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FRACTIONATION OF SOIL ORGANIC MATTER IN LATERITE SOILS OF KERALA

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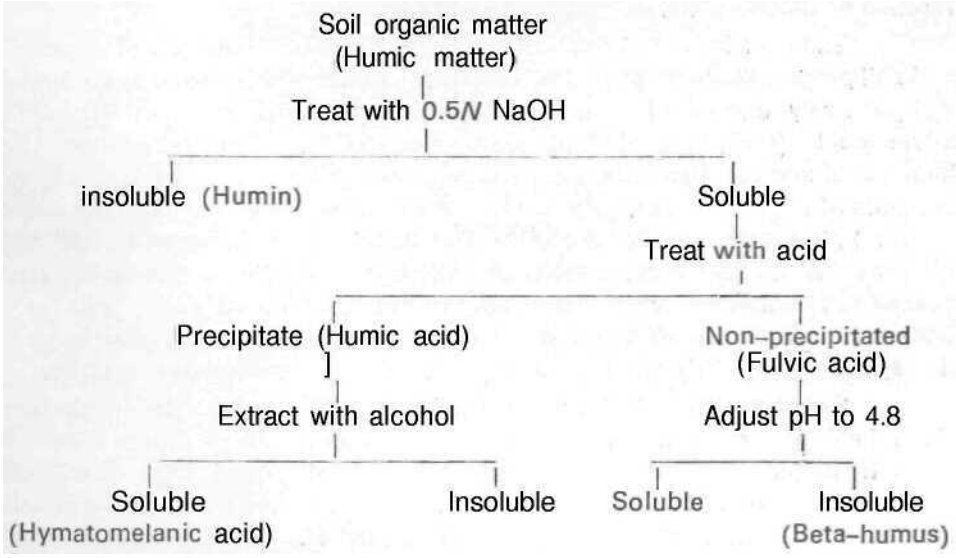
Soil organic matter, the key component of soil includes plant and animal residues at various stages of decomposition, **cells** and tissues of microbes and substances synthesised by soil population. Estimations showed that 98 per **cent** of nitrogen, 80 percent of sulphur and 60 per cent of phosphorus are associated with the organic compounds in soil (Swaby, 1968). The important groups that make up basic substances are humic acid, fulvic acid and humin. Studies on the fractionation and elemental composition of organic matter in laterite soils of Kerala have not so far been reported. The study was therefore undertaken with a view to understand the pattern of distribution of empirical fractions and elemental constituents of soil organic matter in laterite soils of Kerala.

Materials and Methods

Fractionation of organic matter and determination of constituents were carried out using twelve samples collected from laterite zones of Kerala. The general characteristics of these soils have already been reported (Usha and Jose, 1983). Fractionation was carried out using the procedure suggested by Stevenson (1965) as indicated in the flow chart given below:



The elemental constituents of organic matter estimated were carbon (Walkley and Black, 1934), nitrogen (microkjeidahl method as per Jackson, 1958), phosphorus and potassium (Palaniappan, 1975) and sulphur (Evans and Rost, 1945 and Chesnin and Yien, 1951).

Results and Discussion

Humic substances arise from the chemical and biological degradation of plant and animal residues and from the synthetic activities of micro-organisms. They are dark coloured, acidic, predominantly aromatic, hydrophilic, chemically complex and poly-electrolyte like material, the molecular weight ranging from a few hundreds to several thousands. Structurally, the three humic substances namely humic acid, fulvic acid and humin are similar but they differ in molecular weight, ultimate analysis and functional groups.

Data on the distribution of different fractions of organic matter expressed as percentage to soil on moisture free basis are presented in Table 1. The distribution of soil organic fractions expressed as percentage to the total organic matter is given in Table 2.

Humic acid

The humic acid fraction of soil organic matter ranged from 0.172 to 2.706 per cent with a mean value of 0.629 per cent. When the percentage contribution of this fraction to total organic matter was worked out, it accounted for 8.30 to 47.55 per cent of the total organic matter with a mean value of 28.28 per cent. The tropical humid conditions favour the accumulation of humic and fulvic acid as compared to that of humin. The reaction of the soil selected for the study is acidic which favours the relatively higher accumulation of humic acid in soil. Lignin being the chief constituent of humic acid remains resistant to degradation even under strongly leached acid conditions.

