

Extraction of forms of iron from some soil series of West Bengal and Bihar

A.K. Dolui and P.P. Chattopadhyay

Division of Agricultural Chemistry and Soil Science, University College of Agriculture, Calcutta University, 35, Ballygunge Circular Road, Calcutta-700 019

Abstract

Different extractants were used to determine various forms of iron of some soils of West Bengal and Bihar. Interrelationship between them and also with soil properties are discussed in relation to their attachment on soil.

Introduction

Iron is a major soil constituent occurring in several mineralogical forms as discrete particles or associated with surfaces of other minerals. The amount and distribution of extractable iron oxides in soil profiles serve as indicators of the stage and degree of soil development (Mahaney and Fahey 1988). Since little information is available regarding distribution of different forms of iron in red and gravelly red soils of West Bengal and Bihar, the present investigation was undertaken.

Materials and Methods

Three soil profiles, one gravelly red soil (Singredih series) in Deoghore district, one of red soil (Balsum series) in Dumka district, Bihar and third also of red soil (Bhaddi series) in Birbhum district, West Bengal, were collected for the present investigation. The soil samples were processed (< 2 mm) and used for analysis. Different extractants of iron were as follows: (i) potassium chloride (1N), one hour extraction; (ii) ammonium sulphate (1N), one hour extraction (Black 1965); (iii) acetic acid (0.43 M), overnight extraction (Farmer *et al.* 1980); (iv) EDTA (0.05 M), one hour extraction at pH 7 (Farmer *et al.* 1980); (v) sodium pyrophosphate, overnight extraction at pH 10 (Agriculture Canada 1984); (vi) acid ammonium oxalate (0.2 M), four hour extraction at pH 3 (Agriculture Canada 1984); (vii) dithionite-citrate-bicarbonate, 20 minutes extraction twice (CSSC subcommittee on methods of analysis 1978). Iron in the extracts was determined colorimetrically by orthophenanthroline reagent as described by Chen and He (1985).

Results and discussion

The pH(H₂O) and pH(KCl) of the soils ranged from 5.5 to 6.1 and 4.6 to 5.1, respectively, EC from 0.018 to 0.029 dSm⁻¹, organic carbon 1.5 to 3.5 gkg⁻¹, clay from 92 to 592 gkg⁻¹, soil texture from sandy loam to clay.

KCl and (NH₄)₂SO₄ extracted iron, which are held at the charged surface ranged from 80 to 145 and from 80 to 112 mgkg⁻¹ respectively (Table 1). Generally the Fe extracted by both the extractants showed decline in the pedons with depth.

Inorganic oxide Fe (acetic acid extractable) ranged from 86 to 136 mgkg⁻¹ with a mean of 112 mgkg⁻¹. The acetic acid extractable Fe content showed a decline with depth in all the pedons except the surface soil of Balsum series.

EDTA and pyrophosphate extractable Fe (organically bound) were high throughout the profile [112 to 212 mgkg⁻¹ and 125 to 248 mgkg⁻¹ respectively]. Pyrophosphate extracted more iron than EDTA from organic horizons indicating that pyrophos-

Table 1. Iron extracted by different extractants and active iron ratio

Location of sample	Depth (m)	Fe	Fe	Fe	Fe	Fe	Fe	Fe	Active Fe ratio
		KCl	(NH ₄) ₂ SO ₄	HOAC	EDTA	Pyr	oxa	dith	
Singredih series : Gravelly red soil									
Latitude : 24°29'N	0.00 - 0.12	110	88	100	130	145	360	760	0.47
Longitude : 86°30'E	0.12 - 0.23	90	80	88	126	135	350	740	0.47
	0.23 - 0.45+	80	80	86	112	125	340	730	0.46
Balsum series : Red soil									
Latitude : 24°19'N	0.00 - 0.15	130	110	134	175	248	625	800	0.78
Longitude : 87°20'E	0.15 - 0.36	120	112	136	180	210	630	780	0.80
	0.36 - 0.70	115	110	133	195	215	650	770	0.84
	0.70 - 1.08	110	100	132	198	201	620	780	0.79
	1.08 - 1.25+	105	98	131	212	199	640	760	0.84
Bhaddi series : Red soil									
Latitude : 23°50'N	0.00 - 0.11	145	102	129	182	189	604	740	0.82
Longitude : 87°16'E	0.11 - 0.29	130	100	122	180	185	600	730	0.82
	0.29 - 0.58	132	90	120	175	175	575	710	0.81
	0.58 - 0.95	121	90	116	160	165	540	700	0.77
	0.95 - 1.25+	120	88	101	152	160	525	690	0.76

phate is an effective extractant for organically complexed Fe. The Fe extracted by both the extractants showed decline in the pedons with depth except the Balsum series where the trend was reverse. This indicated translocation of organically bound Fe down the profile.

