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# Forms of acidity in some acidic Inceptisols of southern Karnataka

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**Abstract :** Four surface acidic soil samples from southern Karnataka were analyzed to study the nature of soil acidity. Majority of the soils under study were sandy loam in texture with low pH, CEC, base saturation and medium to very high organic carbon status. Total potential acidity values were high ranging from 8.0 to 17.4 cmol ($p^+$) $kg^{-1}$ and exchange acidity values were very low and ranged between 0.20 to 0.45 cmol ($p^+$) $kg^{-1}$, thus contributing very little towards total potential acidity. The pH dependent acidity contributed more than 96 per cent towards total potential acidity. The total acidity extracted by NaOAc ranged between 3.00 and 5.90 cmol ($p^+$) $kg^{-1}$. The extractable acidity values were higher than exchange acidity and ranged from 0.52 to 1.71 cmol ($p^+$) $kg^{-1}$. The values of hydrolytic acidity were higher than the values of exchange and extractable acidity.

**Additional key words:** *Soil classification, land suitability*

## Introduction

Coleman and Thomas (1967) defined soil acidity in terms of KCl extractable and pH dependent acidity. The first type of acidity is ascribed to isomorphous substitution whereas the second type to the polymers of Fe and Al and soil organic matter. The proportion of these two types of acidities determines the production potential as well as lime requirement of these acid soils for amelioration. The soils of southern Karnataka, in general, are acidic with poor base saturation and low exchange capacity. These acid soils come under high humid and heavy rainfall regions and have become acidic due to leaching of bases (Ca, Mg and K) from the soil exchange complex due to high rainfall. These soils are developed from base poor acidic parent material like granite, grano-diorite, granite-gneiss etc. Addition of acid forming fertilizers, intensive cultivation and heavy irrigation also result in the development of acidity in these soils. Hence, these soils are poor in basic cations. Poor growth of crops on these soils is attributed to the presence of toxic amounts of Fe, Al, Mn and deficiency of P, Mo and less activity of soil microorganisms (Ananthanarayana and Manjunatha Prabhu 1992). It is now well recognized that aluminium toxicity is the major cause of reducing crop yield on acid soils having pH less than 5.5 (Foy 1984). Therefore, knowledge of the forms of acidity is the first step in understanding these soils for their improvement. Information on different forms of acidity is available for some Indian soils (Sen *et al.* 1997). The present study is an attempt to characterize soil acidity in some acidic Inceptisols of southern Karnataka.

## Materials and Methods

Surface soil samples belonging to order Inceptisols were collected from three agro-climatic zones in southern Karnataka under different land use. Hassan soil was collected from a wetland rice land use under southern dry zone (agro-climatic zone no. 7), Thirthahally soil from arecanut plantation under hilly zone (agro-climatic zone no. 9) and Kumta and Gundmi soils were collected from cultivated rice fallow land use under coastal zone (agro-climatic zone no. 10), respectively. The annual rainfall varied from 700 to 1800 mm in southern dry zone, 1500 to 3800 mm in hilly zone and 3000 to 4500 mm in coastal zone, respectively (Dhanorkar and Ananthanarayana 2002). Selected physicochemical properties are presented in Table 1. The processed soil samples were analyzed for particle size distribution (pipette method), pH, organic carbon, cation exchange capacity (CEC) (ammonium acetate, pH 7.0) and free oxides of Fe and Al using standard methods (Jackson 1973). Effective cation exchange capacity (ECEC) is determined by the summation of exchangeable cations and extractable $Al^{3+}$ (Sen *et al.* 1997). Lime potential is obtained by subtracting 1.14 from pH (0.01 M $CaCl_2$).

*Forms of soil acidity*: $BaCl_2$ – TEA solution buffered at pH 8.0 $\pm$ 0.02 was used to determine the total potential acidity and exchange acidity was determined by 1 M KCl extractant. The pH dependent acidity was calculated as the difference of these two forms of acidities. Total acidity was determined by 1N NaOAc solution buffered at pH 8.2 and extractable acidity was determined by leaching the soil with $NH_4OAc$ buffered at pH 4.8. Hydrolytic acidity was obtained as the difference between total and extractable acidity (Baruah and Barthakur 1998).

## Results and Discussion

*Physico-chemical characteristics:* The texture was sandy loam in soils of Thirthahally and Gundmi whereas it was sandy clay loam and loamy sand texture in Hassan and Kumta soils, respectively. The clay content was highest (32.4 %) in Hassan soil and varied from 14.1 to 18.6 percent in the remaining soils (Table 1). All the soils were acidic with pH ranging between 4.64 and 6.05. Organic carbon varied from medium to high (6.2 to 15.7 g $kg^{-1}$), highest organic carbon content being noticed in Kumta soil (15.7 g $kg^{-1}$), followed by Hassan soil (10.1 g $kg^{-1}$). The free oxides of Fe and Al were high due to higher solubility of Fe and Al in these soils. The values of CEC and ECEC were low and varied from 10.30 to 22.10 and 3.05 to 5.33 cmol ($p^+$) $kg^{-1}$, respectively. The lime potential values were high (ranging between 2.76 and 4.09) and base saturation percentage varied from 19 to 34 percent. Low CEC values in the soils may be due to many factors *viz.* acidic parent material, coarser texture, high rainfall resulting in leaching of bases.

