IJSAR, 8(1), 2021; 01-09

International Journal of Sciences & Applied Research

www.ijsar.in

Survey on fractions of Humic substances and its carbon distribution in tea soils of South India

Kariappan Poobathiraj*

Chemist, UPASI Tea Research Foundation, Regional Centre, Coonoor – 643 101, Nilgiris district, Tamil Nadu, India.

Corresponding author: *Kariappan Poobathiraj, Chemist, UPASI Tea Research Foundation, Regional Centre, Coonoor – 643 101, Nilgiris district, Tamil Nadu, India.

Abstract

Soil organic matter is considered as a key attribute of soil fertility and productivity because of its importance in physical, chemical as well as biological properties of soil. Most of the soil organic matter or organic carbon is formed by the biological transformation of plant and animal residues into humic substances (humic acid, fulvic acid and humin). The objective of this study was to quantify the extractable fractions of humic acid, fulvic acid and humin (humic substances) from tea soils of south India and to determine the distribution of organic carbon among them. Soil samples were collected from seven tea growing regions of south India based on different organic matter status. Humic acid, fulvic acid and humin were extracted by adopting classical method with certain modifications and organic carbon was determined in the above fractions as per standard method. The results showed that the yield of humic acid fraction was higher compared to fulvic acid fraction. Organic carbon had a positive correlation with humic acid fraction. The carbon content of humic acid fraction was higher when compared to fulvic and humin fractions. The Pearson correlation coefficient worked out between carbon content soil and humic acid fraction showed positive and significant correlation. It can be concluded from this study that the yield of humic acid fraction is positively correlated with soil organic matter and the distribution of organic carbon was higher in humic acid fraction compared to other fractions such as fulvic acid and humin which revealed that humic acid fraction plays a vital role in balancing the carbon content of tea soils in south India.

Keywords: Carbon distribution, humic substance fraction, humic acid carbon, tea soils

Introduction

In south India, tea is grown in the humid belt of the Western Ghats with varied agro climatic conditions. The tea soils of south India are highly weathered undergone considerable leaching and hence distinctly acidic. The quality of soil organic matter is important to justify the productivity of soil. It supports the basic fraction of soil composed of living micro organisms. Soil organic matter or organic carbon is considered to be a key attribute to soil fertility and productivity because of its importance to soil physical, chemical as well as biological properties. (Stevenson, 1986 and Reeves, 1997). There is ample evidence to suggest that certain fractions of soil organic matter are more important in maintaining soil fertility and are more sensitive indicators for effective management practices compared to soil total organic carbon. (Von Lut–zow et al., 2000). Soil organic carbon is a heterogeneous mixture of organic substances and the different forms or fractions of soil organic carbon have varied effects on soil fertility and quality. (Santos & Camargo, 1999). Humic substances are the major components of soil organic carbon. Humus is composed of humic acid, fulvic acid and humin molecules, which in spite of their similar structure and functional grouping are quite different with regard to their molecular weights, aromatic grade and solubility in acidic or alkaline solutions (Wandy heredia et. al., 2006). Most of the soil organic carbon is formed by the biological transformations of plant and animal residues into humic substances (humic acid, fulvic acid and humin). The humic substances are determined by classical procedure of fractionation based on solubility in basic/ acidic media. The humic substances (humic acid, Fulvic acid and humin), involve preliminary separation on the basis of solubility. For example, the alkali soluble compounds can be separated into two fractions, namely acid soluble fraction (Fulvic acid) and the acid insoluble fraction (humic acid). Humic acid is a high molecular weight substance with high carbon and nitrogen contents. Fulvic acid is known to be with low molecular weight and higher oxygen content but lower nitrogen content compared to humic acid (Roland B Londeau, 1986). Humin is defined as the fraction of humic substances that is insoluble in aqueous solution at any pH value (James A. Rice, 2001). The main objective of this study was to investigate the distribution of carbon in different fractions of humic substances by the extraction of humic acid, fulvic acid and humin from the tea soils of south India.

