CHAPTER - V

SOIL RESOURCES OF THE STUDY AREA

PREAMBLE

Soils are one of the most precious resources of the earth, while forming a carpet of variable thickness over the land, it has sustained a succession of varied life-forms and civilizations, providing food, fodder, fuel and fibre, storing life-giving water, supporting shelters and dwellings and all other major and minor man built structures. It is integrally and intimately connected with the rocks beneath, the vegetation growing above and water percolating through it (Valdiya, 1987).

Soils consist of products of the weathering of rocks, intermixed with living organisms and the product of their decay, the moisture and air filling the interstitial space. It thus, has a microclimate of its own. The silt particles constitute the framework (skeleton), the clays (such as montmorillonite, illite, kaolinite, etc.) and the organic matter (humus) hold together the frame work, serving as the nutrient base. The colloidal clays and the humus are endowed with the ability of cation as well as anion exchange, and are thus chemically active; they also hold molecules of water which form a sort of atmosphere around the clay particles. It is these water attracting and holding capabilities of the colloidal clays and humus that keep the soil moist even during the drier seasons and permit microbial activities. It is undeniably a living system (Valdiya, 1987).

According to Charles E. Kellog, Chief of Soil Survey, U.S.A., "Soil is that thin film between earth and sky that supports all living things. Beneath lie the sterile rocks, above it are the air and sunshine. From it, all plants and animals, and man himself draw their nourishment, either directly or indirectly from other things that live in soil. There is no life without soil, and no soil without life" (in Narayan and Shah, 1966).

Hilgard, another great American scientist, gave an edaphic definition of soil as : "the more or less loose and friable material in which, by means of their roots, plants may or do find foothold and nourishment as well as other conditions of growth" (in Narayan and Shah, 1966).

Joffe (1936), a representative of the Russian school of soil science states that "The soil is a natural body, differentiated into horizons of mineral and organic constituents, usually unconsolidated, of variable depth, which differs from the parent material below in morphology, physical properties and constitution, chemical properties and composition, and biological characteristics".

One reason for the lack of concern for soils is the different concepts as to what soils are (Brady, 1990). Thus, the definition of soil is a relative term, as a geologist considers it as the upper part of the weathering mantle (regolith) resting on the bed rock and containing inorganic and organic nutrients. A civil engineer looks upon it as a superficial material which can be easily removed without resorting to blasting by explosives. But according to an environmentalist, soil is a dynamic living layer which forms the foundation of all ecosystems.

Methodology

In general, the soils of the study area are of 'in situ' or 'zonal' category. The soil study was carried out by using 1:50,000 scale Survey of India Topographical Map Nos. 41 K/8, K/11, K/12, K/15, K/16; L/9 & 10, L/13; O/4, and P/1, as a base. Traverses were made along available roads or approaches taking into consideration the variation in topography. All permanent reference points such as villages/ness, streams, temples, roads, railways, etc., indicated on the base map were made use of for the location of sampling sites. Soil samples were taken at frequent intervals (Fig. 16), according to the change in geomorphic units, colour, past erosional conditions, slope and the surface conditions.

Since the study area is extremely rugged and thickly vegetated, complete soil profiles were difficult to get. As the study area forms a wildlife sanctuary, digging of pits

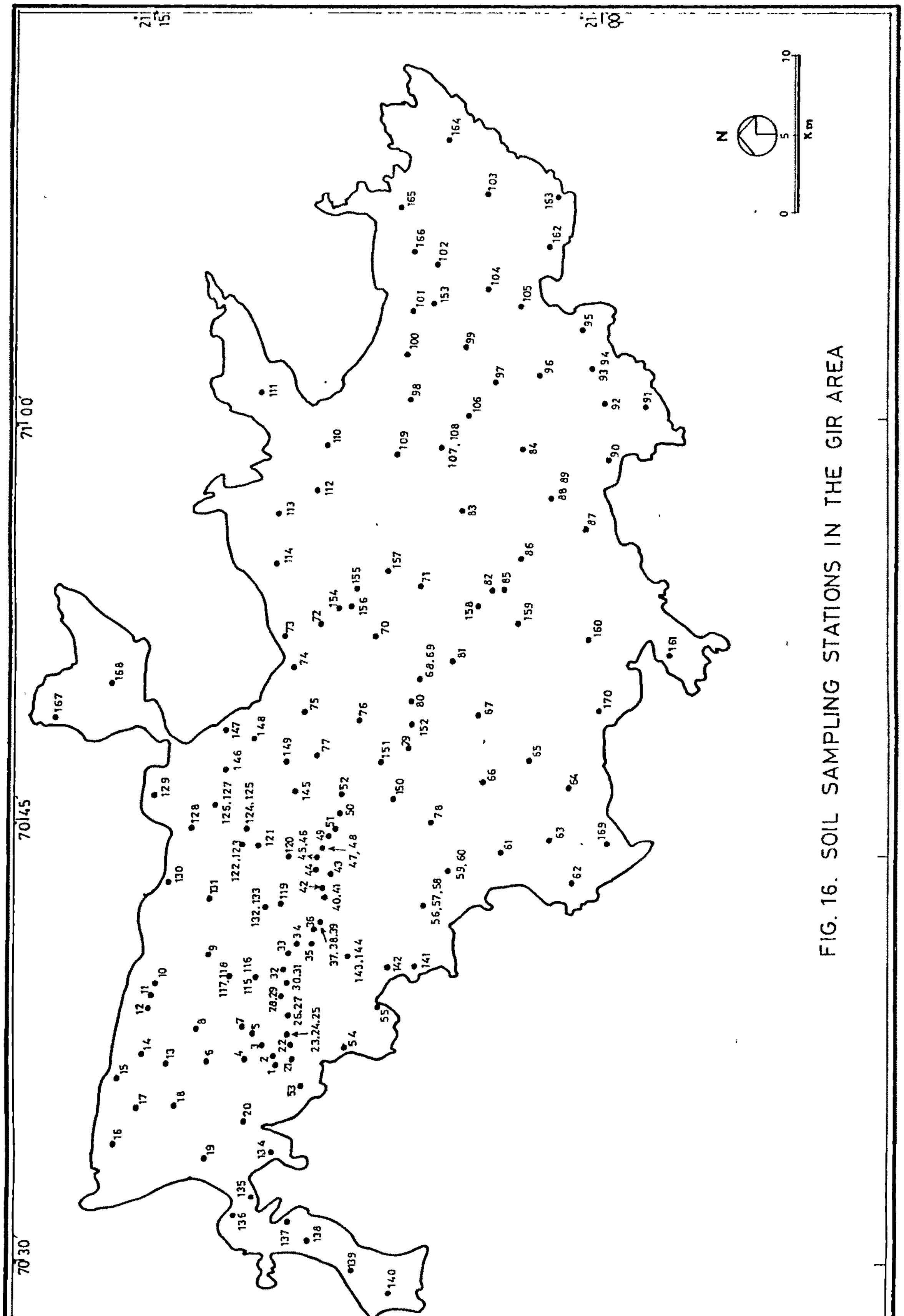


FIG. 16. SOIL SAMPLING STATIONS IN THE GIR AREA

for study of soil profiles was not permitted by the Forest Department officials. However, in general, the soil cover in most of the areas was thin, and the samples were collected from a depth of 15-30 cm, with the help of a hand auger or by digging, for both physical and chemical studies, to augment the morphological observations in the field.

PHYSICAL PROPERTIES

The following physical properties were studied:

(1) Soil colour,
(2) Soil texture, and
(3) Soil moisture.

(1) Soil colour

Colour is the most obvious and easily determined of soil characteristics. The significance of soil colour is almost entirely an indirect measure of other more important characteristics or qualities that are not so easily and accurately observed. For example, the content of organic matter in soil is a characteristic that is commonly indicated only approximately by soil colour.

Soil colours are most conveniently measured by comparison with a colour chart. In the present study, Munsell Soil Colour Chart (1954) was used to determine the soil colour.

The arrangement is by `hue´, `value´, and `chroma´-the three simple variables that combine to give all colours.

Hue-is the dominant spectral (rainbow) colour. The hue notation of a colour indicates its relation to red, yellow, green, blue and purple.

Value - refers to the relative lightness of colour and is a function, (approximately the square root) of the total amount of light.

Chroma - (sometimes called saturation) is the relative purity or strength (or departure from a neutral of the same lightness) of the spectral colour and increases with decreasing grayness.

e.g. 5YR 5/6

Hue = 5 YR

Value = 5

Chroma = 6

The different colour notations for the soils, of the study area are given in Table : 7.

(2) Soil Texture

Soil texture is determined by carrying out particle size analysis. Particle size analyses are also refered to as particle size distribution (PSD) tests, sizing tests or mechanical analyses (MA) tests. Two separate and quite different procedures are used, in order to scan the very wide range of particle sizes which are encountered. These are the sieving and sedimentation procedures. Sieving cannot be used for the very much smaller silt and clay size (fine) particles, so a sedimentation procedure is used instead. Measurements are made either by sampling a suspension with a special pipette (the pipette method), or by determining its density with a special hydrometer (the hydrometer method).

General Principle

Mechanical analysis separates the inorganic mineral portion of soil into classified grades according to particle size and determines their relative proportions by weight.

As the study area comprises of soils containing both coarse and fine particles, composite tests using both sieving and sedimentation by hydrometer methods were carried out for particle size analysis (IS:2720 part IV, 1975; Head, 1980).

Methodology

A 100 gm air-dry soil sample is first passed through ASTM sieve No.10 (2 mm) to separate coarse fragments (i.e. material retained on 2 mm sieve). The amount of coarse fragments (gravels) is then calculated in percentage.

Before proceeding with the hydrometer sedimentation test, the soil is chemically treated to remove organic matter, and possible calcareous matter using a dispersent followed by thorough agitation, to ensure that discrete particles are separated. The following reagents are used for the pretreatment test :

(1) Hydrogen peroxide (20 volume solution),

(2) `standard' dispersent solution - i.e. 33 gm of sodium hexametaphosphate and 7 gm of sodium carbonate in distilled water to make 1 litre, and

(3) Hydrochloric acid (N solution).

The pretreated soil is then transferred to a 1000 ml measuring cylinder and made upto exactly 1000 ml with distilled water. This suspension is then used for the sedimentation analysis. With knowledge of the settling velocity, Stoke's law is used to calculate the radius of the particles as they settle and the percentage of each size fraction in the sample.

The principle involved is simple. When soil particles are suspended in water, they tend to sink. Because there is little variation in the density of most soil particles, their velocity (v) of settling is proportional to the square of the radius (r) of each particle. Thus, according to Stoke's law $V = Kr^2$.

In connection with soil classification based on grain size characteristics, different names are assigned viz. gravel, sand, silt, and clay to different grain size fractions (Fig. 17).

Particle-size analysis was carried out in the Soil Mechanics Division, Gujarat Engineering Research Institute, Baroda.

Textural Classification

Soil texture refers to the relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically, it refers to the proportions of clay, silt, and sand below 2 mm in diameter. Classification of composite soils exclusively based on the particle size distribution is known as textural classification. The best known triangular textural classification given by the United States Department of Agriculture (U.S.D.A., 1966) is followed in this text (Fig. 17). The classification is based on the percentage of sand, silt and clay size fractions (Table 7 & 8).

The results obtained from particle size analyses were plotted on the triangular textural classification to record the various soil types of the study area (Figs 18,19,20,21,& 22). Three broad groups of these classes are recognized; sands, loams, and clays. Within each group, specific textural class

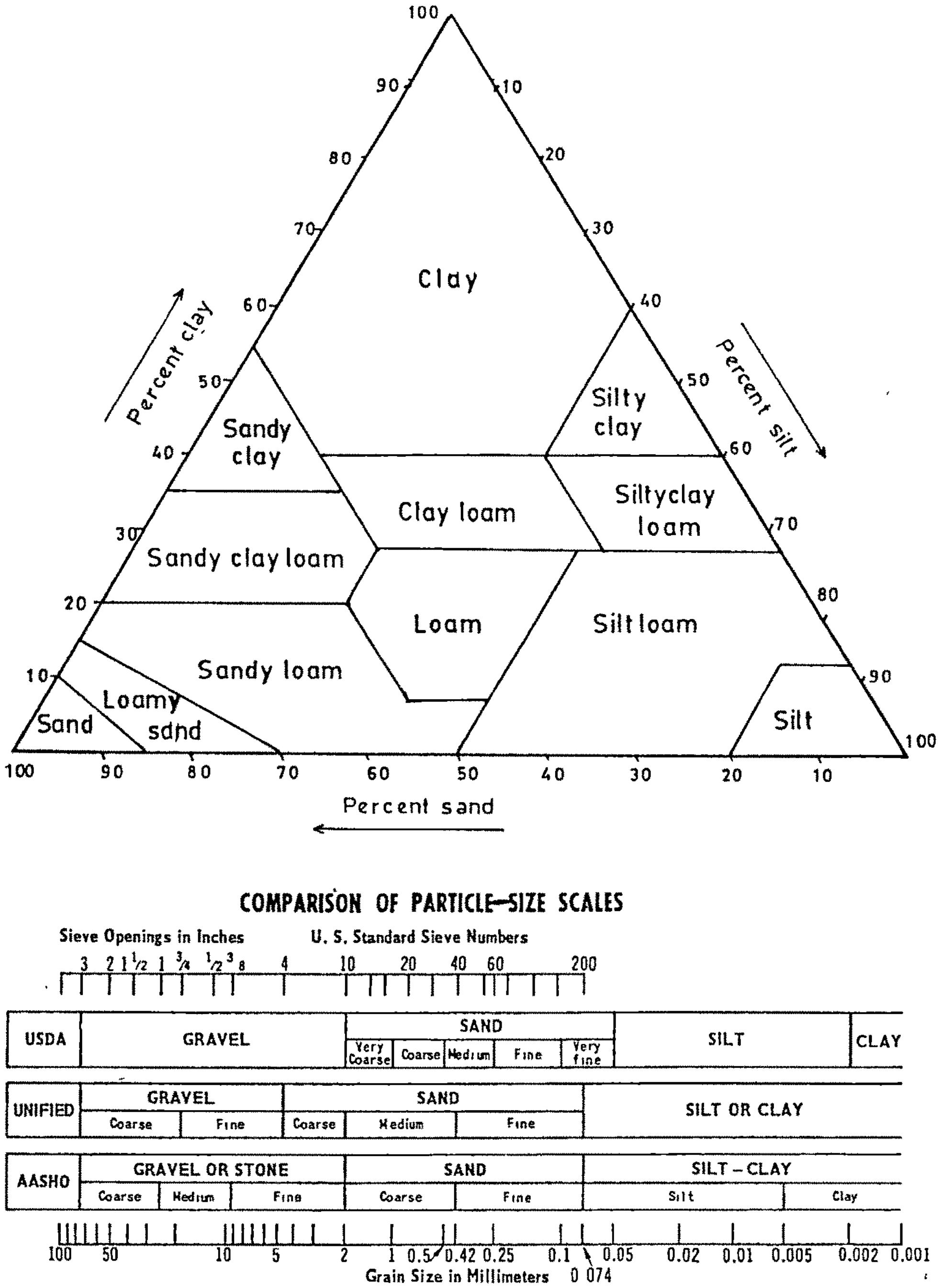


FIG. 17. GUIDE FOR TEXTURAL CLASSIFICATION

(USDA, 1966)

