

## SOIL HUMIC FRACTIONS OF RED FERRALLITIC SOILS AS INFLUENCED BY VEGETATIONAL TYPES

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Abstract: Humic and fulvic acids (HA and FA) extracted from evergreen, semi-evergreen and moist deciduous forests, and plantations of teak, eucalypt and rubber soils belonging to red ferrallitic type of Kerala were quantified and characterised by UV and IR spectroscopies. The HA and FA contents were relatively higher in the natural forests. They differed significantly between vegetational types and varied in chemical composition. The IR spectra of HA and FA were very weak and their aliphatic groups were lower in eucalypt soils.

### INTRODUCTION

Plants differ greatly in relative and absolute absorption of nutrients from the soil. Consequently chemical composition of leaves of the various species is different and so is that of humified materials produced due to microbial decomposition and transformation of organic residues by processes like hydrolysis and oxidation, even within the same habitat. Hence, difference in vegetational types can cause variation in the quantity and characteristics of soil humic fractions. This study was undertaken to quantify the soil humic fractions and evaluate the spectroscopic and chemical differences of red ferrallitic soils as influenced by evergreen, semi-evergreen and moist deciduous forests, and plantations of teak, eucalypt and rubber in Kerala.

### MATERIALS AND METHODS

A linear transect, 9 km long and 500 m wide starting from evergreen (West Coast tropical evergreen), passing through semi-evergreen (West Coast semi-evergreen), and moist deciduous (South Indian moist deciduous) forests, teak (*Tectona grandis*), eucalypt (*Eucalyptus*

*tereticornis*) and rubber (*Hevea brasiliensis*) plantations was taken in Trichur Forest Division, Kerala. The transect was chosen in such a manner that each vegetational type was represented by an area of 1.5 km length and 500 m width. Five subplots of 50 m x 50 m were laid out randomly in one vegetational type, each subplot separated from the other by about 50 m. One surface sample (0-15 cm) was taken from every subplot. The method of Stevenson (1965) was employed for separating humic and fulvic acids (HA and FA). Analysis of variance of humic and fulvic acids due to vegetational types was also found out (Snedecor and Cochran 1975). The UV spectra of HA and FA were recorded using Unicam SP 500 UV and visible spectrophotometer. For this 0.5 g of the material was dissolved in 0.5 N NaOH and the UV spectra recorded. In the case of IR spectra, 0.5 g of the material was ground with nujol and the spectra was taken using Perkin Elmer Infracord 137 Spectrophotometer.

### RESULTS AND DISCUSSION

Mean values of HA and FA in the six vegetational types are given in Table 1. Analyses of variance of HA and FA are

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shown in Table 2. The UV and IR spectra are depicted in Fig. 1 to 4.

### Humic acid

Humic acid contents were 1.12% of soil in evergreen, 1.07% in semi-evergreen, 0.99% in moist deciduous, 0.94% in **teak**, 0.76% in **eucalypt** and 0.98% in **rubber**. The natural forests contained higher amounts of HA when compared with those in the plantations and of these eucalypt soils had the lowest. In evergreen, semi-evergreen and moist deciduous forests, per cent of HA to OM was 33.24, 47.82 and 39.42, respectively whereas the corresponding values in **teak**, **eucalypt** and **rubber** were 38.94, 36.44 and 28.59 in the same order. Analysis of variance of HA in the six vegetational types showed that HA differed significantly.

HA contents in the natural forests and plantations show that they are in support of the results of **Manarino et al.** (1982) and **Li** (1987). Continuous supply of raw materials through litter and the conducive climatic conditions and **microbial** growth contribute to more HA production in the natural forests (**Allison**, 1973). Moreover, it has been pointed out that lignin is the chief contributor of HA (**Hurst and Burges**, 1967). Here also it has been found that as the HA content increased, the proportion of lignin increased (**Balagopalan**, 1991).

The HA generally was about 40% of OM. The contribution of HA to OM for humid soils is reported to be more than 20% and for Tamil Nadu soils, it is less than 10% (**Palaniappan**, 1975). This shows that HA in the OM fraction in the present study

is considerably higher than those in the humid soils of Tamil Nadu which indicates that tropical humid conditions might have favoured the accumulation of HA (**Usha**, 1982), resulting in relatively higher values. On comparing the HA to OM fraction, it could be visualised that it was low in evergreen (33.24) and **rubber** (28.59). Here also HA content increased not in exact proportion to OM content.

