

**“EVALUATION OF SOIL FERTILITY AND
UNDERGROUND WATER QUALITY OF KHEDA
DISTRICT OF GUJARAT”**

**BY
VAGHELA MAHIPALSINH BANSINGH**

B. Sc. (Hons.) Agri.

(Registration No: 04 - 2672 - 2015)



**DEPARTMENT OF
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B. A. COLLEGE OF AGRICULTURE
ANAND AGRICULTURAL UNIVERSITY
ANAND – 388 110, GUJARAT**

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UNDERGROUND WATER QUALITY OF KHEDA
DISTRICT OF GUJARAT”**

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“Evaluation of soil fertility and underground water quality of Kheda district of Gujarat”

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ABSTRACT

To evaluate the physical and chemical properties of soils as well as quality of underground (well/tube well) water. The one hundred sixty samples each of underground irrigation water and (0-20 Cm) surface soil samples were collected from cultivated fields of Kheda district.

The mean bulk density value of the soils of Kheda district was 1.40 Mg m^{-3} and it ranged from 1.24 to 1.54 Mg m^{-3} . The mean particle density of the soils was 2.47 Mg m^{-3} and it ranged from 2.21 to 2.89 Mg m^{-3} . The porosity of soils ranged from 38.01 to 48.79 per cent with a mean value of 43.31 per cent. The overall range of MWHC was 22.71 to 50.63 per cent with a mean value of 35.21 per cent.

The organic carbon status of soils was found in medium category (0.60%). The soils are non-calcareous in nature (4.55% CaCO_3) with alkaline in reaction (pHs 7.66), E_c (2.87 dS m^{-1}). The mean CEC value was $31.44 \text{ Cmol(p}^+) \text{ kg}^{-1}$.

The results further indicated that there was dominance of Ca^{++} ($16.34 \text{ Cmol(p}^+) \text{ kg}^{-1}$) followed by Mg^{++} ($12.53 \text{ Cmol(p}^+) \text{ kg}^{-1}$) among the exchangeable cations, while among the water soluble ions Cl^- (6.42 me l^{-1}) and Na^+ (2.47 me l^{-1}) were found in higher proportion as compared to water soluble CO_3^{--} , HCO_3^- , SO_4^{--} , Ca^{++} , Mg^{++} , and K^+ . About 1.87, 13.75, 15.0 and 69.37 per cent soil samples were found saline, saline-sodic, sodic and normal, respectively.

Overall the soils were low with respect to available N and S (5.90 mg kg^{-1}), whereas high in available P_2O_5 (71.20 kg ha^{-1}) and K_2O ($394.96 \text{ kg ha}^{-1}$) status. Among the DTAP extractable micronutrients, Mn (10.11 mg kg^{-1}), Zn (1.00 mg kg^{-1}) and Cu (0.95 mg kg^{-1}) were found high, whereas the soils were medium in Fe (8.02 mg kg^{-1}) status.

All the soil samples were analyzed for EC and pH from saturated and dilute (1:2.5 and 1:5) extract and the following overall regression equations emerged,

$$\text{EC}_e = -0.082 + 3.206 \text{ ** EC}_{2.5} \quad (r = 0.926^*)$$

$$\text{EC}_e = -0.251 + 6.124 \text{ ** EC}_5 \quad (r = 0.920^*)$$

$$\text{pH}_s = 0.537 + 0.913 \text{ ** pH}_{2.5} \quad (r = 0.953^*)$$

$$\text{pH}_s = 0.604 + 0.887 \text{ ** pH}_5 \quad (r = 0.956^*)$$

Highly significant positive relation was observed between EC_e with $EC_{2.5}$, EC_5 , ESP and $SAR_{2.5}$. The pH_s had highly significantly correlated with $pH_{2.5}$, pH_5 , RSC, SAR and ESP. In ESP, was highly positively significant correlation with SAR, $EC_{2.5}$, EC_e , EC_5 , $pH_{2.5}$, pH_5 , pH_s and SSP.

The result of quality of underground wells/tube wells water revealed that the EC values ranged 0.51 to 8.50 with a mean value of 2.04 dS m^{-1} . The waters were alkaline in reaction (pH 7.97). The overall RSC values ranged from -4.80 to 10.50 with a mean value of 2.41 me l^{-1} and overall 34.37, 20.62 and 45.0 per cent samples fell under safe, marginal and unsafe classes of RSC, respectively. The overall mean value of SSP was found 34.34, which varied from 8.00 to 77.26 and overall 94.37 and 5.62 per cent samples fell under safe and unsafe classes of SSP, respectively. The SAR values ranged from 0.36 to 29.96 with a mean value of 7.48 and overall 75.0, 21.87, 2.50 and 0.62 per cent samples fell under S_1 , S_2 , S_3 and S_4 classes of SAR, respectively.

Highly significant positive relationship between EC_{iw} with EC_e , $EC_{2.5}$, EC_5 , SAR_{iw} , SSP_{iw} , $SSP_{2.5}$, $SAR_{2.5}$, and $RSC_{2.5}$ was observed. The pH_{iw} was highly significantly and positively correlated with RSC_{iw} and SAR_{iw} , while negative correlation with SSP_{iw} , $SSP_{2.5}$, $SAR_{2.5}$ and ESP of soils. The RSC_{iw} was highly significantly and positively correlated with $SSP_{2.5}$ and $SAR_{2.5}$ of soils. The SSP_{iw} was negatively correlated with $EC_{2.5}$, EC_e , EC_5 , $pH_{2.5}$, pH_5 , $SSP_{2.5}$, $SAR_{2.5}$ and $RSC_{2.5}$ of the soils. The SAR_{iw} was highly significantly and positively correlated with $EC_{2.5}$, EC_5 , EC_e and ESP while significant positive relation with $SSP_{2.5}$, $RSC_{2.5}$ and $SAR_{2.5}$ of soils. This study shows that there is a need to use such underground water with almost caution.

Thus, major production constrains of the soils of Kheda district are associated with poor quality of wells/tube water of Kheda (C_4S_2) and Matar (C_4S_1) talukas, low fertility status of available N and S, while medium in Fe and salinity/sodicity of soils in Kheda, Nadiad and Matar talukas.

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C E R T I F I C A T E

This is to certify that the thesis entitled “**Evaluation of soil fertility and underground water quality of Kheda district of Gujarat**” submitted by **Vaghela Mahipalsinh B. (Reg. No. 04 -2672 –2015)** in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Soil Science and Agricultural Chemistry** of the Anand Agricultural University is a record of bonafide research work carried out by him under my personal guidance and supervision. The thesis has not previously formed the basis for award of any degree, diploma or other similar title.

Place: Anand

Date: /07/2017

(J. K. Parmar)

Major Guide

DECLARATION

This is to declare that the whole of the research work reported here in the thesis entitled “**Evaluation of soil fertility and underground water quality of Kheda district of Gujarat**” for the partial fulfillment of the requirement for the degree of **Master of Science (Agriculture) in Soil Science and Agricultural Chemistry** by the undersigned is the results of investigation done by me under the direct guidance and supervision of **Dr. J. K. Parmar**, Associate Professor, Department of Soil Science and Agricultural Chemistry, B.A.C.A, AAU, Anand-388 110 and no part of work has been submitted for any other degree so far.

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(Vaghela Mahipalsinh B.)

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LIST OF ABBREVIATIONS

Anon.	Anonymous
⁰ C	Degree Celsius
Cm	Centimeter(s)
EC	Electrical conductivity
ESP	Exchangeable Sodium Percentage
<i>et al.</i>	et alibi (and others)
Fig.	Figure
G	gram(s)
Ha	Hectare
K ₂ O	Potassium
kg	Kilogram(s)
M	Meter
Mg	Milligram
N	Nitrogen
No.	Number
P ₂ O ₅	Phosphorus
RSC	Residual Sodium Carbonate
SAR	Sodium Absorption Ratio
SSP	Soluble Sodium Percentage
viz.	Videlicet (namely)
CEC	Cation Exchange Capacity
dS m ⁻¹	Deci Siemens per meter
EC _e	Electrical Conductivity of saturation Extract
EC _{2.5}	Electrical Conductivity of 1:2.5 soil:water Extract
EC ₅	Electrical Conductivity of 1:5 soil:water Extract
B.D.	Bulk Density
P.D.	Particle Density
MWHC	Maximum Water Holding Capacity
me l ⁻¹	Milliequivalent per litre

$\text{Cmol}(\text{p}^+) \text{ kg}^{-1}$	Centimol positive ion per Kilogram
m ha m	Million hectare meter
pH_s	pH of saturation extract
$\text{pH}_{2.5}$	pH of 1:2.5 soil:water extract
pH_5	pH of 1:5 soil:water extract
kg ha^{-1}	Kilogram per hectare
Ex.	Exchangeable
R	Correlation coefficient
R^2	Percentage of variance
S_{yx}	Standard error of estimate
<	Lower than
>	Greater than
mg kg^{-1}	Milligram per kilogram
mg l^{-1}	Milligram per litre
N	Normal
SO	Sodic
SS	Saline-Sodic

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1. INTRODUCTION

Soil is a dynamic natural body composed of mineral, organic matter and living organisms in which plant grow. Soil is medium for plant growth, which supplies moisture, air, nutrient, and supports plant life. Soil is vital natural resource. Life supporting system of a country and the socio-economic development of its people depends upon proper use of soil. To meet the requirements of food, fiber, fuel, fruits for the increasing population, farm land development is often extended even to the areas unsuitable for agriculture with the shrinking of land for agriculture. The existing cultivated area is subjected to greater burdens in many cases (Minami, 1990). Success in agriculture depends on the land quality and soil characteristics. At this juncture, our efforts for increasing productivity should aim at the optimum utilization of natural resources viz., water and climate without impairing the environment. In this context, the need for both basic and applied researches is focused in the intensively cultivated area to generate scientific information or utilize it to generate appropriate technology for sustainable agriculture production at improved levels of soil productivity and quality.

Soil survey provides useful information for proper planning of soil and water management practices, which plays important role in augmenting crop production. Among the natural resources, soil is available finite, non-elastic and non-renewable asset. In India the dwindling per capita availability of land that decreased from 0.5 to 0.15 ha in 1999-2000 because of population escalation, is likely to reduce further to 0.08 ha in 2020 AD (Yadav and Singh, 2000). Approximately 80 per cent of total farm holdings fall in the category of small and marginal with an average holding of less than 1 ha. Research findings have amply shown 3 to 4 times productivity potential of land even with the currently available technologies. Thus, land if properly managed shall not be a serious constraint to feed the population (Yadav and Singh, 2000).

Soil fertility is one of the important factors that determine the productivity and profitability of crops and cropping systems in agriculture. In simple terms soil fertility is the ability of the soil to provide all essential nutrients required for plant growth in a proper proportion and in right amount. In order to achieve higher productivity and

profitability, every farmer should realize that fertility levels must be measured as these measurements can be used to manage soil fertility (Anon., 2009).

It is estimated that about 8.087 million hectares of land in India are affected by the problem of salinity and sodicity (Abrol and Bhumbra, 1971; Yadav *et al.* 1983). In Gujarat, about 2.22 million hectares of land is affected due to salinity and sodicity and extensively distributed both on the coastal and inland areas (Anon., 2012). The major part of *Bhal* tract adjoining the Gulf of Cambay in Saurashtra is salt affected and areas under Ukai-Kankarapar command are also salt affected. Coastal saline soils are spread over the districts of Surat, Valsad, Bharuch, Kheda, Ahmedabad, Bhavnagar, Surendranagar, Amreli, Rajkot, Jamnagar, Junagadh and Kuchchh including newly formed Gir Somnath and Dev Bhumi Dwarka districts of Gujarat.

Poor performance of crops on salts affected soil may be due to excessive quantities of soluble salts and/or higher exchangeable sodium percentage, which consequently result in nutritional disorders in plants. Excess salt content in soil create high osmotic pressure of soil solution, which obstructs water and nutrient uptake by plant roots. High ESP level deteriorates the soil physical condition and there by limit adequate supply of air, water and nutrients to the crop. In present time salinity and alkalinity of soil are serious problem in India as well as in Gujarat.

A good crop yield is the result of integrated effect of the prevailing weather conditions of a particular area, genetic potentiality of plant, soil and crop management practices and availability as well as reserve of the plant nutrients. Under normal conditions, moisture and nutrient availability as well as physical condition of the soil are the main three important soil factors, which determine the crop production. In addition to these, the accumulation of excessive quantities of salts in the soils of semi-arid and arid areas affects the crop production adversely.

The pressing demand of higher grain production for the increasing population of the country has urged the scientists and extension agencies to explore most suitable techniques for the best utilization of land and water resources of the country. Though, there has been a regular increase in the irrigated area of the country in the last decade leading to higher yield potential, but due attention has not been given for use of poor quality irrigation waters. Irrigation facilities unfortunately have not smiled happy at

Gujarat state. About 41.73 per cent of the total irrigated area is covered by ground water (Anon., 2004). As per one estimate even if the potential of all the rivers in Gujarat is harvested, the total area that can be brought under irrigation will be only about one third of the total cultivated land. Thus, the remaining land has to depend upon underground water sources only. Thus, underground well/tube well water is an important source of irrigation in Gujarat, where water quality is highly variable due to climatological and hydrological conditions.

In India the length of coastal strips traverse more than 8,129 km along the east to west coast. Most of the ground water aquifers situated along the shoreline have been deteriorated by sea water intrusion. The rapidly growing population in India has too necessarily depends largely on ground water resources for its requirement and altering application of heavy dependency of ground water resources are lowering of water-table and consequent drying has forced the farmer of deepening the wells. According to the present estimate, the coastal saline soils are spread in an area of about 1.4 M ha in the coastal tracts of our country (Dhunushkhodh and Kannathasan 2009).

The water used for irrigation purpose always contain soluble salts irrespective of their source, but the total concentrations and the kind of salts present in any irrigation water are important in deciding weather, it will suitable for irrigation or not. Moreover, due to implementation of new irrigation project, coupled with important use of canal water, more and more areas are being affected by the problem of water logging as well as soil salinity and alkalinity in India. Quality of irrigation water is one of the main factors to be understood in irrigated agriculture. “Injudicious irrigations” even with good quality waters, turn many agriculturally good soils into saline or alkali conditions, specific ion toxicity in plants and restricted water infiltration into soils with consequent adverse effects on crop production. Irrigation with saline waters further complicates the problem where the interactions of several factors are to be understood.

The use of saline water is indispensable in some area where no alternative facility for irrigation is available; such water are being used in Kheda district, knowing the problems related to seawater intrusion have seen a significant rise over the last decades. Seawater intrusion related problems have been reported in various

countries and are especially of great concern to Gujarat State in India, as it has the longest coastline of about 1600 km where the quality of ground water would be continuously decreases. It is important to know the extent of damage caused to land due to use of poor quality underground waters for irrigation in salt affected areas. (Poornima, and Vijayalaxmi, 2008)

Soil fertility and water quality survey furnishes useful information for proper planning of soil and water management practices, which play an important role in augmenting crop production. The main objectives of the present study are:

1. To evaluate the soils with respect to its physical and chemical properties as well as fertility status of Kheda district of Gujarat
2. To evaluate underground water quality of Kheda district of Gujarat
3. To establish relationship among and between salinity/sodicity indices and fertility status of soils of Kheda district of Gujarat

2. REVIEW OF LITERATURE

Monitoring of natural resources is a prime responsibility of every society. Least attention has been paid to this aspect in the developing countries. Particularly the interior regions are least attended. Our target is also one of them. Sporadic efforts have been made to study the soil and water resources of the Middle Gujarat. The present study includes four different aspects of monitoring soil and water resources. Therefore, the whole review has been divided into the following points:

- 2.1 Physical properties of surface soils of Kheda district
- 2.2 Chemical properties and salinity/sodicity status of surface soils of Kheda district
- 2.3 Fertility status of the surface soils of Kheda district
- 2.4 Quality of underground well/tube well water
- 2.5 Relationship among and between soil fertility and salinity/ sodicity parameters of soils

2.1 PHYSICAL PROPERTIES OF THE SOILS

Soil physical properties namely bulk density, hydraulic conductivity, moisture retention characteristics and coefficient of linear extensibility are the reflections of moisture content and genetic characteristics. These properties influence several other properties, such as leaching, deep drainage and inter flow and susceptibility to drought, interacting with climate and land use, and these properties produce aridic condition in shallow soils and humid condition in deep soils (Virmani *et al.*, 1982).

Datta *et al.* (1990) observed that the low land soils have more total pore space than those from the upland. Rao (1993) noticed that the water holding capacity of sandy soils in Chakicharla village of Prakasam district, Andhra Pradesh ranged from 16.45 to 21.42 per cent.

Sharma (1994) observed that the maximum water holding capacity of the soil is generally related to the texture of the soil and increase with increase in clay content. Maji *et al.*, 1995 revealed that the water holding capacity in coastal soils of Sundarban, West Bengal ranged from 21.40 to 37.60 per cent.

Savaliya *et al.* (2000) found that the water holding capacity of surface soils of Uben command area of Saurashtra region at 0, 33 and 1500 kPa ranged from 0.380 to 0.633, 0.214 to 0.379 and 0.111 to 0.176 cm³, respectively.

The water holding capacity in soils of Haldighati region of Rajasthan was low to medium in per cent range of 17.10 to 37.30 (Sharma *et al.*, 2001). Savalia and Gundalia (2004) reported the bulk density, total porosity and water holding capacity of the soils Uben irrigation command area of Saurashtra region in Gujarat ranged from 1.21 to 1.33 Mg m⁻³, 42.4 to 55.0 and 38.9 to 54.1 per cent, respectively.

Ogunwale and Isa (2004) observed the bulk density values of coarse textured soils ranged from 1.01 to 1.65 g cm⁻³. Savaliya (2005) recorded the particle density and WHC values of the soils of Southern Saurashtra region of Gujarat ranged from 2.41 to 2.52 Mg m⁻³ and 32.77 to 53.15 per cent, respectively.

Thangasamy *et al.* (2005) noticed that the water holding capacity in soils of Sivagiri micro watershed in Chittoor district of Andhra Pradesh ranged from 13.05 to 58.99 per cent. These differences were due to the variation in the depth, clay, silt and organic carbon content in the soils. Sitanggang *et al.* (2006) found that the soils of micro watershed having high percentage of sand or gravel have more bulk density than those having high clay content.

Rao *et al.* (2008) found that the bulk density and water holding capacity of soils of Ramachandrapuram Mandal of Chittoor district in Andhra Pradesh varied from 1.45 to 1.66 Mg m⁻³ and 19.96 to 47.81 per cent, respectively. Almost similar results were also found by Sankar and Dhadhwal (2009) and Savalia *et al.* (2009.)

Ram *et al.* (2010) observed bulk density, particle density and total porosity in the flood-prone soils of eastern plains of Rajasthan ranged from 1.32 to 1.61, 2.36 to 2.64 Mg m⁻³ and 37.70 to 46.36 per cent respectively.

