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Effects of Selected Land Use on Soil Reaction and Heavy Metal Concentration in an Ultisol in Umudike, Abia State – Southeast Nigeria

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Abstract
Effects of some land use types on soil reaction and heavy metal concentration in Umudike, Abia State Southeast Nigeria were evaluated. Soil samples were collected from two soil depths of 0-10cm and 10-20cm from oil palm plot(OP), unfertilized cassava plot(UC), bush Fallowed plot(BF), alley cropping with multipurpose trees(AC), Natural Forest(NF), with different histories and similar characteristics. After the data analysis, the results revealed that generally soil pH were acidic. At 0-10cm depth, oil palm(OP) gave significantly the highest pH values in the following order: OP > UC = BF = AC = NF, 10-20cm depth followed same trend. Natural Forest (NF) gave significantly the highest exchangeable acidity more than other land use types in the following order: NF > UC = BF = AC > OP. The results of concentration on the studied heavy metal showed that at 0-10cm and 10-20cm soil depths, oil palm plot gave the highest values of Cu and Mn, alley cropped plot gave the highest value of Pb, bush fallowed plot gave the highest value of Zn. There was no significant difference in Pb concentration among the various land use types at 0-10cm soil depth. Heavy metal concentrations fell within WHO permissible limits.

Keywords: Heavy metal, Land use, reaction, Southeast, ultisol, umudike.

1. Introduction

Land is an integral part of our physical environment. It has always been part of the evolution of human society. Changes occur on land due to changes in the activities of man, hence the need to appraise the value of land resources is necessary. Land use change is an important factor that controls soil organic matter storage since it affects the quality and quantity of litter inputs, the decomposition rate and its stabilization (shepherd et al; 2001). Studies have shown that land use change is presently the most important aspect of environmental change in the tropics and probably will continue to dominate for at least the next generation (Lal et al; 2002b, McGrath et al; 2001).The conversion of forest to agricultural land uses has been on the increase across the tropics as a result of global population growth that creates ever increasing demands on food resources. This conversion of forest to agricultural land according to FAO (1997) shows that about 200 million hectares of forest were affected between 1980 and 1995. Clearing of primary forest for agriculture leads to unsustainable land use characterized by declining soil fertility and early abandonment of the area (Schrot *et al*; 2000). With continuous cultivation, physical properties and productivity of soil decline due to decrease in organic matter content (Oguike and Mbagwu, 2009). Bush fallowing has been proved to be an important method of restoring the physical, chemical and biological properties of soil (Juo et al; 1995). Appropriate land use systems are those ones that minimize degradation in soil properties, maintain ecosystem stability, reduce emission of greenhouse gases (GHG's) into the atmosphere (Opara-Nadi; 1990, Lal *et al*; 2002a). The understanding of dynamics of soil nutrients in tropical soils under different land uses including their chemical and physical properties is very important in addressing questions like the fragility of tropical soils and their sustainability for crop production.Hence,the major objective of this study was to evaluate the effects of different land use types on soil reaction and heavy metal concentration in Umudike,Southeast-Nigeria

2. Materials and Methods

The study was conducted in three different areas; Abia State University Teaching and Research Farm, Michael Okpara University of Agriculture and National Root crops Research Institute. The study area lies within latitude $5^{0}25^{1}$ N and Longitude $7^{0}35^{1}$E . Umudike; the study area lies at a mean elevation of 122 metres above sea level. The rainfall pattern of the area is bimodal (April-July and September-November) with short spell in August. The total mean annual rainfall during the period of study was 2000mm. The annual mean temperature recorded was in the range of 30-40^{0}C which occurred between November and March and the relative humidity was between 80-90%. The soil was characterized by inherent constraints such as low organic matter, low clay activity, susceptible to soil erosion and poor structural stability. The soil is classified as an ultisol according to USDA and as acrisol according to FAO/UNESCO classification scheme as summarized by Opara-Nadi (2000).

2.1 Experimental Layout

The study area was cleared of existing vegetation manually using cutlass, Debris were removed. Two representatives of soil sample were collected from each land use type , samples were collected from 0-10cm and 10-20cm soil depths, using soil auger attached to a core sampler according to IITA 1975 method of free soil sampling.

2.2 Soil Sampling and Laboratory Analysis

Soil samples were randomly collected from 0-10cm and 10-20cm depths on each of the land use system. The soil samples from each study area was bagged and marked. The samples were ground to pass through a 2mm sieve for determination of some soil reaction (soil pH in water and KCl), 20g measured in 1:1 soil/solution was used for soil pH determination using pH meter, 5g was used for determination of Exchangeable acidity; 50ml of KCl was used to extract the soil samples; out of which 20ml was used in titration against 0.05N of NaOH. The concentrations of the selected heavy metals were determined using Atomic absorption spectrophotometer as described by APHA (1998) using HACH/D2/2010 spectrophotometer after digestion.

