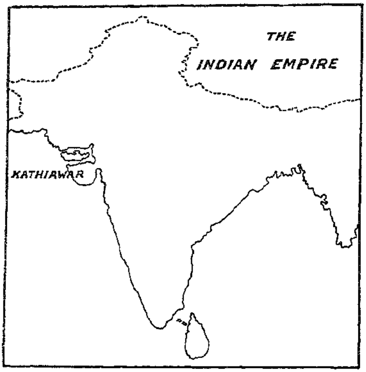
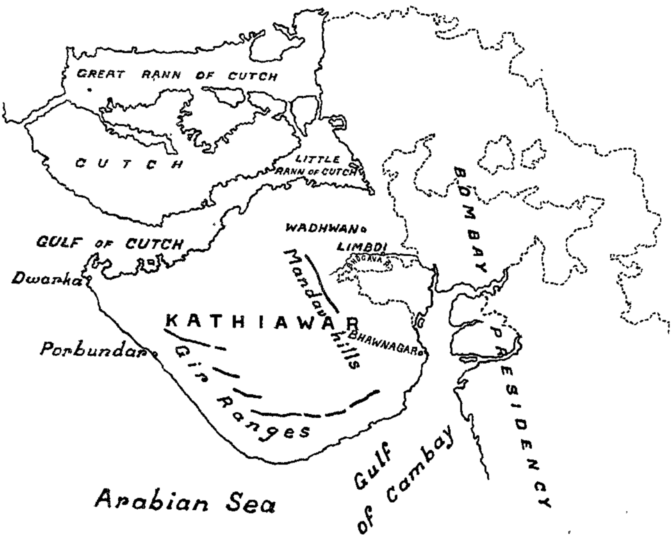


MAP No. 1
Kathiawar Peninsula
Showing
LIMBDI STATE



SOIL SURVEY OF THE NALKANTHA DISTRICT (LIMBDI STATE) AND ITS SIGNIFICANCE.

By C. V. Ramaswami Ayyar.

Limbdi is one of the native states in the Kathiawar Peninsula and is situated between 22°30′ and 22°37′ N. Lat. and 71°44′ and 71°52′ E. Long. It covers an area of about 350 sq. miles and has been divided into several districts of which Nalkantha is the largest and occupies about 100 sq. miles. The surface of the Kathiawar peninsula is for the most part undulating with low ranges of hills running in different directions (Map 1). The physical features suggest that it once might have been an island or a group of islands of volcanic origin, the upheaval of 1820 (*Imp. Gaz. India*, 1908, **15**, 170) having led to its organic connection with the continent. Along the south of the peninsula the Gir ranges of hills run closely parallel to the coast. The Mandev hills situated in the far west of the Limbdi State and at right angles to the Gir ranges may be described as outcrops of the latter. Most of the intervening landscape is quite even and completely free from vegetation.

During the severe south-west monsoon the Gir and Mandev hills act as barriers to the rain-bearing clouds and bring about a fairly heavy rainfall of 50 to 60 inches in the coastal regions and in some parts of the interior; but only exhausted clouds pass over the Mandev hills to Limbdi resulting in 20 to 25 inches of rain. This forms the total annual rainfall of the State since no rain is received during the rest of the year, and even this often falls in torrential showers during a very short period. Although the wet months are from June to September there are hardly 25 rainy days, the rest of the year being characterised by bright sunny days till the following monsoon.

The soils of Kathiawar are basaltic, showing only slight variations in their texture and general behaviour and possessing high retentive power for moisture. The sunny weather following the monsoon may be expected to assist considerably in the cropping of the tract.

Limbdi being one of the states situated in the peninsula is largely influenced by these climatic factors and especially so the Nalkantha district, for it is the most low-lying part of the State. This district forming the easternmost part of Limbdi is a belt of salt lands having a long lagoon, the Nal, which formed until recent times a connecting link during the rains between the Gulf of Cambay and the Little Rann of Cutch. The lagoon occupies over 40 sq. miles serving as a reservoir for the drainage from higher regions.

The general slope of the district is from west to east, i.e., from Wadhwan to the Gulf of Cambay and also from north-west to south-east; the fall in level being 1 in 1000 the country is quite even. The river and drainage systems are few, most of them being in flood during the monsoon with the exception of Brahman river which remains a live stream throughout the year (Map 2). Apart from these water-sources there are numerous tanks scattered over the district serving as rain-water reservoirs to be used for cultivation and drinking purposes.

After the upheaval of the peninsula, this low-lying tract was rendered fit for cultivation by the constant deposition of silt over a very long period. Even now, salty sub-strata at a depth of 3 to 4 feet along with salty subsoil water are found below the silt. Because of the silting in this tract the soils under study are not of the same nature as in the rest of the peninsula; the conditions facilitating cultivation both in the monsoon and the post-monsoon periods make the moisture available for the crops raised.

The soils have been arbitrarily grouped in three classes according to the type of crops grown, and the purposes of revenue assessment are thus well served. The soil and subsoil show considerable variations. The first two classes are mostly black clayey soils with retentive power for moisture, but without good drainable subsoil. The third class soils are sandy with good drainage but of low fertility. There is yet another type, the Khara lands, which are alkaline and are being gradually reclaimed for cultivation by systematic bunding to assist the deposition of silt.

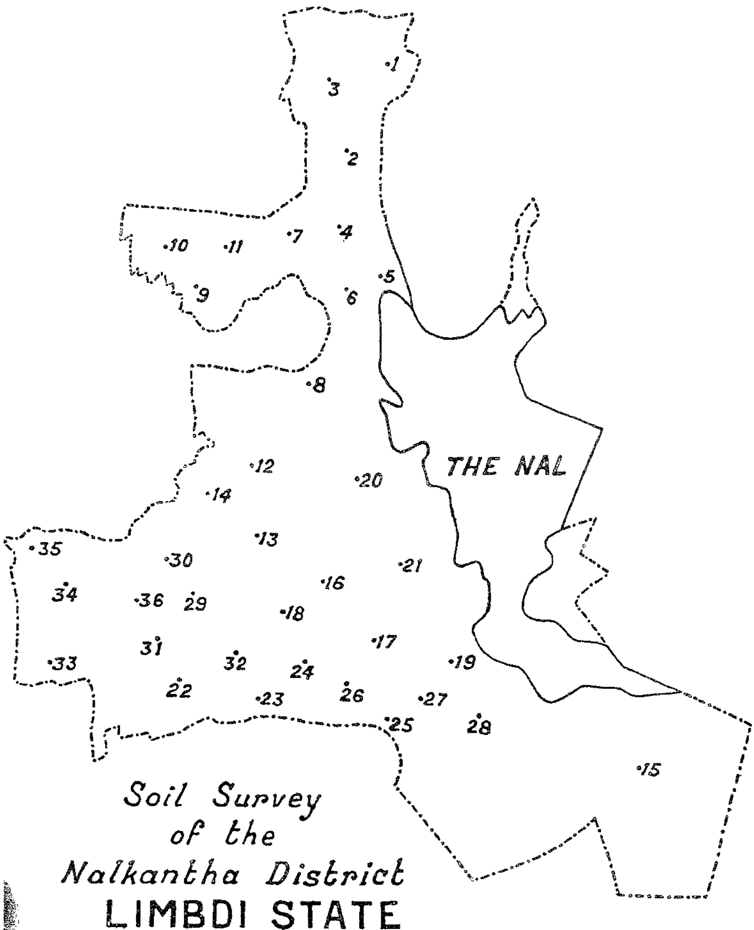
A study of the general character of soils in the district together with observations on the stand of crops suggests that the area is of low fertility. The farmers have no proper understanding of the principles of cultivation, manuring and cropping which in addition to the poverty of soils leads to low productivity.

