Chapter 7
Soil Regime

CHAPTER 7

SOIL REGIME

The soil is an important component in the system comprising the lithosphere, the atmosphere and the biosphere. Soil properties reflect the varying nature of the interaction within this system. Soils' sustainability to various human activities is greatly affected by changes in the system; particularly the manipulation of vegetation and soil. The human activity affects' on soils are highlighted by catastrophic events such as salinization, resulting from poorly managed irrigation system. Apart from of burning of vegetation and reduction in soil organic matter content; soil salinization and impermeabilization and irrigation practices are probably the most fundamental changes caused by cultivation. Evaluation of soil regime, forming a part of canal irrigation system hold prime importance from the point of view of its capability to except water, water retention and drainability, chemical composition of soil, water and their ion exchange capacity, and other relevant factors, maintaining the nutrient levels.

FIELD INVESTIGATIONS

To study the impact of irrigation on the soil regime and its vector and secular pattern in the Matar Branch command area, the author has carried out various field investigations in different seasons. For the purpose of proper evaluation of the various soil parameters, the entire command area was divided in to equal area grid of 10 sq. km each. The locations for detailed sampling and recording information have selected at the node of each grid and numbered accordingly (Fig. 7.1). Soil and sub-soil samples at every nodes have been collected with a view to study their basic soil characteristics such as composition, physical & textural properties, soil types, chemical characteristics and impact of irrigation & suitability of the soils for sustained irrigation. As the seasonal changes and the irrigation practices greatly influence the soil characteristics; the sampling has been carried out for two different seasons. For this author has adopted standard guidelines and methodology prescribed by the USDA and ICAR in their Soil Survey Manuals. Field related inventory and information were recorded in the standard performa sheets (Fig. 7.2).

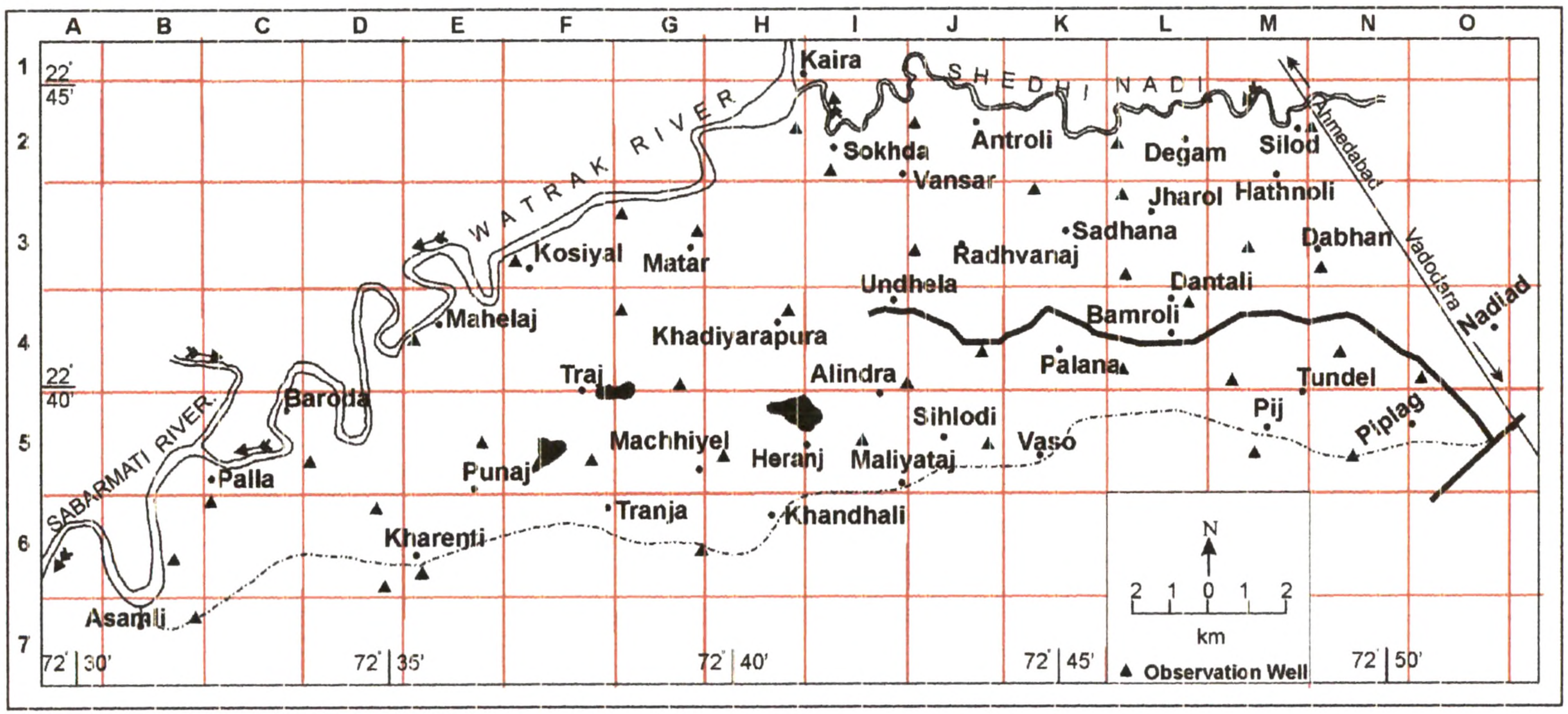


Fig. 7.1 Observation Well and Soil Sampling Locations in Matar Command Area.

SOIL SAMPLING

The collection of soil samples solely depends upon the types of the properties to be studied. As the objective of the present studies are to evaluate the physical textural and chemical characteristics of the soils; for the purpose of giving nomenclature and identifying the various secondary induced characteristics viz. permeability, salinity and alkalinity. For this author has collected two different types of samples i.e.,

(i) Disturbed Samples: Collected for those situations where the natural conditions of the soils are relatively unimportant i.e. the distortion in fabric, moisture loss, density etc. shall hardly alter the physical and chemical properties of the soil. The important element in this type of sampling is that the samples be uniform with depth to be collected for each change in the material.

(ii) Undisturbed Samples: Collected for those situations where it is essential to preserve its natural state for determining certain special characteristics, which may lost during disturbed sampling. These samples are mainly collected for visual examination of the soil structure, determining insitu density, permeability, moisture content etc.

SITE SELECTION CRITERIA

While selecting the locations and sampling the soils following criteria and precautions have been kept:

1. The site should be in continuous use of irrigation any permanent structures viz., building, road cuts, railways etc.
2. The site should not be excavated and refilled or layered with the soil from other locations.
3. Sampling point within the farm should not be nearby field channels, cattle walk, and/or under or near large tree.
4. Avoid sampling from the farm applied with the fertilizer within the past few days or recently.
5. As sampling is to be carried out season wise the maximum care should be taken to collect the sample from the same sites.

SAMPLING PROCEDURE

(A) The *undisturbed soil samples* have been collected in field (Plate VII 1) in accordance with the following:

Plate VII 1 Undisturbed Soil Sampling Using Core Sampler.

1. Clean the surface and remove the tillage layer up to top 50 cm.
2. Sampling surface should not have any root penetrated below from where the samples are to be collected.
3. After removing the surface layer make the surface even so core sampler can stand leveled position. Then keep the rim on the upper surface of core and stamp the core uniformly. Take care that core sampler should penetrate the soil without tilting.
4. Dig out the soil around to extract the core sampler. The sampler should not be disturbed while removing the surrounding soil.
5. Remove the sampler carefully from the pit by cutting the soil at the bottom with the help of knife.
6. Cover the sampler on both the sides either with wax or keeping the plastic and filling the soil of the same location, to prevent the moisture loss; after removing 1 cm soil sample layers from both the ends of the sampler.
7. Mark proper indexing of the soil samples on the core as well as in the field diary.

(B) The procedure for collecting the *disturbed soil samples* using 1.5 inch □ auger (Plate VII 2), at the pre-decided depths viz., 00-10 cm, 10-50 cm, 50-100 cm, 100-150 cm, at each site locations. The steps of disturbed sampling for the collection followed by the author are given as under:

Plate VII 2 Disturbed Soil Sampling Using Standard Auguring Technique.

1. Remove the top tillage layer and clear the surface and surrounding area.
2. Collect the first soil sample of 0-10 cm depth from two or three location dispersed over the entire field to overcome the concentration effect of the fertilizer applied.
3. Auger and remove the soil till the next sampling depth i.e. 10-50 cm is achieved.
4. Once the depth is achieved, broaden the hole by using 4 inch diameter post hole auger till the depth is achieved and collect the soil in the same plate or bucket. The broadening of the hole is essential for smooth penetration of 1.5 dia. auger and to avoid mixing of above lying soil while rotating the auger.
5. Once the depth achieved, extract the auger and collect the sample in the plate or bucket. Mix up the collected sample and reduce the soil to 1 kg by adopting coning and quartering procedure.
6. Pack the soil sample in the cloth bag and give indexing as in the case of the undisturbed sampling.
7. Repeat the above procedure till the final depth is achieved as per requisite depth intervals.
8. Soil sample for the nutrient analysis should be collected separately.

Similarly the soils falling within the limits of fluctuating water table conditions soil it is necessary to collect the soil samples during both the pre- and post-monsoon period. In waterlogged area it is desirable to collect the wet sample rather than saturated soil samples.

SOILS OF MATAR COMMAND

SOIL PROFILES

Soil profiles, which is a resultant development of the soil under the soil forming process is controlled by various local and regional factors. The soil profile consists of several smaller units called layers. Depending upon its degree attained for the development it is named as mature (well developed), immature (partly developed) profile (Rai, 1995). The development of soil profile is generally dealt by taking the basis of organic matter or mineral content. The organic matter profile is one where the first stage of development is seen wherever vegetation is established on a mineral substrate. The development of mineral profile is mainly due to the movement of water in soil (Rai, 1995). The hypothetical soil profile with its different units is as show in the Fig 7.3.

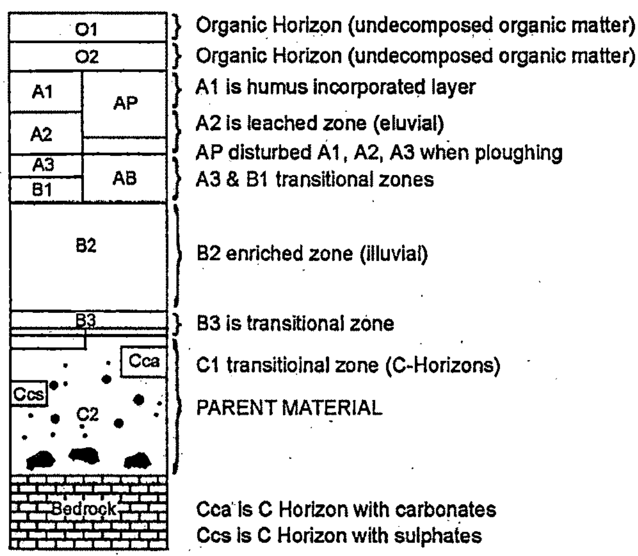


Fig. 7.3 Hypothetical Soil Profile.

Based on the extensive fieldwork and study of soil regime it has been found that the entire Matar command has a prevalence of the mineral soil profiles. It has also been observed that there exists the different kind of matured soil profile with the distinct development of A-B-C horizons comprising number of smaller units. As it has already been eluded in the previous chapter that the MRBC area is characterised by the number of soil types. Accordingly, the Matar command in all has been characterised by 05 different soil types. By taking the basis of available information, the author has made a detailed inventory of these soil types by selecting appropriate locations for mapping the soil profiles. As there already exists a soil series classification of Matar command, developed by Soil Survey Department runs by State; the author has adopted the same classification and also made the inventory of soil profiles accordingly. A descriptive account on location and soil types specific profiles is given as under:

1. Dantali:

The exposed profile with an aggregate depth of 1.80 m is characterised by a mineralized soil with the distinct development of A and B horizons (Fig. 7.4). Taking in to account the physical characteristics the soil profile shows dark yellowish brown color (10 YR. 4/4; 4/3) of Munsell Color index. Top A horizon, which is characterised by an intensive biogenic activities, humus and root system; is poorly developed. This may be attributed to ploughing. The B horizon depicts development of 4 distinct units viz., B_1, B_{21}, B_{23}, B_3. The soil is granular in nature and predominated by the sandy fractions (Sandy loam) with the subordinate proportion of fines. Owing to its granular texture through out its depth, the soil lacks the development of lime kankers. This is possibly on account of high permeability and drainability facilitating the mineralized percolating waters to further downward as well as laterally. The root system, which has almost penetrated the B horizon, is indicating of deeper water table.

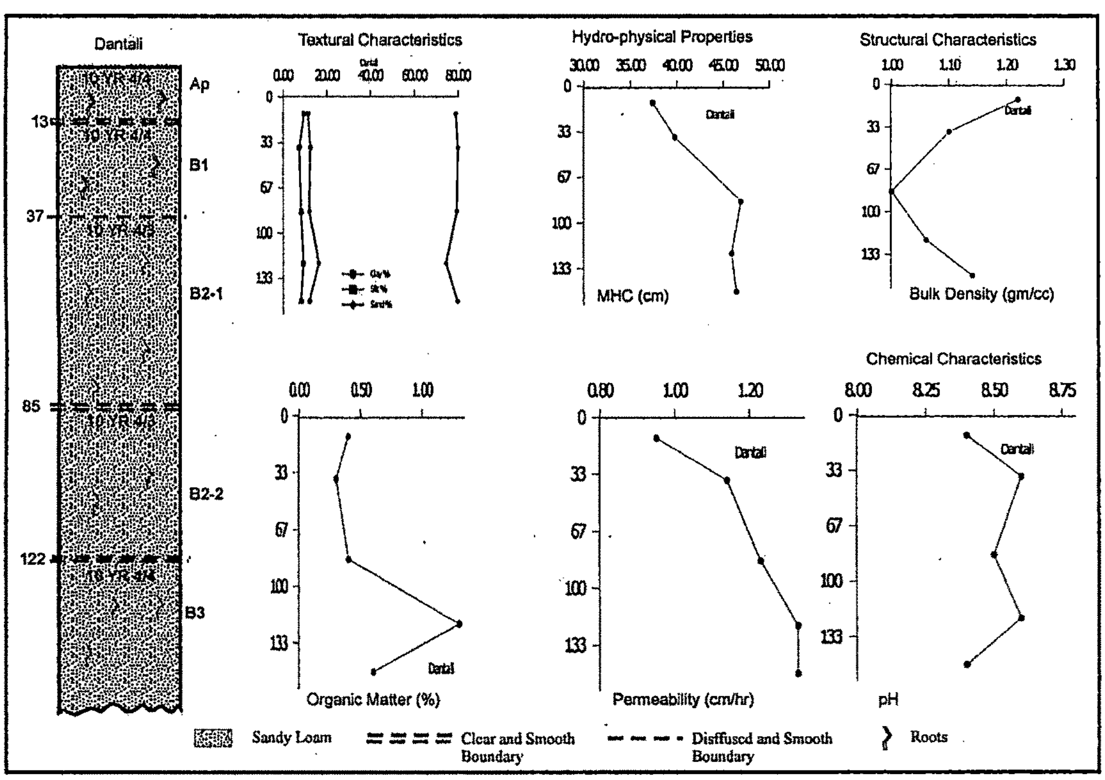


Fig. 7.4 Soil Profile and Its Physico-chemical Characteristics as Visualised at Dantali

2. Sokhada:

It's more than 1.60 m deep exposed profile representing matured mineral soil through out its depth (Fig. 7.5). Here in all 5 sub-soil horizons are present belonging to A and B-horizons. The boundaries of the soil layers are clear and smooth at the surface but as the depth approaches the soil boundary although remains clear but becoming wavy in nature. The mineral soils mainly comprising the higher content of the sand particle and which is decreasing with the depth where as the silt and clay content increase with the depth, thereby indicating that the soil becomes progressively fine with the depth. This mineralogical content of the soil has also reflected by the variation in the color from 10YR 5/4 to 10YR 3/4. Below the depth of 100 cm the soils shows the development of the lime nodules of 2-3 mm diameter, indicating downward decrease in drainability. The root system is also well developed and deeply penetrated.

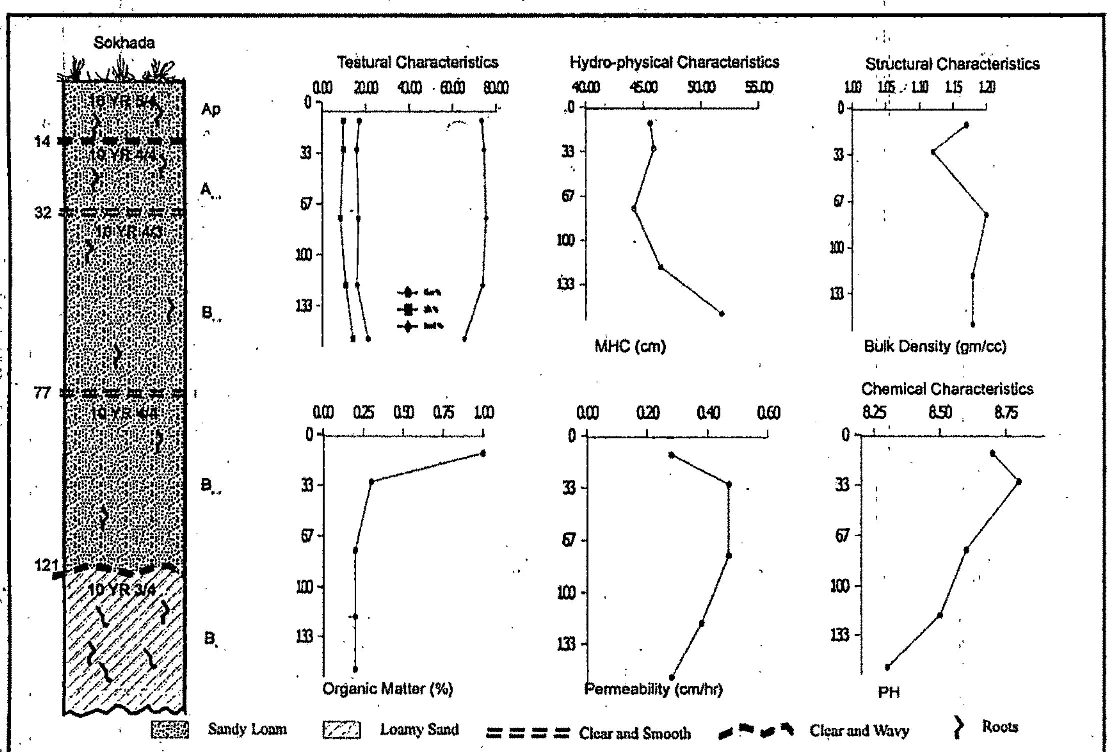


Fig. 7.5 Soil Profile and Its Physico-chemical Characteristics as Visualised at Sokhada

3. Dabhan:

Soil profile at Dabhan has the similar characteristics as that of the Dantali profile (Fig. 7.6). The soil profile depicts the development of 5 sub-soil horizons, belonging to the main A and B horizons. Horizon A (10 YR. 4/4) is well developed with Ap and A_{12}, sub-units and show marked increase in sand and clay content. The below lying B horizon (10 YR. 4/3-4/4) is characterised by 3 distinct sub-horizons viz. B_{21}, B_{22}, and B_3. The B_3 sub-horizon shows the development of lime kanker. The root system is penetrated all through out the depth of soil profile.

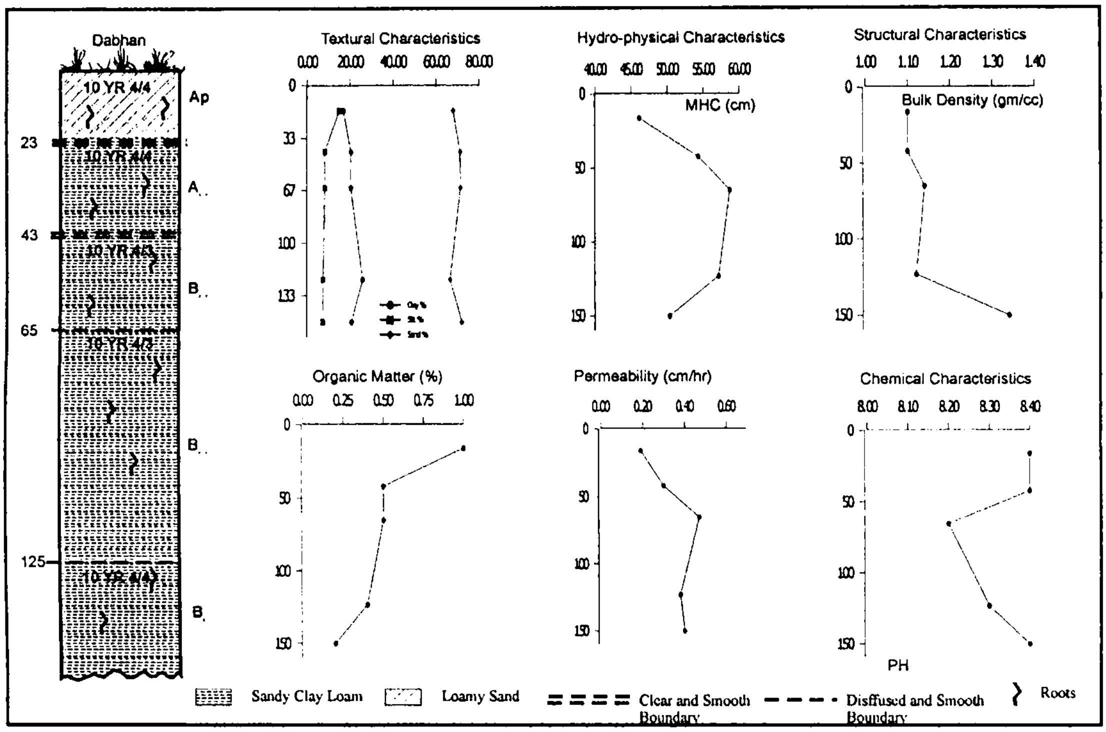


Fig. 7.6 Soil Profile and Its Physico-chemical Characteristics as Visualised at Dabhan

4. Shekhupur:

The soil profile at this location is matured mineralogical type with the clear and smooth boundaries between the upper layers and diffused smooth boundary at the depth (Fig. 7.7). The profile shows development of 5 sub-soil horizons of 10 YR. 4/4. The granularity of soil tend to increase with depth sand >clay>silt. Vertically there is increase in the sand and silt content whereas the clay content decreases slightly. Soil profile depicts well developed root system through out its depth and lime kanker formation in the B-horizon.

5. Traj:

The matured mineral soil profile at this location is mainly clayey in nature (Fig. 7.8). The soil tends to become fine with depth. The soil color varies between 10YR3/2 to 10YR3/3. Structurally the soil horizons depict blocky ped to the sub-angular blocky structure. Soils are comprising the lime nodules of the 3-5 mm diameter from the depth of the 45 cm onwards, indicating poor drainability.