2.3 Data Analysis

Data collected were subjected to a standard statistical Analysis of variance (ANOVA) based on the procedure outlined by Gomez and Gomez (1984). Separation of treatment means for significant effect was done by the use of Fishers Least Significant Difference (F-LSD) at a probability level of 0.05.

3. Results and Discussion

The effects of land use types on soil pH, Exchangeable acidity and some heavy metal concentration at various soil depths is presented in Tables 1 and 2

Table 1: Effect Of Land Use Types On Soil pH, Exchangeable Acidity And Heavy Metal Concentration At 0-10cm.

Treatment	pH_{KCl}	pH_W	EA ($Cmol.\ kg^{-1}$)	Mn	Cu	Pb	Zn
				← ($mg.Kg^{-1}$) →			
NF	3.6^{a}	4.1^{a}	4.10^{a}	6.32^{a}	12.98^{a}	59.30^{a}	54.78^{a}
BF	3.9^{b}	4.5^{b}	2.05^{b}	5.40^{a}	7.98^{b}	79.71^{b}	38.74^{a}
AC	3.7^{c}	4.5^{b}	1.99^{a}	12.80^{b}	43.92^{c}	54.23^{c}	50.03^{a}
OP	4.7^{d}	5.5^{c}	0.03^{d}	13.92^{b}	7.36^{b}	67.42^{d}	120.22^{b}
UC	3.9^{e}	4.6^{d}	2.36^{e}	11.65^{b}	8.14^{b}	32.60^{e}	64.60^{a}
WHO Permissible Limit	6.5-8.5	6.5-8.5	NA	100	100	300	2000
FLSD (P=0.05)	0.12	0.15	1.55	5.43	37.03	16.90	18.01

Note : NF = Natural forest, BF =Bush fallow, AC =Alley cropped, OP =Oil palm, UC=Unfertilised cassava NA=Not available

❖ Treatment means with similar superscripts are not statistically similar

3.1 Soil Reaction- $pH_{(kcl)}$

There were significant differences in the soil $pH_{(KCl)}$ at 0-10cm soil depth when the different land use types were compared with one another. There were 0.30, 0.10, 1.10 and 0.30 units of pH more in the bush fallow plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with the Natural forest. Also, alley cropped plot had 0.20 units of pH more than bush fallowed plot but there was no significant difference when bush fallowed plot was compared with unfertilized cassava plot in ten pH $_{(KCl)}$ values. Oil palm plot had 10 units of $pH_{(KCl)}$ more than the alley cropped plot. There was 0.80 units more of pH when oil palm plot was compared with bush fallowed pot. There was a significant difference when alley cropped plot and oil palm plot were compared with bush Fallowed plot but not significant when compared with unfertilized cassava plot. Significant differences were observed when oil palm plot and unfertilized cassava plot were compared with alley cropped plot with 10 and 0.20 units of pH values. There was no significant difference when alley cropped plot was compared with natural forest. The results showed that the pH $_{(KCl)}$ values obtained from NF (3.6), BF (3.9), AC (3.7), and UC

(3.9) plots were extremely acidic when compared with OP (4.7) plot that showed very strong acidity.

3.2 pH (H_2O)

There were significant differences among the various land use types at a soil depth of 0-10cm when compared with one another. There were 0.40, 0.40, 1.40 and 0.50 units of PH more in Bush fallowed plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with natural forest. Unfertilised cassava plot revealed significantly 0.90 units more than oil palm plot but there was no significant difference when unfertilized cassava plot was compared with alley cropped plot. The results showed that the pH values obtained from NF (4.1), BF (4.5), AC (4.5), and UC (4.6) plots were very strong in acidic content when compared with OP (5.5) plot that is less strong in acidic content.

Generally, the soil of the selected land use were found to be acidic. This acidic nature may have been as a result of the effect of the parent material (strongly leached, low fertility, quartz rich) and not the effect of the land use. The results of this study confirm with the studies of (Opara-Nadi *et al;* 2010) that the acidic nature was more a reflection of the parent material.

3.3 Exchangeable Acidity (EA)

Significant differences were recorded at 0-10cm soil depth among the various land use types when compared with one another. There were 2.05, 2.11, 4.07 and 1.74 units of EA more in bush fallowed plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with natural Forest. Oil palm plot revealed significantly 2.02 units more of EA when compared with bush fallowed plot but there were no significant difference when unfertilized cassava plot and alley cropped plot were compared with bush fallowed plot. There was significant difference when oil palm plot was compared with alley cropped plot. Unfertilized cassava plot revealed significantly 2.33 units more of EA when compared with oil palm plot.