Vijay Kumar *et al.* (2010) found that the bulk density ranged from 1.58 to 1.76 g cm⁻³. Similarly, Patel (2010) observed that the bulk density varied from 1.28 to 1.60 Mg m⁻³ with mean value of 1.41 Mg m⁻³ in soils of different landforms of Meghal Irrigation Command area of Southern Saurashtra.

Shirgire (2012) observed bulk density, particle density, porosity and MWHC in the soils of Jamnagar district varied from 1.15 to 1.52, 2.19 to 2.83 Mg m⁻³, 22.89

to 56.80 and 36.47 to 73.02 per cent with mean value 1.30, 2.40 Mg m⁻³, 45.57 and 52.16 per cent, respectively.

Singh and Sharma (2013) reported that soil bulk density varies from 1.40 to 1.61 Mg m⁻³ in sand dune, 1.42 to 1.66 Mg m⁻³ in interdunal and 1.49 to 1.72 Mg m⁻³ in alluvial terrace soils.

2.2 CHEMICAL PROPERTIES AND SALINITY/ SODICITY STATUS OF THE SOILS

Saline-sodic soils are characterized by the accumulation of salts in the soil solution and adsorption of sodium on exchange complex beyond an arbitrary limit adversely affecting plant growth. Saline soils may be developed due to (I) Continuous use of saline irrigation water. (II) High salt content in the profile. (III) Saline ground water and high water table condition. (IV) Occurrence of salt layer in the soil crust and rise in water table. (V) Weathering of rock minerals. (VI) Seepage from canal and adjacent irrigated areas. (VII) Restricted surface and sub-surface drainage and (VIII) Ingress of seawater (Bhumbla and Abrol, 1979).

The salt affected soils of Kuchchh (Anjar, Bhuj, Mundra and Lakhpatt) and Surendranagar districts are saline, sodic and highly saline sodic in nature. The NaCl was dominant source of salinity. Free lime content decreased with depth. These soils were poorly supplied with organic carbon and nitrogen. The pH_s, EC_e and ESP ranged from 7.6 to 8.9, 1.2 to 60.0 dS m⁻¹ and 5.5 to 74.0 in Kuchchh district and 3.6 to 8.8, 23.3 to 64.2 dS m⁻¹ and 50.7 to 77.4 in Surendranagar district, respectively (Dubey *et al.* 1986b; Dubey and Sharma, 1987).

Sagare *et al.*, (1991) characterized the saline-sodic and sodic soils of Vidarbha region of Maharashtra and noted that the pH_s, EC_e and ESP of saline-sodic soils ranged from 8.3 to 8.8, 2.25 to 3.90 dS m⁻¹ and 16 to 61, whereas those of sodic soils ranged from 8.4 to 8.9, 0.97 to 1.20 dS m⁻¹ and 15.3 to 51.1, respectively.

Singaravel *et al.* (1996) characterized the physico-chemical properties of coastal saline soils of Tamilnadu and revealed that the soils contain ESP as high as 42.75 with pH value ranged from 7.04 to 9.19.

Timbadia and Maliwal (2000) studied the physico-chemical properties of salt affected soils of coastal areas (Jafrabad, Kodinar and Rajula talukas) of Amreli district of Gujarat. The EC_e ranged from 1.0 to 10.0, 0.43 to 16.5 and 0.48 to 10.0

dSm⁻¹, while pH from 8.0 to 9.4, 7.6 to 8.7 and 8.1 to 9.2 in Jafrabad, Kodinar and Rajula talukas, respectively. The ESP value varied from 19.1 to 44.7, 11.7 to 63.4 and 12.0 to 66.7 in Jafrabad, Kodinar and Rajula talukas, respectively.

Polara *et al.* (2004) observed the dominance of Ca⁺⁺ and Mg⁺⁺ among the exchangeable cations, and among water soluble ions, dominance of Na⁺ and Cl⁻ in the soils of nine taluka of Kuchchh district. The soils of Kuchchh district were poor in organic carbon, alkaline in reaction and calcareous in nature. More than half (60.3%) of the cultivated soils of Kuchchh district were saline in nature, followed by saline-sodic (25.7 per cent) and sodic (14.0 per cent).

Baskar *et al.* (2006) carried out an investigation in tsunami affected areas of the Union Territory of Pondicherry to characterize the soils for the developing site specific reclamation. The EC of Pondicherry soils ranged from 0.37-110.38 dS m⁻¹ and that of pH from 7.03 to 10.16. In the case of Karaikal region, the EC was found to range from 0.03- 202.9 dS m⁻¹ and the pH from 5.41 to 9.37. The result from the whole of U.T. of Pondicherry showed that around 26.11 per cent of the tsunami affected soils were saline in nature, 30.59 per cent sodic, 38.38 per cent saline-sodic, while 4.82 per cent was normal.

Kabaria and Polara (2006) twenty surface (0-15 cm) soil samples from each of the eleven talukas of Amreli district were collected from the cultivated soils and were analyzed for different chemical properties. The results revealed that Na⁺ and Cl⁻ were dominant among the water soluble ions, whereas Ca⁺⁺ and Mg⁺⁺ were dominant among the exchangeable cations. More than half (61.4 %) of the cultivated soils of Amreli district were normal in nature, followed by saline (13.6 %), saline-sodic (12.7 %) and sodic (12.3 %).

Polara *et al.* (2006) collected 440 surface soil samples from cultivated farmer's field of North-West Agro climatic Zone of Gujarat and reported that the dominance of Ca⁺⁺ 16.05 (Cmol(p⁺) kg⁻¹) and Mg⁺⁺ 8.12 (Cmol(p⁺) kg⁻¹) among the exchangeable cations, while the Na⁺ (11.8 me l⁻¹) and Cl⁻ (10.7 me l⁻¹) among the water soluble ions and poor in organic carbon (range 0.053 to 0.89, mean 0.312 per cent) and alkaline in reaction (pH mean 8.03). The result further shows that half (49.7 per cent) of the cultivated soils of this zone are having salinity problem, followed by saline-sodic (31.2 per cent) and sodic (19.1 per cent) problem of salinity is acute in

Lakhpur, Rapar, Nakhtrana, Bhauchu and Anjar of talukas of Kuchchh district and Vav, Tharad and Santalpur taluka of Banaskatha district. On other hand, the soils of Mandvi, Hadwad, Dasada, Harij, Deodar and Kankraj talukas have twin problems of salinity as well as sodicity.

Guruprasad *et al.* (2007) an extensive survey was carried out to characterize some of the salt affected soils under Kabini tract of Cauvery command area, southern dry zone of Karnataka. The pHs of soils were ranged from 7.41 to 8.94, E_c from 0.48 to 1.31 dS m⁻¹, SAR from 4.25 to 18.40, CEC from 14.7 to 39.12 Cmol (p⁺) kg⁻¹ and ESP from 11.11 to 39.58 per cent.

Marsonia *et al.* (2008) studied the seventy three surfaces (0-15) soil samples from the three taluka *viz.* Kutiyana, Ranavav and Porbandar of Porbandar district were collected from cultivated field and were analyzed for different chemical properties. The results revealed that Na⁺ and Cl⁻ were dominant among the water soluble ions, whereas, Ca⁺⁺ and Mg⁺⁺ were dominant among the exchangeable cations. Nearly half (48.0%) of the cultivated coastal soils of Porbandar district were found normal in nature, followed by sodic (20.5%), saline (16.4%) and saline-sodic (15.1%).

Sharma *et al.* (2008) studied soils of indo gangetic alluvial plain in Amritsar district of Punjab under three major landform units *viz.* alluvial plain, flood plain and sand bars. They observed that pH of soils varied from 7.0 to 9.76 and nearly 54 per cent soil samples had pH between 7.0 and 8.5 with remaining 46 per cent had pH higher than 8.5. In case of salt concentration, EC of soil varied from 0.1 to 1.0 dS/m with an average of 0.34 dS/m. The majority of soil samples (99 per cent) were in the normal EC range (<0.8 dS/m). The organic carbon content of soils varied from 0.16 to 0.97 per cent with an average value of 0.61 per cent.

Pujar *et al.* (2010) studied surface soils (0-20 cm) of sugarcane growing area of five talukas from Bijapur district and reported that soil pH varied from 5.2 to 8.8 and the electrical conductivity (EC) varied from 0.08 to 2.38 mmhos/cm. They also reported that organic carbon content of soils ranged from 0.29 to 1.24 per cent.

Sojitra (2010) collected 280 soil samples from the Junagadh district and observed that the pHs, E_c, organic carbon, CaCO₃ and CEC of soils varied from 7.20 to 9.01, 0.21 to 2.61 dS m⁻¹, 1.50 to 10.67 g kg⁻¹, 8.06 to 104.6 g kg⁻¹ and 18.06

to $57.94 \text{ Cmol(p}^+)\text{kg}^{-1}$ with a mean values of 8.11, 1.01 dS m^{-1} , 5.32 g kg^{-1} , 42.94 g kg^{-1} and $41.75 \text{ Cmol(p}^+)\text{kg}^{-1}$, respectively.

Bhanwaria *et al.* (2011) determine physico-chemical properties in Mokala soil Series of Rajasthan and revealed that soil pH, EC and OC ranged from pH 7.9 to 8.9, 0.09 to 1.76 dS/m and 0.7 to 2.4 g/kg with mean values of 8.42, 0.78 dS/m and 1.4 g/kg , respectively.

Kumar and Babel (2011) collected seventy surface soil samples (0-30 cm depth) from Jhunjhunu district of Rajasthan and they reported that the soils pH, EC and OC varied from 8.10 to 9.20, 0.20 to 2.14 dS/m and 0.06 to 0.43 per cent with the mean values of 8.52, 1.05 dS/m and 0.21 per cent, respectively.

Rajput and Polara (2012) collected 220 surface soil sample (0-20cm) from eleven talukas of Bhavnagar district during 2009 for monitoring the chemical properties of the soils and reported that the EC_e of these soils ranged from 1.09 to 17.8 dS m^{-1} with an average value of 6.89 dS m^{-1} . The pHs of these soils ranged from 7.3 to 8.9 with an average value of 7.86 and the CaCO_3 content in these soils varied from 8.06 to 199.9 g kg^{-1} with an average value of 49.2 g kg^{-1} , respectively.

Shirgire (2012) reported that the pH, EC, organic carbon, CaCO_3 and CEC of soils varied from 7.66 to 9.01, 0.26 to 3.06 dS m^{-1} , 0.30 to 10.20 g kg^{-1} , 4.18 to 115.6 g kg^{-1} and 15.8 to $56.8 \text{ Cmol(p}^+)\text{kg}^{-1}$ with a mean values of 8.18, 0.86 dS m^{-1} , 4.97 g kg^{-1} , 54.9 g kg^{-1} and $36.5 \text{ Cmol(p}^+)\text{kg}^{-1}$, respectively.

Athokpam *et al.* (2013) collected 200 soil samples (0-30 cm) from Senapati district of Manipur and reported that pH of the soils ranged from 5.08 to 6.97 (slightly acidic to neutral) with mean of 5.93, EC ranged from 0.02 to 0.22 dS/m with mean of 0.07 dS/m and organic carbon ranged from 6.0 to 25.2 g/kg with average of 14.74 g/kg .

Devdas and Srivastava (2013) determine the status of physico-chemical properties in black soil of Navagarh block under Janjgir district of Chhattisgarh and reported that pH, EC and OC ranged from 5.8 to 8.0, 0.04 to 0.98 dS/m and 0.29 to 0.88 per cent with a mean values 6.24, 0.25 dS/m and 0.58 per cent, respectively.

Doneriya *et al.* (2013) collected 50 soil samples (0-15 cm) from Marihan block of Mirzapur district in Uttar Pradesh and they observed that the pH, EC and OC

of soils varied from 5.5 to 7.6, 0.022 to 0.093 dS/m and 0.22 to 0.66 per cent with the mean value of 6.53, 0.065 dS/m and 0.46 per cent, respectively.

Gajare *et al.* (2013) collected 140 soil samples from the Latur district during 2009-10 for monitoring the chemical properties of the soils. The EC of these soils varied from 0.12 to 1.96 dS m⁻¹ with an average value of 0.31 dS m⁻¹, the soils was neutral to alkaline and pH varied from 6.39 to 8.89 with an average value of 7.98, the organic carbon varied from 0.15 to 1.03 per cent with an average value of 0.56 per cent and CaCO₃ in these soils varied from 0.66 to 14.26 per cent with an average value of 4.25 per cent.

Gandhi (2013) reported that the pH, EC, organic carbon and CaCO₃ ranged from 7.13 to 8.15, 0.28 to 4.69 dS m⁻¹, 0.46 to 1.01 per cent and 2.30 to 78.78 per cent with overall mean value of 7.70, 1.91 dS m⁻¹, 0.50 per cent and 27.67 per cent, respectively, which indicate that the soils of Girnar toposequence were slightly alkaline in reaction, low in organic carbon content and highly calcareous in nature. The CEC, SSP and ESP ranged from 18.11 to 68.44 Cmol(p⁺)kg⁻¹, 90.06 to 97.14 and 0.33 to 31.40 with overall mean value of 34.89 Cmol(p⁺)kg⁻¹, 93.38 and 8.27, respectively. The order of dominance of exchangeable base was Ca²⁺ > Mg²⁺ > Na⁺ > K⁺.

Nandy *et al.* (2013) studied the chemical properties of coastal soils (sandy and inland black soils) in the Pedapuluguvaripalem village of Guntur district, Andhra Pradesh. Results revealed that the soil was neutral to strongly alkaline in nature, overall pH ranged from 7.0 to 9.8, low in organic carbon ranged from 1.5 to 4.2 g kg⁻¹, overall CEC ranged from 3.86 to 38.64 Cmol (p⁺) kg⁻¹ and ESP ranged from 5.90 to 24.99, respectively.

Sudharani *et al.* (2013) collected 69 soil samples (0-15 cm) from rice growing soils of Visakhapatnam district in Andhra Pradesh and revealed that the pH, EC and OC of soils were ranged from 5.0 to 8.7, 0.03 to 0.9 dS/m and 1.0 to 8.9 per cent with mean value of 6.8, 0.26 dS/m and 4.27 per cent, respectively.

Srinivasan and Poongothai (2013) collected 30 soil samples (0-20 cm) from 30 revenue villages of Tittakudi taluka of Tamil Nadu and reported that the soils pH and EC ranged from 6.9 to 8.3 and 0.12 to 2.3 dS/m and with a mean value of 7.6 and 1.21 dS/m, respectively.

Verma *et al.* (2013) characterized the physico-chemical properties of *Inceptisols* of Malkharauda block, Janjgir Champa district in Chhattisgarh during 2011-12 cover 110 villages. Soil samples were collected and subjected to analysis. The results revealed that the soils having $EC_{2.5}$ varied from 0.05 to 0.75 $dS\ m^{-1}$ with a mean value of 0.20 $dS\ m^{-1}$, the soils was acidic to alkaline in reaction and pH ranged from 4.7 to 7.1 with an average value of 6.0 and organic carbon ranged from 1.1 to 7.8 $g\ kg^{-1}$ with a mean value of 5.9 $g\ kg^{-1}$.

Singh *et al.* (2014) studied the physico-chemical properties in medium black soils of Chambal region of Madhya Pradesh and reported that the soils pH, EC and OC ranged from 7.0 to 8.4, 0.31 to 1.19 dS/m and 0.26 to 0.92 per cent with a mean value of 7.83, 0.58 dS/m and 0.46 per cent, respectively.

Tundup and Akbar (2014) collected 60 surface soil samples from Kishtwar district in Jammu and Kashmir for determining the chemical properties of the soils. The EC of these soils ranged from 0.15 to 0.23 $dS\ m^{-1}$ with a mean value of 0.18 $dS\ m^{-1}$, the pH of these soils ranged from 6.65 to 7.64 with a mean value of 7.37 and organic carbon of these soils ranged from 0.58 to 0.81 with a mean value of 0.68 per cent, respectively

Tsanglao *et al.* (2014) studied the fertility status and soil acidity under different land use systems in Wokha district of Nagaland. The pH of soils under cultivated and forest land use systems varied from 4.46 to 4.85 and 4.53 to 5.10 with an average of 4.65 and 4.77, respectively, indicating that soils are acidic in reaction. OC of the soils under cultivated and forest land use systems ranged from 9.7 to 19.4 and 15.6 to 23.7 g/kg with an average of 15.4 and 20.0 g/kg , respectively.

Arunkumar and Paramasivan (2015) studied the fertility status of the soils of Orathur village of Veeranam command area of Cuddalore district in Tamilnadu and revealed that the pH, EC and OC of soils varied from 6.70 to 8.30, 0.20 to 1.20 dS/m and 0.49 to 0.88 per cent with the mean value of 7.86, 0.50 dS/m and 0.68 per cent, respectively.

Rajput *et al.* (2015) collected 150 composite surface soil samples (0-15 cm) from irrigated and non-irrigated mustard growing fields covering 30 villages of northern Madhya Pradesh. They reported that overall soil pH, EC and OC varied from

7.0 to 8.2, 0.10 to 0.97 dS/m and 1.12 to 8.1 g/kg with mean values of 7.57, 0.23 dS/m and 4.08 g/kg, respectively.

Hadiyal *et al.* (2016) studied 250 soil samples (0-15 cm) from Girgadhda and Una talukas of Gir Somanth district in Gujarat and revealed that the OC of soils varied from 0.12 to 1.11 per cent with the mean value of 0.61 per cent. Soils were medium in organic carbon.

Karajanagi *et al.* (2016) collected 75 soil samples from Dundur village under Malaprabha command area in Karnataka and reported that soil pH, EC and OC varied from 7.9 to 9.1, 0.13 to 0.41 dS/m and 4.02 to 7.43 g/kg with mean values of 8.4, 0.24 dS/m and 5.02 g/kg, respectively.

Nagaral *et al.* (2016) collected 57 soil samples (0-15 cm) from chilli growing area of northern transitional zone of Haveri, Gadag and Dharwad districts of Karnataka and observed that the pH varied from 6.12 to 9.52 (average 8.15), having 8 per cent samples were acidic, 22 per cent neutral and 70 per cent samples alkaline, while EC of soils varied from 0.09 to 1.43 dS/m (average 0.37 dS/m) and OC content of soils varied from 3.20 to 9.0 g/kg (average 4.78 g/kg) having 61 per cent samples were low, 31 per cent medium and 8 per cent high.

Patel *et al.* (2016) analyzed soil of Patan district of Gujarat and reported that the pH, EC and OC of soils varied from 7.10 to 9.30, 0.10 to 9.23 dS/m and 0.039 to 2.388 per cent with mean values of 7.96, 1.139 dS/m and 0.36 per cent, respectively.

Reddy and Naidu (2016) studied physico-chemical properties in semi-arid region of Chennurmandal of Kapada district in Andhra Pradesh and reported that pH, EC and OC varied from 7.4 to 8.5, 0.13 to 0.77 dS/m and 1.6 to 8.8 g/kg, respectively.