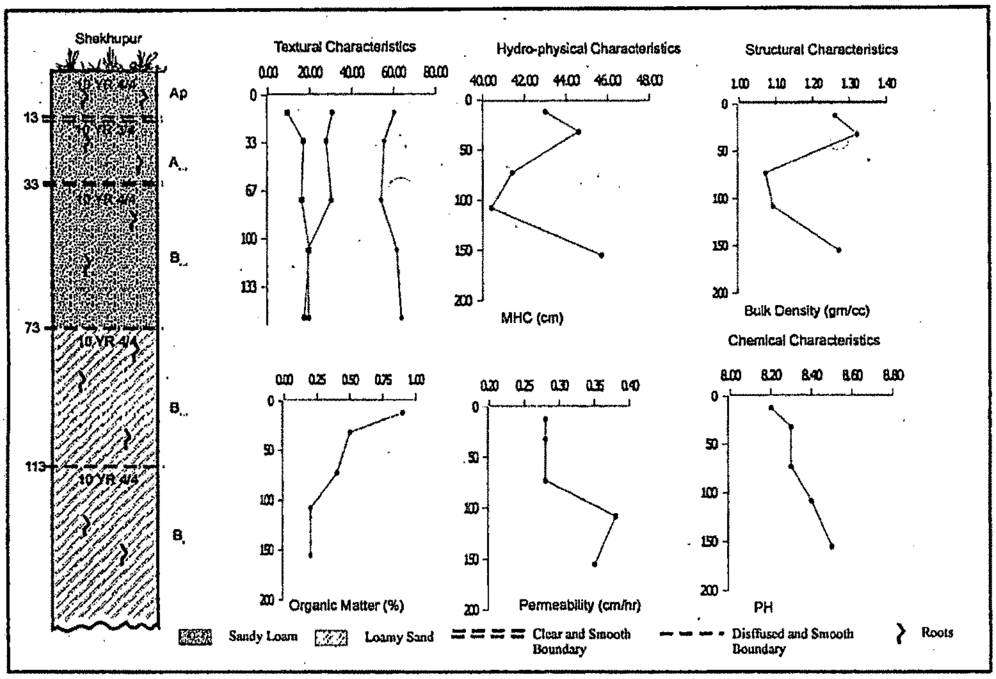


Fig. 7.7 Soil Profile and Its Physico-chemical Characteristics as Visualised at Shekhupur

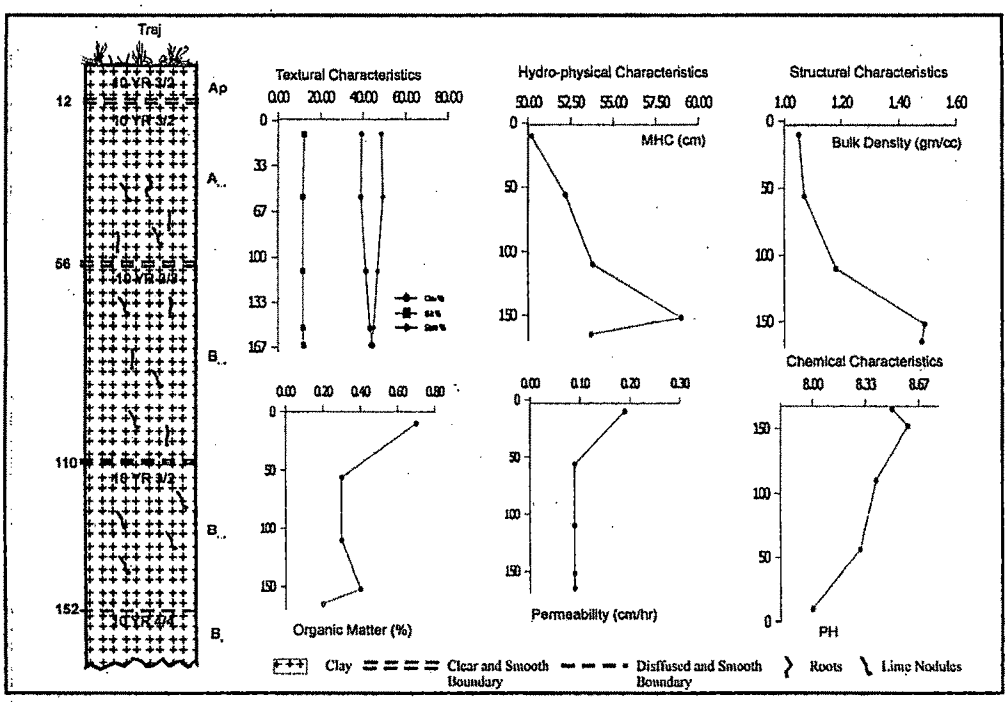


Fig. 7.8 Soil Profile and Its Physico-chemical Characteristics as Visualised at Traj

6. Sandhana:

The soil profile is well developed, very deep and matured in nature (Fig. 7.9). The soil exhibits the well developed A and B horizons with diffused wavy boundary. Top A_p horizons (10 YR. 4/3) is poorly developed and depicts good granularity. The soil belonging to B horizon (10 YR. 2/2-4/2) is characterised relatively fine granularity where in the clay percentage in the soil tend to increase with the depth. Therefore the soil of the surface layer (A horizon) indicates the sandy loam texture, which after 37 cm depth changes to the sandy clay loam, indicating the discontinuity in stratification. Structurally the soils are of sub-angular blocky slightly hard and plastic in nature. The presence of the mottles between 41 and 70 cm depth indicates poor drainability of the soils. Taking in to account the variation in the soil color, surface layer show very pale brown to brown (10 YR. 4/3) and as it passes to B horizon the color changes from grayish brown-dark grayish brown (10 YR. 3/2)-dark brown (10 YR. 2/2)-brown (10 YR. 4/2). These color changes suggest that the soil has suffered under the water table fluctuation and have also the poor drainability.

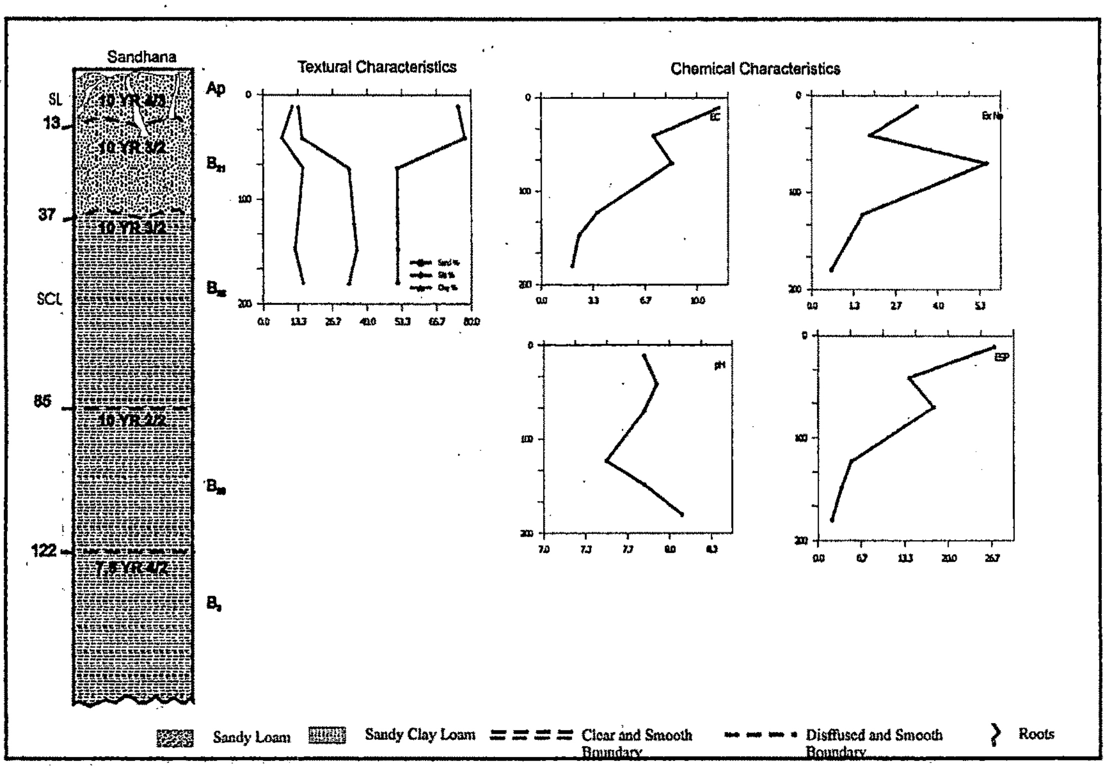


Fig. 7.9 Soil Profile and Its Physico-chemical Characteristics as Visualised at Sandhana

7. Heranj:

Soil profile studied at Heranj is well developed, and of matured one (Fig. 7.10). The soil exhibits the A-B-C horizons with the diffused wavy boundary. Texturally the soils are belonging to various horizons are characterized by the fine granularity, with the predominance of clayey sediments downwards i.e. clayey texture. The surface soils are marked with perceptible development of the salt crust of 5 mm thickness. Structurally the soils are characterised by the sub-angular blocky nature and at places it also shows development of varved like clayey laminations. The development of ferromanganese concretion at the depth of 32 to 56 cm and lime concretion at the depth below the 56 cm are noteworthy. Owing to clayey texture, the drainability of soil is poor and tend to decrease downwards. Soils are showing the varying color from surface with very dark grayish brown to very dark grey to dark brown at the depth (10 YR. 2/2-3/2). These variations in the color and presence of the ferromanganese oxides are indicative of high order of water table fluctuation and the presence of the organic matter.

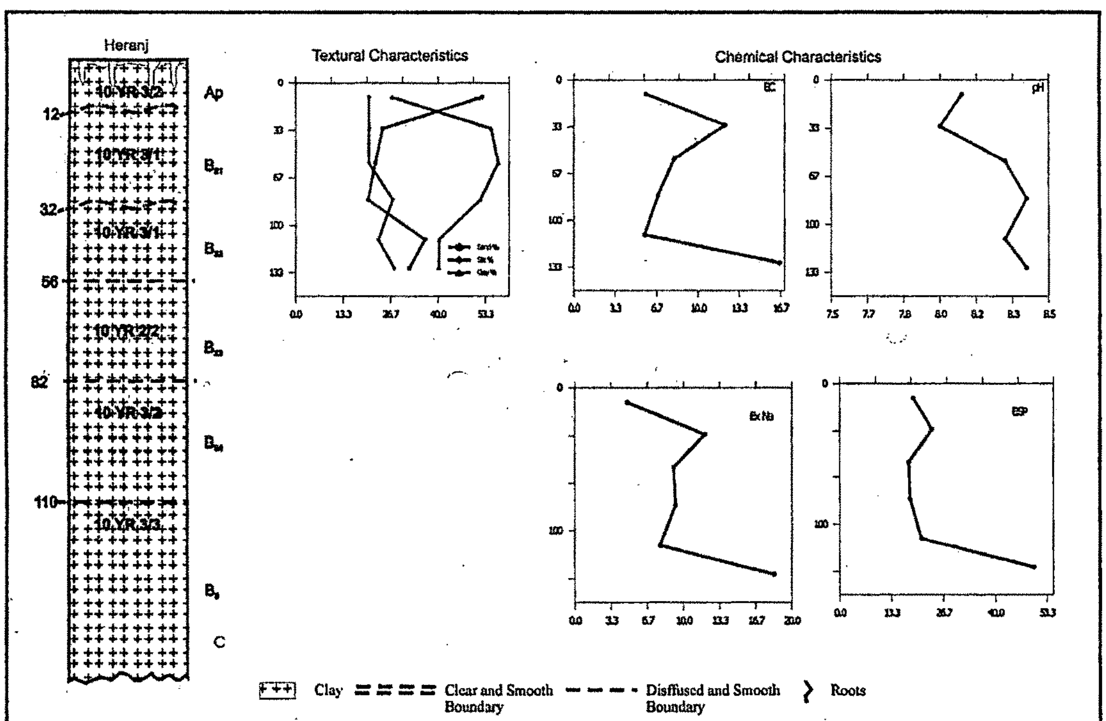


Fig. 7.10 Soil Profile and Its Physico-chemical Characteristics as Visualised at Heranj

The soils around Heranj have been identified to be severely salt affected soil with development of thick crust of the salt at the surface (Plate VII.3, VII.4 and VII.5).

Plate VII 3 Field Photographs Showing View of Salt encrusted Saline Soil. Salt Resistant Prosopis Sp. Can be seen on the Fringe of Waste Land. Location: Heranj.

Plate VII 4 Field Photograph Showing Accumulation of Salt over Dark Colored Soil due to Evaporation and Capillary Rise Location : Heranj

Plate VII 5 Field Photograph of Severely Affected Saline Soils with Super Enriched Salt Solution. Location : Kathoda

The salt affected soil shows a bright white color salt up to the 50 cm depth from the surface and followed by Dark grayish brown (10YR 2/2) colored salt of B_{23} horizon, hence entire A and top B_{22} and B_{21} horizon have been digested under the salt development. Soils at this location are found to be hard at the surface and it is difficult to cut with the knife. But, as one remove the top 50 to 60 cm layer, the soil becomes extremely loose. The development of the varved clayey structure can be ascribed to the phenomenon of the flocculation, generally seen during the salinity development. The soil also shows the development of cracks of 1.5 cm wide and 10-15 cm deep over the area.

Similarly, the development of thick salt encrustation has been observed at the Pij (Plate VII.6 and VII.7) is of 2 mm thickness. The soil shows the development of cracks of 1.5 cm wide and 15 cm deep and tends to closes further downward. Owing to salt formation the soil have become infertile.

At another location near the Pij village (Plate VII.8) it shows development of saline soil. Soil is of yellowish (10 YR. 4/4) color, with small bushes and grass cover. The surface soil layer is very hard and dry. The dugged pit for sampling at this location, when cleaned shows the network of the salt veins, wide at the depth and tend to be merging as they approaches to the surface (Plate VII.8).

Plate VII 6 Field Photographs Giving a View of Highly Saline Soil. Adjoining Agriculture Land is Also Seen Vulnerable to Soil Salinity. Location: Pij.

Plate VII 7 Field Photograph Giving a View of Moderately Affected Saline Soil Location : Pij

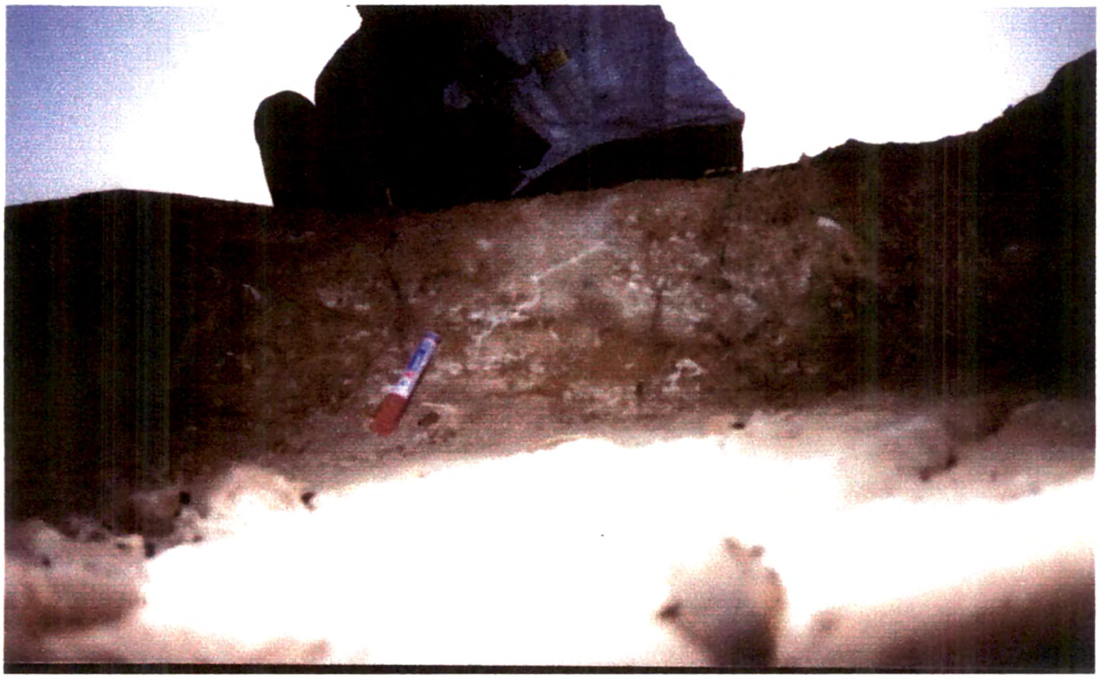


Plate VII 8 Field Photograph of Salt Affected Soils with Dusty Surface and Well Developed Veins of Salt. Location: Pij

Plate VII 9 A View of Moderately Affected Saline Agriculture Land with White and Dark Surface Layer. Location: Machhiyel.

Plate VII 10 A View of Moderately Affected Saline Agriculture Land with White and Dark Surface Layer. Location: Garmala

LABORATORY INVESTIGATION

SAMPLE PREPARATION FOR LABORATORY ANALYSIS

Utmost care is required in the selection of site, accuracy in sampling and handling of samples. The preparation of the soil samples also made precision for the predecided path of chemical analysis. As the soil samples collected from the fields are normally wet and therefore it is necessary to dry up the samples before they are taken for various analysis following the standard procedure was adopted (i) The samples have been dried under the room temperature, (specifically the room temperature should not exceed 35^0 C and relative humidity does not exceed 20 - 30 % (Hesse, 1994). Because drying of samples in sunlight may utter the concentration of certain chemical compounds and properties viz., increase in sodium content, decrease in phosphorus content and also bring changes in the physical properties. (ii) Remove the stones and pieces of the macro-organic matter. (iii) Disaggregation of soil using wooden roller and/or by hand. (iv) Screening/sieving of sample upto 2 mm sieve size.

MINERALOGY OF SOILS

The mineralogy of the soil depends upon the geological environment of sediments' composition, nature and mode of weathering, extent of weathering and to some extent on anthropogenic activity. Generally the alumino-silicates are the principal soil forming minerals followed by the ferromangesiam minerals. Certain minerals remained unaffected by weathering and endured as such in soil viz., Quartz, Magnetite, Titanite etc (Rowell, 1994). The decomposition of the primary mineral viz., Feldspars, Amphiboles, Pyroxene, and Mica results in variety of secondary minerals. These secondary minerals are hydrous aluminum silicates (clay minerals) with some replacement of Si^{+3} by Al^{+3}, Al^{+3} by Mg^{+3}, Mg^{+3} by Fe^{+3} and subordinate Ca and K (Velde, 1995). Clay minerals are of utmost importance as it governs the chemical, physical and morphological properties of soil. The main clays minerals found in the soils are Kaolinite, Montmorrilonite and Illite.

Kaolinite: This mineral has 1:1 type mineral structure with one tetrahedral and one octahedral sheet. Therefore in such balance charged clay structure, the cation exchange occurs on the broken bond developed at the edges of the particles (Rowell, 1994).

Montmorrilonite: This mineral is characterised by 2:1 type of mineral structure with two tetrahedral and one octahedral sheet. Also there always occurs some isomorphous replacement of positive ions by any other ions of same size and co-ordination (viz., Si^{+3} by Al^{+3} and Mg^{+2} by Fe^{+2}). This replacement of ions develops negative charge, which may be accommodated either by water or by other polar molecules.

Illite: This mineral consists of two silicate tetrahedral layer with one aluminate octahedral sheet interlaced between them with a potassium holding adjacent crystal unit together. Substitution of Al^{+3} by Mg^{+2}, Fe^{+2} etc. in octahedral layer gives most of the cation exchange capacity. This mineral has cation exchange capacity between that of Kaolinite and Montmorrilonite.

Fourier Transformation Infra-red Spectroscopy (FTIR) Studies:

In order to analyze the variation in the mineralogy of the different soils and its relation to textural characteristics; the various soil samples have been studied using Fourier Transformation Infrared (FTIR) Spectroscopy. The IR technique is a simple method to characterize the presence of different clay minerals compared to clay XRD (Farmer, 1974).

Principle:

Vibration spectroscopy of the mineral involves the adsorption behaviour of light in IR region (10000 to 0 cm^{-1}). The developed peaks of the spectrum represent the vibrational transition or frequencies of sample indicating the structural groups present within the sample. The obtained spectrum yields the information on occurrence of phases or molecular groups.

Methodology:

For obtaining IR absorption compressed disc form, mechanically grounded powder samples (at KBr 2-5 wt%) have used. In order to minimize the polarization effects the samples were compacted at 10^{10} pa pressure. IR absorption was recorded at room temperature within frequency region of 4000-400 cm^{-1}, using NICOLET Magna IR 550 FT-IR Spectrometer. For this Spectral resolution was set at 4 cm^{-1} and then background effects of atmospheric H_2O and CO_2 were substracted.

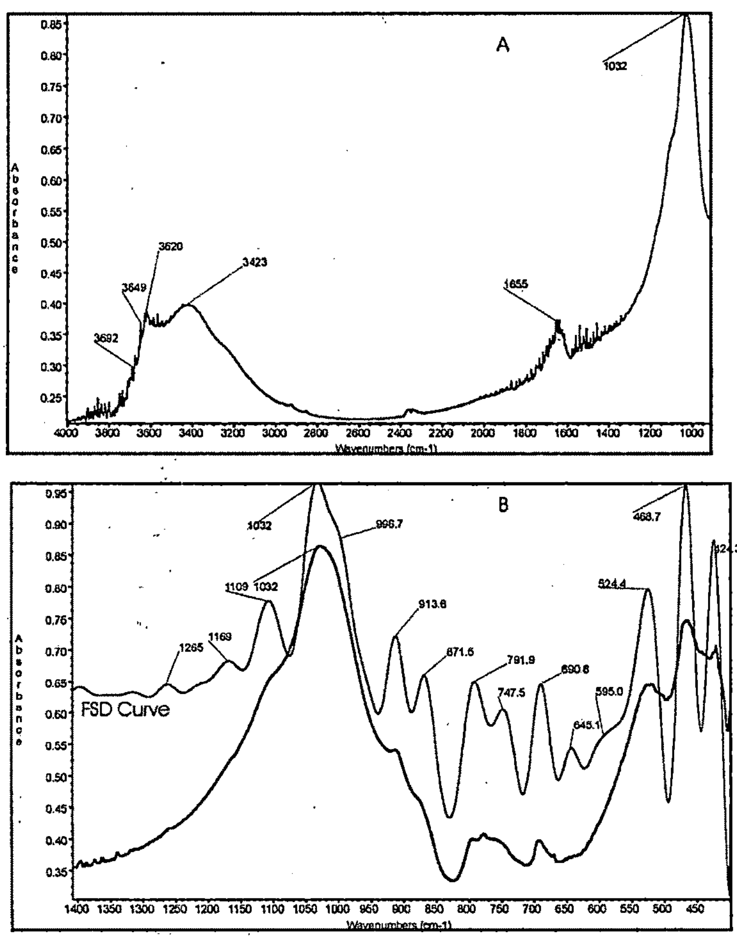


Fig. 7.11 FTIR Spectrum of Sandy Loam Soils Location: Dantali

Inferences:

Obtained FTIR spectrums for the different soil profiles are presented in Fig. 7.11 to 7.14. The FTIR spectrum of sandy loam indicates the dominance of the quartz and K-feldspars (Fig. 7.11 a & b), where as those for the clay loam and clay soils (Fig. 7.12 a & b) are dominated by Kaolinite, Illite and peaks of the Montmorrilonite clay minerals. The details on quantitative spectrum interpretation and identified bond vibrations for different minerals are described below:

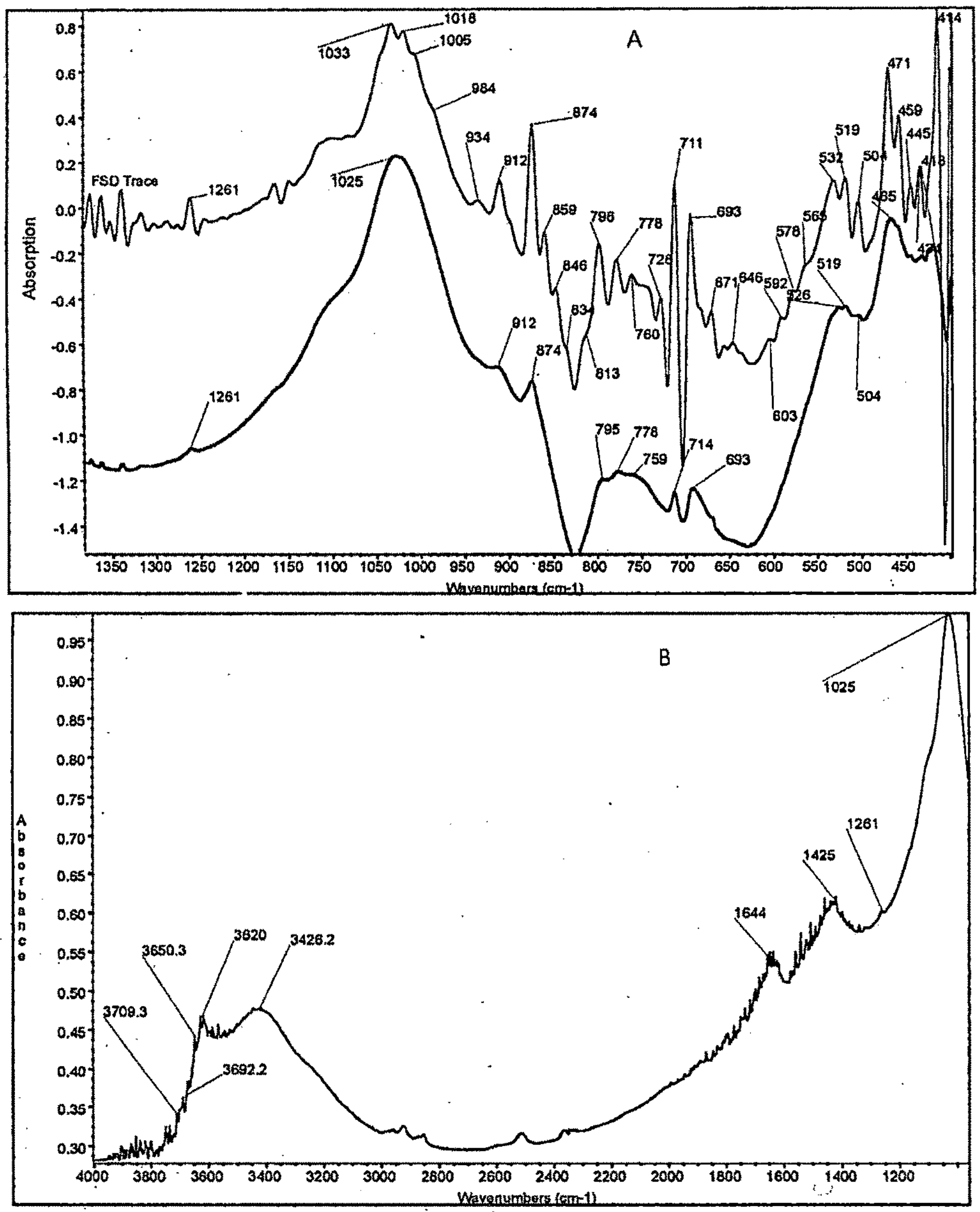


Fig. 7.12 FTIR Spectrum of Clayey Loam Soils Location: Shekhupur

- Presence of sharp peak at 3709 and 3620 cm^{-1} (Fig. 7.12 a) is attributed to OH species associated with Kaolinite group. While complementary peaks of OH deformation is observed at 934 and 912 cm^{-1} is seen in the Fourier Self-Desconvoluted (FSD) spectrum (Fig. 7.12 b). However, its polymorph dictites and nickrite are difficult to be discerned in the present spectra due to interference of surface adsorbance bands. The broad adsorption around 3400 cm^{-1} is on account of the surface adsorbance of hydrous molecules, which on heating to 120^0 C gets disappeared. The small adsorbance bands at 2927 and 2854 cm^{-1} are again due to surface adsorbance.

