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LAND –USE CHANGE EFFECTS ON SOIL QUALITY AT UMUDIKE AREA, ABIA STATE, SOUTH-EAST NIGERIA

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Abstract

Land use change affects soil quality, but the extent of the effect at Umudike area of Abia State Nigeria, remains unclear. The study examined the impact of seven land use types: Natural Forest Reserved land (NFRL), Arable Land (AL), Recreational Land (RL), Pasture Grass Land (PGL), Reforestation Land (RFL), Short Period Fallow Land (SPFL), and Oil Palm Plantation Land (OPPL) on some selected soil properties. The aim of the study were: to investigate what extent, if any, deterioration of the soil as a result of change from forest to other forms of use; and if soil's organic matter was related to the soil's other properties. Soils were sampled under forest and six other forms of land use mentioned. The soil properties determined were; pH, soil organic matter, total nitrogen, bulk density, total porosity, moisture content, particle size distribution, and mean weight diameter. Relationships between the soil properties and soil organic matter, which is assumed as an indicator of soil quality in the study area, were also estimated. Results show that soil organic matter increased significantly ($p<0.05$) under NFRL to 43.47 g kg^{-1}, and decreased to 0.52 g kg^{-1} under AL. Bulk density value was lowest (1.25 g cm^{-3}) for NFRL, followed by the PGL (1.30 g cm^{-3}). Results of the percentage soil deterioration index indicated that RL had the highest value of 24.6%. There was a linear and strong negative relationship (R^2 = 0.8778 and r = -0.83***) between soil organic matter and bulk density. Conversely, between soil organic matter and mean weight diameter, strong positive relationship (R^2 = 0.7428 and r = -0.83***) was estimated. We conclude therefore, that the adoption of good soil management practices that would improve the soil properties of the other land use apart from NFRL should be encouraged.

Keywords: Land conversion, soil quality, soil organic matter, deterioration percentage and Umudike area

Introduction

Land use is defined as the total of arrangements, activities, and inputs that people undertake in a certain land cover type (Di Gregorio, 2005). Hence the changes of these arrangements, activities and inputs over time are described as land use changes. One of the factors that lead to land use change is population increase. The population of the world stands at 7.6 billion in 2017 compared to 7 billion in 2011(UNPF, 2017), this shows an increase of 7.8% within a space of six years. In Nigeria, the estimated population in 2010 was 158.6 million people, and then in 2017, it was 190.8 million with a total land area of 910,770 km² (Worldmeters, 2018), indicating 20.30% increase. With the increasing population especially in Nigeria, some land use is converted into another to accommodate the need of the populace. For instance, the primary or natural forest are being converted to agricultural, residential, industrial, recreational, commercial land among others, to meet the need of the growing population. It was estimated that 350million hectares of tropical forest had been converted to other land uses (Lal, 2005a). Conversion of forest to agricultural land and other land uses, results to global environmental degradation and climate change (Bewket and Stroosnijder, 2003). Agriculture has remained the most significant driver of global deforestation (FAO, 2016). When forests are deforested through biomass burning and other anthropogenic activities, the land covers are destroyed with CO_2 and other greenhouse gases released into the atmosphere (Lal, 2005b). This results to large CO_2 emissions on a global scale (IPCC, 2001) and observed climate changes (Lal, 2008). Land degradation is initiated when land use change occurs, and with time, it affects the biological, physical and chemical properties of soil and the biodiversity and functioning of terrestrial ecosystems (Lal, 1988; Benneh *et al.,* 1996; Sala, *et al.,* 2010; Wang, *et al.,* 2011).

