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ORGANIC CARBON, TOTAL NITROGEN AND AVAILABLE PHOSPHOROUS CONCENTRATION IN AGGREGATE FRACTIONS OF FOUR SOILS UNDER TWO LAND USE SYSTEMS

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ABSTRACT

This study was undertaken to evaluate the effect of cultivation and fallow on the Organic Carbon (OC), Total Nitrogen (TN), and available phosphorous (P) concentration in aggregate fractions of four soils. The four soils used for the study are; Entisol, Ultisol and two Inceptisols, all collected from four different locations in Nsukka area of Southeastern, Nigeria. The land use types considered were Fallow and Cultivated. The soils collected from 0-25 cm depth were separated into five aggregate fractions, 5-2 mm, 2-1mm, 1-0.5 mm, 0.5-0.25 mm and < 0.25 mm, and changes in their OC; TN and P concentrations due to cultivation were determined for both dry and wet sieved fractions. The result of the study showed that the OC concentration among the soils were in the order Entisol at Nsukka (ENsk) > Ultisol at Nsukka (UNsk) > Inceptisol at Eha-Amufu (IEh) > Inceptisol at Ikem (Iik). The total N concentration in dry sieved samples of ENsk was higher compared with those of similar fractions of UNsk, IEh and Iik, while wet sieved samples showed no consistence in the decrease of the TN concentration of the aggregate sizes. The total N concentration in both dry and wet sieved samples of UNsk increased progressively as the aggregate sizes decreased, while the highest TN in IEh was obtained in 0.5-0.25 mm aggregate size of dry sieved of fallow soil and wet sieved of cultivated soil.

The lowest concentrations of TN in Iik was obtained in 1-0.5mm aggregate size for the dry sieved samples of fallow soil, and no particular change in the TN concentration of 1-0.5mm and 0.5-0.25mm size of cultivated soil. The wet sieved samples of the same soil showed that the highest concentration of TN was obtained in 0.5-0.25mm size in fallow soil and 17.3% decrease in < 0.25mm fraction relative to the 0.5-0.25mm fraction in cultivated soil. The TN concentration obtained in two Inceptisol in both dry and wet sieved samples of fallow and cultivated soil was low compared to the ones obtained from ENsk and UNsk. There was no uniform trend or pattern of available Phosphorous distribution in the aggregate fractions of dry and wet sieved samples. From the result of this study it can be deduced that the concentration of OC, TN and P of dry aggregate and wet aggregate fractions differ substantially even though their diameters are same. Hence their loss during fertility erosion will have differing impacts on the residual soil.

KEYWORDS: Fallow, Cultivated, Aggregate, Fractions

INTRODUCTION

Crop production on a large scale is necessary in order to secure constant food supply for the teaming population of Nigeria. Most of this agricultural production however is done in the rural areas by the rural populace, currently growing rapidly, resulting to pressure on the available agricultural land. This has lead to decrease in soil fertility status as the lands are not allowed to regain their fertility through natural fallows. The nutrient elements classified as chemical properties required for good growth and healthy conditions for the crops are mostly sourced from the soil. Among these chemical properties Organic Carbon (OC), Nitrogen (N) and Phosphorous (P) are critical to the establishment, development, growth and productivity of crops. Soil is the reservoir of all these nutrients. Hence Lal (2003) and Verena *et al*; (2010) stated that soil is a significant long term reservoir of OC and play a significant role in the global C cycle.

But these nutrients are been affected by cultivation. Cultivation of which the essence is to break down soil to a fine form to provide an ideal situation for seed germination, causes gradual reduction in soil fertility and crop productivity, year to year. Every form of cultivation in agricultural land whether short term, long term, intensive or continuous cultivation have effect on soil chemical and physical properties as well as biological properties. Su *et al*; (2004) reported significant effect of short term cultivation on soil Carbon, Nitrogen and biological properties with lower basal soil respiration and enzyme activities than the native grassland soils. Lemenin (2004) on the order hand found out that long term cultivation decreased the OM and total N content of soils in highlands of Ethiopia.

Cultivation exposes organic matter (OM) to a greater rate of decay and oxidation (Young and Young, 2001) and therefore low total N content (Havlin *et al*; 2000). It alters soils physical, chemical and biological properties as well as crop yield (Grant and Lafond 1993). According to Chandran *et al*; (2009), increasing conversion of native lands to crop lands might reduce the capacity of soils to retain below ground C. Conversion of forest to cultivated site diminishes the soil carbon within a few years of initial conversion and substantially lowers N mineralization (Majaliwa *et al*; 2010).

While variability of soil P level was found to be related to land use, altitude, slope position, clay and calcium carbonate content such as change in vegetation cover (Forest), cultivation and grazing have significant effect on the dynamics of soil P and total N content of soils (Solomon *et al*; 2002; Bewket and Strossnijder, 2003; Lemenin and Itana, 2004). Solomon *et al*; (2002) attributed the losses of P in continuously cropped lands relative to forested lands to increase in mineralization of organic P and harvest of crop and animal products, while Craswell and Lefroy (2001) observed that the dynamics of soil carbon differ with soil type, mineralogy, climate and management.