### Fulvic acid

Fulvic acid contents were 1.08% of soil in evergreen, **1.01%** in semi-evergreen and 0.95% in moist deciduous forests, 0.88% in **teak**, 0.82% in **eucalypt** and 0.92% in **rubber**. This clearly manifests that FA was higher in the **natural** forests. In evergreen, semi-evergreen and moist deciduous forests, per cent of FA to OM was 32.20, 45.49 and 37.60 while those in **teak**, **eucalypt** and **rubber**, were 36.54, 39.31 and 27.01, respectively. Analysis of variance of FA indicated that FA differed significantly due to vegetational types.

The FA contents in the natural forests and plantations manifest that they all are in consonance with the findings of **Palaniappan** (1975). The relationship between finer **fractions**, sesquioxides, carbohydrates, soil reaction, moisture status and microbial activity and FA resulted in the relatively higher amounts of FA in the natural forests.

FA, in general, accounted to be a high per cent of OM. The proportion of FA to OM appears to be very high when it is compared with the values reported by **Palaniappan** (1975) and is close to those (30%) of **Mandal et al.** (1990). **Schnitzer**

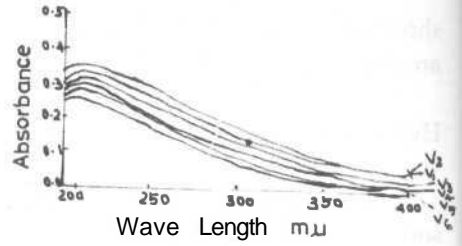
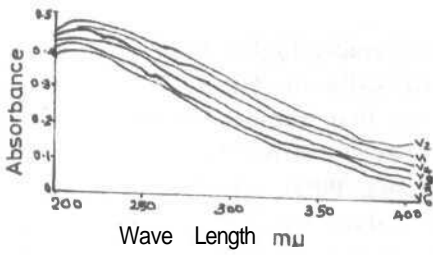


