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MOLYBDENUM AVAILABILITY AND SOME PHYSICO-CHEMICAL PROPERTIES OF THE SOILS OF DIFFERENT PARENT MATERIALS IN ADAMAWA STATE, NIGERIA

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ABSTRACT

The level of 0.2M NH_4oxalate extractable molybdenum (Mo), and physico chemical properties of surface (0-20) and subsurface (20-50cm) soil samples were determined from fifteen different locations representing Alluvium, Basement complex and Sandstone parent materials in Adamawa State. The mean available Mo was 0.051 for the surface, and 0.050 $mgkg^{-1}$ for the subsurface soils There was a significant (P<0.05) variation in Mo levels among the parent materials. The mean Mo level was highest (0.062) in surface soil derived from Alluvium and lowest (0.035 $mgkg^{-1}$) in subsurface soil derived from Sandstone. The Mo correlated positively and significantly (P<0.05) with available P and total N in surface soils. The soils were strongly acidic (5.45) to slightly alkaline (7.79) in reaction and were non-saline (Ec = 0.02-0.17$mScm^{-1}$). The organic carbon content of the soils ranged from 0.48 to 2.99 gkg^{-1} with the mean value of 1.06 gkg^{-1} for the surface and 0.11 to 0.93 gkg^{-1} with the mean value of 0.55 gkg^{-1} for the subsurface. The ECEC ranged from 3.22 to 42.94 $Cmol(+)kg^{-1}$ with the mean value of 17.29 $Cmol(+)kg^{-1}$ for surface and 4.36 to 50.24 $Cmol(+)kg^{-1}$ with the mean of 20.67 $Cmol(+)kg^{-1}$ for subsurface. Available P was low (<7.0 $mgkg^{-1}$) irrespective of depth, likewise total N was low in both surface and subsurface soils. The results indicated low Mo levels in the soils.

Keywords: Molybdenum; NH_4oxalate extractant; Parent materials; Physico-chemical properties.

INTRODUCTION

Molybdenum (Mo) is a trace element required by both plants and animals. Its value in soil can vary widely depending on the parent material (Mengel and Kirkby, 1987). In fertile soil, the available Mo content varies from 0.1 to 0.3 and in sand from trace to 0.005ppm (Jones, 1987). Halvin *et al.* (2005) reported that the normal level of extractable Mo varies from <0.1 to 5ppm. Soils derived from Alluvium parent materials are reported to have higher levels of Mo as compared to other parent materials (Takkar, 1982), while those derived from Sandstone and in some cases Basement complex have lower levels of available Mo (Sandabe *et al.,* 2000).

The behaviour of Molybdenum in soil is regulated by pH. With a decrease in pH, the soluble content decreases, and vice versa (Halvin *et al.*, 2005). Sufficient supply of Mo is essential for nitrogen fixation in legumes (Bohn *et al.*, 1985; Jones, 1987; Graham *et al.*, 1988; Janet and Peter, 1990; Halvin *et al.*, 2005). Molybdenum deficiency symptoms include interveinal chlorosis, stunting of the plant and general paleness (Brady and Weil, 2002). Adamawa state is endowed with vast agricultural soils including Fadama soils. However, scanty information is available on the nutrient status of the soils particularly micronutrient molybdenum. Thus there is need to evaluate the levels of Mo in these soils for proper application and optimum crop yield. The present study was undertaken to determine the distribution of available Mo in some soils in Adamawa state.

MATERIALS AND METHODS

Study Area

The study was conducted in fifteen different locations representing different parent materials in Adamawa State, North East Nigeria. The State is located between latitudes 7° 28' and 10° 55' N and longitudes 11° 30' and 13° 45'E (Adebayo and Tukur, 1999). The State has a tropical climate marked by dry and rainy seasons. The rainy season commences in May and ends in October with dry season starts in November and ends in April. In this period, relatively cold harmattan becomes prominent more especially in the months of November to February. Rainfall is moderate ranging from 700mm in Northwest part to1600mm in the Southern part. The relative humidity reaches 80% in August and drops to 13% in March. The average recorded minimum temperature for the State was 15.2°C in the months of December to January, while the maximum temperature was 39.7°C particularly in April (Adebayo and Tukur, 1999).