In comparison of no-tillage with conventional tillage soils, Saffigna *et al*; (1989), Utomo *et al*; (1990), and Mahboubi *et al*; (1993), found higher content of P, K, Ca, N and C in no-tillage than conventional tillage soils. By examining the particle size fractions from cultivated and similar uncultivated Blaine lake silt loam soils, Tiessen and Stewart (1983) found out that inorganic P contents of coarse fraction increased during the first few years of cultivation, and that a shift of soil P composition towards inorganic P at the expense of organic P occurred in all size fractions with continuous cultivation. Mbagwu and Bazzoffi (1989) observed that there was no consistent pattern in the distribution of available P among aggregation and they were in no way associated with the particle size fractions.

High available P in macro-aggregate than in micro-aggregates was observed by Bhatnagar *et al*; (1985) and Bhatnagar and Miller (1985). Elliot (1986) observed that the C/P, N/P and C/N ratios of micro-aggregates were narrower than those of macro-aggregates in both cultivated and native soils. Kowalinski *et al*; (1982) found that exchangeable cat ions and total OC in dry aggregates of various sizes were fairly similar. Higher OC content reduces the magnitude of the gain in stability with time (Kemper *et al*; 1987). Increased organic C and N and decreased pH of surface soils are commonly noted under long-term no-tillage than in conventional tillage systems (Blevins *et al*; 1983, Dick, 1983). Tabatabai and Han way (1968) observed a decrease in OC with decreasing aggregate size, while Tamboli *et al*; (1964) and

Webber (1965) reported an inverse relationship between OC and aggregate size. However, the disparity might be due to C and N being associated with finer soil particles (Christensen, 1985; Christensen and Sorensen, 1985). Moreover, these aggregates may vary in their contents of the different particle size fractions (Mbagwu and Piccolo, 1990). Less C and N content was observed in tilled than untilled plots in all the aggregate size fractions (Mbagwu and Bazzoffi; 1989).

Many factors such as crop rotation (Janzen, 1987), type and length of tillage operations (Tiessen and Stewart, 1983; Dalad and Mayer, 1987; Bales dent *et al*; 1988; Cambardella and Elliot, 1992), and fertilizer application (Standford and Smith 1972; Christensen 1988) affect clearly the distribution of organic N and C among labile and stable soil OM pools. Blanco-Canqui and Lal, (2004) observed that the physical protection against decomposition conferred by the stable complexes (formed by organo-mineral complexes) is an important mechanism that contributes to the stability of soil OC. Soil organic carbon (SOC) associated with sand size aggregates and silt fraction is often more labile than SOC in the clay fraction (Zhao *et al*; 2006; Solomon *et al*; 2002).

The importance of micro-organism especially fungi, in the formulation of macro-aggregates was also observed (Molope *et al*; 1983; Gupta and Germida, 1988). Dormaar, (1983), Elliot (1986), Gupta and Gemida (1988) and Cambardella and Elliot (1993) reported the effect of cultivation on the microbial and nutrient characteristics of soils which were found to enrich the N and C contents of small macro-aggregate fractions (250-200mm).

Elliot (1986) therefore, summed it up when he said that the disintegration of macro-aggregates with cultivation into nutrient poor micro aggregates and the subsequent release of plant available nutrients may be one explanation for the observed pattern of reduced nutrient supplying efficiencies in cultivated soils when compared with grassland soils. The residence times of C in components of soil OM vary from a few minutes to hundreds of years (Buyanovsky *et al*; 1994).

Some models that adequately describe OC and N transformation in different soil types or under different managements have been developed based on the presumption that soil OM is represented by a changing continuum or by a number of compartments distinguished on the basis of acceptability of OC to micro-organism (Bosetta and Agren, 1985; Janssen 1984). Anderson and Paul (1984), Christensen, (1985,1986) and Wagner *et al*; (1994), however proposed that combining C labeling procedures with a non-degradative fractionation offers an acceptable approach for studying the distribution of C among aggregate fractions.

Studies have shown that agricultural cultivation has several impacts on soil nutrient concentrations which vary from one site to another after cultivation. The sign and magnitude of these changes, however with regard to carbon as reported by Baskin and Binkley (1998) and Van Noordwijk *et al*; (1997), varies with land use and management. Thus the implication of this study is that establishing the effect of land use changes on the concentration of C, N and P on the aggregate fractions of the soils will help to develop management strategies for sustainable use of the lands. Hence this study was undertaken to evaluate OC, N and P concentrations of aggregate fractions of four soils under different land use systems.

MATERIALS AND METHODS

Field Method

Soil samples from the 0-25cm depth were collected from cultivated and adjacent fallow lands in four different locations in Nsukka area of south eastern Nigeria. Care was taken to minimize disturbance during sampling and transportation. The area has a rainforest savannah type of vegetation with a mean annual temperature of 24^{oc}. The area lies within latitude 06^{0} 61^{1}N and longitude 07^{0} 25^{1}E of Nigeria. Eha-Amufu and Ikem locations from which soil samples were collected are hydromorphic type. It cracks when dry becomes sticky when wet, presenting problems to tillage operations. The soil samples for the study were classified according to soil taxonomy as an Ultisol, belonging to the sub-group, Typic Kandiustult (Nkpologu series), Entisol belonging to Lithic Ustorthent (Uvuru series), while the other two soils belong to Vertic Inceptisol (SSS, 1992). These soils have been under cultivation for over or about 8years while fallow soils varied from 3 to 4years old.

