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WATER COLOUR AND  
HUMIC CHARGE  
1ST INTERIM REPORT

by

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## SUMMARY

This interim report presents and discusses, in qualitative terms, the bulk analytical and titration data for the first 13 (of 30) soils studied in the Project.

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## 1. INTRODUCTION

The objective of this work is to investigate the possible relationship between the net electrical charge on soil humic substances (HS) and the concentration of HS dissolved in the soil solution. The starting hypothesis is that the greater is the net charge ( $Z$ ), the greater is the humic 'solubility'. Preliminary work (Tipping & Hurley, 1988) suggests that there may be a direct relationship between  $Z$  and solution [HS]. If so, it may be possible to make quantitative predictions of the concentration of HS in drainage waters, and how that concentration may change with climate, land-use etc. Since dissolved HS are major contributors to perceived 'water colour', this would be useful in the management of peaty catchments and their reservoirs.

The data required in this investigation are from bulk analyses of soil samples and from acid-base titration experiments with the soils. This interim report presents data obtained for the first 13 soil samples (there will be 30 in all), and comments on the major observed trends in the data. Calculations of  $Z$  take into account the binding protons, Al species and divalent base cations ( $Mg^{2+}$ ,  $Ca^{2+}$ ) by HS, and are performed with the organic soil model CHAOS (Tipping & Hurley, 1988). These calculations will most conveniently be carried out when the complete data set is available.

## 2. SUMMARY OF METHODS

The following determinations and experiments are carried out on each soil sample:

1. Water content of original soil, by drying overnight at 110°C.
2. Preparation of soil suspension: approximately 100 g of wet soil, sieved through a 4 mm mesh, suspended in  $10^{-3}$  M NaCl at a final total weight of 350 g. Solids concentration determined by drying sub-samples overnight at 110°C.
3. Loss on ignition of original soil and of sieved soil, determined by heating dried samples at 550°C overnight.
4. Content of extractable (humic) carbon, by extraction with 0.01 M NaOH and analysis of DOC.
5. Content of Al, by extraction with 0.01 M  $\text{HNO}_3$ /0.1 M  $\text{NaNO}_3$ , and determination of Al with pyrocatechol violet.
6. Content of Fe, by extraction with 1% hydroxylamine, and determination with bathophenanthroline.
7. Content of base cations, by extraction with 1 M  $\text{NH}_4\text{Cl}$ , and determination by AAS.
8. Determination of the C, H, N contents of dried soil, by combustion in a Carlo-Erba instrument.
9. Batch titrations, by suspending the soils in solutions containing  $10^{-3}$  M NaCl together with various concentration of HCl or NaOH, giving final pH ranges of ca. 2-6. After equilibration at 10°C overnight, the suspensions are centrifuged (15,000 rpm, 30 mins) and the supernatants analysed for monomeric Al, pH, absorbance at 340 nm, DOC, total Fe. Absorbances are measured after addition of phosphate buffer (pH 7).

10. Soil water pH, by suspending unsieved soil at a concentration of ca. 50 g per litre of solution, to which NaCl at a total concentration of  $10^{-3}$  M is added. (10°C).

### 3. RESULTS AND DISCUSSION

#### 3.1 Sampling sites

Details of the sites and dates of sampling are given in Table 3.1. Samples 1-6 were collected by Dr Adrian McDonald and his staff (University of Leeds, Department of Geography), samples 7, 8, 11, 12, 13 by WRc staff, samples 9 and 10 by FBA staff. Samples 1-6 were taken from the same place and were used to examine local spatial variability and effects of storage of soil samples.

#### 3.2 Bulk soil properties

Results of bulk soil analyses are given in Table 3.2. In all cases the samples had high moisture contents, and, as expected, high contents of organic matter as evidenced by the loss-on-ignition (LOI) values and carbon contents. Of the total carbon present ca. 20% (range 13-31%) is extractable by NaOH, and this is taken to represent the humic fraction: the remaining soil organic matter is assumed to be inert with respect to interactions with ions, and not to contribute to dissolved organic matter at soil pH values.

The content of acid-extractable Al varies considerably among the soils, from 12 to 195  $\mu\text{mol g}^{-1}$ . The iron content also varies, but to a lesser degree (9-44  $\mu\text{mol g}^{-1}$ ). Soil pH values are all low, falling in the range 3.44-4.40.

