

Original Research Article

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Characterization of Soil Acidity under Paddy Land Use Cover of Coastal Karnataka

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ABSTRACT

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The study was conducted at coastal zone of Karnataka to characterize the acidity of soils and to assess calcium and magnesium status of soils under paddy land use cover. Soil samples were collected at depth of 0-15cm from paddy growing areas of Dakshina Kannada and Udupi districts. The collected soil sample were processed and analyzed to know the physical and chemical properties of soil, the nature of soil acidity and the status of exchangeable calcium and magnesium in soils. The result from the present investigation revealed that active acidity was ranged from 2.19×10^{-6} to $8.9 \times 10^{-5} \text{ mol H}^+ \text{ L}^{-1}$, exchangeable acidity was in the range of 0.401 to 5.959 $\text{cmol (p}^+) \text{ kg}^{-1}$ g, pH dependent acidity varied from 3.000 to 49.875 $\text{cmol (p}^+) \text{ kg}^{-1}$ and the total potential acidity which included both exchangeable and pH dependent acidity ranged from 4.98 to 50.818 $\text{cmol (p}^+) \text{ kg}^{-1}$. From the investigation we came to know that more than 99.9 per cent of the total acidity in soils was found to be in the form of potential acidity and out of which nearly 8 per cent was in the form of exchangeable acidity. However, the order of distribution of different forms of acidity was found to be as follows; pH dependent acidity>Exchangeable acidity>Active acidity.

Introduction

Soil acidity is one of the factors affecting the availability of Ca and Mg in soils. Availability of Ca and Mg in soils decreases with increase in acidity of soil. Because of low status in exchangeable Ca and Mg and other acid related problems, the productivity of acid soil found to be low.

The soil which is subjected to heavy rainfall resulting in leaching of nutrients such as

potassium, calcium and magnesium and accumulation of oxides of Al and Fe lead to poor soil fertility and low pH. Balasubramanian and Raj (1969) reported that among the different forms of phosphate in laterite soils Fe and Al phosphate occupied major portion than Ca phosphate in those soils.

Owing to low availability of Ca and Mg in acid soils due to soil acidity related problems such as leaching loss of bases and high

concentration of exchangeable Al and low CEC, the productivity of acid soil is found to be low (Craswell and Pushparajah, 1989). Similarly, Haynes and Ludecke (1981) reported that both soluble and exchangeable Ca decreased with decreasing soil pH. Further, at low pH, the bioavailability of Ca was retarded by high concentration of Al. Similarly, low CEC and high saturation of Fe and Al in acid soils, magnesium remained in soil solution and subjected for leaching loss (Edmeades *et al.*, 1985; Myers *et al.*, 1988). Therefore, it is understood that in highly weathered soils the availability of Ca and Mg is insufficient for crop production. Hence, it is very much essential to supply Ca and Mg in the form of liming material to overcome the problems of acid soils and also to increase their production potential.

The area of Coastal zone of Karnataka comprised of 1.17 m. ha which covers areas of Uttar Kannada, Udupi and Dakshina Kannada districts. The annual rainfall ranges from 3010.9 to 4694.4 mm, of which 80 per cent is received during the months of May to October. The elevation of land ranges from 300 to 800 meters. The soils are red lateritic and coastal alluvial and belong to *Ultisols* order. The Major crops grown in this zone are paddy, coconut and areca nut, cashew, pulses, rubber, groundnut and vegetables. Paddy is generally cultivated in three seasons in a year, Karthika or Yenel (May – October), Suggi (October to January) and Kolake (January to April).

Materials and Methods

The present investigation involved a soil survey to know physical and chemical properties, the nature of soil acidity and the status of exchangeable calcium and magnesium in soils under paddy cover of Coastal Karnataka. As a part of the investigation, a survey was conducted to

assess the physical and chemical properties, distribution of different forms of acidity and exchangeable calcium and magnesium status in soil for this 60 and 100 (Total 160) surface soil samples (0 – 15 cm depth) were collected from soils coming under paddy growing areas of Dakshina Kannada and Udupi districts of coastal Karnataka, respectively. The collected samples were processed in the laboratory and preserved for further analysis (Table 1 and 2).

Results and Discussion

Correlation matrix observed between soil physical, chemical properties and forms of acidity in soils paddy cover of Coastal Karnataka

Soil physical properties

From the present investigation it was found that sand had a positive correlation with active acidity ($r = 0.146$) and negative and significantly correlated with silt ($r = -0.429^{**}$), clay ($r = -0.652^{**}$), exchangeable acidity ($r = -0.224^{**}$), pH dependent acidity ($r = -0.199^{*}$), potential acidity ($r = -0.224^{**}$), EC ($r = -0.214^{**}$), organic carbon ($r = -0.188^{*}$), CEC ($r = -0.556^{**}$), exchangeable calcium ($r = -0.200^{*}$) and exchangeable magnesium ($r = -0.370^{**}$).