Table - 7

Physico-chemical Analysis of the soils

Sr. No.	Colour	Moisture %	Texture	pH	E.C. %	Organic Carbon %	Organic Carbon Grade	Ca %	Mg %	Na %	K_2O kg/Ac	Grade	P_2O_5 kg/Ac	Grade
1	10 YR 6/3	14.1	Sandy loam	8.10	0.12	0.44	L	0.75	0.07	0.20	50.0	L	14.0	M
2	10 YR 2/2	14.4	Clay loam	8.10	0.12	0.84	H	0.74	0.07	0.19	115.0	M	9.6	L
3	10 YR 6/8	18.9	Loam	8.10	0.09	0.17	L	0.77	0.07	0.20	32.5	L	9.6	L
4	10 YR 4/3	17.5	Loam	8.10	0.09	0.62	M	0.77	0.06	0.25	33.2	L	9.4	L
5	7.5 YR 5/4	17.2	Loam	8.15	0.09	0.30	L	0.48	0.14	0.20	37.5	L	12.0	M
6	10 YR 6/8	15.3	Loam	8.10	0.09	0.73	M	0.62	0.05	0.20	176.0	H	9.8	L
7	10 YR 3/3	14.3	Loam	8.05	0.09	0.60	M	0.46	0.15	0.19	85.0	M	12.0	M
8	10 YR 4/3	14.8	Loam	8.00	0.09	0.88	H	0.43	0.12	0.02	160.0	H	16.0	M
9	10 YR 10/4	16.0	Sandy loam	7.80	0.06	0.65	M	0.73	0.15	0.008	55.4	H	16.5	M
10	10 YR 7/3	17.2	Loamy sand	7.80	0.09	0.93	H	0.48	0.04	0.07	156.9	H	16.2	M
11	5 YR 4/8	18.6	Silt loam	7.80	0.09	0.98	H	0.43	0.04	0.02	155.0	H	16.0	M
12	10 YR 5/4	16.0	Loam	7.80	0.09	0.41	L	0.41	0.03	0.05	37.5	L	12.0	M
13	7.5 YR 3/2	14.1	Sandy loam	7.90	0.06	0.93	H	0.65	0.06	0.07	123.0	M	16.0	M
14	7.5 YR 6/2	14.4	Sandy loam	7.70	0.09	0.46	L	0.41	0.03	0.05	40.0	L	20.4	M
15	10 YR 10/4	15.2	Sandy loam	7.80	0.09	0.53	M	0.40	0.03	0.03	47.5	L	14.0	M
16	10 YR 5/4	18.9	Loam	7.80	0.12	0.61	M	0.74	0.02	0.02	49.0	M	15.2	M
17	7.5 YR 3/2	18.1	Loam	7.80	0.12	1.02	H	0.40	0.03	0.03	47.5	L	14.0	M
18	7.5 YR 3/2	19.8	Sandy loam	7.90	0.12	0.88	H	0.44	0.04	0.03	105.0	M	16.0	M
19	5 YR 4/4	17.5	Silt loam	7.80	0.12	0.43	L	0.77	0.04	0.02	109.0	M	16.0	M
20	10 YR 3/2	20.1	Silt loam	7.90	0.12	0.96	H	0.74	0.03	0.03	47.5	L	12.0	M
21	7.5 YR 3/2	20.6	Sandy loam	7.80	0.09	0.88	H	0.85	0.17	0.02	120.0	M	16.0	M
22	5 YR 3/2	23.2	Clay loam	7.80	0.12	0.32	L	0.85	0.15	0.04	70.0	M	16.0	M
23	10 YR 3/3	21.9	Clay loam	7.80	0.12	0.32	L	0.85	0.16	0.04	59.0	L	16.0	M
24	10 YR 2/2	23.2	Clay loam	7.80	0.12	0.30	L	0.84	0.15	0.03	58.7	L	16.0	M
25	10 YR 7/3	20.3	Sandy loam	7.90	0.12	0.30	L	0.84	0.16	0.03	55.0	L	16.0	M
26	7.5 YR 6/2	22.5	Silt loam	7.90	0.12	0.29	L	0.85	0.12	0.04	55.6	L	16.3	M
27	7.5 YR 3/2	21.9	Silt loam	7.80	0.12	0.12	L	0.83	0.13	0.05	35.0	L	16.0	M
28	10 YR 6/3	22.6	Loam	8.00	0.09	0.17	L	0.85	0.15	0.07	27.5	L	16.0	M
29	10 YR 5/4	21.8	Loam	7.80	0.09	0.15	L	0.84	0.12	0.04	26.3	L	16.6	M
30	7.5 YR 4/4	21.3	Sandy loam	7.80	0.12	0.31	L	0.76	0.18	0.09	40.0	L	16.0	M
31	7.5 YR 3/2	24.2	Sandy loam	7.80	0.12	0.23	L	0.77	0.18	0.09	43.2	L	16.1	M
32	10 YR 4/4	24.6	Loam	7.80	0.12	0.31	L	0.77	0.19	0.09	40.0	L	16.0	M
33	5 YR 4/6	24.3	Silt loam	7.90	0.12	0.50	L	0.83	0.19	0.09	32.5	L	1.8	L
34	7.5 YR 5/6	24.3	Sandy loam	7.80	0.12	0.26	L	0.84	0.15	0.10	45.0	L	4.0	L
35	5 YR 2/1	23.1	Silty clay loam	7.80	0.12	1.31	H	0.82	0.16	0.06	42.5	L	4.0	L

contd.

Table-7 contd.

Sr. No.	Colour	Moisture %	Texture	pH	E.C. %	Organic Carbon %	Organic Carbon Grade	Ca %	Mg %	Na %	K_2O kg/Ac	Grade	P_2O_5 kg/Ac	Grade
36	5 YR 4/4	23.7	Sandy loam	7.80	0.12	0.38	L	0.88	0.19	0.09	72.5	M	4.0	L
37	5 YR 6/8	22.9	Silt loam	7.80	0.12	0.25	L	0.88	0.17	0.06	40.0	L	4.0	L
38	5 YR 4/6	21.8	Silt loam	7.80	0.12	0.28	L	0.84	0.17	0.07	41.4	L	4.3	L
39	5 YR 4/6	22.6	Silt loam	7.80	0.12	0.26	L	0.88	0.19	0.09	45.1	L	4.1	L
40	7.5 YR 4/4	23.3	Silt loam	7.80	0.12	0.42	L	0.83	0.19	0.09	47.5	L	4.0	L
41	7.5 YR 5/6	22.9	Silt loam	7.70	0.12	0.25	L	0.84	0.17	0.07	46.8	L	4.3	L
42	7.5 YR 3/2	20.9	Loam	7.60	0.09	0.97	H	0.83	0.13	0.16	100.0	M	4.0	L
43	10 YR 4/4	20.8	Silt loam	7.60	0.09	0.77	H	0.77	0.14	0.16	115.0	M	5.6	L
44	7.5 YR 3/2	20.3	Silt loam	7.60	0.12	1.02	H	0.79	0.19	0.10	55.0	L	4.0	L
45	5 YR 4/6	19.9	Silt loam	7.70	0.12	1.05	H	0.77	0.14	0.10	59.0	L	4.4	L
46	7.5 YR 4/4	21.3	Silt loam	7.70	0.09	1.06	H	0.77	0.14	0.15	500.0	H	57.4	H
47	7.5 YR 3/2	21.6	Silty clay loam	7.70	0.12	2.02	H	0.77	0.17	0.17	52.5	L	7.0	L
48	5 YR 2/1	21.2	Silty clay loam	7.70	0.12	1.98	H	0.79	0.19	0.15	50.3	L	6.9	L
49	5 YR 3/1	18.4	Silty clay	7.70	0.09	1.66	H	0.85	0.16	0.15	65.0	M	5.6	L
50	7.5 YR 3/2	18.7	Silty clay loam	7.70	0.09	1.20	H	0.84	0.15	0.16	62.5	L	4.0	L
51	10 YR 3/4	17.7	Silty clay	7.60	0.09	1.02	H	0.81	0.19	0.16	55.0	L	4.0	L
52	7.5 YR 3/2	17.9	Loam	7.70	0.09	0.47	L	0.63	0.16	0.16	42.5	L	5.6	L
53	7.5 YR 6/8	18.9	Silt loam	7.60	0.09	0.26	L	1.03	0.21	0.02	35.0	L	5.6	L
54	7.5 YR 3/2	18.4	Loam	7.50	0.09	0.97	H	1.00	0.23	0.03	160.0	H	9.6	L
55	10 YR 6/3	17.3	Sandy loam	7.60	0.06	0.17	L	1.01	0.21	0.03	22.0	L	9.6	L
56	5 YR 4/6	16.8	Silt loam	7.50	0.09	0.84	H	1.02	0.21	0.04	77.5	M	8.0	L
57	5 YR 6/8	17.4	Silt loam	7.50	0.09	0.92	H	1.02	0.23	0.03	72.8	M	8.2	L
58	5 YR 6/8	17.7	Silt loam	7.50	0.09	0.88	H	1.01	0.21	0.04	76.4	M	7.8	L
59	7.5 YR 5/6	16.3	Silt loam	7.30	0.09	0.84	H	1.05	0.14	0.01	230.0	H	9.6	L
60	5 YR 4/8	16.8	Silt loam	7.30	0.09	1.17	H	1.05	0.14	0.01	90.0	M	9.3	L
61	5 YR 3/1	15.0	Loam	7.40	0.09	1.14	H	1.05	0.14	0.01	90.0	M	9.6	L
62	5 YR 3/1	16.6	Silt loam	7.20	0.19	0.73	M	1.03	0.19	0.05	59.7	L	14.0	M
63	10 YR 3/2	16.8	Loam	7.30	0.19	1.82	H	1.05	0.19	0.0092	217.5	H	12.0	M
64	10 YR 3/2	16.6	Loam	7.50	0.12	1.82	H	1.06	0.19	0.0098	110.0	M	9.6	L
65	10 YR 5/1	17.5	Silt loam	7.70	0.09	1.20	H	1.03	0.16	0.0098	50.0	L	4.0	L
66	5 YR 3/1	15.3	Loam	7.50	0.09	0.72	M	0.71	0.18	0.0097	53.3	L	4.3	L
67	5 YR 4/6	16.9	Loam	7.80	0.12	1.20	H	1.00	0.15	0.0091	70.0	M	4.0	L
68	10 YR 3/2	15.2	Loam	7.70	0.12	0.43	L	0.65	0.13	0.0095	56.2	L	4.4	L
69	10 YR 7/4	15.4	Loam	7.70	0.12	0.46	L	0.67	0.13	0.0097	62.5	L	4.0	L
70	5 YR 4/6	15.1	Loam	7.50	0.12	0.48	L	0.65	0.15	0.0095	55.0	L	9.6	L

contd.

Table-7 contd.

Sr. No.	Colour	Moisture %	Texture	pH	E.C. %	Organic Carbon %	Grade	Ca %	Mg %	Na %	K_2O kg/Ac	Grade	P_2O_5 kg/Ac	Grade
71	7.5 YR 4/4	14.9	Loam	7.60	0.09	0.69	L	0.65	0.12	0.02	54.8	L	5.8	L
72	7.5 YR 4/4	15.7	Silt loam	7.70	0.09	0.92	H	0.65	0.17	0.0094	70.0	M	8.0	L
73	5 YR 4/8	15.9	Silt loam	7.70	0.09	0.92	H	0.63	0.13	0.0093	52.5	L	5.6	L
74	5 YR 4/6	16.3	Silt loam	7.60	0.09	0.66	M	0.62	0.12	0.0091	42.5	L	5.6	L
75	5 YR 3/2	16.7	Loam	7.60	0.12	0.96	H	0.70	0.14	0.0091	100.0	M	8.0	L
76	5 YR 4/6	16.2	Loam	7.80	0.09	0.71	M	0.82	1.00	0.07	180.3	H	16.3	M
77	5 YR 3/2	16.7	Clay loam	7.80	0.09	1.10	H	0.73	0.13	0.0092	77.5	M	8.0	L
78	5 YR 2/2	07.4	Loam	7.50	0.09	1.26	H	0.01	1.01	0.0098	42.5	L	5.6	L
79	5 YR 4/4	07.4	Loam	7.70	0.09	0.84	H	0.09	1.12	0.0098	50.0	L	1.8	L
80	10 YR 2/2	06.8	Clay loam	7.80	0.09	0.88	H	0.081	1.12	0.0096	62.5	L	1.8	L
81	5 YR 4/6	07.7	Loam	7.40	0.09	1.10	H	0.057	0.001	0.0069	70.0	M	1.8	L
82	7.5 YR 5/6	07.1	Loam	7.50	0.09	0.56	M	0.053	0.003	0.0063	42.5	L	1.8	L
83	5 YR 4/4	07.6	Loam	7.40	0.09	0.68	M	0.081	0.14	0.0061	73.7	M	16.1	M
84	7.5 YR 5/6	07.3	Loam	7.40	0.06	0.62	M	0.082	0.004	0.009	70.8	M	16.4	M
85	5 YR 3/1	06.9	Loam	7.40	0.09	0.49	L	0.083	0.20	0.04	70.2	M	2.0	L
86	10 YR 3/3	06.8	Clay loam	7.50	0.09	0.66	M	0.083	0.003	0.0066	40.0	L	1.8	L
87	10 YR 7/4	07.0	Loam	7.40	0.09	0.41	L	0.800	0.004	0.02	43.8	L	16.8	M
88	5 YR 2/1	07.2	Loam	7.50	0.09	0.84	H	0.081	0.001	0.006	47.5	L	1.8	L
89	7.5 YR 5/6	07.1	Loam	7.50	0.09	0.80	H	0.081	0.001	0.006	42.9	L	1.8	L
90	10 YR 2/2	07.5	Silty clay	7.50	0.09	0.92	H	0.065	0.001	0.006	100.0	M	1.8	L
91	5 YR 3/1	07.3	Silty clay	7.50	0.19	0.50	M	0.064	0.003	0.006	120.0	M	1.8	L
92	10 YR 3/3	07.6	Sandy loam	7.40	0.06	0.38	L	0.800	0.004	0.006	60.0	L	1.8	L
93	7.5 YR 3/2	07.3	Silt loam	7.40	0.06	0.98	H	0.053	0.014	0.006	52.5	L	4.0	L
94	5 YR 3/4	07.7	Silt loam	7.40	0.06	0.95	H	0.800	0.015	0.006	50.9	L	4.3	L
95	5 YR 2/2	06.9	Sandy clay loam	7.40	0.09	0.36	L	0.057	0.014	0.010	52.9	L	1.8	L
96	10 YR 3/3	06.4	Sandy loam	7.40	0.09	0.18	L	0.057	0.024	0.010	60.0	L	1.8	L
97	5 YR 4/4	06.6	Loam	7.40	0.09	0.96	H	0.051	0.011	0.010	100.0	M	4.0	L
98	5 YR 3/4	06.9	Sandy loam	7.40	0.06	0.72	M	0.060	0.003	0.007	44.6	L	16.5	M
99	5 YR 4/8	06.4	Loam	7.40	0.09	0.50	M	0.048	0.016	0.007	42.5	L	1.8	L
100	5 YR 3/3	06.7	Loam	7.40	0.09	0.84	H	0.043	0.011	0.007	52.5	L	1.8	L
101	5 YR 4/3	06.7	Sandy loam	7.40	0.09	0.81	H	0.042	0.014	0.007	60.0	L	1.8	L
102	5 YR 3/4	06.5	Loam	7.30	0.06	0.88	H	0.046	0.014	0.007	40.0	L	1.8	L
103	5 YR 2/1	06.2	Loam	7.30	0.09	0.93	H	0.062	0.015	0.007	127.3	M	17.0	M
104	5 YR 4/8	06.3	Silt loam	7.40	0.06	0.62	M	0.042	0.016	0.007	37.5	L	1.8	L
105	5 YR 2/2	06.0	Sandy clay loam	7.40	0.06	0.46	L	0.057	0.002	0.007	147.1	M	2.3	L

contd.

Table-7 contd.

Sr. No.	Colour	Moisture %	Texture	pH	E.C. %	Organic Carbon %	Organic Carbon Grade	Ca %	Mg %	Na %	K_2O kg/Ac	K_2O Grade	P_2O_5 kg/Ac	P_2O_5 Grade
106	5 YR 3/4	06.1	Loam	7.30	0.06	0.98	H	0.053	0.003	0.008	77.4	M	1.8	L
107	5 YR 4/4	06.1	Loam	7.30	0.06	0.84	H	0.055	0.003	0.008	42.5	L	1.8	L
108	5 YR 4/8	06.2	Loam	7.30	0.06	0.95	H	0.052	0.002	0.009	49.3	L	2.1	L
109	10 YR 4/4	05.9	Sandy loam	7.40	0.06	0.60	M	0.056	0.002	0.010	52.5	L	1.8	L
110	10 YR 5/3	05.9	Sandy loam	7.30	0.06	0.23	L	0.042	0.001	0.010	55.0	L	1.8	L
111	7.5 YR 3/2	06.0	Silt loam	7.30	0.09	0.47	L	0.043	0.003	0.020	62.7	L	1.9	L
112	5 YR 3/4	05.8	Silt loam	7.30	0.06	1.06	H	0.040	0.001	0.009	52.5	L	1.8	L
113	10 YR 3/1	06.1	Silt loam	7.40	0.06	0.98	H	0.043	0.004	0.008	60.0	L	1.8	L
114	5 YR 2/1	06.3	Loam	7.40	0.06	1.02	H	0.045	0.004	0.009	60.0	L	1.8	L
115	5 YR 3/4	19.7	Silt loam	7.70	0.06	0.98	H	0.730	0.001	0.007	42.5	L	1.8	L
116	7.5 YR 3/2	18.9	Silt loam	7.70	0.06	0.95	H	0.750	0.040	0.008	41.1	L	2.5	L
117	10 YR 6/6	18.1	Sandy loam	7.90	0.06	0.78	H	0.700	0.003	0.008	200.0	H	8.0	M
118	5 YR 3/4	19.5	Silt loam	7.90	0.06	0.91	H	0.730	0.030	0.008	233.0	H	17.2	M
119	5 YR 3/4	20.1	Silt loam	7.90	0.09	1.20	H	0.740	0.002	0.007	> 635.0	H	12.0	M
120	5 YR 3/4	20.1	Silty clay loam	7.30	0.06	1.10	H	0.770	0.001	0.007	80.0	M	01.8	L
121	5 YR 4/8	19.7	Silty clay loam	7.10	0.06	1.20	H	0.760	0.003	0.007	52.5	L	01.8	L
122	7.5 YR 6/6	19.8	Silty clay loam	7.40	0.25	1.20	H	0.760	0.003	0.007	70.0	M	04.0	L
123	7.5 YR 4/4	19.6	Silty clay loam	7.40	0.20	1.26	H	0.720	0.003	0.007	68.3	M	05.6	L
124	7.5 YR 4/4	18.9	Loam	7.50	0.57	2.02	H	0.760	0.003	0.007	> 655.0	H	58.4	H
125	5.0 YR 3/3	18.3	Loam	7.50	0.43	2.00	H	0.750	0.004	0.007	623.0	H	55.9	H
126	5.0 YR 5/6	18.8	Silt loam	7.30	0.09	0.60	M	0.730	0.002	0.007	45.0	L	08.0	L
127	7.5 YR 4/4	18.8	Silt loam	7.50	0.09	0.63	M	0.770	0.006	0.007	47.0	L	09.3	L
128	10 YR 5/4	18.9	Sandy loam	7.30	0.09	0.79	H	0.650	0.006	0.006	175.0	H	05.6	L
129	5.0 YR 5/6	17.7	Silt loam	7.30	0.09	0.77	H	0.710	0.007	0.005	46.2	L	05.0	L
130	7.5 YR 4/4	21.3	Silt loam	7.30	0.06	0.96	H	0.630	0.003	0.008	80.0	M	14.0	M
131	10 YR 4/4	20.9	Sandy loam	7.20	0.06	0.31	L	0.600	0.001	0.010	47.5	L	14.0	M
132	7.5 YR 4/4	20.7	Silt loam	7.30	0.06	0.48	L	0.620	0.002	0.010	35.0	L	14.0	M
133	7.5 YR 4/4	19.8	Silt loam	7.30	0.02	0.43	L	0.640	0.140	0.010	46.0	L	14.0	M
134	5.0 YR 4/4	15.8	Silt loam	7.20	0.06	0.62	M	0.830	0.140	0.020	47.5	L	20.4	M
135	5.0 YR 2/1	16.3	Clay	7.30	0.12	1.38	H	0.830	0.210	0.020	195.0	H	43.5	M
136	7.5 YR 4/4	16.2	Silt loam	7.30	0.09	1.38	H	0.840	0.190	0.040	282.5	H	12.0	H
137	2.5 YR 2/0	18.9	Silt clay	7.65	0.09	0.98	H	0.850	0.190	0.040	92.5	M	16.0	M
138	10 YR 3/2	21.7	Clay loam	7.50	0.09	0.85	H	0.870	0.190	0.040	77.5	M	16.0	M
139	5.0 YR 4/6	21.3	Loam	7.70	0.12	0.92	H	0.860	0.210	0.050	100.0	M	16.0	M
140	5.0 YR 3/4	21.2	Sandy loam	7.70	0.09	0.48	L	0.810	0.210	0.020	105.0	M	14.0	M

contd.