Problems have been experienced in the determination of base cations ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ) with  $\text{NH}_4\text{Cl}$ , and data are therefore not yet available.

### 3.3 Batch titrations

For each soil, two batch titrations (8 points each) have been carried out. For logistic reasons, the first of the titrations is routinely begun at the same time as bulk soil analysis, with the result that the soil concentration is not known until the titration has been completed. Initially the aim was to perform all titrations at or near a single soil concentration, and it was hoped that this could be achieved on the basis of wet weights. However the large amounts of root material present in most of the soil samples made sieving essential before titrations could be carried out. Unfortunately the soil samples have been found to differ with respect to their sieving behaviour, giving stock suspensions of varying solids contents. As a result the soil concentrations for the first titrations have varied ( $2.6\text{--}43.1\text{ g l}^{-1}$ ). However the second titrations have all been carried out at nearly the same soil concentration ( $2.6\text{--}3.1\text{ g l}^{-1}$ ). The data at different soil concentrations have yielded important information on humic 'solubility', as discussed below.

The titration data for soils 1-13 are shown in Tables 3.3.1-3.3.13. The following qualitative relationships are apparent from the data:

(a) The DOC concentration increases with pH for each soil, although there are large differences among soils in the [DOC] values for a given pH. For example at pH 4, soil 4 (total concentration  $3.0\text{ g l}^{-1}$ ) gives  $38.5\text{ mg l}^{-1}$  DOC, whereas soil 9 (total concentration also  $3.0\text{ g l}^{-1}$ ) gives  $0.9\text{ mg l}^{-1}$ .

(b) Concentrations of Al, and less markedly Fe, in the solution phase vary with total metal content, and with pH. Metal concentrations tend to be highest at low pH, and also, when [DOC] is high, at higher pH, with a minimum in between. This reflects weak metal-organic interaction at low pH (due to competition with  $\text{H}^+$ ) and solubilisation of metal-organic complexes at higher pH.

(c) The concentration of DOC in solution at a given pH and at constant total soil concentration, is inversely related to the total concentration of Al, and possibly also of Fe. This can be shown by plotting [DOC] in solution, at pH 4 for [soil] =  $3 \text{ gl}^{-1}$ , against the parameter (total Al + total Fe)/(total extractable DOC) (Fig. 3.1). A possible outlier is soil 11, which had a high mineral content (Table 3.2). This result supports the idea that the degree of complexation of metal ions by soil HS has a strong influence on their solubility.

(d) Although 'colour' (as measured by absorbance at 340 nm, at pH 7) is directly related to [DOC] for a given soil, the ratio of absorbance to [DOC] varies with pH, and from soil to soil. There is a general increase in  $A_{340}/[\text{DOC}]$  with pH, the ratio approximately doubling over the pH range 2.5-5 in some cases. Again, at a given pH the ratio shows up to a 2-fold variation among soils. These points are illustrated by the plots in Fig. 3.2. It would appear that the optical properties of the HS differ among soils, and also that different humic fractions come into solution at different pH values.

(e) The concentration of DOC in solution increases with total soil concentration, or with total available DOC. This can be seen by comparing [DOC] values for titrations at different concentrations of the same soil (Tables 3.3.1-3.3.13). It must be concluded that the passage of HS into solution cannot be characterised as a dissolution, with the implied notion of a constant solid activity. The concentration-dependence of humic 'solubility' will require quantification in order to develop a predictive model.

#### 3.4 Examination of variability

Soils 1-6 were taken from the same sampling site. Soils 1-3 were analysed at the same time (6 days after sampling), and gave very similar bulk analyses



and titration results (Tables 3.2 and 3.3.1-3.3.3). Soils 4 and 5 were analysed 21 days after sampling, and gave results again very similar to those for soils 1-3. Soil 6 was analysed 11 weeks after sampling. This soil was found to have less base-extractable carbon than soils 1-6, and to give a slightly higher solution pH (Table 3.2). However, the titration results showed no obviously erroneous results (Table 3.3.6). It is of course quite possible that soil 6 was different originally, i.e. that the differences reflect spatial variability rather than changes with time. Apart from soil 6, all soils have been or will be analysed within 3 weeks of sampling as far as is practicable.

