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Impact of salinity protection by barrage on the acidity characteristics of an acid sulphate soil of Kerala

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Abstract

An investigation was carried out in rice supporting acid sulphate soils occurring in Kuttanad belt of Kerala which has been protected from salinity intrusion for the past twenty five years, by constructing a regulator across the lake through which the sea water enters and spread to the study area. The present paper indicates the acidity status of different soil layers on the upstream side of the regulator and how the acidity varies in accordance with the season and the closure of the regulator by analysing 15 soil profiles and 97 surface samples collected during pre-monsoon, monsoon, post-monsoon and summer seasons. Ninety per cent of the study area belongs to the soil order Entisols, dominated by the Typic Sulfaquents subgroup and the rest to Inceptisols. The other subgroups identified are Typic Tropopsamments, Typic Tropofluvents, Typic Fluvaquents and Fluventic Dystropepts. Among the subgroups, Typic Sulfaquents recorded the highest values for different forms of acidity. An increase in acidity was compared to fire barrage period was observed. The season and the closure of the regulator had influenced the soil acidity components in almost similar way in all the subgroups recording the maximum values during summer and minimum during monsoon season.

Key words : Potential acidity, hydrolytic acidity, seasons.

Introduction

The poor soil and hydrological conditions of acid sulphate soils made them to popular rice soils since the crop can withstand the above situations. In India such soils are present in coastal areas of Kerala, Tamil Nadu, Andhra Pradesh and West Bengal. Kuttanad, one of the major rice belts of Kerala, where the soils are severely acidic due to the presence of pyretic materials in sub-soil and highly saline due to tidal inflow from sea. To protect the rice crop from saline water intrusion during summer a regulator was constructed across the Vembanad lake and kept it closed during December to May. This was an annual phenomenon from 1976 onwards. Closure of the regulator has blocked the tidal flushing of the tract, which was a successful mechanism for the control of salinity. Moreover this has resulted in the lowering of the water table on the upstream side of the regulator where Kuttanad is located. The lowering of water table favours the enhancement of soil acidity due to soil drying. Information on the variation in acidity characteristics in response to the salinity protection are meager. The present paper indicates the acidity status of different soil layers on the upstream side of the regulator and how it varies with season and closure of the regulator.

Materials and methods

Fifteen soil profiles during the summer season and 97 surface soil samples during pre-monsoon, monsoon, post-monsoon and summer seasons were collected from 10,000 ha of rice soils in North Kuttanad. Horizonwise soil samples were collected from each pedon after its morphological examination. About 72 per cent of the tract belongs to soil subgroup Typic Sulfaquents and seven per cent each to Typic Tropopsamments, Typic Fluvaquents, Typic Tropofluvents and Fluventic Dystropepts. Standard procedures were followed for the determination of mechanical composition (Black *et al.* 1965), pH, EC (1:2.5 soil-water) and organic carbon (Jackson 1973). Potential acidity of the soil was estimated from the 0.5 M $BaCl_2$ + 2 M Triethanolamine extract at pH 8.2 (Mehlich 1953) and exchangeable acidity, exchangeable H^+ and exchangeable Al^{3+} from the KCl extract (Yuan 1959). Hydrolytic acidity was calculated from the difference between the potential and exchangeable acidity. Soils were classified as per Soil Taxonomy (Soil Survey Staff 1987).

Results and discussion

Acidity characteristics : The soils of the area were categorized into Entisol and Inceptisol. More than 90 per cent of the area belongs to Entisols, out of which 80 per cent is represented by Typic Sulfaquent subgroup. The other sub-groups identified are Typic Tropopsamments, Typic Fluvaquents, Typic Tropofluvents and Fluventic Dystropepts. The selected soil properties are presented in table 1 and the acidity characteristics in table 2. Among the sub-groups Typic Sulfaquents recorded the highest values for all acidity characteristics due to the presence of large quantities of sulphidic materials which on oxidation produces free sulphuric acid (Iyer 1989). The potential and hydrolytic acidities were found to increase with depth in Typic sulfaqueants up to the 2C1 horizon, which recorded the highest value of 94.1 cmol (+) kg^{-1} followed by a decrease in the 2C2 horizon. Eighty to ninety per cent of potential acidity was contributed by hydrolytic acidity. Adhikari and Si (1991) also reported that exchangeable acidity is rather low in acid soils, and the nature of soil acidity is mostly pH dependent. The exchangeable acidity showed a quite different pattern, recording higher values in surface soils. The surface layers might have favoured the hydrolysis of Fe and Al oxides which release the exchangeable hydrogen and aluminium ions in soil. The behaviour of exchangeable H^+ and Al^{3+} were similar to that of exchangeable acidity.

Typic Tropopsamments recorded very low values for different forms of acidity. These soils are sandy in texture and are very low in organic carbon and total S contents. The potential acidity was highest for the layer just beneath the plough layer and 95 per cent of it was contributed by hydrolytic acidity. The contribution of exchangeable acidity to potential acidity showed wide variation in these soils ranging from 5 to 66.7 per cent. The sedimentary nature of parent materials and the succeeding lacustrine deposition might have resulted large variation in acidity characteristics.