Fig.1. uv Spectra of humic acids

Fig.2. uv spectra of fulvic acids

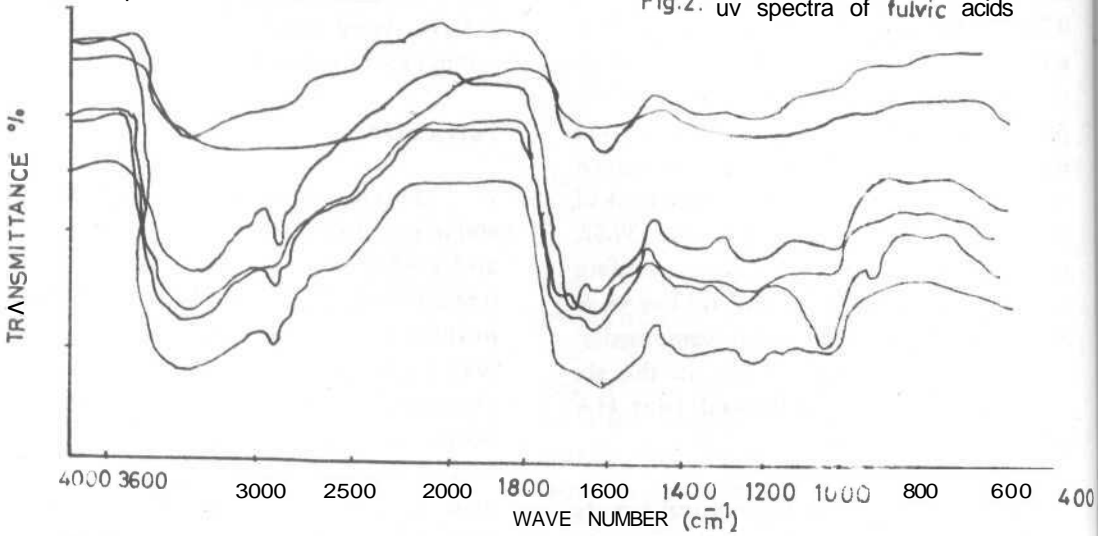


Fig 3 . IR Spectra of humic acids

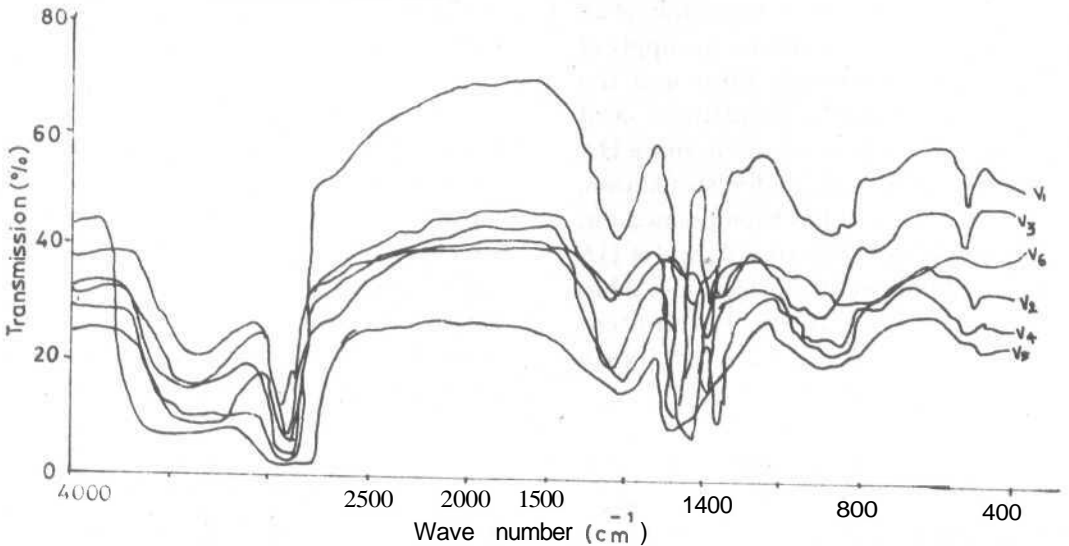


Fig. 4. IR Spectra of fulvic acids

- V<sub>1</sub> = Evergreen    V<sub>2</sub> = Semi-evergreen    V<sub>3</sub> = Moist deciduous
- V<sub>4</sub> = Teak        V<sub>5</sub> = Eucalypt        V<sub>6</sub> = Rubber

Table 1. Mean values of soil humic fractions in six vegetational types

Veg. types	Properties				
	HA		FA		HA :FA
	% of soil	% of OM	% of soil	% of OM	
Evergreen	1.12	33.24	1.08	32.20	1.03
Semi-evergreen	1.07	47.82	1.01	45.49	1.05
Moist deciduous	0.99	39.42	0.95	37.60	1.05
Teak	0.94	38.94	0.88	36.54	1.07
Eucalypt	0.76	36.44	0.82	39.31	0.93
Rubber	0.98	28.59	0.92	27.01	1.06

n = 5

Table 2. Analysis of variance of soil humic fractions in six vegetational types

Source	Degrees of freedom	Properties			
		Humic acid		Fulvic acid	
		MSS	F-values	MSS	F-values
Total	29		-		
Replication	4	0.00037	1.544 <sup>ns</sup>	0.002	12.599**
Veg. types	5	0.076	314.500**	0.043	253.894**
Error	20	0.00024		0.00017	

\*\* significant at 1% level

ns = not significant

(1970) obtained FA to OM proportion in the range of 31 to 56% for podzol. The relatively higher values in the present study could be ascribed to the low pH, high rainfall and sesquioxides.

An attempt is also made to designate the soils as humate, fulvate or humin type. The per cent of HA and FA as a whole of OM accounted to be 61 to 97 except eucalypt where it was 56. The

balance remaining as unextractable (**humins**) was very small and based on this value the soils could be classified as humate- fulvate type. Similar categorisation has also been made by Kononova (1968), Palaniappan (1975) and Balagopalan (1990). The low humin content followed by small OM can be expected under tropical conditions owing to rapid decomposition.

## SPECTRAL ANALYSES

### Humic acid

#### *UV spectra*

There was a broad shoulder at 235 nm in the UV spectra of HA.

#### *IR spectra*

IR spectra of HA showed a broad absorption between 3800-3100  $\text{cm}^{-1}$  in all vegetational types. There was a slightly stronger absorption near 1710  $\text{cm}^{-1}$  in evergreen while in the remaining, it was weak. A slightly stronger band near 1610  $\text{cm}^{-1}$  was also observed in all cases. A stretching near 1000  $\text{cm}^{-1}$  was noted for the IR spectra of HA of rubber soils.