Wagh *et al.* (2016) carried out an investigation in sunflower growing soils of Nagpur district of Maharashtra and they reported that soil pH, EC and OC ranged from 7.93 to 8.64, 0.19 to 0.67 dS/m and 0.24 to 0.79 per cent with mean values of 8.39, 0.28 dS/m and 0.51 per cent, respectively.

2.3 FERTILITY STATUS OF THE SURFACE SOILS

There exists a wide variation amongst soil under different Agro Climatic Zones of Gujarat. The use of high analysis fertilizers coupled with varying management practices of the farmers necessitates regular monitoring of soil fertility.

While changes in physical parameters such as bulk density, moisture retention capacity, infiltration rate and soil aggregation etc. occur over a longer period, but the change in soil available nutrients may happen in a shorter span. To characterize the soils, it is imperative to take into consideration its important soil properties such as pH, EC, texture, organic carbon and status of available nutrients. Moreover, knowledge about the cropping history of the fields along with soil characteristics may help in the formulation of a sound fertilizer recommendation for crops under different Agro Climatic Zone.

2.3.1 Available Macronutrient

Akbari *et al.* (1993) collected 107 surface soil samples from Mewar region (84 from Udaipur and 23 from Chittorgarh district) of Rajasthan. They found that the organic carbon, available P and K varied from 0.03 to 1.44 per cent, 13.44 to 132.16 kg ha⁻¹ and 104.8 to 953.7 kg ha⁻¹, respectively. The available S content varied from 2.25 to 69.75 ppm in soils of Udaipur and 2.25 to 43.75 ppm in soils of Chittorgarh district.

Maliwal and Timbadia (1993) collected 76 surface soil samples from coastal areas of Vallabhipur and Maliya and interior area of Amreli, Liliya and Lathi talukas of Saurashtra region of Gujarat and observed the available N, P₂O₅ and K₂O were ranged from 188 to 439, 15.4 to 99.8 and 120 to 2262 with mean values of 313.5, 48.2 and 841 kg ha⁻¹, respectively.

Singaravel *et al.* (1996) studied nutrient status of the coastal saline soils of Tamilnadu. The data on nutrient status showed that the soils were low in organic carbon, low to medium in available nitrogen, variable in available phosphorus status and medium to high in available potassium.

Choudhary and Shukla (2002) collected 140 soil samples belonging to seven soil great groups of arid soils of western Rajasthan varied widely in their characteristics. The available sulphur content of most of the soils was in the high range, with the mean value of 59.3 mg kg⁻¹. Only a few samples (5.7 per cent) recorded low in available sulphur content.

Kundu *et al.* (2005) found that four village of Nadia district of West Bengal were medium in the organic carbon and available nitrogen status in Utter Duttapara,

Kurumbalia and Dasdia villages and the available P_2O_5 status for all four villages was high but the available K_2O status was medium.

Meena *et al.* (2006) collected 120 surface soil samples (0–20 cm) from Tonk district of Rajasthan and reported that the available N, P_2O_5 and K_2O values were ranged between 125 to 555, 9.2 to 65.2 and 105 to 1059 $kg\ ha^{-1}$ with mean values of 309, 25.2 and 377 $kg\ ha^{-1}$, respectively. Similarly, Polara *et al.* (2006a) collected 440 soil samples from salt affected soils of North West agro climatic zone of Gujarat and found organic carbon, P_2O_5 and K_2O ranged from 0.53 to 9.55 $g\ kg^{-1}$, 5.12 to 122.9 and 104.8 to 1048.4 $kg\ ha^{-1}$ with mean value of 3.2 $g\ kg^{-1}$, 40.0 and 464.4 $kg\ ha^{-1}$, respectively.

Singh *et al.* (2006) collected thirty-seven surface soils (0-15 cm) representing both valley and hill soils of Manipur and revealed that available S (0.15 per cent $CaCl_2$ extractable S) in soils were ranged from 10.0 to 70.0 mg/kg with mean values of 26.6 mg/kg .

Patel and Patel (2008) studied the sulphur fraction in different soil series of South Gujarat and found that on an average, the heat soluble-S varied between 20.3 to 137.7 mg/kg .

Singh *et al.* (2009) reported that available sulphur ranged from 4.6 to 118.4 mg/kg with a mean value of 24.6 mg/kg in soils (500 surface soil samples) of Udham Singh Nagar district of Uttarakhand.

Talukdar *et al.* (2009) reported that the available nitrogen, phosphorus and potassium content of the soils of Golaghat district of Assam (in two agro-ecosystems) varied from 205 to 479, 9.50 to 28.5 and 60 to 347 kg/ha , respectively. The rice ecosystem showed the highest values of available N, P_2O_5 and K_2O as compared to the sugarcane one. The reason might be the high content of organic carbon which on mineralization released higher amounts of NPK as compared to those in sugarcane system.

Patel (2010) observed that the available potassium content ranged from 133.5 to 450.24 $kg\ ha^{-1}$ with an overall mean of 251.97 $kg\ ha^{-1}$ in the in different landforms of Meghal Irrigation Command area of Southern Saurashtra in the Gujarat.

Kumar *et al.* (2011) studied the available major nutrients in arid soils of Churu district of Western Rajasthan and reported that available phosphorus and potassium

content in soils varied from 7 to 80 and 108 to 837 kg/ha with mean value of 18.6 and 258 kg/ha, respectively.

Srinivas *et al.* (2011) collected 72 soil samples (0-15 cm) from Krishna western delta in Andhra Pradesh and reported that the soil organic carbon, available N, P₂O₅ and K₂O were ranged from 0.27 to 0.62 per cent, 244 to 406, 30.6 to 69.4 and 233 to 590 with mean value of 0.49 per cent, 318, 48.2 and 398 kg ha⁻¹, respectively.

Bhaskaran *et al.* (2012) surveyed eight sugarcane growing districts of Tamil Nadu and reported that the sulphur content of soils (0-30 cm) varied widely from 2.45 to 96.07 ppm with an average of 25.37 ppm. About 17 per cent of the soils were found to be deficit (low) in available S content (<10.0 ppm), 35 per cent were in medium category (10 to 20 ppm) and 48 per cent were in high (> 20 ppm) category.

Patel *et al.* (2012a) found that organic carbon of the soils of different landslopes of Meghal Irrigation Command area of Southern Saurashtra ranged from 0.33 to 0.51% with the overall mean value of 0.40%.

Patel *et al.* (2012) reported that available sulphur ranged from 5.24 to 60.17 mg/kg with a mean value of 19.01 mg/kg in soils (240 surface soil samples) of Banaskantha district of Gujarat. They further reported that, 30.0, 32.1 and 37.9 per cent soil samples were found low, medium and high in available sulphur, respectively

Punithraj *et al.* (2012) analyzed 80 soil samples (0-15 cm) from tomato growing area of Hassan district of Karnataka and observed that available N content varied from 205 to 376.3 kg/ha (mean 265.7 kg/ha), having 71.3 per cent samples were low (< 250 N kg/ha) and 28.7 per cent medium (250 to 500 N kg/ha) in status. Available P₂O₅ content varied from 43.6 to 238.7 kg/ha (mean 117.9 kg/ha) with 1.3 per cent medium (28 to 56 P₂O₅kg/ha) and 98.7 per cent high (>56 P₂O₅ kg/ha) in status. Available K₂O content varied from 315 to 692 kg/ha (mean 505.4 kg/ha) with only 10 per cent medium (140 to 280 K₂O kg/ha) and 90 per cent high (> 280 K₂O kg/ha) in status. Available S content varied from 2.7 to 28.4 mg/kg (mean 8.8 mg/kg) with 67.5 per cent samples were low (< 10 S mg/kg), 23.8 per cent medium (10 to 20 S mg/kg) and 8.7 per cent high (> 20 S mg/kg) in status.

Rajput and Polara (2012) studied that the fertility status in eleven talukas of Bhavnagar district and found that the available N, P₂O₅ and K were varied from 72.1

to 516.2, 2.21 to 85.7 and 38.0 to 990.0 kg ha⁻¹ with an average value of 312.1, 28.6 and 451.2 kg ha⁻¹, respectively.

Singh and Kumar (2012) collected 110 surface soil samples from vegetable growing area of Varanasi district and found that the available N, P₂O₅, K₂O and S were varied from 249.0 to 685.0, 8.4 to 14.2, 101.0 to 262.0 kg ha⁻¹ and 4.37 to 23.75 mg kg⁻¹ with a mean value of 295.0, 10.8, 162.0 kg ha⁻¹ and 14.9 mg kg⁻¹, respectively.

Athokpam *et al.* (2013) collected 200 soil samples (0-30 cm) from Senapati district in Manipur and reported that available N, P₂O₅ and K₂O were ranged from 290.20 to 893.17, 24.62 to 64.37, 55.60 to 359.11 and with mean values of 382.04, 38.31 and 208.86 kg/ha, respectively.

Devdas and Srivastava (2013) collected 112 surface soil samples from the Navagarh block under Janjgir district of Chhattisgarh and found that available N, P₂O₅ and K₂O were varied from 88.0 to 399.0, 1.52 to 29.33 and 101.0 to 504.0 with mean value of 265.0, 7.34 and 268.0 kg ha⁻¹, respectively.

Gajare *et al.* (2013) collected 140 soil samples from the Latur district during 2009-10 and found that available P₂O₅ and S were ranged from 0.2 to 21.15 kg ha⁻¹ and 3.62 to 53.52 me kg⁻¹ with an average value of 7.42 kg ha⁻¹ and 21.47 mg kg⁻¹, respectively.

Singh and Munth (2013) studied fertility status of soil under forest and cultivated land use system of Nagaland. The available N, P₂O₅ and K₂O in forest area ranged from 251 to 426.4, 20 to 52.2 and 134.4 to 221.5 with mean values of 318.9, 30.8, 165.1 and 44.6 kg/ha, respectively. The available N, P₂O₅ and K₂O in cultivated area ranged from 230.2 to 413.9, 21.5 to 59.7 and 120.9 to 209.8 13.7 to 59.5 kg/ha with mean values of 286, 31.5 and 154.5 kg/ha, respectively.

Srinivasan and Poongothai (2013) collected 30 soil samples (0-20 cm) from 30 revenue villages of Tittakudi taluka of Tamil Nadu and found that available N, P₂O₅ and K₂O ranged from 21 to 140, 7.5 to 25 and 62.5 to 90 kg/ha with mean values of 80.5, 16.25 and 76.25 kg/ha, respectively.

Sudharani *et al.* (2013) collected 69 soil samples (0-15 cm) from rice growing soils of Visakhapatnam district of Andhra Pradesh and revealed that the available N, P

and K in soils varied from 125 to 392, 9 to 39 and 98 to 420 kg/ha and with mean values of 226, 20.8 and 230 kg/ha, respectively.

Malavath and Mani (2014) carried out study for assessment of the nutrient status of soils of Dryland Agricultural Research Station at Chettinad in Sivaganga district of Tamilnadu and found that the available N, P₂O₅ and K₂O ranged from 123.0 to 209.0, 14.0 to 28.1 and 126.0 to 319 kg ha⁻¹, respectively, while S ranged from 9.1 to 18.9 mg kg⁻¹.

Singh *et al.* (2014) carried out analysis on macronutrients fertility status in medium black soils of Chambal region of Madhya Pradesh. They found that the available N, P, K and S varied from 178 to 408, 7.9 to 28.8, 122 to 386 and 8.5 to 34.4 kg/ha, respectively with corresponding mean values of 227, 16.1, 295 and 17.4 kg/ha, respectively.

Arunkumar and Paramasivan (2015) studied the fertility status of the soils of Orathur village of veeranam command area of Cuddalore district in Tamil Nadu and revealed that the available N, P₂O₅, K₂O and S in soils were ranged from 173.60 to 235.20, 4.90 to 17.10, 180.0 to 330.0 kg/ha and 3.10 to 21.30 mg/kg with mean values of 203.30, 11.77, 237.32 kg/ha and 13.21 mg/kg, respectively.

Polara and Chauhan (2015) analyzed various soil parameters from 180 surface soil (0-15 cm) samples covering different taluka of Gir Somnath district. They reported that available N, P₂O₅, K₂O and S status ranged from 114 to 406 kg/ha (mean 207 kg/ha), 3 to 78.1 kg/ha (mean 21.2 kg/ha), 137 to 778 kg/ha (mean 358 kg/ha) and 1.2 to 54.4 mg/kg (mean 14.0 mg/kg), respectively. They observed that overall samples were deficient with respect to available N and P₂O₅, high in available K₂O and medium in available S status in soils

Hadiyal *et al.* (2016) collected 250 soil samples (0-15 cm) from Girgadhda and Una talukas of Gir Somanth district in Gujarat and revealed that the available P₂O₅, K₂O and S in soils varied from 6 to 285, 22 to 760 kg/ha and 9.50 to 22.70 mg/kg and with mean values of 56, 220 kg/ha and 14.32 mg/kg, respectively.

Nagaral *et al.* (2016) collected 57 soil samples (0-15 cm) from chilli growing area of Northern Transitional Zone of Karnataka and observed that available N content varied from 112 to 672 kg/ha (mean 221 kg/ha), having 48 per cent samples were low (< 250 N kg/ha), 47 per cent medium (250 to 500 N kg/ha) and only 4 per

cent sample high (>500 N kg/ha). Available P₂O₅ content varied from 15.6 to 68.0 kg/ha (mean 32.6 kg/ha) with 8 per cent samples being low (<28 P₂O₅ kg/ha), 85 per cent medium (28 to 56 P₂O₅ kg/ha) and 7 per cent high (>56 P₂O₅ kg/ha). Available K₂O content varied from 168 to 576 kg/ha (mean 332 kg/ha) with 40 per cent medium (140 to 280 K₂O kg/ha) and 60 per cent high (> 280 K₂O kg/ha).

Patel *et al.* (2016) studied the fertility status of soil of Patan district of Gujarat and reported that the available phosphorus, available potassium and available sulphur of soils varied from 9.99 to 138.82, 105.91 to 940.80 kg/ha and 2.22 to 170.32 mg/kg with a mean values of 52.42, 402.21 kg/ha and 29.03 mg/kg, respectively.

Reddy and Naidu (2016) analyze available nutrient status in semi-arid region of Chennurmandal under Kapada district of Andhra Pradesh and reported that available N, P₂O₅, K₂O and S in soils ranged from 168 to 477, 22 to 81, 122 to 744 kg/ha and 17 to 62 mg/kg, respectively. The soils were low to medium in available N, medium to high in available P, low to high in available K and high in available S.

2.3.2 Micronutrient

Timbadia and Maliwal (2000) collected 89 surface soil samples (0-15 cm) of salt affected soils varying from loamy sand to clayey in texture from coastal areas (Jafrabad, Kodinar and Rajula talukas) of Amreli district of Gujarat and analyzed for DTPA extractable micronutrients. The result showed that the Zn, Fe, Cu and Mn were in the range of 0.07 to 2.1, 3.1 to 13.5, 2.0 to 9.6 and 6.9 to 33.6 ppm, respectively. About 36.0 and 7.9 per cent soil samples were found deficient with respect to DTPA extractable Zn and Fe, respectively, but none of the samples for Cu and Mn were found deficient.

Dhage *et al.* (2000) collected the surface soil samples from 69 locations from Shevgaon tehsil of Ahmednagar district and analyzed DTPA extractable micronutrients and reported that the DTPA Fe, Mn, Zn and Cu showed a range of 2.22 to 9.06, 6.08 to 45.83, 0.1 to 2.82 and 2.04 to 11.38 ppm with their mean value of 5.21, 17.34, 0.37 and 3.49 ppm, respectively and concluded that Fe, Mn, and Cu were in sufficient level, while Zn was found to be deficient in these soils.

Sharma *et al.* (2003) studied the status of micronutrients in soil of semi - arid region of Rajasthan. Available Zn, Cu, Fe, and Mn content ranged from 0.1 to 1.7, 0.5

to 3.9, 1.0 to 6.6, and 2.7 to 7.2 mg kg⁻¹ with a mean value of 0.73, 2.11, 4.32, and 5.15 mg kg⁻¹, respectively.

Dwivedi *et al.* (2005) collected surface soil samples from five cultivated field, each from 96 and 50 village of Leh and Kargil districts of Ladakh region and analyzed and found that the DTPA- extractable Zn, Cu ,Fe and Mn were in range from 0.54 to 33.79, 0.43 to 3.52, 0.06 to 16.3 and 0.20 to 32.17 mg kg⁻¹, respectively in soil of Leh district, while the range of Zn , Cu ,Fe and Mn was observed from 0.20 to 38.04, 0.50 to 3.41, 0.14 to 5.17 and 0.34 to 4.74 mg kg⁻¹, respectively in soils of Kargil district.

Mehra *et al.* (2005) studied of 1110 samples from *Haplustallfs* of sub humid plain and Aravalli of Rajasthan, 18.77 %, 40.63 %, 9.63 %, 2.41 % and 36.12% deficiency of Cu, Fe, Mn, Zn and S, respectively were observed.

Meena *et al.* (2006) collected 120 surface soil samples (0 – 20 cm) from Tonk district of Rajasthan and reported that the DTPA extractable Fe, Zn, Mn and Cu varied from 2.23 to 14.16, 0.19 to 1.93, 6.85 to 45.25 and 0.21 to 1.87 with mean values of 5.38, 0.83, 21.56 and 0.61 mg kg⁻¹, respectively.

Polara *et al.* (2006) collected 440 surface soil samples from salt affected area of North-West Agro Climatic Zone of Gujarat, and reported that the soils are low in organic carbon and DTPA extractable Zn, Fe, Mn and Cu status.

Hundal *et al.* (2008) studied the nutrient status of rice crops cultivated in low land areas in the vicinity of Satluj River in district of Ludhiana and reported that the range for Fe, Mn, Zn and Cu were 64-217, 72-187, 15-24 and 3-6 mg kg⁻¹, respectively.

Nagendran and Angayarkanni (2010) collected 56 soil samples from 16 pedons in two transects representing various physiographic positions along a double toposequence of Cumbum valley of Tamil Nadu and reported that DTPA extractable Fe, Mn, Zn and Cu in pedons of soils varied from 1.0 to 16.8, 0.88 to 13.2, 0.13 to 0.90 and 0.14 to 1.32 mg/kg, respectively.

Bhanwaria *et al.* (2011) determined available micronutrient status in Mokala soil Series of Rajasthan and revealed that available micronutrients Fe, Mn, Zn and Cu ranged from 1.40 to 5.43, 2.50 to 7.90, 0.24 to 0.79 and 0.21 to 0.45 mg/kg with average values of 3.43, 4.75, 0.53 and 0.31 mg/kg, respectively.

Rajendra *et al.* (2011) reported the available micronutrient status of soils of Mokala soil series of Rajasthan. They found that the content of Fe, Zn, Mn and Cu varied from 1.40 to 5.43, 0.24 to 0.79, 2.50 to 7.90 and 0.21 to 0.45 mg kg⁻¹ with mean value of 3.43, 0.53, 4.75 and 0.65 mg kg⁻¹, respectively.