Table 1. Selected properties of soils

Horizon	Depth (cm)	pH	EC dS m^{-1}	OC (%)	Clay (%)	Textural class	Total nutrients (%) Fe	Al	S	Av.S (ppm)
Typic Sulfaquents										
Ap	0-15	3.92	1.35	3.74	35.0	scl	6.09	6.99	1.17	1439
C1	15-25	3.51	1.48	4.85	28.5	scl	5.77	5.56	1.87	2310
C2	25-37	3.38	3.46	3.55	31.1	scl	7.17	4.73	3.41	3522
2C1	37-77	2.60	5.84	11.0	34.5	scl	7.23	2.55	3.27	5134
2C2	77-130	3.30	5.25	10.8	26.7	scl	5.46	3.56	2.32	5171
Typic Tropopsamments										
Ap	0-15	4.60	1.14	0.64	6.3	ls	5.45	2.07	1.14	771
C1	15-25	6.10	2.34	0.28	4.1	ls	2.75	1.97	0.36	1184
C2	25-120	5.50	1.52	1.52	10.2	ls	3.49	2.52	3.69	912
Typic Tropofluvents										
Ap	0-15	5.00	0.62	0.36	21.1	scl	2.75	2.44	0.51	435
C1	15-36	3.40	1.21	0.79	12.1	ls	10.72	1.61	0.51	666
C2	36-120	4.80	1.00	1.31	9.7	sl	3.00	5.27	0.54	775
Typic Fluvaqents										
Ap	0-15	4.00	0.55	1.32	8.0	sl	1.62	1.76	0.28	779
C1	15-35	4.20	0.47	0.77	19.8	sl	4.59	5.31	0.38	714
C2	35-110	4.20	0.40	1.49	20.0	sl	4.87	4.23	0.37	702
Fluventic Dystropepts										
Ap	0-20	4.80	0.33	0.12	31.1	scl	7.10	6.52	0.41	686
Bw1	20-64	5.50	0.39	0.07	24.0	scl	5.10	5.08	0.41	449
Bw2	64-120	3.30	3.06	2.75	30.5	scl	5.33	4.56	20.8	2636

Typic Tropofluvents showed a different pattern of distribution with higher values for potential acidity in surface horizon. The hydrolytic acidity contributed 73.1 to 82.4 per cent of potential acidity. In general these soils showed a higher proportion of exchangeable acidity compared to other soil sub-groups. Among the components of exchangeable acidity, exchangeable H^+ was the dominant form except in the C1 layer.

In Typic Fluvaquents, potential acidity was higher in the C1 horizon where 90 per cent of it was contributed by hydrolytic acidity. The exchangeable acidity of these soils were comparatively low and exchangeable Al^{3+} dominated over the exchangeable H^+.

Potential acidity was found to accumulate in lower layers of Fluventic Dystropepts. The contribution of hydrolytic acidity was more than 90 per cent and the exchangeable acidity was very low. The different forms of acidity showed wide variation with depth and hence an uniform pattern of distribution was not observed. The sedimentary deposition and young nature of soils might be the reason for this variation.

Table 2. Vertical distribution of acidity contributing characteristics of different soil subgroups

Horizon	Potential acidity	Hydrolytic acidity	Exch. Acidity	Exch. H^+	Exch. Al^{3+}	Contribution to potential acidity		Contribution to exch. acidity	
			cmol(+) kg^{-1}			Hydr. Acidity	Exch. Acidity	Exch. H^+	Exch. Al^{3+}
				Typic Sulfaquents					
Ap	34.3	27.7	6.60	3.87	2.73	80.8	19.2	58.6	41.4
C1	46.2	40.6	5.60	3.51	2.09	87.8	12.2	62.4	37.6
C2	44.6	35.4	9.20	4.97	4.23	79.4	20.6	54.1	45.9
2C1	.90.4	85.1	5.30	2.92	2.38	94.1	5.9	54.8	45.2
2C2	36.1	33.5	2.60	1.11	1.49	92.9	7.1	44.2	55.8
				Typic Tropopsamments					
Ap	2.8	2.0	0.80	0.42	0.38	71.4	28.6	71.4	28.6
C1	10.1	9.6	0.51	0.13	0.38	95.0	5.0	74.5	25.5
C2	2.7	0.9	1.80	1.14	0.66	33.3	66.7	63.0	37.0
				Typic Tropofluvents					
Ap	16.4	12.0	4.40	4.01	0.39	73.1	26.9	92.4	7.6
C1	4.6	2.7	1.90	0.93	0.97	73.0	27.0	47.2	52.8
C2	15.9	13.1	2.80	1.72	1.08	82.4	17.6	61.9	38.1
				Typic Fluvaquents					
Ap	14.6	12.8	1.20	0.35	1.45	88.1	11.9	20.2	79.8
C1	23.5	21.1	2.40	1.04	1.36	90.0	10.0	44.3	55.7
C2	17.4	15.4	2.00	0.97	1.03	88.6	11.4	49.0	51.0
				Fluventic Dystropepts					
Ap	10.5	9.8	0.70	0.07	0.63	93.6	6.4	10.6	89.4
Bw1	5.6	5.1	0.50	0.47	0.03	91.4	8.6	98.5	1.5
Bw2	32.3	31.1	1.20	0.20	1.20	96.3	3.7	16.5	13.5