The coefficients of correlation between different fractions of organic matter and soil propertiesare presented in Table 3. Humic acid is found to be significantly and positively correlated with total organic C ($r=0.8520^{**}$), total N ($r=0.7397^{**}$), fulvic acid ($r=0.9082^{**}$) and clay ($r=7799^{**}$). The correlation between humic acid and organic carbon is expectedsince humic acid is one of the constituents of organic matter. Because of the same reason it is also correlated with the total nitrogen content of the soil. The relationship between humic acid and fulvic acid is indicative that these two fractions maintain a constant proportion between them irrespective of the variation in the content of total organic matter. The relationship between clay and humic acid may be due to high degree of correlation between clay and organic carbon ($r=0.8244^{**}$) observed in the study.

Based on the solubility in alcohol, the humic acid is fractionated into alcohol soluble hymatomelanic acid and an alcohol insoluble fraction. The percentage of hymatomelanic acid in the twelve soils studied ranged from 0.097 to 0.252 with a mean value of 0.129. In general, the content of hymatomelanic acid increased with the increasing content of total organic matter. Hymatomelanic acid is a naturally esterified or methylated fraction of the humic acid which can be liberated by ethanol extraction and therefore its content will obviously depend upon the total content of organic matter. The alcohol insoluble fraction of humic acid in soil ranged from 0,072 to 2.454 per cent and when expressed as per cent to total organic

matter it ranged from 5,05 to 40.6 with a mean value 18.68, These observations revealed that the major part of humic acid was constituted by alcohol insoluble fractions and the alcohol soluble part was only about half of the alcohol insoluble fraction.

Fulvic acid

This fraction, on an average, accounted for 36-51 per cent of the total organic matter. The relatively high content of fulvic acid observed can be attributed to the low pH, high rainfall and high content of sesqui-oxides of the soil since these factors favour the accumulation of fulvic acid. Fulvic acid can be considered as the more oxidised and degraded products of humic acid with a higher proportion of oxygen containing functional groups like COOH. OH, and C = 0 as compared to other humic fractions of soil. As a result, cultivated soils and high weathered soils of warm humid tropics tend to register high values for fulvic acid fraction. Stabilisation of fulvic acid results from the formation of aggrgates due to hydrogen bonding, Van der Waal's interactions and electron systems of adjacent molecules. Fulvic acid was significantly and positively correlated with total organic carbon ($r=0.9618^{**}$), total N ($r=0.8913^{**}$), humic acid ($r=0.9082^{**}$) and clay ($r=0.8552^{**}$) content of soil. As in the case of humic acid, the relationship of fulvic acid with total organic matter was quite expected since it is one of the constituents of organic matter and hence an increase in the total content of humic substances will obviously reflect on the content of its fractions. The relationship between total nitrogen and fulvic acid appeared to be indirect since organic carbon and total nitrogen are highly correlated, Itwas observed that not only the total content of fulvic acid increased with the total content of humic acid which might be due to increase in the content of total organic matter but also the proportion of fulvic acid in total organic matter increased with the proportion of humic acid. Any increase in the content of humic acid results in the content of fulvic acid even without a change in the content of total organic matter. This relationship was indicative of an intense association between these two fractions of organic matter during its formation and accumulation in soil.

Ratio between humic acid and fulvic acid (HAjFA ratio)

The HA/FA ratio ranged from 0.23 to 1.06 with a mean value of 0.78. Except for two soils the ratio was lower than one thus indicating a higher preponderance of fuivic acid in soil as compared to humic acid. In acid soils which are rich in basic substances, fulvic acid fraction accumulates due to the increased rate of degradation of humid acid,

Hum in

Humin, the alkali insoluble part of organic matter represents the high molecular fractions of humic substances. This fraction accounted for 5.99 to 64.02 per cent of the total organic matter in soils studied. Humin was found to be significantly correlated with total organic carbon ($r = 0.6455^{**}$) and also with total nitrogen ($r = 0.7374^{**}$). Humin is the fraction of basic substances which contributes maximum towards the total nitrogen of the soil.

