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Distribution of Magnesium Fractions in the Nilgiris soil Profiles: 1 Distribution in typic haplohumults

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These profiles contained in most cases weakly weathered sub-soils with very thin surface soil (Kotagiri) to moderate soils. Organic cycle was very active in many cases. Accumulation of fractions of magnesium at 55-65 cm depth indicating a clay pan layer was observed in Thummanatty. High leaching regime was noted in Sholur and Kodaikanal Kotagiri soils were rich in 'reserve' magnesium. In general, high mineral Mg in the top soil and high exchangeable Mg and organic complexed Mg in the sub-soils with a fair amount of reserve magnesium in these profiles precluded magnesium deficiency in the forseeable future.

A distribution study of the soil magnesium provides a chemical characterisation of soil magnesium, each fraction being a factor determining the relative effectiveness of availability. Wide variations in the forms of magnesium could, in general, be related to soil parent material and the degree of soil development, as expressed in the genetic soil classification (Metson and Gibson, 1977). They reported that the parent materials derived from a mixture of metamorphic and igneous rocks gave rise to higher levels of magnesium in the subsoils. Riecken (1944) stated that exchangeable magnesium distribution in the profiles of some solonatzic soils might be due to the weathering of the intrazonal soils.

The Nilgiris where considerable area of acid soils exists covers a wide variation of an annual rainfall from 1300 to 2540 mm and elevation ranging from 1220 to 2637 m. The Nilgiris Plateau is a hilly tract extending over an area of 2532 Km^2 and its average elevation is 1981.2 m above mean sea level. The entire region is dotted with several steep and high hills separated invariably either by stream or a swampy valley. The soils are lateritic in character derived from charnockite (Gneiss) as parent rock, the kind of clay being kaolin which is friable and highly erodible.

Hence an attempt has been made in the present investigation to study the distribution of varies forms of magnesium in the Nilgiris soils and to assess the depthwise distribution of the various discrete forms of magnesium so as to evaluate the pedogenic processes like weathering, soil development, leaching, presence or absence of organic cycle, accumulation of magnesium in various depths and the related changes in the physico-chemical properties.

MATERIAL AND METHODS

A total of 147 horizonwise soil samples from 29 profiles representing

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the agroclimatic regions of the Nilgiris one profile from Kodaikanal and another from Yercaud were collected.

Air dry soil samples passing through 2 mm sieve were analysed for mechanical fractions, moisture content, soil reaction, electrical conductivity. organic carbon, total phosphorus, total cation, cation exchange capacity, exchangeable cations by the standard methods (Jackson 1973). For the magnesium fractionationation, the method of Mokwunye and Melsted (1972) was followed.

Based on the profile characteristics of the soils were classified into the following eight taxanomical subgroups as per the basic system of soil classification for making and interpreting soil surveys (U. S. D. A., 1965). (1) Typic Haplohumults, (2) Typic Palehumults, (3) Typic Hapluals, (4) Ultic Hapluadalfs, (5) Typic Paleudalfs, (6) Plinthic Paleudalfs, (7) Typic Haplumrepts and (8) Fluventic Haplumrepts. The distribution pattern of magnesium fractions in the profiles are summarised as average of each of the subgroups.

In this paper the distribution pattern of magnesium in Typic Haplohumults are discussed in detail. The rest are discussed in subsequent papers.

RESULTS AND DISCUSSION

Profiles from Mulligur, Thummanatty, Hulikkal, Ketty, Nedungula, Kotagiri, Sholur, Gudalur and Kodaikanal were classified under this subgroup, Typic Haplohumults.

A detailed examination of the various forms of magnesium as exchangeable Mg, organic complexed Mg, acid-soluble (reserve) Mg, mineral Mg and total Mg within individual profiles are furnished in Table 1. The above values expressed as percentages of the total Mg and total inorganic Mg are detailed in Table 2. The ratios of surface and sub-soil exchangeable cation contents are given in Table 3. The distribution of different fractions of Mg in the profiles studied are illustrated in Fig. Based on the standard deviation procedure the magnesium status was described in terms of grades (Table 4 and 5). These ratings do not indicate the deficiency or sufficiency levels of maguesium in soils in terms of crop response. In constructing the diagrams the determined values have been plotted for the various depths as suggested by Metson and Gibson (1977).