The vegetation in the State is characterised by trees and open grasses and fringing forest in the river valley. The more abundant tree species found in the State include *Acacia nilotica, Adansonia digitata, Parkia biglobosa,* etc. and grass species include *Panicum maximum, Aristida longiflora, Andropogon gayanus,* etc. (Adebayo and Tukur, 1999). The soils of the State are derived from Basement complex, though soils from Sandstone and Alluvium are also found. The major soils are classified as Ferruginous Tropical soils (D'Hoore, 1974). Based on FAO/UNESCO soil classification system (1988), some of the soil types in the State include: - Luvisols, Regosols, Cambisols, Vertisols and Lithosols.

Soil Sampling and Sample Preparation

Fifteen surface (0-20) and subsurface (20-50cm) soil samples each were collected from fifteen different locations to represent the different parent materials in Adamawa State (Table 1). The soil samples were air-dried, crushed and sieved through 2-mm stainless steel sieve, before laboratory analysis.

Laboratory Analysis

The soil samples were analysed for available Mo as well as their physical and chemical properties. The particle size analysis was determined by Bouyoucos hydrometer method as described by Gee and Bauder (1986). The percentages of sand, silt, and clay were calculated as described by Black (1965). Soil pH was measured in 1:2.5 soil-water suspension using glass electrode pH meter (model 5), after allowing the suspensions to equilibrate for one hour with occasional stirring. Electrical conductivity was determined in 1:2.5 soil-water suspension using EC meter (model Crimson conductivity 522), as described by Rhoades (1982). Organic carbon was determined by Walkley and Black method as described by Nelson and Sommers (1982). Exchangeable bases and exchangeable acidity were determined by the method described by Grant (1982). Total N was determined by the method described by Bremner (1996).The soil available phosphorous was determined by the method described by Bray and Kurtz (1945), and available Mo was determined by the method described by Kubota and Cary (1982).

Statistical Analysis

Simple correlation between available molybdenum and some soil properties was determined using the graph pad Instat statistical software package.

RESULTS AND DISCUSSION

Texture

Sand is the dominant soil fraction in the parent materials. The highest mean sand (75.4%) was recorded in Sandstone surface soils while mean silt was highest (47.8%) in Alluvium subsurface soils. Mean clay was also highest (15.5%) in Basement complex subsurface soils (Table 2). Sandabe and Bapetel (2008) also reported Sand to be dominant (80.3%) in soils of Sandstone origin followed by clay (15.6%) and silt (4.1%). However, earlier studies by Sandabe and Bapetel (2005) showed that Sand was highest (62.1%) in soils derived from Basement complex while mean clay was highest (40.9%) in soils of Alluvium parent materials. Variation of sand fraction was significant ($P<0.05$) in both surface and subsurface soils. Silt fraction differed highly significantly ($P<0.01$) in both surface and subsurface soils. However, no significant variation in clay fraction was observed among the three parent materials.

Soil pH (1: 2.5)

The mean pH values of soil samples derived from Alluvium, Sandstone and Basement complex parent materials were 6.54, 6.47 and 5.70 for the surface and 6.92, 6.27 and 5.79 for the subsurface soils, respectively (Table 2). The result showed that the soil pH ranged from moderately acidic (5.70) to neutral (6.92) in all the parent materials studied. Zata *et al*. (2006) reported that the pH in soils of Sandstone origin is slightly acidic to slightly alkaline in reaction with values ranging from 5.30 to 7.86 with a mean of 6.48. The pH in soils of Alluvium and Basement complex origin had values of 5.64 and 7.79 respectively (Sandabe and Bapetel, 2005).