Silt had a positive and significantly correlation with active acidity ($r = 0.301^{**}$) and positively correlated with exchangeable calcium ($r = 0.045$) and negatively and significantly correlated with clay ($r = -0.406^{**}$), exchangeable acidity ($r = -0.192^{*}$), pH dependent acidity ($r = -0.219^{**}$), potential acidity ($r = -0.237^{**}$), organic carbon ($r = -0.282^{**}$), CEC ($r = -0.185^{*}$) and negatively correlated with EC ($r = -0.106$) and exchangeable magnesium ($r = -0.031$).

Clay positively and significantly correlated with exchangeable acidity ($r = 0.388^{**}$), pH

dependent acidity ($r = 0.385^{**}$), potential acidity ($r = 0.425^{**}$), EC ($r = 0.305^{**}$), organic carbon ($r = 0.427^{**}$), CEC ($r = 0.718^{**}$), exchangeable calcium ($r = 0.165^{*}$) and exchangeable magnesium ($r = 0.400^{**}$) and negative and significantly correlated with active acidity ($r = -0.400^{**}$).

Soil chemical properties

Active acidity

Active acidity had a positive and significant correlation with exchangeable calcium ($r = 0.263^{**}$) and positively correlated with exchangeable magnesium ($r = 0.044$), negative and significantly correlated with exchangeable acidity ($r = -0.540^{**}$), potential acidity ($r = -0.201^{*}$), EC ($r = -0.315^{**}$), organic carbon ($r = -0.440^{**}$) and CEC ($r = -0.471^{**}$) and negatively correlated with pH dependent acidity ($r = -0.117$).

Exchangeable acidity

Exchangeable acidity had a positive and significant correlation with pH dependent acidity ($r = 0.310^{**}$), potential acidity ($r = 0.459^{**}$), organic carbon ($r = 0.433^{**}$) and CEC ($r = 0.724^{**}$), positively correlated with EC ($r = 0.081$), negative and significantly correlated with exchangeable calcium ($r = -0.488^{**}$) and negatively correlated with exchangeable magnesium ($r = -0.146$).

Soil reaction (pH)

pH dependent acidity had a positive and significant correlation with potential acidity ($r = 0.987^{**}$), organic carbon ($r = 0.391^{**}$), CEC ($r = 0.316^{**}$), positively correlated EC ($r = 0.002$), with exchangeable magnesium ($r = 0.002$) and negatively correlated with exchangeable calcium ($r = -0.045$). Potential acidity had a positive and significant correlation organic carbon ($r = 0.438^{**}$) and

CEC ($r = 0.418^{**}$), positively correlated with EC ($r = 0.016$) and negatively correlated with exchangeable calcium ($r = -0.125$) and exchangeable magnesium ($r = -0.023$).

Electrical conductivity

Electrical conductivity had a positive and significant correlation with CEC ($r = 0.232^{**}$) and positively correlated with organic carbon ($r = 0.134$), exchangeable calcium ($r = 0.148$) and exchangeable magnesium ($r = 0.090$). Organic carbon had a positive and significant correlation with CEC ($r = 0.391^{**}$), positively correlated with exchangeable magnesium ($r = 0.095$) and negative and significant correlation with exchangeable calcium ($r = -0.186^{*}$).

CEC had a positive and significant correlation with exchangeable magnesium ($r = 0.389^{**}$) and positively correlated with exchangeable calcium ($r = 0.043$). Exchangeable calcium had a positive and significant correlation with exchangeable magnesium ($r = 0.205^{*}$).

The results of above study indicates that Udupi and Dakshina Kannada districts active acidity in the soils of Udupi and Dakshina Kannada districts is ranged from 2.19×10^{-6} to $8.9 \times 10^{-5} \text{ mol H}^{+} \text{ L}^{-1}$, exchangeable acidity was in the range of 0.401 to 5.959 $\text{cmol (p}^{+}\text{) kg}^{-1}$ g, pH dependent acidity varied from 3.000 to 49.875 $\text{cmol (p}^{+}\text{) kg}^{-1}$ and the total potential acidity which included both exchangeable and pH dependent acidity ranged from 4.98 to 50.818 $\text{cmol (p}^{+}\text{) kg}^{-1}$.

Therefore, it was understood that more than 99.9 per cent of the total acidity in soils was found to be in the form of potential acidity and out of which nearly 8 per cent was in the form of exchangeable acidity.