The soil survey of the Nalkantha district described in this communication comprises the most important aspect of an extended


MAP No. 2
Showing the Villages i
Nalkantha District
LIMBDI STATE
MOTIKATHECHI
KARI. R.
HUKADI. R.
BRAHMAN. R
NANI-KATECHI
GADTHAL
BHAGWANPURA
THE NAL
RANA-GHADH
PHULVADI
ROJHASAR
GORAVA. R.
MULBAVLA
DHANVANA
DHIRJAGHADH
DIGVIJAY GHADH
N
SCALE 7/8" = 2 MILES

MAP No. 3

Showing position of the soil samples



Soil Survey of the Nalkantha District

LIMBDI STATE

investigation into the present agricultural condition of the tract. The enquiry formed a guide to a general recommendation for the amelioration of the agricultural prosperity of the colony; based on these results a scientific programme for stimulating production can be inaugurated side by side with an improvement in the existing state of agriculture. A study of soils was undertaken at the invitation of the Limbdi Durbar and a detailed report was presented embodying a number of recommendations concerning the practice of agriculture. The present paper deals with a study of the soils.

COLLECTION OF SOIL SAMPLES.

In March 1928, the author made an extensive tour in the area under discussion and selected fields in each class, collecting representative samples for examination in the laboratory. The district was divided into blocks of four square miles in extent, samples of soil being drawn from each block. Care was taken to include soils from each class, those pertaining to a particular class being treated as an individual sample. Pits 4 feet square and 4 feet deep were dug in all cases, and a representative sample taken by mixing samples obtained from three fields under each class within a specified area, the top nine inches of soil being chosen for the study.

Pits were dug for the study of the soil *in situ*. This profile study furnished full details regarding the character of the soil, subsoil, disposition of the moist layer from the surface, location of the water table and similar information that could be gathered on the field for guidance in the interpretation of the laboratory results. In addition to the above, a thorough enquiry into the cropping history of the respective fields with special reference to cultivation methods, manuring, the general systems of cropping including the out-turn from crops raised were also recorded. From the tract in question 36 samples of cultivated soil and 20 samples of Khara soils were collected for this study. In Map 2 the general configuration, the river and drainage systems and the several villages in the district are shown. Map 3 gives the position of soil samples collected from the different villages. The samples were analysed to determine their chemical and mechanical composition with a view to finding their manurial requirements and their behaviour in cropping. The chemical analysis comprised the estimation of total and available phosphoric acid and potash, nitrogen, lime and magnesia; whereas the mechanical analysis involved the estimation of the proportion of different grades of particles in order to understand their moisture relationship with reference to the peculiar meteorological conditions of the tract. The results of chemical analysis are given in Table I.

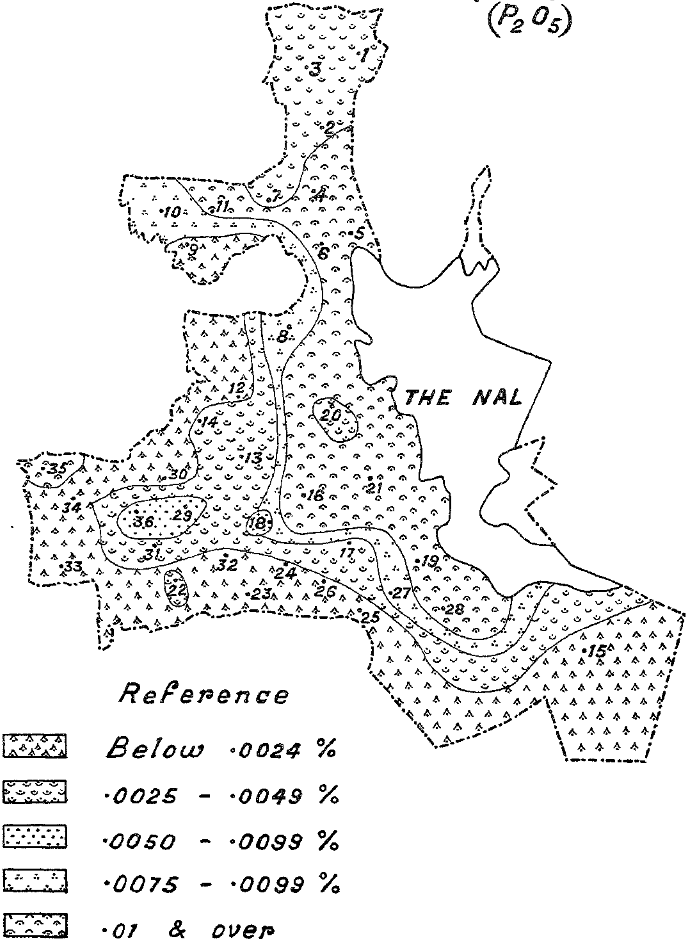
TABLE I.

Chemical Composition of Soils.

Nalkantha District, Limbdi State.

