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RESEARCH ARTICLE

DISTRIBUTION OF MAGNESIUM FORMS IN SURFACE HYDROMORPHIC SOILS OF SOUTHERN NIGERIA

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ABSTRACT

The distribution of Magnesium forms in surface hydromorphic soils of sourthern Nigeria was studied. Fifty-four composite surface (0 to 15cm) soil samples drawn from different parent materials were used. Total Mg ranged from 81.42 to 475.62mg/kg, while water soluble Mg, exchangeable Mg, difficulty exchangeable Mg and Mg reserved ranged from 0.080 to 1.04, 0.160 to 4.56, 0.24 to 5.60 and 0.40 to 150.70 cmol/kg, respectively. Soils formed on crystalline metamorphic and igneous rocks were highest in Mg status when compared to soils formed on shale mixed with sand stone and clay, coastal plain sand, coastal alluvium and fresh water swamps. Magnesium status in these soils was strongly influence by parent materials. Other factors that influenced the Mg formed on the different parent materials were silt and clay contents, organic matter and pH. Fifteen percent of the soils sampled were deficient in available Mg based on already established critical level for Nigerian soils.

KEYWORDS

Crystalline metamorphic rock, Physicochemical properties Hydromorphic Soils, Magnesium Forms, Southern Nigeria.

1. INTRODUCTION

Magnesium occurs in soils as water soluble, exchangeable and non-exchangeable Mg. Exchangeable and water-soluble Mg constitute the forms of Mg that are immediately available to plants. The non-exchangeable Mg is important when the pool of exchangeable Mg is depleted by crop uptake (Salmon, 1963; Rice and Kamporoth, 1968; Osemwota et al., 2007). A researcher reported four forms of Mg namely water soluble, exchangeable, lattice and mineral forms (Salmon, 1963). In soils of temperate and tropical regions Mg had been fractionated into Mineral, acid soluble, organic complexed and exchangeable Mg (Mokwunye and Melsted, 1972; Lombin, 1981; Alasiri,1994; Osemwota et al., 2009). In a study, authors regarded the exchangeable form as the fraction which not in soil solution, is in rapid equilibrium with the soil solution forms (Corex and Schulte, 1973).

The acid soluble form is that form which cannot be extracted with conventional solutions employed in extracting exchangeable forms in soils, but which can only be extracted by using more drastic chemical procedures. The mineral form is the portion that is associated with the primary mineral. All forms of Mg which cannot be extracted with N neutral NH4OAC are collectively referred to as non-exchangeable Mg (Lombin, 1978; Alasiri, 1994; Osemwota et al., 2007). The non-exchangeable soil Mg are found in the primary minerals such as Biotite, olive, Dolomite, Serpentine and Hornblende and Secondary clay minerals such as Chlorite, illite, vermiculite and Montmorillonite.

Some non-exchangeable Mg is contained in organic matter (organic complexed form). Losses of Mg not accounted for by leaching, crop removal or changes in exchangeable Mg have been ascribed to fixation (Mokwunye and Melsted, 1973; Osemwota et al., 2006). There is paucity of information in literature as regards the distribution of Mg forms in hydromorphic soils of Southern Nigeria which accounts for about 1.7% of the entire land mass, hence the investigation.

2. MATERIALS AND METHOD

Fifty-four hydromorphic composite surface (0-15cm) soil samples collected from different locations in Southern Nigeria were used for the study. The composite surface soil sample were air dried, thoroughly mixed crushed and sieved through a 2mm sieve and preserved in plastic containers with covers in dry cool place.

2.1 Analytical Procedure

Particle size analysis of the soil was done by hydrometer method with Calgon as soil dispersing agent (Bouyoucos, 1962). Soil pH (1:1soil- water ratio) was measured with Bechman pH meter using glass electrode. Organic carbon was determined by dichromate wet oxidation method (Walkley and Black, 1934). Exchangeable cations and effective cation exchange capacity were determined by extracting the soil with 1NNH$_4$OAc at pH 7 (Schollenberger and Simon, 1945). Exchangeable Na was determined by flame photometer while Ca and Mg were determined by atomic absorption spectro- photometer. Summation of exchangeable bases and exchange acidity gave effective cation exchange capacity (ECEC) value.

2.2 Magnesium Fractionation

Magnesium content in soil was fractionated into different forms by sequential extraction of the soil samples as follows:

- Water Soluble Mg: Water soluble Mg was extracted in 1:2 soil- water

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(deionized) suspension after shaking for two hours and allowed the mixture to stand for additional sixteen hours (Maclean, 1961).

- Exchangeable Mg: Exchangeable Mg was extracted from the soil with $1NNH_4OAC$ buffered at pH (Schollenberger and Simon, 1945).
- Difficultly available Mg: This was obtained by extracting the soil with $1NNH_3$ in 1:10 soil-acid suspension after ten minutes of boiling (Graley et al., 1960)
- Mg Reserve: Mg reserve was obtained by boiling a 1:10 soil-10MHCl mixture for one hour. (Piper, 1950)

Total Mg: Total Mg was obtained by digesting soil with $HF\text{-}HClO_4$ mixture (Jackson 1958). The Mg in extract was determined by atomic absorption spectrophotometer.