Soil organic matter is seen as an important indicator of soil quality (Abbasi and Rasool, 2005). When soil organic matter is adequate in the soil, it improves the chemical fertility, plant nutrients supply, soil porosity, infiltration capacity, moisture retention, and resistance to water and wind erosion (Cerli, *et al.,* 2009). However, conversion of land use has a significant effect on soil organic matter (Abbasi and Rasool 2005). There is significant reduction in topsoil organic matter (Mohawesh, 2015), as a consequent of transition from forest to arable agriculture. This is mostly due to oxidation/mineralization, leaching and erosion (Lal, 2008) exacerbated by land conversion. Reduction of soil organic matter and carbon often lead to an increase in bulk density (Haghighi, *et al*, 2010), reduction in total porosity, macro aggregates and hydraulic conductivity. Other problems associated with land conversion are decrease in the amount of soil nitrogen, organic phosphorus, basic cations, microbial biomass and overall deterioration of soil properties (Cade-Menun, *et al.,* 2017; Wachendorf 2017; Van Leeuwen, *et al.,* 2017). Nevertheless, it is not in all cases that conversion into another land use may have a detrimental effect on soil properties. Neill *et al*., (1997), stated that establishment of pastures from forest can improve SOC pool, but the improvement will depend on the type of soil, inherent SOC pool, pasture species types and the management practices. Lal (2005b) reported that establishment of plantation results to either maintenance or enrichment of the SOC. This is because there is less soil disturbance, and with the practice of no pruning, a large quantity of leaf litter and detritus material is returned to the soil. The conversion of forest to pasture land results to significantly higher values of soil pH and exchangeable calcium (McGrath *et al.,* 2001), this was attributed to the presence of ash added by the slash -and burn practice. In this study, we hypothesized that there will be a negative deviation from the forest soil properties in comparison to other land use changes. The aim of this study is to investigate to what extent, if any, the soil had deteriorated as a result of change from forest to other forms of use and if the soil's organic matter was related to the soil's other properties.

Materials and Methods

Study area

The study area is located within Michael Okpara University of Agriculture Umudike ((latitude 05°29`N and longitude 07°33`E). Michael Okpara University of Agriculture Umudike (MOUAU) is located in the humid forest zone and is ten kilometers east of Umuahia, which is the capital of Abia State Nigeria. The study area occupies a land mass of 6450 hectares with an altitude of 122m above sea level.

Climate and soil

The climate of the area is tropical rainforest, with a monthly minimum and maximum air temperature ranging from 20°C to 24°C and 28°C to 35°C respectively. The average rainfall is 2176 mm annually and the relatively humidity varies from 51% to 87%. The average sunshine hours varies from 3 to 7 hours and appeared always lowest in the months of July, August and September. Sunshine hours were always highest in the month of May (NRCRI, 2015). The soil is mainly well-drained sandy clay loam derived from coastal plain parent material and belongs to Ultisols (Agboola, 1979; Enwezor, *et al.,* 1989). It is largely dominated by kaolinite with low bases status and classified as Typic Kandiudult (Lekwa and Whiteside 1986).

Soil sampling and location description

All the land use types studied in the experiment were situated within MOUAU. History has it that at the establishment of the former School of Agriculture Umudike in 1955, all the land area was forest reserved area. Gradually, the forest was converted into various uses. The GPS locations and histories of the land use types are outlined in Table 1.