Electrical Conductivity (EC)

The mean EC values of soils derived from Alluvium, Sandstone and Basement complex were 0.10, 0.03 and 0.05 for surface and 0.11, 0.03 and 0.05 $mScm^{-1}$ for subsurface soils, respectively (Table 2), indicating that the soil samples were non-saline. Similar result was also reported by Zata *et al.* (2006), which showed that EC values of soils derived from Sandstone are generally low with values ranging from 1.01 to 1.85 $mScm^{-1}$.

Organic Carbon (OC)

The results showed that soils derived from Alluvium, Sandstone and Basement complex parent materials had mean OC content of 1.70, 0.74 and 0.75 $mgkg^{-1}$ for the surface and 0.71, 0.52 and 0.42 $mgkg^{-1}$ for the subsurface, respectively (Table 2). It was observed that soils derived from Sandstone and Basement complex had low levels of OC while surface soils derived from Alluvium had moderate levels of OC. Kparmwang *et al.* (2001) also reported that OC was low in soils developed on Sandstone in the Benue trough. They pointed out that this could be partly attributed to rapid mineralization of organic matter due to high temperature in the tropical environment, and to annual bush burning.

Effective Cation Exchange Capacity (ECEC)

The result of ECEC of soils (Table 2) showed that subsurface soils derived from Alluvium had the highest (37.58 Cmol (+) kg^{-1}) mean ECEC value, while the surface soils derived from Sandstone had the lowest (6.90 Cmol (+) kg^{-1}). The mean ECEC values increased with depth of soils except in the soil derived from Sandstone. Most soils had low mean ECEC values except soils of Alluvium origin. In Firki soils of alluvial origin in Chad lagoonal complex, Nwaka (2000) reported high ECEC ranging from 13.7 to 41.34 Cmol (+) kg^{-1} in the surficial clay layer with a mean value of 31.7 Cmol (+) kg^{-1} which is similar to the results obtained in this study.

Available Phosphorus (Bray 1-P)

The distribution of available P in soils (Table 2) showed that the mean available P values in soils derived from Alluvium, Sandstone and Basement complex parent materials were 2.89, 2.24 and 2.39 for the surface, and 3.41, 2.52 and 2.45 $mgkg^{-1}$ for the subsurface soils, respectively. Subsurface soils had higher levels of available P than surface soils irrespective of parent material. Subsurface soils from Alluvium had the highest (3.41 mg kg^{-1}) mean value of P and the lowest (2.24 mg kg^{-1}) was recorded in surface soils from Sandstone. In contrast, Oyinlola and Chude (2010) reported that available P content in soils derived from Basement complex in savannah ranged from 3.9 to 19 mg kg^{-1}.

Total Nitrogen

The result of the study showed that the mean N content of Alluvial soils was 0.23 in the surface and 0.17 g kg^{-1}in subsurface. In soils derived from Sandstone, the total N obtained was 0.14 g kg^{-1} in both surface and subsurface indicating a uniform N content in both surfaces. Soils derived from Basement complex contained 0.16 in the surface and 0.14 g kg^{-1} in subsurface. This result was similar to that of Oyinlola and Chude (2010) who indicated that the total N content of the soils derived from Basement complex in Nigerian savannah ranged from 0.4 to 1.4 g kg^{-1}.