Table 1: Location, Classification and Land Use Type

Location	Classification	Treatment Symbol	Land Use Type
Nsukka Hill Site	Lithic Ustorthent	ENsk (F)	Fallow
	(Uvuru Series)	ENsk (C)	Cultivated
Nsukka Poultry Site	Typic Kandiustult	UNsk (F)	Fallow
	(Nkpologu series)	UNsk (C)	Cultivated
Eha-Amufu Site	Inceptisol	IEh (F)	Fallow
	(With vertic properties)	IEh (C)	Cultivated
Ikem site	Inceptisol	Iik (F)	Fallow
	(With vertic properties)	Iik (C)	Cultivated

Laboratory Method

The soil samples were air-dried at room temperature and then sieved through a 5.00 mm sieve. Clods were carefully crushed by hand along lines of natural cleavages to pass the sieve. Two hundred and fifty grammes (250g) of the sieved sample, at a time, were transferred to the upper most of a nest sieve of sizes 2, 1, 0.5 and 0.25mm. They were shaken mechanically for 10minutes. Further sieving by hand was done where necessary. This procedure, similar to that described by Kemper and Chepil (1965), resulted in the separation of the following aggregate fractions 5-2, 2-1, 1-0.5, 0.5-0.25 and < 0.25mm. The separation continued until enough quantity of each fraction was collected for further analysis.

DETERMINATION OF ORGANIC CARBON

Walkley and Black method (1934) as modified by Allison (1965) was used to determine OC. The procedure involved the oxidation of the soil OM with potassium dichromate (K_2 Cr_2O_7) using concentrated sulphuric acid (H_2SO_4) and the percentage OC found by titrating with IN ferrous ammonium sulphate solution.

Available Phosphorous: This was determined by Bray and Kurtz (1934), Bray 11 method (0.03N ammonium Fluoride 0.1N HCL). The available phosphorous was read off from standard curve after obtaining the optical density from a photo-electric colorimeter.

Total Nitrogen: The Kjeldahl method of Bremner (1965) using $CuSO_4$-Na, SO_4 catalyst mixture was used to determine total nitrogen. The ammonia (NH_3) from the digestion was distilled with 45% Na0H into 2.5% Boric acid and determined by titrating with 0.05N HCl.

Data Analysis: Little and Hills (1972), Statistical methods in Agricultural research was used to analyze the data obtained from the study. The mean of the OC, N and P values obtained from dry and wet sieving procedures of each aggregate size was cartographed to show the distribution and concentration of OC, N and P of each soil type.

RESULTS AND DISCUSSIONS

Organic Carbon (OC) Concentration

The OC distribution within the aggregate fractions of both dry and wet-sieved samples of the four soils are given Figure 1. The result of the ENsk showed that the lowest concentration of OC for the dry samples, occurred in the 2-1mm fractions of both the fallow and cultivated soils. The result might be due to decreasing aggregate size, as Tabatabai and Hanway (1968) reported a decrease in OC with decreasing aggregate size.

The percentage decrease relative to < 0.25mm aggregate size was 35.0% for the fallow soil and 23.7% for the cultivated soil. The wet-sieved samples showed that the lowest OC concentration occurred in the 5-2mm fractions for the fallow soil, the result could be due to loss of organic material binding agents by wet-sieving process. Also the lowest OC observed in < 0.25mm in cultivated soil could be attributed either to the length of cultivation, mineralogy or management system adopted on the soil.

Type and length of Tillage operations (Cambardella and Elliot, 1992; Balesdent et al. 1988), mineralogy and management system (Craswell and Leprosy 2001), clearly affect the dynamics of soil carbon. The concentration of OC was higher for the fallow than for the cultivated soils for all the size classes in dry sieved samples. Similar result was reported by Elliot (1986), who observed that the concentration of OC, N and P were almost always higher for the native sod than for the cultivated soils for size classes > 0.09mm. A contrary observation in wet-sieved samples could be due to loss of some of the OC in water solution through the disintegration of organic material binding agents by wet-sieving samples process.

The concentration of OC in the dry-sieved samples of the UNsk was similar to that of the ENsk, indicating higher concentration in fallow than cultivated soils. The lowest concentration in the fallow soil occurred in the 1-0.5mm and < 0.25mm aggregate sizes, respectively. The highest concentration of OC in cultivated soil occurred in the 5-2mm aggregate size and decreased with decreasing aggregate size, but there was no change in the OC concentration of 2-1mm, 1-0.5mm and 0.5-0.25mm aggregate sizes.

Kowalinski et al. (1982) observed that exchangeable cat ions and total OC in dry aggregates of various sizes were fairly similar. The result of wet-sieved samples showed that initially, the OC concentration in the 2-1mm aggregate sizes was high, but decreased in the 1-0.5mm aggregate size for the two land use types. The percentage decrease relative to the 2-1mm aggregate size was 50% for the fallow soil and 25% for the cultivated soil.

For the IEh the concentration of OC was observed to be higher in fallow than cultivated soils for both dry and wet-sieved samples. The dry-sieved fallow soil showed the highest OC concentration in the 0.5-0.25mm fraction with a value of 2.95%. The cultivated soil showed a similar result in the 0.5-0.25mm fraction but with a less value of 1.84% compared to the fallow soil.

The wet-sieved samples for the forested soil showed that cultivation had no effect in the concentrations of 2-1mm and 1-0.5mm fractions. Apart from this, the OC increased with the decreasing aggregate sizes. This result is similar to the one obtained by Tamboli *et al*. (1964) and Webber (1965) who reported increase in OC concentration with decreasing aggregate sizes.