Table 1: Location and history of the seven land use types used for the study

Name	GPS location	Year of establishment and history	Land cover descriptive features
Natural Forest Reserved land (NFRL)	05° 28' 42.9"N 007° 32' 31.5"E	Natural forest land has been in existence for more than 60 years. The forest is reserved to capture biodiversity which may be lost from the other land use. The area is barricaded and entrance into the forest is very strict, except for important research purposes.	Some major trees found in the forest included; *Brachystigia eurycoma*, *Milicia excels*,*Treculia Africana* and *Pterocarpus osun*.
Arable land (AL)	05° 28' 54.0" N 007° 32' 21.6"E	This was part of the forest had been under continuous cultivation for the past 40 years. In the first 15 years, the land was manually tilled and conventional tilled with tractors in the last 25 years. The crops received different rates of Urea to NPK fertilizers.	The major cultivated crops were different species of *Manihot esculenta*, and *Zea mays*.
Recreational Land (RL)	05° 28' 45.2" N 007° 32' 34.2"E	This was an arable land converted into a recreational land in 2001. Used as a football field, other sporting events and entertainment programs.	The dominated grasses were *Cynodon dactylon* (Family: Poaceae) *Axonopus compressus, Urochloa decumbens, Aspilia africana*
Pasture Grass land (PGL)	05° 28' 42.5" N 007° 32' 23.1"E	Established in 1972 by the then School of Agriculture, when it was part of the Federal Agricultural Research and Training Station (FARTS), School of Agriculture, Umudike. It is used for cattle grazing and forage.	*Cynodon plectostachyus,* *Panicum Maximum,* mixed legumes of *calopogonium mucunoides, centrosema pubescens and pueraria phaseoloides* are predominate in the land.
Reforestation land (RFL)	05° 28' 46.3" N 007° 32' 31.0"E	Established in 1996 by the College of Natural Resources and Environmental Management of Michael Okpara University of Agriculture, Umudike.	*Gmelina arborea,* Treculia *Africana, Musa paradisiaca, Musa sapientu, Mangifera indica, Carica papaya and Dacryodes edulis* are some tree species found in the regenerated forest.
Short period fallow land (SPFL)	05° 28' 50.2" N 007° 32' 06.2"E	The land was initially cultivated and was later left to fallow since ten years running now.	*Talinum triangulare, centrosema pubescens* *Mimosa pundica, Panicum Maximum, Chromolaena odorata, Mimosa invisa, Cyperus aromaticus and* Ageratum conyzoides
Oil Palm plantation land (OPPL)	05° 28' 39.5" N 007° 32' 11.0"E	Established in 1972 under the then School of Agriculture, Umudike and was inherited by Michael Okpara University of Agriculture Umudike, in 1993.	*Elaeis guineensis, Ageratum conzoides, Emilia sonchifolia, Mimosa invisa and Nephrolepis bisserata*

Soil sampling and analyses

In July 2015, soil samples were collected according to the description given by Celik (2005). Four sites within each location were randomly selected for sampling. Soil samples were collected randomly from four sites within each of the land use type. Within each sites of each land use type, four disturbed and undisturbed (core sampler of a 5cm diameter and 5cm height) soil samples were randomly taken at the depth of 0-15cm. This added up to thirty-two soil samples for each land use and two hundred and twenty four soil samples for all the land use examined in the experiment.

The disturbed soil samples were used for the determination of particle size distribution, pH, organic matter, total nitrogen and mean weight diameter. The samples were air dried and passed through a 2mm mesh sieve size to remove stones, roots and un-decomposed organic materials. Undistributed soil samples were used in the determination of bulk density, total porosity and moisture content. Particle size distribution was determined by Bouyoucos hydrometer method (Bouyoucos, 1962). Soil pH was determined in water at a ratio of soil water of 1: 2.5 (Mclean 1982).

Walkey–Black wet oxidation procedure modified by Nelson and Sommers, (1982) was used to determine SOC, the values of SOC were multiplied by 1.72 (*Van Bemmelen Factor)* to estimate soil organic matter. Total nitrogen was determined by Kjedahls' method (Bremner, 1965), while mean weight diameter (MWD) of the water-stable aggregates was determined by the method of Kemper and Rosenau (1986).
The mean diameter was estimated thus:

$$\text{MWD} = \sum_{i=1}^{n} \text{XiWi} \ldots\ldots\ldots (1)$$

Where;
MWD = mean weight diameter of water stable aggregates
Xi = mean diameter of each size fraction (mm)
Wi = is the proportion of the total sample mass (WSA) in the corresponding size fraction after deducting the mass of stones.

Core method (Blake and Hartge, 1986) was used to determine the dry bulk density. Total porosity of the samples was calculated by the method of Danielson and Sutherland (1986) using the dry bulk density and particle density value of 2.65g cm^{-3}. Moisture content was measured by the gravitational technique.

Stability index (SI)
The stability index (SI), which is a measure of the stability of the aggregates was calculated as the inverse of the instability index (IS), where instability index is the difference between the initial MWD and the final MWD (Pulido-Moncada *et al.,* 2013).

$$\text{SI} = 1/\text{IS} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The classification of the aggregate stability based on SI (de Leenheer and de Boodt, 1959) cited by Pulido-Moncada *et al*., (2013), for medium-textured Belgian soils was adopted for the purpose of this study included the following rating:
>1 = excellent; 0.8 to 1 = very good; 0.66 to 0.8 = good; 0.5 to 0.66 = unsatisfactory; and <0.5 = bad.

