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Short Communication

Characterization of soil acidity under different land uses in Assam

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Problem of soil acidity is acute in Assam (Sen *et al.* 1997), where most of the soils are predominantly acidic in nature. The rapid weathering and intense leaching under high rainfall condition favours the development of soil acidity. Besides uncontrollable climate, geological and environmental factors, land use also affect the acidity. Soil acidity is an important agricultural problem leading to severe toxicity of iron, aluminium and manganese, in many crops, coupled with deficiency of phosphorus and low microbial activity that led to poor yield of crops. Present study aimed at understanding the nature of acidity in different land use system of Jorhat district in Assam.

The study was carried out in Katonigaon Panchayat, Titabar Block, Jorhat district, Assam, extending between 26°37′20" to 26°37′45" N latitudes and 94°22′00" to 94°23′00" E longitudes covering an area of 475 ha. The climate of the area is humid subtropical. The mean winter and summer air temperatures are 17.0°C and 28.7°C respectively. Annual rainfall is 2250 mm. Geologically most part of the study area is covered by alluvium deposited by the river Brahmaputra and its tributaries. Three pre-dominant land uses *viz.* fallow, cultivated and tea plantation were chosen for profile. pH, organic carbon, exchangeable cations (CA and Mg) and CEC of the soils were analysed by standard methods. The exchangeable acidity, extractable acidity and total potential acidity were determined by the method described by Baruah and Barthakur (1997). The non-exchangeable acidity was estimated indirectly as, Non-exchangeable acidity = Extractable acidity – Exchangeable acidity, The pH-dependent acidity was estimated by the following equation and pH-dependent acidity = Total potential acidity – Exchangeable acidity.

Some relevant physical and chemical characteristics of the soils are presented in table 1. Soils of fallow lands were moderately acidic (pH 5.0 to 5.5). The soils supporting forest and tea plantation had strongly acidic (pH 4.4 to 4.6) whereas paddy-growing soils were strongly to moderately acidic (pH 4.4 to 5.4). However, in all the cases, ΔpH (pH_{KCl} – pHH_2O) was always negative indicating that the soil colloid has a net negative charge and all the soils contain considerable amount of acidity (Gangopadhyay *et al.* 2008). The organic carbon content of the soils varied from 0.13 to 0.89%. The organic carbon content was high at the surface and decreased with depth except cultivated soils due to fluvial process. The organic carbon content of soils under fallow, cultivated and tea garden varied from 0.19 to 0.84%, 0.26 to 0.89% and 0.13 to 0.69%, respectively. Soils of fallow and cultivated land were sandy loam to silt loam, whereas tea garden soils were sandy loam to loam in texture. Soils of cultivated and fallow land recorded higher CEC and Ca+Mg as compared to tea garden soils. The high base saturation value of the cultivated soil particularly in surface and sub-surface horizon is mainly due to deposition of bases washed out from the surrounding upland.