A soil survey was conducted to study fertility status of Banaskantha district of Gujarat with 494 surface soil samples and it was found that DTPA extractable Fe, Mn, Zn and Cu values were ranged between 2.66 to 20.38, 4.10 to 24.38, 0.18 to 2.76 and 0.16 to 2.84 mg/kg with mean values of 6.61, 10.97, 0.71 and 0.68 mg/kg, respectively (Annual Report, 2011-12).

Chouhan *et al.* (2012) studied micronutrient status from medium black soils of Dewas district of Madhya Pradesh. They observed that DTPA-Fe, Mn, Zn and Cu in soils varied from 4.50 to 22.5 mg/kg (mean 6.80 mg/kg), 1.70 to 25.70 mg/kg (mean 5.4 mg/kg), 0.04 to 4.9 mg/kg (mean 0.49 mg/kg) and 0.24 to 5.90 mg/kg (mean 1.80 mg/kg), respectively.

Patel *et al.* (2012) collected 2531 samples from different eighteen sites of Mandvi tahsil near Coastal Region of Kutch district and revealed that available Fe, Mn, Zn and Cu ranged from 1 to 5.2, 2 to 8, 0.2 to 8 and 0.2 to 0.8 ppm with mean values of 2.81, 4.65, 4.56 and 0.39 ppm, respectively.

Punithraj *et al.* (2012) collected 80 surface soil samples (0-15 cm) from Hassan district of Karnataka and reported that the DTPA- Fe, Zn, Mn and Cu ranged from 1.80 to 69.14, 0.15 to 7.61, 1.02 to 68.01 and 0.96 to 9.96 with mean value of 58.12, 1.83, 47.39 and 3.73 mg kg⁻¹, respectively.

Shirgire (2012) studied the fertility status of the soils of different talukas of Jamnagar district and revealed that the available Fe (10.41 mg ha⁻¹), Mn (18.04 mg ha⁻¹) and Cu (1.32 mg ha⁻¹) were found sufficient, whereas the soils were medium in available Zn (0.87 mg ha⁻¹) among the DTPA extracted micronutrients.

Rajput and Polara (2012) collected 220 surface (0-20 cm depth) soil samples from cultivated field of eleven talukas of Bhavnagar district and analyzed for the DTPA extractable Fe, Mn, Zn, and Cu which varied from 2.1 to 20, 2.18 to 33.3, 0.07 to 2.12 and 0.04 to 3.12 mg kg⁻¹, respectively.

Singh and Rathore (2013) studied available nutrient status in different topographic profile of Aravalli mountain ranges and Malwa plateau in Pratapgarh

district of Rajasthan. The DTPA extractable Fe, Mn, Zn and Cu ranged from 4.56 to 10.04, 1.10 to 12.24, 0.04 to 0.66 and 0.14 to 0.89 mg/kg with mean values of 6.40, 6.13, 0.23 and 0.52 mg/kg, respectively in soils of Aravalli mountain ranges. In soils of Malwa plateau, the content of available Fe, Mn, Zn and Cu ranged from 5.86 to 14.20, 0.55 to 36.84, 0.04 to 2.19 and 0.48 to 1.15 mg/kg with mean values 10.09, 15.58, 0.92 and 0.87 mg/kg, respectively. The DTPA extractable micronutrients like iron, manganese and copper were found sufficient and zinc was deficient in soils of both transect.

Srinivasan and Poongothai (2013) collected 30 soil samples (0-20 cm) from 30 revenue villages of Tittakudi taluka of Tamil Nadu and reported that available Fe, Mn, Zn and Cu ranged from 2.52 to 34.66, 4.05 to 21.44, 0.79 to 3.12 and 0.64 to 9.26 mg/kg with mean value of 18.59, 12.75, 1.96 and 9.9 mg/kg, respectively.

Verma *et al.* (2013) collected 1800 soil samples of Malkharauda block of Janjgir Champa district and found that DTPA extractable Fe, Zn, Cu and Mn were varied from 3.2 to 60.1, 0.1 to 5.8, 0.2 to 11.1 and 3.9 to 66.0 with mean value of 21.0, 1.1, 4.1 and 26.0 mg kg⁻¹, respectively. Overall 86.63, 99.22 and 96.62 per cent soil sample were found high in Fe, Cu and Mn, respectively.

Malavath and Mani (2014) reported that the DTPA extractable Fe, Zn, Mn and Cu varied range from 8.9 to 22.4, 0.10 to 3.52, 24.0 to 49.2, and 0.85 to 3.63, respectively for the soils of Dryland Agricultural Research Station at Chettinad in Sivaganga district of Tamil Nadu

Tundup and Akbar (2014) collected 60 surface soil samples from the Kishtwar district of Jammu and Kashmir and found that DTPA extractable Zn, Cu, Mn and Fe ranged from 1.24 to 5.55, 1.20 to 2.97, 13.26 to 47.56 and 7.17 to 17.18 mg kg⁻¹ with mean value of 2.34, 2.10, 22.35 and 10.65 mg kg⁻¹, respectively.

Singh *et al.* (2014) analyzed available nutrient status from medium black soils of Chambal region of Madhya Pradesh. They found that DTPA-Zn, Fe, Cu and Mn content varied from 0.37 to 1.30, 0.93 to 8.79, 0.23 to 0.52 and 1.34 to 7.36 mg/kg, respectively with corresponding mean values of 0.75, 5.10, 0.46 and 3.91 mg/kg, respectively.

A survey work was carried out with 177 surface soil samples from Gandhinagar district of Gujarat to study fertility status of farmer's field and it was

revealed that DTPA extractable Fe, Mn, Zn and Cu values were ranged between 3.34 to 24.08, 3.28 to 23.70, 0.16 to 1.76 and 0.36 to 1.90 mg/kg with mean values of 6.91, 12.93, 0.63 and 0.96 mg/kg, respectively (Annual Report, 2015).

Arunkumar and Paramasivan (2015) studied the fertility status of the soils of orathur village of veeranam command area of cuddalore district in Tamil Nadu and revealed that the available Fe, Mn, Cu and Zn in soils varied from 3.26 to 20.16, 0.94 to 8.26, 0.23 to 10.22 and 0.14 to 1.56 mg/kg with mean values of 10.02, 2.83, 2.56 and 0.50 mg/kg, respectively.

Kumar (2015) studied the fertility status of the soils of different block of Saharsa district of Bihar and revealed that the available Fe, Mn, Cu and Zn in soils were ranged from 11 to 104, 45 to 150, 0.65 to 2.60 and 1.30 to 4.90 mg/kg with mean values of 776.03, 113.93, 1.52 and 2.36 mg/kg, respectively.

Mahajan *et al.* (2015) studied fertility status of the coastal acid saline soils of Goa and found that available micronutrients Fe, Mn, Cu and Zn ranged from 33.4 to 66.4, 8.71 to 126, 0.60 to 4.41 and 0.54 to 2.48 mg/kg, respectively.

Polara and Chauhan (2015) analyzed various soil parameters from 180 surface soil (0-15 cm) samples covering different taluka of Gir Somnath district. They reported that available Fe, Mn, Cu and Zn status ranged from 3.48 to 19.00 mg/kg (average 9.01 mg/kg), 4.04 to 59.81 mg/kg (average 16.58 mg/kg), 1.09 to 6.72 mg/kg (average 2.27 mg/kg) and 0.08 to 5.88 mg/kg (average 1.02 mg/kg), respectively. They observed that soils were sufficient with respect to available Mn and Cu, whereas the soils were medium in Fe and Zn.

Prabhavati *et al.* (2015) studied 69 surface samples from deep black soils of Belgaum district (Yadawadwaterhed) of Karnataka. They found that 100 per cent Yadwad soils were deficient for DTPA-Zn content (mean 0.18 mg/kg) by considering the critical value of 0.6 mg/kg. The DTPA extractable Fe content of entire micro-waterhed soils was low. DTPA-Mn and Cu content was sufficient against the critical level 1.0 mg/kg (Lindsay and Norvell 1978) and > 0.2 mg/kg, respectively in soils.

Rajput *et al.* (2015) collected 150 composite surface soil samples (0-15 cm) from irrigated and non-irrigated mustard growing fields covering 30 villages of northern Madhya Pradesh and reported that DTPA extractable Fe, Mn, Zn and Cu in soil ranged from 1.25 to 18.65, 0.36 to 16.65, 0.18 to 2.56 and 0.12 to 4.62 mg/kg

with mean values of 5.55, 4.36, 0.69 and 1.14 mg/kg, respectively. Available Fe, Mn, Zn and Cu were deficient to the extent of 35, 7, 46 and 7 per cent, respectively.

Hadiyal *et al.* (2016) collected 250 soil samples (0-15 cm) from Girgadhda and Una talukas of Gir Somanth district in Gujarat and revealed that available Fe, Zn, Mn and Cu in soils varied from 0.72 to 14.06, 0.20 to 4.98, 0.96 to 27.0 and 0.46 to 3.16 mg/kg and with mean values of 5.33, 0.57, 10.8 and 1.29 mg/kg, respectively.

Karajanagi *et al.* (2016) analyzed micronutrients of 75 soil samples from Dundur village under Malaprabha command area in Karnataka and reported that available Fe, Mn, Zn and Cu in soils were ranged from 0.47 to 4.67, 2.40 to 9.50, 0.43 to 0.65 and 0.02 to 1.03 mg/kg with mean values of 1.79, 4.80, 0.55 and 0.43 mg/kg, respectively. Major portion of the area was deficient in zinc and iron, whereas copper and manganese were sufficient in these soils.

Nagaral *et al.* (2016) collected 57 soil samples (0-15 cm) from chilli growing area of Northern Transitional Zone of Karnataka and observed that available Zn content varied from 0.19 to 0.80 mg/kg (mean 0.44 mg/kg), with 70 per cent per cent samples being sufficient and 30 per cent deficient. Available Cu content varied from 0.10 to 0.98 mg/kg (mean 0.51 mg/kg) with 97 per cent samples being sufficient and 3 per cent deficient. Available Fe content varied from 1.01 to 7.59 mg/kg (mean 3.48 mg/kg) with 15 per cent samples being sufficient and 84 per cent deficient. Available Mn content varied from 4.86 to 17.38 mg/kg (mean 7.35 mg/kg) with 100 per cent samples being sufficient.

Patel *et al.* (2016) studied the fertility status of Patan district of Gujarat and reported that 316 surface soil samples having DTPA extractable Fe, Mn, Zn, and Cu values were ranged between 3.48 to 23.92, 3.60 to 38.08, 0.14 to 2.10 and 0.10 to 2.76 mg/kg with mean values of 6.77, 12.51, 0.71 and 0.86 mg/kg, respectively.

Wagh *et al.* (2016) studied status of available micronutrients in sunflower growing soils of Nagpur district of Maharashtra and found that available Fe, Mn, Zn and Cu ranged from 10.02 to 22.52, 9.21 to 29.41, 0.18 to 0.54 and 0.76 to 3.32 mg/kg with mean values of 16.10, 18.45, 0.33 and 1.13 mg/kg, respectively. The soil samples were deficient in available Zn and sufficient in available Fe, Mn and Cu.

2.3.3 Nutrient index

Polara and Kabaria (2006) studied the 220 surface soil samples of Amreli district indicates that soils were deficient with respect to available N and S, whereas medium in available P_2O_5 and K_2O status. Among the DTPA extractable micronutrients, Mn and Cu were found sufficient, whereas the soils were medium in Fe and Zn. The nutrient index values were low for available N (1.02) and S (1.27), medium for available P_2O_5 (1.83), K_2O (2.11), DTPA extractable Fe (2.04) and Zn (1.65), and high for Mn (2.68) and Cu (3.0) in the soils of Amreli district. More or less similar, results were also reported by Polara *et al.* (2006) for the soils of North-West Agro Climatic Zone of Gujarat.

Prakash *et al.* (2008) soil survey was done during the year 2004-05, Bajaj sugar mill Bhasana, Muzaffarnagar district, Uttar Pradesh, India, were collected six hundred soil samples from 22 circles of sugar factory zone and analyzed for the current status of the available macronutrients and other parameters. It was found the nutrient index value of the zone for organic carbon (N), available phosphorus and available potash were found 1.41, 1.20 and 1.97, respectively showing the deficiency of all these three nutrients and they required judicious supplementation of the nutrients for sustained productivity.

Rajput and Polara (2012) collected 220 surface soil sample from eleven talukas of Bhavnagar district and reported that the nutrient index values were medium for N (1.59), S (1.62) and P (1.68), high for K (2.67), medium for DTPA-Zn (1.59) and high for Fe (2.35), Mn (2.36) and Cu (2.48) in the soils of Bhavnagar district of Gujarat.

2.4 QUALITY OF UNDER GROUND WELL/TUBE WELL WATER

2.4.1 Quality of well/tube well water and their suitability

In arid and semi-arid areas, irrigation is very essential for successful agriculture. Whatever may be the source of irrigation water, some soluble salt are always dissolved there in. These constitute mostly of sodium, calcium, magnesium and sometimes potassium as cations and chloride, sulphate, bicarbonate and little amount of carbonate and sometimes nitrate as anions. The suitability of irrigation water should be evaluated on the basis of criteria indicative to their potential to create hazardous soil condition for crop growth.

Bhumbla (1969) has classified the RSC as good, fair and bad when the RSC is below 1.25, 1.25 to 2.5 and above 2.5 me l^{-1} , respectively. Where appreciable RSC occurs (perhaps above 2.5 me l^{-1}), special precautions are needed in irrigation to prevent lime accumulation and possible soil alkalization. More frequent irrigation is therefore necessary to prevent soil during and to do leaching at frequent intervals under this situation.

Timbadia (1988) collected 89 underground well water samples from Jafarabad, Kodinar and Rajula talukas of Amreli district to judge the quality of irrigation water and their effect on soil characteristics. He found that well water were slightly alkaline (7.5 to 9.0) in reaction, saline (0.9 to 11.0 dS m^{-1}) in nature and dominated with Na^+ and Cl^- . On an average 57 per cent well water having more than 1 mg l^{-1} and only 18 per cent samples have more than 1 mg l^{-1} fluorine. The percentage of samples falling under class I, II and III of SSP were 13, 21 and 66, respectively.

To evaluate salinity status of underground well water, 77 well water samples were collected during 1987 from coastal areas in Saurashtra and found that EC of well water ranged from 1100 to 15000 $\mu\text{mhos cm}^{-1}$, SAR and RSC values were ranged from 4.3 to 70.5 and traces to 15.8 me l^{-1} , respectively (Anon., 1989).

To study the extent of salinity and sodicity, 42 samples of well water and irrigated soils were collected from various villages of Mangrol, Veraval and Una talukas of Junagadh district. The data on chemical analysis of underground well water revealed that the pH values varied from 7.1 to 8.6. The EC values ranged from 0.6 to 9.9 dS m^{-1} . About 66 per cent samples possess EC more than 2 dS m^{-1} . The SAR varied between 2.38 and 16.82 and about 26 per cent samples had SAR greater than 10. Only five water samples were found to have RSC (Anon., 1989).

Das *et al.* (1991) collected 97 water samples from Orissa to judge their suitability for irrigation purpose. The quality rating of these water indicated that 8 samples from wells, 3 from perennial stream/canals and 7 from ponds were unsuitable for irrigation purpose. Special attentions are to be given while irrigating these water.

Girdhar (1991) studied the compositions of ground water of 8 different wells were evaluated at coconut plantation farm GAU, Mahuva. It was observed that EC of these wells varies from 1.9 to 9.3 dS m^{-1} and SAR ranges from 5 to 31.5. These water are also rich in Na^+ followed by Mg^{++} and Ca^{++} , where as Cl^- is the dominant anion.

Gupta (1991) carried out an integrated classification of ground water based upon EC, SAR, and RSC values of 4145 water samples from 11 districts of western Rajasthan. It was observed that these ground water were sodic in character due to high SAR or RSC values. The SAR ranges from 0.15 to 176.8 with average value of 13.9 in districts of Barmer, Bikaner and Jaisalmer. More than 33.3 per cent water have SAR greater than 18. High RSC generally occurs in low to medium salinity water and ranges from nil to 68.8 me l⁻¹ with an average value of 3.1 me l⁻¹. The districts viz, Jhunjhunu, Nagaur and Sikar have high RSC in ground water; based upon salinity, SAR and RSC distribution, the whole region has been divided in six saline-sodic zones.

One hundred six irrigation water samples from four talukas i.e. Porbandar (49), Ranavav (31), Kutiyana (16) and Manavadar (10) were collected during 1991 for monitoring of quality of irrigation water. The data of the chemical analysis of irrigation water revealed that EC ranged from 0.77 to 44.0 with an average of 20.63 dS m⁻¹. The SAR of irrigation water varies from 1.92 to 36.31 with an average of about 10.41. The SSP ranged from 14.22 to 87.57 with an average of 60.62. Na was the predominant cation followed by Ca, Mg and K. The chloride was the dominant anion (Anon., 1992).

Rai *et al.* (1993) collected 60 well water of Suratgarh and Hanumangarh and analyzed for pH, EC, chloride, sulphate, nitrate, fluoride, calcium, magnesium, sodium, potassium, and boron. The EC of water varied from 5.9 to 43.5 dS m⁻¹, SAR from 8 to 37 and boron from 0.1 to 13.0 mg l⁻¹.

Chand *et al.* (1993) collected two hundred twenty water samples from running tube wells in villages, viz., Tihara, Shahpur, Asalwas, Karnawas and Bawal of Mahandragarh district of Haryana. The RSC and SAR were calculated and the water samples were classified into five categories viz. good, normal, sodic, marginally saline and saline-sodic.

Brar and Singh (1993) studied the quality of underground irrigation water in south western districts of Punjab on the basis of 15468 tube well water samples received from the three districts of these zones. On the basis of EC, 73, 22 and 5 per cent samples fall in the category of <2000, 2000-4000 and >4000 micromohs cm⁻¹, respectively. Where as if we classify the samples on the basis of RSC 36, 23, 23 and

18 per cent samples fall in the category of <2.5, 2.5-5.0, 5.0-7.5 and >7.5 me l⁻¹, respectively. Taking into consideration both EC and RSC, 25, 31 and 44 per cent water samples were found to be fit, marginal and unfit for irrigation purpose.

Patel *et al.* (1993) collected tube well water samples from three talukas of Mehasana district during summer 1989. The results revealed that the water sample had a high salinity hazard but permissible for sandy to sandy loam soil. The SSP and RSC were high and reported to have quicker adverse effect on light textured soils than heavier textured soils. Hence, indiscriminate and excess use of this sodic water is required to be avoided.

Singh *et al.* (1994) studied the quality of ground water in *Samadari-Balotra* region of Western Rajasthan revealed that these water were moderate to highly saline and sodic with EC ranged of 240 to 33213 $\mu\text{S m}^{-1}$ and pH from 7.0 to 9.5. These water have marked concentration of chloride of sodium with high soluble sodium percentage in 97 per cent samples. In all cases, calcium was lower than the magnesium, except in few samples with low salinity of C₁ and C₂ classes. The value of SAR ranges from 1.85 to 96 and 54.4 per cent water samples fall under high SAR classes. The content of RSC in well water ranges from 0.4 to 38.6 me l⁻¹ and 29.20 per cent water samples have RSC more than 8 me l⁻¹. The soils irrigated with saline water have pH of 7.1 to 8.5 at surface and 7.3 to 8.6 in subsurface, while EC at these locations varied from 249 to 9565 and 359 to 2123 $\mu\text{S m}^{-1}$, respectively.