Table-7 contd.

Sr. No.	Colour	Moisture %	Texture	pH	E.C. %	Organic Carbon %	Grade	Ca %	Mg %	Na %	K_2O kg/Ac	Grade	P_2O_5 kg/Ac	Grade
141	05 YR 4/8	17.9	Silt loam	7.50	0.09	0.62	M	1.010	0.210	0.020	52.5	L	04.0	L
142	7.5 YR 4/4	20.2	Silt loam	7.70	0.06	0.46	L	1.050	0.150	0.080	40.0	L	12.0	M
143	10 YR 6/4	20.5	Sandy loam	7.70	0.06	0.18	L	1.030	0.120	0.070	22.0	L	14.0	M
144	7.5 YR 4/4	21.6	Silt loam	7.50	0.06	1.20	H	0.770	0.140	0.020	47.0	L	14.0	M
145	7.5 YR 4/4	18.7	Silt loam	7.50	0.06	1.31	H	0.630	0.160	0.020	50.0	L	14.0	M
146	5.0 YR 4/8	19.5	Silt loam	7.40	0.06	0.98	H	0.660	0.160	0.010	47.5	L	12.0	M
147	7.5 YR 4/4	19.8	Silt loam	7.30	0.06	1.10	H	0.640	0.150	0.030	55.0	L	14.0	M
148	7.5 YR 4/2	19.8	Clay loam	7.30	0.06	0.96	H	0.720	0.170	0.030	52.5	L	14.2	M
149	5.0 YR 3/3	18.7	Loam	7.60	0.09	0.94	H	0.010	1.120	0.030	173.0	H	14.0	M
150	10 YR 7/6	19.6	Sandy loam	7.10	0.06	0.31	L	0.700	0.170	0.050	40.0	L	16.0	M
151	7.5 YR 4/4	18.8	Sandy loam	7.70	0.06	0.34	L	0.710	0.170	0.020	117.5	L	16.0	M
152	7.5 YR 4/4	19.2	Silt loam	7.30	0.06	1.66	H	0.620	0.160	0.020	60.0	L	14.0	M
153	10 YR 3/3	18.1	Loam	7.30	0.06	0.79	H	0.640	0.140	0.010	60.0	L	16.0	M
154	5.0 YR 3/2	19.3	Silt clay loam	7.20	0.09	1.56	H	0.600	0.140	0.050	52.5	L	22.8	M
155	5.0 YR 4/6	19.2	Loam	7.30	0.06	0.06	H	0.600	0.120	0.050	40.0	L	18.2	M
156	5.0 YR 3/3	18.7	Clay loam	7.25	0.09	1.20	H	0.800	0.180	0.040	52.5	L	16.0	M
157	7.5 YR 5/2	18.6	Silt loam	7.25	0.09	0.88	H	0.830	0.180	0.040	47.0	L	04.0	M
158	7.5 YR 6/8	19.1	Sandy loam	7.30	0.09	0.17	L	1.050	0.130	0.040	22.0	L	16.3	M
159	5.0 YR 4/6	15.3	Loam	7.30	0.23	0.19	L	0.820	0.150	0.008	20.3	L	20.4	M
160	7.5 YR 4/4	04.5	Loam	7.00	0.12	0.84	H	0.560	0.001	0.010	430.0	H	20.4	L
161	5.0 YR 5/8	04.9	Loam	7.20	0.12	0.60	M	0.051	0.003	0.020	50.0	L	20.4	M
162	7.5 YR 4/4	04.4	Loam	7.30	0.09	0.81	H	0.058	0.003	0.020	120.0	M	20.4	M
163	10 YR 5/4	05.2	Loam	7.30	0.09	0.60	M	0.059	0.001	0.010	100.0	M	20.4	M
164	7.5 YR 4/2	05.0	Sandy loam	7.30	0.09	0.50	M	0.065	0.001	0.010	170.0	H	18.2	M
165	5.0 YR 4/8	04.7	Silt loam	7.30	0.09	0.98	H	0.058	0.003	0.010	50.0	L	21.9	M
166	10 YR 3/3	05.6	Loam	7.10	0.06	0.93	H	0.570	0.002	0.006	43.0	L	22.8	M
167	10 YR 4/3	14.3	Sandy loam	7.30	0.09	0.48	L	0.081	0.015	0.030	135.0	M	22.8	M
168	7.5 YR 4/4	14.9	Sandy loam	7.30	0.06	0.42	L	1.040	0.019	0.050	62.5	M	22.8	M
169	7.5 YR 3/2	15.7	Silt loam	7.40	0.06	0.45	L	0.080	0.015	0.090	78.0	M	20.6	M
170	7.5 YR 4/2	16.2	Loam	7.60	0.32	0.43	L	1.250	0.130	0.007	46.0	L	19.7	M

Sr.No. = Location code L = Low M = Medium H = High

Table - 8

Textural Analysis of the soils

Sr. No.	Gravel	Sand Coarse	Sand Medium	Sand Fine	Sand Total	Silt	Clay	Texture
1	-	09	13	30	52	37	11	Sandy loam
2	-	13	15	06	34	37	29	Clay loam
3	-	-	12	30	42	50	08	Loam
4	-	-	11	24	35	45	20	Loam
5	-	-	09	38	47	44	09	Loam
6	-	-	13	28	41	42	17	Loam
7	-	10	16	16	42	40	18	Loam
8	-	09	19	12	40	40	20	Loam
9	-	30	17	09	56	26	18	Sandy loam
10	-	30	42	10	82	16	02	Loamy sand
11	-	04	06	06	16	62	22	Silt loam
12	-	04	26	18	48	45	07	Loam
13	-	19	28	08	55	35	10	Sandy loam
14	-	15	37	21	73	23	04	Sandy loam
15	10	14	31	11	56	23	11	Sandy loam
16	-	06	28	16	50	30	20	Loam
17	-	08	26	16	50	37	13	Loam
18	-	02	22	37	61	30	09	Sandy loam
19	-	02	20	22	44	52	04	Silt loam
20	-	02	06	14	22	57	21	Silt loam
21	-	24	28	08	60	26	14	Sandy loam
22	-	10	07	07	24	43	33	Clay loam
23	-	08	09	09	26	40	34	Clay loam
24	-	12	16	12	40	30	30	Clay loam
25	16	13	21	16	50	30	04	Sandy loam
26	-	03	12	20	35	50	15	Silt loam
27	-	02	15	23	40	50	10	Silt loam
28	-	-	07	39	46	47	07	Loam
29	-	05	35	10	50	40	10	Loam
30	-	10	32	14	56	34	10	Sandy loam
31	-	17	35	18	70	20	10	Sandy loam
32	09	08	19	13	40	34	17	Loam
33	-	02	07	12	21	58	21	Silt loam
34	-	15	25	20	60	30	10	Sandy loam
35	-	01	05	08	14	52	34	Silt clay loam
36	-	04	21	28	53	38	09	Sandy loam
37	-	-	05	37	42	51	07	Silt loam
38	-	02	16	17	35	60	05	Silt loam
39	-	01	13	20	34	52	14	Silt loam
40	-	01	05	12	18	64	18	Silt loam

contd.

Table -8 contd.

Sr. No.	Fractions in percentage							
	Gravel	Sand				Silt	Clay	Texture
		Coarse	Medium	Fine	Total			
41	-	02	08	10	20	60	20	Silt loam
42	-	06	17	07	30	45	25	Loam
43	-	02	12	11	25	58	17	Silt loam
44	-	02	15	06	23	62	15	Silt loam
45	-	01	13	11	25	55	20	Silt loam
46	-	02	11	14	27	52	21	Silt loam
47	-	-	04	16	20	52	28	Silt clay loam
48	-	-	04	06	10	60	30	Silt clay loam
49	-	01	05	05	11	49	40	Silty clay
50	-	01	03	05	09	56	35	Silt clay loam
51	-	02	04	07	13	45	42	Silty clay
52	-	12	24	10	46	37	17	Loam
53	-	-	12	24	36	55	09	Silt loam
54	-	05	15	24	44	41	15	Loam
55	-	-	07	41	48	47	05	Sandy loam
56	-	01	06	07	14	70	16	Silt loam
57	-	01	05	04	10	70	20	Silt loam
58	-	02	07	03	12	72	16	Silt loam
59	-	06	10	12	28	56	16	Silt loam
60	-	02	13	15	30	60	10	Silt loam
61	-	03	10	29	42	37	21	Loam
62	-	01	07	37	45	43	12	Loam
63	-	15	12	13	40	40	20	Loam
64	-	12	10	12	34	50	16	Loam
65	-	04	10	05	19	61	20	Silt loam
66	-	27	12	15	50	40	10	Loam
67	19	21	07	09	37	36	08	Loam
68	-	18	09	13	40	35	25	Loam
69	-	28	10	12	50	30	20	Loam
70	09	15	10	15	40	38	13	Loam
71	-	23	13	10	46	40	14	Loam
72	-	05	05	14	24	64	12	Silt loam
73	-	03	03	08	14	72	14	Silt loam
74	-	06	11	13	30	51	19	Silt loam
75	-	05	11	25	41	48	11	Loam
76	-	05	01	26	40	50	10	Loam
77	-	14	10	07	31	38	31	Clay loam
78	-	14	12	11	37	47	16	Loam
79	72	05	03	02	10	12	06	Loam
80	-	07	10	08	25	47	28	Clay loam
81	-	18	22	12	52	35	13	Loam
82	-	05	17	16	38	45	17	Loam
83	-	08	28	10	46	42	12	Loam

contd.

Table -8 contd.

Sr. No.	Fractions in percentage							
	Gravel	Sand				Silt	Clay	Texture
		Coarse	Medium	Fine	Total			
84	-	05	23	10	38	40	22	Loam
85	-	07	26	04	37	39	24	Loam
86	-	05	12	18	35	35	30	Clay loam
87	-	08	17	11	36	44	20	Loam
88	-	02	12	26	40	42	18	Loam
89	-	07	18	08	33	48	19	Loam
90	-	23	17	10	50	20	30	Sandy clay loam
91	-	24	19	16	59	18	23	Sandy clay loam
92	-	18	30	14	62	24	14	Sandy loam
93	-	05	09	16	30	52	18	Silt loam
94	-	02	07	11	20	70	10	Silt loam
95	-	20	26	11	57	21	22	Sandy clay loam
96	13	30	27	07	64	19	04	Sandy loam
97	-	01	35	12	48	39	13	Loam
98	-	32	24	04	60	30	10	Sandy loam
99	-	07	13	24	44	47	09	Loam
100	-	07	21	12	40	40	20	Loam
101	-	07	31	14	52	32	16	Sandy loam
102	-	05	19	09	33	45	22	Loam
103	-	05	16	14	35	45	20	Loam
104	-	03	04	06	13	64	23	Silt loam
105	-	27	15	08	50	20	30	Sandy clay loam
106	-	13	20	16	49	33	18	Loam
107	-	06	04	24	34	50	16	Loam
108	-	06	09	30	45	42	13	Loam
109	-	07	27	24	58	33	09	Sandy loam
110	-	03	49	22	74	19	07	Sandy loam
111	-	04	28	08	40	50	10	Silt loam
112	-	05	10	14	29	50	21	Silt loam
113	-	-	06	08	14	60	26	Silt loam
114	-	10	15	09	34	45	21	Loam
115	-	05	06	10	21	58	21	Silt loam
116	-	02	14	14	30	60	10	Silt loam
117	-	14	22	20	56	40	04	Sandy loam
118	-	05	10	19	34	51	15	Silt loam
119	-	05	07	12	24	50	26	Silt loam
120	-	10	04	04	18	49	33	Silt clay loam
121	-	07	05	04	16	55	29	Silt clay loam
122	-	04	05	18	10	60	30	Silt clay loam
123	-	04	02	06	12	58	30	Silt clay loam
124	-	05	13	22	40	40	20	Loam
125	-	07	18	10	35	42	23	Loam
126	11	04	07	10	21	54	14	Silt loam
127	-	05	13	11	29	51	20	Silt loam

contd.

Table -8 contd.

Sr. No.	Fractions in percentage							
	Gravel	Sand				Silt	Clay	Texture
		Coarse	Medium	Fine	Total			
128	-	16	27	11	54	33	13	Sandy loam
129	-	10	17	13	40	52	08	Silt loam
130	-	08	16	12	36	52	12	Silt loam
131	-	15	43	12	70	20	10	Sandy loam
132	-	01	05	16	22	67	11	Silt loam
133	-	05	02	13	20	70	10	Silt loam
134	-	03	07	20	30	53	17	Silt loam
135	-	02	03	11	16	36	48	Clay
136	-	05	10	14	29	53	18	Silt loam
137	-	02	04	06	12	48	40	Silt clay
138	-	01	11	17	29	37	34	Clay loam
139	-	05	22	10	37	44	19	Loam
140	09	29	29	06	64	13	14	Sandy loam
141	-	09	11	06	26	52	22	Silt loam
142	-	03	09	07	19	51	30	Silt clay loam
143	-	02	02	18	22	60	18	Silt loam
144	-	01	09	42	52	43	05	Sandy loam
145	25	04	09	09	22	38	15	Silt loam
146	-	08	08	08	24	56	20	Silt loam
147	-	06	13	11	30	57	13	Silt loam
148	-	04	12	12	28	54	18	Silt loam
149	-	14	06	06	26	42	32	Clay loam
150	-	09	17	14	40	45	15	Loam
151	-	02	44	24	70	23	07	Sandy loam
152	-	01	21	34	56	34	10	Sandy loam
153	-	05	12	17	34	52	14	Silt loam
154	-	03	07	15	25	56	19	Silt loam
155	-	05	15	12	32	43	25	Loam
156	-	04	04	04	12	53	36	Silt clay loam
157	-	05	27	13	45	38	17	Loam
158	-	05	10	07	22	45	33	Clay loam
159	-	03	09	24	36	57	07	Silt loam
160	-	01	35	23	59	35	06	Sandy loam
161	-	10	13	21	44	38	18	Loam
162	-	12	16	19	47	41	12	Loam
163	-	06	21	13	40	47	13	Loam
164	-	06	25	18	49	41	10	Loam
165	-	11	24	15	50	42	08	Loam
166	-	15	33	12	60	32	08	Sandy loam
167	-	14	34	20	68	24	08	Sandy loam
168	-	02	18	20	40	52	08	Silt loam
169	-	10	28	15	53	40	07	Sandy loam
170	-	12	27	03	42	42	16	Loam