Table 1. Properties of soils under different land use

Depth (cm)	pH (1:2.5) Water	pH (1:2.5) 1*M* KCl	OC (%)	CEC	Exch.Ca	Exch.Mg	Sand	Silt	Clay	Textural Class
				---------- $cmol(p^+)kg^{-1}$	----------	----------	------------	%	------------	
Pedon1: Fallow										
0-18	5.5	4.6	0.84	12.2	3.0	5.2	31.8	54.5	13.7	Silt loam
18-53	5.0	3.8	0.22	8.5	1.1	3.2	43.2	39.2	17.6	Sandy loam
53-81	5.1	3.8	0.19	12.2	2.9	2.4	59.9	29.5	10.6	Sandy loam
81-117	5.1	3.8	0.26	9.4	1.6	2.9	33.7	54.2	12.1	Silt loam
117-141	5.2	3.7	0.24	13.4	4.9	3.8	16.6	66.6	16.8	Silt loam
141-157	5.3	3.8	0.39	11.7	3.7	4.0	15.0	66.0	19.0	Silt loam
Pedon 2: Cultivated										
0-15	5.0	3.8	0.37	5.4	0.8	1.1	44.2	51.1	4.7	Silt loam
15-41	5.3	4.2	0.41	7.5	2.1	2.7	58.8	36.1	5.1	Sandy loam
41-74	5.4	4.0	0.45	10.7	3.3	5.2	20.5	62.8	16.7	Silt loam
74-127	5.4	4.0	0.35	11.2	4.0	4.9	12.5	71.4	16.1	Silt loam
127-162	5.2	3.8	0.26	9.1	1.6	3.3	61.4	36.4	2.2	Sandy loam
162-180	4.4	3.4	0.89	11.0	2.1	3.7	26.3	62.7	11.0	Silt loam
Pedon 3: Tea plantation										
0-18	4.4	3.7	0.69	6.7	0.6	0.6	51.1	43.6	5.3	Sandy loam
18-48	4.4	3.7	0.45	3.2	0.3	0.5	48.4	38.5	13.1	Loam
48-80	4.4	3.7	0.26	5.9	0.2	0.6	44.4	38.6	17.0	Loam
80-122	4.4	3.7	0.37	6.2	0.2	0.5	51.6	35.7	12.7	Sandy loam
122-166	4.6	3.7	0.13	5.3	0.3	0.8	37.3	50.4	12.3	Loam

The exchangeable acidity of soils varied from 0.18 to 2.24 $cmol(p^+)kg^{-1}$ (Table 2) and it decreased gradually with depth. The higher value of exchangeable acidity was observed in soils of tea plantation than the paddy-growing soils. (Patton *et al.* 2007) for Nagaland soils under different land use pattern. The contribution of exchangeable acidity to total potential acidity ranged from 3.2 to 36.9%. These results are similar to the findings of Sen *et al.* (1997). However, it is varied from 3.2 to 27.4% for fallow land, 6.5 to 32.5% for cultivated and 27.7 to 36.9% for tea plantation soils.

Table 2. Forms of acidity under different land use

Depth (cm)	Exch. H^+	Exch. Al^{3+}	Exch. acidity	Non-exch. acidity	Extractable acidity	pH-dependent acidity	Total potential acidity
	cmol(p^+)kg^{-1}						
Pedon1: Fallow							
0-18	0.18	-	0.18	0.17	0.35	5.36	5.54
18-53	0.28	0.89	1.17	0.86	2.03	4.27	6.65
53-81	0.71	0.68	1.39	0.17	1.56	2.07	4.98
81-117	0.73	0.60	1.33	0.16	1.49	2.54	5.54
117-141	0.75	0.39	1.14	0.22	1.36	5.76	7.20
141-157	0.64	0.14	0.78	0.11	0.89	5.57	6.65
Pedon2 : Cultivated							
0-15	0.90	-	0.90	0.14	1.04	1.87	2.77
15-41	0.36	-	0.36	0.05	0.41	1.86	2.22
41-74	0.36	-	0.36	0.33	0.69	4.07	4.43
74-127	0.34	-	0.34	0.18	0.52	3.89	4.43
27-162	0.18	-	0.18	0.57	0.75	2.59	2.77
162-180	0.12	1.05	1.17	0.80	1.97	7.90	9.97
Pedon3 : Tea plantation							
0-18	0.18	1.20	1.38	0.38	1.76	2.61	4.99
18-48	0.04	1.80	1.84	0.24	2.08	3.15	4.99
48-80	0.15	1.60	1.75	0.61	2.36	3.90	6.65
80-122	0.12	1.91	2.03	0.34	2.37	3.06	6.09
122-166	0.22	2.02	2.24	0.18	2.42	3.01	6.65

The extractable acidity of soils varied from 0.35 to 2.42 cmol(p^+)kg^{-1} and irregularly distributed throughout the profiles. The higher value of extractable acidity was recorded in tea plantation soils [1.76 to 2.42 cmol(p^+)kg^{-1}] as compared to fallow land [0.35 to 2.03 cmol(p^+)kg^{-1}] and cultivated [0.41 to 1.97 cmol(p^+)kg^{-1}]. The contribution of extractable acidity to total potential acidity ranges from 6.3 to 41.7% and tea plantation soils had highest contribution due to low pH values and high exchangeable and extractable Al content.