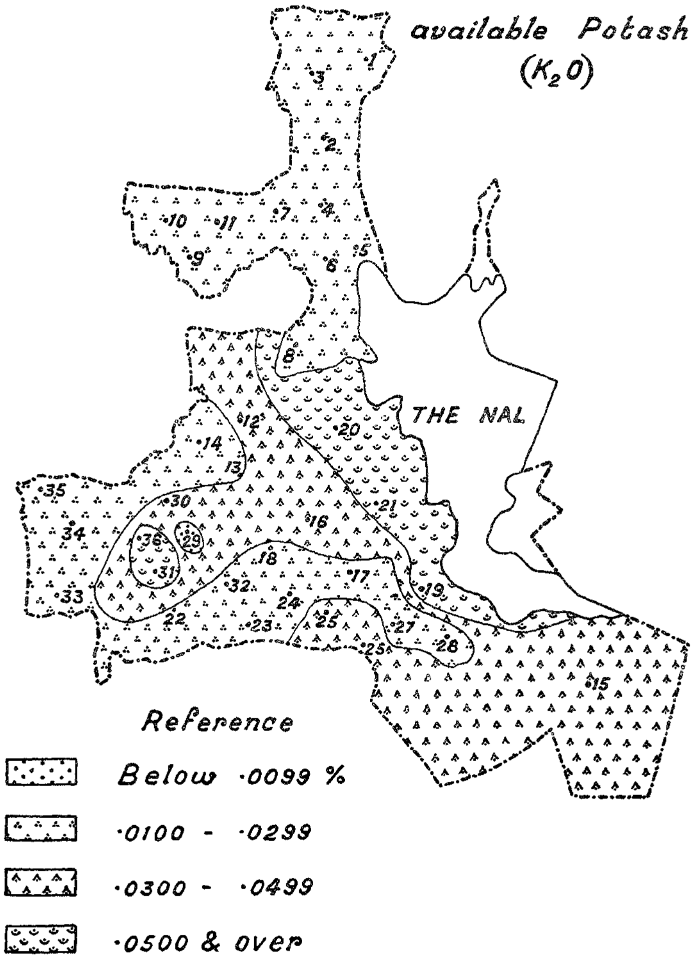
Class of soil	Lab. No.	Village	Nitrogen per cent.	Lime per cent.	Magnesia per cent.	Ratio MgO : CaO.	Phosphoric acid, P_2O_5 per cent. Total	Phosphoric acid, P_2O_5 per cent. Available	Potash, K_2O per cent. Total	Potash, K_2O per cent. Available
FIRST CLASS	1	Mothikathechi ...	0 034	2·72	0·82	1/3·32	0·033	0.0034	0·50	0·0197
	4	Nanikathechi ...	0·023	0·75	0·41	1/1·83	0·048	0·0244	0·37	0 0234
	8	Gadthal ...	0·027	3·78	1·50	1/2·52	0·041	0·0081	0·47	0·0206
	12	Bhagwanpura ...	0·029	7·82	1·03	1/7·60	0·041	0·0009	0·49	0·0415
	15	Dhigvijayagadh ...	0·050	6·22	1·04	1/6·00	0 114	0·0009	1·30	0·0347
	16	Ranagadh ...	0·038	2·85	0·86	1/3·31	0·061	0·0203	0·56	0·0456
	22	Dhanvana ...	0·020	3·76	1·58	1/2·40	0·046	0·0036	0·31	0·0156
	25	Mulbavla ...	0·025	6·87	0·84	1/8·18	0·050	0·0009	0·36	0·0360
	29	Phulvadi ...	0·034	0·92	0·92	1/1·00	0·024	0·0051	0·20	0·0082
	33	Rojhasar ...	0·045	9·68	1·39	1/7·00	0·044	0·0009	0·33	0·0109
SECOND CLASS	2	Mothikathechi ...	0·032	2·04	0·65	1/3·14	0·013	0·0038	0·39	0·0180
	5	Nanikathechi ...	0·036	0·50	0·41	1/1·20	0·034	0·0161	0·42	0·0187
	9	Gadthal ...	0·028	9·02	1·26	1/7·16	0·040	0·0009	0 39	0·0286
	13	Bhagwanpura ...	0·034	2·94	1·65	1/1·77	0.032	0·0047	0·42	0·0156
	17	Ranagadh ...	0·043	2·25	0·59	1/3·81	0·036	0·0042	0·44	0·0143
	23	Dhanvana ...	0·022	3·51	0·83	1/4·20	0·030	0·0012	0·32	0·0238
	26	Mulbavla ...	0·034	4·91	0·53	1/9·23	0·051	0·0009	0·44	0·0442
	30	Phulvadi ...	0·034	5·32	1·15	1/4·63	0·045	0·0014	0·37	0·0415
	34	Rojhasar ...	0·031	6·91	1·85	1/3·73	0·046	0·0009	0·44	0·0245
THIRD CLASS	3	Mothekathechi ...	0·033	6·47	0·55	1/11·80	0·046	0·0036	0·25	0·0199
	6	Nanikathechi ...	0 028	2·45	0·44	1/5·57	0·031	0·0108	0·40	0·0145
	10	Gadthal ...	0·055	3·16	0·63	1/5·00	0·053	0·0082	0·53	0·0190
	14	Bhagwanpura ...	0·028	2·82	0·61	1/4·62	0·025	0·0032	0·26	0·0156
	18	Ranagadh ...	0·032	3·74	0·56	1/6·56	0·026	0·0065	0·23	0·0163
	24	Dhanvana ..	0·024	6·29	0·54	1/11·50	0·058	0 0009	0·30	0·0129
	27	Mulbavla ..	0·046	1·34	1·79	1/0·75	0·047	0·0099	0·29	0·0204
	31	Phulvadi ...	0·039	2·95	0·57	1/5·17	0·039	0·0026	0·36	0·0578
	36	Rojhasar ...	0·035	1·23	1·33	1/0·92	0·032	0·0057	0·27	0·0721
FOURTH CLASS	7	Nanikathechi ...	0·027	0·40	0·42	1/0·95	0·011	0·0030	0·38	0·0179
	11	Gadthal ...	0·036	1·67	0·79	1/2·11	0·037	0·0109	0·46	0·0190
	28	Mulbavla ...	0·034	0· 72	0·51	1/1·41	0·025	0·0125	0·21	0·0122
	32	Phulvadi ...	0·029	8·34	0·64	1/13·00	0·035	0·0014	0·19	0·0122
		RANAGADH								
	19	Paddy Soil Komad ...	0·048	1·46	1·57	1/0·93	0·047	0·0106	0·51	0·0612
	20	,, Wari ...	0·035	0·94	0·76	1/1·23	0·022	0·0044	0·43	0·0687
	21	,, Experimental ...	0·074	1·56	1·21	1/1·21	0·060	0·0361	0·47	0·0564
		ROJHASAR								
	35	2nd Class Special ...	0·025	0·61	0·68	1/0·90	0·031	0·0152	0·24	0·0224

MAP No. 4
Distribution of available phosphoric Acid (P_2O_5)