Available Molybdenum (Mo)

The result in Table 3 showed that mean available Mo extractable with NH_4oxalate in soil derived from Alluvium; Sandstone and Basement complex soils were 0.062; 0.040 and 0.052 $mgkg^{-1}$ for the surface and 0.059; 0.035 and 0.058 $mgkg^{-1}$ for the subsurface soils, respectively. This indicated that, the Mo levels decreased with increasing soil depth in Alluvium and Sandstone, but increased with depth in soils of Basement complex origin. The values of Mo obtained in Alluvium surface soils in this study is comparable with those reported by Ahmad *et al*. (1982) in Alluvial soils (Ganges flood plain) of Bangladesh where NH_4oxalate –Mo values ranged from 0.03 to 0.20 $mgkg^{-1}$. Similarly, Sandabe *et al*. (2000) reported that available Mo in soils of Damboa/Chibok plains ranged from 0.01 to 0.38 ppm with a mean value of 0.17ppm. In soils from India, Takkar (1982) also reported that sandy soils from Sandstone contained < 0.05 $mgkg^{-1}$ Mo while Alluvial soil have a range of 0.004 to 1.30 $mgkg^{-1}$ Mo.

Relationship between Available Mo and Some Physico–chemical Properties of Soil Samples

Correlation studies of some of the properties of surface soils showed that NH_4oxalate extractable Mo correlated positively with available P ($r = 0.562^*$) (Table 4). This indicate that in surface soils, P have proved to influence the availability of NH_4oxalates extractable Mo. Positive correlation between Mo and available P was also reported by Basak *et al*. (1982) and Halvin *et al*. (2005). There was also a significant correlation ($r = 0.529^*$) between NH_4oxalate-Mo and total nitrogen. This means that available Mo is increased with increased total nitrogen levels. Brady and Weil (2002) also reported that increase in the amount of N is induced by sufficient supply of Mo in the soils, hence available Mo is essential for N-fixation in the root nodules of legumes.

Other soil properties like sand, silt, and clay particles, pH (H_2O), EC, OC, and ECEC were not significantly correlated with NH_4oxalate extractable Mo (Table 4). This may be due to the low levels of NH_4oxalates – Mo values that was obtained in this study. Ahmad *et al*. (1982) reported that the extractability of Mo showed an increasing trend with rise in pH and organic matter in soil. The non-significant correlation between available Mo and clay fraction observed in this study is contrary to the report of Chude *et al*. (1993) who showed that clay content is one of the factors affecting Mo availability in the Savannah soils of Nigeria. Similarly, Takkar (1982) reported that available Mo significantly correlated with silt content of soil. Aubert and Pinta (1977) also reported that available Mo was lower in sandy fraction compared to silt and clay fractions. Sandabe *et al*. (2000) did not find a significant correlation between NH_4oxalate extractable Mo and pH, OC, and available P, but there was a significant ($P<0.05$) correlation between Mo and ECEC.

However, the NH_4oxalate extractable Mo did not significantly correlate with all the soil properties of subsurface soils. This implies that subsurface properties including clay content did not have any relationship with NH_4oxalate extractable Mo.

CONCLUSION

The study has shown that most of the soils have low level of 0.2M NH_4oxalate extractable molybdenum. The soils were strongly acidic to slightly alkaline in reaction, and are non saline. Most of the soils had low levels of organic carbon, ECEC, available P, and total N.

Table 1: Location and parent materials of the soil sample

S/No	Location	Parent material	Soil classification
1	Digil	Basement complex	Alfisol
2	Ganye	Sandstone	Alfisol
3	Lake Geriyo	Alluvium	Entisol (Fluvent)
4	Lafiya	Basement complex	Entisol
5	Madagali	Basement complex	Alfisol
6	Mayo Belwa	Sandstone	Alfisol
7	Mayo Kalaye	Sandstone	Alfisol
8	Michika	Basement complex	Alfisol
9	Ngurore	Alluvium	Inceptisol (Vertic)
10	Song	Basement complex	Alfisol
11	Savanna (Numan)	Alluvium	Entisol (Fluvent)
12	Mbamba	Sandstone	Alfisol
13	Gombi	Basement complex	Alfisol
14	Winde	Sandstone	Alfisol
15	Wuro Bokki	Alluvium	Entisol (Fluvent)

Source: Usman, (2005).

