Profile Distribution of Copper in an Alfisols in Minna, Niger State

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ABSTRACT

To assess the effect of toposequence on Copper(Cu) distributions, this study examined the profile variation and storage of Cu at the depth of 0 - 150cm of an alfisol of the upland farm of the Teaching and Research Farm of the Federal University of Technology, Minna. Soil samples were collected from three profiles on toposequence (upper, middle and lower slopes). Results obtained showed that the effect of toposequence (profile pits), soil depth and their interaction on Cu distribution were significantly different ($p<0.05$) and they decreased significantly with soil depth in all the pedons examined. The effect of toposequence was in the following decreasing order: lower slope> middle slope> upper slope. Simple correlation analysis showed that Cu was positively correlated with soil organic carbon but negatively correlated with soil pH the profiles studied. This result suggests that the profile distribution of Cu is largely controlled by plant/biological cycling, soil pH, slope differences and anthopogenic disturbances of the soil.

INTRODUCTION

Copper (Cu) and other micronutrients are essential minerals for plant growth, through their involvement in various enzymes and other physiologically active molecules, these micronutrients are important for gene expression, biosynthesis of proteins, nuleic acids, growth substance chlorophyll and secondary metabolites, metabolism of carbohydrates and lipids and stress tolerance (Rengel, 2003 and Gao *et al.*, 2008).

Original geologic substrate and subsequent geochemical and pedogenic regimes determine total level of Cu in the soil. However, total levels are rarely indicative of plant availability, because availability depends on the levels of soil organic matter, soil pH, soil adsorptive capacity, and other physical, chemical and biological conditions in the rhizosphere (Jiang, *et al.,* 2009).

Considering the dearth of information on Cu and other micronutrient levels in the soil, millions of hectares of arable land in savanna zones where Minna falls, have low availability of these micronutrients and many of these deficiencies were brought about by increased demand of more rapidly growing crops for available forms of micronutrients (Rengel, 2007 and Alloway, 2008).

To achieve food production at sufficiency and security levels in Nigeria, a drastic shift from studies of macronutrient to micronutrient and its implication is necessary. The objective of this study was therefore: to assess and compare the changes of profile distribution and storage of soil available Cu in different soil series.

Materials and Methods

A total of three profiles on a toposequence (upper, middle and lower slopes) as chosen from the upland farm of Teaching and Research Farm of the Federal University of Technology, Minna (Latitude 9° 40°N and Longitude 6° 30°E). Soil samples were collected randomly in five depths (0-30, 30-60, 60-90, 90-120 and 120-150cm) using 2.5cm diameter auger. Soil samples were air dried and passed through 2mm sieve.

Selected physical and chemical properties were analyzed. Particle size distribution was evaluated by hydrometer method (IITA, 1979). The pH was determined with pH meter glass electrode in a 1:2 soil: water ratio (IITA, 1979). Organic carbon was determined by Walkley and

Black method (Allison, 1965). Bray No. 1 method was employed for the estimation of available phosphorus. Available Cu in the soil was extracted with 0.005M diethylenetriaminepentaacetic acid (DTPA), 0.1M $CaCl_2$ and 0.1M triethanolamine (TEA) with pH of 7.3 and determined with flame atomic adsorption spectrophotometer.

The obtained data were analyzed using analysis of variance (ANOVA). Means were using LSD at 5% level of probability.

RESULTS AND DISCUSSIONS

The physico-chemical characteristics of the soils from the study area site are shown in Table 1. The texture ranged from sand clay loam (lower slope) to sandy-loam and loamy-sand (upper slope). Soil reaction ranged from 4.6 (lower slope at 60-90cm depth) 6.8 (lower slope at 90-120cm depth). Organic carbon of the studied soils was generally low. Jones and Wild (1975) reported low to medium organic carbon rate for savanna soils which was attributed to paucity of vegetation cover, rapid mineralization of organic matter, inadequate return of crop residues, bush burning and short fallow periods. Available phosphorus was also low, ranging from 5.18 to 9.12 mg kg^{-1} in the whole profiles.

Table 1: Some selected physico-chemical properties of the soil studied

Depth ($mg\ kg^{-1}$)	Sand Silt (cm)	Clay	(kg)	Texture		pH	OC (H_2O)	Available P (%)
UPPER SLOPE								
	0-0.30	870	40	90	S	5.5	0.56	6.66
	30-60	790	80	130	LS	5.5	0.48	5.86
	60-90	790	100	110	LS	6.2	0.36	5.18
	90-120	710	180	110	SL	6.5	0.36	5.79
	120-150	730	140	130	SL	5.9	0.32	6.05
MIDDLE SLOPE								
	0 -30	790	120	90	LS	6.1	0.64	7.49
	30-60	730	140	130	SL	6.4	0.52	7.30
	60-90	710	160	130	SL	5.8	0.43	7.31
	90-120	710	220	70	SL	5.5	0.40	7.76
	120-150	590	230	180	SL	6.6	0.32	5.41
LOWER SLOPE								
7.18	0-30	650	80	250	SCL	5.2	0.68	
6.92	30-60	530	130	340	SCL	61	0.60	
9.12	60-90	810	90	100	LC	4.6	0.40	
6.02	90-120	510	180	310	SCL	6.8	0.42	
5.89	120-150	570	160	270	SCL	6.7	0.30	

