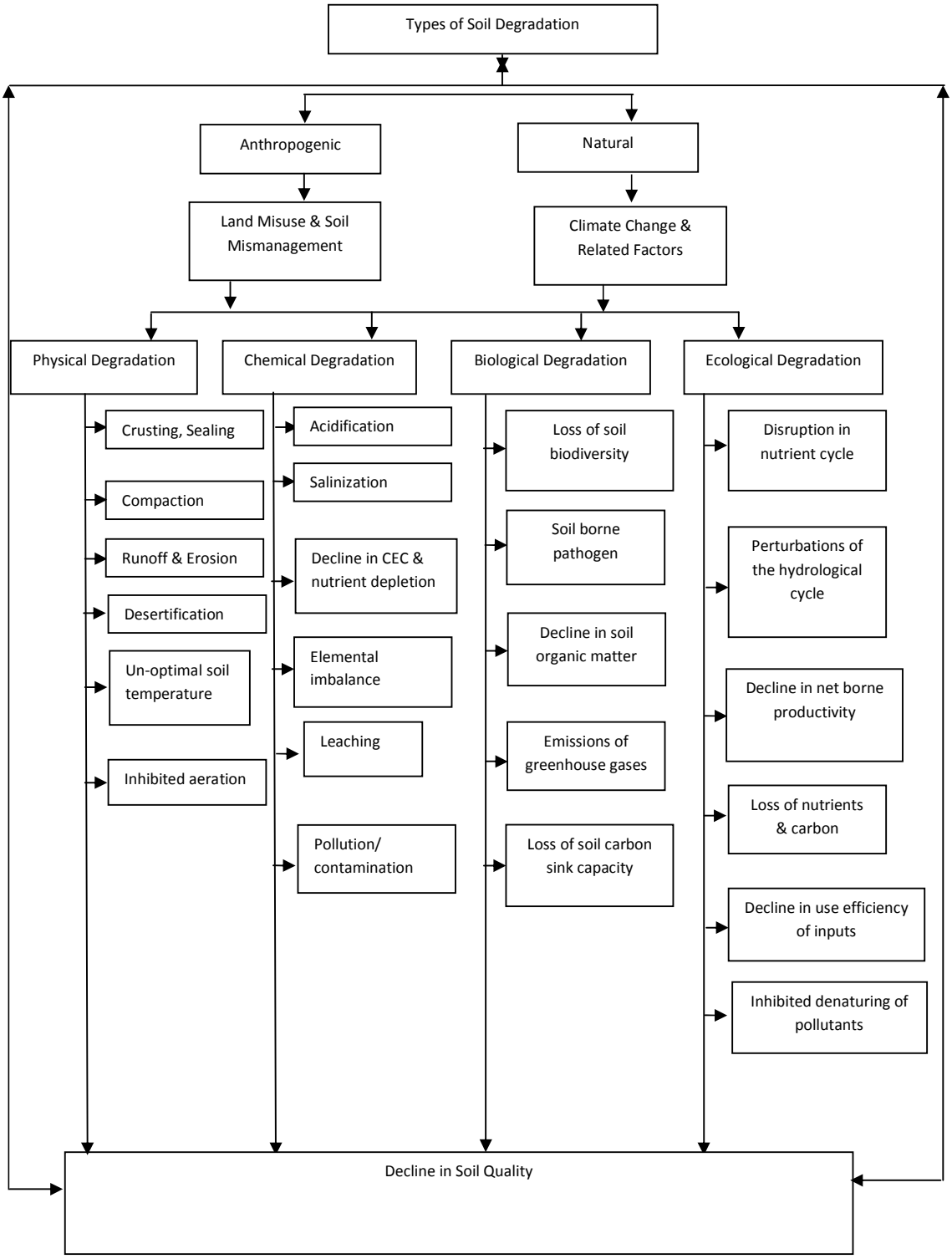

Fig. 1. Various types of soil degradation

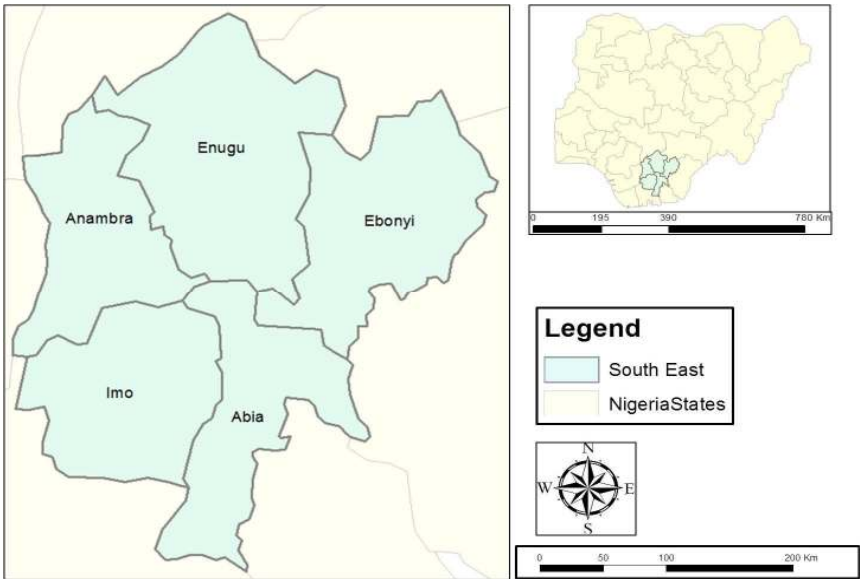

Fig. 2. Location map of the reviewed area

Table 1. Distribution of gully sites in Southeastern Nigeria

S/N	State	No. of gully site	State
1	Anambra	700	Mostly active
2	Abia	300	Some active/some dormant
3	Ebonyi	250	Mostly minor gully site
4	Enugu	600	Some active/some dormant
5	Imo	450	Some active/some dormant

Source: [26, 27]

Fig. 3. Gully sites in Anambra state

2.3.1 Topography

Soil erosion is a function of slope attribute, the amount of soil erosion has always been proportional to the steepness of the slope [28]. The topography of southeastern Nigeria can be classified into three relief units according to [29]. These units are the plains and lowlands including all the river valleys, the cuesta landscapes and the highlands. It is observed that the uplands which are made up of highly friable sandstones yield easily to erosion and induce gullying even on slopes of about 5% [28]. The cuestas and other highlands with somewhat stable lithology

resist gullying but provide aggressive runoff which moves down to devastate the lowland areas especially at the toe slopes and river head-waters [28].

2.3.2 Climate

Rainfall plays very significant roles in the erosion hazard of southeastern Nigeria. Rainfall is generally high and aggressive in this area. The nature of the rainfall regime contributes significantly to the erosivity of rainfall. The rainfall distribution, amount and intensity in combination of other environmental factors contribute in accelerating the rate of interrill rill and gully erosion in southeastern Nigeria.

2.3.3 Vegetation

