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Characterization of acidity in the Northern Kole land of Kerala

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Abstract
The acidity characteristics of northern Kole land of Thrissur district in Kerala were studied in detail by collecting the soil samples at 0-30 depth from 10 locations in Pavutai padashekharam of Mullasseri block. The soils were strongly acidic with a pH range of 5.22 to 5.59 with an average of 5.42. The potential acidity was relatively high and ranged from 21.24 to 35.01 meq 100 g^{-1} followed by pH dependent acidity (19.79-32.19 meq 100 g^{-1}) whereas the exchangeable acidity ranged between 1.28-2.82 meq 100 g^{-1}. The pH dependent acidity was contributing in larger proportions toward total potential acidity (87.9-97.5%) whereas exchangeable acidity contributes slightly (4.3-9.09%). The exchangeable acidity was dominantly contributed by exchangeable Al and less contributed by exchangeable H^+. Active acidity represented least portion of the soil acidity and ranged between 4.4–5.07 pH. For acidity management, it is relevant to consider all the forms of acidity.

Keywords: Acidity, Kole land, potential acidity, pH dependent acidity, exchangeable acidity, exchangeable aluminium, active acidity

1. Introduction
Kole land is the largest and unique wetland of Kerala. A peculiar type of cultivation is practiced in the above land *i.e.*, for almost six months, a portion of this land lies submerged under water (Sreenivasan, 2011) [17], and in the summer months, farmers dewater and bund the fields for the cultivation of paddy. It is found that soil acidity in the above land is a severe cause of limiting crop growth and productivity (Thomas *et al*, 2003) [15]. The acidity along with the toxicity of aluminum and iron which are recognized as the major problem in rice production which in turn affect the root activity (Sahrawat. 2005) [12]. To cope with the food requirement of the state, it is necessary to enhance the productivity of rice in Kole lands. Hence, for sustaining rice production, the knowledge of the different forms of acidity and their contribution to pH is the first step in understanding these soils for their improvement. Here comes the importance of characterization of soil acidity in the Kole land of Kerala. Soil acidity comprises active acidity and potential acidity (Brady, 1991) [3]. Total potential soil acidity was defined by Coleman and Thomas (1967) [5] in terms of exchangeable acidity (KCI extractable) and pH-dependent acidity. The first type of acidity is attributed to isomorphous substitution, while the second type is attributed to Fe and Al polymers and soil organic matter. The proportion of these two types of acidities determines the acid soil's production potential as well as the lime requirement for amelioration. The present study is an attempt to characterize the soil acidity in the northern Kole land of Kerala.

2. Materials and Methods
The study was confined to the Mullasseri block in the Northern Kole lands of the Thrissur district in Kerala (plate 3.1). As part of the study, sampling was done in the post-monsoon season, October 2019 from ten selected locations of the Pavutai Padashekharam before the cultivation of the crop. The GPS details of the locations are presented in table 1. Representative soil samples at 0-30 cm depth were collected in polythene bags and labeled with the name of each site and sample number. These were brought to the College of Agriculture, Vellanikkara, and stored in clean airtight containers and the wet analysis was performed to find out the pH and different forms of acidity.

2.1 Soil pH
The pH of the soils was determined in a 1:2.5 soil water suspension, potentiometrically with the help of a pH meter (Jackson, 1973) [9].

Plate 3.1: General view of Kole land at Pavutai of Mullaseri block

2.2 Forms of acidity

Active acidity was recorded as the pH of the equilibrated solution of soil with 0.01 $CaCl_2$ (1: 2.5 soil – solvent ratio) (Jackson, 1973) [9]. The sum of total H^+ and Al^{3+} retained on the soil exchange complex makes up the exchangeable acidity of the soil. The ions exchanged by neutral salt solution were extracted by shaking 20 gm of soil with 50 mL 1N KCl solution for 30 minutes. After filtering the extract, the measured quantity of extract (20 ml) was titrated against 0.025 N NaOH with phenolphthalein as an indicator. Before titration, the measured quantity of filtrate was heated to the boiling temperature to derive off the CO_2. The titer value was noted at an end point of pink colouration (Baruah and Barthakur, 1999) [1]. Exchangeable Al^{3+} in the KCl extract was determined by adding 5 ml of freshly prepared 1 N NaF and kept it for 5 minutes and then titrated against 0.025 N H_2SO_4 till the pink colour disappears. Exchangeable H^+ is expressed as the difference between exchangeable acidity and exchangeable aluminium. Potential acidity comprises all the components of acidity**.** Ten gm of soil was weighed in 250 ml conical flask, added 100 ml extracting solution (0.5 N $BaCl_2$ and 0.055 N triethanol amine adjusted to a pH 8-8.2). Then the contents were shaken for half an hour and allowed to stand overnight. Filtered the contents through Whatmann No. 42 filter paper and continued the leaching of soil by adding a small amount of extracting solution. Then the leachate was transferred to a 250 ml volumetric flask and made the volume up. Then it was transferred into 500 ml conical flask and 5 drops of mixed indicator solution was added. Then titrated it against 2N HCl to a pink end point. A blank value was also recorded by titrating 250 ml of the original extracting solution (Baruah and Barthakur, 1999) [1]. PH dependent acidity is computed by deducting exchangeable acidity from potential acidity.

