

Characteristics of Acid-Extractable Organic Matter Fraction from Various Soils

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As it is generally admitted that the properties of soil organic matter probably reflect the formation of the soil, much work has been done on the organic matter and particularly alkali-soluble humic substances in relation to soil genesis and classification.

About humification in the soil, Kononova³⁾ assumed the two phases: the microbial degradation and synthesis from plant materials, and the chemical oxidation and polymerization of the products microbially synthesized. By her assumption, it seems that every organic substance produced through both the phases must be present in soils, where humification is going on with the supply of plant remains; and that, of the organic substances, those essentially acid-soluble also can be worth studying, since they probably are characteristic of the soil conditions under which they have been produced. Moreover, such the substances will be important to podzolization through mobilization of sesquioxides and to plant growth also because of its high solubility.

The above substances may be, at least partly, bound with inorganic constituents in soils, but will be able to be extracted directly from soils if a suitable extractant is used. This paper presents a study²⁾ made on a method for studying such "acid-extractable organic matter" (AEOM) and on the properties of AEOM obtained by the method, including their relationships to soil pH as an index of the chemical and physico-chemical properties of the soil.

Materials and methods

1) Samples used

The samples used consisted of four groups (Table 1). The plant materials used were cedarwood and rice straw; the O- and A-horizon

Table 1. Sample groups used

Sample group	Number of samples	Ct ^a	pH(H ₂ O)
Plant materials	2	45-56	—
Peat and muck layers	4	34-50	3.1-3.9
O horizons	9	9-50	1.7-5.6
A horizons	53	1-28	4.0-8.1

^aTotal organic carbon content, % on oven-dry basis.

samples were from the profiles, mostly in Japan, and belonging to nine soil groups: Andosols; *Kuroboku* soils, distributed locally in Japan, rich in humus, but poor in allophane; Brown Forest Soils; Podzols; Red-Yellow Soils; soils derived from basic parent materials, regardless of the soil type, high in soil pH; Chernozems in USSR; Ferralsols in Brazil; and Gray Lowland Soils.

2) Extractant for AEOM

A mixture, 0.2 M H₄P₂O₇+5% Na₂SO₄, pH 1.2, was used as the extractant for AEOM. The mixture, compared with 0.1 N H₂SO₄, extracted more soil organic matter obviously due to the complexing action of pyrophosphate ion releasing organic matter from metal-organic complexes; practically a period of 24 hr was enough for the mixture to extract AEOM completely at room temperature.

3) Total organic carbon

Total organic carbon in the samples was determined by a wet combustion method,⁴⁾ and the percentage on oven-dry basis was represented by Ct.

The method for studying AEOM

1) Extraction and fractionation of AEOM

One to 20 g of the sample was added with 100 ml of the extractant, and left at room temperature for 24 hr. The extract, yellow to orange, was separated from the residue and named AEOM solution.

A portion of the AEOM solution was taken, adjusted to pH 1.0, and then added with active carbon. The mixture was filtered by suction and the active carbon was washed with 0.1 N H_2SO_4 . The filtrate was received into a measuring flask and made to volume. This fraction not adsorbed, almost colorless, was named Fr. 1, which was considered a mixture of non-humic, simple organic substances and soluble metallic salts¹⁾. The fraction adsorbed was named Fr. 2.

Then the active carbon was eluted with 0.1 N NaOH; the eluate, red to yellow, was received into a measuring flask, made to volume, and named Fr. 3; and that not eluted, Fr. 4. Probably Fr. 3 contained phenolic glycosides, polysaccharides, and large-molecular acids¹⁾; Fr. 4 was left unknown.

2) Organic carbon in the form of each fraction

Organic carbon in the solutions of AEOM and Fr.'s 1 and 3 was determined by a permanganate oxidation method⁶⁾; and percentage carbon in the forms of AEOM, and Fr.'s 1, 2, 3, and 4 in the samples was calculated and represented by Cae, C1, C2, C3, and C4, respectively.

3) Optical properties of Fr. 3

Optical properties of Fr. 3 were measured with an alkaline solvent. The UV spectra contained the features: absorption maxima at about 270 and 330 nm clear on the samples except A horizons and on the plant materials particularly, and almost straight spectra differing in gradient on the A-horizon samples. Hence, absorbances at 270 and 330 nm by a solution with a given carbon concentration were measured and repre-

sented by K270 and K330, respectively.