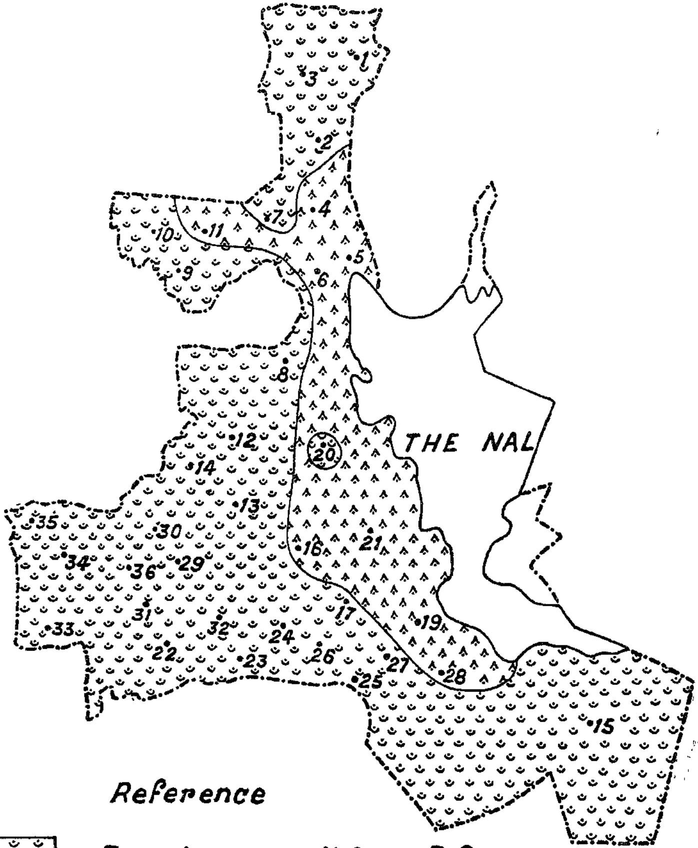
MAP No. 5

Distribution of available Potash (K_2O)



MAP No. 6

Manurial Requirements



Reference

Requires no K_2O or P_2O_5

Requires P_2O_5 only

Available plant nutrients were estimated by Dyer's citric acid method as modified by Hall and Ames (*J. Chem. Soc.*, 1906, 89, 205). Soils containing less than 0·01 per cent. of available phosphoric acid were considered likely to respond to the application of phosphatic manures. The corresponding value for potash was fixed at 0·005 per cent. Soils having values lower than 0·005 per cent. were looked upon as requiring potassic manures.

The distribution of the several manurial ingredients have been plotted in Maps 4 to 12.

DISTRIBUTION OF AVAILABLE PHOSPHORIC ACID.

Map 4 shows the distribution of available phosphoric acid throughout the district contoured between certain limits. It is evident that the only soils which contain over 0·01 per cent. available phosphoric acid and which consequently are not likely to respond to phosphatic manures are those in the proximity of the Brahman river and the tract of land lying within a mile to the west of the Nal. Another small isolated patch rich in available phosphoric acid is in the far south-western corner of the district. With these exceptions the whole tract is highly deficient in phosphates.

DISTRIBUTION OF AVAILABLE POTASH.

Map 5 shows the distribution of available potash. The results judged on the standard fixed show a fair supply of this ingredient indicating that application of potassic manures is not necessary; they confirm the observation that the generality of Indian soils are well supplied with potash, deficiency in this being very rarely encountered.

Map 6 indicates the immediate manurial requirements of the soils. It will be evident that only 20 per cent. of the district contains sufficient available phosphoric acid and potash. Over 80 per cent. of the soils require only phosphate.

It is interesting to observe that the area which is not in need of either phosphoric acid or potash is located within a mile from the Nal, extending from north-west to south-east. This part of the district was till recently a part of the Nal and impregnated with salts; but in the course of a few decades the lands have been reclaimed and the harmful salts removed by frequent application of water. With the removal of salts the dormant plant nutrients became available to the cultivated crops which consequently gave a higher out-turn. Hence a higher amount of plant-food is indicated, and is supported by the available phosphoric acid and potash figures. Barnes and Barkatali

(*Agri. J. India*, 1917, **12**, 379) observed great acceleration in the process of nitrification and the biological processes in general on all the reclaimed lands, lending further support to the foregoing conclusions.

Distribution of total phosphoric acid and potash.

The immediate crop requirements can only be met from the supply of available plant-foods, whereas knowledge of the absolute amounts of phosphoric acid and potash affords a measure of the reserve of these materials which under favourable conditions may gradually become available as plant-food. This is especially so under cultural conditions where manuring is not practised, as in this tract; the amount of total plant-food and the rate at which it is rendered available are two important factors in estimating the comparative fertility of different soils.

The distribution of total phosphoric acid and potash (Maps 7 and 8) shows that these soils contain on an average nearly ten times as much potash as phosphoric acid. This fact points distinctly to the necessity of supplying phosphoric acid in preference to potash. Moreover, the total amount of phosphoric acid in these soils is not sufficient to maintain a normal supply of available phosphoric acid to the crops. Only 15 per cent. of the soils are fairly well supplied with enough reserve phosphate, the rest being comparatively very poor. Unless augmented by a liberal application of phosphatic manures, this reserve is certain to be depleted in continuous cropping, leading to much poorer out-turn from crops than at present.

Norris (*Memoirs Dept. of Agr. in India, Chem. Ser.*, 1923, **6**, 254) emphasised the importance of increasing the reserve phosphate in soils, having observed a rapid depletion of this constituent from soils which, when supplied, exerted beneficial influence on crop-yield; hence he considered phosphoric acid as a limiting factor in crop production. This observation lends further support for augmenting the reserve phosphoric acid in soils.

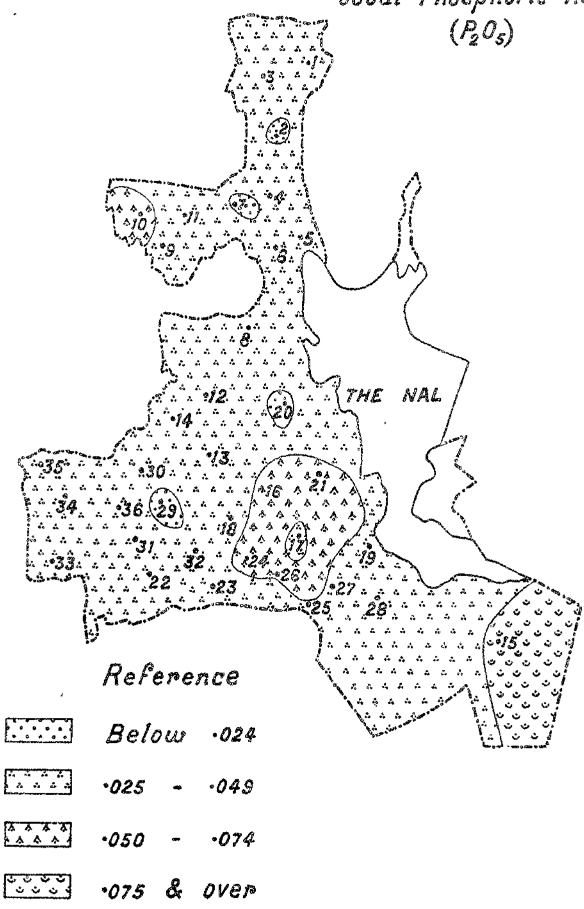
Such a deficiency is not indicated by the potash figures for there is a fair supply of this ingredient combined with appreciable amounts of available potash. Moreover, the lime in these soils will naturally liberate more available potash every year and maintain its supply for a sufficiently long period.