2.3 Statistical analysis

The data obtained were analysed using excel for descriptive statistical analysis and OPSTAT software to know the correlation among the different forms of acidity as well as soil pH.

Table 1: Location details of the sampling sites in Pavutai Padassekharam along with pH

S. No	North latitude	East longitude	pH
1	10.323987	76.632840	5.22
2	10.324046	76.632357	5.42
3	10.324068	76.631341	5.49
4	10.324024	76.630467	5.51
5	10.323975	76.629725	5.54
6	10.323910	76.629855	5.59
7	10.323796	76.630152	5.36
8	10.323789	76.629687	5.29
9	10.323744	76.630922	5.32
10	10.323930	76.633175	5.45

3. Results and Discussion

The soil samples collected from the study area post-monsoon season were tested for pH and found that the pH was ranging from 5.22 to 5.59 with an average of 5.42 (Table 1). It indicated that the sampling area was strongly acidic in reaction. Brady and Weil. (2008) [4] indicated that soil acidity is a major constraint in tropical regions of the world where high precipitation has been a dominant influence on the pedogenic development of the soil. Johnkutty and Venugopal (1993) [10] conducted a detailed study in the Kole lands of Kerala and revealed that the soils of the Kole area, generally, are acidic with pH ranging from 2.6 to 6.3. The pH decreased with depth in the profile. The low pH of soils in the deep layers of the profile is clearly owing to the action of organic matter. But, the washing away of active acidity during monsoon and continuous submergence during cropping season may be the reason slight reduction in acidity.

Table 2: Forms of acidity in soil samples

S. No.	Potential acidity (meq 100 g^{-1})	pH Dependent acidity (meq 100 g^{-1})	Exchangeable acidity (meq 100 g^{-1})	Exchangeable Al (meq 100 g^{-1})	Exchangeable H^+ (meq 100 g^{-1})	Active acidity (pH)
1	35.01	32.19	2.82	1.89	0.93	4.40
2	25.34	23.29	2.05	1.29	0.76	4.54
3	25.51	23.90	1.61	1.14	0.47	4.73
4	24.84	23.07	1.77	1.30	0.47	4.57
5	21.24	19.79	1.45	1.05	0.40	4.87
6	22.40	21.11	1.29	0.87	0.42	5.08
7	29.19	26.74	2.45	1.74	0.71	4.61
8	33.98	31.30	2.68	1.87	0.82	4.46
9	30.47	27.90	2.57	1.80	0.77	4.45
10	26.79	25.01	1.78	1.44	0.33	4.62
Mean	27.48	25.43	2.05	1.44	0.61	4.63

3.1 Forms of acidity

Different forms of acidity are depicted in table 2. The total potential acidity values were high and ranged from 21.24 to 35.01 meq 100 g^{-1} followed by pH dependent acidity ranged from 19.79 to 32.19 (meq 100 g^{-1}) whereas the exchangeable acidity ranged between 1.28 and 2.82 meq 100 g^{-1}. The higher pH dependent acidity values could be attributed to a higher percentage of organic matter as well as higher Fe and Al oxides and hydroxides in the soils contributed via functional groups such as carboxylic and phenolic hydroxyl groups (Das *et al.* 1991 [6]; Sharma *et al.* (1990) [13]. pH dependent acidity contributes in larger proportions toward total potential acidity (87.9-97.5%) whereas exchangeable acidity contributes little to total potential acidity (4.3 -9.09%). Misra *et al.* (1989) also reported a relatively low contribution of exchangeable acidity towards total potential acidity. They suggested that the major contribution of pH dependent acidity may be owing to the higher value of pH dependent charges connected with increased Fe and Al oxides, the presence of low-activity clays, and organic matter in the soils. The exchangeable acidity was comprised of exchangeable Al and exchangeable H^+. Exchangeable Al ranged from 0.87 to 1.89 meq 100 g^{-1} and exchangeable H^+ ranged from 0.33 to 0.93 meq 100 g^{-1}. The exchangeable acidity was dominantly contributed by exchangeable Al and less contributed by exchangeable H^+. Sharma *et al.,* (1990) [13] found that electrostatically bonded hydrogen and electrostatically bonded, aluminium comprises 21 and 79 percent of exchangeable acidity. The amount of H^+ ion activity in the entire solution at any given time is measured as active acidity and it represents the least portion of the soil acidity. It ranged from 4.40 to 5.07 pH. About pH and its relationship with hydrogen and aluminium, Yuan (1963) [16] stated that pH expressed that part of acidity that is present in the equilibrium system with the H^+ ions that have dissociated to varying degrees from the soil complex. And potential acidity was the maximum.