Soil deterioration indices
The soil deterioration indices were computed based on the assumption given by Adejuwon and Ekanade, (1988) and Islam and Weil, (2000). The assumption was since the status of individual soil properties under arable, recreational, pasture grass, reforestation, short period fallow and oil palm plantation lands were once the same as Natural forest reserved land before conversion into the various land uses. The difference between the arithmetic mean values of individual soil properties under arable, recreational, pasture grass, reforestation, short period fallow and oil palm plantation lands were compared to the values of the natural forest reserved land. These were computed and expressed as a percentage of the mean value of individual properties thus;

$$\text{SDI} = \frac{\text{Xs} - \text{Xi}}{\text{Xs}} \text{ x } 100 \ldots\ldots\ldots (3)$$

Where Xs is the value of individual soil properties in natural forest reserved land and Xi is the values of individual soil properties in arable, recreational, pasture grass, reforestation, short period fallow and oil palm plantation lands respectively.

Statistical analysis
The effect of the seven land use types on the soil properties were compared with one-way analysis of variance (ANOVA). The means of the soil properties were separated using LSD at $p \leq 0.05$ and alphabets assigned to the means based on Fisher's unprotected LSD. Relationship between soil organic matter and some selected properties were determined. Data analyses were carried out using Genstat (18^{th} edition).

Results and Discussion
Soil particle size distribution and textual class
Soils under Natural Forest Reserved Land (NFRL) had the highest significant ($p \leq 0.05$) clay than all the other land use types (Table 2) studied. Pasture grass land (PGL), Reforestation land (RFL), Short period fallow land (SPEL) and Oil palm plantation land (OPPL) were statistically the same, whereas, Arable Land (AL) had the lowest clay value. Clay particles are negatively charged and have large surface area which gives it the advantage of attracting positively charged minerals to its surface. This makes clay retain mineral nutrients and water which are important for plant growth. Though there were no statistical significant differences observed among sand and silt of the land use types, forest land had the lowest values for sand and silt.

Table 2: Effect of seven land use types on Soil Particle size distribution

Land use type	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Textural Class
NRFL	656	74	270	Sandy Clay Loam
AL	736	190	74	Sandy Loam
RL	763	134	103	Sandy Loam
PGL	737	127	136	Sandy Loam
RFL	742	127	131	Sandy Loam
SFL	732	135	133	Sandy Loam
OPPL	729	131	140	Sandy Loam
Lsd ($p < 0.05$)	Ns	Ns	16.89	

NRFR (Natural reserved forest land); AL (Arable Land); RL (Recreational Land); PGL (Pasture grass land); RFL (Reforestation land); SPFL (Short period fallow land) and OPPL (Oil palm plantation land)

Soil pH, organic matter and total nitrogen

The pH in water (Table 3) for all the land use types were acidic (because they were below 5.5), and the values were not statically different from one another. The low pH values could be as a result of the coastal plain sand parent material which is acidic in nature (Ayodele and Shittu, 2014), amphoteric nature of aluminum in the tropical soils (Islam and Weil 2000), intensive rainfall which causes chemical weathering of the soil and leaching of the basic cations. Soil organic matter value was significantly ($p \leq 0.05$) higher in the NFRL and PGL (Table 3). Increased organic matter may have resulted from the long term litter recycling and organic matter accumulation because of abundant vegetative growth (Bot and Benites, 2005) of the trees and other biodiversity. Organic matter is primarily of plant origin and accumulates in areas with high trees, shrubs and grass cover (Hagan *et al.,* 2015). The result obtained is in agreement with the findings of Anikwe (2010), who observed that the highest SOC content (which is a component of organic matter) was found in natural undisturbed forest. The ranking of the SOM in the land use types were in the following order; NFRL > PGL > RFL > SPFL> OPPL > RL > AL. From the ranking, PGL had higher SOM after NFRL; the dung from the cattle that grazed on the grassland would have contributed to the high SOM recorded. The mean percentage soil total nitrogen was not significant among the land use. Apart from not being significant, the values of total nitrogen were low, this may be as a result of leaching which according to McCauley, *et al*., (2017), occurs in low pH. Also, at low pH (<6), nitrification is low (McKenzie, 2003), indicating that most of the nitrifying bacteria might have been affected negatively by the low pH in the study area.