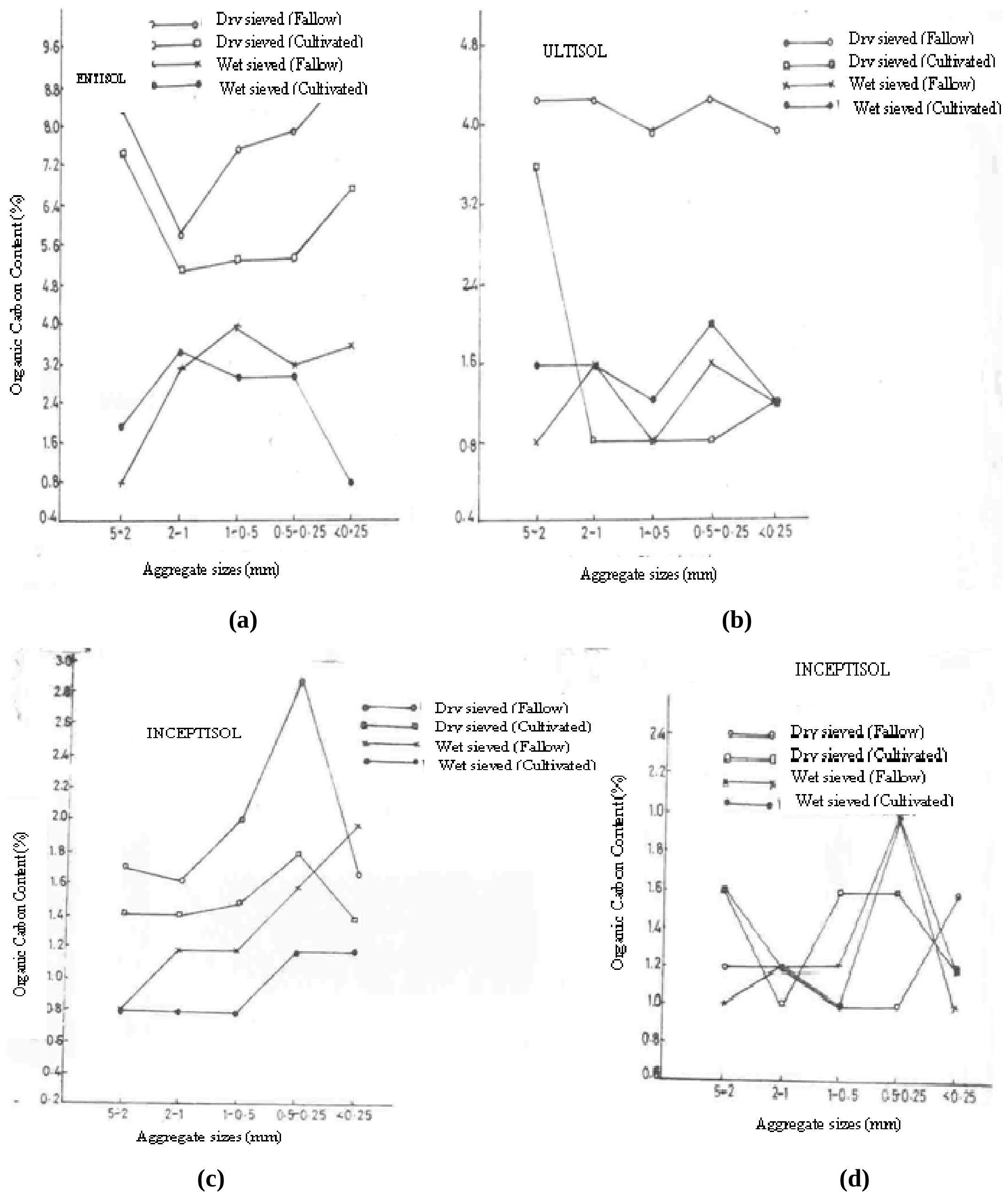

Figure 1: Distribution of Organic Carbon in Aggregate Fractions (Dry and Wet Sieved) of the Fallow and Cultivated Soils for the Four Soils Studied as Influenced by Different Land Uses. (a) Entisol at Nsukka Hill Site (b) Ultisol at Nsukka Poultry Site (c) Inceptisol at Eha-Amufu Site (d) Inceptisol at Ikem Site

The OC concentration in the dry-sieved Iik showed that there was no particular change in that of the 1-0.5mm and 0.05-0.25mm aggregate sizes for the fallow and cultivated soils. For the 2-1mm aggregate fraction of the fallow soil, there was a decrease of 33.3% in the OC concentration relative to 1-0.5mm aggregate fraction, while there was a 50% decrease in 2-1mm aggregate size relative to the 5-2mm aggregate fraction in the cultivated soil. The result of the wet-sieved samples showed that cultivation had no effect on the OC concentrations of the 2-1mm and 1-0.5mm sizes, while the lowest value occurred in the 5-2mm and < 0.25mm aggregate fractions respectively for the fallow soil.

The OC in the 0.5-0.25mm aggregate fraction was high, but decreased in the <0.25mm aggregates size for the two land use types. The percentage decrease relative to the 0.5-0.25mm aggregate size was 60% in the fallow and 40% in the cultivated soils. The trend of OC concentration among all the soils was ENsk > UNsk > IEh > Iik (Figure 1). Generally, the aggregate fractions of the dry-sieved samples of the fallow soils showed higher OC concentration than those of the cultivated soils. This agrees with the result of Elliot (1986). Also Mahboubi *et al*. (1993) and Utomo *et al*. (1990) reported similar result in no-tillage than conventional tillage soils and FallahZade and Hajabbasi (2011) in untilled than the tilled soils. The reduced concentration observed in the cultivated soils may have been due to a reduction in the amount of OM returned to the soil and more rapid OM decomposition in the cultivated soils (Dalal and Mayer, 1986; Young and young 2001).