The constant deforestation of the former rainforest due to population explosion and increased agricultural activities in the region expose the bare soils to the vagaries of weather thus escalating the soil erosion problems. The implication is that the soils are frequently subject to different degrees of erosion including accelerated erosion. Vegetation and land use are one of the most important factors in soil erosion process in southeastern Nigeria. Igwe [28] noted that in southeastern Nigeria soil erosion especially gullies are most intensive on soil on which the former growth has been disturbed, that is mostly on agricultural soils stripped of growth for reasons of infrastructural developments such as road and housing construction. Ofomata [30] showed that in the region soil erosion is connected mainly with agricultural activities and other related land use activities such as mining, road building, urbanization, industrialization and general infrastructural development. These land use activities deprive the soil surface of its vegetation and also contribute directly to sliding, slumping, interrill and rill erosion including gullying.

Fig. 4. Gully sites in Enugu state

Fig. 5. Gully sites in Imo state

2.3.4 Geology

In Nigeria, [31] classified the potential erosion susceptible areas based on underlying geology. He indicated that areas of high susceptibility correspond to geological regions of weak unconsolidated sandy formations while least susceptible areas are within the consolidated tertiary to recent sediments. Also in southeastern Nigeria, the classical gully sites are located in the False-bedded sandstone, Coastal Plain sands, Nanka Sands and the Bende- Ameki Formations [28]. These are all sandy formations which have more gullies than their Shale formation counterparts. In these formations, there exist the sites of worst catastrophic soil erosion in the whole of sub-Saharan Africa. The geology therefore plays direct and indirect influence on the gully formation.