- Presence of bands at 760, 720, 646, 592, 578, 565 cm^{-1} splits in the FSD spectrum in addition to the SiO_2 stretching band around 1000 cm^{-1} indicates presence of K feldspars. The split of bands at 796 and 778 cm^{-1} indicates presence of Quartz (Fig. 7.12 b).

- Presence of dioctahedral Smectites-Montmorillonite also can be accounted by the presence of stretching band at 3620 cm^{-1} (Fig. 7.11 a) which provide an overall envelop for a wide range of Al, Al(OH) and Al-Mg(OH) environments in the highly substituted and distorted smectite structures (Farmer, 1974). The above band occurs close to the inner OH group in Kaolinite. But can be very well distinguished by the presence of well-resolved OH deformation bands around 915 and 840 cm^{-1} (Fig. 7.12 b) (Russell and Fraser, 1971).

- Montmorrilonite contains both tetrahedral and octahedral isomorphic substitutions. As a result of this substitution, crystalline order is reduced and structural imperfections arise. This leads to considerable broadening in IR absorption band. Increasing substitution of Al by Fe^{+3} results in OH deformation bands shifting from 890 cm^{-1} to lower wave numbers. This is evident from the presence of 874 cm^{-1} band in the FSD spectrum (Fig. 7.13 b). It further decreases with further Fe^{+3} substitution and results in appearance of band at 815 cm^{-1}, this results in dominance of Nontronite clay (Farmer, 1974). The presence of 815 cm^{-1} band in the present sample is observed as a shoulder at 813 cm^{-1} indicating presence of notronite clay.

- The presence of carbonate indicated by band of 1433 cm^{-1} (Fig. 7.14 b). However, It is difficult to find out the mineral nature of carbonate type. Also, the FTIR spectrum of clay soils (Fig. 7.14 a) indicates the presence of bicarbonate (2515 cm^{-1}). The presence of carbonate and bicarbonate may be attributed to secondary deposition of Na_2CO_3, $NaHCO_3$ or $CaCO_3$.

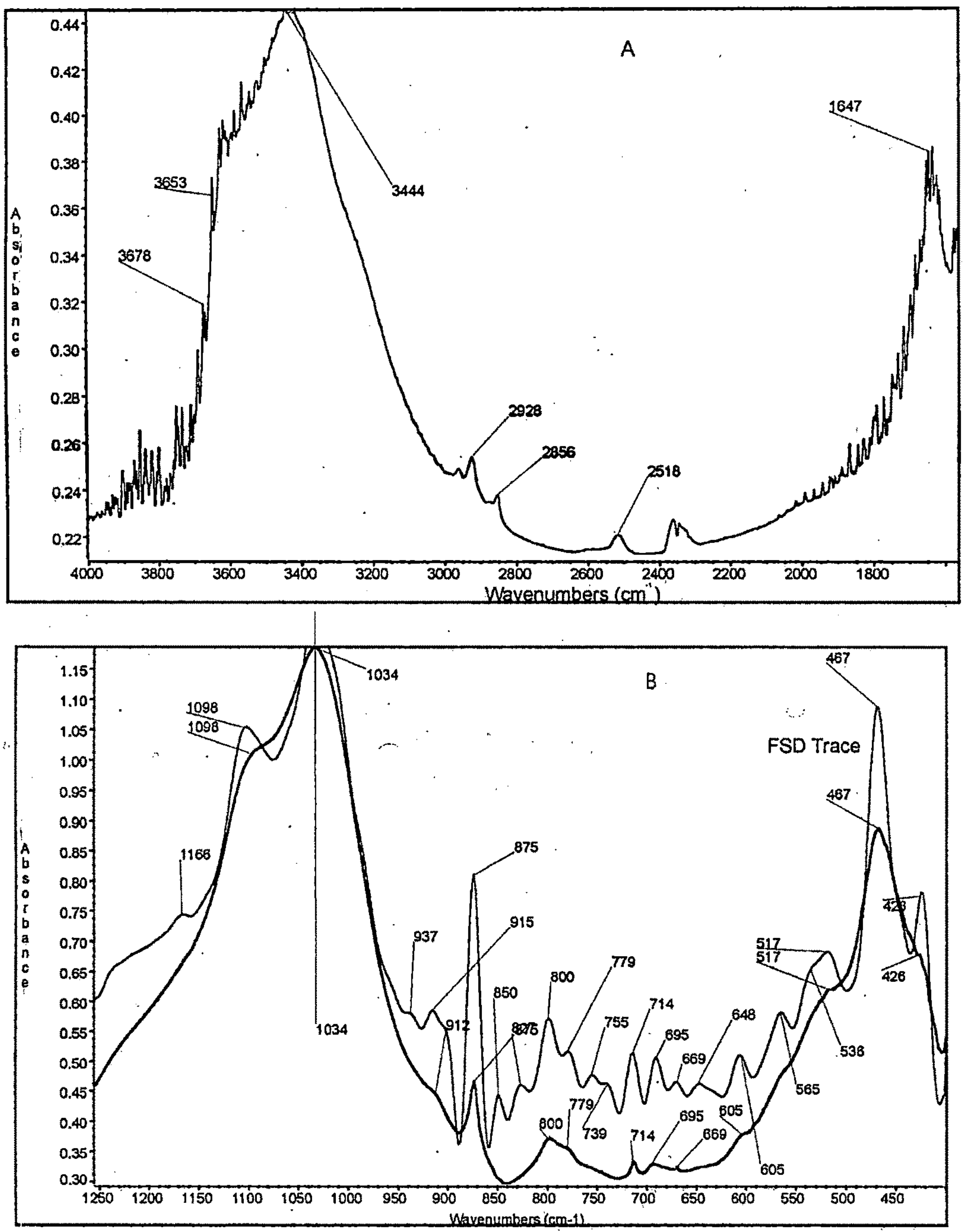


Fig. 7.13 FTIR Spectrum of Sandy Clay Loam Soils Location: Dabhan

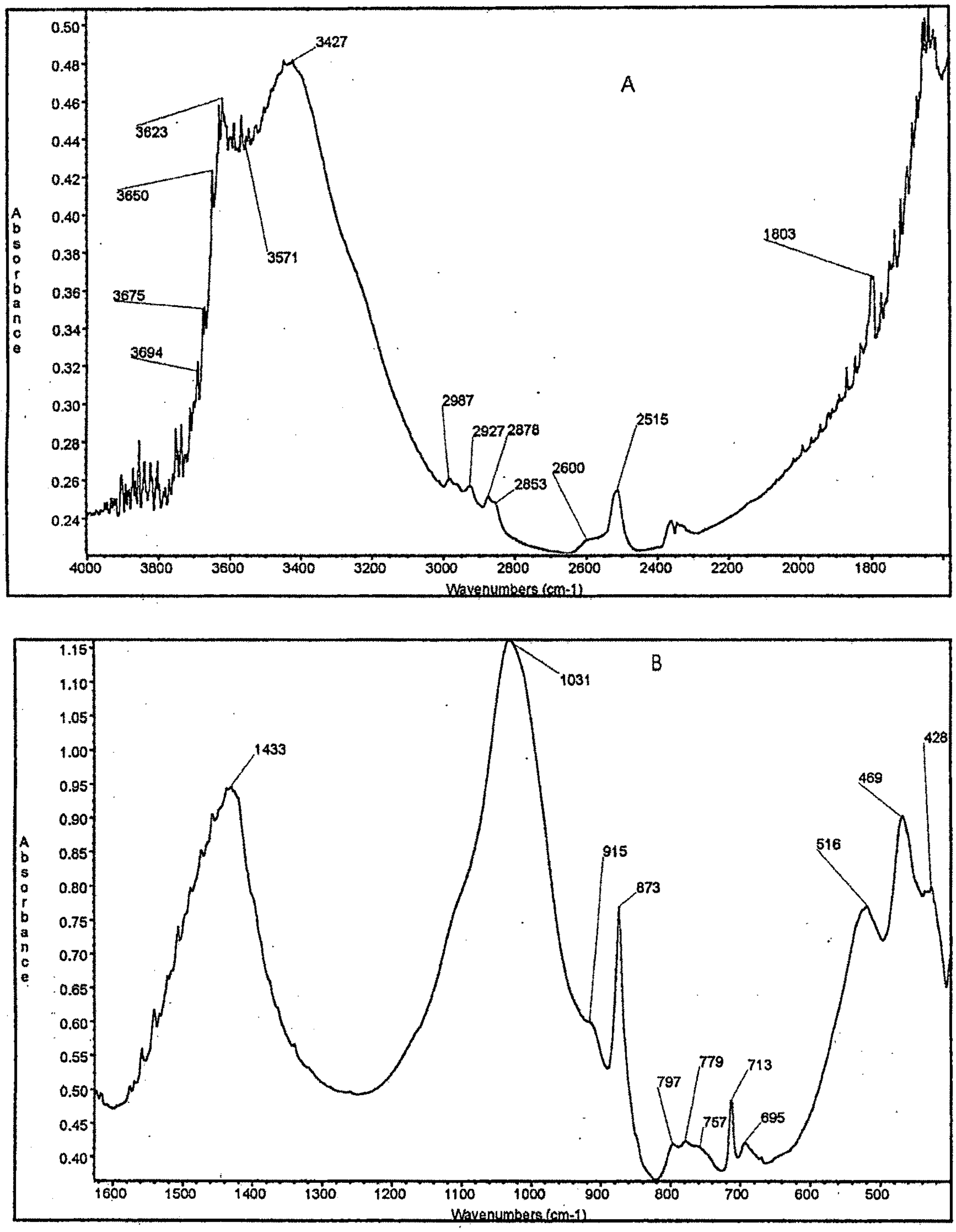


Fig. 7.14 FTIR Spectrum of Clay Soils Location: Traj

PHYSICAL PROPERTIES

Texture

Study of the textural characteristics of the soil serves an important basis in soil identification and their classification. Textural analysis of the soil samples for the samples during pre-monsoon 1999 as given in Annexure I. The textural for the representative soil profiles (Fig. 7.15) have been considered and the aerial coverage of the soils under different class has been delineated as in Fig. 7.16. Figure clearly indicates that the lower command area is characterised by the clayey loam and clayey soil, where as the upper command area is dominated by the sandy loam, loamy and sandy clay loam soils. Depth wise variation in the textural characteristics of the soil along the A-A' line is shown in Fig. 7.17. Figure depicts that there is decrease in the sand percentage with the depth and simultaneous increase in the clay percentage. The aerial coverage of different kind of soils at the various depths is ensued in table below.

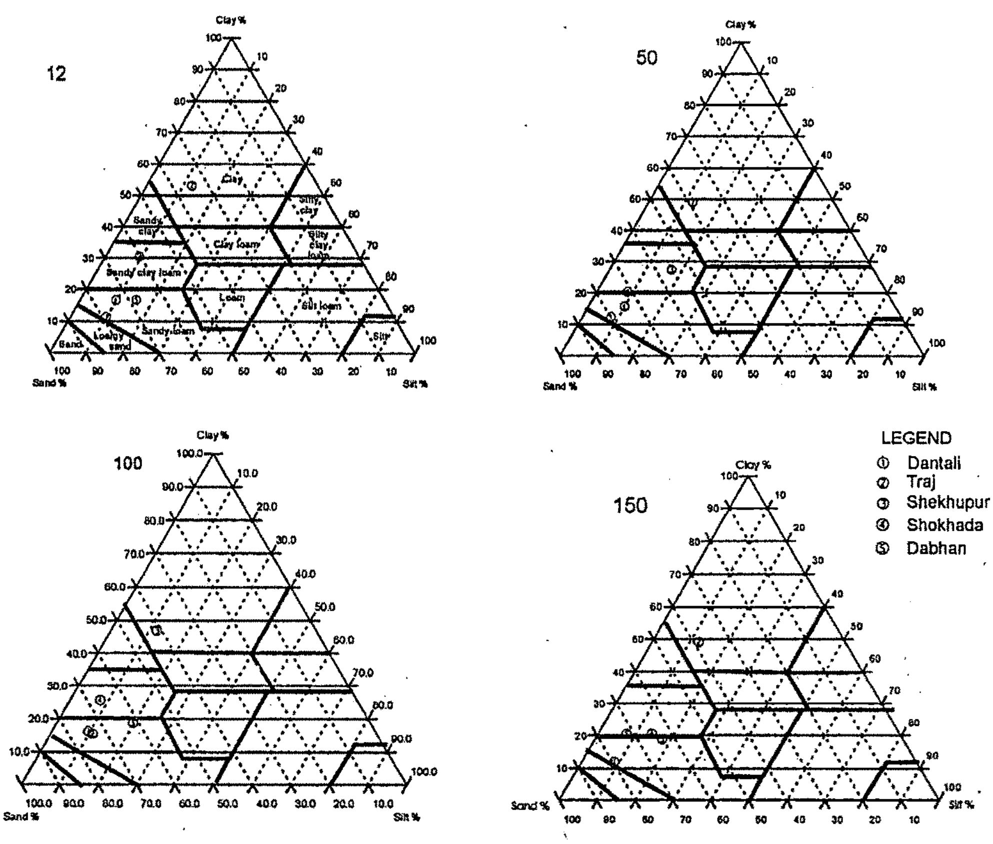


Fig. 7.15 Percentage of Clay and Triangular Diagram Showing Basic Textural Variation of Soils in Matar Command Area.

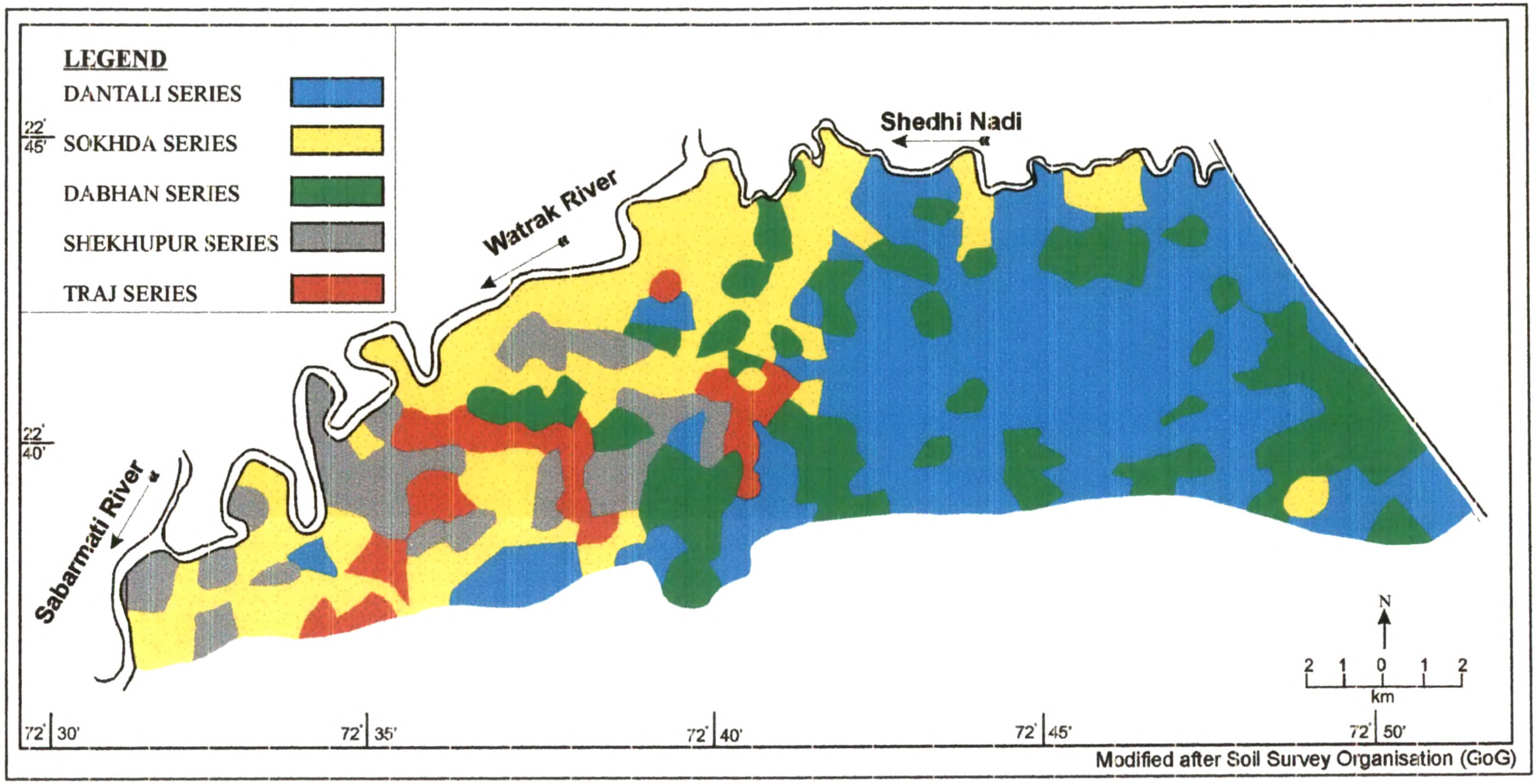


Fig. 7.16 Soil Map Matar Command Area.

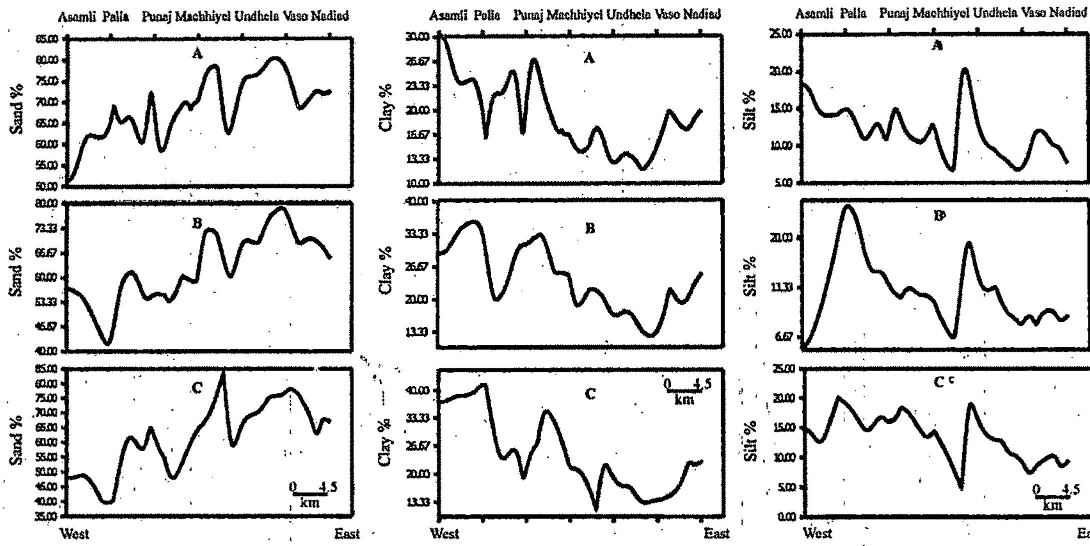


Fig. 7.17 Depth wise Variation in Sand, Silt and Clay Percentage in Soils of Matar Command Area. A) 0-50 cm; B) 50-100 cm; C) 100-150 cm. (Section along W-E)

Texture	0-30 cm	30-90 cm
	Area in ha. (% of Command Area)	
Sand, Loamy Sand	3354 (14.80 %)	600 (2.60 %)
Fine Sandy Loam	12206 (45.10 %)	8377 (37.00 %)
Silty Loam, Silt	1275 (5.60 %)	1484 (6.60 %)
Clayey Loam, Silty Clay Loam	6484 (28.70 %)	9350 (41.30 %)
Clay	1321 (5.8 %)	2829 (12.50 %)

From the above table it can be clearly seen that most of the area comprising the moderately to moderately fine textured soil, which is highly suitable for the irrigation purposes. The considerable area comprises the clayey soil on the surface as well as the subsurface soils, confined to the tail end portion of the command area.

Soil Structure

The soil particle like, sand, silt and clay are commonly denoted as aggregates. Relative arrangement of these soil particles and the aggregates, together constitute the soil structure. This aggregated form of the soil particles is defined as peds. Depending upon the relative proportions of particle and the mineral content the peds attains a particular structure. The various soil structure viz., prismatic, blocky, columnar, platy and spheroidal etc. plays important role in soil water movement, aeration, porosity and heat transfer (USDA, 1966).