The analysis of underground well water of Junagadh district revealed that the quality of well water of this district had wide range of salinity hazards ranging from the EC value of 0.4 to as high as 11.0 dS m⁻¹ with a mean value of 2.11 dS m⁻¹. However, the alkali hazard was negligible in the area. Most of the water had pH range of 7.5 to 8.5 with a mean value of 8.0. Further, it was indicated that there were some of the wells had the problem of RSC. The RSC, SAR and SSP values were ranged from 0.55 to 5.2, 0.60 to 11.2 and 12.2 to 77.4 with their mean values were 2.28 me l⁻¹, 3.40 and 35.81, respectively (Anon., 1994).

Bhamodker *et al.* (1997) carried out analysis of irrigation water under the commands of Kate, Puna and Morna. The result showed that the well water have high to very high salinity with low to very high sodium status. Hence, this well water is not suitable and should not be used for irrigating the crops unless the proper reclamative

measures and drainage are provided. The study suggested that the agriculture in the area should be encouraged only under rainfed condition for *kharif* crops or by selecting salt tolerant crops in *Rabi* season with advanced irrigation practices.

An investigation was under taken by Lal *et al.* (1998) to determine the quality of underground water of non-command area of *Bikaner* district in Rajasthan, their effect on soil properties and to categorize them for their suitability for irrigation. The water is mostly Na^+ - Mg^{++} - Ca^{++} type with dominance of Cl^- followed by CO_3^- , HCO_3^- .

Nilsood *et al.* (1998) suggested that EC of water samples collected from 88 villages of Talwandiabensi (Bhatinda district) varied from 0.55 to 13.74 dS m^{-1} . Soluble carbonate, bicarbonate and RSC of these water varied from nil to 3.2, 2.0 to 17.7 and traces to 14.6 me l^{-1} , respectively. Soluble sodium (3.0 to 19.1 me l^{-1}) was the dominant cation and SAR ranged from 2.3 to 31.3. Based on EC and RSC of water 15, 38, 12 and 35 per cent were good (low EC and RSC) marginal-saline, marginal-sodic and poor (high EC and RSC), respectively, for irrigation purpose. Salinity is more prevalent than sodicity in the area.

Yadav (1999) studied the chemical composition and quality of irrigation water sample was collected from 64 villages of Mahendragarh district. The pH, EC, SAR and RSC in irrigation water were varied from 7.6-9.7, 0.2-23.4 dS m^{-1} , 0.19-80.49 and nil-33.50 me l^{-1} with mean values of 8.68, 3.24 dS m^{-1} , 1.56 and 3.57 me l^{-1} , respectively. The cations and anions viz., Ca^{++} , Mg^{++} , Na^+ , K^+ , CO_3^- , HCO_3^- , Cl^- and SO_4^- in irrigation water were varied from 0.25-26.25, 0.0-80.00, 0.28-234.00, 0.01-2.10, 0.0-10.00, 0.0-29.60, 0.0-203.00 and 0.0-57.10 me l^{-1} with mean values of 3.19, 4.73, 33.15, 0.25, 0.78, 7.08, 21.48 and 3.70 me l^{-1} , respectively.

Srivastava and Lallanram (2000) collected water samples from kalmeshwar tehsil. They found that 76 per cent of total water sample were moderately suitable and only 3 per cent were unsuitable for irrigation. In case of water sample collected from katol tehsil, 94 per cent of the total samples were unsuitable, only 6.0 per cent of total sample were found moderately suitable for irrigation.

In order to study the nature and extent of salinity and sodicity of underground well water of Limbdi and Halvad talukas of Surendranagar district, 10 and 6 well water samples from Limbdi and Halvad talukas, respectively, were collected during 2001. The result revealed that EC values were ranged from 1.3 to 14.0 dS m^{-1} and 2.1

to 7.6 dS m⁻¹ with their mean values of 4.56 and 4.43 dS m⁻¹ for Limbdi and Halvad taluka, respectively. The pH, RSC, SAR and SSP values for Limbdi taluka were ranged from 7.70 to 8.25, 0.0 to 9.4, 4.63 to 28.4 and 60.0 to 89.6 with their mean values of 8.03, 2.3 me l⁻¹, 14.7 and 73.9, respectively, while those for Halvad taluka were 7.13 to 7.43, 0.0-0.0 me l⁻¹, 4.93 to 15.3 and 53.5 to 80.3 with the mean values of 7.29, 0.0 me l⁻¹, 8.84 and 65.42, respectively (Anon., 2001).

Verma *et al.* (2003) collected 556 water samples from seven tehsils of Churu district (Rajasthan) during October to February, 1995-2000. They found that EC of water samples were ranged from 0.4-19.7 dS m⁻¹. About 32 per cent of water samples had EC < 2.0 dS m⁻¹ while 36 per cent water samples showed EC between 2-4 dS m⁻¹. The pH of water samples ranged from 7.2-9.3. The Cl⁻ was dominant anion and it ranged from 1.2-200.4 me l⁻¹ while Na was the dominant cation ranging from 1.7-118.0 me l⁻¹. The SAR of water samples ranged from 2.2 to 33.5 and RSC of water varied from nil to 13.1 me l⁻¹. About 75 per cent water samples were recorded RSC < 2.5 me l⁻¹. Whereas 8.8 per cent samples had RSC between 2.5 to 5.0 me l⁻¹ and 16.0 per cent samples had RSC > 5.0 me l⁻¹.

Kabariya (2004) collected 220 well/tube well water samples from the Amreli district of Saurashtra region of Gujarat and reported that almost three fourth of the samples of irrigation water were found saline (EC 0.75 dS m⁻¹ and above). The EC values ranged between 0.4 and 12.5 with a mean value of 2.32 dS m⁻¹. The water were alkaline in reaction (pH 8.06). The overall RSC values ranged from 0.0 to 7.05 with mean value of 1.07 me l⁻¹ and overall 74.5, 6.8 and 18.7 per cent samples fall under safe, marginal and unsafe classes of RSC, respectively. The overall mean value of SSP was found 56.21, which varied from 4.49 to 89.54 and overall 51.8 and 48.2 per cent samples fall under safe and unsafe classes, respectively. The SAR values ranged from 0.19 to 34.18 with a mean value of 7.18 and overall 75.0, 21.0, 2.3 and 1.2 per cent samples fall under S₁, S₂, S₃ and S₄ classes of SAR, respectively.

Bhatt *et al.* (2006) carried out a preliminary survey of the coastal city-Bhavnagar to assess salinity ingress probed through groundwater quality. Water samples from the wells and bores located in the study area were collected and analyzed. Bhavnagar city is found significantly affected by the seawater intrusion. The ground water showed very high values of SO₄⁻², Cl⁻, and, Na⁺, K⁺ compared to the permissible limits for drinking purposes. The quality of ground water in some of

the areas was found highly saline and can not be used even for irrigation purpose. The results also indicated a gradual encroachment of seawater into the native ground water.

Savalia *et al.* (2006) found that to underground water of open wells/tube wells situated at higher elevations have low pH, EC, water soluble Mg^{+2} , Na^+ , CO_3^- , HCO_3^{2-} , Cl^- , SSP and SAR then in lower elevations in deferent land slopes of Southern Saurashtra.

Ram *et al.* (2006) survey and analysis of water samples collected from 70 tube wells distributed in different villages of Rajgarh tehsil of Churu district, Rajasthan, India, were performed in 2002-03. They revealed that the pH of irrigation water varied from 8.0 to 9.1, EC ranged between 1.70 to 14.10 $dS\ m^{-1}$. Cations, like Ca^{2+} , Mg^{2+} , Na^+ and K^+ of irrigation water of Rajgarh tehsil ranged from 0.70-8.6, 2.3-55.8, 10.6-84.2 and 0.2-0.5 me/litre, respectively. Sodium adsorption ratio (SAR) and adj. SAR of irrigation water varied from 6.0 to 39.3 and 15.3 to 83.7, respectively. Residual sodium carbonate varied from nil to 6.1me/litre. Majority of the water samples were of high SAR-saline category followed by marginally alkalinity problem. Approximately 4.3, 45.7 and 50.2% of the water samples had EC of < 2 , $2-4$ and >4 $dS\ m^{-1}$, respectively. On the basis of salinity (1.96) and alkalinity (2.77) indices, soils of the study area had slight salinity and moderate alkalinity problems.

Prasad and Minhas (2007) collected 1131 well/tube well water samples of Mahboob Nagar district of Andhra Pradesh and found that the depth of water in the bore/open wells varied from 3 to 96 m. The EC and pH of water samples varied from 0.3 to 8.5 $dS\ m^{-1}$ and 6.3 to 9.4, respectively. The soluble carbonate, bicarbonates, RSC and SAR of these water varied from nil to 11.2, 0.2 to 17.0, nil to 16.1 $me\ l^{-1}$ and 0.1 to 27.1 $(mmoll^{-1})^{1/2}$, respectively. About 96.7 per cent of water samples recorded EC values less than 2.0 $dS\ m^{-1}$, 55 per cent of samples recorded pH ranging from 7.0 to 8.0, while remaining 45 per cent had pH ranged from 8.0 to 9.5. Similarly, 58 and 42 per cent of water samples recorded RSC less than and more than 2.5 $me\ l^{-1}$, respectively. Based on EC, SAR and RSC, 56 per cent water samples were characterized as good, 3 per cent marginally saline, 19 per cent marginally alkali and 22 per cent alkali in nature. The predominant cations were in the order of $Na > Mg > Ca$, where as in few cases it was in the order of $Mg > Na > Ca$ with dominance of bicarbonate followed by chlorides.

Rajput *et al.* (2008) a study was conducted to determine the quality of the ground water of Mohindergarh block of Mohindergarh district Haryana, India, their effect on soil properties and to categorize them for their suitability for irrigation. According to Manchanda's classification, half of the water (51.2%) were sodic having $EC < 4 \text{ dS m}^{-1}$, $SAR > 10 \text{ (mmole l}^{-1})^{1/2}$ and $RSC > 2.50 \text{ me l}^{-1}$ followed by saline-sodic (30.1%) and good quality (17.0%) water. Whereas according to CSSRI classification, 16.87, 2.11, 1.00, 25.19, 7.44, 7.44 and 28.41% samples were good, marginal saline, saline, high SAR saline, marginally alkali, alkali and highly alkali, respectively. The water were mostly Na-Mg-Ca type with dominance of chlorides followed by sulphate.

Patel *et al.* (2012b) studied the underground water quality of different landforms of Meghal Irrigation Command area of Southern Saurashtra region of Gujarat. They observed lower values of pH, EC, water soluble Mg^{2+} , Na^+ , CO_3^- , HCO_3^- , Cl, SSP and SAR at higher elevation than in lower elevation.

Gopal (2013) reported the underground water samples from different land slopes of Girnartoposequence were placed under different water quality class. As per the Semi-logarithmic USSL diagrams, out of 43 wells / tube well water sample, 74.4, 18.6 and 6.9 per cent were placed in C_3S_1 , C_4S_1 and C_4S_2 water quality class, respectively indicating the majority of water samples fall in C_3S_1 class.

Rajput and Polara (2013) collected 220 irrigation ground water sample from eleven talukas of Bhavnagar district and analyzed. They reported that the overall EC values of irrigation water ranged from 0.38 to 18.2 dS m^{-1} with mean values of 2.77 dS m^{-1} . The pH values ranged from 6.79 to 8.78 with mean values of 7.72 and the overall mean SAR was 9.80 with values varying from 1.32 to 26.3, respectively. Among the cations, overall highest proportion of Na^+ (20.93 me l^{-1}) was observed, which was followed by Ca^+ (4.45 me l^{-1}), Mg^+ (3.64 me l^{-1}) and K^+ (0.11 me l^{-1}). The overall concentrations of Ca^+ , Mg^+ , Na^+ and K^+ varied from 0.83 to 31.10, 0.39 to 26.20, 1.46 to 139.5 and 0.00 to 1.37 me l^{-1} . In case of anion, overall highest proportion of Cl^- (20.47 me l^{-1}) was observed, which was followed by HCO_3^- (6.16 me l^{-1}), SO_4^- (3.95 me l^{-1}) and CO_3^{2-} (0.27 me l^{-1}). The overall concentrations of CO_3^{2-} , HCO_3^- , Cl^- and SO_4^- varied from 0.0 to 4.10, 1.90 to 38.4, 1.90 to 135.4 and 0.00 to 18.2 me l^{-1} , respectively.

Dhiman (2014) collected 27 underground water samples from Rajkot district and reported that majority of sites have SAR < 10 indicating water class to be of excellent quality and 81.48 per cent samples have RSC less than the permissible limit of 1.5. Furthermore, 70.37 per cent sites have $(Ca^{++} + Mg^{++}) > HCO_3^-$ indicating as base exchanged-hardened water, while remaining 29.63 per cent samples have $HCO_3^- > (Ca^{++} + Mg^{++})$, which may be referred as base exchanged-softened water.

2.5 RELATIONS AMONG AND BETWEEN SOIL FERTILITY AND SALINITY/SODICITY PARAMETERS OF SOILS

Any increase or decrease in soil salinity will depend mostly upon the relative concentration of salts in irrigation water and that accumulate in soil under equilibrium conditions.

Tripathi *et al.* (1971) reported that there was no relationship between electrical conductivity of irrigation water and EC of saturation extract of the soils of Uttar Pradesh.

Paliwal and Maliwal (1971) studied the relationship between irrigation water and irrigated soils. They reported significant correlation of SAR and SSP both of irrigation water and ESP of soil. However, no such relation was found between SAR and ESP of The EC of the irrigated soils has fairly good correlation with EC of the irrigation water. In light textured soils which are well drained, EC_e of the irrigated soils is generally less than EC of the irrigation water, at the end of irrigation, particularly in surface layers. In lower depths, EC may be more in hot summer months, EC_e of the soils may be several times high (Singh *et al.*, 1967, Paliwal and Dinesh, 1970, Paliwal and Maliwal, 1971).

Lal and Lal (1977) collected 47 water samples and an equal number of corresponding soil samples were analyzed for different constituents. Almost all the soils were sandy or loamy sand in texture. Significant positive coefficient of correlation was found between both EC and potential salinity of irrigation water and EC_e of the irrigated soils. Similarly, significant positive coefficients of correlation were obtained between SAR and RSC of the water and ESP of the irrigated soils in respective soils.

Timbadia (1988) found significant relationship between EC of irrigation water and EC of saturation extract. A highly significant correlation between RSC of irrigation water and ESP ($r = 0.877$) was observed.

Khandenwal *et al.* (1990) found that the ECE of soils increased with increase in levels of salinity in irrigation water. The ECE of soil (irrigated with water having EC 2, 4 and 6 dS m^{-1}) was 1.12, 2.21 and 3.03 dS m^{-1} , respectively, which was 56, 55.25 and 50.5 per cent of the EC of respective water used for irrigation. The pH of saturation paste decrease significantly with an increase in EC of irrigation water. The pH of soil irrigated with water having EC level 0.8, 2, 4 and 6 dS m^{-1} was 8.3, 8.24, 8.17 and 8.08, respectively.

Padola and Bhalkar (1995) found that the application of saline water (EC 4.2 dS m^{-1}) or saline-sodic water (EC 1.5 dS m^{-1} and SAR 8.2 and EC 4 dS m^{-1} and SAR 8.6) increased the soil pH, ECE, ESP and SAR. Exchangeable Na decreased with the use of saline-sodic water (EC 1.5 dS m^{-1} & SAR 8.2). Pronounced adverse effect of salinity and sodicity at high level was observed on soil organic carbon, available N, available phosphorus and available potassium. The correlation studies showed positive relationship between EC_{iw} and ECE, SAR_{iw} and ESP and SAR_e and pH.

Girdhar (1996) observed that soil pH and ESP increased significantly with an increase in RSC and its adverse effect became additive at high SAR and EC of water.

Pandey *et al.* (2000) reported that the available P concentration had significant and positive relationship with pH ($r = 0.386^{**}$), EC ($r = 0.397^{**}$), organic carbon ($r = 0.592^{**}$) and CEC ($r = 0.367^{**}$). The available S was significantly and positively influenced by soil properties like pH ($r = 0.521^{**}$), EC ($r = 0.679^{**}$), organic carbon ($r = 0.684^{**}$) and CEC ($r = 0.679^{**}$) in *Inceptisols* of central Uttar Pradesh.

Maliwal and Timbadia (2000) studied on soils of Amreli district and found that EC and pH of irrigation water had significant and positive correlation with ECE ($r = 0.745^{**}$) and pHs ($r = 0.895^{**}$) of soil. Similarly, pH of soil is also correlated positively and significantly with RSC ($r = 0.671^{*}$) and $\text{CO}_3^{--} + \text{HCO}_3^{-}$ ($r = 0.676^{**}$) of well water. Correlation between SAR_{iw} and SAR of soil was found positive ($r = 0.439$). ESP of soils was positively correlated with RSC, and SSP of irrigation water with low coefficient value ($r = 0.294$) with SAR_{iw}. Such relationships were also

reported by Paliwal and Maliwal (1971) and Lal *et al.* (1998) in well water and soils of western Rajasthan.

Prasad and Prasad (2001) observed that EC and pH of irrigation water were highly significantly correlated with E_{Ce} ($r = 0.914^{**}$) and pH ($r = 0.394^{**}$) of soils. Similarly, SAR_{iw} was also correlated positively and significantly with SAR of soil ($r = 0.386^{**}$).

Patel (2004) found that the simple correlation among fertility parameters (O.C., available N, P₂O₅, K₂O and S) and salinity/sodicity, parameters (EC_{2.5}, pH_{2.5}, CaCO₃, ESP and SAR) were worked of the soils of Surendranagar district. The examination of correlation values indicates significant positive relations of EC_{2.5} with pH_{2.5} ($r=0.1714^*$), ESP ($r=0.2964^{**}$), SAR ($r=0.8778^{**}$), OC ($r=0.1589^*$) and P₂O₅ ($r=0.1476^*$). The pH_{2.5} was significantly and positively correlated with CaCO₃ content ($r=0.422^{**}$), ESP ($r=0.7308^{**}$) and P₂O₅ ($r=0.1943^*$). A significant positive correlation ($r=0.2390^{**}$) was observed between ESP and SAR of soils. Organic carbon was significantly and positively correlated with available N ($r=0.6932^{**}$) and available K₂O was also significantly and positively correlated with available N ($r=0.1764^*$) and available P₂O₅ ($r=0.1981^*$).