2.3.5 Nature of the soil

This deals with the erodibility of the soil, defined as the vulnerability or susceptibility of the soil to erosion. In southeastern Nigeria, the nature and the long weathering history of the soils parent material evident in the dominance of the clay mineralogy by non-expanding minerals and low soil organic matter concentration due to high mineralization rates and excessive leaching of nutrients could be linked to the worsening situation [28].

2.3.6 Anthropogenic factor

An important factor that contributes heavily to soil erosion in Southeastern part of Nigeria is the anthropogenic factor and this is because it also affects the other factors listed above. Inappropriate farming systems, uncontrolled grazing, deforestation, road constructions including uncontrolled infrastructural developments have contributed significantly in gully developments. Some road networks under construction have been abandoned in the region due to gully formation.

2.4 Impact of Land Degradation

The impact of land degradation can be felt and has been felt in all areas of life from the loss of soil nutrient down to International level, some of them include; organic matter decline, carbon storage decline, soil moisture storage decline, loss of water for irrigation, compaction, salinization, landslides, soil contamination , soil sealing , loss of biodiversity, soil nutrient decline, soil deformation, land productivity decline, decline of vegetative cover, increased inputs at greater costs, loss of flexibility in land management, diversion of resources to reclamation, lower and less reliable food supply, lower incomes, abandonment by members of the communities, forcing automatic or emergency migration on the people or their means of livelihood, less food production, food insecurity and rural poverty [24,28,32,33, 34,35].

3. SOIL CONSERVATION AND LAND RESTORATION

Land restoration is the process by which land resources are restored to their former state or “baseline condition” which is the condition of the natural resource and its services which would have existed had environmental damage not occurred. Restoration involves land management practices which can remove, control, contain or reduce environmental risks, so that the site no longer poses any significant threat to human health or the environment. Soil conservation according to [36] is a set of management strategies for prevention of soil being eroded from the earth’s surface or becoming chemically altered by over use, salinization, acidification, or other chemical soil contamination. Effective soil conservation practices reduce land and water pollution; reduce long-term dependency on external inputs which often times led to increased cost of production, enhance environmental management, improved water quality and water use efficiency, reduced emission of green house gases through lessened use of fossil fuel and finally improved agricultural productivity with minimum cost [37].

The need for land restoration by soil conservation techniques is critical to control environmental degradation, so that agricultural, and thus economic and social development can be sustained. One approach to land restoration is to consider the transition from degraded to non- degraded land as two phases [38].

- The first phase is concerned with the abiotic barriers to successful restoration - this is the reclamation phase.
- The second (restoration) phase deals with the biotic barriers, and will involve measures designed to restore ecosystem function, services and structure.

3.1 Abiotic (Physical) Land Restoration Measures

Remediating land from a degraded to an "in- tact" state may first require engineering of the physical landscape. In the reclamation of degraded land, an understanding of the fundamental properties of soil and water, including hydrology, hydraulics and geotechnics is essential. These disciplines are also the basis for designing, laying out and re constructing the physical landscape of the site to minimize degradation processes, and protect the environment. Thus, land restoration often starts with the selection, design and engineering of appropriate physical structures such as channels, weirs, spillways, terraces, berms and culverts to control these environmental threats, and create a landscape suitable for the intended end land use. Once the abiotic/physical barriers to successful restoration are crossed, the second phase of the restoration process can be implemented, whereby the biotic / biological status of the site is restored.

3.2 Biotic (Biological) Land Restoration Measures

Abiotic or physical reclamation is only the first phase of land restoration. Restoring the ecological functions and services of a site, and preventing further degradation can be achieved with bio- and phyto-restoration techniques. Micro-organisms such as fungi, bacteria, vegetation and their enzymes can restore, rehabilitate and reclaim damaged soil resources. However, conditions must be favourable for this biota, and physical restoration alone may not be able to create a "healthy" substrate. Soil amendments (sources of carbon and nutrients) may be added (in the form of compost, organic fertilizers, treated sewage sludge etc.) to provide sustenance for (micro) biological communities.