3. Results and Discussion

The mean value of the physico-chemical properties of the soil used for the study in relation to parent materials are shown in Table 1. Soils derived from shale mixed with sand stone and clay had the highest value for clay which was followed by soils derived from crystalline metamorphic and igneous rock then the soils derived from coastal alluvium, coastal plain sands and fresh water swamps respectively. The highest value of silt was obtained from soils derived from crystalline metamorphic and igneous while the lowest silt was obtained from coastal plain sands. On the basis of parent materials, the pH of the soils varied from 4.92 to 5.90. The highest pH was obtained from soils derived from crystalline metamorphic and igneous rocks. While the lowest was obtained from the soils derived from fresh water swamps. The organic matter content of the soils varied from 1.36 to 3.36%.

The highest value of organic matter content on average basis was obtained from soils derived from coastal alluvium while the lowest was obtained from soils derived from coastal plain sands. The base saturation varied from 36.85 to 91.16% on average basis. The highest percentage base saturation of 91.16% was obtained from soils derived from crystalline metamorphic and igneous rocks while the lowest of 36.85% was obtained from soils derived from fresh water swamps. The effective cation exchange capacity (ECEC) varied from 2.28 to 6.51cmol/kg. The highest ECEC value was obtained from soils derived from crystalline metamorphic and igneous rocks while the lowest was obtained from soils derived from coastal plain sands.

Table 1: Mean values of physico-chemical properties in relation to soil parent material

Parent material	U.S Taxonomy	Sand	Silt	clay	Organic matter	pH	Base Saturation	ECEC
Crystalline metamorphic and igneous rocks	Typictropaqualfs	69.93	10.56	18.62	2.02	5.90	91.06	6.51
Shale mixed with Sandstone and Clay	Typictropaquults	73.27	6.63	19.81	1.78	5.31	73.54	4.62
Coastal plain sand	Typictropaquults/Typictropaquepts	82.09	3.36	14.90	1.36	5.16	59.72	2.28
Coastal Alluvium	Typictropaquents	79.88	4.77	15.33	3.37	5.01	61.88	3.83
Fresh water swamp	Typictropaquents	81.14	4.00	13.28	1.64	4.92	36.85	2.85

Total Mg content of the soil ranged from 15.00 to 1,425.00 mg/kg with a mean of 223.70 mg/kg. The mean value of the various Mg forms in the surface hydromorphic soils in relation to parent materials are shown in Table 2. Total Mg varied from 81.42 to 475.62 mg/kg on the basis of parent materials. The highest value of total Mg of 475.62 mg/kg was obtained from crystalline metamorphic and igneous rocks which was followed by that obtained from coastal alluvium, shale mixed with sandstone and clay, coastal plain sand and freshwater swamps respectively. Total Mg contents of these soils were influenced by parent materials. The values obtained on the basis of parent materials were higher than that obtained from the distribution of Mg forms in surface soils of Central Southern Nigeria (Osemwota et al., 2009). For soils derived from fresh water swamp, Total Mg was positively and significantly correlated with the silt content of the soils with the 'r' value of 0.725*. The lack of significant correlation among the various Mg forms is an indication that no dynamic equilibrium exist among them, in contrast to the case of potassium (Table 3 and 4). Total Mg was positively and significantly correlated with Mg reserve with 'r' value of 0.341* (Table 4). The soil derived from crystalline metamorphic and igneous rocks were highest in total Mg content, this was expected as they are rich in biotite and hornblende which are Magnesium containing minerals

Table 2: Mean values of various Mg forms in the surface hydromorphic soils in relation to parent materials

Parent material	H_2O Soluble Mg	Exch. Mg	Diff Exch. Mg	Mg Reserve	Total Mg
	←	Cmol/kg	→	←	Mg/kg →
Crystalline metamorphic and igneous rocks	0.14	0.95	1.37	36.59	475.62
Shale mixed with Sandstone and Clay	0.13	0.76	1.25	9.49	161.81
Coastal plain sand	0.17	1.22	0.69	7.69	95.45
Coastal Alluvium	0.25	0.68	0.84	9.55	178.88
Fresh water swamp	0.25	1.07	0.94	9.37	81.42

Table 3: Correlation coefficient (r) of the relationship between the various forms of soil Mg and physico-chemical properties in relation to soil parent materials

Physico-chemical properties/forms of Mg	Crystalline metamorphic and igneous rocks	Shale mixed with Sandstone and Clay	Coastal plain sand	Coastal Alluvium	Fresh water swamps
pH vs H_2O soluble Mg	-0.107	0.020	0.051	-0.468	0.561
pH vs Exch. Mg	-0.114	0.312	0.125	-0.107	-0.398