Kabaria (2004) studies the correlation between the different properties (EC, pH, RSC, SSP and SAR) of well/tube well water of Amreli district. The data indicate that EC was negatively correlated with pH ($r= -0.1827^{**}$) of irrigation water. Highly significant positive correlations between EC and SSP ($r= 0.3951^{**}$) and SAR ($r= 0.8201^{**}$) of irrigation water were observed. Which indicate the SSP and SAR of irrigation water increase with increasing the EC of irrigation water. The pH of irrigation water were highly significantly positively correlated with RSC ($r= 0.7259^{**}$), SSP ($r= 0.3957^{**}$) and SAR ($r= 0.1345^*$). The RSC of irrigation water significantly correlated with SSP ($r= 0.4535^{**}$) and SAR ($r= 0.2272^{**}$) of water. A highly significant correlation ($r= 7637^{**}$) was observed between SSP and SAR of irrigation water.

Baskar *et al.* (2006) investigated the impacted of *tsunami* incident on the ground water of Pondicherry. The analytical results of 203 water samples collected before *tsunami* were compared with the samples analyzed after the incident for studying its impact on ground water of Pondicherry. The results had shown that there were no

marked variations in the pH, EC or on their ionic composition between pre-*tsunami* and post-*tsunami* samples. Similarly the quality indices like soluble sodium percentage (SSP), residual sodium percentage (RSC), sodium adsorption ratio (SAR), potential salinity (SI), Puri's salt index (PSI), and permeability index (PI) did not shows marked variation between the two stages.

Babar *et al.* (2007) were observed in Vidarbha region of Maharashtra. The forms of potassium except exchangeable and available K, were decreased with increase in depth. The available K, exchangeable K, total K and lattice K, influenced by total N ($r=0.3268^*$, $r=0.3122^*$, $r=0.2950$, $r=0.3079^*$) respectively. The available K and exchangeable K was also affected by available N ($r=0.9784^{**}$, $r=0.9773^{**}$) respectively, in Vidarbha region. In Central Vidarbha available and exchangeable K influenced by total and available N respectively. In eastern Vidarbha the available K and exchangeable K influenced by total S and available N.

Waghmare *et al.* (2009) collected 100 surface soil samples for studied available N, P, and K in relation to chemical properties in soils of AUSA tahsil of Latur district. The data shows that these soils were neutral to alkaline in reaction, safe in EC, low to medium in organic carbon and non-calcareous to calcareous in nature. Considering soil nutrient index values these soils were medium in available N and P while high in respect of available K. Availability of N, P and K shows relationship with chemical characteristics. Further data showed that available N and P showed significant relationship with organic carbon. Available P showed negative correlation with pH and EC, whereas available K was significantly related with pH, EC, and CaCO_3 .

Shirgire (2012) studied the Correlation between soil fertility and salinity/sodicity indices of soils and results indicated that E_c had highly significantly positive relationships with EC_{2.5} ($r = 0.988^{**}$), SAR ($r = 0.672^{**}$) and ESP ($r = 0.484^{**}$). Similarly, pHs had highly significant and positive relations with pH_{2.5} ($r = 0.977^{**}$), RSC ($r= 0.222^{**}$) and SAR ($r= 0.234^{**}$). There was a highly significantly close correlation between SAR_{2.5} and ESP ($r = 0.487^{**}$) and SSP_{2.5} ($r=0.289^{**}$) obviously, the O.C. was significantly correlated with available N ($r =0.626^{**}$), K₂O ($r =0.179^*$) and B.D. ($r=0.191^{**}$).

Gajare *et al.* (2013) reported that the available P_2O_5 was significantly negative correlated with pH ($r = -0.362^{**}$) and $CaCO_3$ ($r = -0.253^*$), while positively significantly correlated with organic carbon ($r = 0.362^{**}$), while available S had significantly negative relationship with $CaCO_3$ ($r = -0.311^{**}$).

Rajeshwar and Mani (2014) reported that the pH had significant positive correlation with EC, organic carbon and sulphur ($r = 0.239^*$, 0.293^* and 0.241^* , respectively) and negatively correlated with $CaCO_3$ ($r = -0.302^*$). Though, the pH had also positive correlation with CEC, available P_2O_5 , Zn and Mn but not significant and showed negative correlation with available N, K_2O , and Fe respectively.

Tundup and Akbar (2014) reported that the available Zn, Cu, Mn and Fe was significantly and negatively correlated with pH ($r = -0.183^*$), ($r = -0.281^*$), ($r = -0.455^{**}$) and ($r = -0.367^{**}$), while positively significantly correlated with organic carbon ($r = 0.417^{**}$), ($r = 0.256^*$), ($r = 0.395^{**}$) and ($r = 0.422^{**}$), respectively.

3. MATERIALS AND METHODS

The general features of Kheda district *viz*, geographic location, physiography, geology, climate, soil, water, vegetation, land use pattern and cropping pattern are described below.

3.1 GENERAL INFORMATION OF KHEDA DISTRICT

3.1.1 Geographic Location

Kheda district falls in Middle Gujarat Agro Climatic Zone, located at 22°30' N–72°32' E, 23°18' N–73°37' E. It has an average elevation of 21 meters (68 ft). It is bounded by Sabarkantha district to the North, Ahmedabad district to the West, Panchmahal district to the East and Vadodara district to the South. On the Southern part, Khambhat Tehsil of Anand district has natural boundary of the Gulf of Cambay with Kheda district. Kheda district is famous by the name Golden Leaf since many decade it a major producer of tobacco in Gujarat State. The area covered by the district is 3959 sq.km. Sabarmati, Mahi, Mesvo, Khari, Luni, Vatrak and Shedhi are main rivers flowing in Kheda district.

3.1.2 Physiography

Kheda District is an administrative district of Gujarat state in western India and is popularly known as Charotar. Kheda consists of 8 talukas with 529 villages. Total district area is 3959 sq.km and total population of 2,299,885 as per 2011 census. The average rainfall of district is 723 mm. It covers 8 talukas *viz.*, Nadiad, Mahudha, Matar, Kheda, Kapadvanj, Thasra, Mehmedabad and Kathlal. Geomorphologically, the district can be broadly classified into three major zones *viz.*, Piedmont plain, Alluvial Plain, and The Coastal Plains (Bhal).

3.1.3 Geology

Quaternary, Post Miocene and Tertiary sediments in the area were deposited over a sinking basement. The main formation is of quaternary age, formed by alluvium deposited by Mahi, Sabarmati and Watrak rivers. They comprise multilayered formations of gravel, sand, clay and kankars intermixed at places. The clay and sand horizons form alternate layers having pinching and swelling nature. The kankars, pebbles and the gravels form lenses. Thickness of alluvium increases from

north and North West towards south and south west direction. Alluvium is underlain by Deccan traps in general with intervening blue clays at some places.

3.1.4 Climate

The normal rainfall of this district is 723 mm from South-West Monsoon with an average of 45 rainy days. The normal onset of monsoon is from 3rd week of June and the normal cessation is in the 4th week of September.

The climate of this district is semi-arid with hot, dry summers from mid-March to mid-June and the wet monsoon season from mid-June to October, when the area receives 776 mm of annual rain. The months from November to February are mild, the average temperature being around 20 °C, with low humidity. The year may be divided into four seasons. The cold season from December to February is followed by the hot season from March to May. June to September is the south-west monsoon season and two months of October and November form the post monsoon season.

3.1.5 Soils

The following are the main soil types generally found in Anand district.

- Medium black soils
- Shallow black soils
- Alluvial soils
- Loamy sand (*goralu*)
- Sandy soils

Most of the Soils of Kheda district is nearly level to gently sloping. Very little area of Kheda district have moderate to strong sloping. Most soils of the district are composed of alluvium, which is deep with high productivity. In talukas viz., Nadiad, Mehmedabad, Kapadvanj have sandy to sandy loam, while in Matar, Mahudha and Thasra shallow black to medium black soil found.

3.1.6 Water

Sabarmati, Mahi, Mesvo, Khari, Luni, Vatrak and Shedhi are main rivers flowing in Kheda district. Source of irrigation water are open well, bore well, canals and ponds. Generally water quality of Kheda district is good except Matar and some villages of Nadiad talukas. Sabarmati and Mahi are rivers that flow towards southeast and meet the Bay of Khambhat. Irrigation water is available throughout the year in most of the parts except in Matar and Mehmedabad taluka.

3.1.7 Natural Vegetation

The area under study is occupied partly by arable land and partly by natural grass or weed lands and scattered shrubs. Alternating with these grass lands or weed lands, there are entirely barren stretches. The natural vegetations observed in surveyed area are as under.

Sr. No.	Common Name	Botanical Name
1	2	3
Trees and shrubs		
1.	Babul	<i>Acacia arabica</i>
2.	Neem	<i>Azadirachta indica</i>
3.	Gandobaval	<i>Prosopis juliflora</i>
4.	Aval	<i>Cassia auriculata</i>
5.	Khakharo	<i>Butea monosperma</i>
6.	Akado	<i>Calotropis procera</i>
7.	DesiBaval	<i>Acacia nilotica</i>
8.	Kantadothor	<i>Euphorbia nivadia</i>
9.	Ber (chania)	<i>Zizyphus nummularia</i>
10.	Piludi	<i>Salvadora persica</i>
11.	Amaltas	<i>Cassia fistula</i>
12.	Saru	<i>Casuarina equisetifolia</i>
13.	Gunda	<i>Cordia maxa</i>
14.	Shisum	<i>Dalbergia sissoo</i>
15.	Gulmohar	<i>Delonix regia</i>
16.	Bamboo	<i>Dendrocalamus strictus</i>
17.	Amla	<i>Emblica officinalis</i>
18.	Nilgiri	<i>Eucalyptus camaldulensis</i>
19.	Glyricidia	<i>Glyricidia maculate</i>
20.	Gorusambali	<i>Inga dulcis</i>
21.	Su-babul	<i>Leucaena leucocephala</i>
22.	Sargvo	<i>Morigina oleifera</i>
23.	Karanj	<i>Pongamia pinnata</i>
24.	Ashok	<i>Polyalthia longifolia</i>
25.	Pipal	<i>Populus ciliate</i>
26.	Khijado	<i>Prosopis cineraria</i>
27.	Rain tree	<i>Samania saman</i>
28.	Aritha	<i>Sapindus mukorossi</i>

Sr. No.	Common Name	Botanical Name
30.	Jamun	<i>Syzygium cuminis</i>
31.	Ambli	<i>Tamarindus indica</i>
32.	Sal	<i>Tectona grandis</i>
33.	Indian badam	<i>Terminaliacatappa</i>
34.	Kadamb	<i>Anthocephalus chinensis</i>
35.	Pomegranet	<i>Punica granatum</i>
36.	Banana	<i>Musa acuminata</i>
37.	BilvaPatra	<i>Aegle marmilos</i>
Grasses and weeds		
1.	Dharo	<i>Cynodon dactylon</i>
2.	Chidho	<i>Cyprus rotandus</i>
3.	Zinzvo	<i>Dicanthium annulatum</i>
4.	Darudi	<i>Argemon maxicana</i>
5.	PardesiBhangaro	<i>Tridex procumbens</i>
6.	Gokhru	<i>Tribulus terrestris</i>
7.	Agiya	<i>Striga lutea</i>
8.	Phulni	<i>Vernonin cinaria</i>
9.	Gaderdi	<i>Xanthium strumarium</i>
10.	Barru	<i>Sorghum halphense</i>
11.	Amar bel	<i>Cuscuta reflexa</i>
12.	Kala bhangro	<i>Eclypta erecta</i>
13.	Dhatura	<i>Datura stramonium</i>
14.	Dudheli	<i>Euphorbia macrophylla</i>
15.	Nori	<i>Ipomoea reptans</i>
16.	Baghnakhi	<i>Martynia diandra</i>
17.	Jangalijoot	<i>Corchorus fascicularis</i>
18.	Nagphani	<i>Opuntiadillenia</i>
19.	Hazardana	<i>Phyllanthus niruri</i>
20.	Bhoiringani	<i>Solanum nigrum</i>

3.1.8 Agriculture

The main fields crops grow in the district of Kheda are tobacco, wheat, rice, cotton, pearl millet etc. while banana, papaya, sapota, citrus, aonla etc. are the important fruit crops. Potato, chilli, brinjal, tomato, cabbage, Cucumber etc. are major cultivated vegetable crops. jowar, maize lucern etc. are major fodder crops. Palmarosa, Ashwagandha, Drum stick etc. are major medicinal crops grown in Kheda district.

3.1.9 Land use pattern

The land utilization pattern of the district is presented below

Particulars	Area ('000ha.)
Geographical area	394.30
Cultivated area	298.54
Gross cropped area	375.65
Area under irrigation	224.85
Area under non-agriculture use	1.50
Current fallow	6.30
Cultivable waste	15.80
Area under forest	7.90
Pasture land	7.90
Cropping intensity	126 %

Source: Census of India NABARD, 2011-12

3.1.10 Cropping pattern

The major field crops cultivated in *Kharif* season are rice, tobacco, cotton, pulses and castor. Rice is grown in all the talukas. Nadiad, Kheda, Mehmedabad, Mahudha, and Thasra are Major talukas for cultivation of tobacco. Vegetable crops are grown in all the talukas except Matar and some part of Mehmedabad. Wheat, potato, tobacco, gram, fodder maize etc. are *Rabi* crops of the area. The season crops, tobacco, cotton and castor are spread over the two seasons (*kharif* and *rabi*). Pearl millet and rice are the main summer crops.

3.2 COLLECTION OF SOILS AND WATER SAMPLES

Twenty representative surface (0-20 cm) soil samples were collected from each taluka of Kheda district, simultaneously twenty irrigation water samples were also collected from each taluka of Kheda district. These talukas are Nadiad, Mahudha, Matar, Kheda, Kapadvanj, Thasra, Mehmedabad and Kathlal. Thus, 160 each soil as well as irrigation water samples were collected during April-May, 2016. Sample wise name of the farmer, village and taluka are given in Appendix I.

3.3 PREPARATION OF SOIL SAMPLES

Surface (0-20 cm) soil samples collected from the cultivated fields of the farmer's were allowed to dry completely in the laboratory. The air-dried samples were ground carefully with a wooden mortar and pestle to break soil lumps. These samples were passed through 2 mm sieve and then stored in polyethylene sample bags with proper labels. Working samples were drawn from these bulk samples. These samples were used for chemical analysis as well as for available nutrients status.

3.4 CHEMICAL ANALYSIS OF SOIL SAMPLES

For the analysis of water soluble cations and anions in surface soil samples, 1:2.5 soil-water ratio was used for analysis of water soluble cations *i.e.* Na^+ , K^+ , Ca^{++} and Mg^{++} , as well as anions *i.e.* Cl^- , CO_3^{--} , HCO_3^- and SO_4^{--} were determined as per the methods described by Richard (1954). The 1:2.5 and 1:5 soil-water ratio were used for the determination of EC, pH of the soils.

For the determination of exchangeable cations (Na^+ , K^+ , Ca^{++} and Mg^{++}) neutral normal ammonium acetate was used as per the methods described by Richard (1954).

Saturation paste of soil was prepared as described by Richard (1954). The extract was obtained after transferring the paste on the Buchner funnel under vacuum. These extract were utilized for determination of EC_e and pH_s as per the methods described for irrigation water analysis. Other soil properties were determined by the methods given in Table 3.1.

Table 3.1: Methods used for analysis of soil samples

Characteristics	Method	Reference
Chemical characteristics		
EC (1: 2.5)	Conductivity method	Richard (1954)
pH (1: 2.5)	Potentiometric method	Richard (1954)
Exchangeable cations		
Sodium	Flame photometrically	Richard (1954)
Potassium	Flame photometrically	Richard (1954)
Calcium	Versenate method	Cheng and Bray (1951)
Magnesium	Versenate method	Cheng and Bray (1951)
CEC (cmol (p+) kg-1)	Ammonium acetate method	Chapman (1965)
Available nutrient		
Organic carbon	Walkley and Black method	Jackson (1973)
Available N	Alkaline KMnO ₄ method	Subbiah and Asija (1956)
Available P ₂ O ₅	0.5 M NaHCO ₃ (pH 8.5) method	Olsen <i>et al.</i> (1954)
Available K ₂ O	1 N NH ₄ OAc method	Jackson (1973)
Available S	Turbidimetry	Williams and Stainbergs (1959)
Available micronutrient	DTPA extractable	Lindsay and Norvell (1978)
Free CaCO ₃ content	Rapid acid neutrali-zation method	Piper (1950)

3.5 SOIL FERTILITY STATUS

Parameters	Low	Medium	High
Organic carbon (%)	<0.50	0.50-0.75	>0.75
Available N (kg ha ⁻¹)	<250	250-500	>500
Available P ₂ O ₅ (kg ha ⁻¹)	<28	28-56	>56
Available K ₂ O (kg ha ⁻¹)	<140	140-280	>280
Available S (mg kg ⁻¹)	<10	10-20	>20
DTPA extractable Fe (mg kg ⁻¹)	<5	5-10	>10
DTPA extractable Mn (mg kg ⁻¹)	<5	5-10	>10
DTPA extractable Zn (mg kg ⁻¹)	<0.5	0.5-1.0	>1.0
DTPA extractable Cu (mg kg ⁻¹)	<0.2	0.2-0.4	>0.4

(Kanwar, 1976)

3.5.1 Nutrient index (NI)

Nutrient index was calculated utilizing the following formula,

$$\text{Nutrient Index} = \frac{(Nl \times 1) + (Nm \times 2) + (Nh \times 3)}{Nt}$$

Where, Nl, Nm and Nh are the number of samples falling in low, medium and high categories for nutrient status and are given weightage of 1, 2 and 3, respectively. Nt is the total no. of sample.

Nutrient index was classified based on class given by Ramamoorthy and Bajaj (1969)

Class	Index
Low	<1.67
Medium	1.67-2.33
High	>2.33

3.6 METHODS OF ANALYSIS OF IRRIGATION WATER SAMPLES

The underground (well/tube well) water samples were collected, filtered and stored in the plastic bottle. The methods used for analysis of different constituents of water are as under.

Table 3.2: Methods Used For Analysis Of Irrigation Water

Characteristics	Methods used	Reference
pH	Potentiometric method	Richard (1954)
EC	Conductivity method	Richard (1954)
CO ₃ ⁻ & HCO ₃ ⁻	Neutralization method	Reitemeir (1943)
Cl ⁻	AgNO ₃ precipitation method	Richard (1954)
SO ₄ ⁻	Turbidity method	Chesnin and Yien (1950)
Na ⁺	Flame photometrically	Richard (1954)
K ⁺	Flame photometrically	Richard (1954)
Ca ⁺⁺	Versenate method	Cheng and Bray (1951)
Mg ⁺⁺	Versenate method	Cheng and Bray (1951)

The following water and soil quality indices were calculated by standard formulas for categorization purpose.