4. IMPORTANCE OF ORGANIC MANURE FOR CONSERVATION AND RESTORA-TION OF DEGRADED LAND

4.1 Organic Manure

One of the forms of soil amendments been used is organic manure. Manure is organic matter, mostly derived from animal matter, human excreta or vegetables, which can be used as organic fertilizer in agriculture. It is also products obtained after decomposition of organic matter like cow dung which replenishes the soil with essential elements and add humus to the soil.

Organic manures are made with natural raw materials which refer to our biodegradable wastes. They are mostly sourced from animal and plant residues. The main organic fertilizers are, in ranked order, peat, animal wastes (often from slaughter houses), plant wastes from agriculture, and sewage sludge [39]. Organic matter can be supplied to marginal soils from a number of sources including (1) on-farm wastes such as animal manures and crop residues, as well as green manure crops or (2) off-farm wastes such as sewage sludge and composted refuse. Off-farm wastes can be important sources of organic matter to farmers who do not have sufficient animals or cropping area to produce the amount of manure and crop residues needed to maintain soil productivity. Some sources of organic manure in Southeastern Nigeria are; poultry litter/droppings, cow dung/waste, abattoir waste, rice husk dust, pig manure green manure and other agricultural wastes.

Organic materials can differ widely in their properties and characteristics. Some materials, such as uncomposted animal manures, green manures, and sewage sludges, are subject to rapid microbial decomposition (i.e., mineralization) in soils and tend to release their plant nutrients rapidly. This is desirable for soils that are already at a relatively high level of fertility and productivity. On the other hand, some other materials, such as cereal straws, wood bark, and composted animal manures and sewage sludges, would be more resistant to microbial attack and release their nutrients at a relatively slower rate. This higher level of organic stability provides a distinct advantage in the initial reclamation of marginal soils because it imparts a beneficial and long-term residual improvement of soil physical properties.

Organic manures are important primarily because of their organic matter content. All soils require the supply of organic matter as carrier of utilizable energy and nutrients for the soil organisms, as well as for: improvement of soil structure and porosity; increase in water-holding capacity of soils; improvement of aeration; reducing soil temperature fluctuations; and storage of nutrients in exchangeable form. Organic manure contributes in restoration and conservation of soil through three aspects of soil

properties; namely chemical, physical and biological properties.

4.2 Physical Properties

Soil to which organic fertilizer is applied forms aggregate structure by holding the soil particles together which contributes to improve soil permeability and fertility in addition to water holding capacity, and this condition then supports root growth in the soil and reduces the rate of erosion [40]. It can improve the soil structure (aggregation) so that the soil holds more nutrients and water, and therefore becomes more fertile.

Organic manure (OM) decreases the bulk density of soils because it helps to increase the soil matrix thereby reducing soil bulk density. These findings were made by [41,42,43,44,45,46] in southeastern Nigeria (Table 3). Lower soil bulk density is a positive productivity indicator in soil as it helps in easing root penetration and therefore, encourages downward movement of water through old root channels [47]. Organic Manure also improves the saturated hydraulic conductivity (K_{sat}) which is a measure of how well the soil transmits water under saturated conditions according to Marshal [48]. Higher conductivity implies that soils amended with OM will transmit water better under saturated conditions. According to [41,45,49] incorporation of organic wastes significantly increased soil hydraulic conductivity in southeastern Nigeria, but the magnitude of increase depended on the rate of application. Generally higher K_{sat} values imply that run-off and erosion can be checked with the application of different forms of OM.

These changes in soil physical properties are important, because the increased level of organic matter increases the soil's capacity to retain water, including more plant nutrients, resulting in reduction of runoff and erosion and increased crop growth/yield.

4.3 Chemical Properties

Organic manure increases the organic matter of soils which serves as a reservoir for essential and non-essential mineral elements for plant growth and development; hence increased organic matter may lead to increased soil productivity. Decomposition of soil organic manure releases nutrient elements such as nitrogen, phosphorus, potassium and a range of other nutrients for plant growth. Organic manures vary widely in the amount of plant nutrients that they contain, some are more concentrated than others Table 2 shows average nutrient content of some OM found in SE Nigeria.