Table.1 Correlation matrix (‘r’ values) recorded between exchangeable calcium and magnesium, soil properties and forms of acidity in soils under paddy cover of Coastal Karnataka

	Sand	Silt	Clay	AA (pH)	EA	pH DA	PA	EC	OC	CEC	Ex. Ca ²⁺	Ex. Mg ²⁺
Sand	1.000											
Silt	-0.429**	1.000										
Clay	-0.652**	-0.406**	1.000									
AA (pH)	0.146	0.301**	-0.400**	1.000								
EA	-0.224**	-0.192*	0.388**	-0.540**	1.000							
pH DA	-0.199*	-0.219**	0.385**	-0.117	0.310**	1.000						
PA	-0.224**	-0.237**	0.425**	-0.201*	0.459**	0.987**	1.000					
EC	-0.214**	-0.106	0.305**	-0.315**	0.081	0.002	0.016	1.000				
OC	-0.188*	-0.282**	0.427**	-0.440**	0.433**	0.391**	0.438**	0.134	1.000			
CEC	-0.556**	-0.185*	0.718**	-0.471**	0.724**	0.316**	0.418**	0.232**	0.391**	1.000		
Ex. Ca²⁺	-0.200*	0.045	0.165*	0.263**	-0.488**	-0.045	-0.125	0.148	-0.186*	0.043	1.000	
Ex. Mg²⁺	-0.370**	-0.031	0.400**	0.044	-0.146	0.002	-0.023	0.090	0.095	0.389**	0.205*	1.000

(Note:AA: Active Acidity (pH) EA: Exchangeable Acidity, pH DA: pH Dependant Acidity PA: Potential acidity, EC: Electrical Conductivity, OC: Organic carbon, CEC: Cation Exchange Capacity)

Table.2 Exchangeable calcium and magnesium Status (deficient & sufficient) in soils under paddy cover in Coastal Karnataka

District	Udupi	Dakshina Kannada	Total
Calcium			
Total no. of samples analysed	100	60	160
No. of samples recorded above the critical limit of calcium	46 (46.0%)	20 (33.33%)	66 (41.25%)
No. of samples recorded below the critical limit of of calcium	54 (54.0%)	40 (66.67%)	94 (58.75%)
Magnesium			
Total no. of samples analysed.	100	60	160
No. of samples recorded above the critical limit of of magnesium	44 (44.0%)	22 (36.67%)	66 (41.25%)
No. of samples recorded below the critical limit of magnesium	56 (56.0%)	38 (63.33%)	94 (58.75%)

[Note: Critical limits of exch. Ca²⁺ and Mg²⁺ in soils are 2.00 and 0.5 meq 100g, respectively. (Fundamentals of Soil Science, Published by ISSS)]

However, the order of distribution of different forms of acidity was found to be as follows; pH dependent acidity > Exchangeable acidity > Active acidity. High potential acidity in soils may be attributed to the soils are dominated with Fe and Al oxides, kaolinite minerals and medium to high in organic matter status. The above materials saturated with H⁺ and Al³⁺ ions in exchangeable and non exchangeable forms. Further, it is known that the potential acidity is in a dynamic equilibrium with active acidity in soils as a result the pH of soils was found to be low due to high active acidity in soils (Dolui and Sarkar 2001, Arunima *et al.*, 2012 and Chimdi *et al.*, 2012)

In conclusion,

The exchangeable Ca status in soils ranged from 0.58 to 3.86 cmol (p⁺) kg⁻¹ with a mean of 1.88 cmol (p⁺) kg⁻¹ and exchangeable Mg varied from 0.02 to 2.59 cmol (p⁺) kg⁻¹ with a mean of 0.54 cmol (p⁺) kg⁻¹. Further, out of 160 samples analyzed for exchangeable Ca and Mg, 68.75 per cent samples recorded the exchangeable Ca below critical limit (2.0 cmol (p⁺) kg⁻¹). Similarly, 48.75 per cent samples recorded the exchangeable Mg status below the critical limit of Mg (0.5 cmol (p⁺) kg⁻¹).

Soils were fractionated for different forms of acidity and their distribution in soils whereas follows; Active acidity ranged from 2.19 x 10⁻⁶ to 8.9 x 10⁻⁵ mol H⁺ L⁻¹, exchangeable acidity was in the range of 0.401 to 5.959 cmol (p⁺) kg⁻¹, pH dependent acidity varied from 3 to 49.875 cmol (p⁺) kg⁻¹ and total potential acidity which includes exchangeable and pH dependent acidity ranged from 4.98 to 50.818 cmol (p⁺) kg⁻¹. Therefore, it was noticed that more than 99.9 per cent of the total acidity in soils was found to be in the form of potential acidity and out of which nearly 8 percent was in the form of

exchangeable acidity. However, the order of their distribution in soils was found to be as follows; pH dependent acidity > Exchangeable acidity > Active acidity.

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