PROXIMATE CONSTITUENTS OF SOIL ORGANIC MATTER IN RELATION TO ELEVATION IN THE RED FERRALLITIC SOILS OF KERALA, INDIA

M. Balagopalan

Division of Soil Science, Kerala Forest Research Institute, Peechi - 680 653 Kerala India

Received 1994

BALAGOPALAN, M. 1995. Proximate constituents of soil organic matter in relation to elevation in the red ferrallitic soils of Kerala, India. A study was carried out to determine the proximate constituents of soil organic matter in relation to elevation in the red ferrallitic soils of Kerala, India. Fats and waxes, resins, free sugars, hemicellulose, cellulose, lignin and protein increased significantly with elevation. Hemicellulose accounted for double the amount of cellulose and free sugars taken together. Lignin and protein accounted for a major portion of organic matter.

Key words: Proximate constituents - red ferrallitic soils - elevation - organic matter

BALAGOPALAN, M. 1995. Unsur-unsur proksimat jirim organik tanah berkaitan dengan ketinggian di dalam tanah feralitik merah di Kerala, India. Satu kajian telah dijalankan untuk mempastikan unsur-unsur proksimat jirim organik tanah berkaitan dengan ketinggian di dalam tanah feralitik merah di Kerala, India. Lemak dan lilin, resin, bebas gula, hemiselulosa, selulosa, lignin dan protein bertambah secara signifikan dengan ketinggian. Hemiselulosa dianggap sekali ganda amaun selulosa dan bebas gula yang diambil serentak. Lignin dan protein dianggap bahagian utama jirim organik.

Introduction

The usefulness of gross chemical constituents of organic matter (OM) as determined by proximate analysis has been quite often debated (Palaniappan 1975). They can indicate the stage of OM decomposition as influenced by varying environmental factors (Balagopalan 1991). Information on the chemical composition of OM as revealed by proximate analysis would disclose the processes responsible for stabilisation of important components such as nitrogen (N) and sulphur (S) in OM. Very few studies have been carried out to determine the proximate constituents of tropical soils (Palaniappan 1975). This study was undertaken to elucidate the quantities of proximate constituents in relation to changing elevation in the red ferrallitic soils of Kerala, India.

Materials and methods

Study area

The study area in Kerala lies between 8° 18' and 12° 48' N and 74° 52' and 77° 22' E. It is a linear strip of land extending to about 560 km in the southwestern part of India bordered by the sea on the west and the Western Ghats on the east throughout its entire length.

Three study sites were selected in a hilly region at (1) Arippa E_1 (150 m asl) in Trivandrum Forest Division, (2) Chandanathod E_2 (750 m asl) in Wynad Forest Division, and (3) Myladumpara E_3 (1450 m asl) in Munnar Forest Division (Figure 1).

The underlying rock at E_1 is gneiss which has undergone lateritic decomposition. Minimum and maximum temperatures are 20.3 °C and 39.4 °C respectively. Mean rainfall during the 10-y period (1978-88) was 2000 mm. March, April and May are the hottest months. The southwest monsoon, which brings the greater part of the total rainfall, occurs normally from the first week of June through August. The northeast monsoon brings some rain in October and November. Relative humidity is greater than 55% and attains 100% during rainy days. This site has a westerly aspect and a slope of 30°. The vegetation type is lowland west coast tropical evergreen forest.