Table 3 (cont): Correlation coefficient (r) of the relationship between the various forms of soil Mg and physico-chemical properties in relation to soil parent materials					
pH vs Diff. Exch. Mg	0.491	0.335	0.034	0.026	-0.770
ECEC vs H_2O soluble Mg	-0.001	0.119	0.054	-0.083	-0.358
ECEC vs Exch. Mg	0.238	0.511	0.232	-0.281	0.028
ECEC vs Diff. Exch. Mg	0.115	0.460	0.146	-0.056	0.248
Clay vs Diff. Exch. Mg	-0.175	0.488	0.176	-0.006	0.174
Clay vs Mg reserve	-0.035	0.586*	0.037	-0.146	-0.531
Clay vs Total Mg	0.214	0.197	0.041	-0.518	0.404
Silt vs Diff. Exch. Mg	-0.182	0.507	0.374	-0.311	0.523
Silt vs Mg Reserve	-0.275	0.486	0.190	-0.317	-0.208
Silt vs Total Mg	0.237	0.368	0.065	-0.096	0.725*
Organic matter vs $H_2$0 soluble Mg	-0.004	-0.268	0.265	0.818**	-0.259
Organic matter vs Exch. Mg	0.293	0.196	0.197	0.624*	-0.097

Table 4: Matrix of correlation coefficient showing relationships among Magnesium Forms

	$H_2$0 Soluble Mg	**Exch. Mg**	**Diff. Available Mg**	**Mg Reserve**	**Total Mg**
Water soluble Mg	1	0.046	-0.134	-0.016	-0.175
Exchangeable Mg	0.046	1	0.059	0.043	0.044
Difficulty Available Mg	-0.134	0.059	1	0.514***	0.222
Mg Reserve	-0.016	0.043	0.514***	1	0.341***
Total Mg	-0.174	0.044	0.222	0.341***	1

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3.1 Water soluble Mg

Water soluble Mg ranged from 0.080 to 1.04 cmol/kg with a mean of 0.181 cmol/kg. It constituted 0.08% of the total Mg content of the soil. The distribution of the water soluble Mg values on the basis of the parent materials were 0.14, 0.13, 0.17, 0.25 and 0.25cmol/kg for soils derived from crystalline metamorphic and igneous rocks, shale mixed with sandstone and clay, coastal plain sand, coastal alluvium and fresh water swamps respectively. For the soils derived from coastal alluvium, organic matter was positively and significantly correlated with water soluble Mg with ‘r’ value of 0.818.**

3.2 Exchangeable Mg

Exchangeable Mg ranged from 0.160 to 4.56 cmol/kg with a mean of 0.94 cmol/kg. It constituted 0.20% of the total Mg. The distribution of the average exchangeable Mg values on the basis of parent materials were 0.95, 0.76, 1.22, 0.68 and 1.07 cmol/kg for soils derived from crystalline metamorphic and igneous rocks, shale mixed with sand stone and clay, coastal plain sand, coastal alluvium and fresh water swamps respectively. For soils derived from coastal alluvium, organic matter was positively and significantly correlated with exchangeable Mg with ‘r’ value of 0.624*. The range of exchangeable Mg between the lowest and highest values obtained in this study was wider than what was obtained by a group researcher, when they evaluated the distribution of Mg forms in some surface soils of Central Southern Nigeria (Osemwota et al., 2009). Since water soluble Mg plus exchangeable Mg constituted available Mg, 15.4% of the surface soils were deficient in available Mg based on the established critical level of 0.40cmol/kg for Nigerian soils (Lombin, 1974; Adeoye and Agboola, 1985).

Difficulty available Mg ranged from 0.24 to 5.60 cmol/kg with a mean of 1.06 cmol/kg. soils derived from crystalline metamorphic and igneous rocks had the highest mean value of 1.37 cmol/kg, which was closely followed by soils derived from shale mixed with sandstone and clay with a mean value of 1.25 cmol/kg. the soils derived from the rest parent materials appeared not to have much differences in terms of their difficulty available Mg contents (Table 2). When the difficulty available Mg was related to soil properties, pH was positively and significantly correlated with difficulty available Mg with r value of 0.491 for soils derived from crystalline metamorphic and igneous rocks only (Table 3)

Magnesium reserve ranged from 0.40 to 150.70 cmol/kg with a mean of 17.15 cmol/kg respectively. On the basis of parent materials, the average Mg reserve values were 36.59, 9.49, 7.69, 9.55 and 9.33 cmol/kg for crystalline metamorphic and igneous rocks, shale mixed with sand stone and clay, coastal plain sands, coastal alluvium and fresh water swamps, respectively. When related to soil properties, clay was positively and significantly correlated with Mg reserve with ‘r’ value of 0.586* for soils derived from shale mixed with sandstone and clay only (Table 3). Magnesium reserve was positively and significantly correlated with difficulty available Mg with ‘r’ value of 0.514*** (Table 4).

4. Conclusion

Magnesium status in these soils was influenced by parent materials. Soils derived from crystalline metamorphic and igneous rocks appear endowed with difficulty available Mg, Mg reserve and Total Mg. Only 15% of the surface soils were deficient in available Mg based on the established critical level.

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