Table 3: Effect of seven land use types on Soil pH, Organic matter and Total nitrogen

Land use type	pH(1:2.5)	Organic Matter (g kg^{-1})	Total Nitrogen (g kg^{-1})
NFRL	5.27	43.47	1.98
AL	5.49	0.52	0.88
RL	4.50	10.00	1.12
PGL	5.00	37.50	1.41
RFL	4.70	26.12	1.40
SPFL	5.30	18.50	1.27
OPPL	4.30	18.40	1.17
LSD ($p < 0.05$)	Ns	9.39	Ns

Soil bulk density, total porosity and moisture content

Soils under NFRL (Table 4) had significant lowest bulk density (1.25 g cm^{-3}), and highest total porosity value (52.90%), though the value was not significantly different from the other land use values. The high organic matter level which was built up over the years, might have contributed to these. RL and AL had statistically highest bulk density values and lowest total porosity. The reason for the high bulk density could be as a result of the compaction of the soil due to continuous human and automobile trafficking for RL and tillage practices for AL. AL been under continuous cultivation for the past forty years (Table 1) It is expected that the tractor wheel traffic would have caused soil compaction which pressed the soil particles together thereby reducing the pore spaces between them. Also, when the soil is tilled, the residues are incorporated into the soil with air. This creates an aerobic environment for the micro-organisms to speed up decomposition, with the resultant products being formation of less stable humus, increased release of CO_2 to the atmosphere and reduced organic matter (Bot and Benites, 2005). With reduced organic matter, the soil bulk density will be affected. Other factors such as human and animal trafficking, wetting and drying cycles in soils, raindrop impact energy, (Anikwe, *et al.,* 2003) caused increased soil bulk density. All these factors could be why AL which had been under continuous tillage had high bulk density and low porosity as shown on Table 4.With the constant human movement over the recreational land, it is expected that the soil gets compacted and hence the high bulk density in relation to NFRL recorded. Compared to the other land use types, NFRL had significant ($p \leq 0.05$) higher moisture content. This was followed by RFL and PGL which had values of 12.00 and 11.67% respectively. The high clay and organic matter values recorded at NFRL could have contributed to the high moisture content. The small pores of the clay soils hold much water against gravity and this increase the soil water content. It has been reported that as the percentage of soil organic matter increases, the soil water-holding capacity increased because of the affinity organic matter has for water (Hudson, 1994). The shading of the sun from reaching the forest ground by the tall trees and the mulching effect of the fallen leaves prevents evaporation of moisture from the forest ground. This will in turn increase the soil water content.

Table 4: Effect of seven land use types on soil bulk density, total porosity and moisture content

Land Use Type	Bulk density (g cm^{-3})	Total Porosity (%)	Moisture Content (%)
NFRL	1.25	52.90	15.54
AL	1.65	37.80	9.82
RL	1.67	37.00	8.12
PGL	1.30	50.90	11.67
RFL	1.40	47.20	12.00
SPFL	1.42	46.50	10.87
OPPL	1.42	46.50	9.00
LSD($p < 0.05$)	0.19	Ns	3.30