The protective effect of clay on OM is well known (Sorensen, 1981, Zhao et al. 2006; Blanco-Canqui and Lal, 2004); this could be the reason why some aggregate sizes of cultivated soils showed higher OC concentration compared to the fallow soils. For it is known that Montmonillonitic clays can protect OM substances better than Illitic clays (Morlland, 1970) it might also be that through the processes of wet-sieving the soils, some of these OM binding agents dissolved and moved out with water solution. These reasons might equally be behind the higher concentrations observed in the dry sieved samples compared to the wet-sieved ones among the four soils.

The concentration of OC in the four soils was also observed to be varied with site and cultivation history. Similar observation was made by Mbagwu and Piccolo (1998) on wet-sieved soil samples from Southern Nigeria. The general reduction in the OC concentration of cultivated soils relative to the forested ones is an indication that cultivation reduced the OC of these soils. Similar result was reported by Mbagwu and Bazzoffi (1989), when they observed that soils of the tilled plots contained less OC than those of the untilled plots in all the aggregate size fractions.

There was an increase in OC as the aggregate sizes decrease when considered on the average. This is however contrary to the observations made by Metzer and Hides (1938 and Tabatabai and Hanway (1968), who reported a decrease in OC with decreasing aggregate size. Christensen and Sorensen (1985) and Christensen (1985) observed that C and N were associated with the fine soil particles. Also these particles may vary among different aggregate fractions (Mbagwu and Piccolo, 1990).

The OC in dry-sieved aggregates of various sizes were not similar, contrary to the observations of Kowaliski et al. (1982). The macro-aggregates (> 250mm had greater OC concentration than did the micro-aggregates (< 250mm). Buyanovsky et al. (1994) reported that most of the OC associated with aggregates are found in macro-aggregates which comprised about 80% of the total aggregated soil material.

Total Nitrogen (TN) Concentration

The total N concentration in the aggregate fractions of all the soils for dry and wet-sieved samples of the fallow and cultivated soils are shown in Figure 2. From these results, ENsk fallow soil had the highest total N concentrations in all the dry sieved fractions, compared with those of similar fractions in the UNsk, IEh and Iik. This probably may be due to the fact that Entisols are somehow less weathered than the Ultisols and Inceptisols (Foth, 1951).

The total N in the ENsk cultivated soil showed a similar trend as that of the fallow soil in all the dry-sieved aggregate fractions. The result could be attributed to the amount of OM concentration in the fallow and cultivated aggregate sizes of the ENsk. This may have contributed to the high total N observed in their fractions.