Distinguishing feature of Mulligur profile [4]* was that Mg_{oc} constituted 30.4 to 52.2 per cent of Mg_t. Its distribution through the profile was fairly uniform. From a substantially medium amounts in the surface layer (1.6 me/100 g soil). Mg_e decreased to negligible amounts (0.2 me/100g soil) in the horizons below. Tendency of Mg_t to gradually decrease along the depth was observed. Weakly weathered sub-soil with organic cycle might be the reason for such a pattern of distribution of magnesium fractions. Presence of clay pan at a depth of 55-85 cm associated with highest amounts of clay (51.5 per cent) was the special feature of Thummanatty profile (17). All the fractions of magnesium were also observed to get accumulated at this layer. Cation exchange capacity was also at its highest (29.8 me/100 g soil) in this layer. Accumulation of

* These indicate profile members as noted in the figure.

clay associated with CEC might be the probable reason for accumulation of magnesium fractions in this layer as evidenced by a positive correlation between CEC and both Mg_e and Mg_t This was in line with the findings of Martin and Page (1969).

Hulikkal profile (20) contained medium amounts of Mg_m and Mg_{oc} and these comprised the major components of Mg_t. The distribution pattern of Mg_m througout the profile suggests the possibility of a weakly developed profile. Total magnesium did not show much variation. This was in line with the observations of Protz and Riecken (1968) who reported that soils with high amounts of non-exchangeable magnesium would be least developed. Medium quantities of Mg_e were recorded in the top soil which decreased appreciably in the lower layers and this furthcr confirmed the observation that very weakly developed sub-soil were present. Strong organic cycle was indicated by high amounts of Mg_{oc} in the profile, associated with higher content of organic carbon (3,5 to 7.3 per cent) even up to 125 cm. Ketty profile (21) consisted mostly of Mg_m and Mg_r (64.5 to 84.2 per cent Mg_t) fractions. Distribution of all the fractions of magnesium in the profilewas consistent except Mg_{eo} which was higher in the top horizon with gradual decrease of Mg_e throughout the profile. The above observations coupled with negligible amounts of Mg3 (0.3 to 0.5 me/100g soil) throughout the profile suggested that these soils were weakly weathered.

Distribution pattern of magnesium in Nedugula profile (23) was almost similar to Ketty profile. In Kotagiri profile (25) high Mg_r and Mg_e and medium Mg_m and Mg_{oc} were present. A steady decrease of Mg_t was recorded in this profile. Mg_m and Mg_r put together constituted 55.7 to 85.9 per cent of Mg_t . These two non-exchangeable fractions presented a picture of higher amounts in the first 50 cm which decreased drastically below this depths. These observations combined with the fact that higher Mg_e in the upper horizons decreasing steadily with depth suggested that s fairly well weathered surface soil was lying over a weakly weathered parent meterial. The soil contained adequate amount of reserve magnesium which clearly indicated the possibility of reaching the deficiency status to be remote in the near future, Nemeth (1972) stated that the reserve magnesium reflected the availiability of magnesium for longer periods.

Sholur profile (26) contained medium amounts of all the fractions in the surface layer. Not much variation was observed in the distribution of Mg_m and Mg_r down the profile. Higher amounts of Mg_t and Mg_e in the lower depths were reflective of a regime of intense leaching (mean annual rainfall of 2540 mm was recorded), This was associated with a steady and gradual increase in clay content from 48.4 to 54,2 per cent down the profile. Catton exchenge capacity was also found to increase steadily with depth. It is to be noted here that not only did the Mg_e increase with increasing depth, but also the exchangeable Ca increased with depth. However, the increase in exchangeable Mg was relatively greater, than that of exchangeable Ca with the result that the ratio of ex. Ca/Mg, decreased with depth. It was possible that the removal of magnesinm from the surface soil by water would be more rapid than that of calcium. When these bases passed into the lower levels, the solution would not tend to remove further quantities of magnesium as readily as calcium. It is conceivable that these bases would be absorbed in these lower horizons from such a solution, the Mg at a relatively faster rate than Ca.