Elemental constituents of organic matter

Data on the elemental constituents of soil organic matter are presented in Table 4.

1. Organic carbon

The content of organic carbon ranged from 0.28 to 4.09 per cent with a mean value of 1.34. Organic carbon was positively and significantly correlated with humic acid, fulvic acid, humin and clay. Humic acid, fulvic acid and humin are compounds of organic carbon and hence the positive significant correlation between them.

2. Nitrogen

The content of nitrogen in soil ranged from 0.025 to 0,362% with a mean value of 0.153. Total nitrogen was positively and significantly correlated with humic acid, fulvic acid, humin and clay. A positive significant correlation between organic carbon and nitrogen ($r=0.7966^{**}$) for laterite soil had already been reported (Usha and Jose, 1983).

3. *Organic phosphorus*

This constituent of organic matter accounted for 0.05 per cent of the total organic matter in soil. In general, the organic phosphorus per cent of soil organic matter is very low as compared to that of nitrogen and sulphur. The important phosphorus containing organic compounds in soil are inositol phosphates, nuclic acid and phospholipids. Under warm humid tropical conditions these compounds are easily subjected to mineralisation. These compounds do not form the structural component of organic matter. As a result, phosphorus content of organic matter derived from plants grown in soil which are deficient in available phosphorus will naturally contain only negligible quantities of phosphorus.

4. Organic sulphur

On an average, this component of organic matter accounted for 6.96 per cent of total organic matter, the values ranging from 1.32 to 27.62. The increased dissolution of sulphates under acid conditions leads to increased availability of this nutrient to plants resulting in its accumulation in plant tissue. Organic matter derived from such plant material will have a higher proportion of sulphur in it. Sulphur compounds form a strong linkage with carbon and therefore resist the chemical and physical forces of decomposition. Cellulose, protein and hemi-celluloses can form stable complexes with sulphur. The acid conditions prevailing in these soils inhibit the activity of sulphur oxidising bacteria resulting in the accumulation of sulphur compounds at larger proportion in soil organic matter.

5. Organic potassium

The relative contribution of this element to the total weight of soil organic matter was negligible since, on an average, this element accounted only for 0.32 per cent of total organic matter. Potassium does not form the structural component of soil organic matter and as a result this element easily moves into its inorganic pool in soil during the process of decomposition of organic residues.

Table 1

Fractions of organic (humic) matter expressed as percentage to soil on moisture free basis

Sl. No.	Humic acid			Fulvic acid			Humin	Total humic substances
	Hymato-melanic acid	Insoluble	Total	Soluble	Beta-humus	Total		
1	0.127	0.294	0.421	0.453	0.057	0.510	1.086	2,017
2	0.100	0.072	0.172	0.038	0.141	0.179	0.367	0.718
3	0.131	0.349	0.480	0.126	0.329	0.455	1.644	2.599
4	0.136	0.241	0.377	0.060	0.670	0.730	0.987	2.094
5	0.252	2.454	2.706	2.537	0.348	2.885	1.362	6.953
6	0.113	0.116	0.229	0.152	0.072	0.224	0.029	0.482
7	0.125	0.219	0.344	0.517	0.050	0.567	0.066	1.977
8	0.122	0.394	0.516	0.470	0.071	0.542	0.081	1.139
9	0.114	0.132	0.246	0.230	0.264	0.494	0.474	1.214
10	0.136	1.341	1.477	1.426	0.122	1.538	0.288	3.303
11	0.097	0,132	0.229	0.134	0,170	0.304	0.097	0.630
12	0.099	0.248	0.347	1.444	0.084	1.528	2.302	4.177
Mean	0.129	0.500	0.629	0.632	0.197	0.830	0.817	2.276

Table 2

Fractions of organic (humic) matter expressed as percentage to total organic matter on moisture free basis