Table 3.1 Details of sampling

<u>soil</u>	<u>name of site</u>	<u>NGR</u>	<u>type of site</u>	<u>date sampled</u>	<u>date analysed</u>
1	Scar House Pasture (Yorks)	SE 069763	hill top	3-11-87	9-11-87
2	"	"	"	"	"
3	"	"	"	"	"
4	"	"	"	"	24-11-87
5	"	"	"	"	"
6	"	"	"	"	19-1-88
7	Ladyclough (Derbys)	090934	plateau	27-11-87	8-12-87
8	"	"	"	"	"
9	Wrynose (Cumbria)	32775028	slope	14-12-87	15-12-87
10	"	32755033	flat bog	"	"
11	Dark Peak (Derbys)	SK145921	slope	5-1-88	12-1-88
12	"	SK143918	level	"	"
13	"	SK145921	slope	"	19-1-88

Table 3.2 Bulk analyses of soil samples 1-13

	1	2	3	4	5
%H <sub>2</sub> O	88	87	88	88	88
LOI% original soil	98	98	97	-	-
sieved soil	97	97	97	98	97
elemental analysis					
% C	52.4	53.2	53.6	52.9	54.1
% H	6.2	6.1	6.2	6.0	5.9
% N	1.6	1.4	1.6	1.4	1.1
extractable DOC mg/g	110	143	123	132	167
extractable Al $\mu\text{mol g}^{-1}$	15	16	16	14	20
Fe $\mu\text{mol g}^{-1}$	10	19	15	13	20
pH in 0.001 M NaCl ( $\sim$ 50 g/l)	3.54	3.53	3.51	3.45	3.44

6	7	8	9	10	11	12	13
89	85	62	69	89	50	77	75
99	94	35	57	92	34	93	66
98	95	59	70	93	37	90	60
52.1	49.8	34.7	36.7	55.0	28.9	53.3	38.9
5.5	6.0	3.9	4.5	6.5	3.0	5.4	4.0
0.8	1.6	1.0	2.9	2.5	0.7	0.9	0.9
77	113	104	71	72	62	119	70
12	32	72	195	104	39	40	54
9	28	23	14	40	11	16	44
3.79	3.57	3.51	4.40	4.09	3.70	3.52	3.97

Table 3.3.1 Titration data for soil 1; [soil] = 2.7 g/l (1-8), 2.7 g/l (1'-8')

suspension	HCl, mM	NaOH, mM	pH	DOC, mg l <sup>-1</sup>	A340(pH 7)	Al <sub>m</sub> , μM	Fe, μM
1	14.3	0	1.92	3.4	-	27	12
2	2.86	0	2.62	7.9	-	6	3
3	1.43	0	2.93	13.3	-	2	1
4	0.57	0	3.37	18.8	-	2	1
5	0	0	4.05	21.1	-	2	2
6	0	0.57	5.30	38.7	-	3	1
7	0	1.43	6.22	75.0	-	-	-
8	0	2.86	7.84	126.8	-	-	-
1'	0.86	0	3.17	-	-	2	2
2'	0.29	0	3.56	-	-	0	2
3'	0	0.07	4.19	-	-	0	2
4'	0	0.14	4.26	-	-	0	2
5'	0	0.29	4.71	-	-	0	2
6'	0	0.71	5.47	-	-	1	1
7'	0	0.86	5.66	-	-	2	2
8'	0	1.14	6.01	-	-	2	1

- not determined

Table 3.3.2 Titration data for soil 2; [soil] = 2.6 g/l (1-8), 2.6 g/l (1'-8')

suspension	HCl, mM	NaOH, mM	pH	DOC, mg l <sup>-1</sup>	A340(pH 7)	Al <sub>m</sub> , μM	Fe, μM
1	14.3	0	1.94	9.4	-	19	20
2	2.86	0	2.61	19.4	-	4	5
3	1.43	0	2.93	25.3	-	3	2
4	0.57	0	3.43	30.2	-	2	1
5	0	0	3.99	34.0	-	1	1
6	0	0.57	5.31	55.0	-	4	3
7	0	1.43	6.14	101.4	-	-	-
8	0	2.86	8.03	143.2	-	-	-
1'	0.86	0	3.16	-	-	2	-
2'	0.29	0	3.95	-	-	1	-
3'	0	0.07	4.14	-	-	2	-
4'	0	0.14	4.22	-	-	1	-
5'	0	0.29	4.68	-	-	2	-
6'	0	0.71	5.43	-	-	3	-
7'	0	0.86	5.74	-	-	2	-
8'	0	1.14	6.11	-	-	3	4