1) Soluble Sodium Percentage (SSP)

$$SSP = \frac{Na^+}{Ca^{++}+Mg^{++}+Na^++K^+} \times 100$$

(Concentration of all cations are in me l⁻¹)

2) Sodium Adsorption Ratio (SAR)

$$SAR = \frac{Na^+}{\sqrt{(Ca^{++}+Mg^{++})/2}}$$

(Concentrations of all cations in me l⁻¹)

3) Residual Sodium Carbonate (RSC)

$$RSC = (CO_3^{--} + HCO_3^-) - (Ca^{++} + Mg^{++})$$

(All ionic concentrations are in me l⁻¹)

4) Exchangeable Sodium Percentage (ESP)

$$\text{ESP} = \frac{\text{Exchangeable Na}^+}{\text{CEC}} \times 100$$

3.7 RATINGS USED FOR WATER QUALITY AND SOIL APPRAISAL

The results of water and soil analysis were appraised in view of the salinity/sodicity indices and fertility ratings mentioned below

3.7.1 Rating Used For Water Quality Appraisal

3.7.1.1 Electrical Conductivity (Richard, 1954)

EC (dSm ⁻¹ at 25°C)	Symbol	Salinity class
0-0.25	C ₁	Low
0.25-0.75	C ₂	Medium
0.75-2.25	C ₃	High
2.25-5.00	C ₄	Very high

3.7.1.2 Sodium Adsorption Ratio (Richard, 1954)

SAR value	Symbol	Class
0-10	S ₁	Low Na water
10-18	S ₂	Medium Na water
18-26	S ₃	High Na water
>26	S ₄	Very high Na water

3.7.1.3 Residual Sodium Carbonate (Eaton, 1950)

RSC (me/l) value	Class
<1.25	Safe
1.25-2.50	Marginal
>2.50	Unsafe

3.7.1.4 Soluble Sodium Percentage (Richard, 1954)

Sr. No.	SSP	Class
1.	<60	Good
2.	>60	Fair

3.7.2 RATING USED FOR CATEGORIZING THE SOIL

3.7.2.2 Soil Salinity/Sodicity Status

3.7.2.2.1 Electrical Conductivity of Saturation Extract (EC_e in dSm⁻¹).

Sr. No.	EC _e (dSm ⁻¹)	Salinity class	Effect on plant growth
1.	0-2	Normal soil	Salinity effects mostly negligible
2.	2-4	Low saline soil	Yield of very sensitive crops may be restricted
3.	4-8	Moderate saline soil	Yield of many crops restricted
4.	8-16	Saline soil	Only tolerant crops yield satisfactorily
5.	>16	Highly saline soil	Only a few very tolerant crops yield satisfactorily

(Richard, 1954)

3.7.2.2.2 Exchangeable Sodium Percentage (ESP)

Sr. No.	ESP	Class
1.	<15	No alkalinity
2.	15-25	Slight alkalinity
3.	25-35	Moderate alkalinity
4.	35-50	Strong alkalinity
5.	>50	Very strong alkalinity

(Richard, 1954)

3.7.2.2.3 Soluble Sodium Percentage (SSP)

Sr. No.	SSP	Class
1.	<60	Good
2.	>60	Fair

3.7.2.2.4 Sodium Adsorption Ratio (SAR)

Sr. No.	SAR	Class
1.	<10	I
2.	10-18	II
3.	18-26	III
4.	>26	IV

(Richard, 1954)

3.7.2.3 CLASSIFICATION OF SALT AFFECTED SOILS

By making use of EC_e and exchangeable sodium percentage (ESP) of the soil, the criteria as initially suggested by Richard (1954), the 160 soil samples so collected from the different talukas of Kheda district were categorized into three classes *viz.*, saline, saline-sodic and sodic soils as below.

Salt affected soils	EC_e (dSm ⁻¹)	pH _s	ESP
Saline	>4	<8.5	<15
Saline-sodic	>4	8.5-10.0	>15
Sodic	<4	>8.5	>15

3.8 STATISTICAL ANALYSIS

Descriptive statistic was used for percentage distribution of soil samples in a particular parameter. Correlation and regression were calculated as described by Steel and Torrie (1980).

4. RESULTS AND DISCUSSION

Assessment of soil and water resources of Kheda district is our prime object. For this purpose, 160 surface (0-20 cm) soil samples and 160 underground water samples were collected from the cultivated fields from where soil samples were taken. The details of soil samples and underground well/tube well water samples collected from cultivated fields of different talukas of Kheda district are given in Appendix I.

The findings of the present investigation are recorded in the following sub-heads;

- 4.1 Physical properties of soils of Kheda district
- 4.2 Chemical properties of soils of Kheda district
- 4.3 Salinity/sodicity status of the soils of Kheda district
- 4.4 Fertility status and nutrient index of the soils of Kheda district
- 4.5 Inter-relationships among and between fertility and salinity/sodicity parameters of the soils
- 4.6 Irrigation water quality appraisal of Kheda district

4.1 PHYSICAL PROPERTIES OF SOILS OF KHEDA DISTRICT

Maintenance of favorable physical environment in soil is a prerequisite in soil management for the better plant growth in sustainable agriculture. The soil physical condition consisting of different parameters like bulk density, particle density, porosity and MWHC were determined by using the standard methods. Sample wise values for different physical parameters for 160 samples of Kheda district are given in Appendix II and the taluka wise range and mean values are given in table 4.1.

4.1.1 Bulk Density

The bulk density is commonly used as an index of soil physical conditions. The bulk density of the soils for the entire district was ranged from 1.24 to 1.54 Mg m⁻³ with a mean value of 1.40 Mg m⁻³ (Table 4.1). The lowest bulk density value of 1.24 Mg m⁻³ was recorded in a sample collected from Kheda taluka. The highest bulk density value of 1.54 Mg m⁻³ was recorded in the samples collected from Kathlal taluka. The data further revealed that the lowest mean value of 1.37 Mg m⁻³ was obtained in the soils of Nadiad taluka due to medium black soil of this area. The

highest mean value of 1.44 Mg m^{-3} was recorded in the samples collected from Kapadvanj and Kathlal talukas, because light texture soils of this area. These results are in conformity with an earlier report of Ogunwale and Isa (2004), Rao *et al.* (2008), Savalia *et al.* (2009), Shirgire (2012) and Singh and Sharma (2013).

4.1.2 Particle Density

The particle density of soil sample was determined by using pycnometer. Overall, it was varied from 2.21 to 2.89 Mg m^{-3} with mean value of 2.47 Mg m^{-3} (Table 4.1). The lowest particle density value of 2.21 Mg m^{-3} was recorded in a sample collected from Matar taluka. The highest value of 2.89 Mg m^{-3} was recorded in the samples collected from Thasra taluka. The data further revealed that the lowest mean value of 2.42 Mg m^{-3} was obtained in the soils of Nadiad and Matar talukas. The highest mean value of 2.52 Mg m^{-3} was recorded in the samples collected from Kapadvanj and Thasra taluka. These results are in close conformity with an earlier report of Ogunwale and Isa (2004), Savalia *et al.* (2009), Ram *et al.* (2010) and Shirgire (2012).

4.1.3 Porosity

The pore space was worked out by using the value of particle density and bulk density of soil and the data presented in table 4.1. The overall pore space ranged from 38.01 to 48.79 per cent with mean value of 43.31 per cent. The lowest pore space value of 38.01 per cent was recorded in a sample collected from Matar taluka. The highest pore space value of 48.79 per cent was recorded in a sample collected from Thasra taluka. The data further revealed that the lowest mean value of 42.54 per cent was obtained in the soils of Kathlal taluka and the highest mean value of 44.21 per cent was recorded in the samples collected from Thasra taluka. These findings are parallel to those of Savalia and Gundaliya (2004) and Ram *et al.* (2010).

4.1.4 Maximum Water Holding Capacity

An appraisal of data on MWHC of soil are depicted in table 4.1 showed that the overall MWHC of soils of Kheda district varied from 22.71 to 50.63 per cent with mean value of 35.21 per cent. The lowest MWHC value of 22.71 per cent was recorded in a sample collected from Kathlal taluka. The highest MWHC value of 50.63 per cent was recorded in the sample collected from Kheda taluka. The data further revealed that the lowest mean value of 31.18 per cent was obtained in the soils

of Kathlal taluka due to high bulk density of soils. The highest mean value of 39.44 per cent was recorded in the samples collected from Matar taluka due to medium black soil with low bulk density. Similar results were reported for Southern Saurashtra (Savalia, 2005), for Chittor district of Andhra Pradesh (Rao *et al.*, 2008) and for Jamnagar district (Shirgire, 2012).

Table 4.1: Taluka wise range and mean values for bulk density, particle density, porosity and MWHC of soil of Kheda district

Name of Taluka	Bulk density (Mg m ⁻³)	Particle density (Mg m ⁻³)	Porosity (%)	MWHC (%)
Nadiad	1.26-1.44 (1.37)	2.26-2.55 (2.42)	39.38-46.19 (43.16)	31.04-48.75 (38.13)
Mahudha	1.26-1.49 (1.39)	2.30-2.56 (2.45)	38.24-45.88 (43.32)	26.82-48.74 (36.66)
Matar	1.28-1.45 (1.36)	2.21-2.56 (2.42)	38.01-48.18 (43.67)	29.44-46.95 (39.44)
Kheda	1.24-1.45 (1.38)	2.28-2.55 (2.46)	41.94-45.61 (43.78)	31.67-50.63 (37.48)
Kapadvanj	1.33-1.52 (1.44)	2.33-2.65 (2.52)	38.20-45.35 (42.76)	24.91-42.73 (31.45)
Thasra	1.36-1.48 (1.41)	2.41-2.89 (2.52)	41.70-48.79 (44.21)	27.23-38.51 (34.60)
Mehmedabad	1.34-1.48 (1.42)	2.35-2.59 (2.50)	39.84-45.56 (43.00)	27.80-41.74 (32.77)
Kathlal	1.28-1.54 (1.44)	2.37-2.65 (2.51)	40.32-46.22 (42.54)	22.71-46.08 (31.18)
Overall	1.24-1.54 (1.40)	2.21-2.89 (2.47)	38.01-48.79 (43.31)	22.71-50.63 (35.21)

Note: Values in parenthesis are mean values

4.2. CHEMICAL PROPERTIES OF SOILS OF KHEDA DISTRICT

Soil samples were analyzed for different chemical properties *viz.*, EC_{2.5}, pH_{2.5}, free lime, organic carbon and CEC by using standard methods. Sample wise values for different chemical parameters for 160 samples given in Appendix III& IV and the taluka wise range and mean values are given in table 4.2.

4.2.1 EC_{2.5}

The EC_{2.5} of soil samples were determined by use of 1:2.5 soil water ratio. Overall, it was varied widely ranging from 0.14 to 6.00 with a mean value of 0.87 dS m⁻¹ (Table 4.2). The lowest (0.14 dS m⁻¹) EC value was recorded in the soil sample collected from Kapadvanj and Thasra talukas; whereas highest value of (6.00 dS m⁻¹) was recorded in the soil sample collected from Mahudha taluka. The data further revealed that the lowest mean value of 0.40 dS m⁻¹ was obtained in the soils of Kapadvanj taluka and the highest mean value of 1.27 dS m⁻¹ was registered in the soils of Mahudha taluka. The wide variation in EC_{2.5} could be due to the accumulation of salts in underground water (Anon., 1994) prevailing in a particular location. Similar results were also obtained for Girnar toposequence by Gandhi (2013), for Patan district by Patel *et al.* (2016), Reddy and Naidu (2016) for Kapada district of Andhra Pradesh and Wagh *et al.* (2016) for Nagpur district of Maharashtra.

4.2.2 pH_{2.5}

In general, the soils of Kheda district are alkaline in reaction. The pH values of the soils for the entire district were ranging from 7.01 to 8.73 with a mean value of 7.80 (Table 4.2). The lowest pH value of 7.01 was recorded in a soil samples collected from Matar taluka. The highest value of 8.73 was recorded in the sample collected from Nadiad taluka. Similar results were also obtained for Pedapuluguvaripalem village of Guntur district by Nandy *et al.* (2013), for Patan district by Patel *et al.* (2016), Reddy and Naidu (2016) for Kapada district of Andhra Pradesh and Wagh *et al.* (2016) for Nagpur district of Maharashtra

4.2.3 Free Lime (CaCO₃)

Free lime (equivalent) content in soil was also estimated by the rapid acid neutralization method and the values are reported in Table 4.2. The overall free lime content was ranging from 3.22 to 6.75 with a mean value of 4.55 per cent. The highest mean value of 4.71 per cent was recorded in Matar and Kathlal talukas and the lowest

mean value of 4.32 per cent was obtained in Kapadvanj taluka indicate non calcareous soils prevailing in entire district. Similar results were observed for Girnar toposequence by Gandhi (2013) and Latur district by Gajare *et al.* (2013).

4.2.4 Organic Carbon

Organic carbon content in the soils is important parameter from the fertility and physical properties points of view. Hence, the samples were analyzed for organic carbon content (Table 4.2). In general, the soils of this district are low to medium in O.C. status. The overall organic carbon content in the soils was ranged from 0.08 to 0.97 per cent having mean value of 0.60 per cent. Such low values for organic carbon status of soils are expected because of the semi arid climate and light texture of soil. Similar findings were made for Kishtwar district of Jammu and Kashmir by Tundup and Akbar (2014), for Veeranam command area of Cuddalore district of Tamil Nadu by Arunkumar and Paramasivan (2015), by Hadiyal *et al.* (2016) for Gir Somnath district and Nagaral *et al.* (2016) for Haveri, Gadag and Dharwad districts of Karnataka.

4.2.5 Cation Exchange Capacity (CEC)

The CEC was worked out from the values of exchangeable cations (Ammonium acetate extractable) are given in Table 4.2. The overall range of CEC was 15.13 to 59.45 $\text{Cmol}(\text{p}^+) \text{kg}^{-1}$ with a mean value of 31.44 $\text{Cmol}(\text{p}^+) \text{kg}^{-1}$. The highest mean value of 38.04 $\text{Cmol}(\text{p}^+) \text{kg}^{-1}$ was resulted in Matar taluka due to medium black texture of soil. Whereas, the lowest mean value of 23.20 $\text{Cmol}(\text{p}^+) \text{kg}^{-1}$ was recorded in Kapadvanj taluka because of loamy sand texture of soil. Similar result was observed for soils of Gantur of Andhra Pradesh district by Nandy *et al* (2013) and Girnar toposequence by Gandhi (2013).

Table4.2: Taluka wise range and mean values of chemical properties of soils of Kheda district

Name of Taluka	EC _{2.5} (dS m ⁻¹)	pH _{2.5}	CaCO ₃ (%)	O.C. (%)	CEC Cmol (p ⁺)kg ⁻¹
Nadiad	0.17-2.10 (0.90)	7.08-8.73 (7.93)	3.25-6.25 (4.39)	0.43-0.89 (0.70)	23.85-48.51 (31.35)
Mahudha	0.26-6.00 (1.27)	7.02-8.28 (7.72)	3.50-6.74 (4.68)	0.25-0.89 (0.68)	16.20-55.45 (32.91)
Matar	0.26-3.40 (1.14)	7.01-8.72 (7.66)	3.50-6.74 (4.71)	0.46-0.90 (0.73)	26.78-58.72 (38.04)
Kheda	0.33-4.70 (1.23)	7.14-8.51 (7.85)	3.25-6.25 (4.34)	0.46-0.89 (0.73)	21.98-57.86 (36.72)
Kapadvanj	0.14-0.69 (0.40)	7.35-8.48 (7.89)	3.25-6.22 (4.32)	0.24-0.81 (0.49)	15.13-34.56 (23.20)
Thasra	0.14-4.40 (0.61)	7.12-8.39 (7.66)	3.52-6.25 (4.68)	0.24-0.85 (0.54)	17.24-59.45 (33.46)
Mehmedabad	0.23-3.40 (0.76)	7.18-8.50 (7.90)	3.22-6.75 (4.59)	0.21-0.97 (0.51)	15.23-55.52 (28.02)
Kathlal	0.21-1.81 (0.70)	7.09-8.39 (7.78)	3.72-6.75 (4.71)	0.08-0.83 (0.46)	16.76-56.78 (27.81)
Overall	0.14-6.00 (0.87)	7.01-8.73 (7.80)	3.22-6.75 (4.55)	0.08-0.97 (0.60)	15.13-59.45 (31.44)

Note: Values in parenthesis are mean values

4.3 SALINITY/SODICITY STATUS OF SOILS OF KHEDA DISTRICT

For characterizing the soils of Kheda district for salinity/sodicity status, all the 160 soil samples were analyzed for EC_e, pH_s, water soluble ions (1:2.5 soil: water extract) and exchangeable cations. The salinity /sodicity indices were then worked out. Sample wise values of EC_e, pH_s, water soluble ions and exchangeable cations are given in Appendix – IV and V.

4.3.1 Exchangeable Cations

The values for exchangeable cations (Ammonium acetate extractable) estimated from the soils of Kheda district are given in table 4.3.

The overall range of Ca^{++} 3.00-70.00 $\text{Cmol(p}^+) \text{ kg}^{-1}$, Mg^{++} 0.00-27.00 $\text{Cmol(p}^+) \text{ kg}^{-1}$, Na^+ 0.26-24.17 $\text{Cmol(p}^+) \text{ kg}^{-1}$ and K^+ 0.19-2.97 $\text{Cmol(p}^+) \text{ kg}^{-1}$ with mean value of 16.34, 12.53, 4.68 and 0.70 $\text{Cmol(p}^+) \text{ kg}^{-1}$ were recorded, respectively. With respect to the exchangeable cation of different talukas, highest Ca^{++} (23.30 $\text{Cmol(p}^+) \text{ kg}^{-1}$), Mg^{++} (16.55 $\text{Cmol(p}^+) \text{ kg}^{-1}$), Na^+ (7.90 $\text{Cmol(p}^+) \text{ kg}^{-1}$) and K^+ (0.87 $\text{Cmol(p}^+) \text{ kg}^{-1}$) were found in Matar, Nadiad, Kheda and Kathlal talukas, respectively. Whereas, lowest exchangeable Ca^{++} (12.10 $\text{Cmol(p}^+) \text{ kg}^{-1}$) and Na^+ (1.89 $\text{Cmol(p}^+) \text{ kg}^{-1}$) were found in Kapadvanj taluka while exchangeable Mg^{++} (8.90 $\text{Cmol(p}^+) \text{ kg}^{-1}$) and K^+ (0.47 $\text{Cmol(p}^+) \text{ kg}^{-1}$) were found in Kathlal and Mehmedabad talukas, respectively.

4.3.2 Water Soluble Ions

Water soluble cations (Ca^{+2} , Mg^{+2} , Na^+ and K^+) and anions (CO_3^{-2} , HCO_3^- , Cl^- and SO_4^{-2}) were estimated from the soil: water (1:2.5) extract and the range and mean values are reported in table 4.4 and 4.5, respectively.