Mean weight diameter and aggregate stability index and classification

Mean weight diameter was highest in NFRL and lowest in RL and AL (Table 5). Statistically, the values obtained for RFL, PGL, OPPL and SPFL were the same. The same trend of results was also seen on the stability index values where NFRL had the highest value of 1.29. The percentage stability decreases with NFRL over the other land use changes were -82.94%, -57.36%, -37.98%, -37.86%, -39.95% and -38.75% for AL, RL, PGL, RFL, SPFL and OPPL respectively. The aggregate stability index classification for NFRL was excellent, while AL was bad. Greater mean weight diameter value of NFRL is consistent with greater value of organic matter obtained. It is a known fact that organic matter help bind the soil aggregates. The part that organic matter play in MWD could be better understood by the explanations given by Tisdale and Oades, (1982); Elliott, (1983) cited by Islam and Weil (2000). They reported that the extracellular polysaccharides produced during decomposition of labile organic matter and fungal hyphae associated with the extensive perennial roots systems, and grass could be important binding agents for macro aggregates. Igwe, (2011), also reported that the thick dense grass root system improve aggregation within a larger soil volume and also improves aeration of the soil. This may be the reason while the MWD of PGL was improved. When the macro aggregates bond, the soil aggregate will be improved as well as the MWD. High MWD are at advantage to soils because according to Celik (2005), soils with higher MWD and WSA will have greater resistance to soil degradation and erosion, unlike those with less. Soil aggregates play a vital role by physically protecting organic matter molecules from further mineralization (biodegradation) caused by microbes (Oades and Waters 1991; Rice, 2002).

Table 5: Effect of seven land use types on soil mean weight diameter, aggregate index value and classification

		Aggregate Stability	
Land Use Type	Mean Weight Diameter (mm)	Index value	Classification
NFRL	2.65	1.29	Excellent
AL	0.33	0.22	Bad
RL	0.76	0.51	Unsatisfactory
PGL	1.20	0.80	Good
RFL	1.21	0.80	Good
SPFL	1.16	0.78	Good
OPPL	1.19	0.79	Good
LSD($p < 0.05$)	0.63	0.35	

Percentage soil deterioration index of the land use types

The percentage soil deterioration index shows the negative divergence of the soil properties of AL, RL, PGL, RFL, SPFL and OPPL from those of NFRL (Fig 1). RL had the highest percentage soil deterioration index of 24.6% and this was followed by OPPL with a value of 22.75%. Al had a value of 17.31% while SPFL, RFL and PGL had values of 12.86%, 12.11% and 8.61% respectively. PGL had the lowest significant deterioration value, and this implies that its mean values for individual soil properties did not diverge away from the individual values of NFRL. The result from the percentage soil deterioration indices is a pointer that changing the natural forest land into recreational and cultivation lands affects the soil health and soil quality.

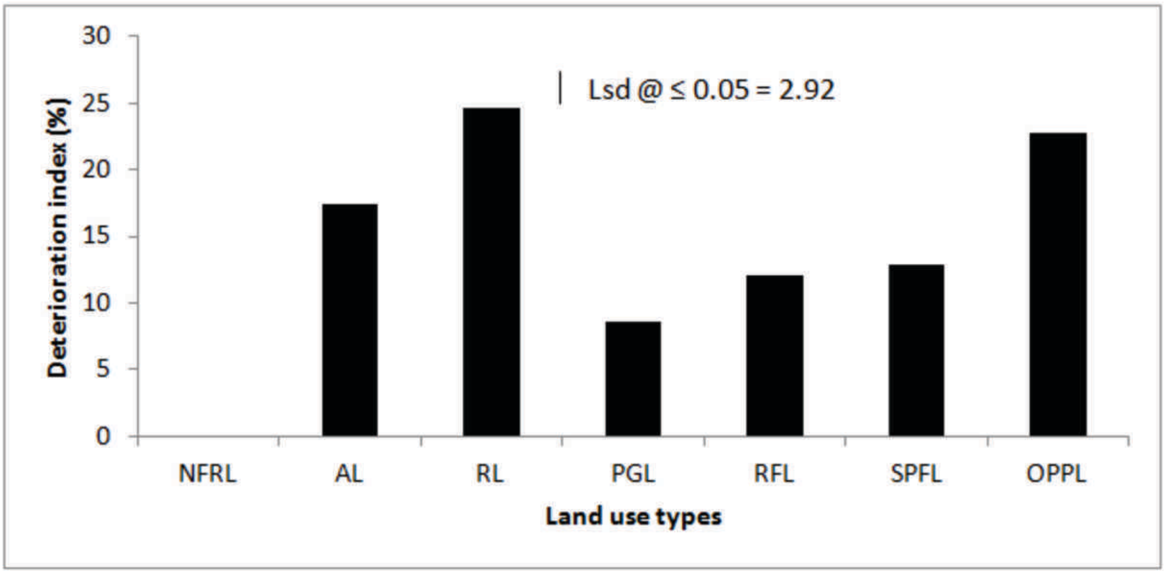

Fig 1: Percentage soil deterioration index of soil properties for different land use types. Each deterioration percentage was calculated from the sum of the individual soil properties determine