- not determined

Table 3.3.3 Titration data for soil 3; [soil] = 2.7 g/l (1-8), 2.7 g/l (1'-8')

suspension	HCl,mM	NaOH,mM	pH	DOC,mg $l^{-1}$	A340(pH 7)	Al <sub>m</sub> , $\mu$ M	Fe, $\mu$ M
1	14.3	0	1.92	9.4	-	21	25
2	2.86	0	2.60	15.3	-	4	7
3	1.43	0	2.92	23.4	-	3	2
4	0.57	0	3.29	27.4	-	3	2
5	0	0	3.97	32.3	-	3	2
6	0	0.57	5.51	53.7	-	2	4
7	0	1.43	6.21	105.0	-	-	-
8	0	2.86	8.20	192.6	-	-	-
1'	0.86	0	3.16	-	-	1	-
2'	0.29	0	3.54	-	-	1	-
3'	0	0.07	4.16	-	-	1	-
4'	0	0.14	4.23	-	-	1	-
5'	0	0.29	4.70	-	-	2	-
6'	0	0.71	5.55	-	-	2	-
7'	0	0.86	5.80	-	-	2	-
8'	0	1.14	6.20	-	-	3	4

- not determined

Table 3.3.4 Titration data for soil 4; [soil] = 5.05 g/l (1-8), 3.0 g/l (1'-8')

suspension	HCl,mM	NaOH,mM	pH	DOC,mg $l^{-1}$	A340(pH 7)	Al <sub>m</sub> , $\mu$ M	Fe, $\mu$ M
1	2.86	0	2.67	24.1	0.250	4	4
2	1.43	0	2.98	35.8	0.414	2	1
3	0.57	0	3.33	45.6	0.618	2	2
4	0.29	0	3.55	49.8	0.706	2	1
5	0	0	3.93	51.6	0.790	6	2
6	0	0.14	4.12	55.5	0.974	5	2
7	0	0.29	4.35	64.5	1.176	3	3
8	0	0.57	4.75	75.2	1.544	3	3
1'	2.86	0	2.57	16.4	0.170	3	1
2'	1.43	0	2.90	25.1	0.328	2	1
3'	0.57	0	3.30	33.5	0.546	3	3
4'	0.29	0	3.54	35.3	0.578	2	2
5'	0	0	3.99	38.5	0.692	2	2
6'	0	0.14	4.30	40.0	0.844	2	2
7'	0	0.29	4.66	46.0	1.058	2	2
8'	0	0.57	5.28	56.6	1.420	4	3



Table 3.3.5 Titration data for soil 5; [soil] = 7.2 g/l (1-8), 2.9 g/l (1'-8')

suspension	HCl, mM	NaOH, mM	pH	DOC, mg l <sup>-1</sup>	A340(pH 7)	Al <sub>m</sub> , μM	Fe, μM
1	2.86	0	2.68	24.4	0.244	5	1
2	1.43	0	3.01	36.1	0.470	3	2
3	0.57	0	3.31	42.8	0.738	2	2
4	0.29	0	3.53	47.6	0.858	2	3
5	0	0	3.72	51.8	0.978	5	3
6	0	0.14	3.95	60.0	1.308	5	4
7	0	0.29	4.08	72.7	1.668	3	2
8	0	0.57	4.36	84.7	2.278	6	8
1'	2.86	0	2.60	12.5	0.168	3	0
2'	1.43	0	2.92	20.3	0.280	3	1
3'	0.57	0	3.31	28.6	0.458	3	1
4'	0.29	0	3.55	29.1	0.488	6	2
5'	0	0	3.97	29.1	0.670	3	3
6'	0	0.14	4.25	33.0	0.956	3	3
7'	0	0.29	4.52	44.3	1.314	5	3
8'	0	0.57	5.14	53.3	1.946	5	5