Sl. No.	Humic acid			Fulvic acid			Humin	HA/FA ratio
	Hymatomelanic acid	Insoluble	Total	Soluble	Beta-humus	Total		
1	6.28	14.57	20.85	22.39	2.82	25.30	53.85	0.82
2	13.87	10.06	23.93	5.34	19.64	24.98	51.09	0,96
3	13.43	5.05	18.48	4.84	12.66	17.50	64.02	1.06
4	6.48	11.50	17.98	2.86	32,00	34.86	47.16	0.52
5	3.62	35.30	38.92	36.49	5.00	41.49	19.59	0.94
6	23.43	24.12	47.55	31.57	14.89	46.46	5.99	1.02
7	6.31	11.08	17.40	26.16	1.26	28.69	53.91	0.61
8	10.70	34.49	45 19	41.20	6.24	47.44	7.37	0.95
9	9.44	10.84	20.28	18.94	21.72	40.66	39.05	0.50
10	4.13	40.60	44.73	43.19	3.37	46.56	8.71	0.96
11	14.14	20.60	35.74	20.99	26.61	47.60	16,66	0.75
12	2.38	5.92	8.30	34.57	2.01	36.58	55.12	0.23
Mean	9,60	18.68	28.28	24.05	12.35	36.51	35.21	0.78

Table 3

Relationship between soil properties and empirical fractions of organic matter

X	Y	r	Regression equations
Organiccarbon	Humic acid	0.8520**	HA% = 0.5794 C% - 0.1468
Organiccarbon	Fulvic acid	0.9618**	FA% = 0.6954 C% 0.1011
Organic carbon	Humin	0.6455**	Humin% = 0.4273 C% + 0.2428
Organiccarbon	Ciay	0.8244**	Clay% = 8.1 935 C% + 9.3039
Total nitrogen	Humic acid	0.7379**	HA% = 5.3142 N% —0.216
Total nitrogen	Fulvic acid	0.8913**	FA% = 6.8081 N% - 0.2525
Total nitrogen	Humin	0.7374**	Humin% 5,1568 N% + 0.0312
Total nitrogen	Clay	0.8448**	Clay% 88.7035 N% + 6.1711
Humic acid	Fulvic acid	0.9082**	FA% = 0,9656 HA% + 0.2226
Humic acid	Clay	0.7799**	Clay% = 11,3983 HA% + 13.1055
Fulvic acid	Ciay	0.8552**	Clay% = 11.7557 FA% + 10.5178

** **Significant** *at* 1% level

Table 4

Elemental constituents of organic matter on moisture free basis

Sample No,	Percentage to soil					Percentage of total organic matter			
	C	N	P	K	S	N	P	K	S
1	1.19	0.161	0.0003	0.0100	0.060	7.98	0.015	0.496	2.97
2	0.42	0.046	0.0011	0.0025	0.065	6.41	0.153	0.348	9.05
3	1.53	0,220	0.0030	0.0000	0.101	8.47	0.012	0,000	3.89
4	1.23	0.168	0.0000	0.0000	0.101	8.02	0,000	0.000	4.82
5	4.09	0.362	0.0000	0.0000	0.096	5.21	0.000	0.000	1,38
6	0.28	0.060	0.0000	0.0000	0.099	12.45	0.000	0.000	20.45
7	1.16	0.121	0.0040	0.0250	0.090	6.12	9.020	1.265	4.55
8	0.67	0.091	0.0003	0.0075	0.024	7.98	0.026	0.657	2,10
9	0.71	0.105	0.0006	0,0000	0.016	8.65	0.049	0.000	1.32
10	1.94	0,240	0.0000	0.0000	0.095	7.27	0 000	0.000	2.88
11	0.37	0.025	0.0003	0.0063	0.171	3.91	0.047	0.985	27.62
12	2.46	0.235	0.0008	0.0038	0,102	5.63	0.019	0.091	2.44
Mean	1.34	0.153	0.0003	0,0046	0.085	7.34	0.051	0.320	6.96

