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Soil Carbon Sequestration Management Practices In Savannah Ecosystem Of Dambatta L.G.A Kano State

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Abstract

The aim of this paper is to identify and explain the soil related problems and their management practices with potentials of soil organic carbon (SOC) sequestration in some selected site of Dambatta L.G.A whereby soil management problems and practice were examined and the role of the soil management in the sequestration of soil carbon were examined. Qualitative methodology was adopted where respondents were interviewed and direct field observation was carried out to identify the soil related problems and the prominent soil management practices in the area. The results show that soil related problems identified in the area are erosion, nutrient problem, water scarcity and deforestation. Some soil management practices highlighted and used by the farmers were erosion control, nutrient management, water management, crops management and afforestation. Based on the findings it was concluded that soil related problems identified have great impact in exposing the SOC which can easily escape to the atmosphere, while the soil management identified in the area have a great potential in enhancing SOC concentration and storage thereby serve as soil carbon sequester. Therefore it is recommended that farmers should continue on the usage of crop residue, cover crops and leguminous crops to maintaining soil quality.

Keywords: Soil, savannah ecosystem, carbon, management and sequestration

INTRODUCTION

The savannah ecosystem is a region with a total evapotranspiration ranges from 0.05 – 0.65 Lal (2001). The world savannah soil is about 40 times more than what was added to the atmosphere through anthropogenic activities IPCC (2001), it contains about 241 petagram of soil organic carbon (Eswaran et al., 2000).The savannah soils have more inorganic carbon than organic carbon (Batjes, 1998). The soil organic management pools play a major role in reducing the rate of enrichment of atmospheric carbon dioxide (Lal, 2001). It is important to note that this region has been pervaded with desertification, desert encroachment, land degradation, and other environmental degradation, these often times results in the discharge and emission of carbon dioxide into the atmosphere (Lal, 2004). Land Use Land Cover has a great influence on the concentration of Soil Organic Carbon (SOC), Mohammed (2014) found out that soils of forest land use has higher amount of SOC than soil of cultivated land because of low erosion and accrual of vegetation litter in the forest.

The world's soil approximately contains about 1500 Petagram (Pg) (1Pg=1Gt = 1015g) of organic carbon (Batjes, 1996), about twice the amount of carbon in the atmosphere and three times that of vegetation(IPCC, 2001; Breeman and Kessler, 1997). The annual global net primary productivity of $CO_2$and that of respiration are of an imperative order of 60 Pg C y−1 (IPCC, 2007). The volume of CO_2deposited globally in the soil is therefore large compared to the net annual fluxes of carbon to and from the terrestrial biosphere and the pool of carbon in the atmosphere.

Soil carbon sequestration can be achieved by increasing the net flux of carbon from the atmosphere to the terrestrial biosphere by increasing global Net Primary Production (NPP) (thus increasing carbon inputs to the soil), by storing a larger proportion of the carbon from NPP in the longer term carbon pools in the soil, by adding additional carbon-containing materials to the soil (such as manures or cereal straw) or by slowing decomposition. For soil carbon sinks, the best options are therefore to increase carbon stocks in soils that have been depleted in carbon, i.e. agricultural soils and degraded soils (Lal, 2004; Smith, 2004), since the capacity for increasing carbon storage is greatest in these soils. It is also important to minimize further losses of soil carbon stocks by more judicious land management, for example avoiding land degradation (Bellamy *et al.*, 2005).

The principal soils of the savannah region are Aridisols, Entisols, Alfisols and Vertisols (Dregne, 1976) whereas drought stress is the principle constrain to biomass production, deficiency of water and low SOC concentration are main factors that cause low net primary productivity. It was reported the soil of Dambatta LGA have low Nitrogen content in upland cultivated land which is attributed to low SOC, continuous cultivation and fertilizer imbalance (Mohammed, 2004). The physicochemical properties of soil vary widely in accordance with the major soil types. Most of the savannah soils are coarse textured, low water and nutrient retention capacity, low inherent soil fertility and the SOC contained is usually less than 0.5% by weight (Lal, 2004).