Table 3.3.6 Titration data for soil 6; [soil] = 5.5 g/l (1-8), 3.0 g/l (1'-8')

suspension	HCl,mM	NaOH,mM	pH	DOC,mg $l^{-1}$	A340(pH 7)	Al <sub>m</sub> , $\mu$ M	Fe, $\mu$ M
1	2.86	0	2.63	9.0	0.078	4	2
2	1.43	0	2.98	10.4	0.136	2	0
3	0.57	0	3.35	19.1	0.272	1	0
4	0.29	0	3.65	24.0	0.398	0	0
5	0	0	4.05	29.0	0.566	0	1
6	0	0.14	4.28	37.2	0.748	1	1
7	0	0.29	4.50	38.7	0.936	0	2
8	0	0.57	4.84	50.4	1.312	1	2
1'	2.86	0	2.59	5.4	0.066	3	1
2'	1.43	0	2.90	8.0	0.120	1	1
3'	0.57	0	3.33	13.6	0.238	1	1
4'	0.29	0	3.62	18.2	0.354	1	1
5'	0	0	4.13	19.1	0.416	1	1
6'	0	0.14	4.47	22.2	0.486	1	2
7'	0	0.29	4.81	27.9	0.694	1	1
8'	0	0.57	5.35	35.9	1.014	1	3

Table 3.3.7 Titration data for soil 7; [soil] = 12.4 g/l (1-8), 3.1 g/l (1'-8')

suspension	HCl,mM	NaOH,mM	pH	DOC,mg $l^{-1}$	A340(pH 7)	Al <sub>m</sub> , $\mu$ M	Fe, $\mu$ M
1	2.86	0	2.64	6.1	0.068	40	0
2	1.43	0	2.95	11.9	0.138	15	0
3	0.57	0	3.33	18.6	0.314	6	2
4	0.29	0	3.50	20.7	0.380	5	1
5	0	0	3.79	22.6	0.512	5	2
6	0	0.14	3.92	26.0	0.686	5	5
7	0	0.29	4.05	33.2	0.784	5	6
8	0	0.57	4.26	44.0	1.076	5	8
1'	2.86	0	2.62	2.1	0.044	14	0
2'	1.43	0	2.93	3.5	0.058	6	0
3'	0.57	0	3.33	5.6	0.102	2	1
4'	0.29	0	3.60	6.2	0.122	2	1
5'	0	0	4.07	6.3	0.162	1	1
6'	0	0.14	4.45	7.9	0.210	1	0
7'	0	0.29	4.83	10.2	0.268	1	1
8'	0	0.57	5.48	16.5	0.490	1	2

Table 3.3.8 Titration data for soil 8; [soil] = 31.5 g/l (1-8), 3.2 g/l (1'-8')

suspension	HCl, mM	NaOH, mM	pH	DOC, mg l <sup>-1</sup>	A340(pH 7)	Al <sub>m</sub> , μM	Fe, μM
1	2.86	0	2.72	6.5	0.109	178	0
2	1.43	0	2.97	10.9	0.150	63	0
3	0.57	0	3.25	20.8	0.472	19	2
4	0.29	0	3.44	28.4	0.702	13	3
5	0	0	3.72	38.4	1.050	10	4
6	0	0.14	3.80	45.1	1.368	14	6
7	0	0.29	3.86	49.6	1.580	21	7
8	0	0.57	4.08	68.5	1.234	17	10
1'	2.86	0	2.62	2.4	0.040	50	0
2'	1.43	0	2.92	1.8	0.058	26	0
3'	0.57	0	3.30	3.2	0.110	6	0
4'	0.29	0	3.55	3.6	0.136	4	0
5'	0	0	4.15	4.6	0.188	1	0
6'	0	0.14	4.36	6.4	0.244	1	1
7'	0	0.29	5.10	9.9	0.394	2	1
8'	0	0.57	6.07	21.8	0.798	3	2

Table 3.3.9 Titration data for soil 9; [soil] = 22.6 g/l (1-8), 3.0 g/l (1'-8')

suspension	HCl, mM	NaOH, mM	pH	DOC, mg l <sup>-1</sup>	A340(pH 7)	Al <sub>m</sub> , μM	Fe, μM
1	2.86	0	3.27	5.4	0.050	593	3
2	1.43	0	3.71	4.4	0.030	293	2
3	0.57	0	3.99	3.6	0.024	117	1
4	0.29	0	4.22	4.0	0.030	44	1
5	0	0	4.64	4.7	0.044	8	1
6	0	0.14	4.99	7.3	0.122	8	2
7	0	0.29	5.09	10.7	0.182	10	3
8	0	0.57	5.41	20.4	0.440	18	5
1'	2.86	0	2.84	2.0	0.030	326	0
2'	1.43	0	3.27	1.2	0.022	206	0
3'	0.57	0	3.75	0.6	0.018	102	0
4'	0.29	0	4.02	0.9	0.014	46	0
5'	0	0	4.81	1.1	0.030	2	1
6'	0	0.14	5.81	2.1	0.058	2	1
7'	0	0.29	6.49	3.7	0.088	3	1
8'	0	0.57	7.21	10.0	0.236	3	2