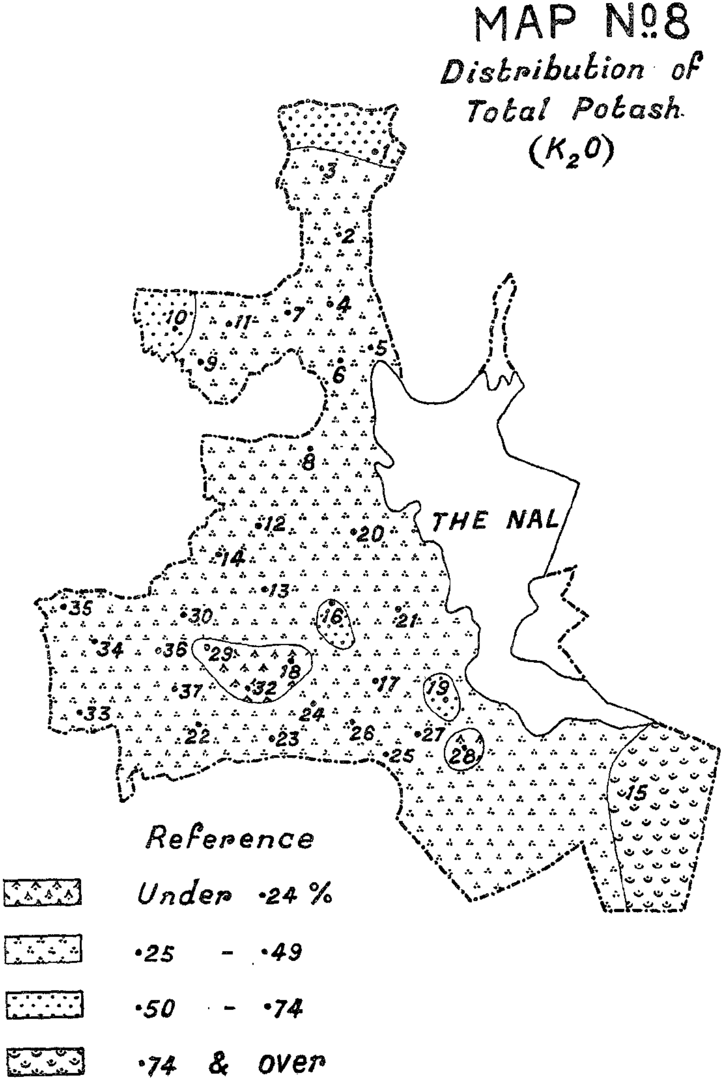
Distribution of nitrogen.

From the distribution of nitrogen (Map 9), it may be seen that more than 85 per cent. of the area contains less than 0·04 per cent.,

MAP No 7

Distribution of total Phosphoric Acid (P_2O_5)




MAP No. 8
Distribution of Total Potash (K_2O)
THE NAL
1
2
3
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14
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34
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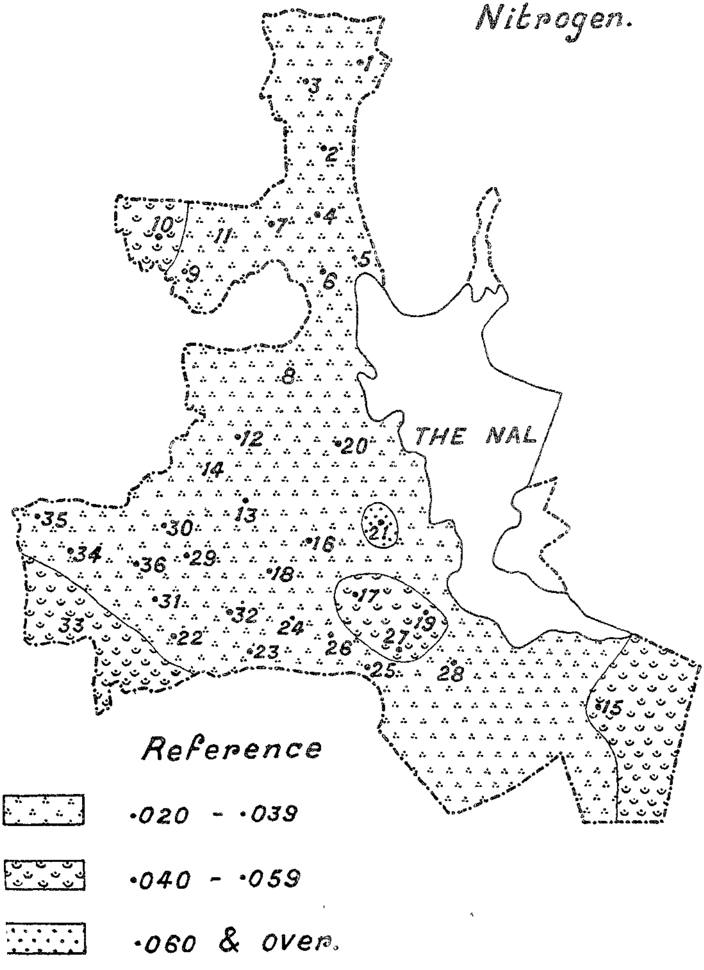
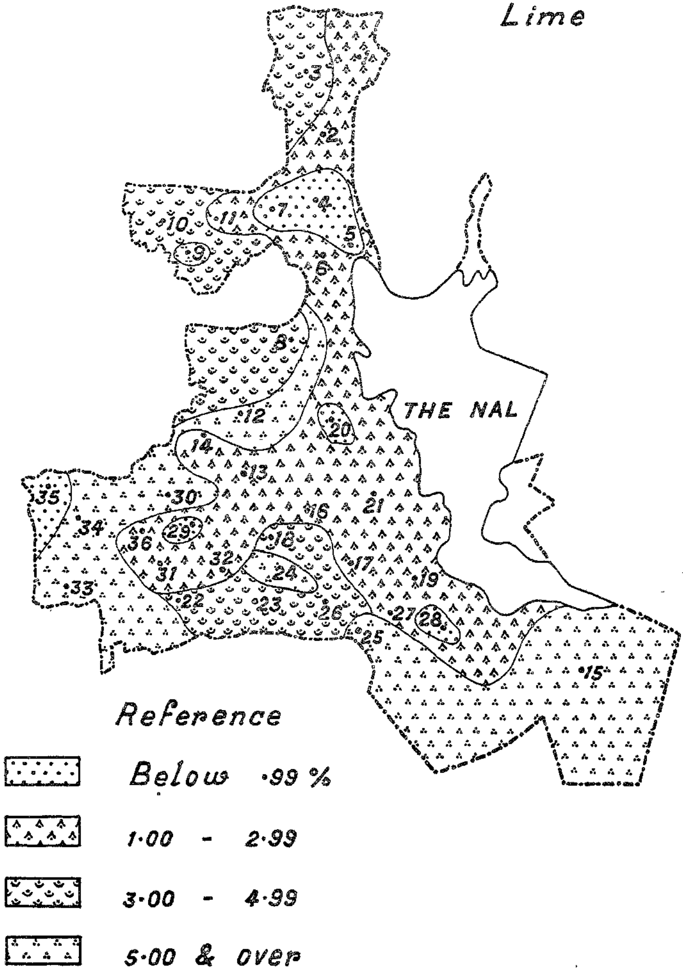
36
37
Reference
Under ·24 %
·25 - ·49
·50 - ·74
·74 & over

MAP No. 9

Distribution of Nitrogen.