Results and discussion

1) Analytical results

Analytical results on AEOM from the samples are shown in Table 2. The table shows that both the quantitative and the optical properties of AEOM were characteristic of the sample groups. The relationships between the individual values including those of soil pH will be discussed in a little detail below.

2) Distribution of the fractions in AEOM

The percentage distribution of C1, C3, and C4 in Cae on all the samples is shown in Fig. 1. The percentage of Fr. 3 in AEOM, on the whole, was high in the order: plant materials < peat and muck layers < O horizons < A horizons; and that

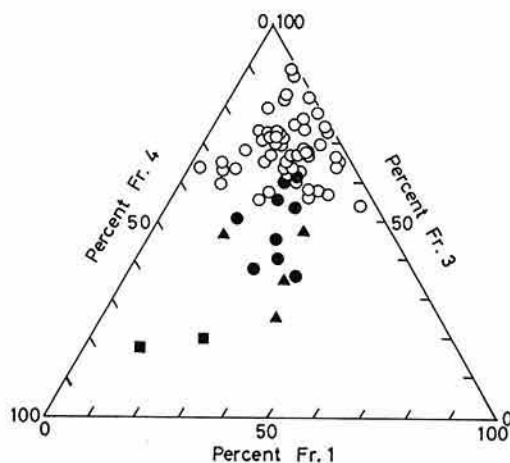


Fig. 1. Distribution of the acid-extractable organic carbon between the Fr.'s 1, 3, and 4 on the samples of plant materials (■), peat and muck layers (▲), O (●) and A horizons (○).

Table 2. Analytical results on AEOM

Sample group	Cae/Ct	C1/Cae	C3/Cae	C4/Cae	Optical properties	
	%	%	%	%	K270	K270/K330
Plant materials	3-5	13-26	17-20	54-70	1.4-1.8	1.1-1.8
Peat and muck layers	0-8	17-39	26-47	18-37	1.1-1.6	1.4-2.3
O horizons	2-8	18-38	36-63	11-34	1.3-1.8	1.8-2.2
A horizons	4-36	3-43	54-89	0-34	1.1-2.9	1.8-2.7

Table 3. Correlation coefficients (statistically significant) between the properties of AEOM from the samples of plant materials, peat and muck layers, and O horizons (n=15)

1. Cae (log)										
2. C1 (log)	.94***									
3. C2 (log)	.99***	.88***								
4. C3 (log)	.88***	.86***	.87***							
5. C4 (log)	.92***	.80***	.94***	.66**						
6. C1/Cae										
7. C3/Cae					-.73**					
8. C4/Cae					.68		-.86***			
9. K270										
10. K330								.69**	.60*	
11. K270/K330			-.53*		-.68**		.74**	-.80***		-.76**
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.

*Significant ($p < 0.05$), **highly significant ($p < 0.01$), ***ditto ($p < 0.001$); these apply to Tables 4 and 5 also.

Table 4. Correlation coefficients (statistically significant) between the properties of AEOM and soil pH on the A-horizon samples (n=53)

1. Cae (log)											
2. C1 (log)	.93***										
3. C2 (log)	1.00***	.89***									
4. C3 (log)	.99***	.91***	.99***								
5. C4 (log)	.66***	.51***	.68***	.62***							
6. C1/Cae		.55***									
7. C3/Cae	-.41**	-.47***	-.37**	-.31*	-.58***	-.46***					
8. C4/Cae					.65***	-.53***	-.51***				
9. K270	.55***	.47***	.55***	.53***	.49***		-.33*	.27*			
10. K330	.48***	.37**	.49***	.45***	.54***		-.41**	.40**	.89***		
11. K270/K330										-.33*	
pH (H ₂ O)	-.37**	-.36**	-.44**	-.40**	-.51***		.45***	-.38**	-.53***	-.67***	.39**
pH(KCl)	-.38**	-.29*	-.38**	-.34*	-.45***		.44**	-.40**	-.47***	-.67***	.49***
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.

of Fr. 4 in the reverse order. The formation of humic substances from plant materials is probably accompanied with the increase in C3/Cae and the decrease in C4/Cae.