Thus an increase in the proportion of the exchangeable Mg to Ca in the lower horizons would be more pronounced in these types which are apparently more mature than in those with relatively less maturity. Cain and Riecken (1958) observed Ca/Mg ratios diminishing with depth. slope of the Ca/Mg ratio indicative of the rate of leaching.

Gudalur profile (27) was similar to Ketty profile except that Gudalur profile contained comparatively lesser amounts of Mg_m and Mg_r. The top soil of this profile was weathered to a higher degree than that of the Ketty profile. This was evident from the fact that the top soil contained high amounts of Mg_e. Kadaikanal profile (30) was observed to be highly leached as reflected by the accumulation of higher amounts of Mg_e and Mg_t at the bottom layers than the top soil. This was associated with a shift in the clay percentage from 33.9 in the top soil to 42.3 per cent in the bottom horizon. Further the exchangeable Ca/Mg ratio decreased with depth.

The mean Mg_m the soil was lowest than that in the sub-soil. Top soil Mg_r was higher than sub-soil Mg_r. These observations indicated release of Mg from the mineral from to the reserve pool. The variation or Mg_t between top and sub-soil was negligible. Accumulation of both Mg_e and Mg_{ec} was indicated by a higher amount of these two fractions in the sub-soil. This was associated with the increase of clay content in the sub-soil from 42.5 to 46·1 per cent. The above observations suggested the influence of leaching resulting in the movement of clay alongwith magnesium. Such a situation with high Mg_t in the top soil and high Mg_e and Mg_{ec} in the sub-soils would preclude a deficiency of magnesium in the immediate future.

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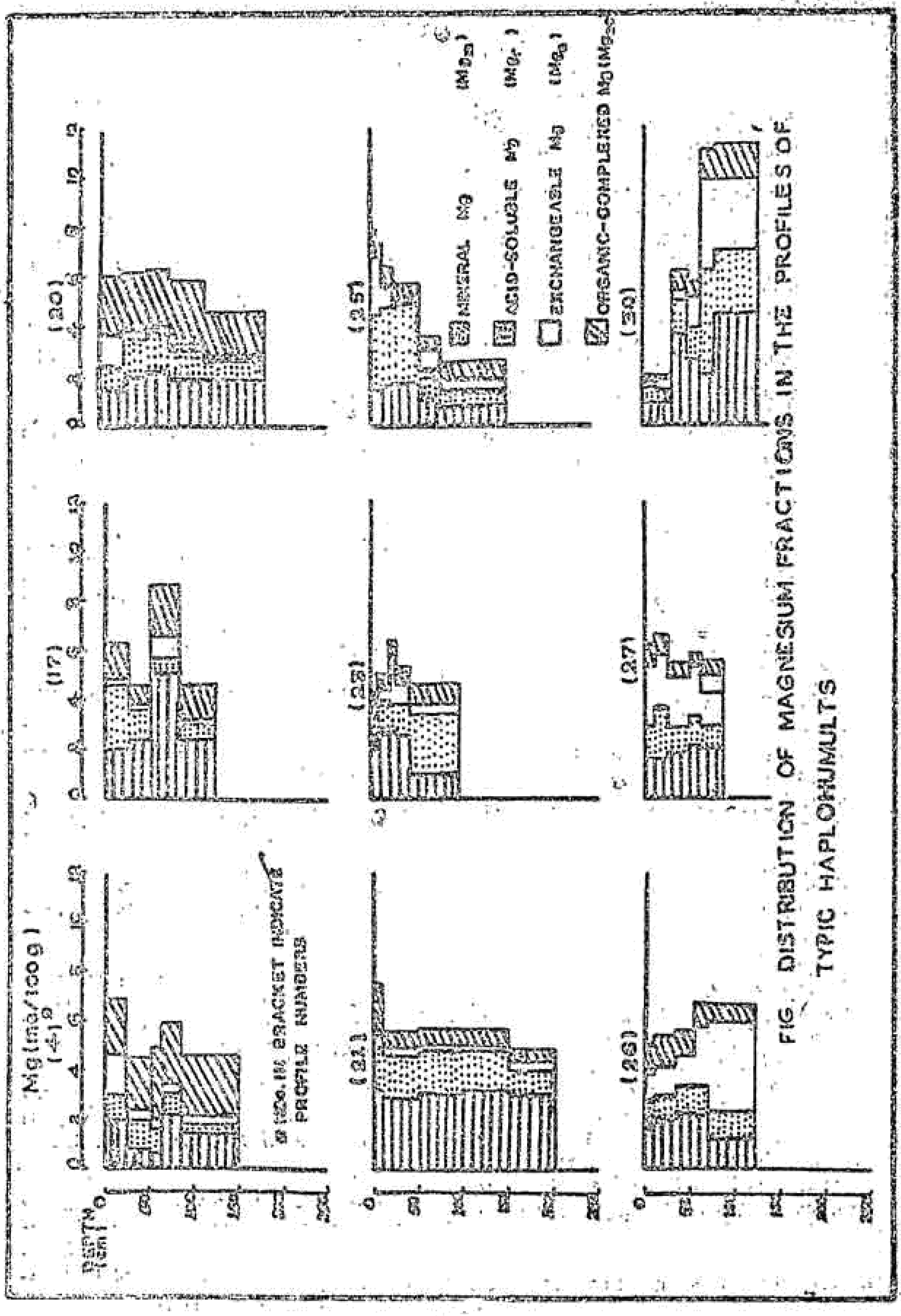