Table 7.1 Salient Physico-chemical Properties of Soils of Matar Command Area

Village	Depth cm	Clay %	Silt %	Sand %	Tex Class	MHC %	AWHC	K cm/hr	E.C. mmohs/cm	pH	OM %	Bulk Density gm/cc
Dantali	0-12	11.50	9.50	79.00	SL	37.40	9.00	0.95	0.40	8.4	0.40	1.22
	12-37	12.50	7.50	80.00	SL	39.80		1.14	0.30	8.6	0.30	1.1
	37-84	12.00	8.20	79.52	SL	46.90		1.23	0.20	8.5	0.40	1
	84-122	16.30	9.20	74.50	SL	45.90		1.33	0.20	8.6	1.30	1.06
	122-150	12.00	8.20	79.80	SL	46.40		1.33	0.20	8.4	0.60	1.14
Sokhada	0-12	16.90	9.60	73.50	SL	45.60	9.00	0.28	0.40	8.7	1.00	1.17
	12-31	15.80	9.60	74.60	SL	45.90		0.47	0.30	8.8	0.30	1.12
	31-76	16.40	8.10	75.50	SL	44.20		0.47	0.30	8.6	0.20	1.2
	76-120	15.70	10.50	73.80	SL	46.50		0.38	0.40	8.5	0.20	1.18
	120-155	20.80	13.80	65.40	L	51.80		0.28	1.20	8.3	0.20	1.18
Dabhan	0-16	17.00	15.00	68.00	L	46.10	13.30	0.19	0.20	8.4	1.00	1.1
	16-42	20.40	8.30	71.30	SCL	54.30		0.19	0.10	8.4	0.50	1.1
	42-65	20.30	8.30	71.40	SCL	58.70		0.47	0.10	8.2	0.50	1.14
	65-123	25.90	7.50	66.60	SCL	57.10		0.38	0.10	8.3	0.40	1.12
	123-150	20.70	7.30	72.00	SCL	50.30		0.57	0.70	8.4	0.20	1.34
Shekhupur	0-12	30.60	9.20	60.20	CL	43.00	14.80	0.28	2.50	8.2	0.90	1.26
	12-32	27.70	16.80	55.50	CL	44.60		0.28	0.20	8.3	0.50	1.32
	32-73	30.10	16.00	53.90	CL	41.40		0.38	0.20	8.3	0.40	1.07
	73-108	18.90	19.60	61.50	L	40.40		0.38	0.20	8.4	0.20	1.09
	108-155	19.30	17.10	63.60	L	45.70		0.47	0.20	8.5	0.20	1.27
Traj	0-10	34.60	12.30	53.10	C	50.20	14.40	0.19	0.20	8.0	0.70	1.05
	10-56	39.00	11.70	49.30	C	52.20		0.19	0.20	8.3	0.30	1.07
	56-110	41.40	11.70	46.90	C	53.80		0.09	0.90	8.4	0.30	1.18
	110-152	38.90	11.80	49.30	C	59.00		0.09	0.10	8.6	0.40	1.49
	152-165	34.70	12.00	53.30	C	53.70		0.19	0.10	8.5	0.20	1.48

The bulk density of the soil reflects the soil structure. The computed bulk density of the soil samples for all the available series in study area is less than 1.5 gm/cc (Table 7.1), which indicates that the soils are by and large are characterised by sub-angular blocky structure which belongs to the S_1 class signifying its high suitability for the irrigation (USDA, 1960, WALMI, 1987).

Hydraulic Properties

Available Water Holding Capacity (AWHC)

Available water holding capacity plays an important role while irrigation continues; the AWHC is the measure of water that can hold upon by the soil under natural conditions. As the soil has higher AWHC, the soil has more chances of waterlogging. The AWHC of the soil is measured following the procedure suggested under (USDA, 1996). As the author has more concern to irrigation impacts, the author has evaluated this parameter by utilizing the data collected by the State Soil Survey Department in field.

The obtained data on the AWHC of the soils for 90 cm depth in the study area (Table 7.1) have been categorized as high 15.30 cm for Dabhan, medium 14.80 cm for Shekhupur and Low 9.00 cm for Traj, 9.00 cm Dantali and 13.40 cm Sokhada soil profiles.

Moisture Holding Capacity (MHC)

Textural characteristics of the soils greatly influence the soil-moisture regime. in other words the availability of water to the plant is attributed to the moisture holding capacity of the soil. The moisture holding capacity of soil has been calculated with the help of Keen's Box method. Author has determined the MHC of few soil samples at the Soil Survey Organization Laboratory, GERI. The Moisture Holding Capacity of the collected soil samples has been computed at 50,100 and 150 cm depths.

On the basis of data author has found that the magnitude of water retention follow the order Fluventic Ustorthents > Vertic Ustochrepts > Typic Ustorthents > Typic Ustochrepts> Fluventic Ustochrepts. Based on the obtained values of MHC, the author has developed Iso-MHC contour plans. The Iso-MHC contour map for the 50cm depth (Fig. 7-18A) shows an increasing trend from north-east to south-west (60%) i.e. at Punaj. However, the MHC varies in accordance with the soil types. The average MHC in the command area stands at 44%. The area around Matar also shows higher MHC of 54%. These observed variations in the MHC are attributed to the percentile concentration of fine soil particles. Higher the clayey particles will have high MHC.

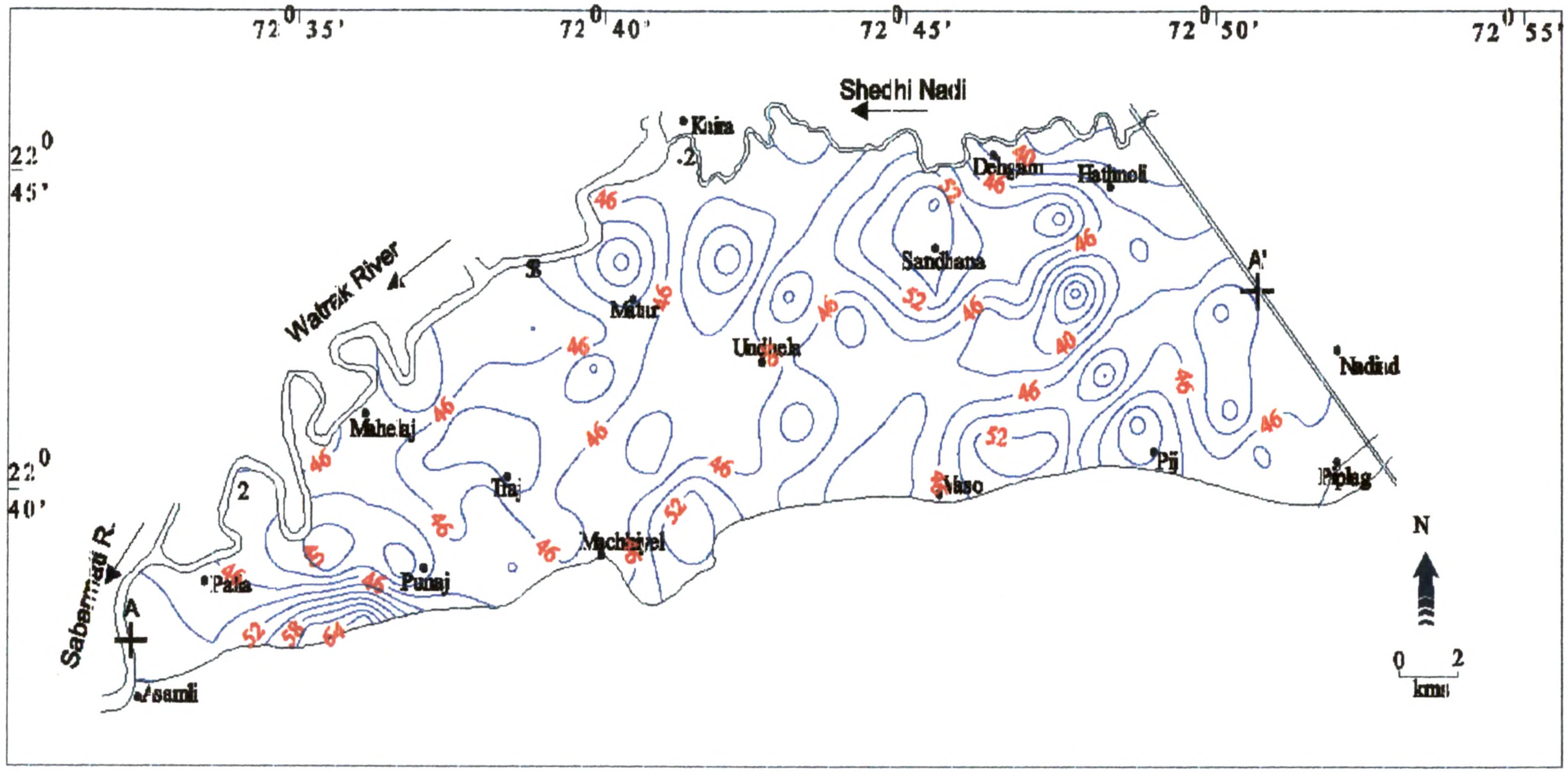


Fig. 7.18 A Iso-MHC Contour Map of Soils in Matar Command Area. Depth: 0-50 cm

Iso-MHC contour map at 100 cm depth (7-18B) depicts relatively higher MHC than thc top laycr. In all thcrc arc 5 maximum dcvclopcd ncar Piplag, Vaso, NE of Matar, having MHC almost 56%, while the maximas near Sandhana and Punaj are suggestive of increasing trend in finer particles with the depth. Similarly, the MHC values at 150 cm depth (Fig. 7-18C) shows consistent rise. Development of two maximas near Sandhana (68%) and Punaj (62%) arc thc highcst obtaincd MHC valucs; corroborating that thc depth wise there is increase in fine soil particles.

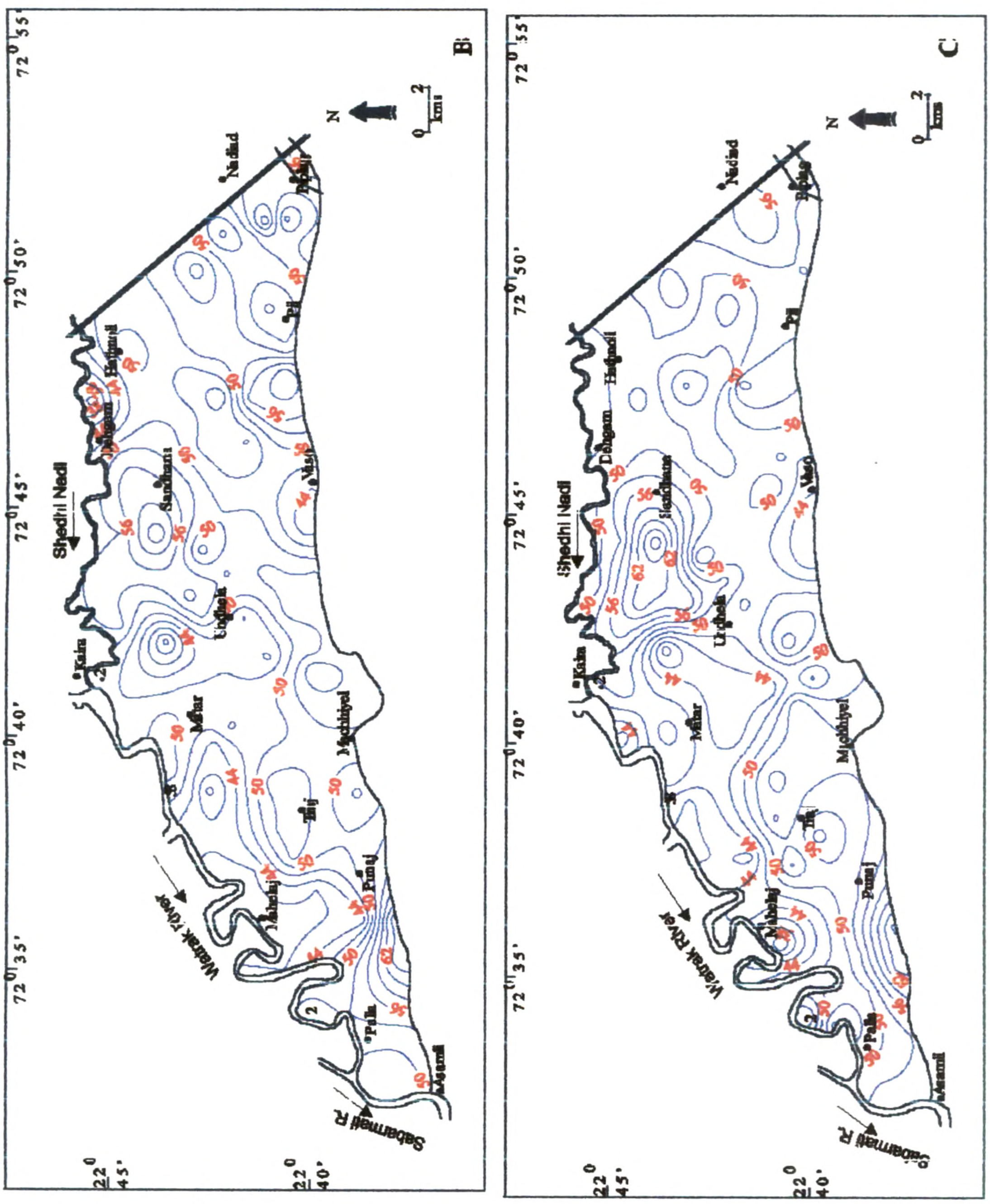


Fig. 7.18 B Iso-MHC Contour Map of Soils in Matar Command Area.
B: Depth: 50-100 cm C: Depth: 100-150 cm

The depth wise MHC profiles drawn across the study area (Fig.7.19) i.e. along Matar - Undhela, Vaso - Nadiad localities depicts consistent increase in MHC from east to west. Therefore, the entire command shows there is an increase in fine particles laterally as well as vertically. The moisture holding capacity calculated for various soil profiles (Table 7.1) also supports this fact.

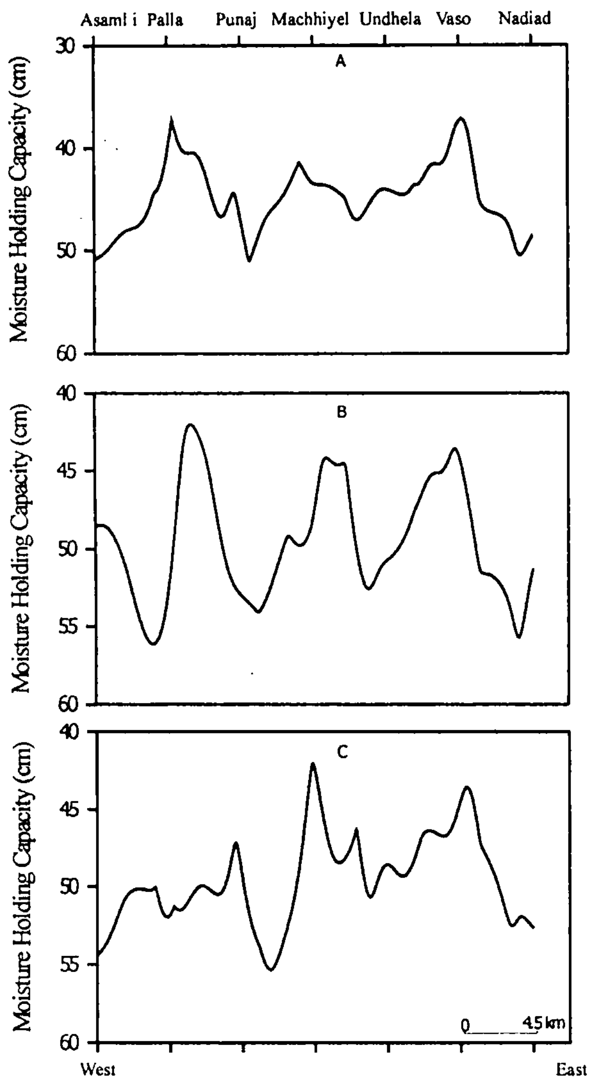


Fig. 7.19 Depth wise Variation in Moisture Holding Capacity of Soils in Matar Command Area. (Section along A-A')

Infiltration Rate (I)

Soil's textural and structural characteristics are having maximum bearing in governing the soil infiltration properties. Soil texture and structure together serves an important mode for interstice development, thereby, the infiltration. Sandy soils owing to large interstice perceives higher infiltration than the clayey soils. The infiltration capacity of soil attains importance being its indicator for soil drainability, as well drained soils are less vulnerable to water logging than the poorly drained soils.

The infiltration rate at the different localities measured by the State Irrigation Department, Govt. of Gujarat, using the Standard Percolation Test procedures. The author has utilized the same data for evaluation purpose. The obtained infiltration values for different location upto 150 cm depth, within the command area are furnished in ensuing table.

Village	Infiltration Rate	Village	Infiltration Rate
	cm/hr		cm/hr
Sokhada	1.03	Dabhan	1.29
Antroli	0.94	Bamroli	0.98
Haijrabad	1.34	Traj	0.18
Hathnoli	1.05	Alindra	0.97
Jharol	0.97	Sihlodi	1.08
Kamla	1.25	Nadiad	0.57
Piparia	1.10	Pij	1.14
Raghvanaj	1.27	Palla	1.11
Sadhana	0.95	Dantali	1.29

From the above listed infiltration data it can be seen that infiltration rate in the Matar Branch command area is ranging between 0.18 to 1.34 cm/hr. The infiltration rate is high (0.97-1.34 cm/hr) in Dantali and Sokhda Series while soils of Dabhan and Shekhupur soils has moderate (0.57-0.97 cm/hr) and soils of the Traj series has low infiltration rate (0.18 cm/hr).

The author has carried out the infiltration measurement in field for three different soils viz., Clay, Clay Loam, and Sandy Loam at Traj and near by areas using the Double Ring Infiltrometer at the constant load of 6 cm (maximum thickness of water during farming practices). For this water is filled between the two rings and is allowed to pass under gravitational movement. The readings are noted at intervals of 2, 15, 30, minutes till the constant thickness of water percolation has been achieved. The soil samples from different depths and time intervals during the test have also been collected to measure the moisture content. The plotted curves on time v/s infiltration rate, for the three different kinds of the soil (Fig. 7.20). From figure it is clear that the initial rate of the infiltration and cumulative infiltration rate is rapid, irrespective to the soil type. This high rate of infiltration is attributed to the presence of cracks in case of clayey soil and open voids in case of the sandy loam and clayey loam soils. Further decrease in the rate of infiltration may be attributed to the swelling of the clay and horizontal as well as vertical migration of water in sandy loam and clayey loam soils. This very fact is also reflected by the presence of heaps in their respective curves. Further, after the 390 minutes the infiltration rate becomes constant in all the three soils.

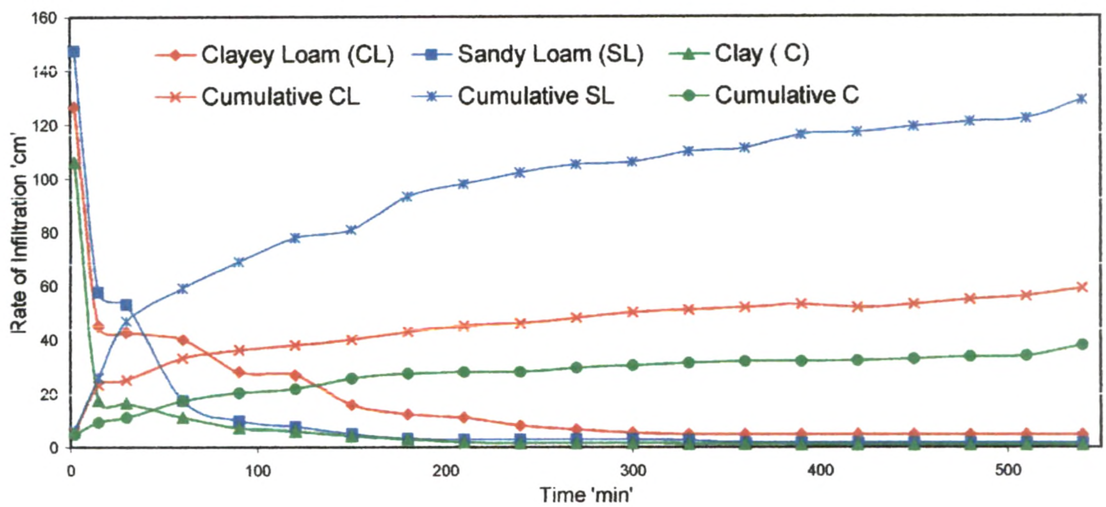


Fig. 7.20 Rate of Infiltration as a Function of Time in Different Soils of Matar Command Area.

Plotted curve for moisture content versus depth (Fig. 7.21) for determining the zone of saturation, under the influence of infiltration, depicts that the comparative movement of water is high in sandy loam, moderate in clay loam and slow in clayey soils. The water movement in the clayey soil has reached up to the depth of 67.5 cm after 540 minutes but has saturated only 18-25 cm. In case of the clay loam soil it has reached to the depth of 117 cm and saturated the soil of 37-47 cm in 540 minutes, where as in the sandy loam soil water has reached up to the > 140 cm and saturated the 45-65 cm in 540 minutes. This differential response in saturation may be attributed causative factors related to (i) Higher lateral as well as vertical migration of water in sandy loam soil, (ii) Vertical migration is less as compared to the lateral migration in clayey loam soil. (iii) Clayey soil has more tendencies to have lateral migration than the vertical migration.

Hydraulic Conductivity (K)

Hydraulic conductivity is of utmost importance for planning the cropping pattern. In the irrigation command area soils hydraulic conductivity is greatly dependent of textural and structural properties of soil. Sandy soils generally have higher conductivity than finer textured soils. Fine clay and silt can clog the small connecting channels of even larger pores..

In order to measure the hydraulic conductivity the author has collected the undisturbed soil samples (both the salt affected and fresh soil samples) of different soil series. As the soils in the command area are of moderate texture soil, which allows the slow discharge, the hydraulic conductivity of the soil samples has been measured using the standard falling head permeability procedure (IS: 2720:Part 17-1986). The obtained results on hydraulic conductivity of the saline and non-saline soils at 90 cm depth are given as under:

Soil Series	Hydraulic Conductivity (cm/hr)	
Location	Fresh Soil	Saline Soil
Mahelaj	0.003	0.037
Heranj	0.0067	0.059
Punaj	0.0019	0.028
Pij	0.47	0.68

It is clearly visible from the above data that there is considerable improvement in the hydraulic conductivity of saline soils then the non-saline one. The soils of Mahelaj, Heranj and Punaj, which can be categorized as impermeable, upon salinization have gained the hydraulic conductivity. The improvement in hydraulic conductivity of the soil may be attributed to the flocculation of clay minerals where in the original structure of the soil gets destroyed, providing conduits for water to pass (Shainberg et. al., 1981).

As considerable data on hydraulic conductivity, measured by the state soil survey Dept. are available, the author has attempted the spatial change in Hydraulic conductivity over 20 years time span (i.e. 1975-95 (Table 7.2).