CONCEPT OF SOIL CARBON RELATIONS

In terrestrial ecosystems the source of soil organic carbon input is from photosynthesis or net primary productivity. Assimilates can be transferred directly to the roots via the phloem or can be converted to biomass that might be transferred to the soil via litter. The 'assimilate-fed' and the 'litter-fed' pathways have also been named 'autotrophic' and 'heterotrophic' components of soil respiration in many studies. For many concepts and methods related to soil carbon dynamics it is a prerequisite to distinguish between these components of soil respiration because they depend on very different mechanisms determining their response to environmental conditions. The autotrophic component can be further separated into respiration of the rootsand the microbiota of the rhizosphere, which depend directly or indirectly on carbohydrate sources from roots or mycorrhiza (Werner *et al.,* 2009)

In many conceptual approaches three pools of organic matter are distinguished. The easily decomposable active soil organic matter and the more stable slow and passive humic substances, also often called the recalcitrant pool receive fresh organic matter via litter input and also from microbial turnover and other events such as fire (Werner*et al.,* 2009;Ekschmitt*et al*., 2008; Krull *et al*., 2003). Litter and the resulting humic substances are decomposed mainly by the bulk soil micro-organisms that comprise bacteria, fungi and the soil meso- and macro-fauna, resulting in respiration and subsequent soil CO_2 efflux and changes in the chemical composition of soil organic matter. This biological activity is the driving force for the conversion of litter into stable humus and is also related to bioturbation such as earthworm, millipede and snail.

The aim of this paper is to identify and explain the soil related problems and their management practices with potentials of SOC sequestration and the specific objectives are to examine some of the major soil problem, soil management practices and their impact on SOC sequestration.

Study Area

Dambatta Local Government Area is located between latitude 12^{0}15′N to 12^{0}35′Nand longitude 8^{0}29′E to 8^{0}49′E with total land area of 732Km^2 (Mohammed, 2004). Two villages were selected purposively as shown in figure 1; this is because the areas have similar crop production and soil management practices. The climate of the study area is the tropical wet and dry type coded as Aw by W. Koppen and influenced by the movement of the two air masses, the maritime air mass originating from Atlantic Ocean and the dry desiccating tropical continental air mass emanating from the Sahara desert. These air masses meet at the zone called Inter Tropical Convergence Zone and it is the seasonal movement of this front that determines the climate of the area (Mohammed, 2004). The soil of the area is ferruginous type and many forms of hydromorphic soils were found in depression, low terrace and abandoned channels which termed as *Fadama* soil. The soil is well drained and is often fine sandy texture, sandy loam, very permeable and good for both rainfed and irrigation farming (Mohammed, 2004).