Sr.No. = Location code

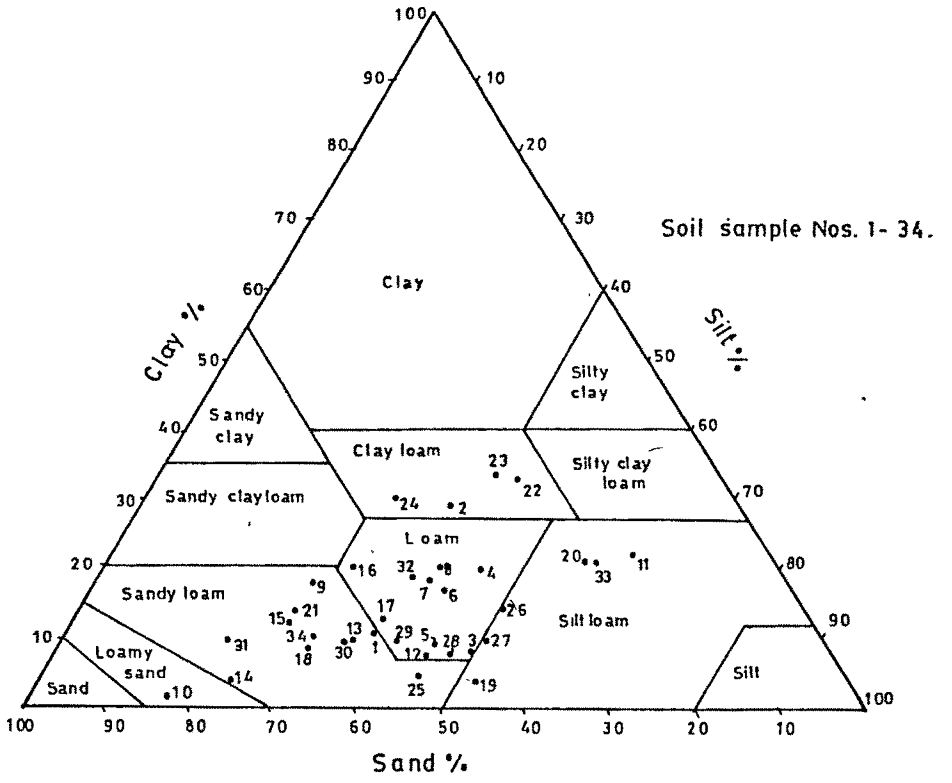


FIG. 18. TEXTURAL CLASSIFICATION PLOTS

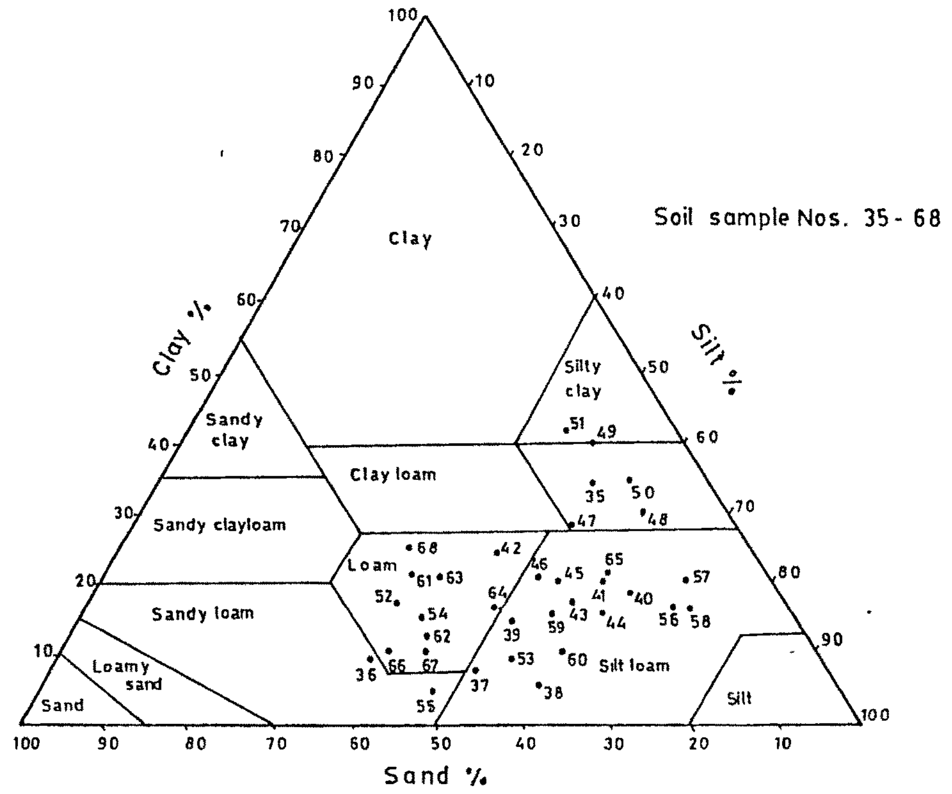


FIG. 19. TEXTURAL CLASSIFICATION PLOTS

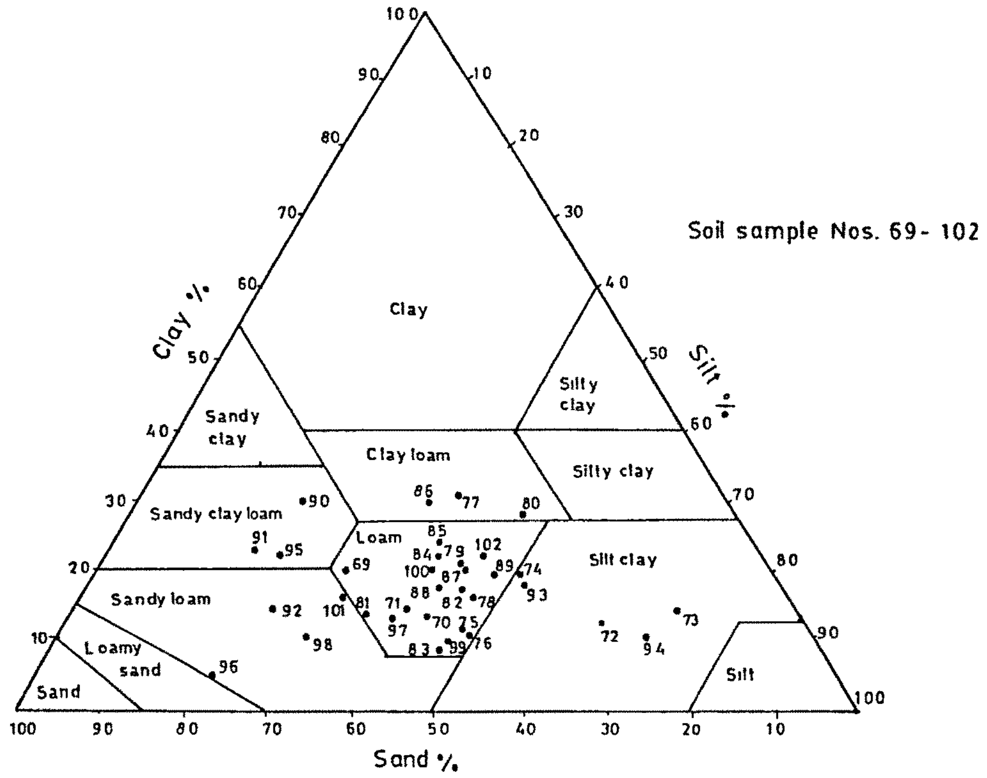


FIG. 20. TEXTURAL CLASSIFICATION PLOTS

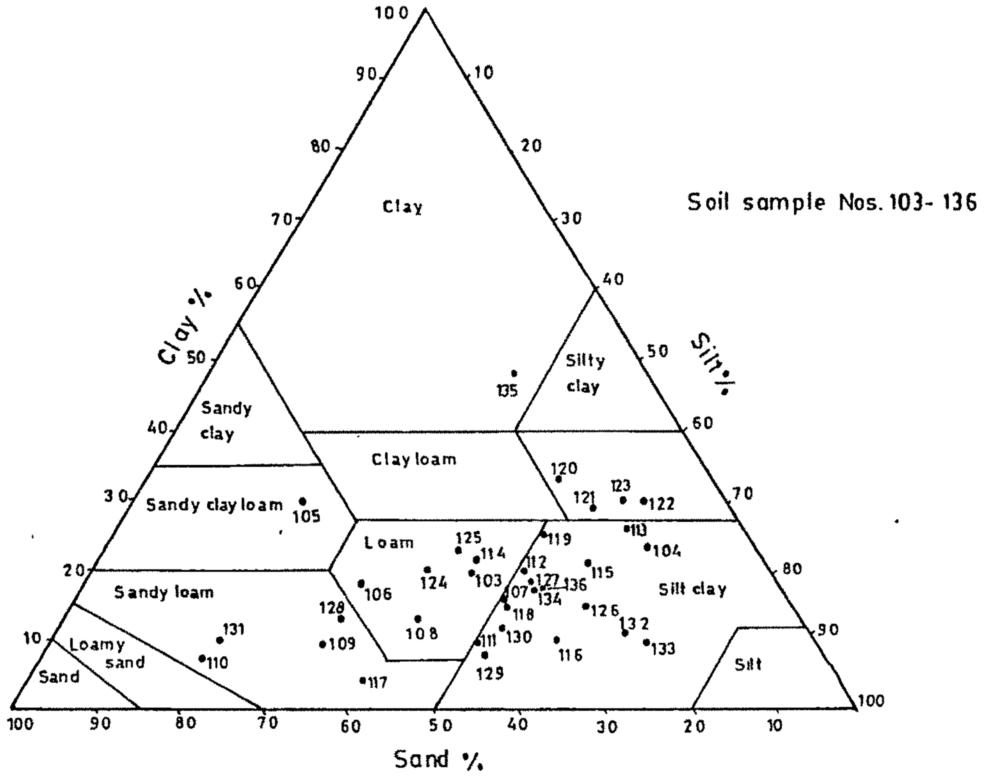


FIG. 21. TEXTURAL CLASSIFICATION PLOTS

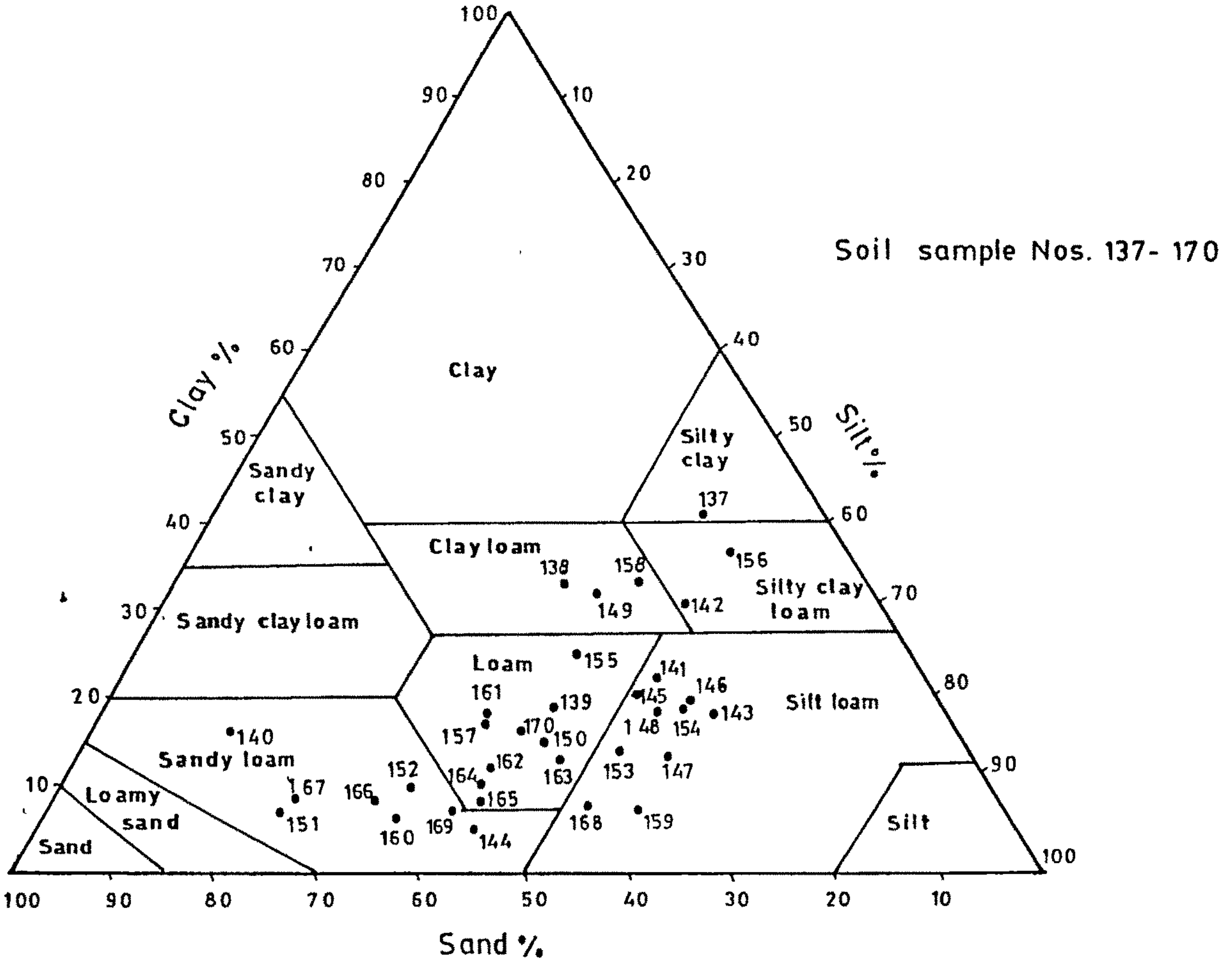


FIG. 22. TEXTURAL CLASSIFICATION PLOTS

names have been devised (Table : 9). A generalized soil map has been prepared based on the various soil textural classes (Fig. 23).

SOIL TYPES

Soil types of the study area based on the soil texture are given below.

(A) SANDY SOILS

The sand group includes all soils in which the sand separate makes up at least 70% and the clay separate 15% or less of the material by weight. The properties of such soils are therefore characteristically those of sand in contrast to the stickier nature of clays.

(i) Loamy sands

Soil material that contains at the upper limit 85 to 90% sand, and the percentage of silt plus one and half time the percentage of clay is not less than 15%; at the lower limit it contains not less than 70 to 85% sand, and the percentage of silt plus twice the percentage of clay does not exceed 30%. In particular, loamy sand has 25% or more very coarse, coarse and medium sand, and less than 50% fine or very fine sand.

Table - 9.

General Terms used to describe soil texture in relation to the basic soil textural class names

[U.S.Department of Agriculture classification system (in Brady, 1990)].

General Terms

Common names	Texture	Basic Soil Textural Class Names
Sandy soils	Coarse	Sands Loamy sands
Loamy soils	Moderately coarse	Sandy loam Fine sandy loam
	Medium	Very fine sandy loam Loam Silt loam Silt
	Moderately fine	Sandy clay loam Silty clay loam Clay loam
Clayey soils	Fine	Sandy clay Silty clay Clay

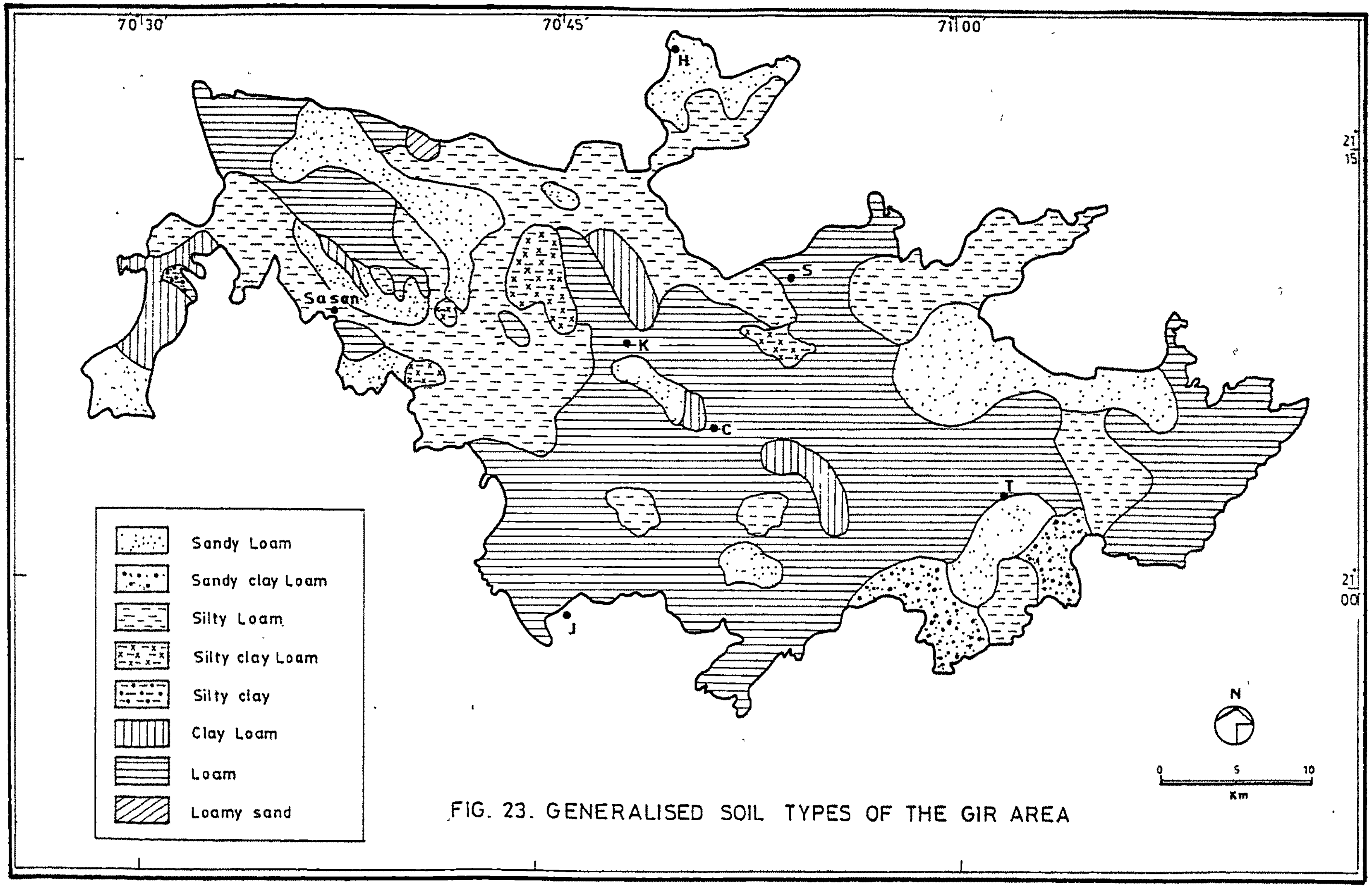


FIG. 23. GENERALISED SOIL TYPES OF THE GIR AREA

Areal extent

This soil type occurs in a very small pocket in the north-western part of the study area occupying an area of approximately 3.30 sq.km.