Materials and methods

Sample site and soil sampling

The south Indian tea growing areas were divided into seven different agro climatic zones viz Anamallais, Nilgiris, Nilgiri - Wayanad, High Range, Central Travancore, Wayanad and Karnataka. The division was done based on their differences in elevation, annual precipitation, ambient temperature and physical properties of the soil. Four soil samples with varying organic matter status were collected from each region. The elevation of the Anamallais varies from 900 to 1600 m above MSL with the annual rainfall ranging between 3000 and 3800 mm. The elevation of the Nilgiris ranges between 1000 and 2634 m above MSL (mean sea level). The district receives a mean annual rainfall varying from 1000 to 1500 mm. The elevation of High Ranges varies from 950 to 2600 m with the annual rainfall varying from 1300 mm in the east to 7000 mm at the western end all within a distance of 26 km. Vandiperiyar (Central Travancore) is one of the oldest planting districts in south India. Besides tea, other crops such as coffee, pepper and cardamom are also grown in a sizeable area. It is situated at an elevation varying from 750 m to 1350 m above mean sea level. Annual rainfall of Central Travancore lies around 2000 mm. The elevation of Wayanad ranges between 850 and 1200 meters above MSL. It enjoys tropical to humid subtropical climate with an average annual rainfall of 2,600 mm. In Karnataka (Koppa) plantation crops are cultivated mostly in the Malnad region which comprises Chikmagalur, Hassan and Kodagu districts. Amongst the plantation crops Karnataka holds an enviable position in coffee in terms of acreage and production. The tea area in Karnataka falls in the northern end of the tea growing tracts in south India and it enjoys a humid and subtropical climate. The estates receive 2000 to 3500 mm rainfall annually and 70 per cent of it is received during the south-west monsoon period. Four soil samples were collected from each region based on the different organic matter status. Sampling depth is 0-9 inches (0-22.5 cm) using sampling "Auger"

Extraction and analysis of humic substances

The collected soil samples were air dried in shade and passed through the 2 mm sieve for the extraction of humic acid, fulvic acid and humin. The extraction scheme was proposed by the IHSS (Swift, 1996) with some modifications applied for extraction and purification of humic substances from the soil sample (Aiken et. al., 1985). Twenty grams of soil was washed with 0.1 N HCl and added with the alkaline solution of 0.5 N NaOH (at a ratio of 1:10) and shaken for 12 hours at 25ºC and 180 rpm. The suspension was centrifuged and the supernatant solution was collected and acidified with 0.5 N HCl. The residue of this extraction is termed as "Humin", as described by Khan 1971 which is purified by washing with HCl-HF mixture and distilled water before use for organic carbon estimation. In the supernatant, humic acid was precipitated by adjusting pH of solution to 1.5 – 2.0. The solution was kept at room temperature for 12 hours for settling the precipitate of humic acid. The precipitate of humic acid was separated using centrifugation and washed with HCl-HF mixture at least 3-4 times followed by distilled water and oven dried at 80°C. The pH of the supernatant was adjusted between 4.0 and 4.5 using alkaline solution of 0.5 N NaOH. The solution was kept at room temperature for 12 hours for settling the precipitate of fulvic acid, after 12 hours the precipitate was centrifuged and dried on hot water bath. The dried fraction of humic acid, fulvic acid and humin were used for the analysis of organic carbon. The schematic diagram for the extraction of humic acid, Fulvic acid and humin is furnished in figure. 1. The analysis of organic carbon in humic acid, fulvic acid and humin fraction was carried out by employing the method of Walkley and Black (1934).

Statistical analysis

Statistical calculations such as standard deviation and Pearson correlation coefficient were carried out as per the methods suggested by Gomez and Gomez, 1984.