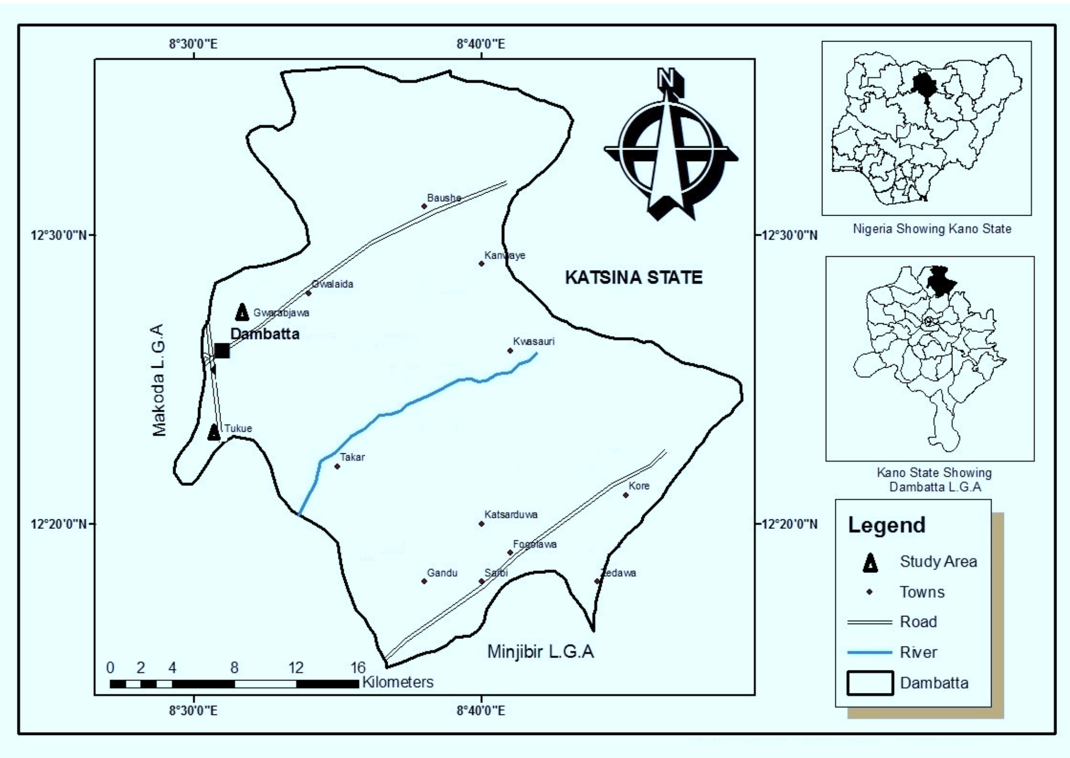

Figure 1: Dambatta Local Government Showing Study Locations
Source: Cartography BUK (2014)

Methods

Qualitative research methodology was adopted and the study area was stratified to into two based on location (North and South), two sites with similarity in soil management practices were purposely selected Gwarabjawa and Tukue were Information on soil related problems, and soil management practices were obtained from the farmers through interview and the respondents were identified accidently i.e. based on the respondent found in the field at the time of interview. However, direct field observation was also conducted where information on soil related problems that can be identified physically such as erosion, deforestation, solidity as well as soil management option for enhancing SOC in the area were obtained.

RESULTS AND DISCUSSION

The information derived from the interview records were analyzed, some of the soil management problems, strategic management and practices employed by the farmers were identified and presented in table 1. Four soil problems, strategies and practices were identified in the study area and the impact of the strategies and practices adopted by the farmers for soil carbon sequestration were evaluated in this section.

Table 1: Soil Problems, Strategies and Practices identified by the respondent in the Area

Soil problems	Strategies	Practice
Erosion (rills and gullies)	Erosion control, water conservation Stone cover and bags of sand	No-till faring and cover crops
Nutrient Problem	Integrated nutrient management Crops-livestock integration	Manurin, crop biomass and legueneous crops
Inadequate water	Water management, crop diversification and Early matured crops	Irrigation, water harvest and use of light equipment like *Ashasha*
Deforestation	Planting more trees	*Parkiaspp* like *buglobosa* and *nilotica*since they are leguminous trees

Source: Field Survey (2014)

Adoption of recommended soil management practices by farmers in the study area are the major problems identified that lead to the release of SOC to the atmosphere without storing it for a long period of time due to disturbance from unsustainable soil management practices. The soil problems identified in the area that exposed the SOC and there management strategies that enhance the concentration and storage in the soil are discussed below:

Erosion Management

From the interview the respondents shows that no-tillage farming, and planting cover crops increase water efficiency by reducing losses due to surface runoff, evaporation and decreasing soil temperature. These reduce the risk of soil degradation and improve soil quality and SOC concentration stored in the soil. This is because soil carbon are normally stored in sub-surface soil in form of tiny particle which are easily released to the atmosphere when the soil surface is exposed to erosion. This adduced by Lal (2004) that soil erosion is the major source of atmospheric carbon and erosion management that sequester SOC. Steward and Robinson (2000), also confirmed that gratifying consequences of no-tillage system is increased in SOC concentration and storage in the soil which may range from 60kg to over 600kg c/ha/yr. Any soil management that can reduce the rate of erosion would enhance the soil carbon storage capacity by the soil and the carbon can be remained in the soil for long period of time rather than been emitted to the atmosphere (Lal, 2004).

