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EFFECT OF ELEVATION AND RAINFALL ON THE PHYSICOCHEMICAL PROPERTIES OF THE SOILS OF THE HIGH RANGES OF KERALA *

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The characteristics of a soil are determined for the most part by climatic influences such as precipitation, temperature, evaporation, humidity and wind velocity, the nature of the vegetative cover, the composition of the parent material and by the topography of the land. The climatic factors express themselves through the moisture and energy they contribute to an environment. The rainfall which is a component of climate imprints its effect on the soil through the cycle of water which enters the soil and which is used for the production of organic matter or for hydration and hydrolysis or is released by the reverse process and removed through evaporation, transpiration and percolation. The effect of rainfall and elevation on the development of soil properties has been studied by several workers such as Dames (1955), Muir (1955), Sen and Deb (1941), Ray Chaudhuri (1943, 1965), Durairaj (1951, 1966), Dhir (1967) and Gopalaswamy (1967). The present investigation aims at studying the influence of rainfall and elevation on the properties of soils in the High Ranges of Kerala, where the elevation ranges from 600 metres to 2100 metres and rainfall from 325 cm to 625 cm. An assessment of the extent of the soil deterioration by the extremes of climate and topography is another objective of this study.

Material and Methods

The soils used in this study were collected from the High Ranges of Kerala, situated in the Devikulam Taluk of Kottayam District. Soil profiles were taken from different elevations and regions of varying rainfall. The places selected for taking profile pits were in the natural forests. Profiles were taken from elevations of 600, 900, 1200, 1500, 1800 and 2100 metres. Three profiles were taken from each elevation from sites separated by distances of 3 to 5 km. Samples were collected from depths of 0-15 cm, 15-45 cm, 45-75 cm and 75-105 cm. They were air-dried in the laboratory, ground to pass through a 2 mm sieve and stored in glass bottles. The samples were analysed for their mechanical and chemical composition, as well as single value constants, by adopting standard methods of analysis.

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Results

Mechanical composition. The results of mechanical analysis of the soils are given in Table 1. The highest percentage of coarse sand (46'5%) was found in the second layer of the soil collected from an elevation of 1200 m and the lowest (11·9%) in the surface layer from an altitude of 1500 m. The percentage of fine sand was highest in the second layer of the soil from 1200 m (24·2%) and lowest in the second layer from the elevation of 1200 m (4·5%). The silt fraction showed a maximum value (28·3%) in the fourth layer at 1200 m and the lowest (6·4%) in the second layer at the elevation of 600 m. The clay content ranged from as low as 17·3% in the second layer at 1200 m to as high as 60·8% in the second layer at 1500 m.

Single value constants. The single value constants are given in Table 2. The apparent density varied from 1·06 in the surface layer at 1500 m to 1·42 in the fourth layer at 600 m. The absolute specific gravity, on the other hand, ranged from 2·09 in the top layers at 2100 m to 2·69 in the fourth layer at 1500 m. The maximum water holding capacity varied from 23·65% in the fourth layer at 2100 m to 45·66% in the surface layer at 1500 m. The maximum pore space obtained was 50·96% in the surface layer at 900 m and the lowest was 25·70% in the fourth layer at 1800 m.

Reaction, moisture and loss on ignition. From the data in Table 3 it may be seen that all the soils are acid in reaction, the pH ranging from 4'7 in the fourth layer at 1200 m to 6·0 in the fourth layer at 2100 m. The moisture content of the air-dried soil varied from 3·04% in the fourth layer at 1200 m to 13·44% in the surface layer at 2100 m. The variation in loss on ignition was from 3·62% in the fourth layer at 1200 metres to 33·8% in the surface layer at 1800 m.