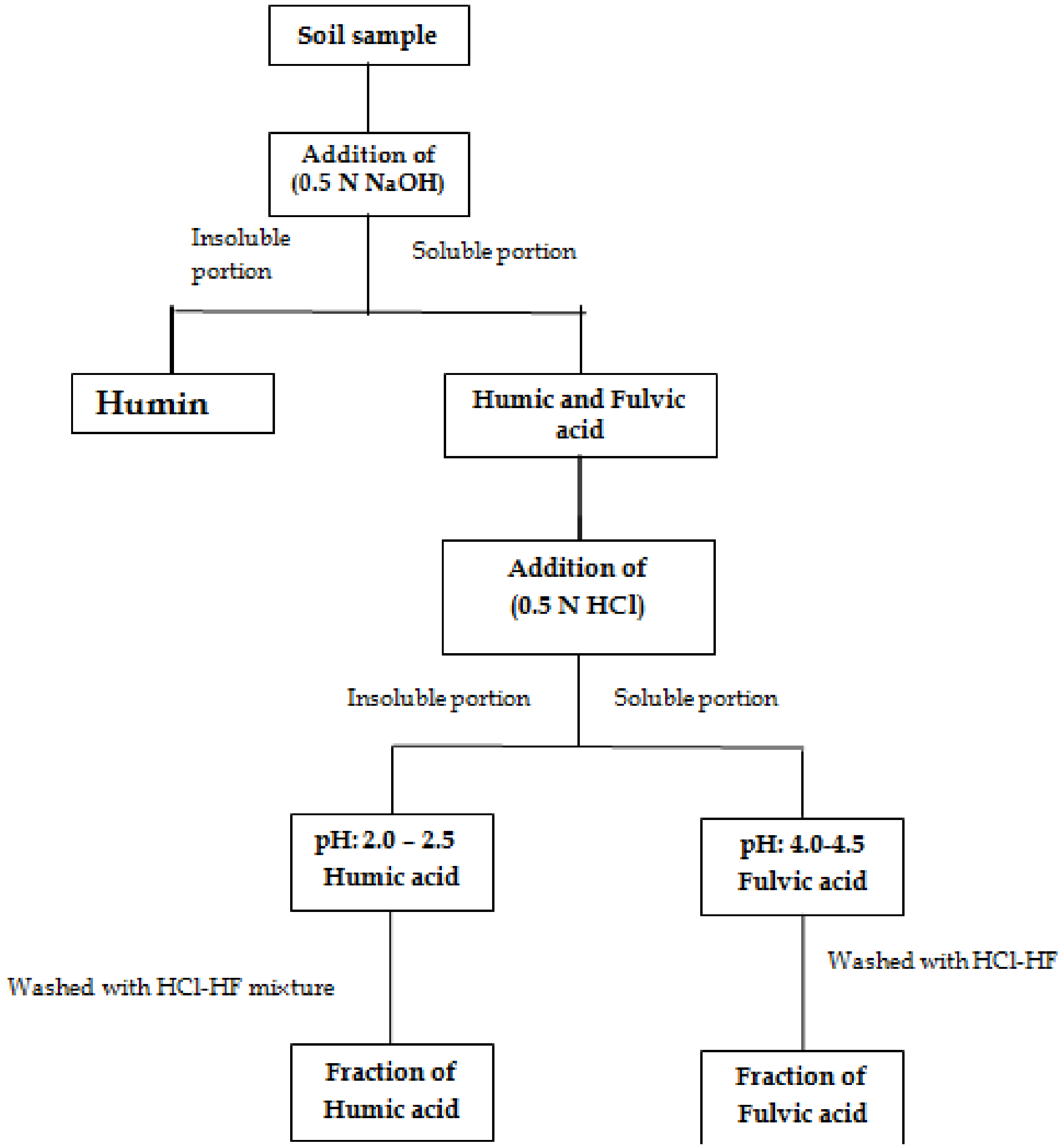


Figure 1: Schematic diagram for extraction of humic acid, fulvic acid and humin.

Results and discussion

Properties of South Indian tea soils

The properties of soil samples collected from various zones of south India are the pH is varied between 4.3 and 4.8 and the electrical conductivity ranged from 0.09 to 0.44 dSm-1. Total nitrogen content of south Indian soils varied between 0.26 and 0.82 g/100g. The available phosphorus content of various regions ranged from 8 to 59 mg/kg while the exchangeable potassium content differed from 114 to 374 mg/kg.