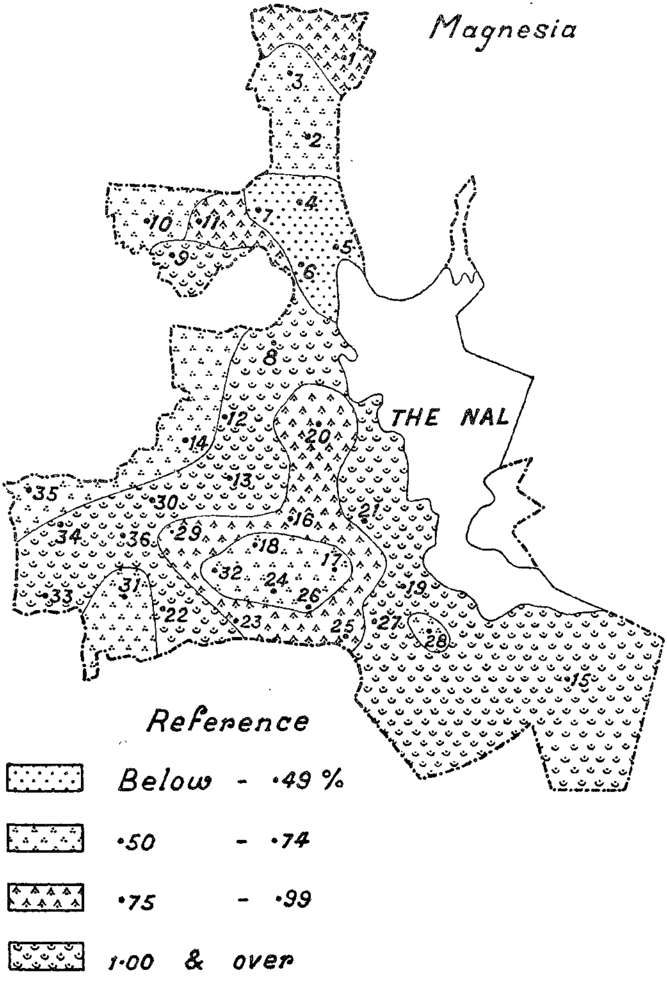


MAP No. 10
Distribution of Lime



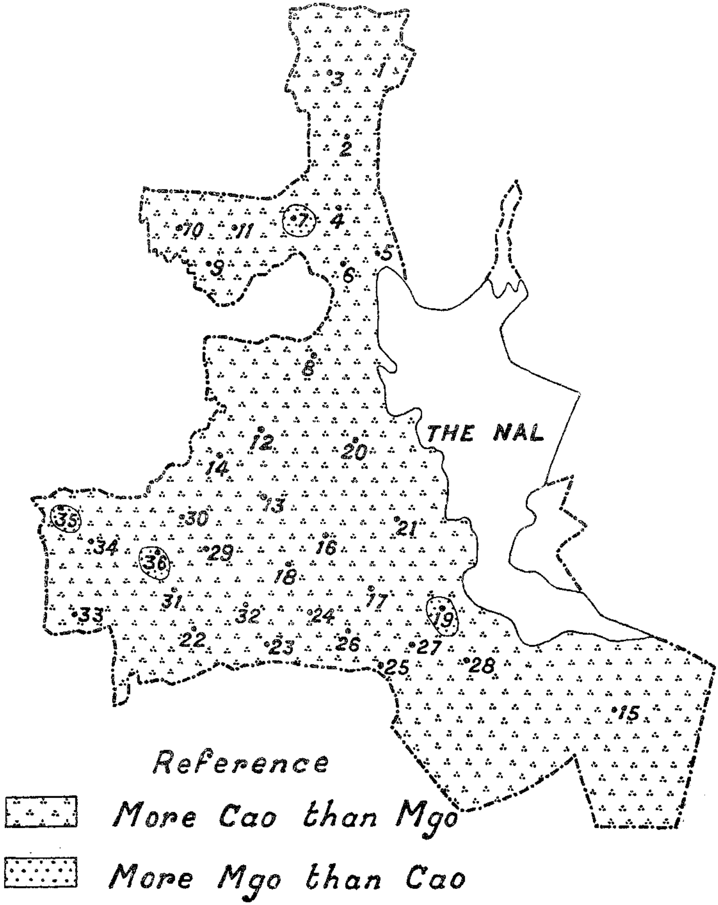
MAP No. 11

Distribution of Magnesia



MAP No. 12

Magnesia-Lime Ratio



suggesting high deficiency in nitrogen. The fact that no bulky organic manures, such as well preserved cattle manure, have been used in the cropping of these soils, points to this deficiency. Hence it is essential to lay out a systematic scheme of manuring whereby the soil requirements might be supplied. The preservation of cattle-manure combined with the utilisation of organic waste vegetation as suggested by Hutchinson (E.P., 219, 384) in the form of artificial cattle-manure may be suggested to supply this deficiency in the agricultural practices of the district.

The distribution of lime and magnesia (Maps 10 and 11) shows that 80 per cent. of the soils are well supplied with over one per cent. of lime. The supply of magnesia is far less than that of lime, the latter being always present in great excess. In the presence of much lime the organic matter of the soil is more readily broken down, hence the figures obtained furnish an additional argument for more extensive use of cattle-manure or other bulky organic manures in cropping. The magnesia-lime ratio is shown in Map 12.

It is interesting to observe that the foregoing observations are similar to those in most other parts of India.

MECHANICAL ANALYSIS OF SOILS.

Mechanical composition of the soils was determined by the sedimentation process using distilled water without subjecting the soils to any preliminary treatment with hydrogen peroxide or hydrochloric acid. Ammonia was not used to disperse the finer particles.

Puri (*Bull. Agri. Res. Inst. Pusa*, 1928, **175**, 11) has shown that treatment with hydrogen peroxide is quite unnecessary for Indian soils which usually contain very little humus ; hence the first treatment with hydrogen peroxide as recommended by the International method (*J. Agri. Sci.*, 1926, **16**, 123) was not adopted. It was also considered that treatment of soil with acid prior to the analysis was drastic and would materially alter the mechanical composition in the case of soils rich in lime such as those under study. Since the purpose of mechanical analysis is mainly to interpret the behaviour of soil as handled in the preparation of the land for raising crops, any preliminary treatment would naturally lead to the disintegration of the particles as they exist in nature. According to Hilgard (*Soil*, 1921, 288) " the disintegration of compound particles by means of acid as prescribed and practised should wholly change the physical nature of the soil by the breaking up of mechanical aggregates which in the usual course of tillage would remain intact " and hence a method in which such a change is not effected should be commended. The method followed in these studies and used in the study of Iraq soils

TABLE II.