The non-exchangeable acidity of soils varied from 0.05 to 0.86 cmol(p^+)kg^{-1} and irregularly distributed throughout the profiles. The mean values of non-exchangeable acidity was higher in soils of tea plantation than cultivated and fallow lands and it varied from 0.18 to 0.61, 0.05 to 0.80 and 0.11 to 0.86 cmol(p^+)kg^{-1} respectively. The contribution of non-exchangeable acidity towards total potential acidity ranged from 1.6 to 20.6%. However, the same varied from 1.6 to 12.9% for fallow land, 2.3 to 20.6% for cultivated and 2.7 to 9.2% for tea plantation soils.

The pH-dependent acidity ranged from 2.07 to 5.76 cmol(p^+)kg^{-1} for fallow soils, 1.87 to 7.90 cmol(p^+)kg^{-1} for cultivated soils and 2.61 to 3.90 cmol(p^+)kg^{-1} for tea soil. The pH-dependent acidity increased irregularly with depth. The pH-dependent acidity contributed significantly towards the potential acidity (41.6 to 96.7%). Similar results have also been observed by Bandyopadhyay and Chattopadhyay (1997). The contribution of pH-dependent acidity to total potential acidity followed the sequence: fallow soils (41.6 to 96.7%) > cultivated soils (67.5 to 93.5%) > tea soils (45.3 to 63.1%).

Total potential acidity of the soils varied from 2.77 to 9.97 cmol$(p^+)kg^{-1}$. Its higher value is mainly related to high content of organic carbon and clay of the different horizons of the profiles. The organic matter might have contributed significantly to total potential acidity through their functional groups like –COOH and phenolic - OH.

Correlation between soil properties and forms of acidity of both surface and sub-surface soil samples have been shown in table 3. It was observed that the pH (pH_w and pH_k) had significant negative correlation with all types of acidity viz. exchangeable acidity (–0.824** and –0.636**), extractable acidity (–0.787** and –0.725**) and total potential acidity (–0.068 and –0.486*). Similar findings have been also reported by Kumar *et al.* (1995) and Dolui and Karak (2000). Clay had significant positive correlation with pH-dependent acidity (0.549*). CEC, exchangeable Ca and Mg had highly significant and negative correlation with exchangeable and extractable acidity. These results are in accordance with those of Sen *et al.* (1997). The total potential acidity had significant positive correlation with extractable acidity (0.571*) and pH-dependent acidity (0.793**). Since the pH-dependent acidity and total potential acidity are in a dynamic equilibrium, they are related to each other. Similar findings are also reported by Dolui *et al.* (2010).

Table 3. Correlation matrix for different forms of acidity and physicochemical properties

Soil Properties	Forms of acidity				
	Exchangeable acidity	Non-exchangeable acidity	Extractable acidity	pH-dependent acidity	Total potential acidity
pH_w	–0.824**	–0.126	–0.787**	0.394	–0.068
pH_k	–0.636**	–0.448	–0.725**	–0.136	–0.486*
Organic carbon	–0.289	0.152	–0.210	–0.503*	0.241
Clay	0.159	0.085	0.172	0.549*	0.574*
Exchangeable Ca	–0.616**	–0.301	–0.658**	0.448	0.062
Exchangeable Mg	–0.791**	–0.026	–0.723**	0.514*	0.051
CEC	–0.557*	–0.056	–0.522*	0.530*	0.245
Exchangeable acidity	1.00	0.119	0.943**	–0.121	0.458
Non-exchangeable acidity		1.00	0.443	0.399	0.469
Extractable acidity			1.00	0.025	0.571*
pH-dependent acidity				1.00	0.793**
Total potential acidity					1.00

*Significant at the 0.05 level, **Significant at the 0.01 level

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