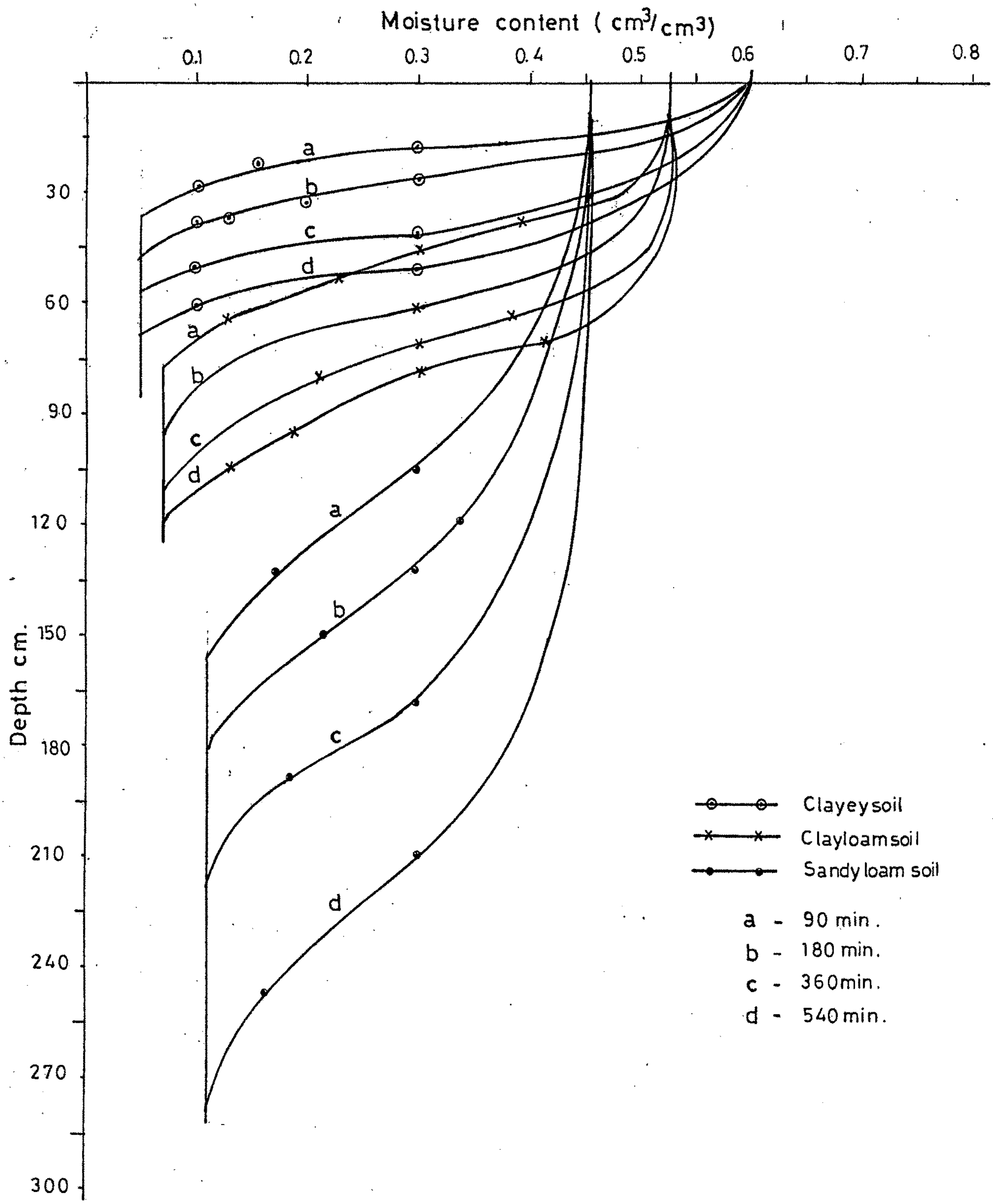
The data clearly shows an overall decrease in the hydraulic conductivity of the various soils in the Matar branch command area. The maximum decrease in the soils' hydraulic conductivity of the soil has been observed in Dantali series soils whereas the hydraulic conductivity has improved in Dabhan Series soils. This decrease in the hydraulic conductivity of the soils may be attributed to the agglomeration of the residues developed from the soil solutions carrying ample amount of the dissolved solids (Shainberg et. al., 1981).

Table 7.2 Spatial Changes in the Hydraulic Conductivity in Soils of Matar Command Area.

Soil Series	Depth of Sample (cm)	Permeability (cm/hr)	
		1975	1995
Dantali	0-15	4.810	0.28
	15-40	1.730	0.47
	40-100	0.540	0.47
	100-130	0.340	0.38
	130-150	0.240	0.28
Dabhan	0-18	0.099	0.12
	18-43	0.094	0.12
	43-110	0.099	0.32
	110-150	0.099	0.28
Shekhupur	0-17	0.440	0.28
	17-60	0.440	0.28
	60-135	0.440	0.38
	135-160	0.360	0.47
Sokhada	0-12	0.750	0.28
	12-31	0.860	0.47
	31-80	1.190	0.47
	80-155	1.320	0.38
Traj	0-20	0.240	0.19
	20-48	0.490	0.19
	48-80	0.240	0.09
	80-120	0.240	0.09
	120-150	0.250	0.19

(Source: Agri. Tech. Bull., Soil Survey Org.)

In order to evaluate the lateral behaviour of hydraulic conductivity in the study area, the author has constructed the longitudinal profiles of hydraulic conductivity at 50, 100 and 150 cm depth along E-W azimuth (Fig 7.22). The profile depicts strong control of textural characteristics of the soils. The upper reaches and up to the central parts of the command is predominated by the sandy loam soils. While the soils in lower parts is clayey and clayey loam. This varying soil nature has strongly governed the hydraulic



IG. 7.4 SUCCESSIVE DISTRIBUTION OF SOIL MOISTURE DURING INFILTRATION IN VARIOUS SOIL OF MATAR COMMAND AREA

conductivity. Presence of sharp peak at various depths in sandy loam soils is indicative of rapid vertical movement of the water. While broad curvature with little mound indicate more lateral movement of water characteristics of fine textured soils. The rapid movement of water exhibited in the clayey surface soils (50 cm) is attributed to the locally variable proportion of sand (Fig 7.22 a). Therefore, over all behaviour of hydraulic conductivity in the command area shows decreasing trend from east to west, while the conductivity tend to increase vertically.

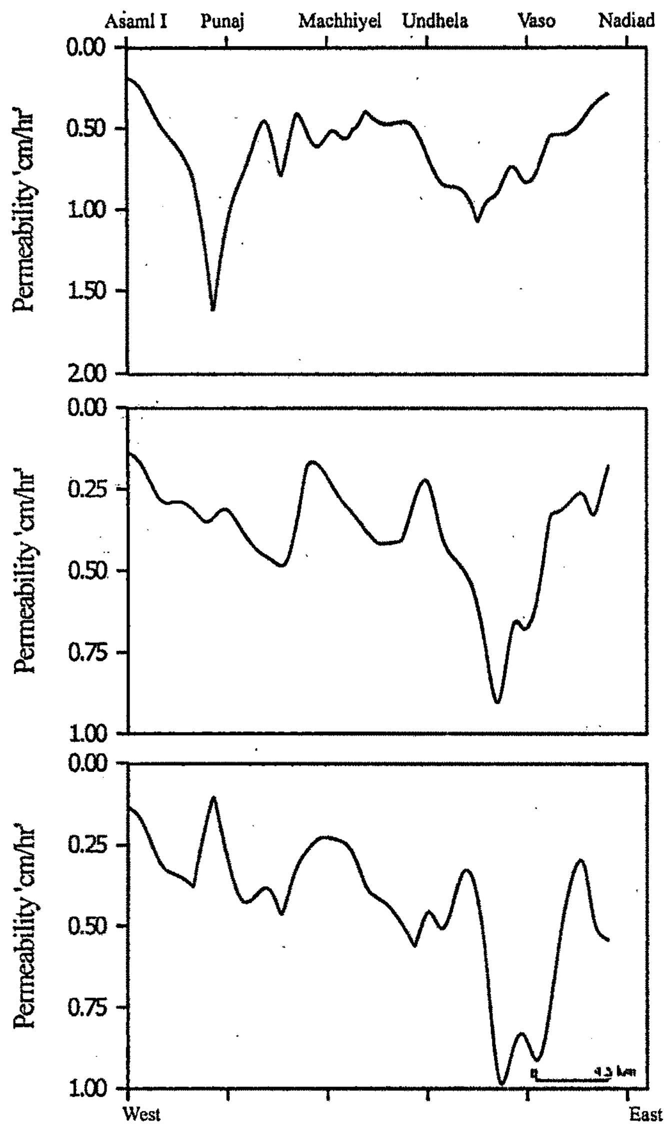


Fig. 7.22 Depth wise Variation in Permeability of Soils in Matar Command Area.

SOIL CHEMISTRY

Inadequate ionic concentration in the soils causes the harmful effects to the soil. As it has already been highlighted the study area is characterized by lack of adequate surface drainage, featureless topography, complex hydrogeological situation and, varying hydro-physical characteristics. The combined effect of these factors coupled with semi-arid climatic conditions has grossly modified an overall quality of the soils.

The study of chemistry of the soil holds vital significance in understanding the various physico-chemical processes, influencing the physical, hydraulic and fertility characteristics of the soils.

During the present investigation where in the aim was to study the impact of irrigation on the soil quality; the author has attempted to chemically examine the soil of Matar command area, by evaluating the different parameters viz., pH, Electrical Conductance, Soluble Cations (Na^{+1}, Ca^{+2}, Mg^{+2}, and K^{+1}) and Anions (Cl^{-1}, CO_3^{-2}, HCO_3^{-1}, and SO_4^{-2}), Exchangeable Cation (Na), Cation Exchange Capacity (CEC) and Exchangeable Sodium Percentage (calculation method); using standard analytical techniques suggested by Jackson (1940) and FAO bulletin 10 (1960). For this the author has carried out a detailed sampling on a specified grid pattern and at varying depths. In order to evaluate the seasonal changes, sampling has been done for different seasons.

HYDROGEN ION CONCENTRATION (pH)

The Hydrogen ions in soils are present primarily as exchangeable cations and equilibrium exists between the hydrogen ions in solution and as the exchange. This equilibrium shifts with changes in soil concentration, CO_2 content of the water, and soil : water ratio. Climatic parameter viz., temperature and precipitation has a major influence on soil properties and generally governs the intensity of leaching and weathering of soil minerals, influencing the acidity (pH 3-7), alkalinity (pH > 8.5) and salinity (pH 7-8.5) (Rowell, 1994).

As it has already been discussed in the preceding chapter on soil regime that the study area is predominated by 05 major soil sub-classes, ranging between sandy loam and clayey soils. The behavioral pattern of pH accordingly has been evaluated. Clays being negatively charged and having larger surface area has got tremendous cationic exchange capacity, therefore pH serves an important basis to evaluate the alkalinity and sodicity of the soils, particularly the clayey one (Miller and Donahue, 1997). As the soils exhibits

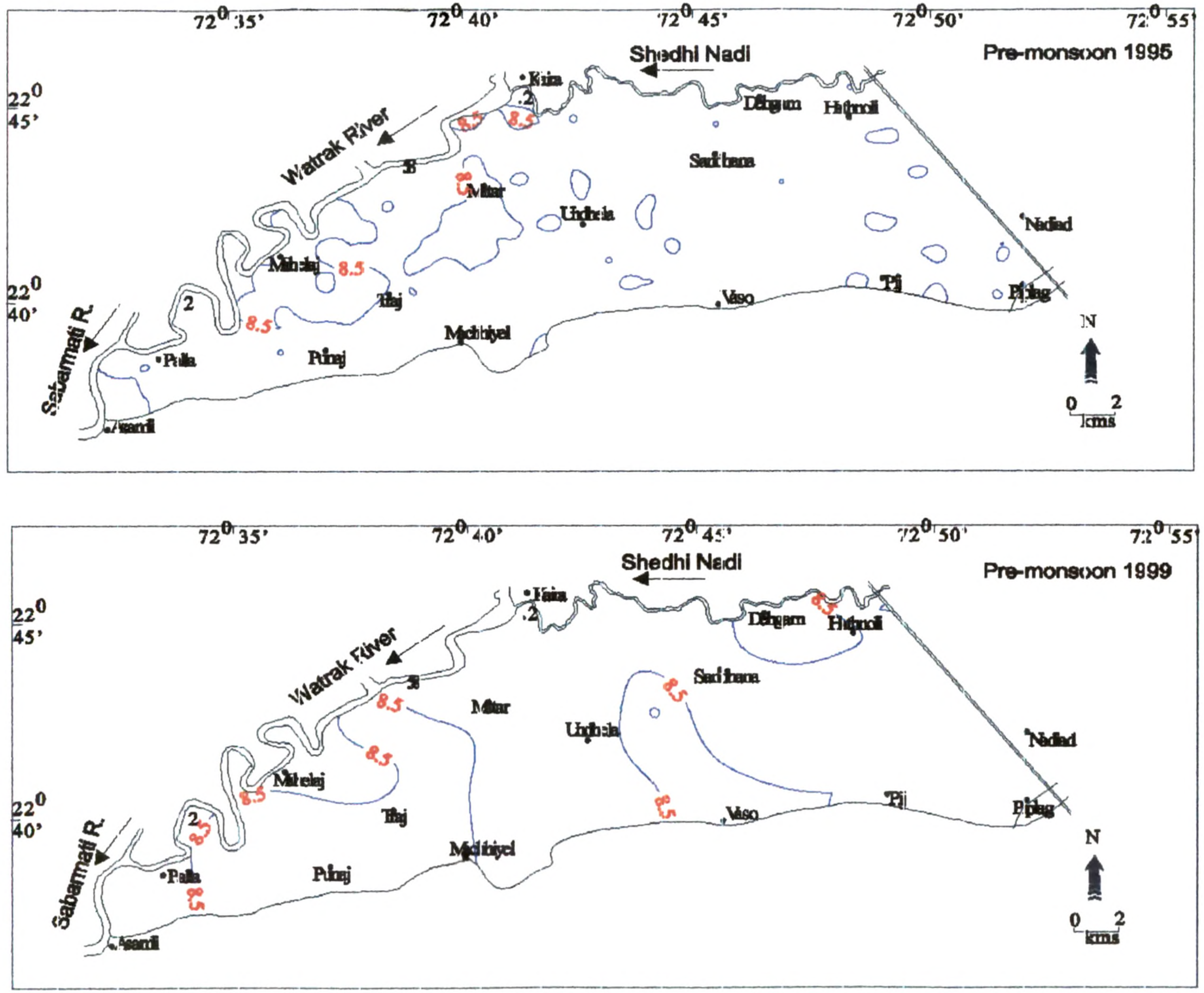


Fig. 7.23 Temporal Behaviour of pH of Soils in Matar Command Area. (Depth: 0-50 cm)

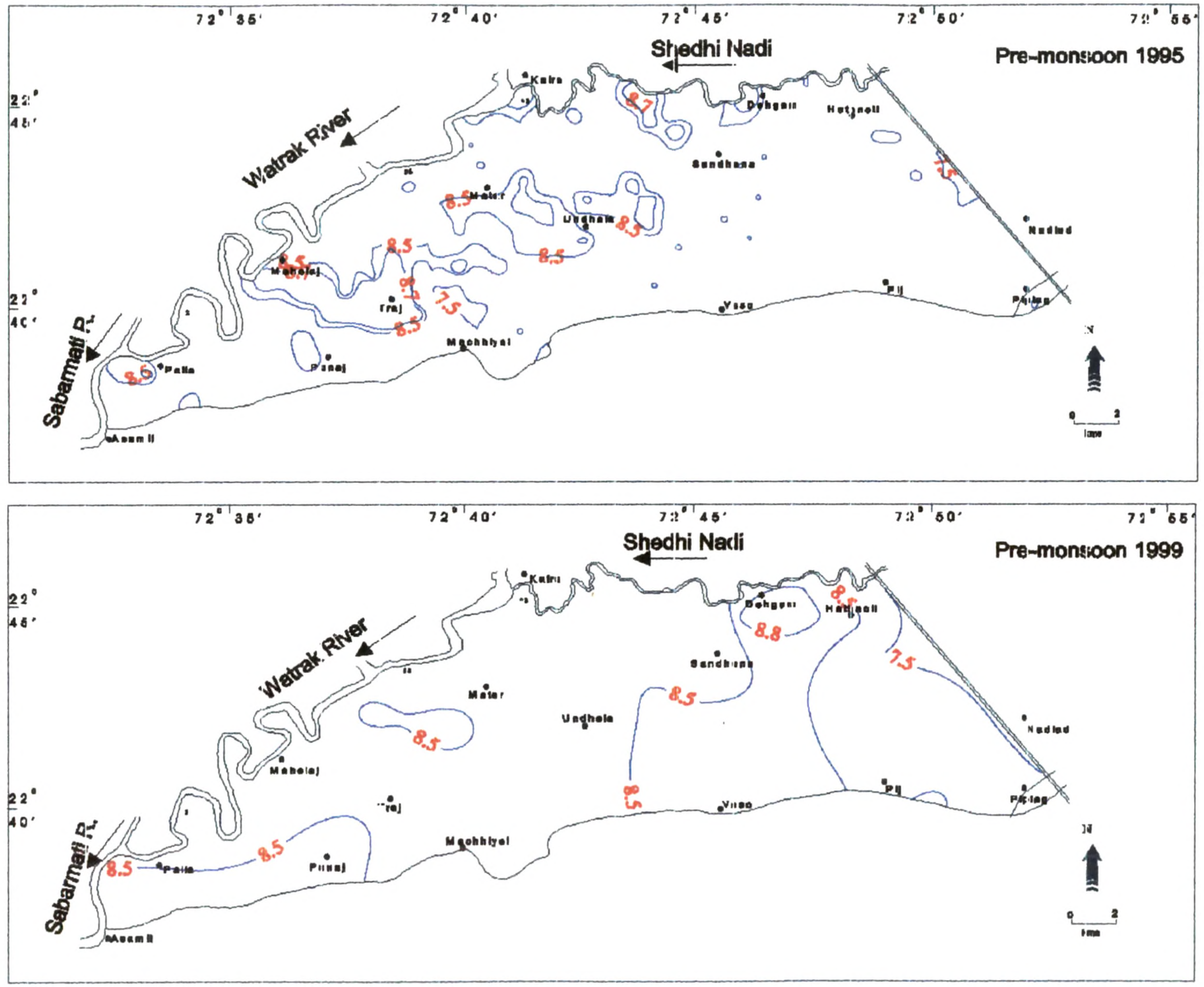


Fig. 7.24 Temporal Behaviour of pH of Soils in Matar Command Area. (Depth: 50-100 cm)

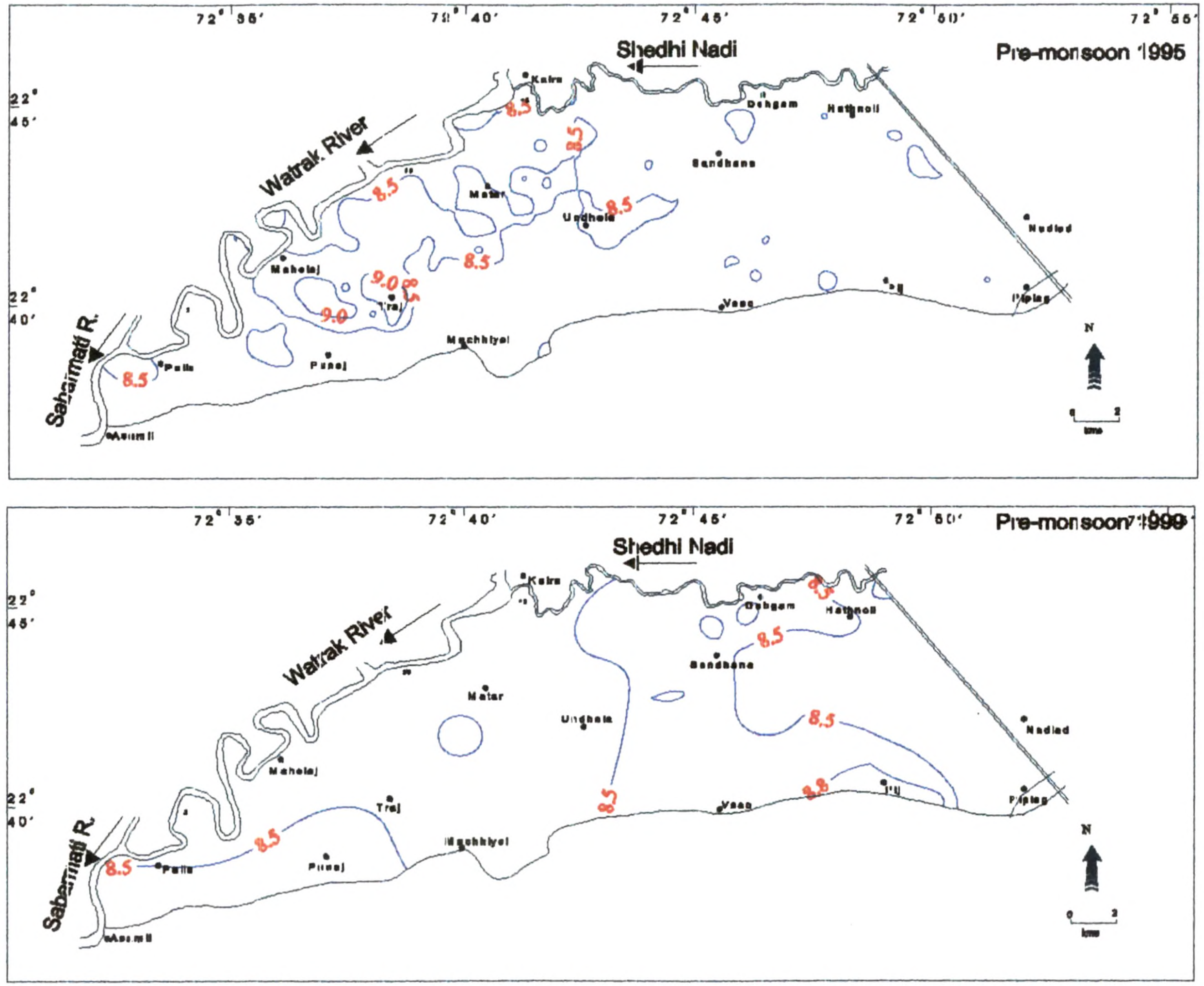


Fig. 7.25 Temporal Behaviour of pH of Soils in Matar Command Area. (Depth: 100-150 cm)

considerable compositional variations laterally as well as vertically; the author has made an attempt to evaluate the behavioral pattern of pH in two dimensions, by utilizing the pH data of 1995 and 1999 (Appendix I). So far surface soils are concern the pH values do not differ much. However, a general increase in pH has been observed as one moves from the upper command (east) to lower command (west). The pH values for the year 1995 is ranging between 7.9 and 8.8, while during 1999 it has increase and show a range between 7.7 and 8.9 (Fig. 7.23).

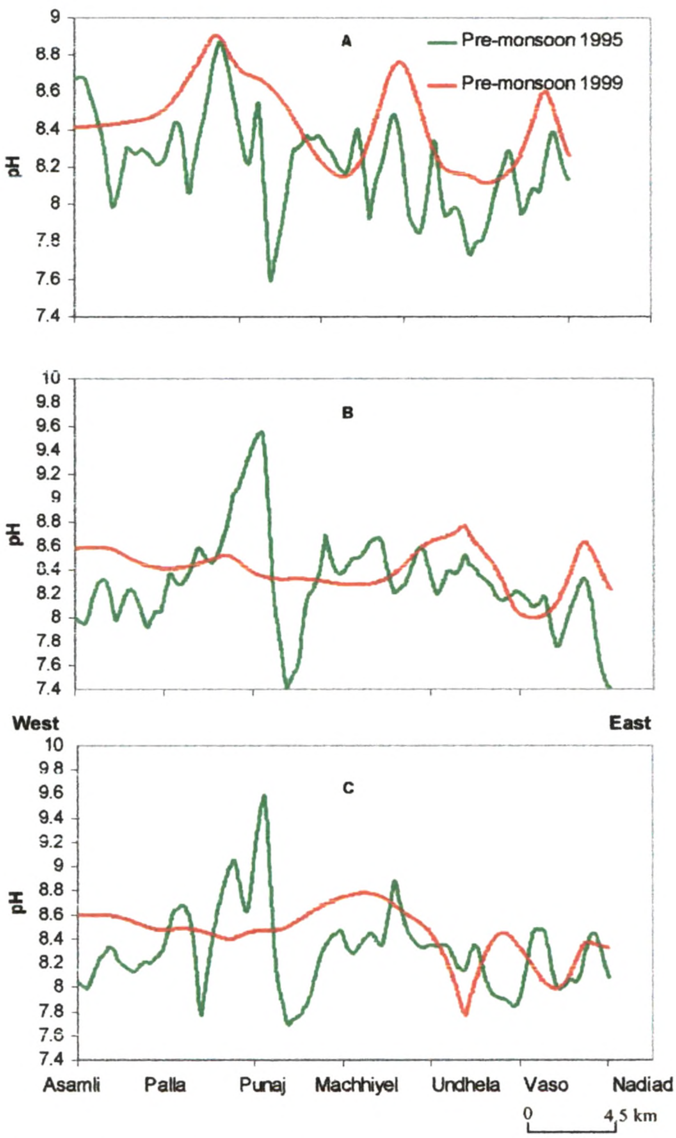


Fig. 7.26 Depth wise Temporal and Secular Behaviour of pH of Soils in Matar Command Area. A) 0-50 cm; B) 50-100 cm; C) 100-150 cm

Exceptionally higher pH has been observed around the localities viz., Palla, Punaj, Machhiyel, Undhela, and tend to decrease sub-surface. This corroborates that the surface soils are predominated by clayey sediment, which tend to become granular in depth.