Table 3: Levels of available Molybdenum extractable with 0.2M NH_4oxalate ($mgkg^{-1}$) based on Parent materials

	Depth (cm)			
	0 - 20		20 – 50	
Parent Materials	Range	Mean	Range	Mean
Alluvium	0.036 - 0.103	0.062	0.036 – 0.083	0.059
Sandstone	0.025 - 0.058	0.040	0.023 – 0.050	0.035
Basement complex	0.013 – 0.093	0.052	0.047 – 0.074	0.058

Table 4: Simple correlation coefficient (r) between available Molybdenum and some soil properties [(1)]

Soil Property	r
Sand (%)	-0.437^{ns}
Silt (%)	0.470^{ns}
Clay (%)	0.135 ^{ns}
Soil pH (H_2O)	0.354 ^{ns}
E.C. (mScm^{-1})	0.108 ^{ns}
Organic carbon (g kg^{-1})	0.476 ^{ns}
ECEC (Cmol (+) kg^{-1})	0.362 ^{ns}
Available phosphorus (mg kg^{-1})	0.562*
Total nitrogen (g kg^{-1})	0.529*

ns = Non significant, * = Significant at 5% ** = Significant at 1%, [(1)] = 13 degrees of freedom

Table 2: Some physico-chemical properties of surface and subsurface soil samples based on parent materials

		Parent materials					
		Alluvium		Sandstones		Basement complex	
Soil properties	Depth (cm)	Range	Mean	Range	Mean	Range	Mean
Sand (%)	S	36.0 – 61.0	49.1	53.2 – 89.6	75.4	62.1 – 77.1	70.2
	SS	23.5 – 56.0	37.9	48.3 – 89.6	69.1	48.2 – 85.8	66.1
Silt (%)	S	28.4 – 45.9	39.7	5.9 – 35.0	16.7	15.8 – 24.5	20.7
	SS	43.4 – 53.4	47.8	7.1 – 30.0	16.9	8.3 – 24.0	18.3
Clay (%)	S	0.6 – 20.6	11.2	3.1 – 15.8	7.9	0.9 – 15.9	9.1
	SS	0.6 – 33.1	14.3	3.1 – 30.9	14.0	0.9 – 27.8	15.5
pH (1:2.5 H_2O)	S	5.64 – 7.18	6.54	5.45 – 5.87	6.47	5.75 – 7.79	5.70
	SS	6.11 – 7.54	6.92	5.52 – 6.01	6.27	5.46 – 6.90	5.79
E.C. ((1:2.5 H_2O, $mScm^{-1}$)	S	0.04 – 0.16	0.10	0.02 – 0.04	0.03	0.03 – 0.08	0.05
	SS	0.04 – 0.17	0.11	0.02 – 0.05	0.03	0.03 – 0.08	0.05
Organic carbon (g kg^{-1})	S	0.74 – 2.99	1.70	0.55 – 1.33	0.74	0.48 – 0.95	0.75
	SS	0.40 – 0.93	0.71	0.34 – 0.78	0.52	0.11 – 0.70	0.42
ECEC (Cmol(+)kg^{-1})	S	26.89 – 42.94	33.62	3.22 – 6.32	6.90	8.10 – 17.81	11.35
	SS	31.63 – 50.24	37.58	4.36 – 23.24	9.84	5.48 – 25.85	14.60
Bray1-P ($mgkg^{-1}$)	S	1.40 – 5.60	2.89	2.10 – 2.45	2.24	1.05 – 3.15	2.39
	SS	2.10 – 5.60	3.41	2.10 – 2.80	2.52	1.40 – 3.15	2.45
Total-N (g kg^{-1})	S	0.18 – 0.29	0.23	0.11 – 0.17	0.14	0.13 – 0.20	0.16
	SS	0.14 – 0.21	0.17	0.13 – 0.15	0.14	0.11 – 0.18	0.14

S = surface soil samples (0 – 20cm) , SS = subsurface soil samples (20-50cm)

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