Table 5

Relationship between elemental constituents of soil organic matter

Sl. No.	Ratios									
	C/N	C/P	C/K	C/S	N/P	N/K	N/S	P/K	P/S	K/S
1	7.37	3966.6	119.0	19.8	536.7	16.1	2.68	0.03	0.005	0.17
2	9.28	381.8	168.0	6.5	18.4	18.4	0.71	0.44	0.017	0.04
3	7.04	5100.0	—	15,1	733.3	—	2.18	0.00	0.003	0.00
4	7.33	—	—	12.2	—	—	1.66	0.00	0.000	0.00
5	1.29	—	—	42.6	—	—	10.42	0.00	0.000	0.00
6	4.77	—	—	2.8	—	0.0	0.60	0,00	0.000	0,00
7	9.63	2900.0	464.0	12.9	302.5	4.8	1.34	0.02	0.004	0.28
8	7.38	2233.0	89.3	27,9	303.3	12.1	3.79	0.04	0,013	0.31
9	6.80	1183,3	—	44.4	175.0	—	6.56	0.00	0.038	0.00
10	8.10	—	—	20.4	—	—	2.52	0.00	0.000	0.00
11	15.04	1233.3	58.7	2.1	83,3	4.0	0.14	0.05	0.002	0.04
12	10.47	3075.0	647.4	24.1	293.8	61.8	2.30	0.21	0.008	0.04
Mean	8.71	1672.8	94.1	19.2	205.8	9.7	2.91	0.07	0.008	0.007

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Summary

Soil samples collected from laterite zones of Kerala were examined for fractions and elemental components of organic matter. The humic acid accounted for 28.28 percent of organic matter. Humic acid was found to be significantly and positively correlated with organic C (r=0.8520**), total nitrogen (r = 0.7397**), clay (r= 0.7799**) and fulvic acid (r = 0.9082**). Humic acid and fulvic acid maintained a constant proportion irrespective of the variation in content of organic matter. Fulvic acid accounted for 36.51 per cent of total organic matter. Significant and positive correlations were observed for fulvic acid with organic carbon (r=0.9618**), total N ;r = 0.891 3**) and humic acid (r = 0.8552**). The HA/FA ratio of soil organic matter ranged from 0.23 to 1.06 with a mean value of 0.78. Humin fraction accounted for 35.21 per cent of soil organic matter. Humin content was found to be positively and significantly correlated with total nitrogen (r -- 0.7374**) and organic carben (r = 0.6455**). The mean contents of nitrogen, phosphorus, sulphur and potassium in soil organic matter were 7.34, 0.051, 6.96 and 0.32 per cent respectively.

സംഗ്രഹം

കേരളത്തിലെ ചെങ്കൽമണ്ണുള്ള പ്രദേശങ്ങളിൽ നിന്നും ശേഖരിച്ച മേൽമണ്ണിലെ ജൈവപദാർത്ഥത്തിന്റെ ഘടന പരിശോധിക്കുകയുണ്ടായി. ജൈവാംശത്തിന്റെ 28 28 ശതമാനം ഹ്യൂമിക്ക് അമ്ലമാണ്. ഈ അമ്ലം ffljspplsiej ജൈവ കാർബൺ, നൈട്രജൻ, ചള്ളി, ഫുൾവിക്ക് അമ്ലം എന്നിവയുമായി cum സഹബന്ധം പുലർത്തുന്നു. ഹ്യൂമിക്ക് അമ്ലവും ഫുൾവിക്ക് അമ്ലവും എപ്പോഴും ഒരു നിശ്ചിത അനുപാതത്തിൽ സ്ഥിതിചെയ്യുന്നതായി മനസ്സിലായി. ജൈവപദാർത്ഥത്തിന്റെ 36,51 ശതമാനം ഫുൾവിക്ക് അമ്ലവും, 35.21 ശതമാനം ഹ്യൂമിൻ എന്ന അംശവും ആയിരുന്നു. ഈ അംശങ്ങൾക്ക് മണ്ണിന്റെ മറ്റു ഘടകങ്ങളുമായുള്ള ബന്ധവും മണ്ണിലെ ജൈവപദാർത്ഥത്തിന്റെ പോഷകമൂലകങ്ങളുടെ അളവും പഠിക്കുകയുണ്ടായി.

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