The clay and organic carbon contents of the soil decide the extent of soil acidity as evidenced by the significant positive correlation with potential acidity ($r = 0.578^{**}$ and $r = 0.598^{**}$) and hydrolytic acidity ($r = 0.548^{**}$ and $r = 605^{**}$). Neue (1985) also reperted similar findings. Compared to the above values, the correlation with exchangeable acidity was low ($r = 0.464^{*}$ and $r = 0.204^{*}$). There was significant positive correlation between hydrolytic and potential acidities ($r = 0.993^{*}$). The correlation between potential and exchangeable acidity was comparatively lower ($r = 0.489^{*}$). The results are in agreements with the finding of Adhikari and Si (1991).

There was an increase in soil acidity evidenced by the lowering of pH during the post-barrage period. Major factors attributable for the increase in acidity are the prevention of saline water flushing and the lowering of water table in response to the closure of the regulator. The pH values reported during the pre-barrage period by Money (1961) and Kabeerathumma and Nair (1973) ranged between 5.2 to 6.4 in Kuttanad soils.

Table 3. Different forms of soil acidity during different seasons

Time of collection	Poten. acidity	Hydr. acidity	Exch. Acidity	Exch. H+	Exch. Al^{3+}	Al saturation
	cmol (+) kg^{-1}					%
			Typic Sulfaquents			
Pre-monsoon	25.5	20.9	4.60	1.47	3.13	19.2
Monsoon	17.9	12.0	5.90	3.11	2.79	20.2
Post-monsoon	20.3	13.8	6.50	3.29	3.21	20.2
Summer	34.4	26.7	7.70	4.20	3.50	22.2
			Typic Tropopsamments			
Pre-monsoon	9.6	8.8	0.80	0.64	0.16	1.5
Monsoon	3.9	2.3	1.60	0.85	0.75	11.3
Post-monsoon	6.1	4.8	1.30	0.62	0.68	12.1
Summer	12.8	10.8	2.00	0.57	1.43	7.4
			Typic Tropofluvents			
Pre-monsoon	18.6	17.0	1.60	1.13	0.47	5.2
Monsoon	15.9	13.0	2.90	1.49	1.41	21.0
Post-monsoon	17.9	13.9	4.00	2.27	1.73	17.4
Summer	19.4	15.0	4.40	4.01	0.39	3.5
			Typic Fluvaqents			
Pre-monsoon	22.7	15.9	6.80	1.49	5.31	34.8
Monsoon	14.7	5.8	8.90	5.64	3.26	21.0
Post-monsoon	15.6	13.8	1.80	0.35	1.45	13.5
Summer	29.5	19.7	9.80	7.38	2.42	12.7
			Fluventic Dystropepts			
Pre-monsoon	16.2	13.1	3.10	0.70	2.40	24.2
Monsoon	16.3	13.2	3.10	1.37	1.73	21.8
Post-monsoon	17.7	15.1	2.60	1.57	1.03	13.7
Summer	19.5	14.8	4.70	3.07	1.63	20.5

Impact of season and closure of regulator on acidity characteristics: The season and the closure of the regulator has influenced the soil acidity components (Table 3) in almost similar way in all soil sub-groups. The different components of acidity followed a definite pattern of variation. The values were the highest for Typic Sulfaquents evidently due to the presence of sulphur containing compounds. For different acidity components, the maximum was noticed during the summer season. This was due to soil drying in response to higher evaporation. The closure of regulator prevented the saline water entry to Kuttanad and resulted in lowering of water table which facilitated the oxidation of ferrous compounds and caused an increase in soil acidity. The large scale use of acid forming fertilizers has also a role in increasing the soil acidity. The highest values noted for potential, hydrolytic and exchangeable acidities were 34.4, 26.7 and 7.70 cmol (+) kg^{-1} respectively. By the time of pre-monsoon season, the acidity components were slightly reduced under the influence of summer showers compared to the summer season. The monsoon showers have washed out a larger portion of acidity from the surface soils and the flooded condition prevented the increase in acidity components during monsoon period. This had reduced the potential acidity of surface soils to almost half in Typic Sulfaquents and to one fourth in Typic Tropopsamments compared to that of summer season. In other sub-groups *i.e.* Typic Tropofluvents and Fluventic Dystropepts, the potential acidity was not so high and the reduction was also small. After the monsoon season, the acidity characteristics showed an increase in response to drainage and soil drying and recorded the maximum value during summer season.On evaluating the pH and EC of Kuttanad soils at monthly intervals, Kurup and Aiyer (1973) observed that the maximum pH and minimum EC was recorded during the months of October-November and the minimum pH and maximum EC during March -April.

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