FIG. DISTRIBUTION OF MAGNESIUM FRACTIONS IN THE PROFILES OF TYPIC HAPLOHUMULTS

Table 1 Distribution of Magnesium Fractions in the profile samples (me/100 g, moisture free basis

Locality	Profile No.	Depth (cm)	Mineral Mg	Acid soluble Mg	Exchangeable Mg	Organic complexed Mg	Total Mg (Summation)	Total Mg (Estimated	CEC (me/ 100g	Ex Ca me/100 g
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Mulligur	4	0-25	1.9	1.1	1.6	2.3	6.9	6.2	13.0	5.3
		25-55	0.8	1.2	0.4	2.1	4.5	4.8	10.3	3.9
		55-65	0.6	1.0	0.4	2.9	4.9	4.7	10.3	3.9
		65-85	2.2	0.9	0.4	2.4	5.9	5.9	10.7	2.6
		85-150	1.4	0.4	0.4	2.4	4.6	4.8	6.1	3.9
Thurmmanatty	17	0-30	2.0	2.6	0.2	1.5	6.3	0.1	14.0	3.3
		30-55	2.4	1.2	0.4	0.8	4.6	4.6	14.5	2.6
		55-85	5.1	0.7	0.8	2.1	8.7	8.9	29.8	2.6
		85-125	2.4	0.6	0.2	1.4	4.6	4.9	22.4	4.6
Hulikkal	20	0-25	1.4	1.1	1.2	2.3	6.0	5.5	14.4	2.6
		25-50	2.1	1.4	0.4	2.3	6.2	5.3	13.2	2.0
		50-75	2.2	1.6	0.2	2.3	6.3	6.8	12.2	2.6
		75-115	1.9	1.2	0.2	2.6	5.9	6.0	8.3	4.6
		115-180	1.9	0.7	0.2	1.8	4.6	5.4	8.3	2.0
Ketty	21	0-10	3.2	1.7	0.5	2.2	7.6	7.0	21.3	3.6
		10-50	2.9	1.7	0.4	0.6	5.6	6.1	19.3	3.3
		50-100	3.1	1.7	0.3	0.6	5.7	6.0	17.1	2.8
		100-150	3.2	1.6	0.3	0.6	5.7	5.8	17.6	2.4
		150-200	3.0	1.0	0.3	0.6	4.9	5.1	12.1	2.0