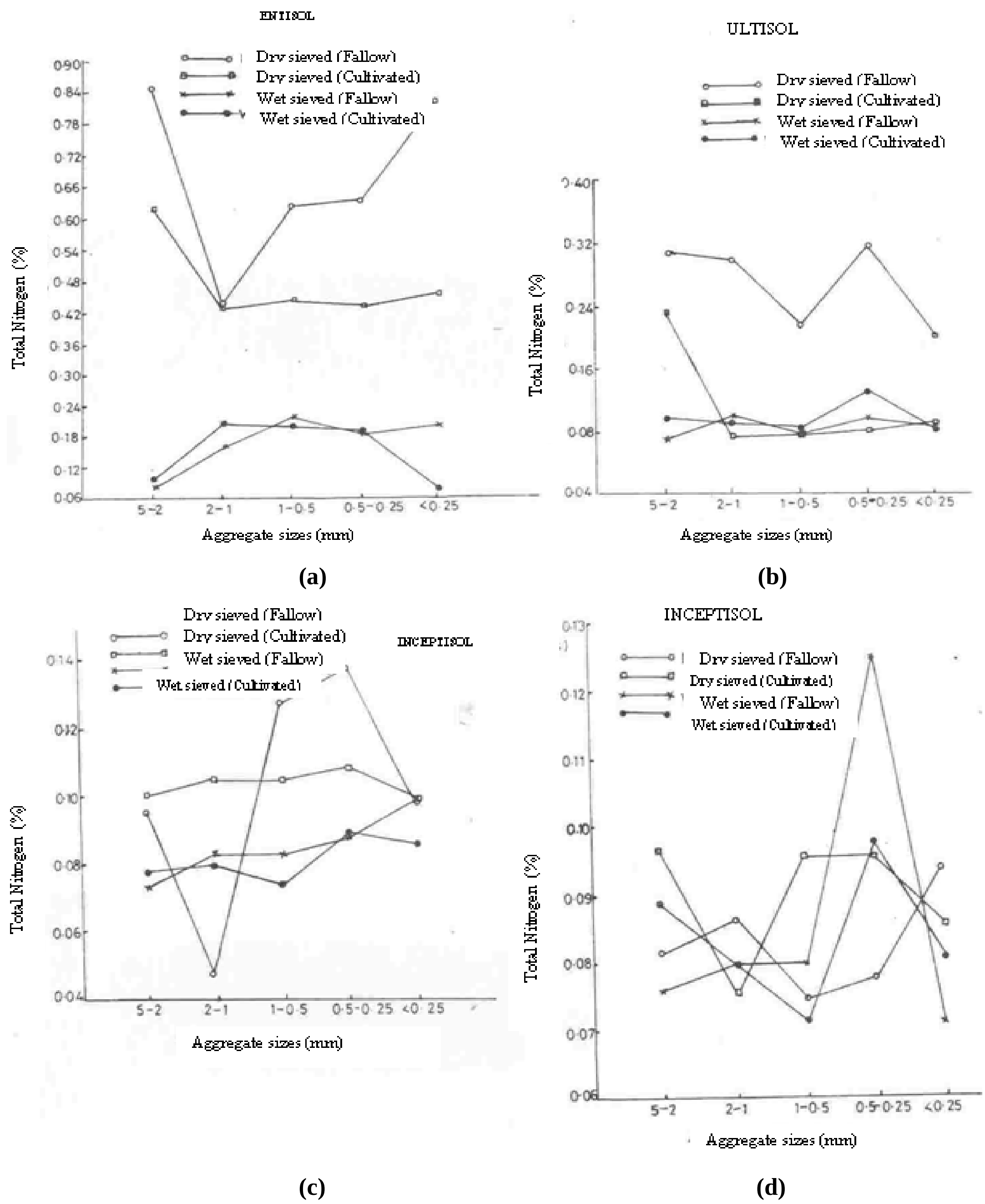

Figure 2: Distribution of Total Nitrogen in Aggregate Fractions (Dry and Wet Sieved) of the Fallow and Cultivated Soils for the Four Soils Studied as Influenced by Different Land Uses. (a) Entisol at Nsukka Hill Site (b) Ultisol at Nsukka Poultry Site (c) Inceptisol at Eha-Amufu Site (d) Inceptisol at Ikem Site

The total N concentration of the dry sieved samples increased as the aggregate sizes decreased. Percentage decreases of 48.6% and 32.0% for fallow and cultivated soils respectively, relative to the 5-2mm aggregate size. For wet sieved samples, there was no consistence in the percentage decrease of the total N. In the UNsk fallow soil the total N concentration in the dry-sieved samples increased up to the 2-1mm aggregate size than decreased and later increased. The percentage decrease was 29.4% relative to 2-1mm aggregate Fractions. The total N concentration decreased initially, but later increased progressively as the aggregate sizes decreased (Figure 2). The total N of the wet-sieved samples showed the same trend as the dry-sieved samples. The lowest concentration of total N in the fallow soil occurred in the 5-2mm fraction, while in the cultivated soil it occurred in the < 0.25mm fraction. The result might be due to the chemical characteristics of the soil as this modifies the rate of organic matter decomposition and release of N or due to decline in organic matter content in the aggregate fractions. The total N obtained in UNsk in both its dry and wet-sieved fallow and cultivated soils was relatively less in comparison to what was obtained in ENsk.

This might be associated to low biomass production and fast oxidation of organic matter more in UNsk than ENsk soils. Havlin et al; (2002) reported strong positive relationship between soil nitrogen and soil organic matter content. It can also be explained on the basis of differences in their soil humus content held by clay particles in organic mineral complexes that protect the humus from decomposition. Muller and Hope, (2004), observed that as much as 50% of the soil humus is held by clay particles in organo-mineral complexes and is there by protected from rapid decomposition. The result also could be explained on the basis of few weather able minerals that exist in the soil or due to low OM concentration (Lepsch and Buol, 1974).

For the IEh, the highest concentration of total N was obtained in the 0.5-0.25mm fraction in the 0.5-0.25mm fraction in the dry sieved samples of the fallow soils. In the cultivated soils, the total N increases progressively up to the 0.5-0.25mm fraction and then decreased. That is, it increased with a decrease in aggregate size.

The result probably may be due to clay content in the smaller aggregate sizes, as Verdade (1999) observed that clayey soils have double N content of sandy soils. For the wet-sieved samples, there was a progressive increase in the total N of a fallow soil as the aggregates sizes decreased. In cultivated soil the highest concentration of total N was recorded in the 0.5-0.25mm fraction.

The lowest concentration of total N in the dry sieved fallow samples of the Iik (Figure 2) was obtained in 1-0.5mm size, while there were no significant change in the concentration of N in the cultivated soil in the aggregate sizes, 1-0.5mm and 0.5-0.25mm. The total N concentration in the wet-sieved, fallow soil sample increased up to the 0.5-0.25mm fraction, and then decreased. The percentage decrease of total N in cultivated soil in the < 0.25mm fraction was 17.3% relative to the 0.5-0.25mm aggregate size. The total N obtained in the two inceptisols in both dry and wet-sieved samples of fallow and cultivated soils was low compared to the ones obtained from ENsk and UNsk.

This is most probably due to their low OC concentration (Figure 1). The inhibition of aerobic micro-organism activities in these two soils, due to their hydromorphic nature might have contributed to the low total N observed in the two soils. This is because, if the microbial biomass in a soil is increased, they enhance the release of N to the soil through their easily decomposable compounds (Gupta and Germida, 1988).