3) *Relationships between the properties of AEOM from the samples except A horizons*

Correlation coefficients between the properties of AEOM from the samples except A horizons are shown in Table 3. The aforesaid properties, namely, C3/Cae and C4/Cae were negatively related each other and positively or negatively to C4 and K270/K330. This indicates that, during the formation of the organic horizon or layer from plant remains, AEOM tends to increase in C3/Cae and K270/K330 and decrease in C4/Cae and C4.

4) *Relationships between the properties of AEOM and soil pH on A horizons*

The correlation coefficients are listed in Table 4. Almost all the quantitative properties were related to K270 and K330. The distribution of the values of C2 and K270 is illustrated in Fig. 2. The figure shows a distribution of the soil groups fairly well distinguished from each other, and may be useful for identifying soil types.

Table 4 shows also that almost all the properties of AEOM were highly related to soil pH; this fact leads to the assumption that the properties of AEOM will reflect the biological status in the soil, as soil pH is a factor directly and indirectly affecting soil microorganisms.

5) *Relationships between the properties of AEOM from O horizons and soil pH*

The correlation coefficients are given in Table 5. The table shows that the properties of AEOM from O horizons were equally or more highly correlated to the pH of A horizons than to that

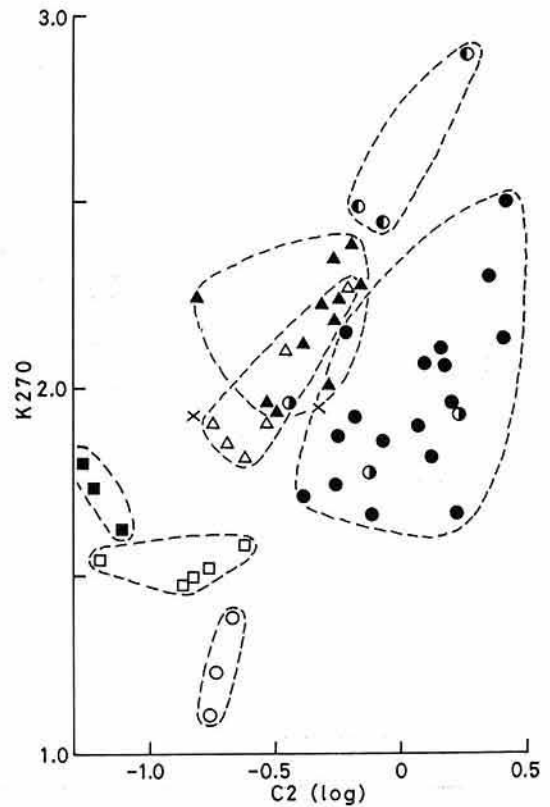


Fig. 2. Distribution of the values of C2 and K270 of acid-extractable organic matter from the A horizon samples of Andosols (●), Kuroboku soils (○), Brown Forest Soils (●), Podzols (×), Red-Yellow Soils (△), soils derived from basic parent materials (□), Chernozems (○), Ferralsols (▲), and Gray Lowland Soils (■). Correlation: $r = 0.55^{***}$ ($n = 53$).

of O horizons. This may be interpreted that the quality and quantity of plant remains supplied to, and the biological status in, O horizons must be at least partly influenced by the chemical and physico-chemical properties of underlying horizons and, hence, the properties of microbial

Table 5. Correlation coefficients (statistically significant) between the properties of AEOM from the O horizon samples and soil pH (H₂O) (n=9)

pH(H ₂ O) of	O horizons	-.76*		-.79*	-.73*	-.77*			-.68*			
	A horizons	-.74*	-.83**	-.68*		-.87**	.83**	-.88**				.78*
		Cae (log)	C1 (log)	C2 (log)	C3 (log)	C4 (log)	C1 /Cae	C3 /Cae	C4 /Cae	K270	K330	K270 /K330
		of O horizons										

products from the plant remains and, consequently, of AEOM in O horizons can depend, in part, on the pH of A horizons.

Conclusion

It was shown that several properties of soil organic matter extracted and fractionated by this method were related not only to each other but to soil pH and characteristic of the soil types examined. The method may be useful for characterizing humus of soils and, moreover, possibly applied to the studies of aquatic humus containing little humic acids and of decaying process of composts also with a few modifications.

References

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