(B) LOAMY SOILS

The loam group, which contains many sub-divisions, is a more complicated soil texture class. An ideal loam may be defined as a mixture of sand, silt, and clay particles that exhibit the properties of these separates in about equal proportions.

(i) Sandy loam

Soil material that contains either 20% clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30, and 52% or more sand; or less than 7% clay, less than 50% silt, and between 43% and 52% sand. In particular, sandy loam soil has 30% or more very coarse, coarse and medium sand. but less than 25% very coarse sand, and less than 30% very fine or fine sand.

Areal extent

This soil type is well distributed throughout the area and covers approximately 232.51 sq.km.

(ii) Loam

Soil material that contains 7 to 27% clay, 28 to 50% silt, and less than 52% sand.

Areal extent

This soil type is well distributed and covers extensive areas. It is the most dominant soil type of the study area covering an area of about 665.28 sq.km.

(iii) Silt loam

Soil material that contains 50% or more silt and 12 to 27% clay (or) 50 to 80% silt and less than 12% clay.

Areal extent

This soil type covers large areas in the western portion and occurs as small pockets in the central and eastern portions. It occupies an area of approximately 356.69 sq.km.

(iv) Sandy clay loam

Soil material that contains 20 to 35% clay, less than 28% silt, and 45% or more sand.

Areal extent

This soil type covers a small area (24.18 sq.km) in the south eastern part of the study area.

(v) Clay loam

Soil material that contains 27 to 40% clay and 20 to 45% sand.

Areal extent

This soil type forms small pockets in the central and western parts of the study area and occupies an area of about 58.40 sq.km. It is totally absent in the southern and eastern parts of the study area.

(vi) Silty clay loam

Soil material that contains 27 to 40% clay and less than 20 percent sand.

Areal extent

This soil type forms very small pockets in the central part of the study area. It occupies an area of about 69.43 sq.km.

(C) CLAYEY SOILS

To be designated a clay, a soil must contain at least 35% of the clay separate and, in most cases not less than 40%. Only silty clay is found in the study area.

(i) Silty clay

Soil material that contains 40% or more clay, and 40% or more silt.

Areal extent

This soil type occurs in a very small pocket (2.34 sq.km) in the western most part of the study area.

(3) Soil moisture

It is defined as the ratio of weight of water to the weight of solids in a given mass of soil. The moisture content of the soil samples was determined by the oven-drying method.

Methodology

Weigh 2 gm soil into a tared, shallow, stoppered weighing bottle and heat with the bottle uncovered for several hours, or overnight, in a drying oven at 110°C. Cover, cool in a desiccator, and weigh. Report percentage loss in weight as moisture.

All moisture determinations are stated on the dry weight basis, that is expressed as percentages where the oven-dry soil is taken as 100.

Areal behaviour

There is a consistent decline in moisture content from west to east. Maximum moisture content (24.6%) is found in the western part of the area, whereas, the eastern part shows minimum moisture content (4.4%). The northern and southern parts show intermediate moisture content ranging between 7.4% and 21.6%. However, moisture content is high in the areas bordering major streams. Development of reservoirs in the study area has probably increased the moisture content in their adjoining and downstream areas.

CHEMICAL PROPERTIES

The following chemical properties were analysed (Table : 7) :

(1) pH,
(2) electrical conductivity,
(3) organic carbon,
(4) calcium,
(5) magnesium,
(6) sodium,
(7) potassium, and
(8) phosphorous.

(1) pH

The soil solution contains small but significant quantities of soluble inorganic and organic compounds, some of which contain elements that are essential for plant growth.

One of the critical properties of the soil solution is its 'acidity' or 'alkalinity'. Many chemical and biological reactions are dependent on the levels of hydrogen ions (H+) and hydroxide ions (OH-) in the soil. These levels influence the solubility, and in turn the availability to plants, of several essential nutrient elements such as iron, manganese, phosphorous, zinc, and molybdenum. The concentration (activity) of hydrogen and hydroxide ions in the soil solution is commonly ascertained by determining its pH.

The pH of an aqueous solution is defined as the negative logarithm of the hydrogen ion activity in that solution. Thus, each unit change in pH represents a tenfold change in the activity of the hydrogen and hydroxide ions. Soil pH was determined by glass electrode method.

Methodology

Transfer 50 gm < 2 mm air-dry soil to a 100 ml beaker, add 50 ml H_2O and stir occasionally for 1 hour. Determine pH of sample with glass electrode and pH meter while stirring.

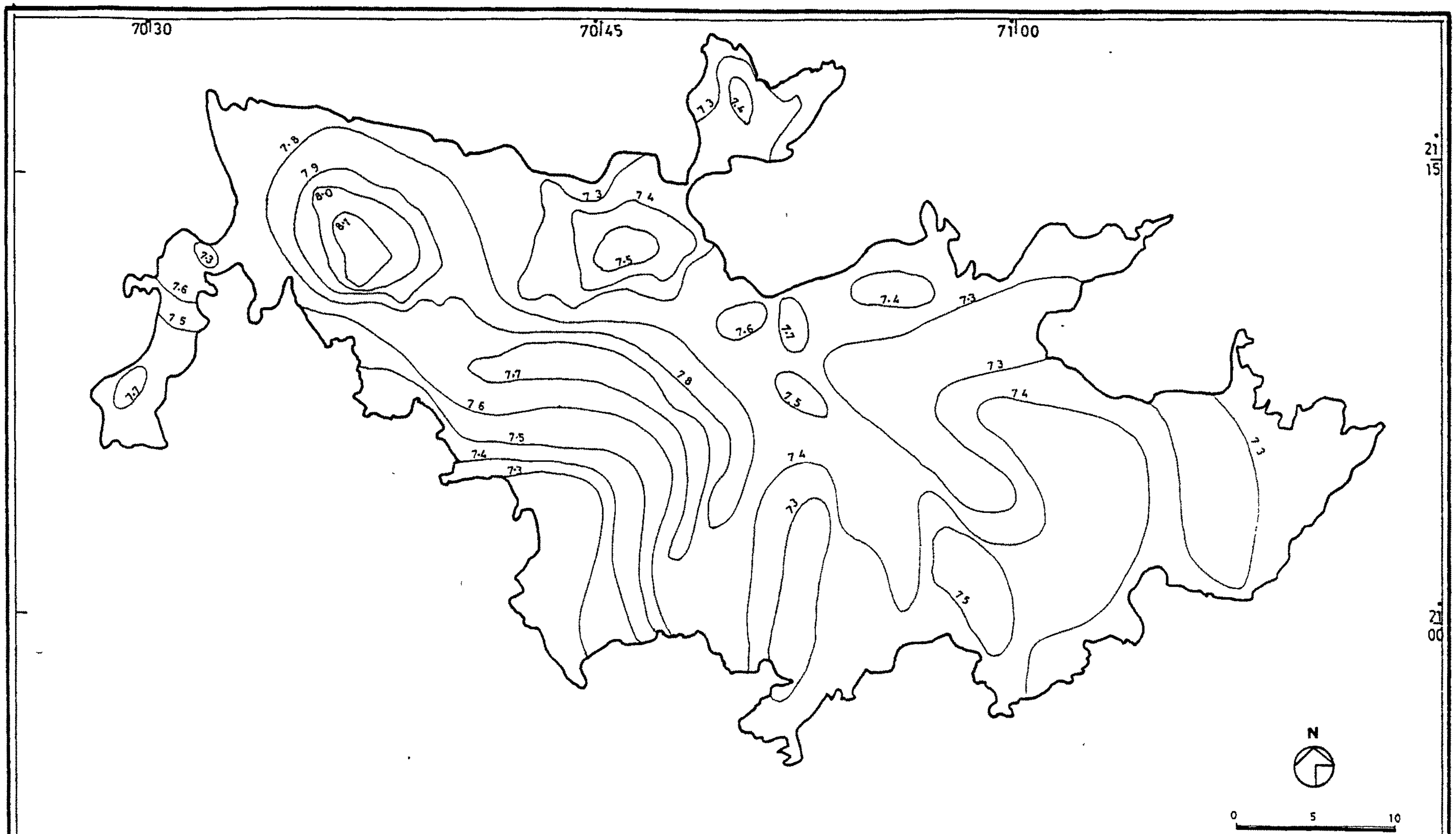


FIG. 24. SOIL ISO- pH MAP

Areal behaviour

In the study area, soil pH ranges from 7.3 in the east to 8.1 in the west (Table : 7). Iso-curves for soil pH of the study area were drawn (Fig. 24) to indicate the pattern of 'acidity' or 'alkalinity' of soil. The soils of the study area are slightly alkaline and exhibit the pH range common for arid region mineral soils (Fig. 25).

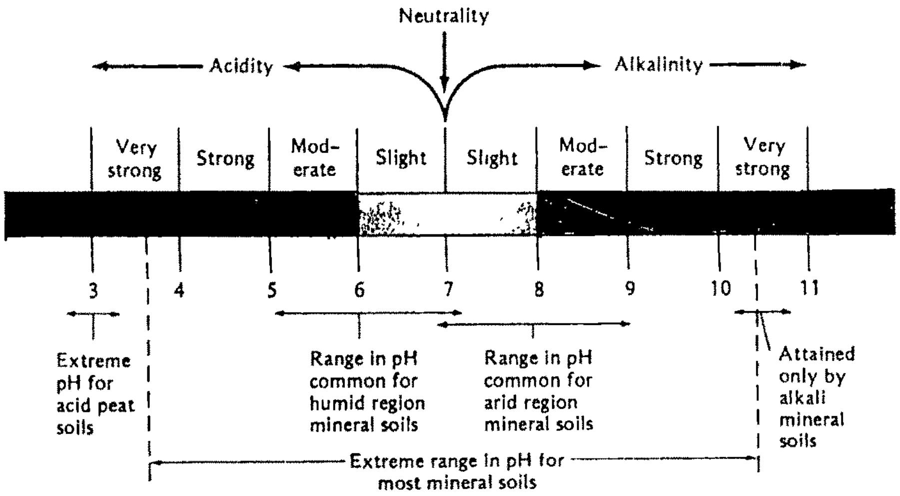


FIGURE-25
Extreme range in pH for most mineral soils and the ranges commonly found in humid region and arid region soils. Also indicated are the maximum alkalinity for alkali soils and the minimum pH likely to be encountered in very acid peat soils

(after Brady, 1990)

In the northern and eastern parts, the soil pH ranges from 7.3 to 7.5. In the central and southern parts it ranges from 7.5 to 7.8, whereas in the western part it ranges from 7.5 to 8.1.

(2) ELECTRICAL CONDUCTIVITY: (E.C.)

Electrical conductance is the reciprocal of resistance. As it increases with salt content, it is more suitable for salinity measurements. Electrical conductivity of samples were measured using the E.C. meter, and the results are always reported in terms of millimhos/cm i.e. E.C. x 10^3.

Methodology

Weigh a 50 gm sample of soil into a 250 ml Erlenmeyer flask. Add 100 ml of distilled water and let it stand at least 30 minutes, shaking occasionally. Filter or pour off supernatant liquid and measure conductivity of liquid with a bridge and conductivity cell.

Areal behaviour

Iso-curves for the electrical conductivity of the soils of the study area were drawn (Fig. 26). In the northern and north-eastern parts the values of electrical conductivity range from 0.06 to 0.12 mmhos/cm. In the southern and eastern portions it ranges from 0.06 to 0.09 mmhos/cm. Whereas in the central and western parts it ranges from 0.09 to 0.12 mmhos/cm. The electrical conductivity increases towards the centre of the study area. However, it is very clear (Table : 7 & 10) that the soils of the study area are normal and not saline.

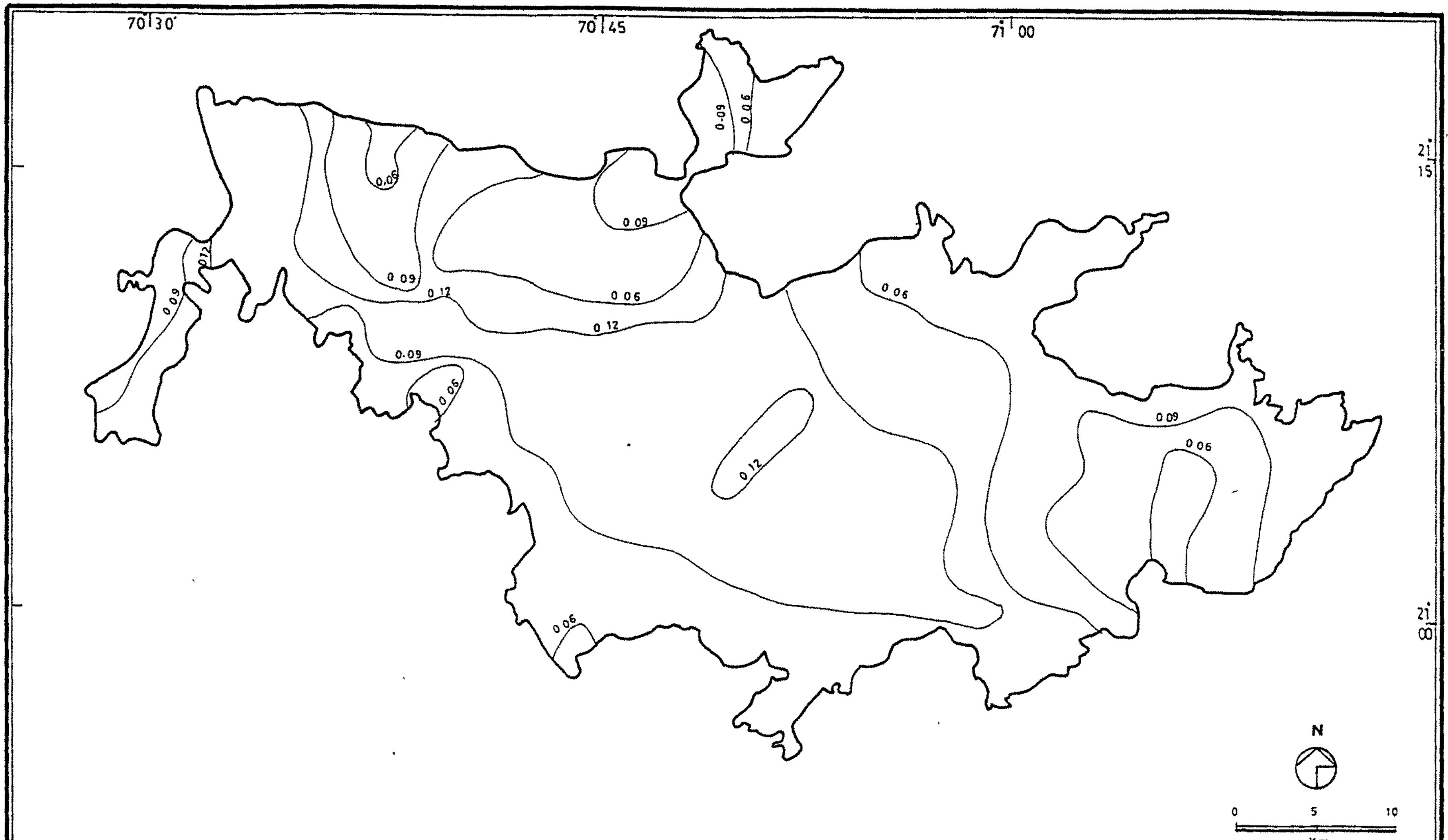


FIG. 26. SOIL ISO E.C. (mmhos/cm) MAP

TABLE - 10

Interpretation of Electrical Conductivity Readings
(after Bear, 1964)

Conductivity (1×10^{-5} mhos)	Relative level	Plant response
0 - 20	Low	No injury to any plants; may indicate lack of nutrients.
20 - 80	Medium	Optimum level for most plants; salt-sensitive plants may be injured.
80 - 150	High	Injury to salt-sensitive plants; germinating seeds or seedlings are likely to be injured.
> 150	Excessive	Definitely injurious to most plants of all ages.