Mechanical Composition of Soils.

Naikantha District, Limbdi State.

Class of soil.	Lab. No.	Village	Stones per cent.	Fine soil contains: Fine gravel per cent.	Coarse sand per cent.	Fine sand per cent.	Silt per cent.	Fine silt per cent.	Clay per cent.
First Class	1	Mothikathechi ...	22·22	10·01	21·10	20·72	14·70	24·57	7·30
	4	Nanikathechi ...	20 71	12·06	44·14	19·78	5·83	12·48	5·69
	8	Gadthal ...	29·77	9·06	20·29	21·19	11·95	26·92	9·62
	12	Bhagwanpura ...	25·71	4·35	10·40	21·24	17·34	30·68	13·49
	15	Dhigvijayagadh ...	19·50	1 07	0·81	11·34	25·72	37 29	22·83
	16	Ranagadh ...	33·29	9·61	15·59	14·00	7·74	33·99	18·15
	22	Dhanvana ...	34·08	7·94	25·84	16·10	10·81	26·48	11·14
	25	Mulbavla ...	16·58	4·47	20·91	16·64	11·17	32·93	10·20
	29	Pulvadi ..	28·69	9·82	25·83	25·01	11·48	18·29	9·71
	33	Rojhasar ...	34·15	6·24	20·28	20·75	18·52	25·80	7·68
Second Class	2	Mothikathechi ...	21·83	16·26	34·50	20·31	7·07	16·24	5·56
	5	Nanikathechi ...	22·21	14·71	44·50	16·35	4·38	13·90	5·73
	9	Gadthal ...	37·70	7·06	15 63	16·41	16·06	31·07	12·84
	13	Bhagwanpura ...	28·12	11·70	17·48	21·18	11 84	27·19	9·55
	17	Ranagadh ...	23·62	7·25	16·14	24·29	13·56	26·94	10·70
	23	Dhanvana ...	30·89	10·35	28·79	17·37	10·54	23·00	7·75
	26	Mulbavla ...	31·96	7·47	19·45	9·90	11·23	36·97	14·53
	30	Phulvadi ...	38 85	8·26	16 30	17·29	10·47	34 15	13·20
	34	Rojhasar ...	36·41	9·85	19·91	17·15	9·42	32·55	10·10
Third Class	3	Mothikathechi ...	40·13	29·42	25·04	27·62	4·00	9·84	1·29
	6	Nanikathechi ...	27·81	19·04	36·89	20·56	6·19	11·51	4·90
	10	Gadthal ...	22·53	7·85	20·91	24·36	14·06	22 46	10·29
	14	Bhagwanpura ...	29·10	21·92	31·52	26·32	4·68	13·19	2·96
	18	Ranagadh ...	26·63	26 30	35·92	20 90	3·73	8 58	3·36
	24	Dhanvana ...	27·02	7·36	19·72	28·26	15·97	21·06	6·94
	27	Mulbavla ...	37·20	10·96	17·36	10·02	12·13	29·86	16 79
	31	Phulvadi ...	28·58	8·10	23 63	20·07	10·24	27·64	8·13
	36	Rojhasar ...	33·98	10·86	28 51	16·33	7·62	26·27	9·42
Fourth Class	7	Nanikathechi ...	28·92	23·21	47·37	11·96	4·05	9·25	4·35
	11	Gadthal ...	34·84	11·60	24·39	27·48	12·30	15·11	7 33
	28	Mulbavla ...	35·75	24·82	36·19	21 61	4·40	9·01	3·90
	32	Phulvadi ...	36·37	23·19	31·89	25·70	3·98	10·79	3·22
		RANAGADH							
	19	Paddy soil Komad ...	37·02	13·64	23·14	14·08	10·22	27·19	10·16
	20	,, Wari ...	29·27	18·91	37·98	17·66	4·55	8·62	10·93
	21	,, Experimental	26·54	16·74	25·05	17·75	6·63	24·93	7·42
		ROJHASAR							
	35	2nd Class Special ...	33·08	14·60	44·87	20·86	3·45	10·96	5·00

by Viswanath (private communication) has been found to suit the purpose of these investigations.

The general technique of sedimentation was followed for the separation of the various sizes of particles, using distilled water as the dispersing medium. The different fractions were steam dried and weighed, the results being expressed as percentages on the moisture-free soil for comparison. The results are given in Table II, arranged according to the existing classification of soils in the district. The figures for mechanical analysis of these soils are quite irregular and show the absence of any scientific basis for the present classification.

Hence an attempt was made to arrive at a workable scheme by grouping the results under two heads, namely, coarse and fine fractions. The coarse fraction represented the sum of the percentages of fine gravel, coarse sand and fine sand, particles of sizes ranging from 3 mm. to 0·04 mm. in diameter, and the fine fraction other grades ranging from 0·04 mm. to less than 0·002 mm. in diameter and including silt, fine silt and clay. This classification was made, because the above-mentioned finer fractions show, more or less, the same capacity for retaining moisture and manures, contributing considerably towards ease of cultivation and cropping. Although the coarse fractions also possess features in common amongst themselves, they have no such capacity for holding moisture or manurial ingredients as would constitute them a collective member in soil economy. Nevertheless, their presence in optimum amounts along with the finer grades of particles introduces factors quite favourable to the growth of plants. Hence this assumption seems well justified not only to the soil under study but may be of wider applicability to others. Further proof for this new classification is afforded by the behaviour of the soils in nature which agrees quite well with the depth of soils, their relationships to moisture and accordingly the types of crops now grown on them.

Table III shows the irregularity in the composition of different classes of soils according to the existing classification.

TABLE III.

Class of soil	Per cent. coarse fraction	Per cent. fine fraction
First	75·98	24·00
Second	50·36	48·58
Third	55·34	43·97
Fourth	82·62	17·31

The crops best suited to second class soil conditions are often indiscriminately raised on other classes indicating clearly the want of appreciation of principles underlying scientific cropping.

Table IV specifies the limits of variation between the two grades forming the basis of re-classification of soils and Table V shows actual average mechanical composition.

TABLE IV.

Class of soil	Depth of soil in feet	Limits in percentages of	
		Coarse fraction	Fine fraction
A	over 2	35 to 45	55 to 65
B	1½ – 2	45 to 55	45 to 55
C	1 – 1½	55 to 65	35 to 45
D	¾ – 1¼	70 to 80	20 to 30
E	¾ – 1	80 to 85	15 to 20

TABLE V.