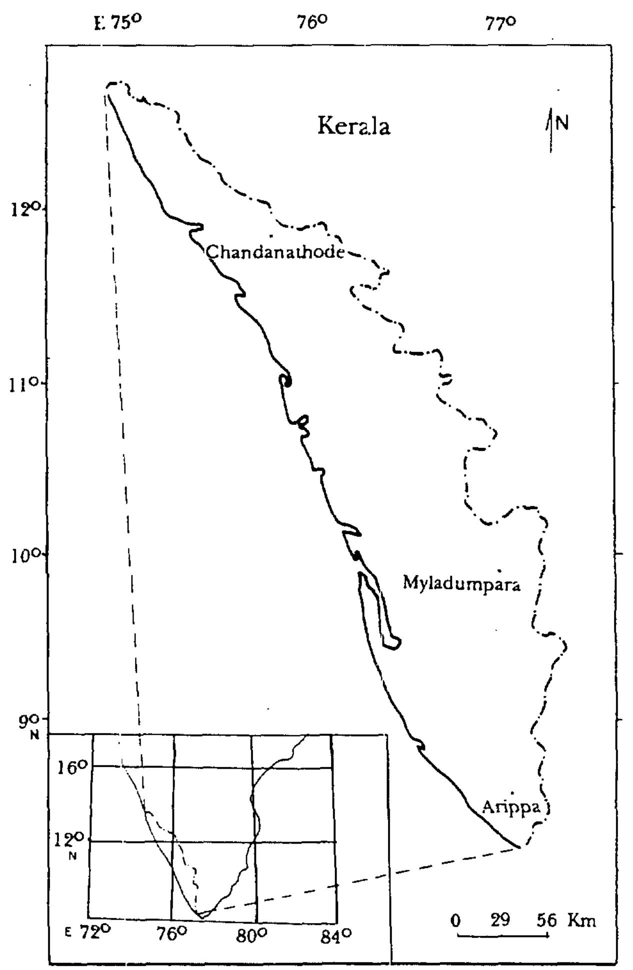

Figure 1. Location of the study area

The underlying rock at E_2 is principally coarse biotite gneiss. Minimum and maximum temperatures are 12 °C and 32 °C respectively. Mean annual rainfall during the 10-y period (1978-88) was 2650 mm. The southwest monsoon occurs during June to August and the northeast monsoon occurs during October through mid November. December to April are the hottest months. Mists are common during November to February. The humidity varies from 60 to 90% touching saturation point during rainy season. The site has a westerly aspect and a slope of 30°. The vegetation type is west coast tropical evergreen forest.

The underlying rock at E_3 is igneous in origin and consists of granitic gneiss. Minimum and maximum temperatures are 5 °C and 28 °C respectively. Mean annual rainfall during the 10-y period (1978-88) was 3210 mm. The wet weather commences in May with the outburst of southwest monsoon and continues until the end of November. March and April are the hottest months. From the beginning of December, the mornings are dewy until the middle of February. The humidity varies from 75 to 95% reaching saturation during rainy days. This site has a westerly aspect and a slope of 30°. The vegetation type is southern subtropical broad leaved hill forest.

Sampling

At each site, plots of 250 × 250 m were laid out randomly and further subdivided into five subplots of 50 × 50 m. Five surface (0-15 cm) samples were collected from one subplot and composited into one sample. As such there were 5 composite samples from one site and 15 composite samples from three sites. The samples were analysed to determine pH, organic carbon, total N and S as per the procedures in Black *et al.* (1965) and the proximate constituents by the method of Stevenson (1965). The proximate constituents estimated were fats and waxes, resins, free sugars , hemicellulose, cellulose, lignin and protein. Analysis of variation was conducted on the data using the method of Snedecor and Cochran (1975).

Results and discussion

The mean values for soil pH, organic carbon, N, S and proximate constituents of fats, waxes, resins, free sugars, hemicellulose, cellulose, lignin and protein are given in Table 1. Analysis of variance of proximate constituents are presented in Table 2.

The results show that with rise in elevation, the contents of constituents increased (Table 1). As OM also increased with elevation, the distribution pattern of these components seems to be a function of OM status itself. The effect of elevation on proximate constituents is due to the modifying influence of rainfall and pH and consequently of temperature and microbial activity (Balagopalan 1991).

The fats + waxes and resins are proportionately larger in E_2 and E_3 and are related to low soil pH in E_2 and E_3. Low pH results in inhibition of activity of microbes responsible for rapid decomposition and depletion of these components. This corroborates with the observation of Wang (1967).

Table 1. Mean values of soil pH, organic carbon, N, S and proximate composition in the three elevations

Elevation	Properties										
	Soil pH	Organic carbon (%)	N (ppm)	S	Fats + waxes (%)	Resins	Free sugars	Hemi-cellulose	Cellu-lose	Lignin	Protein
E_1	6.0	1.41	1290	292	0.05	0.07	0.06	0.34	0.12	1.37	0.81
E_2	5.6	1.98	1478	522	0.10	0.11	0.10	0.89	0.22	2.77	1.36
E_3	5.0	3.75	2091	827	0.18	0.20	0.17	1.39	0.41	3.89	2.29

Table 2. Analysis of variance of proximate composition in the three elevations

Source	Degrees of freedom	Properties						
		Fats + waxes	Resins	Free sugars	Hemicellulose	Cellulose	Lignin	Protein
Total	14							
Replication	4	1.174^{ns}	8.094**	2.781*	1.553^{ns}	2.827*	3.008*	4.297**
Elevation	2	235.124**	931.009**	243.978**	103.214**	809.767**	627.727**	2737.424**
Error	8							

*p = 0.05; ** p = 0.01; ns = not significant.

The free sugars content, similar to the contents of fats + waxes and resins, was quite low when compared with the other components. The increase in the free sugars content with elevation is in conformity with the results of Gupta and Sowden (1964) for some of the forest soils.

The hemicellulose content constituted roughly double the amounts of cellulose and free sugars together. The hemicellulose contents were greater at E_2 and E_3 than at E_1. The increase in hemicellulose content with elevation was also recorded by Folsom *et al.* (1974). Higher contents of hemicellulose at E_2 and E_3 are attributable to factors like lignin and protein which tend to form stable complexes with hemicellulose (Gupta 1967). Moreover, Palaniappan (1975) reported increasing N and S contents along an elevational gradient which mediate and stabilise hemicellulose, leading to its increased accumulation at higher elevations. This was also indicated by Kononova (1966).

Low values for cellulose agreed with the results of Allison (1973). The general increase of cellulose content with elevation can be traced to the higher OM status itself (Gupta & Sowden 1964).