(3) ORGANIC CARBON

Organic matter influences physical and chemical properties of soils far out of proportion to the small quantities present. It commonly accounts for as much as one third or more of the cation exchange capacity of surface soils and is responsible, perhaps more than any other single factor, for the stability of soil aggregates. Furthermore, organic matter supplies energy and body-building constituents for most of the soil micro-organisms.

The remarkable effects of this all-important constituent on a number of soil properties are summarized below (after Brady, 1990) :

(1) effect on soil colour - brown to black,

(2) influence on physical properties:

   a. granulation encouraged,

   b. plasticity, cohesion, and so on, reduced,

   c. water-holding capacity increased,

(3) high cation exchange capacity,

(4) supply and availability of nutrients :

   a. easily replaceable cations present on humus colloids,

   b. nitrogen, phosphorous, sulfur, and micronutrients held in organic forms, and

   c. release of elements from minerals by humic acid.

Because of its complex nature, numerous difficulties beset the accurate determination of soil organic matter. Organic matter is far more generally calculated from a determination of organic carbon on the assumption that the organic matter of the average soil contains 58% of carbon. Sinoe organic carbon can be determined directly, and with considerable accuracy, by any of the usual methods of dry combustion, it is preferable to report it as such, rather than a value for organic matter derived from it on the above assumption (Piper, 1950).

Methodology

Waksman and Stevens (1930); Wright (1990) consider that the most reliable way for the estimation of the soil organic matter is the determination of the organic carbon, the percentage of which is multipled by 1.724. This factor is based on the assumption that the soil organic matter contains 58% of carbon.

The most accurate procedure for determination of organic carbon in soils is the dry cumbustion method. In this method the soil is ignited in a current of purified air and the carbon dioxide, produced by the combustion of organic matter is absorbed in a suitable absorbent and weighed. If carbonates are present in the soil they are first removed by treatment with sulphuric acid. For the combustion, a silica tube packed with copper oxide is preferred. The detailed procedure as mentioned by Piper (1950) was followed for determining organic carbon.

Areal behaviour

Iso-curves of organic carbon (Fig. 27) shows low values along the periphery of the study area. There are a few pockets showing medium values ranging from 0.5 to 0.75%. A major part of the study area shows higher values of organic carbon (Table : 7). The low values coincide with areas having extensive biotic pressure. The medium and high values correspond to zones of moderately and densely forested areas respectively.

(4) CALCIUM

An adequate supply of calcium appears to stimulate the development of root hairs and in fact, of the entire root system. It is necessary for normal leaf development (Millar, 1955).

Methodology

A finely ground 2 gm soil sample is subjected to sodium carbonate fusion. The resulting dehydrated silica residue is used to determine silicon content. Concentrate the combined filtrates (200 ml) from the Na_2CO_3 fusion and Si

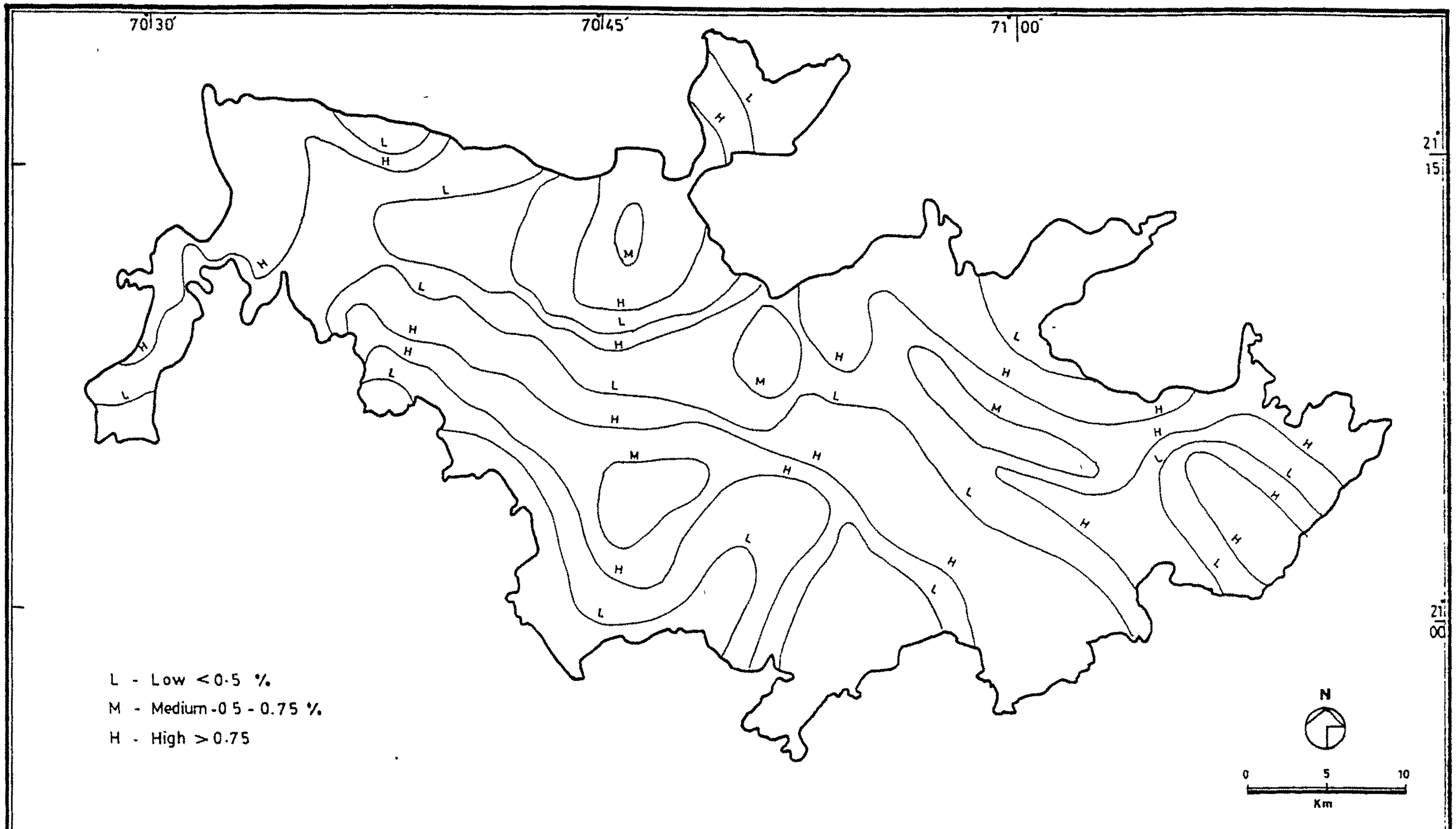


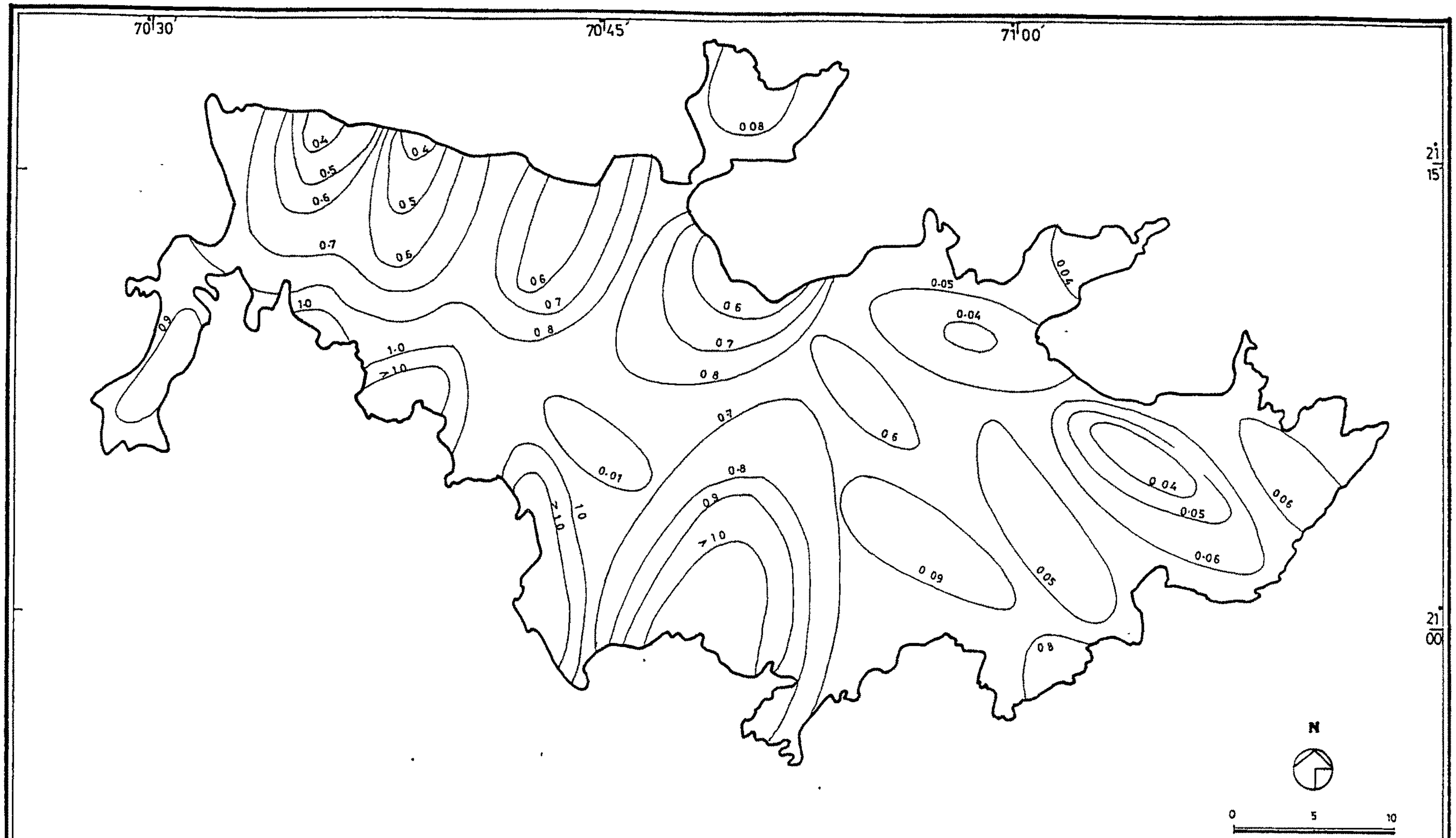
FIG. 27 SOIL ISO - ORGANIC CARBON (%) MAP

determination by evaporation to about 150 ml, transfer to 250 ml flask, and make to volume with H_2O. Designate as solution A, remove two 50 ml aliquots, and reserve for determination of phosphorous. Wash the remaining 150 ml into a 400 ml beaker and evaporate to 100 ml. Add NH_4OH solution, carefully with stirring, to pH 6.3.

Cover beaker with watchglass, bring to boil on hot plate or low flame, remove from heat, allow precipitate to settle for 2 to 3 minutes, and stir and filter rapidly through Whatman No.41 paper. Wash beaker and filter several times with hot NH_4NO_3 solution. Return the paper containing the precipitate to the original beaker, add 10 ml HCl solution, macerate the paper with a stirring rod, add 75 ml H_2O, and heat to boiling. Remove from heat, adjust pH to 6.3 with the NH_4OH solution, heat to boiling, and filter as before. Wash precipitate free of chlorides with hot NH_4NO_3 solution; combine the filtrates and save for Ca and Mg determinations (Solution B). Determine Ca and Mg in solution using the flame photometer and report the results in terms of percentage.

Areal behaviour

Iso-calcium contour map (Fig. 28; Table : 7) indicates that calcium is comparatively low in the north-west and east, and high in the south. This could be attributed to the presence of miliolite limestone along the southern fringe of the study



-FIG. 28. SOIL ISO-CALCIUM (%) MAP

area. The calcium value ranges from 0.08% to 0.8% in the north, and from 0.8% to > 1.0% in the south. In the east it ranges from 0.04% to 0.8%, and from 0.4% to 1.0% in the west.

(5) MAGNESIUM

Magnesium is essential in the growth of all green plants, as it is a constituent of chlorophyll. The element is also connected with the transportation of phosphorus in the plant (Millar, 1955).

Methodology

As described in calcium.

Areal behaviour

Iso-curves of magnesium (Fig. 29; Table : 7) indicate comparatively high values in the central and southern parts. In the north and east, the values of magnesium range from 0.001 to 0.15%, and from 0.15 to 1.0 % in the south. Whereas in the west it ranges from 0.004 to 0.20 %.

(6) SODIUM

Most plants contain considerable quantities of sodium, and certain groups of plants absorb quite large quantities of it when the supply in the soil permits. Nevertheless, the evidence is not sufficient to prove that the element is

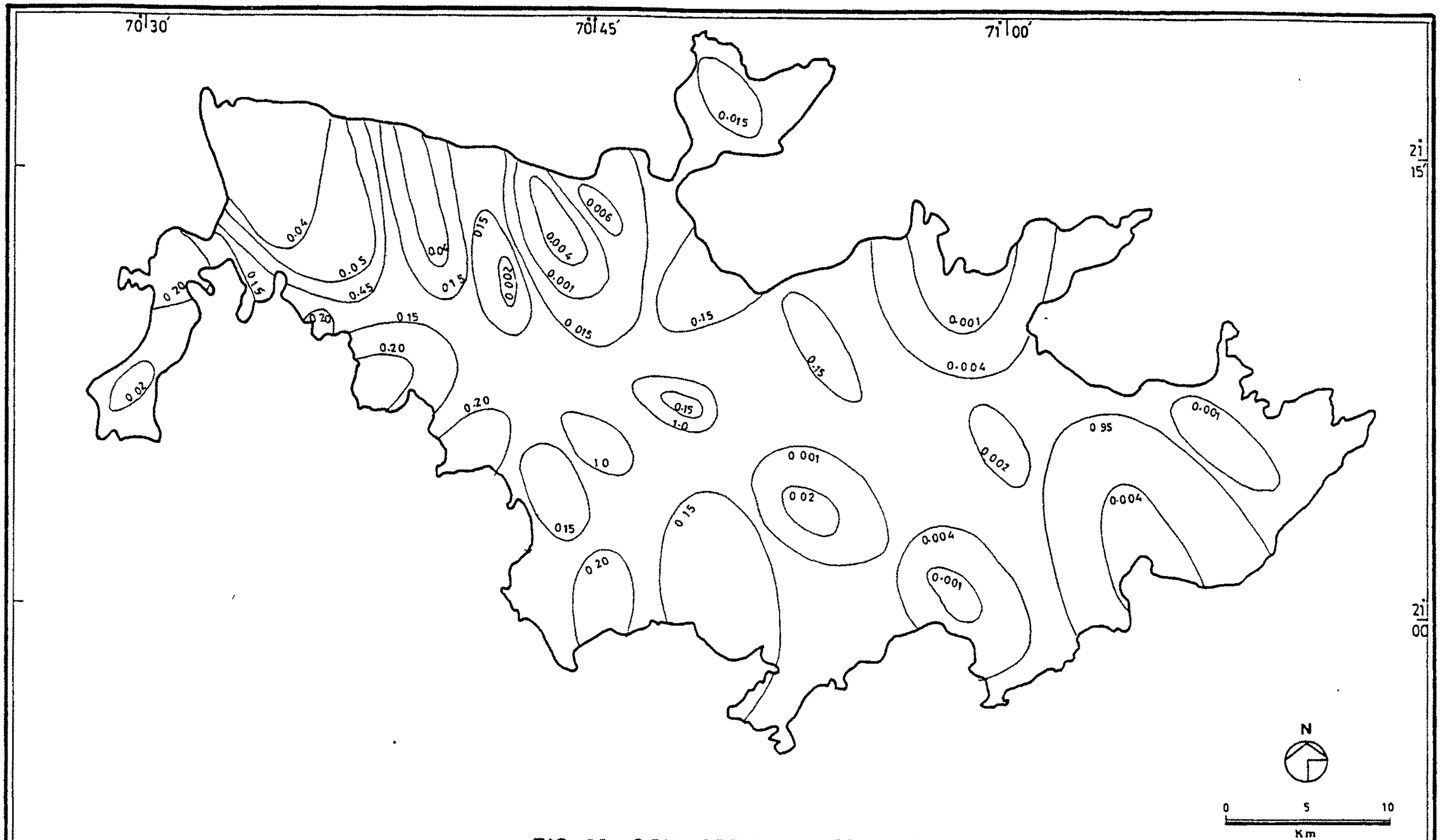


FIG. 29. SOIL ISO MAGNESIUM (%) MAP

essential for the normal growth of plant (Millar, 1955). Sodium has been found partially to take the place of potassium in the nutrition of certain plants. Where there is deficiency of potassium, native soil sodium may be useful (Brady, 1990).