Contrary to this, the upper command soils show opposite behaviour. However, the subsurface increase in pH may be attributed to predominance of calcareous contents. The constructed pH profiles along A-A' transact (Fig. 7.26) at various depths clearly indicates the changes in soils pH secular temporally as well as the depth wise.

Table 7.3 Secular Variations in Electrical Conductance of Soil in Matar Command.

Village	Depth	1958		1995		1999		Remark
	(cm)	EC*	PH	EC*	PH	EC*	pH	
Undhela	0-10	0.096	8.00	0.30	8.30	0.60	8.10	SL
	10--50			0.20	8.60	0.40	8.00	
	50-100			0.30	8.80	0.40	8.10	
	100-150			0.30	8.70	0.30	8.20	
Antroli	0-10	0.029	8.00	0.30	8.20	NA	NA	L
	10--50			0.30	8.60	NA	NA	
	50-100			0.40	8.40	NA	NA	
	100-150			0.70	8.50	NA	NA	
Sandhana	0-10	0.414	8.00	0.30	8.10	11.40	7.80	SCL
	10--50			0.20	7.90	7.20	7.90	
	50-100			0.20	8.10	8.40	7.80	
	100-150			0.20	8.00	3.60	7.50	
Haijrabad	0-10	0.065	8.00	0.90	8.60	0.40	7.90	LS
	10--50			0.60	8.50	0.50	7.90	
	50-100			0.50	8.40	0.20	8.00	
	100-150			0.30	8.40	0.20	8.40	
Alindra	0-10	0.414	8.00	1.70	8.10	1.50	8.10	SCL
	10--50			1.20	8.10	1.10	8.10	
	50-100			1.00	8.20	1.20	8.30	
	100-150			0.90	8.20	0.90	8.40	
Ratanpur	0-10	0.036	8.50	0.50	8.50	2.60	7.50	LS
	10--50			0.40	8.50	2.40	7.50	
	50-100			0.30	8.80	2.30	7.60	
	100-150			0.40	8.50	2.80	7.60	
Garmala	0-10	0.09	9.00	0.30	8.20	31.50	8.20	CL
	10--50			0.20	8.50	25.80	9.30	
	50-100			0.20	8.40	28.60	8.90	
	100-150			0.30	8.20	34.50	8.10	
Matar	0-10	0.029	8.00	0.50	8.80	2.60	8.20	CL
	10--50			0.40	8.80	2.80	8.10	
	50-100			0.40	8.60	2.20	8.20	
	100-150			0.30	8.60	2.30	8.20	
Aslali	0-10	0.207	10.00	0.50	8.30	3.30	8.40	CL
	10--50			0.80	8.10	2.90	8.41	
	50-100			0.70	8.00	3.60	8.46	
	100-150			0.70	8.10	3.80	8.56	
Punaj	0-10	0.03	8.00	NA	NA	4.70	8.00	C
	10--50			NA	NA	4.30	8.20	
	50-100			NA	NA	4.50	8.30	
	100-150			NA	NA	4.60	8.50	
* mmhos/cm	S: Sand	C: Clay	L: Loam	SCL: Sandy Clay Loam			NA: Data not available	

Similarly the soil type specific changes in the pH, EC and ESP for the years 1995 and 1999 for the study are is given in Table 7.3. The data clearly indicates that moderate textured soils are little responsive to pH as compared to the fine textured soils.

ELECTRICAL CONDUCTANCE

The salt content of the soil solution or irrigation water is usually represented in three ways as mg/lt, meq/lt and electrical conductance (Hansen, 1980). In the present investigation the electrical conductance has been used as measure of the salt content.

The spatial and temporal behaviour of electrical conductance of the soils at various depths has been evaluated using 1995 and 1999 data as well as pre-canal irrigation data wherever available. The change in electrical conductance level with respect to pre-canal irrigation scenario i. e. 1958 depicts sharp rise. During 1958 as the data suggests (Table 7.3) the command area soils were practically free from soil salinity hazard with EC values ranging between 0.029 and 0.414 mmhos/cm. subsequently on applying irrigation water the command area has experienced sharp rise in EC. The spatial distribution patterns of EC for the years 1995 and 1999 (Fig. 7.27) corroborate this fact. The observed EC range for the pre-monsoon 1995 was 0.5 - 3.5 that show sharp increase to 1.0 to 4.2 during pre-monsoon 1999. However, spatial distribution of EC shows an increasing trend from upper command to lower command. Also, the magnitude of rise in EC values is significantly high in lower command area, particularly the area around Palla, Punaj and Machhiyel.

In order to evaluate the changes in EC levels within the sub-soil horizons, the author has constructed sub-surface profiles (Fig. 7.28) of EC at various depth levels, for the three different seasons (pre-monsoon 1995, 1999 and post-monsoon 1999) along X-Y transact of the study area. It can be clearly seen through the EC profiles that the change in EC levels are of very higher magnitude i. e. 3.5 - 0.2, in surface and/or near surface soils. This may be on account of the climatic factors characterised by low precipitation and high temperature lead to the relatively limited leaching in the soil and high evaporation rate. As a result soluble salt reaching to the surface through capillary rise. This further lead to the higher salt concentration in the topsoil, which decreases as, traced deeper (Dan and Yaalon, 1982; Lavee et. al., 1991)

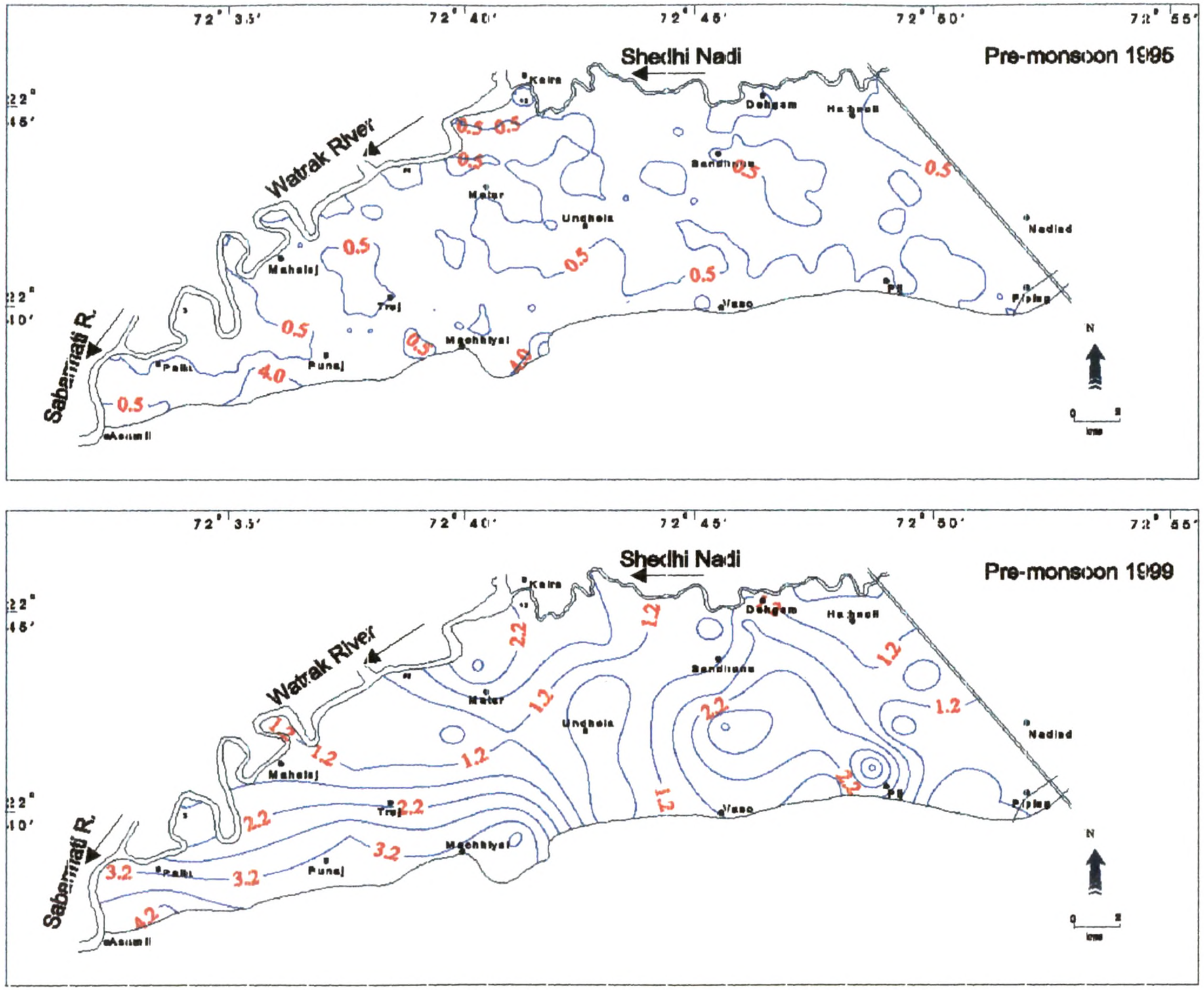


Fig. 7.27 Temporal Behaviour of Electrical Conductance of Soils in Matar Command Area. (Depth: 0-50 cm)

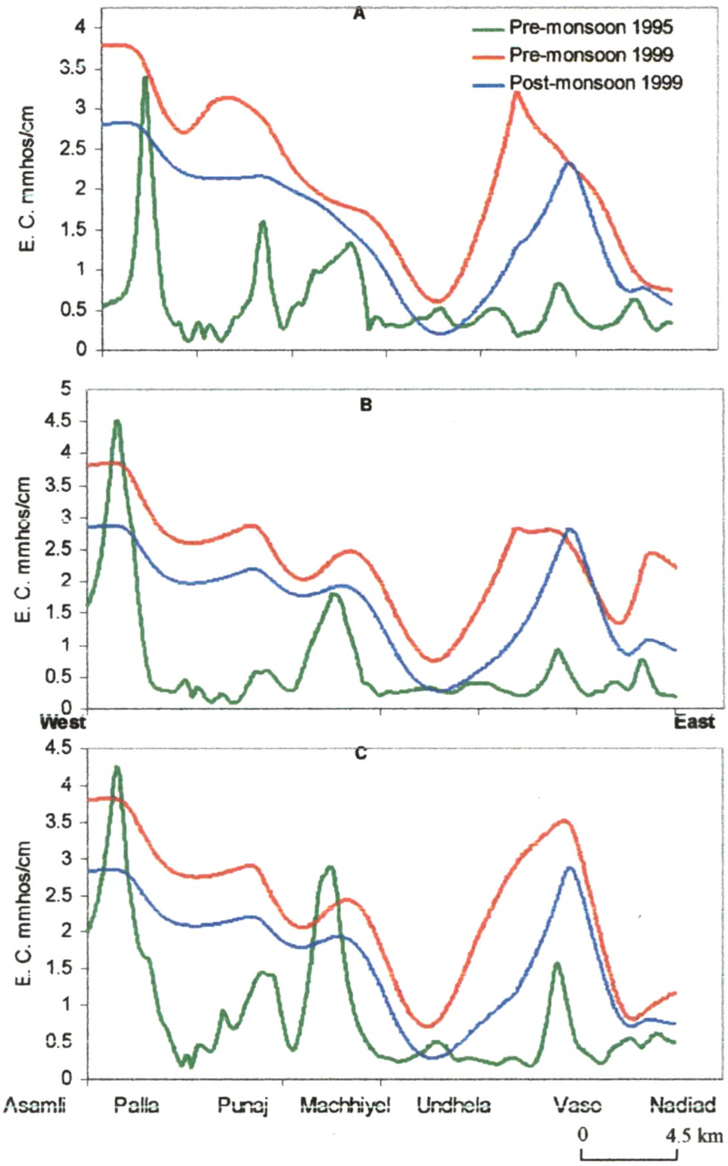


Fig. 7.28 Depth wise Temporal and Secular Behaviour of Electrical Conductance of Soils in Matar Command Area. A) 0-50 cm; B) 50-100 cm; C) 100-150 cm

The magnitude of change in EC levels for the deeper soil horizons at 100 and 150 cm depth is comparatively low i. e. 2.8 - 0.2. In all sub-soil EC profiles there exists two conspicuous peaks i. e. near Vaso (upper command) and Palla (lower command); these sharp changes in EC levels are attributed to clayey constituents forming a bulk composition of the soil. EC values for the post-monsoon season shows significant decline, this decline in EC level can be ascribed to the leaching and dilution of salt contents due to monsoonal recharge and canal water irrigation (Pariente, 2001). Long-term analysis of the electrical conductance for the soil has shown the general increase in the EC values over the command area. This increase in EC is of higher order in lower command area as compared to the upper command. The decrease in the EC in the sub-soil horizons may be attributed to threshold climatic condition, affecting the abiotic soil process and abiotic soil properties (Pariente, 2001). General increase in the salt concentration of surface soil layer with time may be attributed to several factors:

(I) The secular variation in the soil may be attributed to the drying and wetting cycles, which results in the upward migration of soluble salts through capillary rise and concentration increases as approached to the surface (Dan and Yaalon, 1982; Lavee et. al., 1991; Pariente, 2001).

(II) Ponding of water during monsoon in the micro-depression in topography (Singh and Nayak, 1999).

(III) Dust deposition that containing higher salt content brought from upper reaches (Pariente, 2001).

The variation in the electrical conductance of soil layers indicates the dynamic nature of the salt. The differentiation between soil layers with respect to soil water regime was described by Arkeley, 1963; Yaalon, 1964 a & b; Dregne, 1976; Dan and Yaalon, 1982. The dynamic nature of salt as on the one hand and rainfall and return irrigation seepage on the other hand greatly affects the surface soil layer up to 50 cm depth. Also the lower part of the area forms the tail end portion, and the soils being clayey have higher moisture holding capacity and lower permeability ultimately result in accumulation of salt laden water from upper command on the surface.

Taking in to account the available soil sub-classes and the behavioral pattern of the EC through time, the rise in the electrical conductance has followed the order Clay > Sandy Clay Loam > Clay Loam > Loam > Sandy Loam. The soils in the upper command area is characterised by the sandy loam and sandy clay loam texture, which has higher permeability and lower moisture holding capacity which allow the easy passage for the dissolve solid in the pore spaces carried out by the return irrigation water and seepage from the canal water.

IONIC CONTENT

Soluble salts, which may be present in the soil, consists mainly of the chlorides and sulfates of the calcium, magnesium or sodium. There are also small amounts of potassium, bicarbonate and carbonate, present in alkaline soils. Soils samples have been analyzed for determining the various dissolved cations and anions. The quantitative data of the soluble anions and cations for the different locations and for different seasons are given in Appendix I.

Soluble Cations

The overall concentration of the cationic content in the soils of study area shows Na > Ca > Mg > K order of abundance. Higher concentration of the sodium generally indicates the predominance of alkalization process and may be attributed to the precipitation of calcium-magnesium carbonate, owing to high pH conditions (Prasad, et al., 1999; Durgude, 1999; Challa et., al., 2000). It may also be on account of higher solubility of soils' mineral matter and get precipitated during the process of cation exchange (Gupta and Shah, 1994).

Sodium:

As it has already been mentioned that the soluble sodium content in the soils are found to be dominating over the other cations and its concentration ranges from 3.3 to 12.5 meq/l (pre-monsoon) and 3.3 to 13.5 meq/l (post-monsoon). The higher values of the soluble sodium is observed at the localities viz., Jharol, Pij, Raghvanaj, Khadiarapura. This higher concentration of sodium is attributed to the soils' mineralogical composition. In the study areas' case the soils are quartzo-felspathic nature. Slight seasonal increase in the soluble sodium content can be ascribed to accumulation of the soluble sodium leached out due to return irrigation water and seepage from the canal water causing fluctuation in water table as well as capillary rise.

Calcium and Magnesium

Calcium content of the soils in the study area is ranging between 0.02 to 2.0 meq/lt. The maximum concentration is observed at the localities viz., Pij, Palana, Vansar, Raghvanaj, Palla, Kharenti, Punaj. During post-monsoon season the data show slight increase in its concentration which ranges between 0.05 and 2.6 meq/l. Soils are invariable rich in the magnesium content than that of the calcium. The concentration of magnesium is in the range of 0.5 - 18.0 meq/l (post-monsoon) and 0.5 - 14 meq/l (pre-monsoon) periods. The higher values of the magnesium content may be attributed to the presence of micaceous and chloritic clay minerals (Hesse, 1994).

Potassium:

The concentration of soluble potassium in Matar command soils is found to be 1-2 meq/l. this extremely low concentration of soluble potassium is attributed to very low solubility of potassium bearing minerals viz., orthoclase and mica and also very low mobility in soil solution (Miller and Donahue, 1997).

Soluble Anions

The order of concentration of the soluble anions in the soil solution is Cl > SO_4 > HCO_3. The chloride content increases with the increase in EC (Hesse, 1994). Also, the carbonate content is absent and bicarbonate content is least among the available anions, which may be attributed to the precipitation of the calcium and magnesium as carbonates or bicarbonates.

Carbonate and Bicarbonate:

Soil in the command area are devoid of the carbonate content, where as the bicarbonate content found to be ranging between 0.3 to 7 meq/l and does not show any significant change during the post-monsoon season. At certain localities viz., Traj, Palana, Dantali, Sandhana its concentration is as high as 12.5 meq/l; these location are characterised by clayey soils.

Chloride:

The chloride is the most dominant among the anions. The chloride content in the soil during the year pre-monsoon 1999 found to be ranging between 0 and 10 meq/l, it exhibits marginal increase during the post-monsoon period i. e. upto 13 meq/lt. The anamolously higher values up to 17 meq/l are obtained from the clayey loam and clayey textured soils in lower command areas.

EXCHANGEABLE CATIONS

Cations exchange is an important reaction in soil fertility, in causing and correcting soil acidity and basicity, in changing altering soil physical properties, and as a mechanism in purifying or altering percolating waters (Miller and Donahue, 1997). A soil leached with a salt solution has a capacity to adsorb the cations of the percolating solution and also to liberate an equivalent amount of other cations. Different cations have different power of replacement, depending upon their dominance (Kelley, 1964). The predominant cations involved in exchange are hydrogen, calcium, magnesium, potassium, sodium and ammonium. As the sodium predominates among the soluble exchangeable cations for the present study only exchangeable sodium is evaluated.

In order to identify the level of exchangeable sodium under seasonal changes the samples have been analyzed for both the pre- and post-monsoon seasons and it has been found that the data does not show much variation in the exchangeable sodium content. Contour diagrams (Fig. 7.29) and cross profiles (Fig. 7.30) were prepared to study the spatial and temporal changes in exchangeable sodium. For this samples at specified grids and 50-100-150 cm depths were collected. The evaluation of exchangeable sodium concentration for the periods 1995 and 1999 has brought out the following inferences:

1. In the surface soils, there is a significant increase in exchangeable sodium from pre-monsoon 1995 (5 meq/ 100 gm of soil) to pre-monsoon 1999 (7.5 meq/ 100 gm of soil) in lower command area; which is depicted by an enlarged maxima around Traj and Matar (Fig. 7.29). This rise in ES may be attributed to the predominance of clayey soils.
2. Contrary to this the upper command area exhibits decrease in ES from 2.5 to 0.5 meq/ 100 gm of soil in a span of 05 years. This decline in ES may be attributed to the presence of granular soils with appreciable drainability.

Various ES profiles prepared along X-Y transact for the different sub-soil horizon depths (Fig. 7.30).

ES levels show sharp rise in lower command area i. e. west of Traj. This trend continues up to the 150 cm depth. Downward increasing values of the ES corroborate clayey nature of soils. While decrease in ES values in upper command pre-monsoon 1995 to 1999 may be accounted to sandy/granular soils. The observed seasonal fluctuation in ES may be attributed to combination of factors:

(I) The soils are of sandy clay loam in the upper command and clay or clayey loam in the lower command, which has comparatively higher porosity and lower permeability.

(II) Higher order of seasonal fluctuation in the groundwater.

(III) Exchangeable sodium of the soil solution has been replaced by Ca or Mg from the groundwater (Ionic Exchange) (Rai, 1995).