The result of the total N concentration obtained in the aggregate sizes of the four soils showed that the values of fallow soils were higher than those of the cultivated soils in both the dry and wet-sieved samples. This could be attributed to the fact that the fallow enhances abundant plant residues in the surface layer of the soil which are not incorporated by ploughing (Doran 1987; Dala *et al*; 1991), thereby increasing microbial biomass by enhancing the easily decomposable C and N compounds (Gupta and Germida, 1988). The difference in the result might also be due to the decline in OC concentration of the cultivated soil as a result of decrease in amount of organic materials returned to the soil (Dala and Mayer, 1986). The similar result above was observed by Saffigna *et al*; (1989), Utomo *et al*; (1990) and Mahboubi *et al*; (1993), who reported higher concentrations of N, OC, P, K and Ca in the no-tillage than conventional tillage soils. The result also agrees with the work of Adamu (1996) and Mbagwu and Piccolo (1998) who reported higher concentrations of total N in forested than cultivated soils in Nigeria. A more clear difference was shown in the dry than wet-sieved samples. This is probably due to the presence of considerable discrete mineral particles freed from clumps during the wet-sieving process (Solomon, 1962), that might have influenced the total N concentration obtained in the wet-sieved samples. The result showed that micro-aggregates were enriched with the total N in both dry and wet-sieved samples. This however, agrees with the findings of Christensen and Sorensen (1985) and Christensen (1985). This was as a result of the fact that the amount of N mineralized was always greater for macro-aggregates than micro-aggregates (Elliot, 1986; Gupta and Germida, 1988). Furthermore, Beare *et al*; (1994b) observed that the distribution of total aggregate associated N and OC was considerably different in no-tillage than in conventional tillage.

Available Phosphorous Concentration

The available P concentration in the aggregates of the four soils is given in Figure 3. The ENsk showed that in dry-sieved samples of fallow soil available P increased in 5-2mm, but decreased in 2-1mm fraction, then another progressive increase up to the 0.5-0.25mm followed by a decrease in < 0.25mm fraction. In the cultivated soil, there was no change in the available P concentration of 5-2mm and 1-0.5mm fraction.

For the wet-sieved samples, the available P concentration initially increased in the 5-2mm fraction and decreased in 2-1mm fraction, then increased progressively up to the < 0.25mm for the fallow soil. In the cultivated soil, the available P concentration increased up to the 0.5-0.25mm fraction and then decreased. It was found that the available P in the wet-sieved samples was higher than those of the dry sieved samples for both the fallow and cultivated soil. This result could be due to the mineral particles of the soil which differ in their susceptibility to attack during weathering (Fair bridge and Finkl, 1962).

The higher values of available P obtained in ENsk comparable to the other three soils could also be attributed to the above reason. The high concentrations of available P observed in the cultivated soil compared to the fallow soil for both dry- and wet-sieved samples could be attributed to the clay and silt contents of the soils. This is because the quantity and type of clay have effect on decomposition and clay absorbs many organic nutrients or substrates which are then unavailable (Fair bridge and Finkl, 1962).

The result of available P for the dry-sieved samples of UNsk in Figure 3 showed that cultivation decreased the available P of the 5-2mm fraction by 16%, but increased those of 0.5-0.25mm and < 0.25mm fractions by 7.1% and 23.1%, respectively relative to the fallow soil. The result of the wet-sieved samples showed that cultivation had little or no effect on the available P concentration of 2-1mm, 1-0.5mm and < 0.25mm fractions of the fallow soil, but decreased that of the 0.5-0.25mm fraction by 14.3%. Cultivation had no effect on the available P concentration of 2-1mm, 1-0.5mm and 0.5-0.25mm aggregate sizes of the cultivated soil, although it increased the P concentration of the < 0.25mm fraction. The variation of available P observed in UNsk could be attributed to the mineralogical composition of the soil.

The Ultisols are characterized by the presence of Kaolinite clay mineral, due to their ultimate in weathering and leaching as well as extreme infertility (Jackson and Sherman, 1953). This could have contributed to the available P obtained from the aggregate sizes of the soils. The result of available P obtained was not in any way associated or closely related to the OC concentration of the aggregate sizes (Figure 1). That is the available P of the aggregate sizes does not increase or decrease with increasing or decreasing values of OC. Therefore, the OC concentration did not contribute to the variation in the available P of this soil.