Organic Manure helps to retain mineral nutrients in the soil; making them available to plants over many years in small amounts as it is mineralized [50]. Organic residues have also been found to reduce P sorption capacity of soils and increase crop yields in P limiting soils [51]. In addition, during microbial decomposition of incorporated organic manure, basic cations are released which would

Table 2. Average nutrient content of bulky manure that can be found in Southeastern Nigeria

Manure	Percentage content		
	N	P_2O5	K_2O
Animal refuse	0.3-0.4	0.1-0.2	0.1-0.3
Cattle dung, fresh	0.4-0.5	0.3-0.4	0.3-0.4
Poultry manure, fresh	1.0-1.8	1.4-1.8	0.8-0.9
Sewage sludge, dry	2.0-3.5	1.0-5.0	0.2-0.5
Sewage sludge, activate dry	4.0-7.0	2.1-4.2	0.5-0.7
Ash, coal	0.73	0.45	0.53
Ash, household	0.5-1.9	1.6-4.2	2.3-12.0
Ash, wood	0.1-0.2	0.8-5.9	1.5-36.0
Rural compost, dry	0.5-1.0	0.4-0.8	0.8-1.2
Urban compost, dry	0.7-2.0	0.9-3.0	1.0-2.0
Farmyard manure, dry	0.4-1.5	0.3-0.9	0.3-1.9
Rice hulls	0.3-0.5	0.2-0.5	0.3-0.5
Groundnut husks	1.6-1.8	0.3-0.5	1.1-1.7
Banana, dry	0.61	0.12	1.00

Source: [52]

raise the initial pH of the soil to a more favourable level for good crop production [53,54]. Akande [55] suggested that organic materials could ameliorate slightly acidic tropical soil to improve crop production. Additionally, organic components in the soil play a buffering action and increase ion exchange capacity in the same way as clay minerals.

In southeastern Nigeria several researchers have found out that various organic manure inputs into the soil improves the chemical properties (Table 3) such as; organic matter/carbon, CEC, available phosphorus, exchangeable cations and base saturation [45,55,56,57,58,59,60].

Table 3. Summary of the effect of organic manure on soil properties

S/N	Soil properties	Organic manure used	Location	Authors
.	**Physical properties**			
1	Aggregate stability	Rumen digesta	Nsukka, Enugu	[61]
		Agricultural Waste	Umudike, Abia	[62]
		Rice waste	Abakiliki, Ebonyi	[63]
2	Bulk density	Cassava peels	Abakiliki, Ebonyi	[45]
		Mulch	Nsukka, Enugu	[64]
		Saw dust (SD) and rice husk dust (RHD)	Abakiliki, Ebonyi	[65]
3	Saturated Hydraulic Conductivity	Cassava peels	Abakiliki, Ebonyi	[45]
		Mulch	Nsukka, Enugu	[64]
		Poultry manure, compost, SD, Brewers, Spent grain	Nsukka, Enugu	[66]
4	Total porosity	SD, RHD, Rice mill waste (RMW)	Abakiliki, Ebonyi	[67]
			Abakiliki Ebonyi	[68]
		Rice mill waste (RMW)	Abakiliki Ebonyi	[69]
		Animal manures		
5	Moisture content	RHD & poultry droppings	Ishiagu, Ebonyi	[70]
6	Infiltration rate	RMW	Abakiliki Ebonyi	[71]
.	**Chemical properties**			
1	Soil pH	Agricultural waste	Umudike, Abia	[62]
		Poultry dropping	Owerri, Imo	[72]
		Rumen digesta	Nsukka, Enugu	[61]
2	Organic carbon/matter	Agricultural waste	Umudike, Abia	[62]
		Combined waste	Nsukka Enugu	[66]
		Guinea grass compost	Igbariam, Anambra	[73]
3	Exchangeable bases	Rumen digesta	Nsukka, Enugu	[61]
		Crop residue	Agbani	[74]
		Compost from poultry manure & green manure	Umudike, Abia	[62]
4	Available phosphorus	Poultry manure & cow dung	Owerri, Imo	[75]
		Household compost	Okpuno, Anambra	[76]
		Swine waste	Agbani, Enugu	[77]
5	Cation exchange capacity	Crop residue	Agbani, Enugu	[74]
		Guinea grass compost	Igbariam, Anambra	[73]
		Swine waste	Agbani, Enugu	[77]
6	Total nitrogen	Poultry manure &cow dung	Owerri, Imo	[75]
		Poultry droppings	Owerri, Imo	[72]
		Household compost	Okpuno, Anambra	[76]