Table 3.3.10 Titration data for soil 10; [soil] = 8.1 g/l (1-8), 3.0 g/l (1'-8')

suspension	HCl,mM	NaOH,mM	pH	DOC,mg $l^{-1}$	A340(pH 7)	Al <sub>m</sub> , $\mu$ M	Fe, $\mu$ M
1	2.86	0	2.81	3.6	0.040	194	3
2	1.43	0	3.17	4.0	0.048	78	1
3	0.57	0	3.61	5.7	0.106	16	1
4	0.29	0	3.87	6.8	0.142	9	1
5	0	0	4.20	8.4	0.194	6	1
6	0	0.14	4.47	10.7	0.318	6	3
7	0	0.29	4.71	13.1	0.432	6	5
8	0	0.57	5.09	41.1	0.770	8	7
1'	2.86	0	2.67	2.1	0.024	100	9
2'	1.43	0	3.00	1.8	0.030	53	4
3'	0.57	0	3.45	3.2	0.064	15	3
4'	0.29	0	3.78	3.8	0.084	5	2
5'	0	0	4.38	3.9	0.122	2	1
6'	0	0.14	4.96	5.3	0.158	2	2
7'	0	0.29	5.44	6.0	0.224	2	2
8'	0	0.57	6.27	9.9	0.344	2	3

Table 3.3.11 Titration data for soil 11; [soil] = 43.1 g/l (1-8), 3.0 g/l (1'-8')

suspension	HCl, mM	NaOH, mM	pH	DOC, mg l <sup>-1</sup>	A340(pH 7)	Al <sub>m</sub> , μM	Fe, μM
1	2.86	0	2.70	4.3	0.094	116	1
2	1.43	0	2.97	4.8	0.162	38	1
3	0.57	0	3.29	8.6	0.330	13	2
4	0.29	0	3.45	11.3	0.416	11	2
5	0	0	3.72	14.6	0.562	9	3
6	0	0.14	3.82	20.5	0.850	10	4
7	0	0.29	3.94	27.6	1.222	16	6
8	0	0.57	4.11	40.6	1.920	19	9
1'	2.86	0	2.59	1.3	0.028	33	0
2'	1.43	0	2.88	1.1	0.044	15	0
3'	0.57	0	3.31	0.5	0.064	5	0
4'	0.29	0	3.62	1.0	0.082	4	1
5'	0	0	4.27	0.9	0.094	3	0
6'	0	0.14	4.88	5.9	0.358	5	1
7'	0	0.29	5.58	13.8	0.770	6	3
8'	0	0.57	6.58	25.4	1.544	11	6

Table 3.3.12 Titration data for soil 12: [soil] = 22.6 g/1 (1-8), 2.9 g/1 (1'-8')

suspension	HCl,mM	NaOH,mM	pH	DOC,mg $l^{-1}$	A340(pH 7)	Al <sub>m</sub> , $\mu$ M	Fe, $\mu$ M
1	2.86	0	2.64	10.6	0.232	49	1
2	1.43	0	2.92	23.1	0.584	19	2
3	0.57	0	3.20	40.0	1.152	11	3
4	0.29	0	3.36	50.9	1.488	12	4
5	0	0	3.54	58.4	1.802	13	5
6	0	0.14	3.59	65.8	2.306	17	6
7	0	0.29	3.67	69.1	2.730	23	7
8	0	0.57	3.84	78.1	3.416	24	8
1'	2.86	0	2.60	2.6	0.114	22	1
2'	1.43	0	2.89	4.9	0.190	8	1
3'	0.57	0	3.28	6.9	0.282	4	1
4'	0.29	0	3.52	7.9	0.304	3	1
5'	0	0	3.95	8.1	0.354	2	1
6'	0	0.14	4.22	13.9	0.682	4	2
7'	0	0.29	4.51	21.3	1.034	5	2
8'	0	0.57	5.11	33.5	1.790	9	4