Amorphous and organically bound Fe (oxalate extractable) content in these soils varied from 340 to 650 mgkg⁻¹ with an average of 543 mgkg⁻¹. The depth function of oxalate extractable Fe indicated Fe maximum in the surface horizon and minimum in the lowest horizon of all the soil series except Balsum series where such trend was irregular.

The dithionite extraction is presumed to remove finely crystalline iron oxides in addition to the oxalate soluble fractions and showed a variation of 690 to 800 mgkg⁻¹. The depth function of dithionite extractable Fe indicated a maximum in the surface horizon and a minimum in the lowest horizon of all the soil series except the Balsum series where such trend was irregular.

With increasing soil age, the crystalline iron oxides increase at the expense of the poorly crystalline forms. This trend is reflected in the Fe_{oxa} to Fe_{dith} (active Fe ratio). According to Mahaney and Fahey (1988), soils with higher ratio are younger soils whereas low ratios denote older soils. The high average active Fe ratio value (0.81) in Balsum series suggests that this soil is relatively younger than that of Bhaddi (0.79) and Singredih (0.47) series.

Interrelationship between different forms

KCl and (NH₄)₂SO₄ extractable Fe showed significant relationship with EDTA (0.62*, 0.78***), pyrophosphate (0.89***, 0.96***) and oxalate (0.78***, 0.86***) extractable Fe. (NH₄)₂SO₄ extractable Fe had positive and significant correlations with KCl (0.68**) and dithionite (0.66**) extractable Fe. This may be due to iron transformation and its availability in soils depend on various forms of this nutrient, with which the different forms of Fe have significant and positive correlations.

ETDA extractable Fe had significant positive correlation with pyrophosphate and oxalate extractable Fe, the r values being 0.83*** and 0.94***, respectively. Oxalate and dithionite extractable Fe were significantly correlated with pyrophosphate (0.90***, 0.53*) extractable Fe. The significant positive correlations indicate that the amount of Fe extracted by these extractions had strong association among themselves (Dolui *et al.* 1988).

Relationship with soil characteristics

pH(KCl) was positively and significantly correlated with (NH₄)₂SO₄ (0.66**), pyrophosphate (0.76**) and oxalate (0.65*) extractable Fe. These relationship might be due to the precipitation of Fe as ferric hydroxide at higher pH.

Organic carbon showed significant relationship with KCl, (NH₄)₂SO₄, pyrophosphate and dithionite extractable Fe, the r values being 0.58*, 0.63*, 0.55* and 0.71**, respectively indicating that organic carbon influenced the solubility and availability of Fe which protects itself from oxidation and precipitation of available Fe into unavailable form thus increasing its availability in these soils. Similar relationship of organic carbon and pyrophosphate extractable Fe was also reported by Dolui *et al.* (1988) in different soil series of West Bengal.

Clay content gave a correlation with Fe_{dith} , the r value being -0.54^* . This result indicated that this fraction might have been either incorporated within the crystal lattice or sorbed on the surface and interlayer of clay and iron oxides (Hawkes and Webb 1962).

References

- Agriculture Canada (1984). 'Analytical methods manual' B.H. Sheldrick, (ed), Land Resource Research Institute. Ottawa, ON, LLRI Contribution 84-30.
- Black, C.A. (1965). 'Methods of Soil Analysis, Part II. Chemical and Microbiological properties'. Agron. Monog. 9 (Am. Soc. Agron. Inc: Madison, Wisconsin, USA.)
- Canada Soil Survey Committee, Subcommittee on Methods of Analysis (1978). 'Manual of soil sampling and methods of analysis.' pp 98-106. (Canadian Society of Soil Science: Ottawa, ON.)
- Chen, J.F., and He, Q. (1985). Chemical distinction of oxide mineral in soil colloid. In : Y.Hseung, *et al* (eds.) pp. 241- 303. Methods for Soil Colloid Research (in Chinese). (Science Press: Beijing.)
- Dolui, A.K., Chandran, P. , and Nayek, A. K. (1988). Nature and profile distribution of iron in some soil series of Jalpaiguri district, West Bengal. *Proc. Natn. Aca. Sci. India* **58**, (A) Part-I 1-6.
- Farmer, V. C., Russell, J. D., and Berrow, M.L. (1980). Imogolite and protoimogolite allophane in spodic horizons : evidence for a mobile aluminium silicate complex in podzol formation *J. Soil Sci.* **31**, 673-684.
- Howkes, H. E., and Webb, J. (1962). '*Geochemistry of Mineral Exploration*'. (Harper and Row : New York.)
- Mahaney, W. C., and Fahey, B. D. (1988). Extractable Fe and Al in late Pleistocene and Holocene paleosols in Niwot Ridge, Colorado Front Range. *Catena* **15**, 17-26.