Table 1 (Contd.).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Nedugula	23	0-6	2.0	1.3	0.4	0.6	4.3	4.8	12.3	2.6
		6-18	2.6	1.4	0.4	0.6	5.0	6.0	14.5	2.6
		18-24	2.7	1.0	2.0	0.8	6.3	6.8	15.1	5.3
		24-40	2.5	1.3	0.8	0.7	5.3	5.1	9.7	3.9
		40-96	1.1	2.4	0.4	0.7	4.6	4.9	8.2	2.6
Kotagiri	25	0-10	1.4	3.0	2.4	1.1	7.9	6.7	21.4	5.3
		10-20	1.6	3.1	0.8	0.9	6.4	5.8	24.6	2.0
		20-50	1.7	3.2	0.2	0.6	5.7	5.9	20.5	2.0
		50-75	1.0	1.2	0.8	0.6	3.0	4.1	42.1	2.0
		75-145	0.7	0.7	0.4	0.7	2.5	2.3	41.8	2.6
Sholur	26	0-9	1.7	1.1	1.0	1.2	5.0	0.2	21.7	2.9
		9-35	2.0	1.0	1.2	1.3	5.5	6.0	26.2	3.2
		35-55	2.3	1.1	1.2	1.0	5.6	4.9	25.9	3.4
		55-67	2.2	1.2	2.4	1.0	6.8	6.9	28.2	5.9
		67-120	1.2	1.2	3.0	0.7	6.7	5.2	38.1	5.9
Gudalur	27	0-12	1.6	1.3	2.4	0.9	6.2	6.3	19.0	5.3
		12-25	1.6	2.2	2.0	0.7	6.5	7.1	14.2	3.3
		25-48	1.8	1.0	2.0	0.7	5.5	5.7	19.0	3.3
		48-60	2.1	1.2	2.0	0.6	5.9	5.5	18.5	3.9
		60-85	1.9	1.0	2.0	0.7	5.6	5.7	28.2	4.6
Kodaikanal	30	0-15	0.9	0.6	0.2	0.3	2.0	2.9	22.4	3.9
		15-30	0.9	0.5	0.4	0.2	2.0	2.0	27.8	2.0
		30-45	3.6	1.4	0.4	0.8	6.2	6.3	19.2	2.6
		45-60	2.6	1.3	1.2	0.7	5.8	6.0	21.1	2.0
		60-75	2.0	4.2	3.6	1.2	11.0	11.1	20.6	2.6
	25	75-120	4.4	2.6	2.8	1.4	11.2	10.9	20.6	3.3

Table 2 Forms of Magnesium in the soil profiles Expressed as percentage of the total Magnesium and total Inorganic Magnesium

Profile No.	Locality	Depth	Mineral Mg	Percentage of the total Mg: Acid soluble	Percentage of the total Mg: Exchangeable Mg	Percentage of the total Mg: Organic complexed Mg	Percentage of the total Inorganic Mg: Mineral Mg	Percentage of the total Inorganic Mg: Acid soluble	Percentage of the total Inorganic Mg: Exchangeable Mg
(1)	(2)	(3)	(4)	(5)	(6)	(7)	[8]	[9]	[10]
4	Mulliyur	0-25	27.5	15.9	23.2	33.3	41.3	23.9	34.8
		25-55	11.6	17.4	5.8	30.4	33.3	50.0	16.7
		55-65	9.7	14.5	5.8	42.0	30.0	50.0	20.0
		65-85	37.3	15.3	6.8	40.7	62.9	26.7	11.4
		85-150	30.4	8.7	8.7	52.2	63.6	18.2	18.2
17	Thummanatty	0-30	31.8	41.2	3.2	23.8	41.7	54.2	4.2
		30-55	62.2	26.1	8.7	17.4	63.2	11.6	10.5
		55-85	68.6	8.0	9.2	24.1	77.3	10.6	12.1
		85-125	52.2	13.0	4.3	30.4	75.0	18.8	6.3
20	Hulikkal	0-25	23.3	18.3	20.0	38.3	37.8	29.7	32.4
		25-50	33.8	22.6	6.5	37.1	51.8	35.9	10.3
		50-75	34.9	25.4	3.2	36.5	55.0	40.0	5.0
		75-115	32.2	20.3	3.4	44.1	57.6	36.4	6.1
		115-180	41.3	15.2	4.3	39.1	67.9	25.0	7.1
21	Ketty	0-10	42.1	22.4	6.6	28.9	59.3	31.5	9.4
		10-50	51.8	30.4	7.1	10.7	58.0	34.0	8.0
		50-100	54.4	29.8	5.3	10.6	60.8	33.3	5.9
		100-150	56.1	28.1	5.3	10.6	62.7	31.4	5.9
		150-200	61.2	20.4	6.1	12.2	69.8	23.3	7.0