Relationship among fractions of humic substances and organic carbon

The range of contents of soil organic matter, organic carbon and fraction of humic acid & fulvic acid estimated from the soils of various zones of south India are presented in Table 1 and the average data on soil organic matter fraction of humic acid and fulvic acid along with organic carbon are presented in figure 2. In the Anamallais region, organic matter varied between 4.5 and 5.2 g/100g, the yield of humic and fulvic acid fractions ranged from 0.61 - 0.69 g/100g and 1.94-2.34 g/100g, respectively. In Nilgiris region, organic matter ranged from 6.5 - 8.4 g/100g while humic and fulvic acids varied from 1.48-2.69 g/100g and 0.89-1.28 g/100g, respectively. In Wayanad region organic matter, humic acid and fulvic acid varied from 3.5-4.1 g/100g, 1.33 – 1.62 g/100g and 1.51 – 1.62 g/100g, respectively. In High Ranges and Central Travancore regions, soil organic matter varied from 7.3 to 8.9 g/100g and 4.5 to 5.4 g/100g, respectively. The fraction of humic acid in soils of High Ranges was 3.99-4.58 g/100g; while in Central Travancore it was 0.69 – 0.76g/100g. The amount of fulvic acid extracted from soils of High Ranges was 0.77 – 0.90 g/100g and in Central Travancore it was 1.73-2.34 g/100g. In Karnataka region, organic matter content varied from 2.9 to 3.2 g/100g, the fractions of humic and Fulvic acids varied from 0.76-0.98 g/100g and 1.00-1.03 g/100g, respectively. In Nilgiri Wayanad, soil organic matters ranged from 2.2-3.6 g/100g while the fractions of humic and fulvic acids differed from 0.73 – 1.12 g/100g and 0.82 – 1.03 g/100g, respectively. The Pearson correlation coefficient was worked out among organic carbon and fractions of humic and fulvic acid (no of degrees of freedom: 28) and presented in Table 2. Organic carbon was positively correlated with yield of humic acid which is significant at 1% probability level (r = 0.750**), but negatively correlated with fraction of fulvic acid. The fractions of humic and fulvic acids are negatively correlated with each other (r = -0.533). Among the regions, Nilgiris and High Ranges had higher humic acid fractions, while in other regions fulvic acid dominated. The accumulation of humic acid fraction on the surface soil could be attributed to higher biological activity. It has been reported that, the formation of humic acid was inversely related to soil pH. At a lower pH, the humic acids tend to precipitate because of their reduced solubility. According to Schnitzer (1986), humic acids form insoluble complexes when pH is less than 6.5 and associated into colloids, thus enabling immobilization and accumulation of this fraction in acid soils.

Table 1. Analytical data on range of organic matter, organic carbon and fractions of humic and fulvic acids

Region	Soil organic matter (%)	Soil organic carbon (%)	Fraction of humic acid (%)	Fraction of fulvic acid (%)
Anamallais	4.5-5.2	2.6-3.0	0.61-0.69	1.94-2.34
Nilgiris	6.5-8.4	3.8-4.9	1.48-2.69	0.89-1.28
Wayanad	3.5-4.1	2.0-2.4	1.33-1.62	1.51-1.62
High Ranges	7.3-8.9	4.3-5.2	3.99-4.58	0.77-0.90
Central Travancore	4.5-5.4	2.8-3.1	0.69-0.76	1.73-2.34
Karnataka	2.9-3.2	1.7-1.8	0.76-0.98	1.00-1.03
Nilgiri wayanad	2.2-3.6	1.3-2.0	0.73-1.12	0.82-1.03

Table 2. Pearson correlation coefficient among organic matter, fractions of humic and fulvic acid

Parameters	Organic carbon	Fraction of HA	Fraction of FA
Organic carbon	1.000		
Fraction of HA	0.750**	1.000	
Fraction of FA	-0.152	-0.533**	1.000