Nutrient Management

Soil fertility management is very important for improving SOC storage in the soil. From the interviews, the respondents in the two study sites testified that application of farmyard manure is important for crop yield particularly when used in conjunction with no-tillage and residual management. The interviewee shows that the use organic manure reduced the dependency or use of inorganic fertilizer. However, it was reported that inorganic fertilizer increase the green house gas (GHG) to the atmosphere. This is adduced by Ekschmitt *et al.* (2004) in Mohammed (2017) that applications of Nitrogen, Phosphorous, Potassium (NPK) fertilizers result in GHG emissions ranging from 0.8 to 10.0 kg CO_2-eq per kg of fertilizer-N depending on fertilizer production plant design and efficiency, emission control mechanisms, and raw-material inputs. This is contended by Smith *et al.* (1997) that the application of inorganic fertilizers in the field is estimated to emit from 0.25 to 2.25 kg N_2O per 100 kg N. the interviewee also mentioned that increasing organic fertilizer efficiency and reducing inorganic fertilizer inputs are the two major ways to optimize nutrient management for reducing GHG emissions. However, the interviewees maintained that they practiced no-tillage system and the use of crop biomass thereby these management practices increased the SOC concentration and storage capacity in soil. In the study area, it was observed and testified by the interviewee that, they normally use farm yard manure, green manure, composite and other bio-solid for enhancing soil fertility, which have great impact on increasing concentration and storage of SOC.

Water management

The interviewee confirmed that they normally store water in their farms in small pond to supplement the inadequacy of the water for crop production in the area which enhanced the quality of their environment by production of biomass from plant and animal litters and consequently enhance SOC in the area. This is contended by Follet *et al.* (2003) that water management is crucial to enhancing biomass production in the savannah region which in turned enhance SOC sequestration through long term storage of soil carbon. It was observed that the irrigation farming was practiced in depression where the soil colour is dark brown and called *Bakarkasa* by the interviewee which is equivalent to vertisol (United State Department of Agriculture, 1987) based on their characteristics, which have high potential of storing soil carbon. Follett*et al.* (2003) adduced that adoption of soil conservation on irrigated vertisol sequesters soil carbon at the rate of 1.8mg/ha/y.

Cover crops and afforestation

The beneficial effect of soil conservation for enhancing SOC concentration are noticeable when used in conjunction with cover crops and planting trees. It was observed and confirmed by the interviewee that some trees such as *Parkia* (*Gawo*) species normally enhance the fertility of the surrounding soil thereby reducing the use of inorganic fertilizer which consequently release NO_2 to the atmosphere. Brady and Weil (1999) explained that leguminous trees such as *Parkia* of various species have the ability to fix atmospheric nitrogen through the process of nitrogen fixation. The cover crops protect the surface soil from exposure to various form of erosion thereby protecting soil carbon from being released from the soil.

CONCLUSION AND RECOMMENDATION

Based on the information derived from the interview it was concluded that erosion, low soil fertility, deforestation and drought are the major soil related problems, while no-till system, cover crops, manuring, leguminous crops, water harvest and planting more trees are the soil management practices identified by the interviewee and testified that they have a great potential in enhancing SOC concentration and storage thereby serve as soil carbon sequencer. Based on that it is recommended that farmers in the area should continue and improve on the usage of crop residue or biomass on their farm, improve on the efficient use and storage of water, improve on the usage of manure, cover crops and leguminous crops for maintaining soil quality and enhancing soil carbon production and storage in the area.

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