Table 2 - (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	[8]	[9]	[10]
23	Nedugula	0-8	46.5	30.2	9·3	14.0	54.1	39 1	10.8
		8-18	52.0	23.0	8.0	12 0	59.1	31.8	9.1
		18-24	42.9	15.9	31.7	9.5	47.4	17.5	39.1
		24-40	47.2	24 5	15.1	13.2	54.3	28.3	17 4
		40-96	23.9	52.2	8.7	15.2	28.2	61.5	10.3
25	Kotagiri	0-10	17.7	38 0	30.4	13.9	20.6	44.1	35.3
		10-20	25.0	48.4	12.5	14.1	29.1	56.4	14.5
		20-50	29.8	56.1	3.5	10·6	33.3	62.7	3.9
		50-75	27 8	33 3	22.2	16.7	33.3	40.0	26.7
		75-145	28.0	28.0	16.0	28.0	38 9	38 9	22.2
27	Sholur	0-9	30.4	19.6	28.6	21.4	38.6	25.0	36.4
		9-35	35.7	17.9	14.3	32.1	52 6	26 3	21.1
		35-55	54·8	26.2	4.8	14.3	63.9	30.6	5.6
		55-67	32.4	17.6	35.3	14.7	37.9	20.7	41.4
		67-120	17.9	17.9	53.7	10.4	20.0	20.0	60.0
29	Gudalur	0-12	25.8	21.0	38.7	14.5	30.2	24.5	45.3
		12-25	24.6	33 8	30.8	10.8	27.6	37.9	34.5
		25-48	32.7	18.2	36.4	12.7	37.5	20.8	41.6
		48-80	35.6	20.3	33.9	10.2	39.6	22.6	37.7
		80-85	33.9	17.9	35.7	12.5	38.8	20.4	40.8
30	Kodaikanal	0-15	45 0	30.0	10.0	15 0	52 9	35 3	11.8
		15-30	45 0	25.0	20 0	10.0	50.0	27.8	22.2
		30-45	58.1	22.6	6.5	12.9	66.7	25.9	7.4
		45-60	45.6	22.8	21.1	12.3	51 0	25.5	23·5
		60-75	18.2	38.2	32.7	10.9	20.4	42.9	36.7
		75-120	39.3	41.1	7.1	12.5	44.9	46.9	8.2

Table 3 Mean Distribution of Magnesium Fractions in top and sub soils of each of the soil Taxonomical sub Groups

Soil sub group	No. of profiles	Magnesium content (me/100 g of soil)					Clay content
		Mineral	Acid soluble	Exchangeable	Organic complexed	Total	
Typic Haplohumults	9						
Top soil		1.9	1.6	1.1	1.3	5.8	42.3
Sub soil		2.2	1.4	1.6	1.6	5.7	46.1
Mean		2.1	1.5	1.4	1.5	5.8	

Table 4 Classification of Different forms of soil Magnesium

Forms of magnesium	Mean [me/100 g]	Standard deviation	Low	Medium [me/100 g]	High
Mineral Mg	2.2	1.0	1.2	1.2 – 3 2	3.2
Acid-soluble Mg	1.5	0.9	0.6	0.6 - 2.4	2 4
Exchangeable Mg	1.4	1.5*	0.7	0.7 - 2.1	2 1
Organic complexed Mg	1·6	0.8	0 8	0.8 - 2 4	2.4
Total Mg	6.7	2.1	4.6	4.6 - 8 8	8 8

* Since the standard deviation is very high half the deviation is taken for calculation

Table 5 The status of magnesium fractions in the surface soils of various profiles

Profile	Location	Magnesium				
		Mineral	Acid soluble	Exchangeable	Organic complexed	Total
4	Mulligur	M	M	M	M	M
17	Thummanatty	M	H	L	M	M
20	Hulikkal	M	M	M	M	M
21	Ketty	H	M	L	M	M
23	Nedugula	M	M	L	M	L
25	Kotagiri	M	H	H	M	M
26	Sholur	M	M	M	M	M
27	Gudalur	M	M	H	M	M
30	Kodaikanal	L	M	L	L	L

L : Low M : Medium H : High