Table 3.3.13 Titration data for soil 13; [soil] = 22.3 g/1 (1-8), 3.0 g/1 (1'-8')

suspension	HCl,mM	NaOH,mM	pH	DOC,mg $l^{-1}$	A340(pH 7)	Al <sub>m</sub> , $\mu$ M	Fe, $\mu$ M
1	2.86	0	2.87	7.1	0.390	123	87
2	1.43	0	3.13	4.6	0.176	60	92
3	0.57	0	3.48	7.7	0.222	25	40
4	0.29	0	3.68	11.9	0.316	16	21
5	0	0	3.96	20.1	0.574	11	17
6	0	0.14	4.10	26.5	0.790	12	18
7	0	0.29	4.23	30.1	1.038	12	18
8	0	0.57	4.49	36.5	1.574	18	20
1'	2.86	0	2.61	1.8	0.048	55	2
2'	1.43	0	2.92	0.9	0.048	27	1
3'	0.57	0	3.30	1.1	0.064	9	1
4'	0.29	0	3.59	3.1	0.072	4	1
5'	0	0	4.32	1.5	0.090	2	1
6'	0	0.14	4.97	3.4	0.168	2	2
7'	0	0.29	5.76	5.3	0.272	2	3
8'	0	0.57	6.79	14.6	0.614	4	6