Methodology

Grind together in an agate mortar 0.5 to 1.0 gm of soil and an equal weight of NH_4Cl. Add 4 to 5 gm $CaCO_3$ powder and mix thoroughly. Put approximately 0.2 gm $CaCO_3$ at the bottom of a platinum crucible and add mixture from mortar. Clean mortar of all the sample mixture with an additional 0.5 gm $CaCO_3$ and add this to the top of the mixture in the crucible. Tap to settle, cover, and heat over very low flame until release of ammonia ceases. Do not let temperature in any part of the crucible get high enough to cause NH_4Cl to be lost. When all ammonia has evolved, increase the flame until the crucible is dull red, and continue heating at this temperature for 40 to 60 minutes or until the mass is completely fused. Cool and transfer the shrunken fusion to a 150 ml procelain evaporating dish. Wash all remains of the fusion from the crucible and its cover into the dish with hot H_2O. Cover the dish with a watchglass and digest on steam bath for several hours until fusion mass is thoroughly disintegrated. If after digesting overnight the mass is not completely slaked, crush any lumps remaining with a stirring rod or pestle. Filter through Whatman No.2 paper into a 400 ml beaker. Wash the dish and filter with hot H_2O in small portions until the filtrate volume is 300 ml. Add 50 ml $(NH_4)_2CO_3$ solution to precipitate most of the Ca. Concentrate by evaporation to about 50 ml, filter into 250 ml beaker and wash paper and residue with at least 100 ml hot H_2O in small portions. Concentrate volume of 50 ml on steam bath and transfer to 150 ml porcelain evaporating dish. Rinse beaker with hot H_2O and add rinsings to dish. Evaporate contents of dish to dryness and ignite to expel ammonia salts. Dissolve residue in hot H_2O; cool, transfer to 100 ml volumetric flask, and make to volume with H_2O. Determine Na and K on aliquots of this solution on flame photometer after adding Li as internal standard and diluting to an appropriate volume, depending on Na and K content of soil. Results of Na are usually presented in terms of percentage.

Areal behaviour

Sodium values of the study area indicate that the soils are poor in sodium content (Table : 7). Iso-curves of sodium (Fig. 30) expressed as Na_2O, indicate that it ranges from 0.01 to 0.09% in the northern, southern and eastern parts, whereas in the western part it ranges from 0.02 to 0.07%. The central region shows the highest sodium content and the widest range from 0.01 to 0.1%.

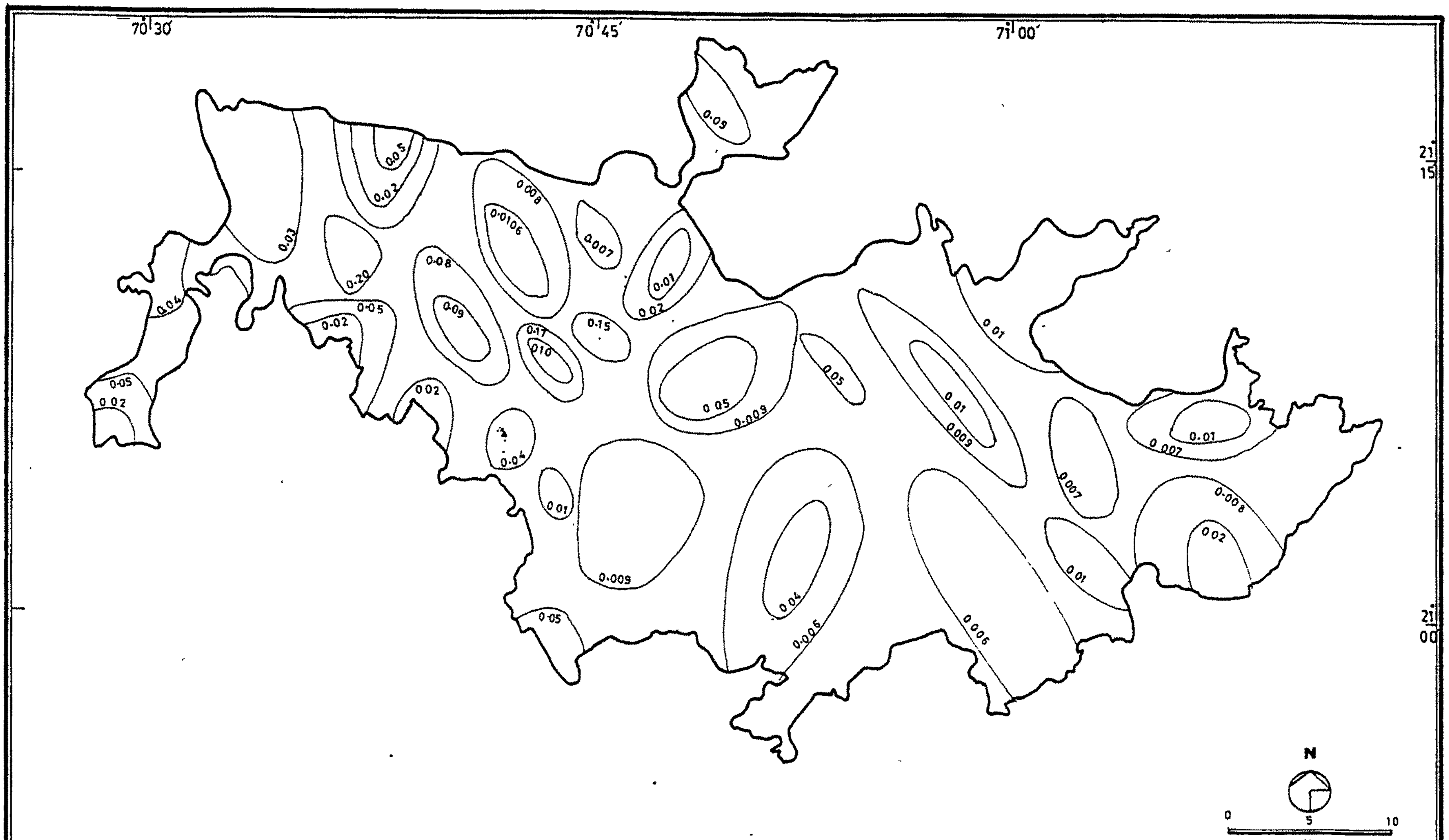


FIG. 30. SOIL ISO SODIUM (%) MAP

(7) POTASSIUM

Potassium is essential for photo- and protein synthesis, for starch formation, and for the translocation of sugars. It increases plant resistance to certain diseases and encourages strong root and stem systems. It helps regulate the opening and closing of stomatoes in the leaves and the uptake of water by root cells (Brady, 1990).

Methodology

As described in sodium. The potassium content is presented in terms of kg/Ac (1 acre = 1000000 kg of soil) using the standard curve, for comparing with the specified range. However, if required, percentage values can be derived by using 1 gm = 0.10%.

Areal behaviour

Iso-curves of potassium (Fig. 31) show that potassium is well distributed over the area and ranges from low to high (Table : 7). Only in the northern, north-eastern and south-eastern parts, the values range from low to medium.

<u>Potassium (K_2O)</u>

Low	=	62.5 kg/Ac
Medium	=	62.5-150 kg/Ac.
High	=	150 kg/Ac (after Perur et al.,1973)

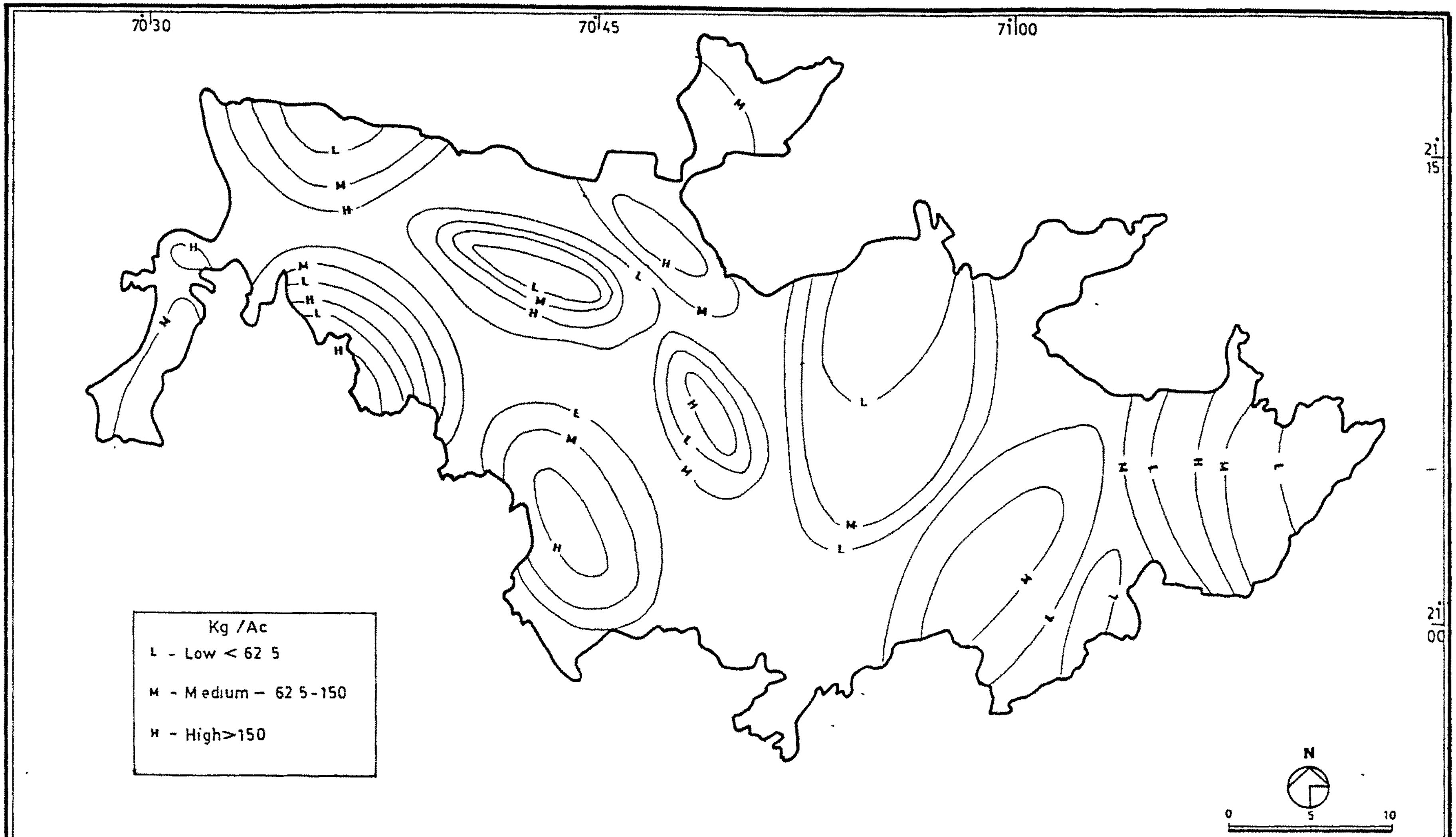


FIG. 31. SOIL ISO POTASSIUM (Kg / Ac) MAP

(6) PHOSPHOROUS

Phosphorous is essential for plant growth and plays a critical role in the life cycle of plants (Brady, 1990). It is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance in plants as well as animals, and of the various forms of ribonucleic acid (RNA) needed for protein synthesis. Obviously, phosphorus is essential for numerous metabolic processes.

Methodology

Pass the 50 ml aliquot reserved for phosphorous determination from solution A (from Ca & Mg methodology) above through a small Jones reductor into a 100 ml volumetric flask. Rinse the Jones reductor column with several small portions of H_2O to bring the volume in the flask to the mark. Mix and transfer an aliquot to a 50 or 100 ml volumetric flask. Dilute with H_2O to about half the volume of the flask, add 1 ml ammomium molybdate solution, and mix well. Add 5 drops stannous chloride solution, mix at once, and make to volume with H_2O. Read the intensity of the blue colour after 5, but within 20 minutes at 660 m . From the standard curve of phosphorous solution find out the unknown values. In accordance with potassium values, phosphorous content is also presented in terms of kg/Ac.

Phosphorous P_2O

Low	=	10 kg/Ac
Medium	=	10-25 kg/Ac
High	=	25 kg/Ac (after Perur et al.,1973)

Areal behaviour

Iso-curves of phosphorous distribution (Fig. 32) shows high values (Table : 7) in the northern and western parts of the study area. Whereas medium and low values are found to occur all throughout the area.

Great variability is a characteristic of the phosphorous content of soils. Soils of the semi-arid regions are usually richer in phosphorous than are those of similar texture in humid areas, and also there is less variation in the amount of the element in different horizons (Millar, 1955).

TOPOGRAPHY - SOIL RELATIONSHIPS

Topography, or local relief, controls much of the distribution of soils in the landscape, to such an extent that soils of markedly contrasting morphologies and properties can merge laterally with one another and yet be in equilibrium under existing local conditions (Birkeland, 1984). Soil properties vary laterally with topography; one reason for this is the orientation of the hill slopes on

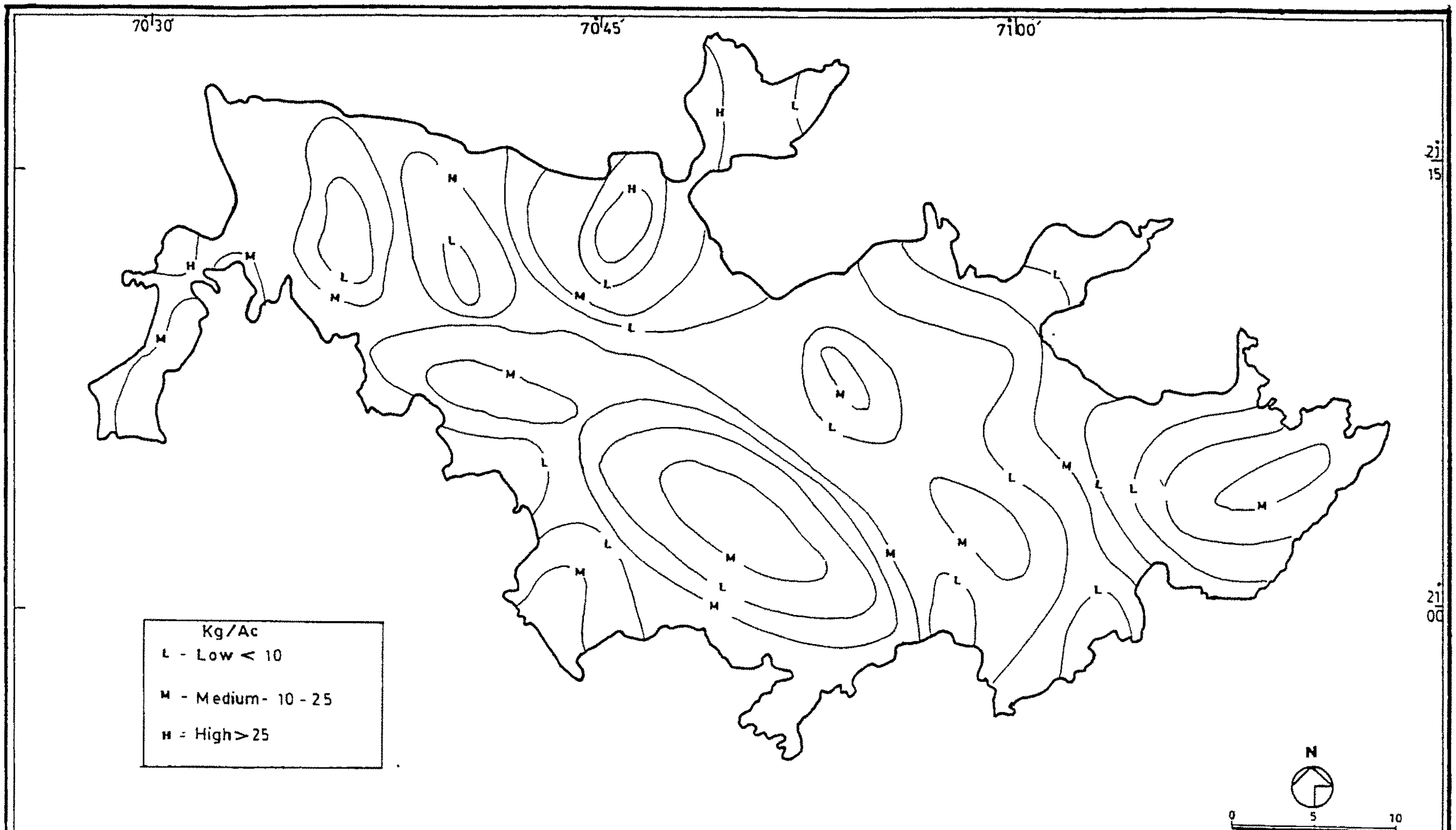


FIG. 32 SOIL ISO PHOSPHOROUS (Kg/Ac) MAP

which soils form; this affects the microclimate and, hence, the soil. Another is the steepness of the slope; this affects soil properties because the rates of surface water runoff and erosion vary with the slope.