**Significant at 1% probability level; HA: Humic acid; FA: Fulvic acid; N=28

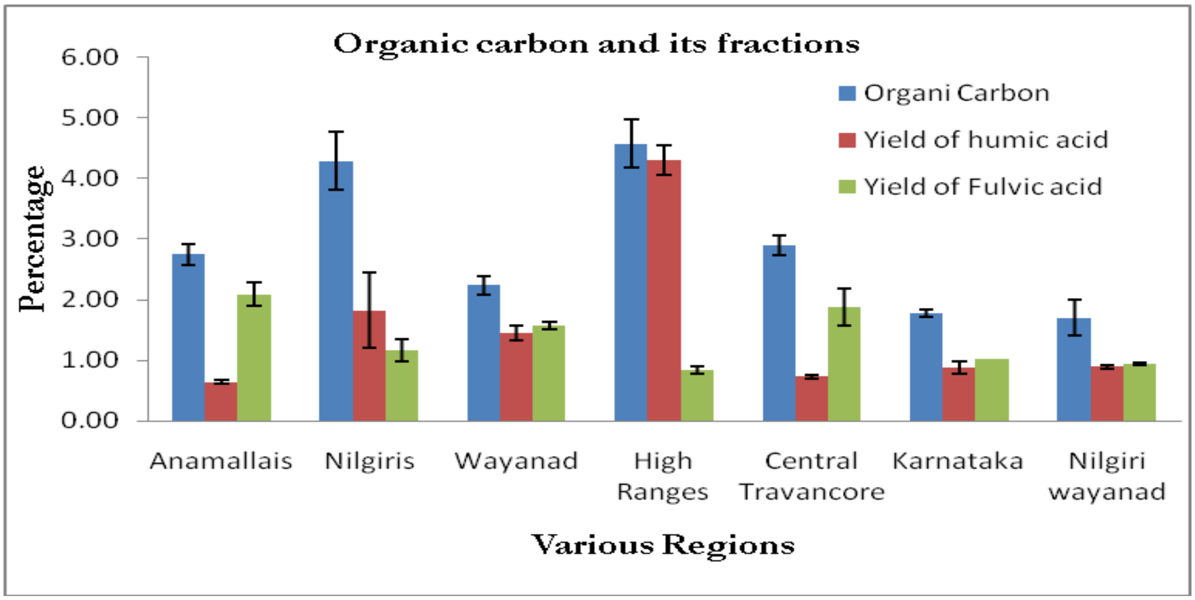


Figure 2. Percentage of soil organic carbon, fraction of humic acid and fulvic acid in tea soils of different tea growing regions of south India.

*Values represent mean of four estimations and error bars represent the relative standard deviation

Distribution of carbon in fractions of humic substances

The range of carbon contents of soil, humic acid, fulvic acid and humin are presented in Table 3 and the distribution of carbon in fractions of humic substances are depicted in figure 3. The data revealed that the carbon content of humic acid fraction varied between 20.51 and 38.42 g/100g, and the carbon content of fulvic acid fraction ranged between 11.93 and 16.59 g/100g. Humic acid fraction possessed higher carbon content compared to fulvic acid fraction. Similar results were observed in volcanic soils as reported by schnitzer (1982). The data clearly revealed that humic acid fraction contributes to higher organic carbon in the soil organic matter pool which corroborate with the results reported earlier by Agurilla et.al. (1996). The carbon content of humin varied between 0.34 and 1.25 g/100g. The distribution of organic carbon was higher in humic fraction compared to fulvic and humin fraction in acid soils as observed by Ingrid Kogel- knabner and Frank Ziegler (1993).

The Pearson correlation coefficient worked out among organic carbon contents of humic acid, fulvic acid, humin are presented in Table 4. A positive correlation existed between soil carbon and humic acid carbon which was significant at 1 % probability level (r = 0.922) while fulvic acid carbon had positive correlation with carbon content of humin significant at 5% probability level. There was a positive correlation between carbon contents of humic acid and fulvic acid and that of humin but it is not significant. Similar results were observed by Jayaganesh et. al. (2010).