Table 3: Descriptive statistical values of acidity fractions of soils under study

S. No.	Parameter	Mean	Range		Std deviation
			Min	Max	
1	Potential acidity (meq 100 g^{-1})	27.48	21.24	35.01	4.61
2	pH dependent acidity (meq 100 g^{-1})	25.43	19.79	32.19	4.09
3	Exchangeable acidity (meq 100 g^{-1})	2.05	1.28	2.82	0.54
4	Exchangeable Al (meq 100 g^{-1})	1.44	0.87	1.89	0.36
5	Exchangeable H^+ (meq 100 g^{-1})	0.61	0.33	0.93	0.21
6	Active acidity (pH)	4.63	4.40	5.07	0.20

3.2 Correlation among different forms of acidity and soil pH

The correlation coefficients among pH and different forms of acidity in soils are given in table 4. Correlation studies revealed that all the forms of acidity were significantly and negatively correlated with soil pH. Soil pH showed a significant negative correlation with potential acidity (-0.963**), pH dependent acidity (-0.953**), exchangeable acidity (-0.983**), exchangeable Al (-0.958**) and exchangeable H^+ (-0.892**). Active acidity as it is expressed in pH, was significantly and positively correlated with pH (0.863**). All forms of acidity were significantly and positively correlated with each other. It was indicated that there exists a significantly strong positive correlation between potential acidity and pH dependent acidity (0.999**) and exchangeable acidity (0.946**), exchangeable Al (0.0.942**), exchangeable H^+ (0.825**) and active acidity (0.809**). Exchangeable acidity was significantly positively correlated with Ex Al (0.972**), Ex H^+ (0.912**), and active acidity (0.868**). Exchangeable Al and Ex H^+ showed significant positive correlation with active acidity with r of 0.874** and 0.738* respectively. The higher contribution of pH dependent acidity to the total potential acidity may be owing to variable charge due to higher organic matter content and sesquioxide present in soils, and the presence of low activity clays (Hoyt 1977) [8]. Dewan (1966) [7] proposed that exchangeable Al is the predominant source of acidity, indicated by soil pH in kaolinite or vermiculite-rich soils. Bloon *et al.* (1979), stated the activity of ($A1^{3*}$) in soil solution as function of soil pH was dependent on the transfer of aluminium ions from organic matter to the exchange sites on the clay surfaces. In the acid soils, Al is present either as adsorbed on the negative side of colloids or as the aluminium or aluminium hydroxy cations. Under acidic conditions, these are much soluble and contribute to soil acidity through their tendency to hydrolyse.

The basic chemistry of aluminium in soil acidity involved in that, hydrogen-saturated clay decomposes spontaneously and the ion of hydrogen enters the octahedral layer and replaces the Al atoms. The Al released is then adsorbed by the clay complex, resulting in the rapid formation of an H-Al-clay complex. Al ions may hydrolyze and generate H^+ ions.

Clay Al + 3 H^+-> Al $(OH)_3$ + H Clay <=> H^+.

Table 4: Correlation (r) among forms of acidity and soil pH

	Pot. acidity	pH dep acidity	Ex acidity	Ex Al	Ex H^+	Active acidity	pH
Pot. acidity	1.000						
pH dep acidity	0.999**	1.000					
Ex acidity	0.946**	0.932**	1.000				
Ex Al	0.942**	0.930**	0.972**	1.000			
Ex H+	0.825**	0.807*	0.912**	0.790*	1.000		
Active acidity	0.809*	0.794**	0.868**	0.874**	0.738*	1.000	
pH	-0.963**	-0.953**	-0.983**	-0.958**	-0.892**	-0.863**	1.000

4. Conclusion

From the above investigation, it was evident that, potential acidity was the highest among the different forms of acidity, with pH-dependent acidity contributing the large portion and exchangeable acidity contributing the least. The exchangeable acidity was dominated primarily by exchangeable Al and to a lesser extent by exchangeable H^+. The soil acidity was contributed by all forms of acidity and hence for acidity management, it is essential to consider all the forms of acidity not only the pH.

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