Class of soil	Per cent. coarse fraction	Per cent. fine fraction	Character of soil
A	38·26	60·49	Clayey
B	50·74	48·01	Clayey loam
C	58·34	40·56	Loamy
D	75·88	23·59	Sandy loam
E	81·83	17·42	Sandy

Table VI gives the nature of the crops grown on the respective class of soil.

TABLE VI.

Class of soil	Nature of crops
A	Wheat (*Triticum vulgare*) and rarely cotton (*Gossypium Herbaceum*)
B	Cotton (*Gossypium Herbaceum*), Post monsoon Juar (*Sorghum vulgare*) and rarely Bajri (*Pennisetum typhoideum*)
C	Monsoon Juar (*Sorghum vulgare*), Bajri (*Pennisetum typhoideum*) and Banti (*Panicum crus-Galli* var. *Frumentaceum*)
D	Barley (*Hordeum vulgare*), Mhut (*Phaseolus aconitifolius*) and Mung (*Phaseolus mungo*)
E	Mhut (*Phaseolus aconitifolius*) and Mung (*Phaseolus mungo*)

It will be seen from the general nature of the crops grown on each class of soil that the character of their root-system and feeding habits are quite in keeping with the texture and moisture relationship of those soils. Thus the new scheme of classification agrees closely with the behaviour of soil in nature and the general system of cropping in the locality.

Under the suggested re-classification the soils have been placed under five groups A to E, each exhibiting definite characteristics. It will also be evident from the study of Table IV that the irregularities observed under the old system (cf. Table III) have been systematised and a more rational scheme has been evolved showing distinct gradation in the sizes of soil particles; class E being the most open textured containing more of coarse particles and class A the finest, with the highest amount of fine particles the other classes passing through the intermediate grades of sizes. With the help of these tables it is now possible to interpret the results of mechanical analysis and understand their behaviour in cropping.

The first two classes of soils, as their mechanical composition indicates, possess very high capacity for retaining moisture and hence they bear crops only after the cessation of the monsoon when the moisture conditions will be favourable for cropping. Besides, wheat always requires a very fertile field for its growth and hence in these two soils wheat and cotton are the commonest crops grown. Whereas the other three classes of soil bear such crops as have a very shallow root-system principally during the monsoon period when most of their vegetative phase is passed and they come to maturity before all moisture is lost from the soil.

Additional support is afforded by the results of average chemical composition of the corresponding groups of soil as shown in Table VII, wherein an abstract of the average mechanical composition of those groups is also given with a view to bringing out the correlation between them.

TABLE VII.

(A). *Average mechanical composition of soils.*

Serial No.	Class of soil	Fine soil contains							
		Coarse fraction			Aggregate coarse fraction	Fine fraction			Aggregate fine fraction
		Fine gravel per cent.	Coarse sand per cent.	Fine sand per cent.		Silt per cent.	Fine silt per cent.	Clay per cent.	
1	A	7·13	15·66	15·47	38·26	13·98	32·53	13·98	60·49
2	B	8·84	20·77	21·13	50·74	12·45	26·03	9·53	48·01
3	C	10·00	25·45	22·89	58 34	11·58	20·75	8·23	40·56
4	D	15·33	40·98	19·57	75·88	5·19	13·02	5·38	23·59
5	E	24·81	34·66	22·36	81·83	4·14	10·10	3·18	17·42

(B). *Average chemical composition of soils.*

Serial No.	Class of soil	Nitrogen per cent.	Lime per cent.	Magnesia per cent.	Phosphoric acid, P_2O_5 per cent.		Potash, K_2O per cent.	
					Total	Available	Total	Available
1	A	0·036	5·95	1·17	0·054	0·0045	0·50	0·0328
2	B	0·036	3·08	1·05	0·040	0·0050	0·43	0·0232
3	C	0·030	2·72	0·88	0·036	0·0048	0·32	0·0272
4	D	0·029	1·27	0·52	0·031	0·0141	0·37	0·0194
5	E	0·030	3·75	0·55	0·028	0·0050	0·25	0·0157

There is a distinct gradation in the fertility of these soils, as shown by the figures of chemical analysis, agreeing closely with their mechanical composition. The correlation existing between the mechanical and the chemical composition of these soils requires some explanation. In this connection it will be of interest to examine the average composition starting from class E, when the peculiarities in the results will become evident. It is known that a large percentage of the coarse fraction with a proportionate decrement in the finer is associated with low figures for the reserve phosphoric acid and potash apart from other mineral constituents; for the reserves are derived more from the finer grades than from the coarser, the latter being composed principally of sand particles. This inference is borne out by the chemical analysis; with the progressive increase in the finer grades and a corresponding gradual decrease of the coarser fraction, an increase in total phosphoric acid and potash is found. Hence the total phosphoric acid and potash in class A soils is nearly double that of class E. Owing to the precipitation of the available phosphate by other mineral constituents such as iron, alumina, lime and magnesia, whose percentage increases in the finer grades, the latter, although containing a useful phosphate-reserve, do not make this so freely accessible to crops. The stationary aspect of available phosphate is thus explained. This influence is not noticed with available potash which shows a marked increase with increasing fineness; access of lime will have a beneficial influence in liberating potash from minerals containing it.

No significant change is noticeable in the nitrogen figures as these depend less on the size of particles than on organic matter in the soil. The fact that these soils have not been manured for over a long period with bulky organic manures easily explains the constancy in the nitrogen values of all soils.

It has been definitely shown in the case of this soil survey that a classification of soils on the basis of their texture will naturally in generality of soils closely correspond to their chemical composition which, in other words, signifies their fertility. This observation may be of wide applicability to other soils.

SUMMARY.

The results of the soil survey of the Nalkantha district, Limbdi State, comprising the chemical and mechanical analysis of the soils are discussed.

The chemical analysis has brought out the great deficiency in phosphoric acid and nitrogen in the soils of the district indicating the need for phosphatic and nitrogenous manures. In this connection the utilisation of bones and the use of well preserved cattle-manure, along with the proper use of all waste vegetation found in abundance, in the practice of agriculture is strongly recommended.

The supply of potash and lime in these soils is quite adequate.

Thus the chemical analysis has borne out the manurial requirements of the soils which may be mentioned as a common feature of almost all the Indian soils so far examined.

The mechanical composition of these soils shows a great range of irregularity when viewed by the *existing method of* classifying soils, indicating absence of a scientific basis for this classification.

A new scheme has been proposed for the scientific classification of soils based upon their physical texture as shown by the results of mechanical analysis, and this agrees closely with the general behaviour of soils in nature.

The correlation shown by the results of chemical analysis of the corresponding groups of soils classified on the above basis lends further confirmation to the soundness of the principles advocated under the new scheme.

As the new basis clearly indicates the fertility of soils with special reference to the tract under discussion, it may prove of wide applicability to other soils.

I wish to take this opportunity of expressing my grateful thanks to Prof. Roland V. Norris for the keen interest he has taken in this work.

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