**Table 1.** Selected physicochemical characteristics of soils

| Location | Soil sub group | Texture | Clay (%) | pH | Organic Carbon (g $kg^{-1}$) | Free oxides (%) $Fe_2O_3$ | Free oxides (%) $Al_2O_3$ | CEC [c mol ($p^+$) $kg^{-1}$] | ECEC [c mol ($p^+$) $kg^{-1}$] | Lime potential | **Base saturation (%)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hassan (District: Hassan) | Typic Dystrustepts | scl | 32.4 | 6.05 | 10.1 | 2.98 | 0.08 | 22.10 | 4.33 | 4.09 | 22 |
| Thirthahally (District: Shimoga) | Fluventic Haplustepts | sl | 18.6 | 5.47 | 7.4 | 2.33 | 0.17 | 10.30 | 3.09 | 3.27 | 34 |
| Kumta (District: Uttara Kannada) | Typic Dystrustepts | ls | 14.1 | 5.19 | 15.7 | 4.28 | 0.13 | 11.20 | 4.85 | 3.37 | 28 |
| Gundmi (District: Udupi) | Typic Dystrustepts | sl | 18.0 | 4.64 | 6.2 | 3.24 | 0.04 | 12.40 | 3.05 | 2.76 | 19 |

**Table 2.** Forms of acidity in experimental soils

| Location | Different forms of acidity [c mol ($p^+$) $kg^{-1}$] | | | | | |
|---|---|---|---|---|---|---|
| | Total potential acidity | Exchange acidity | pH dependent acidity | Total acidity | Extractable acidity | Hydrolytic acidity |
| Hassan (District: Hassan) | 12.60 | 0.20 | 12.40 | 3.00 | 0.52 | 2.80 |
| Thirthahally (District: Shimoga) | 17.40 | 0.25 | 17.15 | 5.90 | 1.71 | 5.65 |
| Kumta (District: Uttara Kannada) | 15.00 | 0.25 | 14.75 | 4.80 | 0.67 | 4.55 |
| Gundmi (District: Udupi) | 8.00 | 0.45 | 7.55 | 3.60 | 0.66 | 3.15 |

*Different forms of acidity:* Various forms of acidity of the soils are presented in Table 2. The total potential acidity values were high and ranged from 8.0 to 17.4 cmol ($p^+$) $kg^{-1}$ in these soils. The lowest value of total potential acidity [8.0 cmol ($p^+$) $kg^{-1}$] was noticed in Gundmi soil and the highest value of 17.4 cmol ($p^+$) $kg^{-1}$ was observed in Thirthahally soil followed by Kumta and Hassan soils. The exchange acidity in the soils ranged between 0.20 and 0.45 cmol ($p^+$) $kg^{-1}$. The higher values of total potential acidity may be due to higher percentage of organic matter in the soils which contributed to total potential acidity through their functional groups like carboxylic and phenolic hydroxyl groups (Das *et al.* 1991). Sharma *et al.* (1990) attributed the higher total potential acidity values to the higher content of Al on the soil exchange complex and organic matter contents of the soils.

The magnitude of pH dependent acidity obtained by subtracting exchange acidity from total potential acidity, ranged between 7.55 to 17.15 cmol ($p^+$) $kg^{-1}$, thus contributing in larger proportions (more than 94 to 98 %) towards total potential acidity. The contribution made by exchange acidity towards total potential acidity is low (2 to 6 %). Misra *et al.* (1989) also reported relatively low contribution of exchange acidity towards total potential acidity. They reported that higher contribution made by pH dependent acidity may be due to higher value of pH dependent charges associated with increased Fe and Al oxides and organic matter in the soils.

The total acidity in the soils ranged from 3.00 to 5.90 cmol ($p^+$) $kg^{-1}$. Highest value of total acidity was noticed in Thirthahally soil [5.90 cmol ($p^+$) $kg^{-1}$] followed by Kumta soil [4.80 cmol ($p^+$) $kg^{-1}$] and lowest value [3.00 cmol ($p^+$) $kg^{-1}$] was observed in Hassan soil followed by Gundmi soil, respectively. Extractable acidity was higher than exchange acidity and ranged from 0.52 to 1.71 cmol ($p^+$) $kg^{-1}$ in the soils. Highest value of 1.71cmol ($p^+$) $kg^{-1}$ was noticed in Thirthahally soil. Adhikari and Si (1991) also reported higher values of extractable acidity in acid soils of West Bengal. Sharma *et al.* (1990) reported that soils containing little amount of exchangeable Al also indicated fairly good amount of extractable acidity.

Misra *et al.* (1989) suggested that the source of extractable acidity might be from clay mineral structure, hydroxyl polymeric interlayer Al, dissolution of gibbsitic minerals or from discrete non-crystalline Al phase. The pH 4.8 $NH_4OAc$ suggested as a source of standard extractant, extracts exchangeable Al and soluble or reactive portion of the hydroxyl Al ions which may be strongly adsorbed on clay surface or between clay layers. Hence, it indicates that $Al^{3+}$ combined with organic matter was not participating directly in controlling pH of these soils.

The magnitude of hydrolytic acidity values obtained by subtracting the exchange acidity from total acidity followed the trend of total acidity values and ranged between 2.80 to 5.65 cmol ($p^+$) $kg^{-1}$. The trivalent Al contributed a major portion of this form of acidity and as such the values were higher than the exchange and extractable acidity. This may be due to partial hydrolysis of trivalent Al. Singh and Aleoshin (1983) while working on acid soils of former USSR, also noted that, portion of hydrolytic acidity was higher than exchange acidity.

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