3.4 Heavy metals (Cu, Pb, Zn, Mn)

3.4.1 copper(Cu)

Significant differences were observed in various land use types when compared with one another. There were 0.92, 6.48, 7.60 and 5.33 units more of Cu in bush fallowed plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with natural forest. There were significant differences when alley cropped plot and oil palm plot were compared with natural forest but there was no significant difference when unfertilized cassava plot and bush fallow were compared with natural forest. There were 7.40, 8.82, 6.25 units of Cu more that were significantly different when alley cropped plot, oil palm and unfertilized cassava plots were compared with bush fallowed plot. On the whole, the concentration of Cu in different land uses fell within the WHO limits for copper concentration in the soil.

3.4.2 Lead(Pb)

There were no significant difference in the Pb concentration at 0-10cm soil depth when the different land use types were compared with one another. However, 5, 5.62, 4.84 units of Pb concentration were more in Bush fallowed plot, oil palm plot and unfertilized cassava plot when compared with Natural forest. On the whole, the concentration of Pb in different land uses fell within the WHO limits for Lead concentration in the soil.

3.4.3 Zinc(Zn)

There were significant differences in the Zn concentration when the different land use types were compared with one another. There were 20.41, 5.07, 8.12 and 26.70 units of Zn more in bush fallowed plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with natural forest. Alley cropped plot and oil palm plot were not significantly different when compared with natural forest. Alley cropped and unfertilized cassava plots had 25.48, 47.11 units of Zn concentration more than the bush fallowed plot but there was no significant difference when oil palm plot was compared with bush fallowed plot. Unfertilized cassava plot revealed significantly 21.63 units more than alley cropped plot but there was no significant differences when oil palm plot was compared with alley cropped plot. There was 38.82 units more of Zn concentration when unfertilized cassava plot was compared with oil palm plot. On the whole, the concentration of Zn in different land uses fell within the WHO limits for Zinc concentration in the soil.

3.4.4 Manganese(Mn)

Oil palm plot showed significantly 65.44 units more when compared with natural forest. Significant differences were observed when oil palm plot and unfertilized cassava plot were compared with bush fallowed plot but there was no significant difference in Mn concentration when alley cropped plot was compared with bush fallowed plot. There was a significant difference when oil palm plot was compared with alley cropped plot but there was no significant difference when unfertilized cassava plot was compared with alley cropped plot. There was 55.62 units of Mn concentration more that significantly differed when unfertilized cassava plot was compared with oil palm plot. On the whole, the concentration of Mn in different land uses fell within the WHO limits for Manganese concentration in the soil.

Table 2: Effect Of Land Use Types On Soil pH, Exchangeable Acidity And Heavy Metal Concentration At 10-20cm.

Treatment	**pH_{KCl}**	**pH_W**	**EA (Cmol. kg^{-1})**	**Cu Mn**	**Pb**		**Zn**
				← (mg. Kg^{-1}) →			
NF	3.7[a]	4.1[a]	4.87[a]	6.92[a]	16.17[a]	57.27[a]	47.03[a]
BF	3.9[a]	4.5[a]	2.29[b]	7.50[a]	8.00[b]	79.60[b]	32.14[b]
AC	3.7[a]	4.4[b]	2.91[b]	14.00[b]	13.63[c]	53.45[a]	40.17[a]
OP	4.7[b]	5.5[b]	0.12[c]	19.20[b]	7.39[d]	64.23[a]	123.22[e]
UC	3.8[a]	4.5[a]	2.78[b]	10.02[b]	8.02[d]	37.20[c]	59.04[d]
WHO Permissible Limit	6.5-8.5	6.5-8.5	NA	100	100	300	2000
FLSD (P=0.05)	0.52	0.15	1.20	11.5	1.75	9.30	6.6

Note: NF= Natural forest, BF =Bush fallow, AC =Alley cropped, OP =Oil palm, UC=Unfertilised cassava NA=Not available

❖ Treatment means with similar superscripts are not statistically similar

3.5 Soil Reaction-$pH_{(KCl)}$

There were significant differences in the soil pH_{KCl} at 10-20cm depth when the different land use types were compared with one another. There were 0.20, 10, 0.10 units of $pH_{(KCl)}$ more in bush fallowed plot, oil palm plot and unfertilized cassava plot when compared with natural forest. There were 0.80, 10, 0.20 units more of $pH_{(KCl)}$

when alley cropped plot, oil palm plot and unfertilized cassava plot were compared with bush fallowed plot but there was no significant difference when alley cropped plot was compared with bush fallowed plot. There was 0.90 units of $pH_{(KCl)}$ more that differed significantly when unfertilized cassava plot was compared with oil palm plot. No significant difference was observed when unfertilized cassava plot was compared with alley cropped plot but differed significantly by 10 units more of $pH_{(KCl)}$ when oil palm plot was compared with alley cropped plot. Results obtained on the level of acidity of the selected land use followed same trend as seen in 0-10cm soil depth.