Chemical composition. The data relating to the chemical composition of the soils are given in Table 4. The organic carbon content of the soils was found to vary from 0·3% in the fourth layer at 1200 m to 3·45% in the surface layer at 2100 m. The nitrogen content also showed considerable variation with elevation and rainfall and ranged from 0·03% in the third layer at 1200 m to 0·55% in the surface layer at 1800 m. The variation in the C/N ratio was 5·6% in the surface soil at 1800 m elevation to 19·2 in the second layer at 600 m elevation. It is als noteworthy that the sesquioxides were lowest (20·70%) in the surface layer at 1200 m where the rainfall was the maximum. The highest sesquioxide content (41·55%) was found at 600 m elevation.

Discussion

The mechanical analysis data and textural classification of the soils indicate that the soils are either clay or clay loam. At 1200 metres the clay content shows a sudden decrease in the intermediate layers and the decrease

The elevation of 1200 metres receiving the highest rainfall was critical as far as soil characteristics were concerned because most of the soil properties were found to be either a maximum or a minimum at this elevation.

References

Alway, D. F. 1916. The soils of Nebraska portion of transmission I, II *Soil. Sci.* *1:* 197-258

Bloomfield, C. 1955, Leaf leachates as a factor in pedogenesis J. Sci. *Fd. Agri.* *6:* 641-651

Costin, A. B. 1955. A note on the basalt soils in Britain and Australia J. *Soil* Sci. *6:* 268-269

Craig, N. and Halais, P. 1934. The influence of maturity and rainfall on the properties of laterite soils in Mauritius *Emp. J. Expt,* Agri. *2:* 349-359

Dames, T. W. G. 1955. The soils of Central Java. *Contributions of the General Agricultural Research Station, Eogor*

Dean, L. A. 1937. The effect of rainfall on the carbon and nitrogen content and C/N ratios in Hawaiian Soils. *Soil.* Sci. *Soc. Amer. Proc.* *2:* 455-460

Dhir, R. P. 1967. Pedological characteristics of soils of North Western Himilayas. *J. Ind. Soc. Soil Science* *13:* 61-69

Gopalaswamy, A. 1968. Relationship between loss on ignition nitrogen and phosphorus in the alluvial and laterite soils of Madras State. J. *Ind. Soc. Soil Sc.* *16:* 379-382

Govindarajan, S. V. and Datta Biswas, N. R. 1968. Characteristics of certain soil in the sub tropical humid zones in the South eastern part of Indian soils of Machknd Basin. J. *Ind. Soc. Soil Sct.* *16* (2): 179-186

Jenny, H. and Ray Chudhuri, S. P. 1958. Effect of climate and cultivation on the organic matter reserves of Indian Soil, ICAR, New Delhi

Mahalingam, P. K. 1961. A study of the physical and chemical properties of the high level Nilgiri soils—Disseration for M. Sc. (Agri.) submitted to and accepted by the University of Madras

bulk density associated with higher levels of organic matter than to the actual loss of phosphorus. The relation between phosphorus and nitrogen is found to be positive at 600 metres elevation and there is no correlation between the two at higher elevations. These differences can be atributed to the difference in the quantum of organic matter naturally added to the soil and to the varied nature of its decomposition products at the different elevations. The data on sesqui-oxides reveal that they have been leached from the surface soil to lower horizons in all profiles except those developed at 1800 metres and 2100 metres. The variation in leaching may be due to the differences in the amount of complexing agents produced as a result of organic matter decomposition in the leaching medium (Bloomfield 1955 ; Thomas 1964).

The study also shows that calcium content is highest in the surface soils and that it decreases down the profile at all elevations. The highest content of calcium in the surface soil may be due to the accumulation of this element through leaf-fall. The relation between rainfall and the content of magnesium is negative which may be due to the leaching conditions consequent on a high rainfall.

Summary and Conclusions

A study was made of the influence of rainfall and elevation on the physico-chemical properties of the soil profile of the High Ranges of Keraala. The surface horizon generally contained the maximum amount of clay which decreased with depth down the profile. The translocation of clay was maximum in the soils at an elevation of 1200 metres where the highest amount of rainfall was received. The highest soil acidity was noticed at an elevation of 1200 metres.