The presence of higher lignin contents at the E_2 and E_3 sites may be due to the fact that the functional groups associated with OM could have bound the cellulose fractions and formed stable compounds capable of retarding the process of decomposition (Russell 1971). Moreover, high moisture and acidic conditions, and low aeration and temperature at E_2 and E_3 sites might have resulted in low microbial activity and higher cellulose content. This was also reported by Cheshire *et al.* (1971). There was a similarity of behaviour between cellulose and S compounds like that between OM and N (Balagopalan 1991). A close and parallel variation in the cellulose and S content under conditions of lower and higher elevations indicated that both these were affected to the same degree by any or several of the processes taking place in these soils.

Lignin-protein accounted for the major portion of OM, in consonance with the finding of Waksman (1968). Hurst and Burges (1967) reported that lignin is a main component in humus fractions. The higher proportion of lignin at sites E_2 and E_3 may be caused by fungi, which are found to thrive better at higher elevation and able to synthesise stable lignin components (Palaniappan 1975).

It could be postulated that the same set of factors were responsible for affecting the protein and lignin contents either way. There was a close similarity in the distribution of OM and protein. Enrichment of protein may be due to polyphenols, tannin-like compounds, amino acids resistant to microbial attack (Campbell & Lees 1967), and protein and carbohydrate interaction with lignin (Larina *et al.* 1970). Maintenance of soil lignin and protein compounds was apparently due to the tendency of these lignin and protein complexes to become stable.

Acknowledgements

I am grateful to S. Chand Basha, IFS, Director, KFRI, Peechi for providing facilities for this work and other valuable suggestions.

References

ALLISON, F.E. 1973. *Soil Organic Matter and Its Role in Crop Production.* Elsevier Scientific Publishing Company, Amsterdam. 637 pp.

BALAGOPALAN, M. 1991. Studies on soil organic matter. Ph.D. thesis, University of Calicut.

BLACK, C.A. (Ed.). 1965. *Methods of Soil Analysis. Parts 1 & 2.* American Society of Agronomy, Wisconsin, USA. 1572 pp.

CAMPBELL, N.E.R. & LEES, H. 1967. The nitrogen cycle. Pp. 194-215 in McLaren, A.D. & Peterson, G.H. (Eds.) *Soil Biochemistry. Volume 1.* Marcel Dekker Inc., New York.

CHESHIRE, M.V., MUNDIE, C.M. & SHEPHERD, H. 1971. The origin of the pentose fraction of soil polysaccharide. *Journal of Soil Science* 22 : 222 - 236.

FOLSOM, B.L., WAGNER, G.H & SCRIVNER, C.L. 1974. Comparison of soil carbohydrate in several prairie and forest soils by gas-liquid chromatography. *Proceedings of the Soil Science Society of America* 38 : 305 - 309.

GUPTA, U.C. 1967. Carbohydrates. Pp. 91-108 in A.D. McLaren & G.H. Peterson (Eds.) *Soil Biochemistry. Volume 1.* Marcel Dekker Inc., New York.

GUPTA, U.C. & SOWDEN, F.J. 1964. Isolation and characterization of cellulose from soil organic matter. *Soil Science* 97 : 328 - 333.

HURST, H.M. & BURGES, N.A. 1967. Lignin and humic acids. Pp. 260 -286 in McLaren, A.D. & Peterson, G.H. (Eds.) *Soil Biochemistry. Volume 1.* Marcel Dekker Inc., New York.

KONONOVA, M.M. 1966. *Soil Organic Matter. Its Nature, Its Role in Soil Formation and in Soil Fertility.* 2nd edn. Pergamon Press, Oxford. 544 pp.

LARINA, N.K. DROZDOVA, T.V. & KASATOCHKIN, V.I. 1970. Participation of proteins in the formation of humic substances in nature. *Pochvovedeniye* 12: 55 - 61.

PALANIAPPAN, R. 1975. Studies on soil organic matter. Ph.D. thesis, University of Madras.

RUSSELL, E.W. 1971. The role of organic matter in soil productivity. Pp. 3 - 19 in *The Use of Isotopes in Soil Organic Matter Studies.* FAO/IAEA Report, Vienna, Pergamon Press, Oxford.

SNEDECOR, W.G. & COCHRAN, G.W. 1975. *Statistical Methods.* Oxford & IBH Publishing Company, New Delhi. 593 pp.

STEVENSON, F.J. 1965. Gross chemical fractionation of organic matter. Pp. 1409 - 1421 in Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E. & Clark, F.E. (Eds.) *Methods of Soil Analysis. Part 2.* American Society of Agronomy, Madison, Wisconsin.

WAKSMAN, S.A. 1968. Microbes, organic matter and soil fertility. Pp. 473 - 494 in *Study Week on Organic Matter and Soil Fertility.* North Holland Publishing Company, Amsterdam.

WANG, T.S.C. 1967. Soil organic compounds as plant growth promoters and inhibitors. Pp. 1 - 13 in *Soils and Fertilizers in Taiwan.* Society of Soil and Fertilizer Sciences of the Republic of China, Taiwan.