Slope orientation results in micro-climatic and vegetational differences, and thus in soil differences. Jenny (1958, 1980) argues that topography is the primary factor in explaining soil variation. In the study area, as there is a topographic leap of meters, or tens of meters, the regional climate can be considered a constant.

An attempt has been made to correlate the distribution of soils with major geomorphic landforms.

From (Fig. 13 & 18) it can be clearly seen that there is a general geomorphological control over the distribution of soils, which is aptly brought out in Table : 11. Another observation is the merger of soils of markedly contrasting properties with one another.

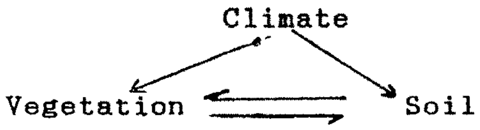
VEGETATION-SOIL RELATIONSHIPS

The biotic factor in pedogenesis is difficult to assess because of the dependence of both vegetation and soil on climate and the interaction of soil and vegetation. Jenny (1941, 1958, 1980) depicts the inter-relationship of these three factors as :

Table - 11

POSSIBLE CORRELATION BETWEEN SOIL TYPES AND GEOMORPHIC UNITS

	Soil Type	Geomorphic Unit
(1)	Loamy sand	Moderately dissected plateaux.
(2)	Sandy loam	Dissected plateaux and denudational hills.
(3)	Loam	Dissected plateaux, denudational hills, buried pediments and buried pediplains.
(4)	Silt loam	Buried pediments and buried pediplains.
(5)	Sandy clay loam	Moderately dissected plateaux.
(6)	Clay loam	Buried pediments and buried pediplains.
(7)	Silty clay loam	Highly dissected plateaux and denudational hills.
(8)	Silty clay	Buried pediplains.



The lower part of the triangle is of concern, specifically, the influence of soil on vegetation including any geomorphological control.

An attempt has been made to the correlate major forest types and the various soil types (Table : 12).

It can be seen from the above table that loam, silty loam and sandy loam types of soils are most conducive for vegetal growth.

SOIL MOISTURE BALANCE OF THE GIR AREA

It has been demonstrated by plant ecologists and physiologists that when moisture supply to a region is adequate within certain limits, the rate of plant growth and abundance of vegetation vary directly with temperature. In the same way where thermal, edaphic and cultural conditions are constant there is a direct relation between the abundance of vegetation on an area and effectiveness of precipitation. Thus, temperature efficiency and precipitation effectivity are equivalent phenomena in the growth and development of vegetation. The most favourable thermal conditions for plant growth are in the tropical regions.

Table - 12

POSSIBLE CORRELATION BETWEEN SOIL TYPES AND FOREST TYPES

	Forest Type	Soil Type
(1)	Dry deciduous teak	Loam, silt loam, silty clay loam, clay loam and sandy loam.
(2)	Dry deciduous mixed	Loam, silt loam, sandy loam and sandy clay loam.
(3)	Thorn scrub	Sandy loam, silt loam, loamy sand, clay loam and silty clay.
(4)	Open scrub	Loam, silt loam, sandy loam, sandy clay loam, silty clay loam and clay loam.
(5)	Savanna	Loam and sandy loam.
(6)	Riverine	Loam, silt loam, sandy loam and clay loam.

When the soil moisture is continuously high so that plants can get as much water as they need, transpiration to air and carbon dioxide from air both respond in the same way to the various factors of climate. The greater the incoming energy, the more rapid is the plant development and the greater the water use. Because solar radiation is not ordinarily measured, it is customary to relate plant development and water use to temperature instead. If there is always enough water in the soil for the use of vegetation, water-losses to the atmosphere and, therefore, the development of plant are related to the thermal factors of climate than to the type of vegetation.

In developing a rational scheme of classification of world climates Thornthwaite (1948) introduced a parameter called "Potential Evapotranspiration" (P.E.) defined as the maximum amount of water that would evaporate and transpire from a thickly vegetated extensive territory with no deficiency of water for full use at any time.

Thornthwaite (1948) evolved a formula for the computation of P.E. from temperature records provided the latitude of the place is known.

Since P.E. is derived from air temperature and length of the day (duration of the sunshine), both of which determine the growth and development of vegetation in the absence of water deficiency, Thornthwaite (1948) considered it as an index of thermal efficiency too, for many phyto-biological purposes.

Computation of Potential Evapotranspiration (P.E.) according to the method of Thornthwaite (1948)

In order to determine the potential evapotranspiration or thermal efficiency, three steps are involved in the computation and all the three are accomplished by means of a nomogram and standard values (given in Subramanyam 1982).

1. The first step is to obtain the annual Heat Index "I"; Monthly value of "i" corresponding to mean monthly temperatures of the station are obtained from the standard values. Summation of the twelve monthly values of "i" gives the Annual Heat Index "i".

2. The next step is to determine the unadjusted values of thermal efficiency from the nomogram in Fig. 33. Since there is a linear relation between the logarithm of temperature and the logarithm of unadjusted thermal efficiency, straight lines on the nomogram define the relationship. All the lines pass through the point of convergence at t = 26.5^{o}C and thermal efficiency = 13.5 cm. The slope of the line is determined by the annual heat index (I) of the station. Based on the standard monthly mean heat index, the Annual Heat Index for Sasan (Table : 13) is 134.60 and the line ruled on the nomogram represents the relationship between thermal

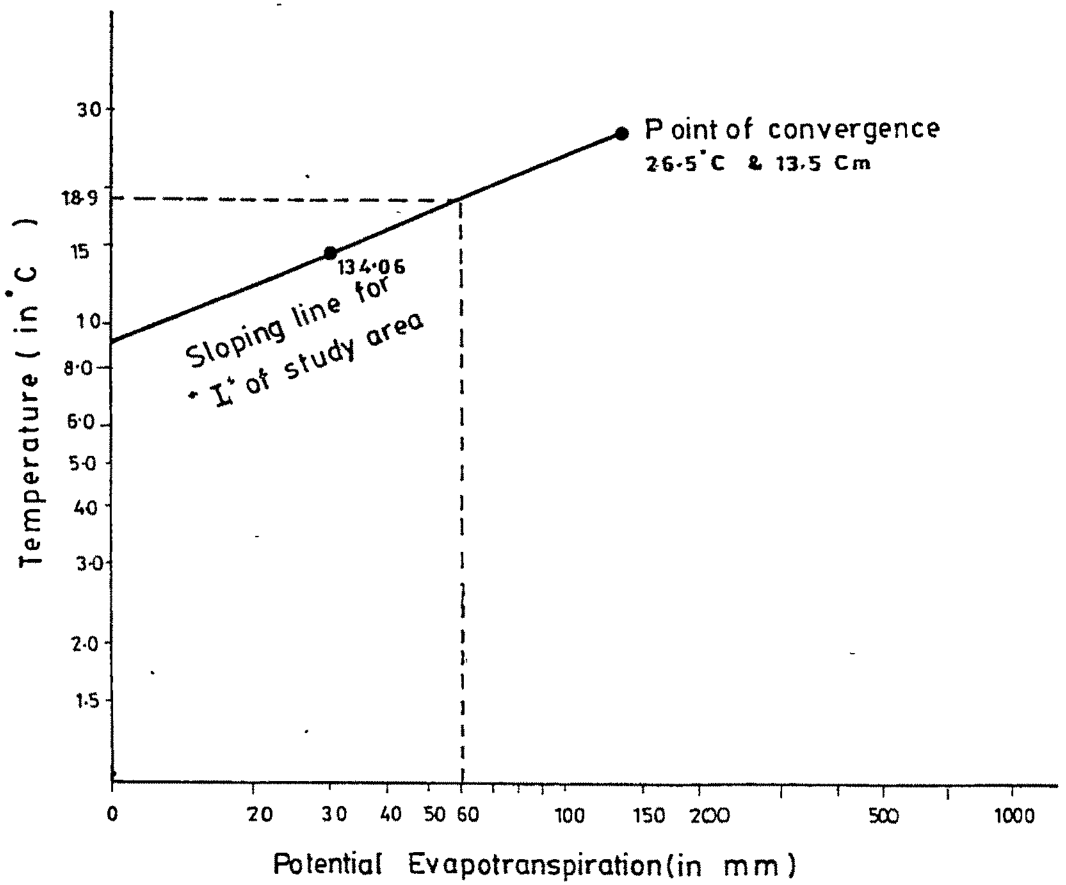


FIG. 33 NOMOGRAM FOR THE GIR AREA

efficiency and temperature at that place. At the mean temperature of 18.9°C for January, the unadjusted thermal efficiency (UTE) is 6.00 cm.

Knowing the annual Heat Index (I) of the station from the straight edge of the nomogram, one can derive the value of thermal efficiency corresponding to the mean temperature of the month. The nomogram is used only, when the mean

Table - 13

Thermal Efficiency (TE) or Potential Evapotranspiration (PE) of the study area (based on Thornthwaite Method)

Station : Sasan Gir Lat :21°N Long :70°30'E Period -1985-90

Month	Monthly mean Temp.(T°C)	Monthly mean heat index "i"	Unadjusted Thermal Efficiency UTE cm	Adjusted Thermal Efficiency ATE cm
Jan	18.9	07.49	06.00	05.60
Feb	20.9	08.72	07.60	06.80
Mar	23.9	10.68	10.90	11.22
Apr	29.5	14.69	15.89	16.68
May	29.9	14.99	16.13	18.22
Jun	27.1	12.85	14.30	15.87
Jul	25.6	11.85	12.50	14.37
Aug	24.9	11.37	11.00	12.21
Sep	25.6	11.85	12.50	12.75
Oct	26.4	12.42	13.30	13.30
Nov	22.1	09.42	08.90	08.18
Dec	19.3	07.73	06.20	05.82
Annual	24.5	I =134.60		141.00

temperature of the month is 26.5°C or less. Thermal efficiency values corresponding to higher temperatures are obtained from the table of standard values. Twelve values are obtained for the twelve months. These are the unadjusted values for months of 30 days of twelve hours of bright sunshine each day.

3. Finally these values of thermal efficiency are adjusted for the length of the day (i.e. actual number of hours of sunshine between sunrise and sunset) and the actual number of days in the month. The appropriate correction factors obtained from standard chart is multiplied with the unadjusted thermal efficiency value of each month. The summation of the twelve monthly values gives the annual TE in cm.

Discussion

From Table : 14 & Fig. 33a, it is clear that only during the monsoon month of August there is positive soil moisture, while during the ensuing dry winter and summer months, there is negative soil moisture. In fact, there is a negative soil moisture balance of -69.9 cm.

This is an indication of :

1. that there is heavy run off, and less precipitation, possibly due to the highly rugged terrain.

2. the regional semi-arid climatic regime has played a big hand in controlling the micro-climate of this forested area.

Table - 14

Soil moisture balance of the study area

Months	Parameters		
	P (in cm)	PE(ATE) (in cm)	(P-PE)
Jan	-	5.60	-5.60
Feb	-	6.80	-6.80
Mar	-	11.22	-11.22
Apr	-	16.68	-16.68
May	-	18.22	-18.22
Jun	15.07	15.87	-00.80
Jul	06.50	14.37	-07.90
Aug	44.91	12.21	32.70
Sep	04.62	12.75	-08.13
Oct	-	13.30	-13.13
Nov	-	08.18	-08.18
Dec	-	05.82	-05.82
Annual	71.10	141.00	-69.90
+ve = 32.7			-ve = 171.85

P = Precipitation

PE = Potential evapotranspiration

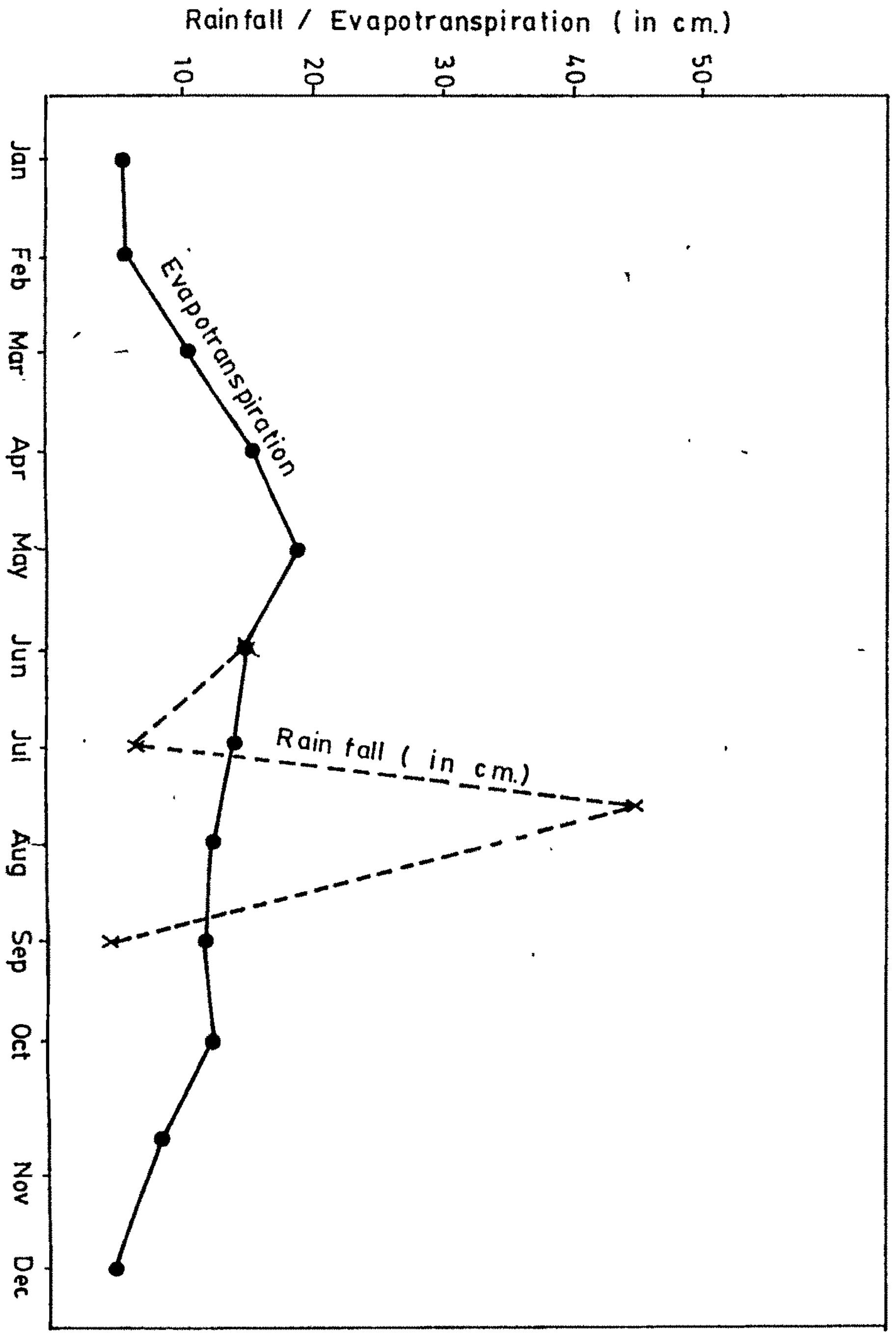


FIG. 33 a. SOIL MOISTURE BALANCE

Moisture Index

When precipitation is in excess of the water-need (i.e. potential evapotranspiration) then the climate is moist, while when the water deficiency is large in comparison with the water-need, the climate is dry.

Where there is only a water surplus and no water deficit, the relation between water surplus and water need constitutes an Index of Humidity (I_h).

Similarly, where there is only water deficiency and no surplus, the ratio between water deficiency and water need constitutes Index of Aridity (I_a).

Expressed as percentages, the two Indices are

$$I_h = \frac{100s}{n} \quad \text{and} \quad I_a = \frac{100d}{n}$$

Where s is water surplus, d is water deficiency and n is the water-need all on an annual basis.

$$I_h = \frac{100 \times 32.7}{141} \quad \& \quad I_a = \frac{100 \times 102.65}{141}$$

$$I_h = 23.2\% \qquad I_a = 72.8\% \text{ at the station.}$$

The Thornthwaite Moisture Index

Since water surplus and water deficiency occur in different seasons at most places, both must go into an Index of

Moisture effectivity (or, simply, 'Moisture Index', I_m as Thornthwaite (1948) calls it), the one affecting it positively, the other negatively.

Thornthwaite and Mather (1955), Mather and Carter (1956), proposed a definition of Moisture Index, viz.

$$I_m = (I_h - I_a) = 23.2 - 72.8$$

$$I_m = -49.6\%$$

Table - 15

Moisture Index and Climatic Types (after Thornthwaite and Mather, 1955)

Symbol	Climatic Type	Moisture Index (%)
C_1	Dry Sub-humid	-33.3 to 0
D	Semi-arid	-66.5 to -33.4
E	Arid	-66.6 and below

The calculation of the moisture index and its relation with climatic types (Table :15), shows that the area belongs to the 'semi-arid type', indicating that, though the area is forested, the regional semi-arid climatic regime has had a very firm imprint on it. This poses a severe geo-environmental problem.