Soils at all the elevations had high amounts of carbon and nitrogen; there was significant positive correlation between the elevation and the contents of these elements.

The surface soil generally showed a higher content of phosphorus than the corresponding sub-soil. There was positive correlation between the phosphorus content and organic matter in the soil from elevations of 600-1500 metres. The relationship between phosphorus and nitrogen was positive only at 500 metres.

The sesqui-oxides were leached downwards from the surface soils at all elevations except in the soils at 1800 metres and 2100 metres. The calcium content was highest in surface soils and it decreased down the profile at all elevations.

The magnesium content of the soil was inversely proportional to the rainfall.

continues to the lower depths. Costin *et al* (1952) found in the Alpine soils a critical elevation with respect of the physicochemical properties of these soils. The clay content is a minimum at the elevation of 1200 m where the rainfall is a maximum and more at other elevations where the rainfall is lower. Evidently more clay is translocated downwards at the elevation of 1200 m due to the heavy rainfall. Similar observations were made earlier by Govindarajan and Datta Biswas (1968) in the soils of Machkund basin and by Mahalingam (1962) in Nilgiri soils.

The water holding capacity is found to be highest in the soils developed at 1500 metres and having a clay content of 60·2%. The soils with the lowest clay content have also the lowest water holding capacity. It can therefore be assumed that the clay content of the soil is related to the water holding capacity which agrees with the findings of Mahalingam (1962) for Nilgiri soils.

The loss on ignition which is an approximate measure of the organic matter content is positively correlated to the clay content. The cooler climate in these regions appears to favour a higher production of organic matter which is reflected in the relatively higher values for loss on ignition.

The highest acidity is noticed at an elevation of 1200 metres where the rainfall is a maximum. The acidity can therefore be attributed to the long and continued leaching of soils, the higher additions of organic matter and the production of organic acids by its decomposition.

The soils have a significant positive correlation with the contents of nitrogen and organic carbon. This may be due to the high moisture content of the soils which favours vigorous plant growth and consequently higher organic matter production at higher elevations. Furthermore, as elevation increases, the climate becomes cooler which favours accumulation rather than humification of organic matter (Jenny and Ray Chaudhuri 1958). The investigation reveals that the nitrogen content of these soils is fairly high and is positively correlated with rainfall and elevation which is in accordance with the findings of Alway (1916), Seivers and Holtz (1923), Dean (1937) and Ray Chaudhuri and Sen (1957). The organic carbon content of the soil profile decreases with depth at all elevations which *is* evidently due to the vertical translocation of organic matter to the lower horizons by leaching. The high C/N ratio observed in some of the soils may be due to the reduced activity of the microorganisms under the acid conditions and low temperature prevailing at the higher elevations. Ray Ghaudhuri and Anjaneyalu (1965) also reported similar results in a study of the foot hill soils of the Himalayas.

The present study shows that the surface soils are sometimes richer and sometimes poorer in phosphorus than the corresponding sub-soil. This is in agreement with the findings of Walker and Adam (1965) that a decrease in total phosphorus with increased degree of leaching was due more to decrease in