3.6 pH(H_2O)

There were 0.40, 0.30, 1.40 and 0.40 units of pH more in bush fallowed plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with natural forest. oil palm plot had 10 units of pH more when compared with bush fallowed plot but no significant difference was seen when alley cropped plot and unfertilized cassava plot were compared with bush fallowed plot. There was 1.10 units of pH more that differed significantly when oil palm plot was compared with alley cropped plot The result showed that the level of acidity in the selected land use types followed same trend as seen in 0-10cm soil depth

3.7 Exchangeable Acidity (EA)

At 10-20cm soil depth, the land use types differed significantly with one another. There were 2.58, 1.96, 4.75 and 2.09 units more of EA in bush fallowed plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with natural forest. Also, there was 2.17 units of EA more that differed significantly when oil palm plot was compared with bush fallowed plot Oil palm plot revealed significantly 2.79 units of EA more when compared with alley cropped plot but there was no significant difference when unfertilized cassava plot was compared with alley cropped plot. Significant difference was observed when unfertilized cassava plot was compared with oil palm plot. The results showed that natural forest gave the highest value of Exchangeable acidity as confirmed by (Uche, 2006) that the capacity of forest soil to conserve organic matter has a positive effect on nutrient conservation.

3.8 Heavy Metals (Cu, Pb, Zn, Mn)

3.8.1 copper(Cu)

Oil palm plot had 12.28 units of Cu more that significantly differed when compared with natural fores.Significant differences were recorded when oil palm plot was compared with bush fallowed plot. Other land use systems were not significantly different when compared with one another. On the whole, the concentration of Cu in different land uses fell within the WHO limits for copper concentration in the soil.

3.8.2 Lead(Pb)

There were significant differences in Pb concentration at 10-20cm soil depth when the different land use types were compared with one another. There were 8.17, 2.54, 8.78, 8.15 units of Pb concentration more in Bush fallowed plot, alley cropped plot, oil palm plot and unfertilized cassava plot when compared with Natural forest. Alley cropped plot revealed significantly 5.63 units more of Pb concentration than Bush fallowed plot but there was no significant difference when oil palm plot and unfertilized cassava plot were compared with Bush fallowed plot. Oil palm and unfertilized cassava plot revealed significantly 6.24, 5.61 units more of Pb concentration when compared with alley cropped plot. There was no significant difference when unfertilized cassava plot was compared with oil palm plot. On the whole, the concentration of pb in different land uses fell within the WHO limits for lead concentration in the soil.

3.8.3 Zinc(Zn)

At soil depth of 10-20cm, there were significant differences when different land use types were compared with one another. Bush fallowed plot and alley cropped plot revealed significantly 22.33 and 20.07 units more of Zn concentration when compared with natural forest. There were no significant difference when alley cropped plot and oil palm plot were compared with Natural forest. Alley cropped plot, oil palm plot, unfertilized cassava plot revealed significantly 26.15, 15.37, 42.4 units of Zn more than the bush fallowed plot. Oil palm plot and unfertilized cassava plot differed significantly when compared with alley cropped plot. There was 27.03 units of Zn more that differed significantly when unfertilized cassava plot was compared with oil palm plot. On the whole, the concentration of Zn in different land uses fell within the WHO limits for zinc concentration in the soil.

3.8.4 Manganese(Mn)

There were significant differences among the various land use types when they were 14.89, 6.86, 76.19 and 12.01 units more of Mn concentration when compared with the Natural forest. Significant differences were observed when alley cropped plot, oil palm plot and unfertilized cassava plot were compared with Bush fallowed plot. Oil palm plot and unfertilized cassava plot differed significantly when compared with alley cropped plot. Unfertilized cassava plot revealed significantly 64.18 units more of Mn concentration when compared with oil palm plot.

Results obtained, showed that generally the selected land use types contained the concentrations of the studied heavy metals within WHO permissible limits.

4. Conclusion

The research documented basic information on the effects of selected land use on soil reaction and heavy metal concentration at 0-10cm and 10-20cm soil depths. Lower pH values found were not as a result of land use effect rather that of the parent material. The concentrations of heavy metals studied were within WHO permissible limits.

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