Table 3. Range of carbon contents of humic acid, fulvic acid and humin

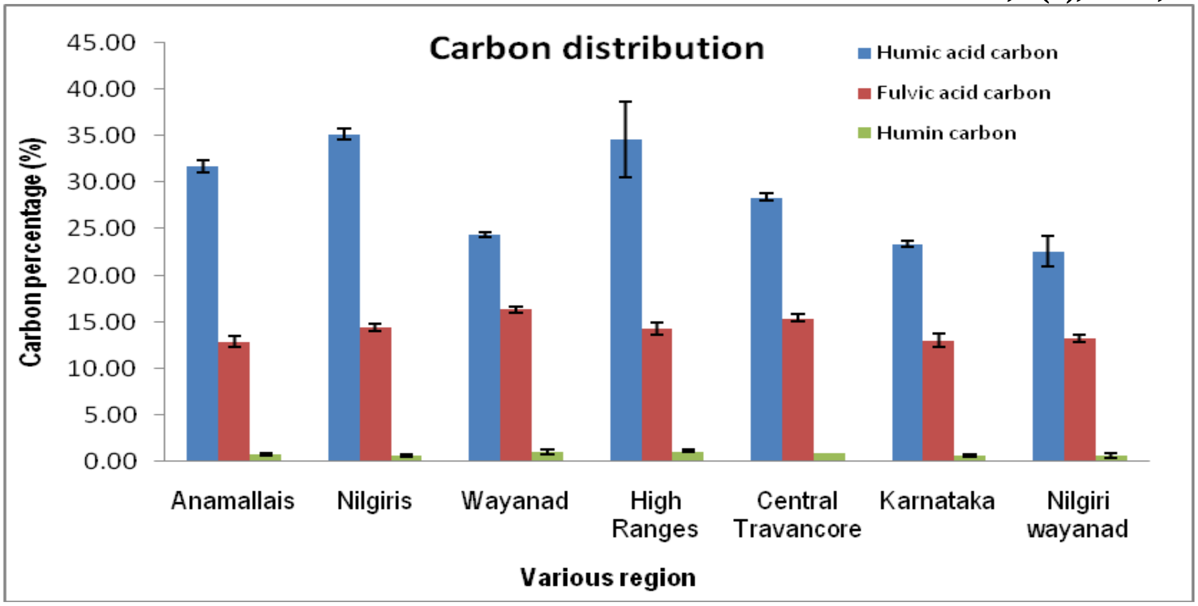
Region	Soil organic carbon (%)	Humic acid carbon (%)	Fulvic acid carbon (%)	Humin carbon (%)
Anamallais	2.6-3.0	30.95-32.34	13.71-12.98	0.69-0.85
Nilgiris	3.8-4.9	34.52-35.76	13.98-14.80	0.56-0.84
Wayanad	2.0-2.4	23.96-24.53	15.96-16.59	0.81-1.25
High range	4.3-5.2	29.58-38.42	13.56-14.89	0.99-1.24
Central Travancore	2.8-3.1	27.86-28.67	14.95-15.85	0.86-0.98
Karnataka	1.7-1.8	22.95-23.65	11.93-13.46	0.46-0.79
Nilgiri wayanad	1.3-2.0	20.51-23.98	12.87-13.56	0.34-0.95

Table 4. Pearson correlation coefficient worked out among carbon contents of humic acid, fulvic acid and humin

Parameters	Soil carbon	Humic acid carbon	Fulvic acid carbon	Humin carbon
Soil carbon	1.000			
Humic acid carbon	0.922**	1.000		
Fulvic acid carbon	0.191	0.014	1.000	
Humin carbon	0.366	0.260	0.530*	1.000

** - Significant at 1% level; * - Significant at 5% level; N= 28

Figure 3. Distribution of carbon in fractions of humic substances



*Values represent mean of four estimations and error bars represent the relative standard deviation

Conclusion

The study revealed that humic acid fraction was generally high in south Indian tea soils compared to fulvic acid and humin fractions. The fraction of humic acid had a positive correlation with organic matter or organic carbon content of soil. The results of carbon contents of humic substances showed that humic acid fraction had the highest carbon content which was positively correlated with organic carbon content of soil. The results of present study proved that humic acid fraction plays a vital role in balancing the carbon content and consequently contributes to the status of organic matter in tea soils.