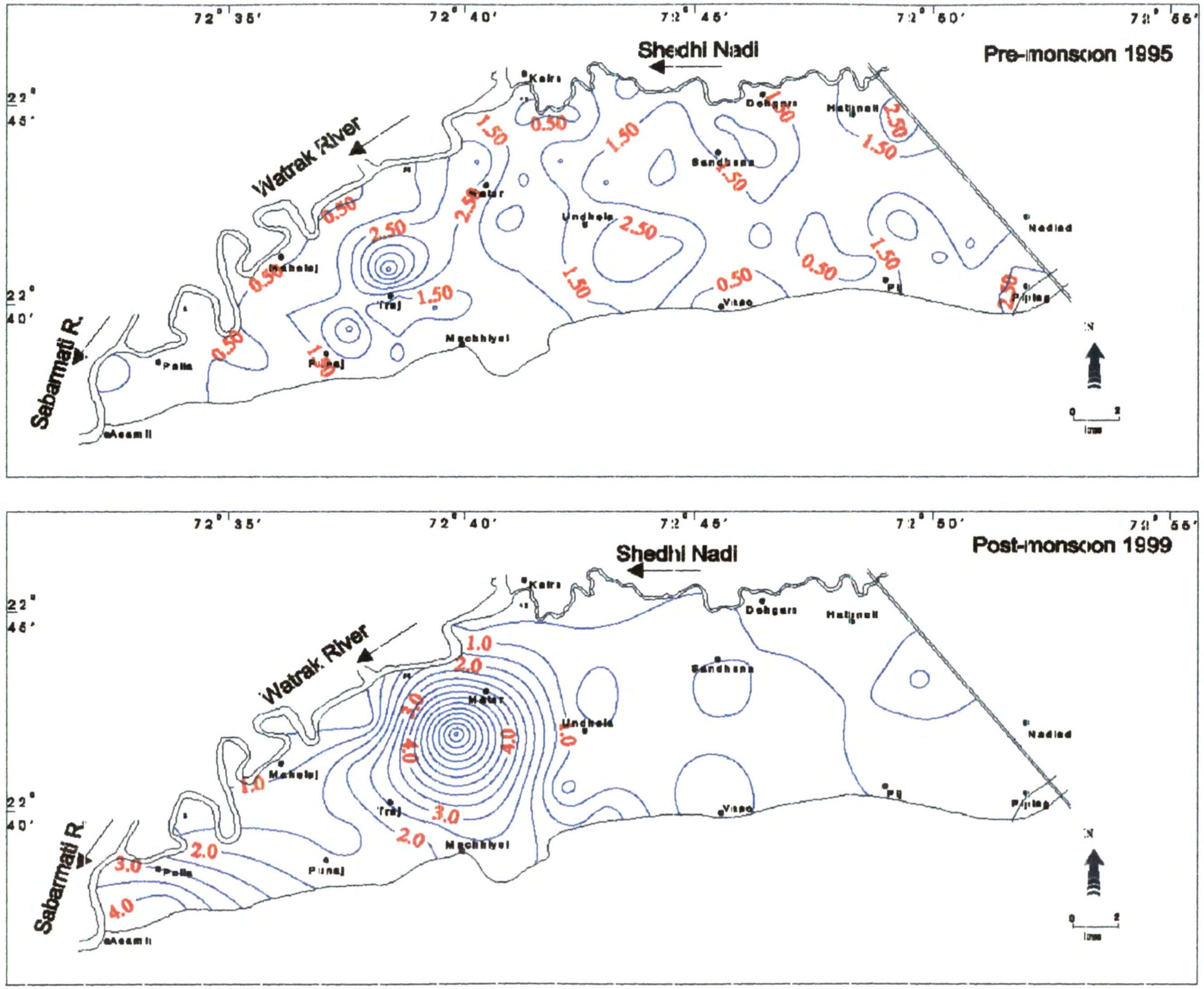


Fig. 7.29 Temporal Behaviour of Exchangeable Sodium of Soils in Matar Command Area. (Depth: 0-50 cm)

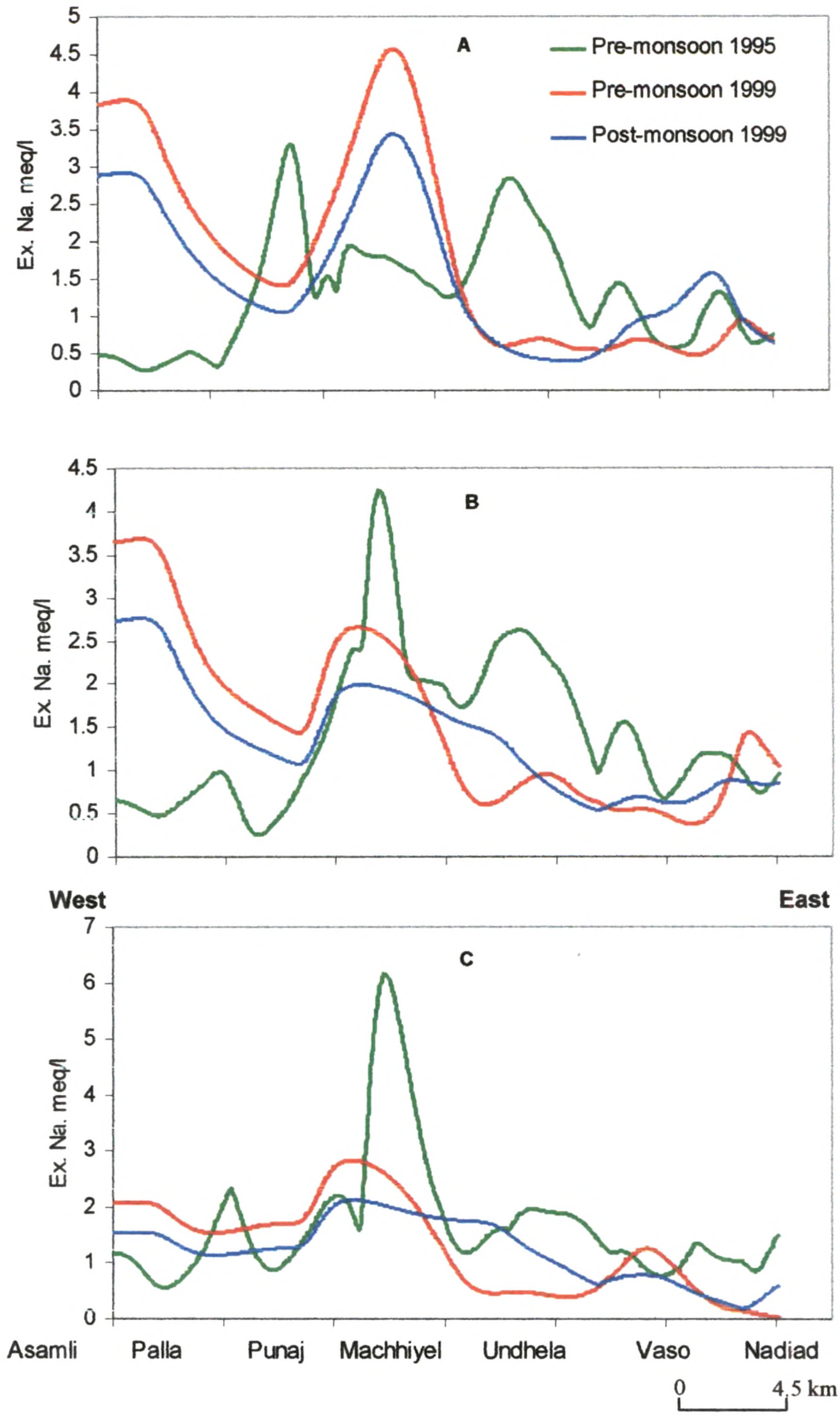


Fig. 7.30 Depth wise Temporal and Secular Behaviour of Exchangeable Sodium of Soils in Matar Command Area. A) 0-50 cm; B) 50-100 cm; C) 100-150 cm

A summary on observed ES for different soil types, subsoil horizons and temporal behaviour is given in Table 7.4.

Table 7.4 Spatial and Temporal Behaviour of Exchangeable Sodium in Matar Command area

Soil Type	Depth (cm)	1995	1999
		Ex Na meq/ 100 gm of soil	
Sandy Loam			
	0-50	0.70-1.50	0.10-0.60
	50-100	0.90-1.90	0.10-1.00
	100-150	0.60-2.70	0.10-0.60
Fine Sandy Loam, Loam			
	0-50	0.40-1.70	0.10-0.60
	50-100	0.40-1.80	0.10-0.57
	100-150	0.40-1.50	0.10-0.43
Sandy Clay Loam			
	0-50	0.30-1.50	0.10-1.15
	50-100	0.30-1.70	0.10-1.82
	100-150	0.30-1.80	0.10-1.80
Clay Loam			
	0-50	1.0-3.20	1.00-2.80
	50-100	1.0-2.30	1.30-2.90
	100-150	1.0-2.10	1.10-2.36
Clay			
	0-50	3.00	1.16-1.60
	50-100	2.80	0.60-2.10
	100-150	5.60	1.00-2.40

CATION EXCHANGE CAPACITY:

CEC is expressed as amount of exchangeable cations per unit weight of soil and it is measured as meq/100 gm of soil. The cation exchange capacity is usually measured by leaching the soil or colloid with 1 N salt solution buffered at a neutral or slightly alkaline (8.2) pH value to avoid secondary effects due to a change of hydrogen ion concentration during saturation (Jackson, 1940). The author has determined the cation exchange capacity following the standard method described in Jackson (1940).

The results indicates that the Cation Exchange Capacity of the surface soil during the pre-monsoon (1995) period it was ranging between 5-55 meq/ 100 gm of soil. Invariably higher values have been observed at the Silod, Hathnoli, Dabhan, Tundel, Haijrabad, Traj, Palla, Kharenti, Punaj having clayey texture soils. The Cation Exchange Capacity in the pre-monsoon 1999 shows considerable increase in CEC i. e. 5-75 (Fig. 7.31).

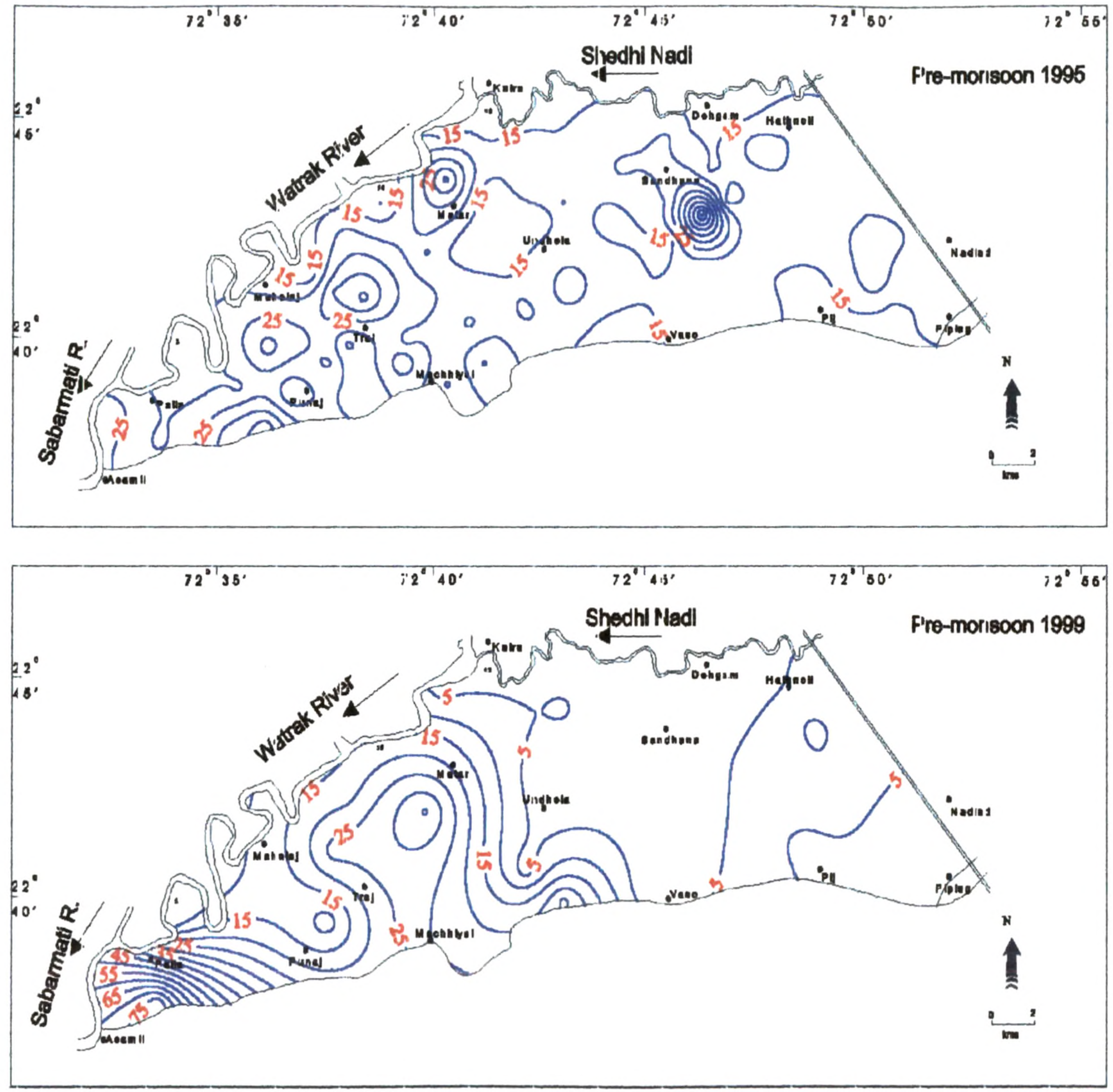


Fig. 7.31 Temporal Behaviour of Cation Exchange Capacity of Soils in Matar Command Area. (Depth: 0-50 cm)

This sharp rise in CEC is restricted to the lower command area, which is characterised by clayey soils. The upper command area for this period show sharp decline in CEC with the maximum value of 5 meq/100 gm of soil. This reduction in CEC may be attributed to granular nature of soils, responsible for rapid movement of groundwater to lower reaches.

The distribution of the cation exchange capacity of the soils at varying depths in command area has been attempted with the help of CEC profiles constructed along X-Y transact (Fig. 7.32). Broad salient features of the plotted CEC profiles are as under:

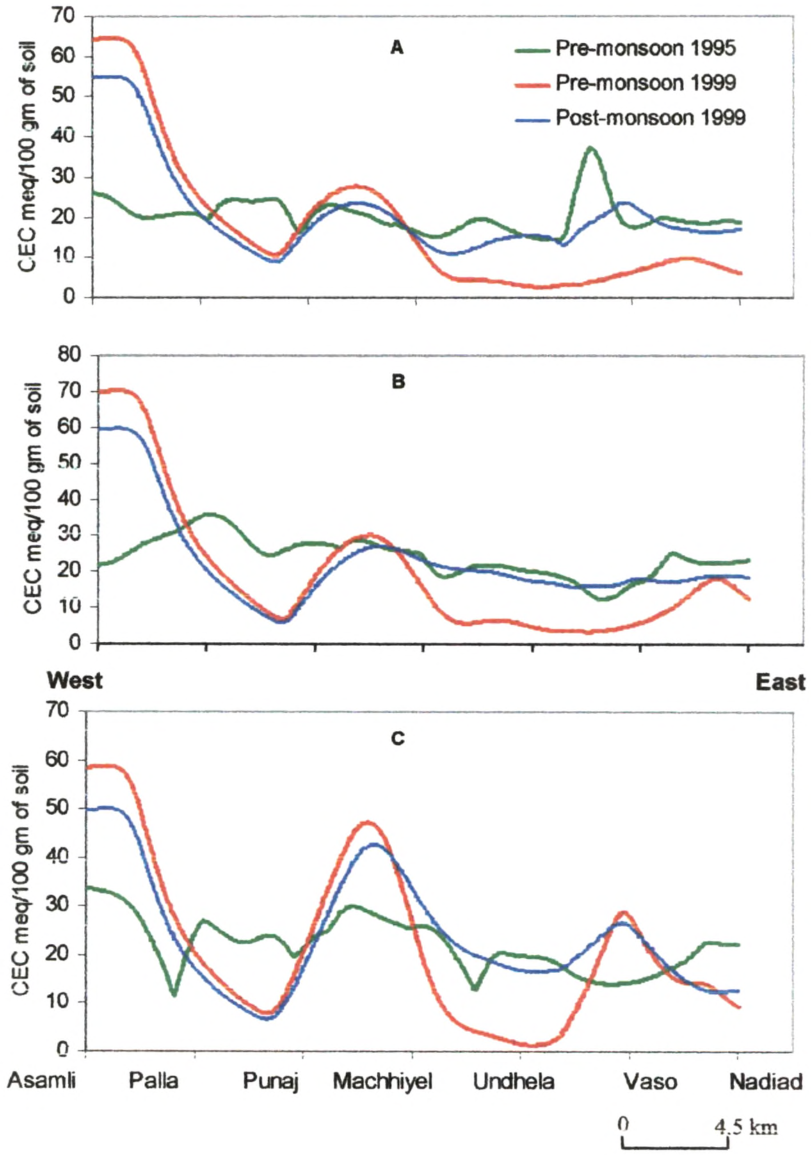


Fig. 7.32 Depth wise Temporal and Secular Behaviour of Cation Exchange Capacity of Soils in Matar Command Area. A) 0-50 cm; B) 50-100 cm; C) 100-150 cm

1. From pre-monsoon 1995 to 1999 the CEC level shows declining trend in upper command area soils at 50 cm depth. However, in the lower command there is a perceptible rise of almost 40 meq/100 gm of soil. CEC values show marginal decline during post-monsoon period all through out the profile. This may be attributed to dilution due to excessive recharge.
2. CEC values at the lower sub-soil horizons i. e. 100 and 150 cm more or less remain constant in upper command; thereby signifying homogenous nature of soils. However, in the lower command CEC tend to increase at 100 and 150 cm depths. This point to clayey nature of sub-soils as well as reversibility characteristic of cation exchange process (Rai, 1995).

A summary on observed CEC for different soil types, sub-soil horizons and temporal behaviour is given in Table 7.5.

Table 7.5 Spatial and Temporal Behaviour of Cation Exchange Capacity in Matar Command area

Soil Type	Depth (cm)	1995	1999
		CEC meq/ 100 gm of soil	
Sandy Loam			
	0-50	9.60-16.00	0.63-10.62
	50-100	11.00-20.00	0.66-18.20
	100-150	12.00-22.00	0.77-12.54
Fine Sandy Loam, Loam			
	0-50	12.00-14.00	0.74-5.53
	50-100	12.00-17.00	1.18-4.57
	100-150	10.00-17.00	0.44-4.95
Sandy Clay Loam			
	0-50	7.80-15.00	1.90-11.24
	50-100	16.00-21.00	1.34-7.56
	100-150	15.00-24.00	1.92-6.73
Clay Loam			
	0-50	2.60-15.00	8.80-13.00
	50-100	1.40-25.00	3.10-13.2
	100-150	3.10-21.00	7.95-10.70
Clay			
	0-50	32.00	
	50-100	33.00	
	100-150	33.00	

EXCHANGEABLE SODIUM PERCENTAGE:

ESP is the amount of exchangeable sodium expressed as a percentage of the cation exchange capacity. At an ESP of between 10 and 15 clays are liable to swell and disperse, causing deterioration of soil structure, particularly when the soil solution is diluted by rainwater or low salinity irrigation water is applied (Shainberg and Letey, 1984). The deterioration soil structure due to highest ESP has several adverse effects (Shainberg, 1985):

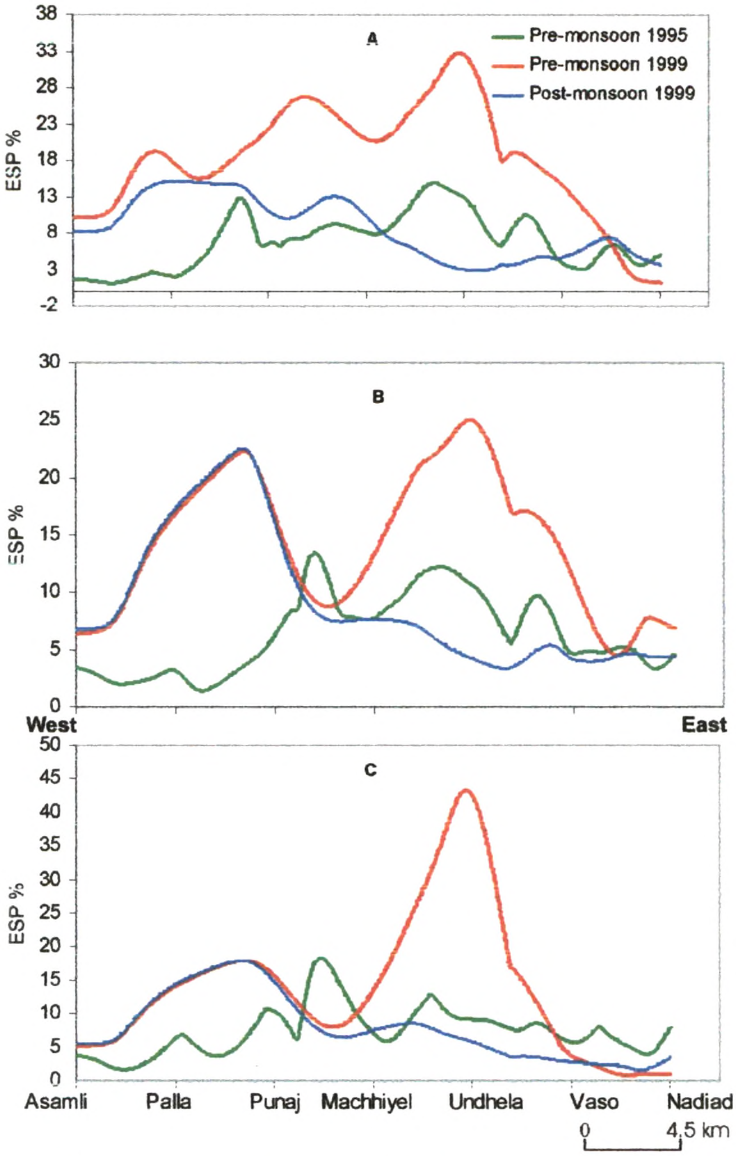


Fig. 7.33 Depth wise Temporal and Secular Behaviour of Exchangeable Sodium Percentage of Soils in Matar Command Area. A) 0-50 cm; B) 50-100 cm; C) 100-150 cm

1. Heavy textured soils become more sticky and plastic under wet and dry conditions, leading to the cultivation problems.
2. Considerable decrease in soils' hydraulic conductivity, leading to ponding on the soil surfaces thereby difficulties in leaching out the salts from soil profile.
3. Saturated soils restrict the air entry, and anaerobic conditions may develop, causing denitrification and production of plant toxins.

ESP constitutes an important norm for classifying the soil sodicity i. e.

Sodic Soils ESP > 15 %

Non-sodic Soils ESP < 15%

The spatial and temporal behaviour of ESP of the surface soils of Matar Command area has been evaluated by considering ESP data for pre-monsoon 1995 and 1999 periods (Appendix I). Level of ESP during pre-monsoon 1995 period was ranging between 5 and 17 while 1999 pre-monsoon data show considerable rise in ESP (Fig. 7.33). The lower limit of ESP remained same by the upper limit has almost doubled i. e. 40. Particularly the central parts of the command area i. e. around Undhela-Sandhana villages, rise in ESP is very perceptible.

Broad characterization of Exchangeable Sodium Percentage values from the year 1995 to 1999 with relation to study areas soil sub-classes (Table 7.6) show considerable increase. The response to ESP change is more pronounced in case of sandy loam and clayey soils. These soils are fast attaining the sodicity where as the moderate textured soil i. e. fine sandy loam and loam, the ESP show an overall decrease. Similarly, sub-soil horizons exhibits an overall decrease in ESP values.

Table 7.6 Spatial and Temporal Behaviour of Exchangeable Sodium Percentage in Matar Command area

Soil Type	Depth (cm)	ESP %	
		1995	1999
Sandy Loam			
	0-50	3.10-15.00	2.27-18.70
	50-100	4.00-14.00	1.87-16.30
	100-150	5.00-17.00	1.58-19.92
Fine Sandy Loam, Loam			
	0-50	1.60-12.00	8.21-11.17
	50-100	3.60-12.00	4.79-9.35
	100-150	3.60-14.00	5.84-9.61
Sandy Clay Loam			
	0-50	1.90-16.00	1.85-37.88
	50-100	1.50-20.00	2.38-31.80
	100-150	2.00-22.00	6.66-29.52
Clay Loam			
	0-50	0.80-12.00	5.64-24.05
	50-100	0.50-12.70	4.34-23.23
	100-150	0.50-10.70	2.84-16.82
Clay			
	0-50	1.50-9.40	1.08-9.32
	50-100	0.50-3.70	0.81-8.36
	100-150	0.50-2.40	1.08-9.46

This observed rise in the clayey and sandy loam soils is attributed to the increase of the exchangeable sodium and decrease in Cation Exchange Capacity i.e. replacement of the cation by Exchangeable Sodium (Chhabra 1995). Therefore, the behavioral pattern of ESP corroborates that area is witnessing the increase in electrical conductance, negligible changes in the pH values and trend of the rise in the ESP indicates the development of the saline and alkali soils and the order of salinity to alkalinity hazards would stands as Clayey > Clayey Loam > Fine Sandy Clay Loam > Sandy Clay Loam > Sandy Loam.

FERTILITY OF SOILS

Soil fertility plays a key role in increasing crop production both quantitative and qualitative. It is the quality that enables the soil to provide proper nutrients in required amounts for the easy growth of plants. Soil fertility, does not mean only the supply of nutrients but also their efficient management. However, soil degradation, which is the out come of unhealthy anthropogenic interaction viz., excessive use of fertilizers, pesticides, growth regulator and water; with natural soil environment causing salinisation, alkalinisation, waterlogging etc., particularly in semi-arid regions.

The evaluation of soil fertility includes:

- Measurement of the available plant nutrients content of the soil and
- Estimation of the capacity of a soil to maintain a continuous supply of plant nutrients for a crop.

The quality of soils from the point of view of its fertility is usually judged by evaluating N, P, K, and organic carbon as nutrients. The standards used for evaluating soil fertility in relation with nutrients level suggested by the Indian Council for Agricultural Research (ICAR, 1987) are given as under:

Critical Level of Plant Nutrient in Soil

Nutrients	Low	Moderate	High
O. C. (%)	< 0.40	0.41-0.80	> 0.81
Available N (kg/ha)	< 250	250-500	> 500
Available P (kg/ha)	< 20	20-40	> 41
Available K (kg/ha)	< 150	150-250	> 251

Organic Carbon:

The organic matter is an important component of the soil that contributes to soil fertility. It is obtained by estimating organic carbon from soil. The organic matter in a soil comes from decay of plants and animals. The organic carbon occurs in soil in elemental form (Coal Graphite, etc.); in the inorganic forms of carbonate, hydrogen carbonate and carbon dioxide; and organically as plant and animal matter, their immediate decomposition products and the more resistant humus. Organic matter assists in improving the soil fertility in variety of ways (Tamhare et. al., 1964):

1. It increases the water holding capacity of soil
2. It serves as a reservoir of chemical elements in the soil.
3. After decomposition it produces organic acids and CO_2 which helps to dissolve the minerals.
4. It reduces evaporation losses of water.
5. It helps in the reduction of alkalinity of the soils.
6. Improves physical properties of the soils.