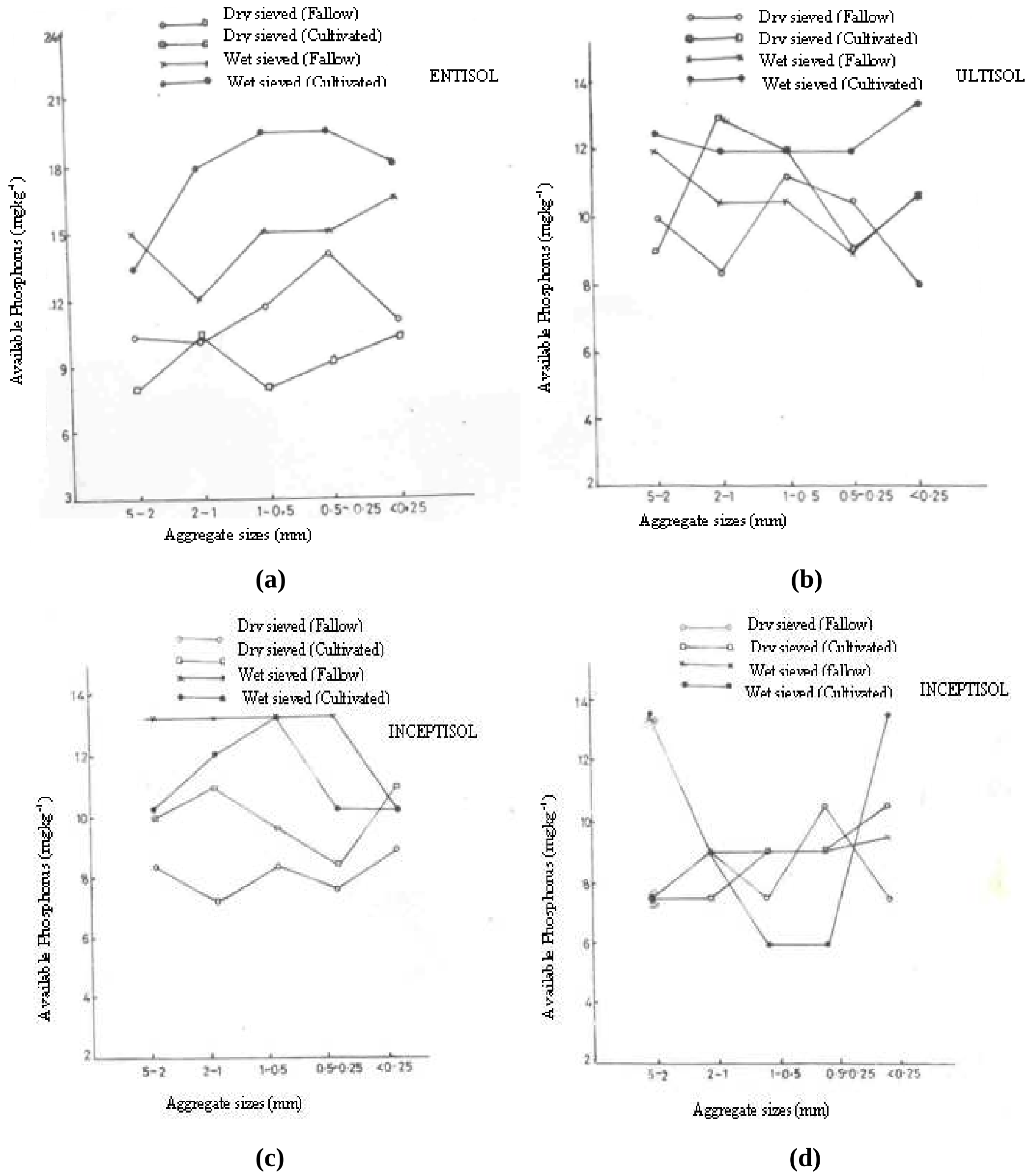

Figure 3: Distribution of Available Phosphorous in Aggregate Fractions (Dry and Wet Sieved) of the Fallow and Cultivated Soils for the Four Soils Studied as Influenced by Different Land Uses. (a) Entisol at Nsukka Hill Site (b) Ultisol at Nsukka Poultry Site (c) Inceptisol at Eha-Amufu Site (d) Inceptisol at Iced Site

For the IEh, the values of available P in Figure 3 showed that cultivation increased the concentration of the available P in all the aggregates of the dry-sieved samples relative to the fallow soil. This could be due to immobilization of the available P by the soil microbes very active in the fallow soil as well as the higher plants (Clark 1957). This might have contributed to the available P obtained in the dry-sieved samples of IEh. For wet-sieved sample, cultivation had no effect on virtually all the aggregates of the fallow soil. Cultivation increased the available P concentration up to 1-0.5mm fraction, but had no effect on the P concentration of 0.5-0.25mm and < 0.25mm aggregate sizes.

In the Iik there was a high concentration of available P in 0.5-0.25mm fraction of the dry-sieved samples of the fallow soil, while cultivation had little or no effect on virtually all the aggregates of the cultivated soil. For the wet-sieved samples, cultivation had no effect on the available P concentration in 5-2mm and 2-1mm aggregates of the fallow and cultivated soils. The available P obtained in the aggregate sizes of both dry and wet-sieved samples of this soil showed no direct or inverse relationship to OC concentration in the aggregate fractions of the soils. This means that the concentration of OM to the variation of available P is very insignificant in this soil. Also as available P is subject to leaching losses, this may have contributed to the result obtained in this soil. Tiessen and Stewart (1983) also observed that cultivation lowered the organically held nutrients such as N and P. The available P distributions in the four soils presented in Figure 3 showed that they did not fallow any particular trend, an observation also made by Mbagwu and Bazzoffi (1989). There was higher available P in the larger aggregates than the smaller aggregates. Similar results were reported by Bhatnagar *et al*; (1985) and Bhatnager and Miller (1985). The non-uniform distribution of available P among aggregates, which could be a random process or dictated by preferential sorption of P by specific aggregate fractions on specific surface areas, proposed by Bhatnagar *et al*; (1985), as the determinant mechanisms to account for the distribution of P within soil aggregates, may be the possible mechanism to explain the P distribution in the different aggregates here. Furthermore, Mbagwu and Piccolo (1990), observed that the P distribution in aggregates of organic waste amended soils was not uniform within the aggregates irrespective of the type of waste material added. They attributed this to a random process that occurred at the time of manure addition, a possibility suggested by Bhatnagar *et al;* (1985). Nonetheless, Lal (1986); Saffigna *et al;* (1989), Utomo *et al;* (1990) and Mahboubi *et al*; (1993) found higher concentrations of P, N, OC, Ca and K in the no-tillage than conventional tillage soils.

CONCLUSIONS

From the result of this study it was found out that the concentration of OC in the dry sieved samples was higher than that of the wet-sieved samples. The evidence of total N reduction as a result of cultivation was more clearly shown in dry-sieved than the wet-sieved samples. The aggregate fractions of both dry- and wet-sieved samples differed in their available P concentration which did not follow any particular pattern. The result obtained is evidence that land use changes such as cultivation diminishes rapidly the quality of a soil and soil quality attributes. Therefore, appropriate conservation practices within different land use system should be employed to maximize the productivity of soil without undue risk.

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