Acknowledgement

The author is thankful to UNITED PLANTER'S ASSOCIATION OF SOUTH INDIA and Director, UPASI Tea Research Foundation, Tea Research Institute, Valparai for financial support and encouragement throughout the study.

References

Aguilera, S. M., Borie, G., Galindo, G., Peirano, P. Organic matter in volcanic soils in Chile: chemical and biochemical characterization. COMMUNICATION IN SOIL SCIENCE AND PLANT ANALYSIS, 1996: 28, 899-912.

Aiken. G. R., Mcknight. D. M., D. M. Wershaw, R. C., Maccarthy. P. (Eds), 1985. Humic substances in soil, sediment and water, GEOCHEMISTRY, Isolation and Characterisation. Wiley, New York.

Gomez, K, A and Gomez, A. A. Statistical procedures for agricultural research. JOHN WILEY AND SONS, New York. 1984. Pp. 20-30.

Ingrid Kogel-Knabner and Frank Ziegler. Carbon distribution in different compartments of forest soils. GEODERMA, 1993: 56. pp: 515-525.

James A. Rice. 2001. Humin. SOIL SCIENCE 2001: Vol. 166(No. 11).pp 848-857.

Khan, S.U. Distribution and characteristics of organic matter extracted from the black solonetzic and black chemozemic soils of Alberta, the humic fraction. Soil sci.,1971: 112: 401-410

Reeves, D. W. The role of soil organic matter in maintaining soil quality in continuous cropping systems. SOIL TILLAGE RES. 1997: 43, 131-167.

Roland B Londeau. Comparison of soil humic and Fulvic acids of similar molecular weights. Org. GEOCHEMISTRY. 1986: Vol. 9. No. 1. Pp: 47-50.

S. Jayaganesh and V. K. Senthurpandian. 2010. Extraction and Characterization of Humic and Fulvic Acids from Latosols under Tea Cultivation in South India. ASIAN JOURNAL OF EARTH SCIENCES. 2010: 3(3): 130-135

Santos, G. de A. and F. A. O. Camargo. 1999. Fundamentos da material organica: Ecosystemas tropicais e subtropicias. Genesis. Porto Alegre, Brasil.

Schnitzer, M. (1982). Organic matter characterization. In: AL Page, RH Miler, & DR Keeney (Eds.), Methods of soil analysis part 2 Agron. No. 9 (pp. 581-594). American Society of Agronomy, Madison, WI, USA.

Schnitzer, M. 1986. Binding of humic substances by soil mineral colloids. In Interactions of Soil Minerals with Natural Organics and Microbes, eds. P. M. Huang and M. Schnitzer, 77–102. Madison, Wisc: SSSA.

Stevenson, F. J., 1986. Carbon balance of the soil and role of organic matter in soil fertility. Cycles of soil-Carbon, Phosphorus, Sulphur, Micro-nutrients. Wiley, New York, pp. 45-77.

Swift, R. S. 1996. Organic matter characterization. In. Methods of soil Analysis, Part 3: Chemical methods, eds. D. L. Sparks, A. L. Page, P. A. Helmke, R. H. Loeppert, P. N. Soltanpour, M. A. Tabatabai, C. T. Johnston and M. E. Sumner, 1011-1020. Madison, Wisc.: SSSA.

Von Lutzow, M., Leifeld, J., Kainz, M., Kogel-Knabner, I. and Munch, J. C. Indicators for soil organic matter quality in soils under different management. GEODERMA. 2000: 105, 243-258.

Walkley, A. and A. Black. Determination of organic carbon in soils. Soil Sci., 1934: 37: 27-38.

Wendy Heredia, Pedro Peirano, Gilda Borie, Hugo Zunino and Maria Aguilera. Organic carbon balance in Chilean volcanic soils after human intrusion and under different management practices. ACTA SCANDINAVICA, SECTION B-SOIL & PLANT SCIENCE 2006: 57(4): 329-334.