The analytical data on soil fertility nutrients for the year 1999 (Appendix II) of the soils in the Matar command area ranges between 0.73 and 0.16 %. On comparison of these obtained values with the standard norms as recommended by the ICAR the organic carbon content of the soils fall with in the group of Moderate to Low fertility class. Majority part of the lower command area belongs to low fertility class. Whereas the soils of the upper command area falls under the moderate fertility class. The values of the organic carbon during the post-monsoon period ranges between 0.65-0.13 %. Therefore, the fertility status of the soil does not change in the fertility status during the post-monsoon period.

So far spatial distribution is concern, the author has prepared the contour diagram for both pre-monsoon and post-monsoon 1999 seasons (Fig. 7.34). The contour diagram for pre-monsoon season indicates that concentration of the organic carbon content in the lower command is increasing from periphery to the interior command area. Whereas during the post-monsoon season the situation is just reverse (values increases from interior command to peripheral area). Contour diagram for the sub-soil layers (i.e. depth > 50 cm) not support the above observation. The fertility of the soil in terms of organic carbon decreases with depth. The decrease is almost 50 % of the surface values.

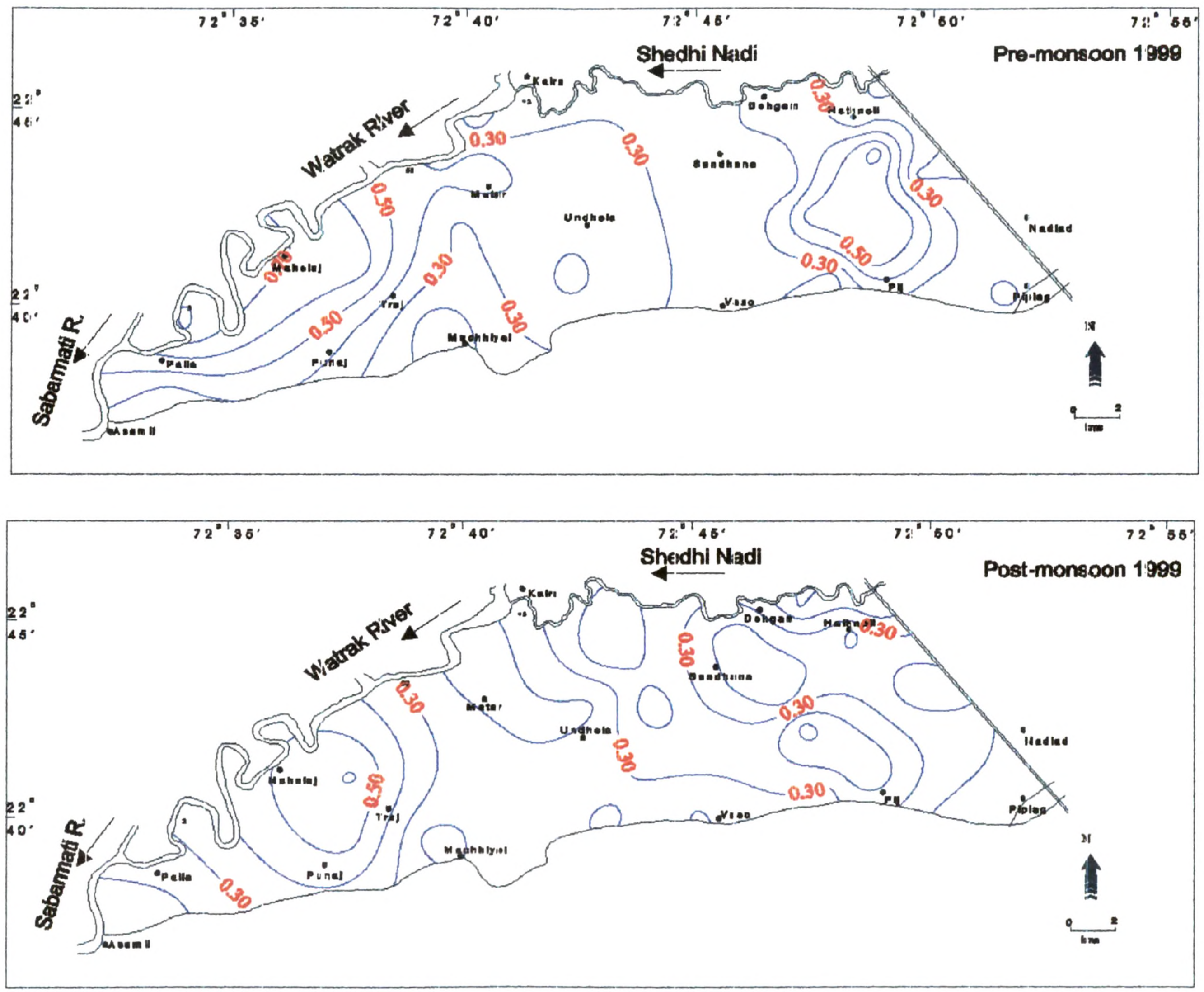


Fig. 7.34 Seasonal Behaviour of Organic Carbon Content of Soils in Matar Command Area.

This observed seasonal behaviour in organic carbon content might be attributed to the (I) Flushing of the organic carbon by rainfall and/or return irrigation seepage. (II) The low application of organic manure and higher application of chemical fertilizer during kharif season (Miller and Donahue, 1994).

Available Phosphorous:

Deficiency of Phosphorous content in soil leaches to low crop production. The importance of the phosphorous in plant nutrition is manifold. The phosphorous content of the soil improves the fertility and plays key role as (Tandon, 1997):

- It is essential for growth, cell division, root growth and elongation seed and fruit development
- It helps in energy storage and transfer.
- It is a constituent of several organic compounds including oils and amino acids.
- Phosphate ion enters the soil solution either as a result of mineralisation of organophosphate or the application of fertilizer.

Soil phosphorous can be considered as non-available, potentially available and immediately available. Immediately available phosphorous is the inorganic form occurring in soil solution as orthophosphate. Plants normally unable to absorb phosphorous directly from solid compounds or from organic phosphorous compound even though the latter may be available in soil solution form. The most important form of potentially available phosphorous occurs both as organic and inorganic forms.

The data on the study areas' soil phosphorous content (appendix II) analyzed for the pre-monsoon 1999 season (Fig. 7.35) show P_2O_5 content ranges between 0.98 to 4.00 kg/ha, falling under the range of higher to low class of ICAR (1987) classification. The lower command soils are falling under the low fertility class, where as that of the upper command are falling under moderate to high fertility class. The higher soil phosphorous values are mainly shown by the surface soil i. e. up to depth of 50 cm, where as sub-soils at the depth of 50-100 cm and 100-150 cm shows 15-75 kg/ha.

The contour diagrams for post-monsoon 1999 season (Fig. 7.35) shows decrease in soil area with high fertility and comparative increase in moderate and low fertility class of soils. This seasonal variation in soil phosphorous content may be attributed to flushing or washing away of phosphorous with the rainwater or excessive irrigation during the kharif season.

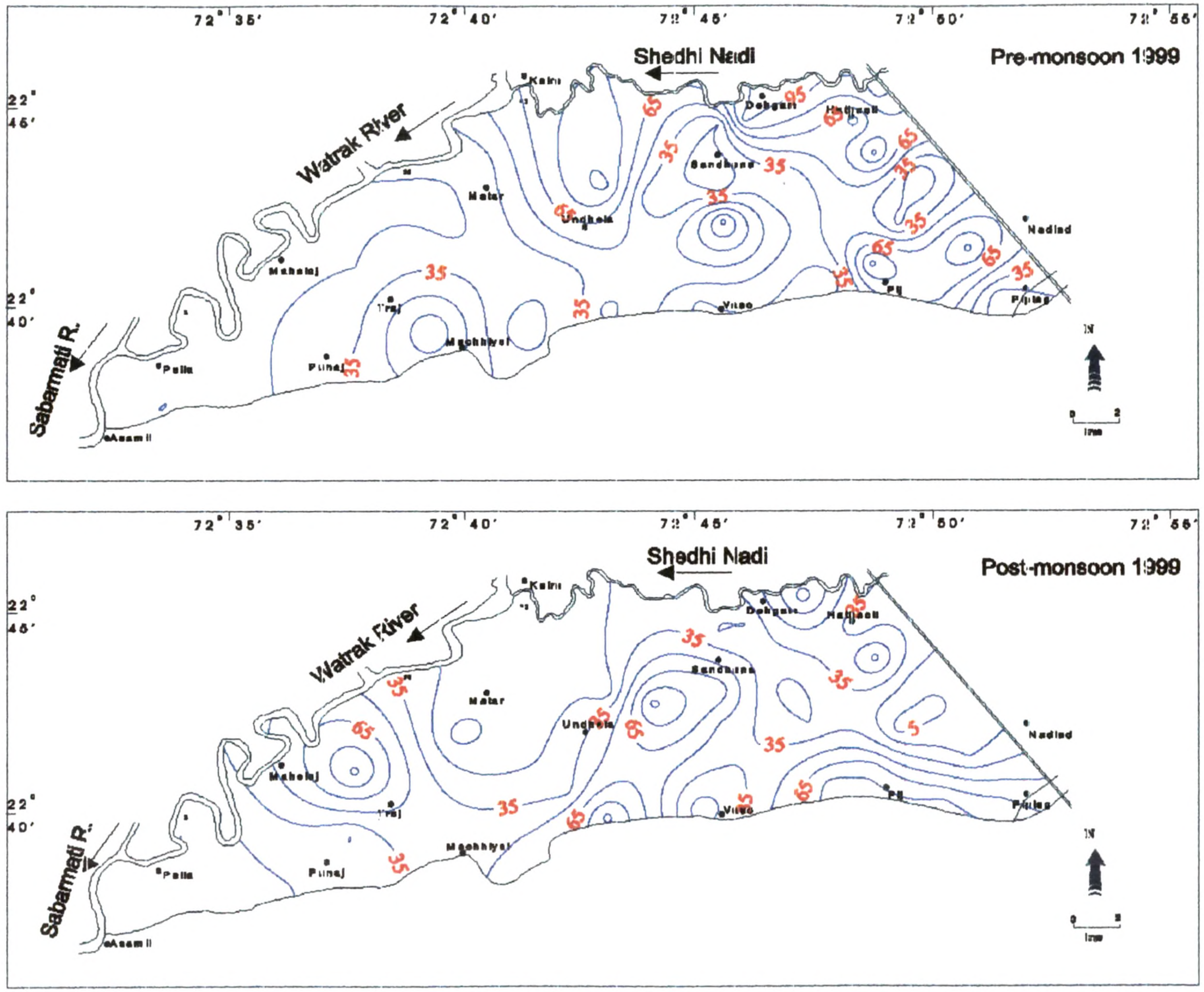


Fig. 7.35 Seasonal Behaviour of Available Phosphorous Content of Soils in Matar Command Area.

Available Potassium:

The potassium content of the soil depends primarily upon the parent material and degree of weathering. In weakly weathered soils the feldspars and micas are the most abundant potassium bearing minerals except Illite. Most of the soil potassium occurs in non-exchangeable form.

Williams (1962) has classified the status of potassium in to soil as:

(I) The immediately available, water soluble and exchangeable.

(II) Moderately available but as fixed potassium.

(III) Unavailable i. e. very slowly available potassium bounded in lattice and released upon weathering.

Micaceous clay is largely responsible for release of exchangeable potassium from non-exchangeable potassium (Rouse and Bertramson, 1950). Very high potassium content in a soil may induce iron chlorisis and magnesium deficiency. The deficiency of the K_2O in soil may result in to

- Decrease in protein formation from amino acid.
- Limitation in carbohydrate production and thereby the leaf area and weak crop yield both quantitatively and qualitative.
- Poor keeping quality of fruit.
- Increase in deceasc susceptibility.
- Increase in incidence of low temperature damage and retardation of maturity. (Rouse and Bertramson, 1950)

Potassium level also affects plant's water utilization. High concentration of potassium in a soil contributes to excessive osmotic pressure in the plant and thereby increases in its absorptive capacity for water.

The analytical data of the soil indicates that the soils of the entire command area fall under high to moderate class fertility i. e. > 700 kg/ha as available potassium. Contour diagram (Fig. 7.36) plotted for the pre-monsoon and post-monsoon seasons for various sub-soils depth indicates marginal decrease in potassium level. This decline may be attributed to dilution of soil solution and washing action due to monsoon recharge. The exceptionally higher available potassium content in the soils is attributed to the presence of inherent potassium bearing minerals viz., K-feldspars (orthoclase) and micaceous minerals derived from the catchment area by the process of denudation.

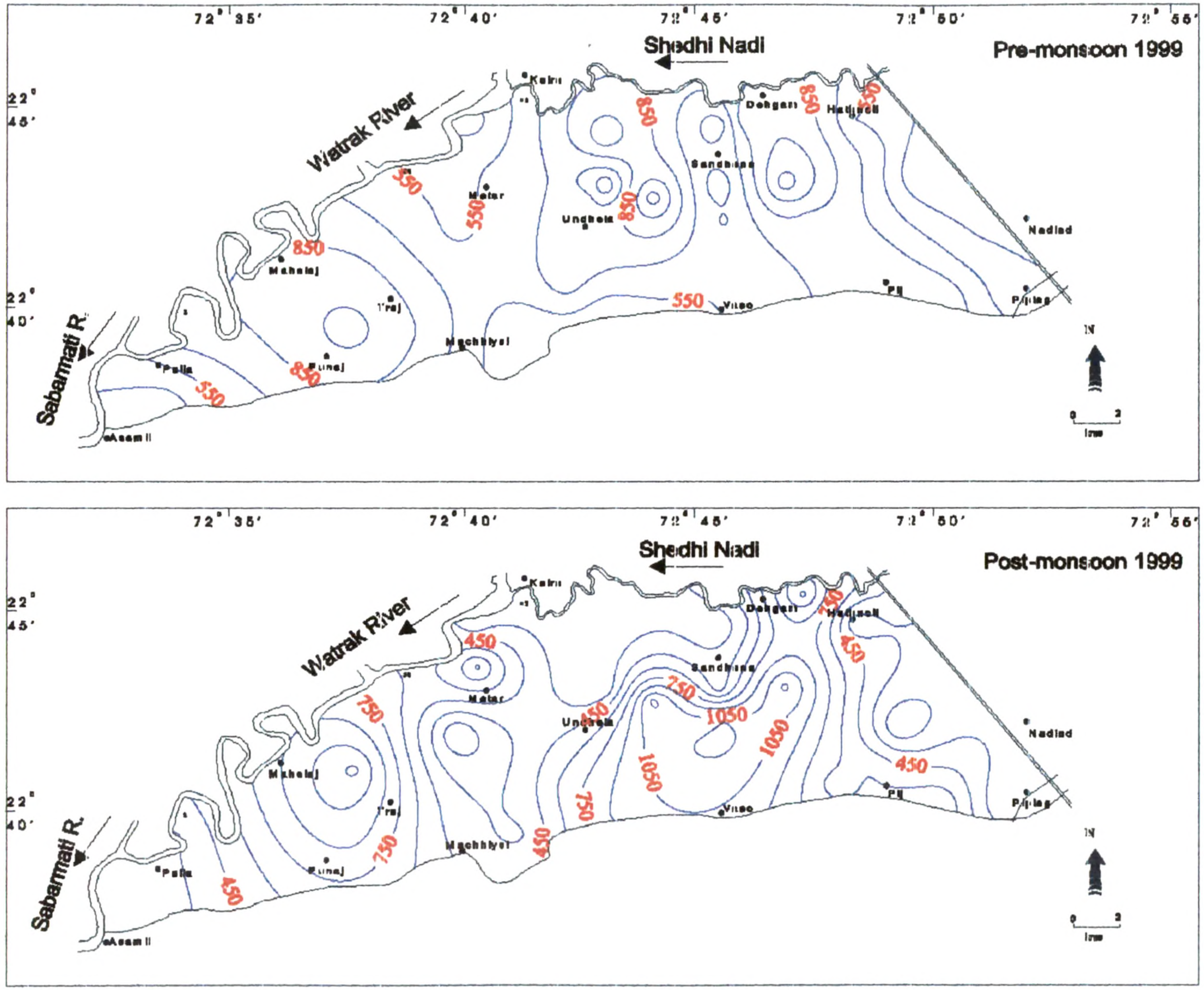


Fig. 7.36 Seasonal Behaviour of Available Potassium Content of Soils in Matar Command Area.

Taking in to account the concentration of studied macro-nutrients i. e. P, K and OC in various sub-soil classes and their depth horizons, the author has summarized the quantitative information as percentage of the total samples studied for both pre- and post-monsoon season (Table 7.7). this clearly indicates an overall but marginal depletion in their levels during post-monsoon season, particularly in high fertility classes. The decreasing order of fertility status may be arranged as OC > P_2O_5 > K_2O.

Table 7.7 Fertility Status of Soils in Matar Command

Depth	Available Phosphorous (kg/ha)			Available Potash (kg/ha)			Organic Carbon (%)		
	High*	Moderate*	Low*	High*	Moderate*	Low*	High*	Moderate*	Low*
Pre-monsoon 1999									
0-10	75.00	15.63	9.38	93.75	6.25	0.00	9.09	81.82	9.09
10-50	53.13	34.38	12.50	96.88	3.13	0.00	3.03	78.79	18.18
50-100	46.88	34.38	18.75	93.75	6.25	0.00	0.00	63.64	36.36
100-150	56.25	28.13	15.63	93.75	6.25	0.00	0.00	69.70	30.30
Post-monsoon 1999									
0-10	62.50	21.88	15.63	81.25	12.50	6.25	0.00	81.82	18.18
10-50	40.63	34.38	21.88	62.50	31.25	6.25	0.00	54.55	45.45
50-100	56.25	12.50	31.25	59.38	34.38	6.25	0.00	63.64	36.36
100-150	37.50	28.13	34.38	56.25	34.38	9.38	0.00	60.61	39.39

* Fertility Class

LAND IRRIGABILITY EVALUATION

It is known fact that the irrigation only contributes significantly towards the agricultural production. In India the irrigation projects have been constructed with the intention of achieving an average crop yield of 4-5 t/ha (planning commission 2000). Although the irrigation was designed to enhance crop productivity, cropping intensity and sustainability without depleting and degrading the soil; but merely 1.7-t/ha crop yield could be achieved till now. The yield of several crops has shown a negative relationship with soil index- a combination of the physical and chemical properties (Basu and Rajgopalan, 1990). Several studies on the water management have indicated that over-irrigation is the main reason for development of waterlogging and secondary salinisation. Soil characteristic viz., soil depth, texture, slope, water holding capacity, internal drainage (wetting front movement) etc guide the production performance of any crop. Based on these criteria the soil has been divided in to eight different land capability classes (IS: 8810, 1969). Out of that only first four classes are considered suitable for the irrigation and crop production. The remaining four classes have been assigned for pasture, recreation and wildlife use.

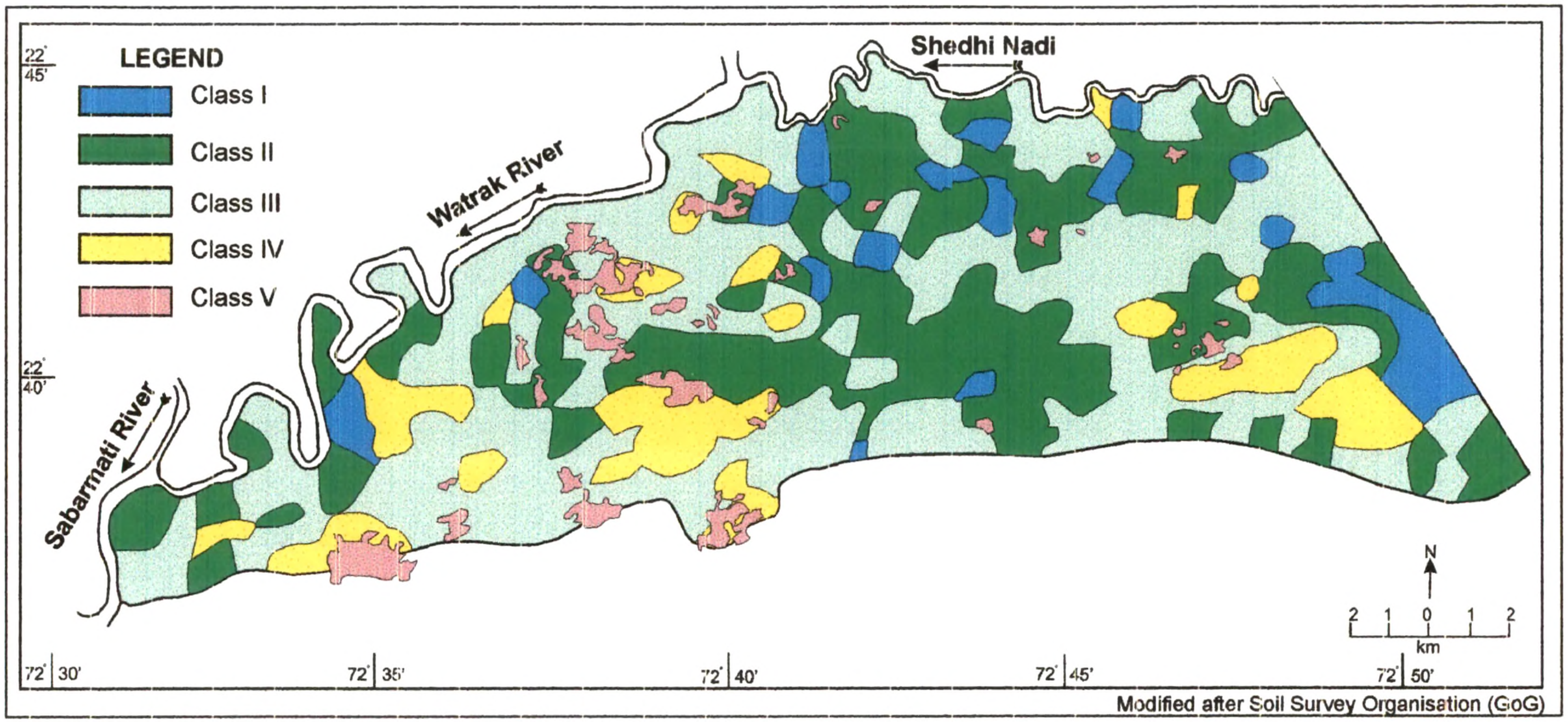


Fig. 7.37 Land Irrigability Classification Map for Soils in Matar Command Area.

The choice of crop and cropping pattern should be based on capabilities of soils with a specific view to provide higher returns per unit area, without degrading the natural resources (Van Wmabeke and Rossiter, 1987). Under the irrigated condition the land capability classes are know as Land Irrigability Classes (LIC) (Roy, 1982; Satpute, 1988; Alagh, 1990; Khosoo and Deekshatulu, 1992).

As it has already been enumerated in preceding chapter on soils of MRBC area that the entire MRBC command area has been characterised by the Land Irrigability Classes of I to V having variable aerial extent (please refer Table 5.7 A & B). Similarly by considering important soil parameters like, EC, pH, ESP, permeability, and water table fluctuation trends the Matar command has also been divided in to 05 Land Irrigability Classes of I to V (Fig. 7.37), the LIC II and III dominates the other classes. The LIC I covers a few patches of the command area. From the foregoing account on the basic soil properties, soil and water chemistry, secular changes in groundwater levels and the use of remotely sensed data; it may be conjectured that the prevailing irrigation practices have resulted in to the problems of waterlogging and soil salinisation.

All such soil which are now falling under the adverse effects of salinity and waterlogging have been ascribed to Land Irrigability Class V. These soils are characterised by the higher water table or higher order of water table fluctuation, higher water holding capacity, clayey texture, low permeability, low drainage capacity and EC between 2.5 and 4.5 mmhos/cm.