Table 4. Summary of the effect of organic manure on yield of crops

S/N	Yield	Organic manure used	Location	Authors
1	Maize	SD & RHD	Abakiliki, Ebonyi	[67]
		Cassava peels	Abakiliki, Ebonyi	[45]
		Poultry manure	Igbariam, Anambra	[78]
2	Tomatoes	Poultry manure	Nsugbe, Anambra	[79]
3	Fluted pumpkin	RHD & poultry manure	Ishiagu, Ebonyi	[70]
		Poultry droppings	Owerri, Imo	[80]
4	Cowpea	Poultry manure & cow dung	Owerri, Imo	[75]
5	Cassava	Poultry droppings	Owerri Imo	[72]
		Burnt palm bunch ash & poultry manure	Owerri Imo	[81]
6	Yam	Poultry droppings	Owerri Imo	[72]
		Burnt palm bunch ash & poultry manure	Owerri, Imo	[81]
7	Cucumber	Abattoir waste	Abakiliki, Ebonyi	[82]
8	Okra	Animal manure	Emene, Enugu	[83]
9	Garden egg	Poultry dropping	Owerri, Imo	[84]
		Pig slurry & ash	Umudike, Abia	[85]
10	Sweet potatoes	Poultry manure	Umudike, Abia	[86]
		Burnt palm bunch ash & poultry manure	Owerri, Imo	[81]

Through the improvement of the chemical properties of soils organic manure inputs help in restoration of the productivity of degraded soils.

4.4 Biological Soil Health

Organic materials have also been observed to increase microbial biomass and activity in soils [87,88]; which suggests a more responsive microbial community in such soils. Animal manure also encourages soil microbial activity which promotes the soil's trace mineral supply, improving plant nutrition.

As a food source for soil fauna and flora, soil organic matter plays an important role in the soil food web by controlling the number and types of soil inhabitants which serve important functions such as nutrient cycling and availability, assisting root growth and plant nutrient uptake, creating burrows and even suppressing crop diseases.

4.5 As a Buffer against Toxic and Harmful Substances

Soil organic matter can lessen the effect of harmful substances e.g. toxins, and heavy metals, by acting as buffers, e.g. sorption of toxins and heavy metals, and increasing degradation of harmful pesticides.

4.6 Yield of Crops

Organic manure in addition to improving soil properties also increases yield o crops as shown in Table 4 above.

5. RECOMMENDATIONS

The following observations and recommendations were made;

- Evaluation and auditing - Manure varies considerably in nutrient content creating difficulties for accurate nutrient applications. Therefore, carrying out a comprehensive and appropriate ecological audit of the site and manure type before application of any form of amendment is essential, because it will help assess the sustainability and give better information on the type of organic amendment best suited for that particular land.
- Flooding is a threat to physical infrastructures and it also destroys farmlands including standing crops. Nigeria government especially in the south east should enforce environmental sanitation laws in towns and cities, ensure appropriate management and maintenance of dams, enforce compliance with town planning/urban laws/edicts and ensure

appropriate maintenance of existing drainage channels.

- Solid wastes, chemicals, hazardous and radioactive waste constitute pollution that also results to land degradation. Environmental audits of existing industries to improve hazardous waste management should be done by the government and they should also promote the development and adoption of appropriate technologies for the conversion of organic municipal solid waste to compost and encourage markets for its use as soil conditioners.
- Easy access to scientific and technological information should be generated

6. CONCLUSION

The use of organic manure to increase productivity and sustainability of land is increasing and the benefit greatly supersedes the usage of inorganic fertilizers. If proper dissemination of information to farmers is carried out the problems of low productivity, poverty, food insecurity and land degradation would be greatly reduced in Southeastern Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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