Table 4

Chemical composition of soils from different elevations*

Elevation (m)	Rainfall (cm)	Depth (cm)	Carbon %	Nitrogen %	C/N ratio	P_2O_5 %	K_2O %	CaO %	MgO %	Sesquioxides %
600	325	0–15	2·58	0·17	15·2	0·121	0·078	0·064	0·185	31·68
		15–45	2·30	0·12	19·2	0·105	0·089	0·045	0·164	34·66
		45–75	2·07	0·12	17·3	0·112	0·062	0·029	0·102	37·77
		75–105	1·82	0·11	16·6	0·091	0·141	0·025	0·065	41·55
900	425	0–15	2·41	0·16	15·1	0·135	0·251	0·038	0·057	29·49
		15–45	1·28	0·11	11·6	0·144	0·248	0·019	[illegible]	33·35
		45–75	1·19	0·10	11·9	0·146	0·211	0·011	[illegible]	36·24
		75–105	1·17	0·12	9·8	0·111	0·207	0·007	0·094	37·41
1200	625	0–15	0·98	0·12	8·2	0·168	0·210	0·037	0·251	20·70
		15–45	0·34	0·03	11·3	0·172	0·259	0·035	0·147	21·83
		45–75	0·32	0·03	10·7	0·120	0·159	0·038	0·158	22·43
		75–105	0·30	0·04	7·5	0·160	0·238	0·038	0·160	26·54
1500	535	0–15	3·02	0·36	8·4	0·144	0·434	0·022	0·051	24·19
		15–45	2·11	0·20	10·6	0·129	0·381	0·012	0·128	29·52
		45–75	1·89	0·21	9·0	0·132	0·382	0·014	0·098	29·78
		75–105	1·19	0·10	11·9	0·132	0·324	0·021	0·076	30·96
1800	540	0–15	3·10	0·55	5·6	0·161	0·419	[illegible]	0·067	40·08
		15–45	1·39	0·09	15·4	0·123	0·362	0·032	0·082	38·22
		45–75	1·14	0·10	11·4	0·167	0·384	0·029	0·070	35·98
		75–105	1·31	0·11	11·9	0·157	0·401	0·026	0·069	35·10
2100	550	0–15	3·45	0·37	9·3	0·152	0·376	0·029	0·112	36·43
		15–45	2·07	0·21	9·9	0·251	0·338	0·018	0·152	27·[illegible]4
		45–75	1·33	0·13	10·2	0·223	0·260	0·021	[illegible]	25·62
		75–105	0·94	0·12	7·8	0·184	0·302	0·019	0·092	25·42

* Average of three profiles.

Table 3

pH, moisture and loss on ignition of soils from different elevations *

Elevation (m)	Rainfall (cm)	Depth (cm)	pH	Moisture %	Loss on ignition %
600	325	0-15	5·5	7·51	15·57
		15-45	5·2	4·75	14·12
		45-75	5·1	4·33	12·76
		75-105	5·0	3·83	12·04
900	425	0-15	5·0	9·08	17·95
		15-45	5·1	8·56	15·19
		45-75	5·1	7·07	13·11
		75-105	5·1	6·51	10·72
1200	625	0-15	4·9	7·05	13·32
		15-45	5·0	4·94	8·42
		45-75	4·0	3·91	5·14
		75-105	4·7	3·04	3·62
1500	535	0-15	5·1	12·35	30·73
		15-45	5·2	10·49	27·45
		45-75	5·4	9·32	22·22
		75-105	5·5	7·77	17·06
1800	540	0-15	5·2	12·99	33·80
		15-45	5·3	9·14	22·90
		45-75	5·5	8·48	12·68
		75-105	5·6	7·44	11·27
2100	550	0-15	5·3	13·44	27·55
		15-45	5·7	9·04	20·18
		45-75	5·9	8·03	19·26
		75-105	6·0	6·91	8·92

* Average of three profiles.