Absorption in the UV region is due to the presence of multiple bonds and to unshared electron pairs in organic molecules. The optical density decreases with wavelength. In HA, the chromophores C=C and C=O and auxochromes, C-OH, C-NH<sub>2</sub> etc. are present in considerable amounts leading towards overlapping of absorption and so the interpretation of UV spectra becomes difficult. The UV spectra are very similar in spite of the differences in elementary composition, sedimentation and other

characteristics. This agrees with the findings of Schnitzer and Khan (1972).

As regards the IR spectra of HA the broad absorption between 3800-3100  $\text{cm}^{-1}$  in all the spectra indicates the presence of hydrogen bonded -OH groups. The spectrum as a whole, of eucalypt, is very weak. The presence of aliphatic chains (-CH<sub>2</sub> absorption near 2900  $\text{cm}^{-1}$ ) is pronounced in evergreen, followed by in rubber, semi-evergreen and teak. It is very weak in eucalypt and moist deciduous. The absorption near 2900  $\text{cm}^{-1}$  is also unrelated to the acid character of HA (Mindermann, 1979). The weak absorption near 1710  $\text{cm}^{-1}$  manifests **carboxylic** group which is slightly stronger in evergreen. The absorption near 1610  $\text{cm}^{-1}$  shows the presence of aromatic system (Mindermann, 1979) and this band is slightly stronger in all the cases except eucalypts. The stretching near 1000  $\text{cm}^{-1}$  in rubber may be due to the C-O stretching frequencies of open chain (mixed) anhydrides (other linkages of **polysaccharides**). The spectral studies reveal that the aliphatic chains are weak in moist deciduous and eucalypt and *vice versa* in the remaining four. There is strong aromatic ring in all the spectra. The spectra, in general, agree with those recorded by Singhal and Sharma (1983) and Arshad and Schnitzer (1989). The HA varied in chemical composition in different vegetational types.

### Fulvic acid

#### *UV spectra*

The UV spectra of FA also showed a broad shoulder at 235 nm.

*IR spectra*

Comparing the IR spectra in the six vegetational types, a strong absorption near  $1640\text{ cm}^{-1}$  was noticed in evergreen, semi-evergreen, moist deciduous and teak, while in eucalypt and rubber, a weak band near  $1600\text{ cm}^{-1}$  was found. The spectra had a strong absorption band near  $1460\text{ cm}^{-1}$  and  $1380\text{ cm}^{-1}$  in evergreen and moist deciduous, less pronounced in teak, while in semi-evergreen, it was shifted to  $1360\text{ cm}^{-1}$  from  $1380\text{ cm}^{-1}$ . In eucalypt and rubber, the spectra were weak at  $1460\text{ cm}^{-1}$  and  $1340\text{ cm}^{-1}$ . In the  $720\text{ cm}^{-1}$  region, there was a strong absorption band in evergreen and moist deciduous and a weaker one in teak. A shift in the absorption to  $700\text{ cm}^{-1}$  in semi-evergreen was noticed while in eucalypt and rubber, there was a broad absorption in this region.

The UV spectra of FA show that the optical density decreases with wave length. It is noteworthy that UV spectra of HA and FA are very similar, even though they are of diverse origins. Since there is same amount of material taken, the length of spectra can be inferred to be due to the concentration of material. It is found to be slightly higher in HA.

Comparing the IR spectra of different vegetational types, it can be seen that the spectrum in evergreen forest is most intense, followed by moist deciduous, while it is very weak in eucalypt and rubber. The weak spectrum gives, in general, evidence for less material. The IR spectra reveal that the bands near  $1640\text{ cm}^{-1}$ ,  $1460\text{ cm}^{-1}$ ,  $1380\text{ cm}^{-1}$  and  $720\text{ cm}^{-1}$  are strong in evergreen and

moist deciduous while in others, either the bands are less pronounced or slightly shifted. The IR spectra, thus, manifest that there is slight difference in the chemical composition of FA in the vegetational types. Such reports of variation in chemical composition of FA are not uncommon (Chernikov *et al.*, 1982; Gupta and Bhardwaj, 1989).

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