Relationship between soil organic matter (SOM) to other soil properties

All the data collected from the different land use types were pooled together to estimate the correlation between SOM and moisture content, bulk density, clay, sand, total porosity, mean weight diameter, pH and total nitrogen. The relationship between SOM and moisture content was significant at $p \leq 0.001$ (Table 6) and positively correlated (0.86). SOM and bulk density had a negative correlation (-0.83) that was linear with coefficient of determination of (R^2) of 0.8778 significant at $p \leq 0.001$. There were linear relationships between SOM and clay, total porosity and mean weight diameter with R^2 values of 0.6825, 0.8747, and 0.7428 respectively. The relationships were all significant at $p \leq 0.001$ and correlated with 0.71, 0.91 and 0.67 for clay, total porosity and mean weight diameter respectively. The relationship between SOM and sand was negative, with R^2 value of 0.4201 but not significant. There was a significant ($p \leq 0.05$) and positive relationship between SOM and total nitrogen with R^2 and r values of 0.8479 and 0.50 respectively. The inverse relationship between SOM and bulk density was also reported by Sakin *et al.,* (2011). As SOM increases, bulk density decreases. Activities that promote high bulk density through soil compaction reduce the organic matter level in the soil. When the soil is tilled, it is aerated, and this provides oxygen that speeds up decomposition of SOM by soil microbes (Bot and Benites, 2005). When soil bulk density is increased, it results to a decrease in total porosity (Fageria, 2013; Chaudhari *et al.*, 2013; and McCarty, *et al*., 2016). As SOM increases, soil porosity also increases, This shows that soils with more soil organic matter will have better porosity. Bot and Benites (2005), reported that when soil is high in clay and organic matter, it improves the porosity. The highly significant positive correlation between SOM and MWD is an indication that SOM positively enhanced MWD which is an index of soil aggregate stability (Li, *et al,* 2017). Roose and Barthes (2001) reported that soil organic matter improves soil aggregate stability. Increased SOM, reduced soil bulk density and this will result to stability of the aggregates and improvement in soil porosity. The highly significant and positive correlation between clay and SOM show that the increase of one is a consequent of the other. Bot and Benites (2005) reported that soil organic matter tends to increase, as the clay content increases.

Table 6: Relationship between soil organic matter, moisture content, bulk density, clay, sand, total porosity, mean weight diameter, pH and total nitrogen of the land use types studied

Soil properties	Coefficient of determination (R^2)	Correlation coefficient (r)	Relationship strength of correlation
Soil organic matter and moisture content	0.6682	0.86***	Strong positive correlation
Soil organic matter and bulk density	0.8778	-0.83***	Strong negative correlation
Soil organic matter and clay	0.6825	0.71***	Strong positive correlation
Soil organic matter and sand	0.4201	-0.25	Negative correlation
Soil organic matter and total porosity	0.8747	0.91***	Strong positive correlation
Soil organic matter and mean weight diameter	0.7428	0.67***	Strong positive correlation
Soil organic matter and pH	0.0002	0.05	Positive correlation but not significant
Soil organic matter and total nitrogen	0.8479	0.50*	Positive correlation

*****=p ≤ 0.001, **=p ≤ 0.01, *=p ≤ 0.05**

Conclusion

Conversion of forest to other land use types; arable, recreational, pasture grass, reforestation, short period fallow and oil palm plantation lands resulted in the deterioration of some of the soil properties studied. Arable land had the highest bulk density, lowest SOM, MWD and total porosity. There was an improvement of SOM, bulk density, total porosity of PGL in comparison to the other land use types. The least deterioration percentage was found in PGL while the highest was found in RL. The result generally showed that conversion of forest land into other land uses degrades the soil quality. It will be appropriate to minimize the conversion but where this is not possible due to population increase, PGL, RFL should be encouraged based on the results obtained. Management practices that enhance soil health restoration of degraded soil should be employed.

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