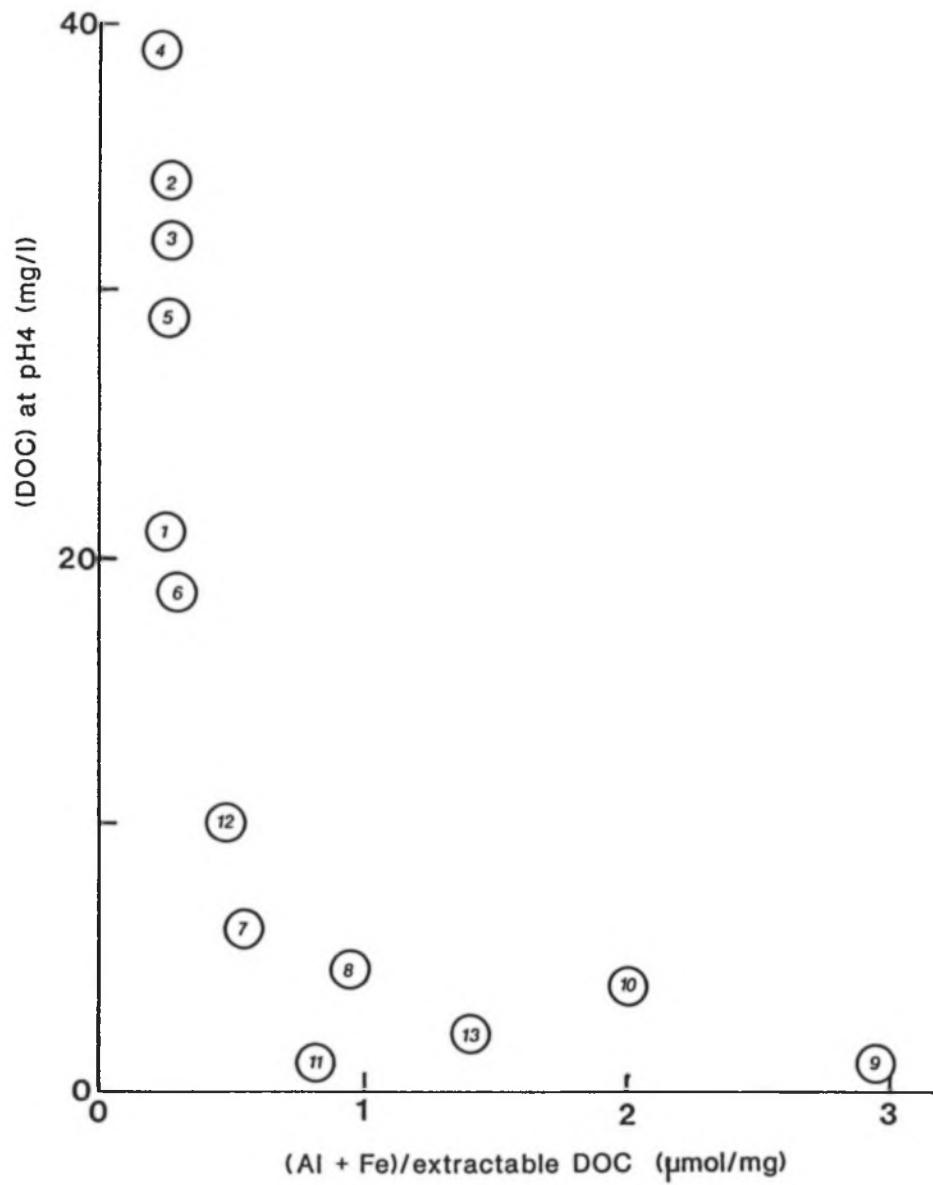


Fig. 3.1 Dependence of [DOC] on Al and Fe content of soil.

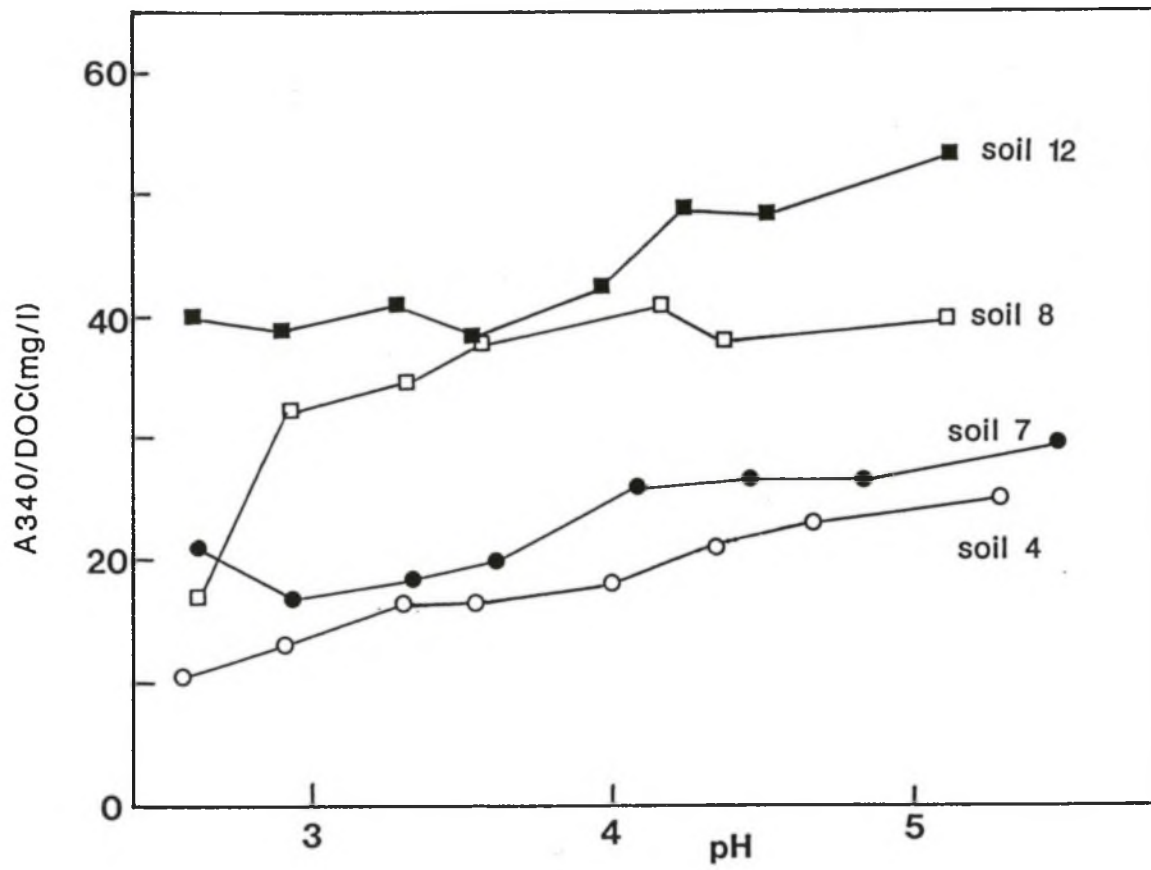


Fig. 3.2 Variation of A340/[DOC] among soils and with pH

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#### 5. REFERENCE

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