Table 2

Single value constants of soils from different elevations *

Elevation (m)	Rainfall (cm)	Depth (cm)	Apparent density	Absolute specific gravity	Maximum water holding capacity	Pore space %
600	325	0-15	1·13	2·43	41·91	48·00
		15-45	1·39	2·67	33·22	46·69
		45-75	1·36	2·62	35·57	47·05
		75-105	1·42	2·62	30·26	43·45
900	425	0-15	1·15	2·43	45·41	50·96
		15-45	1·23	2·54	40·34	40·77
		45-75	1·33	2·64	37·18	38·31
		75-105	1·34	2·69	37·43	39·28
1200	625	0-15	1·23	2·50	36·90	48·54
		15-45	1·33	2·54	35·23	37·04
		45-75	1·26	2·51	30·67	37·24
		75-105	1·17	2·57	35·44	46·99
1500	535	0-15	1·06	2·19	45·66	47·24
		15-45	1·12	2·22	44·38	45·09
		45-75	1·21	2·32	40·18	43·36
		75-105	1·30	2·34	31·84	40·39
1800	540	0-15	1·07	2·14	41·88	44·82
		15-45	1·17	2·21	38·14	3959
		45-75	1'28	2·26	32·57	34·74
		75-105	1·39	2·30	24·59	25·70
2100	550	0-15	1·25	2·09	40·67	43·06
		15-45	1·28	2·09	37·24	38·79
		45-75	1·29	2·11	28·36	29·59
		75-105	1·33	2·16	23·65	27·24

* Average of three profiles.

Table I

Mechanical composition of soils from different elevations *

Elevation (m)	Rainfall (cm)	Depth (cm)	Coarse sand %	Fine sand %	Silt %	Clay %
600	325	0-15	27·3	9·9	6·6	50·6
		15-45	33·1	11·7	6·4	44·9
		45-75	36·6	10·9	7·8	41·0
		75-105	37·0	11·5	8·2	39·8
900	425	0-15	23·9	13·4	7·5	50·8
		15-45	25·5	12·1	8·5	51·8
		45-75	25·2	10·0	9·1	53·6
		75-105	28'6	11·8	9·4	48.1
1200	625	0-15	40·4	20·4	11·7	25·8
		15-45	46·5	24·2	11·4	17.3
		45-75	40·6	20·8	17·8	20·2
		75-105	24·1	19·3	28·3	25·5
1500	535	0-15	11·9	5·4	19·3	57·8
		15-45	12·7	4·5	18·4	60·8
		45-75	33·2	21·8	14·4	27·4
		75-105	27·8	19·1	16·2	34·9
1800	540	0-15	23·5	8·5	14·6	48·1
		15-45	15·6	6·4	21·9	52·9
		45-75	20·4	7·2	18·9	51·2
		75-105	31·7	7·9	14·0	44·6
2100	550	0-15	16·2	7·9	17·7	52·3
		15-45	22·2	5·8	11·4	56·9
		45-75	35·7	17·1	8·1	37·2
		75-105	32·9	12·6	8·1	45·0

* Average of three profiles.

Muir, J. W. 1955. The effect of soil forming factors over an area in the South of Scotland. *J. Soil Sci.* 6: 84-93

Ray Chaudhuri, S. P. Anjaneyalu, B. S. R. and Shukla, S. S. 1965. Studies of some foot hill soils of Himalayas J. *Ind. Soc. Soil Sci.* 13: 115-122

Ray Chaudhuri, S. P. 1943. Studies on Indian red soils IV. Influence of rainfall and altitude above sea level on the chemical composition of the clay fraction of the soil types. *Ind. J. Agri.* Sci. 13: 252

Ritcher, G. 1931. Physical properties of Hawaii Soils with special reference to the colloidal fraction. *Hawaii Agri. Expt. St. Bull.* 62: 1-45

Sen, A. T., Ashutosh and Bhupendra Chandra Deb. 1941. Laterite and red soils of India II. *Ind. J. Agri. Sci.* 11: 617

Sievers, F. T. and Holtz, H. F. 1923. The influence of precipitation on soil composition and soil organic matter maintenance *Wash. Agri. Expt. Sta. Bull 176:* 1-30

Thomas, K. M. 1964. Studies on some forest soils of Kerala. Thesis submitted to and accepted by the University of Kerala

Walker, T. W. and Adams, A. F. R. 1965. Studies on soil organic matter. 2. Influences of increased leaching at various stages of weathering on levels of carbon, nitrogen and organic and total phosphorus. *Soil.* Sci. 87: 1-10

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