Profile Distribution of Copper

In soil located at different slopes, there was tendency of Cu concentrations to decrease with depths (Table 2). Statistical analysis showed that profile location, soil depth and cross effect of profile location and soil depth was significantly different for Cu concentration. This indicates that profile location and soil depth were the key factors responsible for Cu distribution in the soil. DTPA – extractible Cu concentration were significantly higher in lower slope (LS) than in both middle and upper slopes (Table 2). The accumulation of Cu was also significantly higher at 0–30cm depth and subsequently decreased with the depth irrespective of the profile location. Plant cycling was considered as the leading factor and anthropogenic and leaching were the secondary factors that affect the vertical distribution and top soil accumulation of micronutrients as suggested by Jiang, *et al* (2009). Jiang, *et al* (2006) reported that, in the soil surface horizon, micronutrients distribution is controlled by pH, organic matter and cation exchange capacity. Biological cycling generally moves nutrients upwards, because, some proportion of the nutrient absorbed by plants are transported above ground and then recycled to the soil surface by litterfall and throughfall.

Table 2: Profile distribution of copper ($mg\ kg^{-1}$)

Depth (cm)	Toposequence		
	US	MS	LS
0-30	2.33^{b}	2.40^{ab}	3.53^{a}
30-60	1.28^{ab}	1.24^{b}	2.32^{a}
60-90	0.85^{ab}	0.67^{b}	0.97^{a}
90-120	0.58^{a}	0.50^{b}	0.54^{ab}
120-150	0.53^{a}	0.50^{a}	0.52^{a}

US = Upper Slope MS = Middle Slope
LS = Lower Slope

Different letters in the same row indicate significantly different values at $P<0.05$.

Several authors concluded that organic matter, organic residues and manure applications affect the immediate and potential availability of nutrient cations (White and Zasoski, 1999 and Rengel, 2007). These authors reported that the cationic micronutrients react with certain organic molecules to form organometallic complexes as chelates and the soluble chelates can increase the availability of micronutrients and prevent it from precipitation reactions. These chelates may be synthesized by plant roots and released to the surrounding soil, may be present in soil humus or may be synthetic compounds added to the soil to enhance micronutrients availability (Brady and Weil, 2002).

Copper Accumulation Correlation With Soil Properties

Simple correlation coefficient relating Cu accumulation to some properties of investigated soil is depicted in Table 3. The results showed that organic carbon was positively and significantly correlated with DTPA – extractible Cu under the different profile location, indicting the role of soil organic matter in enhancing the availability of Cu. Similar results were reported by Jiang, *et al* (2006). Jiang, *et al* (2009) and Stalk (1994) reported that soil organic matter does not only mobilize microelements but immobilizes them as well. They concluded that EDTA – extractible Cu was significantly higher at higher soil organic matter content than at low organic matter content. This was attributed to the formation of higher stable copper-humate complexes and to their increasing dissolution that occurred in the soils with higher organic matter levels (Di Palma, *et al*, 2007).

Soil pH was negatively and significantly correlated with DTPA – extractible Cu in all the soil profile. Brady and Weil (2002) reported similar findings. They reported that Fe, Mn, Cu and Zn are the most soluble under acid conditions. And as soil pH is increased, ionic forms of these micronutrient cations are changed first to the hydroxyl ions and finally to the insoluble hydroxides or oxide of these elements. For every unit increase in soil pH, solubility of cationic micronutrients may decrease from 100-fold for divalent Mn, Cu and Zn to 1000-fold for a trivalent Fe (Rengel, 2001).

Table 3: Simple correlation coefficients relating soil properties to copper accumulation

Independen t variables	Cu accumulation		
	US	MS	LS
Soil organic C	8.894***	0.776***	0.878***
Soil pH	-0.819***	-0.407***	-0.861***

US = Upper Slope MS = Middle Slope
LS = Lower Slope

***, ** Significant at 1% and 5% levels respectively.

CONCLUSION

Results from this study revealed that the profile location and soil depth were the key factors affecting DTPA – extractible Cu distribution in soil profiles. Copper accumulation was positively correlated with soil organic carbon but negatively with pH. The variation can be explained by the interaction between abiotic and biotic after land use changes.

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