4.3.2.1 Water Soluble Cations

The overall range values of water soluble Na^+ , Ca^{++} , Mg^{++} and K^+ were 0.60-7.60, 0.10-8.00, 0.30-5.19 and 0.01-1.71 me l^{-1} with mean values of 2.47, 1.64, 1.41 and 0.20 me l^{-1} , respectively in the soils of Kheda district (Table 4.4). The highest mean values of water soluble Ca^{++} (2.06 me l^{-1}), Mg^{++} (1.87 me l^{-1}) were found in soils of Matar and Thasra talukas, respectively. While highest mean value of Na^+ (3.35 me l^{-1}), K^+ (0.33 me l^{-1}) were found in soils of Kheda and Mahudha talukas, respectively. The lowest mean values of water soluble Ca^{++} (1.15 me l^{-1}), K^+ (0.07 me l^{-1}) were found in Mehmedabad taluka and Mg^{++} (1.00 me l^{-1}), Na^+ (1.91 me l^{-1}) were found in Nadiad and Thasra taluka, respectively. This finding is in concurrence with the findings of Polara *et al.*, (2004), Kabaria and Polara (2006) for soils of Amreli district, Polara *et al.* (2006) for North-West Agroclimatic Zone of Gujarat and Marsonia *et al.* (2008) for Porbandar district.

4.3.2.2 Water Soluble Anions

In case of water soluble anions, the highest overall mean value of 6.42 me l^{-1} was recorded for Cl^- and it was followed by HCO_3^- (2.38 me l^{-1}) and SO_4^- (1.10 me l^{-1}), while CO_3^- was not found in any collected soil sample of Kheda district (Table 4.5). Since the content of chloride and bicarbonate is considerably high, the type of salinization prevailing in these soils can be of Cl^- and HCO_3^- type. The results are in line with those reported by Polara *et al.*, (2004), Kabaria and Polara (2006) for soils of Amreli district, Polara *et al.* (2006) for North-West Agroclimatic Zone of Gujarat and Marsonia *et al.* (2008) for Porbandar district

Table 4.3: Taluka wise range and mean values of exchangeable cations in soils of Kheda district

Name of Taluka	Exchangeable cations in $\text{Cmol(p}^+) \text{ kg}^{-1}$			
	Ca^{++}	Mg^{++}	Na^+	K^+
Nadiad	3.00-49.00 (12.25)	8.00-27.00 (16.55)	0.48-13.22 (5.12)	0.26-2.97 (0.82)
Mahudha	7.00-31.00 (15.30)	5.00-22.00 (13.85)	0.43-18.04 (4.86)	0.32-1.58 (0.73)
Matar	10.00-48.00 (23.30)	1.00-22.00 (13.40)	0.67-22.57 (6.08)	0.23-2.32 (0.65)
Kheda	10.00-37.00 (17.30)	2.00-26.00 (13.90)	1.54-23.59 (7.90)	0.26-2.06 (0.72)
Kapadvanj	7.00-18.00 (12.10)	2.00-20.00 (9.25)	0.26-7.47 (1.89)	0.29-1.19 (0.55)
Thasra	7.00-70.00 (19.55)	8.00-26.00 (13.70)	0.59-18.90 (2.73)	0.35-2.64 (0.82)
Mehmedabad	8.00-23.00 (13.65)	2.00-18.00 (10.65)	0.37-24.17 (5.83)	0.19-1.68 (0.47)
Kathlal	8.00-47.00 (17.25)	0.00-25.00 (8.90)	0.34-12.74 (3.01)	0.23-2.37 (0.87)
Overall	3.00-70.00 (16.34)	0.00-27.00 (12.53)	0.26-24.17 (4.68)	0.19-2.97 (0.70)

Note: Values in parenthesis are mean values

Table 4.4: Taluka wise range and mean values of water soluble cations in soils of Kheda district

Name of Taluka	Water soluble cations in me l ⁻¹			
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺
Nadiad	0.80-1.90 (1.20)	0.30-2.00 (1.00)	0.65-5.18 (2.73)	0.04-0.99 (0.22)
Mahudha	0.80-6.60 (1.83)	0.30-7.10 (1.83)	0.44-5.19 (2.67)	0.07-1.71 (0.33)
Matar	1.00-3.80 (2.06)	0.10-3.20 (1.07)	0.30-4.05 (2.13)	0.04-0.56 (0.12)
Kheda	1.00-7.00 (1.85)	0.10-8.00 (1.18)	1.72-5.06 (3.35)	0.05-1.54 (0.30)
Kapadvanj	0.90-2.70 (1.60)	0.40-3.30 (1.35)	0.32-5.02 (1.97)	0.02-0.45 (0.16)
Thasra	0.70-7.60 (1.76)	1.00-4.60 (1.87)	0.58-5.05 (1.91)	0.04-0.49 (0.15)
Mehmedabad	0.60-2.90 (1.15)	0.30-2.00 (1.32)	0.40-4.85 (2.72)	0.01-0.29 (0.07)
Kathlal	0.70-5.00 (1.67)	0.50-2.80 (1.70)	0.37-4.87 (2.29)	0.06-0.74 (0.22)
Overall	0.60-7.60 (1.64)	0.10-8.00 (1.41)	0.30-5.19 (2.47)	0.01-1.71 (0.20)

Note: Values in parenthesis are mean values

Table 4.5: Taluka wise range and mean values of water soluble anions in soils of Kheda district

Name of Taluka	Water soluble anions in me l ⁻¹			
	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
Nadiad	0.00-0.00 (0.00)	1.00-5.00 (3.00)	2.50-14.00 (6.38)	0.31-1.71 (0.60)
Mahudha	0.00-0.00 (0.00)	1.00-6.00 (2.90)	3.00-35.00 (8.18)	0.28-3.09 (1.12)
Matar	0.00-0.00 (0.00)	1.00-4.00 (2.25)	1.00-15.00 (5.83)	0.33-2.53 (1.01)
Kheda	0.00-0.00 (0.00)	2.00-6.00 (3.70)	4.00-31.00 (8.55)	0.50-1.75 (0.84)
Kapadvanj	0.00-0.00 (0.00)	1.00-2.00 (1.35)	2.50-6.00 (4.03)	0.29-5.00 (1.78)
Thasra	0.00-0.00 (0.00)	1.00-2.00 (1.45)	3.00-19.50 (5.85)	0.50-2.27 (1.19)
Mehmedabad	0.00-0.00 (0.00)	1.00-3.00 (2.00)	3.00-25.00 (6.15)	0.29-4.32 (1.40)
Kathlal	0.00-0.00 (0.00)	1.00-4.00 (2.35)	3.00-16.50 (6.38)	0.24-1.70 (0.83)
Overall	0.00-0.00 (0.00)	1.00-6.00 (2.38)	1.00-35.00 (6.42)	0.24-5.00 (1.10)

Note: Values in parenthesis are mean values

4.3.3 Salinity/Sodicity Indices

Salinity/sodicity indices are very important criteria for classifying salt affected soils into saline, sodic, saline-sodic or normal. Samples wise values for all the 160 samples for salinity/sodicity indices viz., E_c, pHs, ESP, SSP and SAR are given in Appendix IV and V and taluka wise range and mean values are presented in Table 4.6.

4.3.3.1 E_c

Electrical conductivity of saturation extract was determined from all 160 samples. The E_c of Kheda district was ranged from 0.41 to 18.80 dS m⁻¹, which

showed the wide variation in Kheda district in respect to E_{Ce}, while mean value of E_{Ce} was 2.87 dS m⁻¹ (Table 4.6). So, as per classification given by Richards (1954), the soils of Kheda district were in low saline soil. The highest mean E_{Ce} value (3.78 dS m⁻¹) was recorded for the soils of Kheda taluka followed by Mahudha (3.74 dS m⁻¹) and Matar (3.59 dS m⁻¹) talukas. The lowest value (1.35 dS m⁻¹) was recorded in the soils of Kapadvanj taluka. From this information we can say that the soils of Kheda district were normal to highly saline, but on the basis of mean, it can be said that the soils of Kheda district were moderately saline. This might be due to arid and semi-arid climate and less annual rainfall prevailed in the area. So, it is necessary to monitor soil frequently in respect to E_{Ce}. This finding is in conformity with the findings of earlier work done by Guruprasad *et al.* (2007) in Southern dry zone of Karnataka, by Sojitra (2010) for Junagadh district for Bhavnagar district by Rajput and Polara (2012).

4.3.3.2 pHs

The pH_s values of the soils for the entire district were ranging from 7.00 to 8.65 with mean values of 7.66 (Table 4.6). The values of pH_s do not differ much from the values of pH_{2.5}. Although, pH_s values are slightly lower than the pH_{2.5} at all the times. In general, the soils of Kheda district are alkaline in reaction. This finding is in conformity with the findings of earlier work done by Guruprasad *et al.* (2007) in Southern dry zone of Karnataka, by Sojitra (2010) for Junagadh district and for Bhavnagar district by Rajput and Polara (2012).

4.3.3.3 Exchangeable Sodium Percentage (ESP)

The overall ESP value of Kheda district was ranged from 1.00 to 48.47 with mean value of 13.48 (Table 4.6), which showed that the soils of Kheda district are non-alkaline to alkaline. Among the different talukas, the highest ESP value of 48.47, and lowest ESP value 1.00 were found in the soils of Mehmedabad and Kathlal talukas, respectively. However, the highest mean value of ESP was noted in Kheda talukas, and lowest mean value of ESP was noted in Kapadvanj taluka. The highest and lowest ESP of soils were mainly due to the exchangeable Na⁺ present in soil, the soils contained high content of Na⁺ resulted in higher ESP and vice versa. Similar results were also observed for Southern dry zone of Karnataka by Guruprasad *et al.* (2007), Guntur district of Andhra Pradesh by Nandy *et al.* (2013) and Girnar toposequence by Gandhi (2013).

4.3.3.4 Soluble Sodium Percentage (SSP)

The SSP values for all 160 samples were calculated from water soluble cations expressed in me l^{-1} , and the presented in (Table 4.6). The overall mean SSP value was 42.16, which was ranged from 8.90 to 75.92. The highest (53.72) mean value of SSP was recorded with the soils of Kheda taluka, whereas the lowest (31.53) in Thasra taluka. It might be due to Na^{++} was dominated cation, among different water soluble cations. Similar results were also observed for Girnar toposequence by Gandhi (2013).

4.3.3.5 Sodium absorption ratio (SAR)

The SAR values were also calculated from the values of water soluble cations expressed in me l^{-1} and presented in (Table 4.6). The overall mean value of SAR was 3.08 and it was ranged from 0.37 to 7.71. The highest mean value of SAR (4.49) was recorded in the soils of Kheda taluka, whereas the lowest mean values of SAR (2.08) was recorded in the soils of Thasra taluka. The lowest SAR value (0.37) was registered in the soil sample collected from Kapadvanj taluka and the highest SAR value (7.71) was registered in soil sample collected from Kheda taluka. Similar results were also observed for soils of North-West Agro Climatic Zone of Gujarat by Rajput and Polara (2012).

Table 4.6: Taluka wise range and mean values of salinity/ sodicity indices of soils of Kheda district

Name of Taluka	EC _e (dS m ⁻¹)	pH _s	ESP	SSP	SAR
Nadiad	0.98-6.25 (2.73)	7.00-8.65 (7.80)	1.96-36.21 (15.87)	22.42-75.78 (49.74)	0.87-7.61 (3.79)
Mahudha	0.98-16.84 (3.74)	7.00-8.10 (7.58)	1.96-42.44 (13.63)	15.17-63.52 (42.45)	0.67-5.62 (3.10)
Matar	0.75-10.60 (3.59)	7.00-8.65 (7.52)	1.76-38.43 (14.95)	14.73-65.85 (38.33)	0.46-5.72 (2.53)
Kheda	0.98-14.55 (3.78)	7.05-8.39 (7.72)	5.43-40.94 (20.10)	15.65-75.92 (53.72)	1.46-7.71 (4.49)
Kapadvanj	0.41-2.15 (1.35)	7.32-8.36 (7.80)	1.37-25.96 (7.46)	9.16-70.60 (35.26)	0.37-7.10 (2.45)
Thasra	0.98-18.80 (2.52)	7.02-8.26 (7.54)	1.98-35.13 (7.97)	14.87-60.46 (31.53)	0.68-5.94 (2.08)
Mehmedabad	0.65-16.30 (2.98)	7.01-8.32 (7.67)	2.27-48.47 (16.53)	13.76-69.31 (48.79)	0.54-6.69 (3.51)
Kathlal	0.62-5.25 (2.24)	7.02-8.24 (7.66)	1.00-44.36 (11.33)	8.90-67.01 (37.48)	0.44-6.25 (2.68)
Overall	0.41-18.80 (2.87)	7.00-8.65 (7.66)	1.00-48.47 (13.48)	8.90-75.92 (42.16)	0.37-7.71 (3.08)

Note: Values in parenthesis are mean values

Soil Characterization

The 160 soil samples collected from the Kheda district were categorized into three classes viz., saline, saline-sodic and sodic soils according to guid line given by Richards (1954) by using the values of EC_e and ESP of soil. The soils having EC_e value > 4.0 dSm⁻¹ and ESP values < 15 were classified as saline, those having EC_e value < 4.0 dSm⁻¹ and ESP value > 15 as sodic and those having EC_e values > 4.0 dSm⁻¹ and ESP > 15 as saline-sodic soils. While some soils are not having EC_e values > 4.0 dSm⁻¹ and ESP > 15 are called normal soil.

Out of 160 samples 03, 22, 24 and 111 samples were tested as saline, saline-sodic, sodic and normal soil with 1.87, 13.75, 15 and 69.37 per cent, respectively (Table 4.7). The highest numbers of samples were found under normal class followed by sodic, saline-sodic and saline.

Among the salt affected soils, Mahudha taluka recorded highest (10 %) saline soil, followed by Matar (5%), while all other soils were not found saline. The highest (30 %) soils of Kheda taluka were saline-sodic, while Kapadvanj taluka does not possess saline-sodic soil. The highest percentage (35 %) of sodic soil samples were recorded in Nadiad taluka followed by Matar and Kheda (20 %). Among the different talukas, highest salt affected soils were found in Kheda and Nadiad talukas followed by Matar, Mahudha, Mehmedabad, Kathlal, Kapadvanj and Thasra.

After exclusion of normal soil samples, the remaining 49 samples were then grouped into three different salt affected soil classes by adopting USDA norms (Table 4.7). The distribution indicates that 48.97 per cent soil samples were falling in the sodic, followed by 44.89 per cent into saline-sodic and 6.12 per cent into saline group. This finding supported by Basker *et al* (2006), Polara and Kabaria (2006), Marsonia *et al* (2008) and Rajput and Polara (2012).

Table 4.7: Taluka wise percentage distribution of soil samples into different categories of salt affected soils of Kheda district

Name of Taluka	Percentage distribution				
	Saline	Saline-Sodic	Sodic	Total salt affected soils	Normal
Nadiad	00	15	35	50	50
Mahudha	10	15	15	40	60
Matar	05	20	20	45	55
Kheda	00	30	20	50	50
Kapadvanj	00	00	10	10	90
Thasra	00	05	05	10	90
Mehmedabad	00	15	10	25	75
Kathlal	00	10	05	15	85
Overall (160)	1.87 (03)	13.75 (22)	15 (24)	30.62 (49)	69.37 (111)
Classification of salt affected soils (49)	6.12 (03)	44.89 (22)	48.97 (24)		-----

Note: Values in parenthesis are number of samples

4.4 FERTILITY STATUS OF SOILS OF KHEDA DISTRICT

For studying the fertility status of soils of Kheda district, 160 soil samples collected from the cultivated farmer's field were analyzed for available N, P₂O₅, K₂O, S and DTPA extractable Fe, Mn, Zn and Cu. Sample wise values of fertility parameters (for all the 160 samples) are given in Appendix III.

4.4.1 Available Macro Nutrients:

Taluka wise range and mean values for available macronutrients are given in Table 4.8.

4.4.1.1 Available N Status:

The overall, available N status for the target district was low and it was ranged from 78.40 to 862.40 kg ha⁻¹ with mean value of 202.50 kg ha⁻¹. The highest mean value of available N was found in Matar taluka (275.97 kg ha⁻¹) followed by Kheda (255.58 kg ha⁻¹) and Mahudha taluka (230.50 kg ha⁻¹). The lowest mean value of available nitrogen was found in Kapadvanj taluka (152.88 kg ha⁻¹).

About 87.50 per cent samples were tested as low (< 250 kg N ha⁻¹), 7.50 per cent were under medium classes for available N and only 5.0 per cent samples fall in high available N classes (Table 4.10). Such lower values for available N might be because of lower content of organic carbon (Table 4.2) and poor addition of organic matter as well as less use of organic manures in the semi arid tract. Similar results were also reported for Bhavnagar district by Punithraj *et al.* (2012) for Hassan district of Karnataka, Srinivasan and Poongothai (2013) for Tittakudi taluka of Tamil Nadu, Sudharani *et al.* (2013) for Visakhapatnam district of Andhra Pradesh, Polara and Chauhan (2015) for Gir Somnath district, Nagaral *et al.* (2016) for Northern Transitional Zone of Karnataka, for Kapada district of Tamil Nadu by Reddy and Naidu (2016).

4.4.1.2 Available P₂O₅ Status

Taluka wise range and mean values of available P₂O₅ are given in Table 4.8. The available P₂O₅ was high in most of talukas except Mehmedabad taluka. The available P₂O₅ status of soils varied widely (10.02 to 98.22 kg ha⁻¹) with mean value of 71.20 kg ha⁻¹, which was in high categories. The highest mean value of available P₂O₅ was found in Kheda taluka (85.40 kg ha⁻¹) followed by Kapadvanj (83.95 kg ha⁻¹), Matar (72.93 kg ha⁻¹) and Mahudha (72.80 kg ha⁻¹) talukas. The lowest mean value was found in Mehmedabad taluka (52.39 kg P₂O₅ ha⁻¹).

About 6.87, 15.62 and 77.50 per cent soil samples were observed as low, medium and high in available P₂O₅, respectively (Table 4.10). The higher status of P in the soil is attributed to the application of large amount of fertilizers against the crop requirement. Similar results were also reported by Punithraj *et al.* (2012) for Hassan district of Karnataka, Srinivasan and Poongothai (2013) for Tittakudi taluka of Tamil Nadu, Sudharani *et al.* (2013) for Visakhapatnam district of Andhra Pradesh, Polara and Chauhan (2015) for Gir Somnath district, Nagaral *et al.* (2016) for Northern Transitional Zone of Karnataka, for Kapada district of Tamil Nadu by Reddy and Naidu (2016).

4.4.1.3 Available K₂O Status:

Taluka wise range and mean values of available K₂O are given in Table 4.8. As like P₂O₅, available K₂O status of the Kheda district was high. It was varied widely from 71.50 to 996.44 kg K₂O ha⁻¹ with an average of 394.96 kg ha⁻¹. The highest mean value for available K₂O was found in Kheda (458.86 kg ha⁻¹) followed by Thasra (439.80 kg ha⁻¹) and Nadiad (434.09 kg ha⁻¹) talukas. The lowest mean value of available K₂O was found in Mehmedabad taluka (264.24 kg ha⁻¹).

Overall, 3.12, 37.50 and 59.37 per cent soil samples were distributed in low, medium and high categories for available K₂O, respectively (Table 4.10). Such high status of available K₂O might be due to presence of potassium bearing minerals (feldspar muscovite, and biotite) which upon weathering slowly release potassium. Similar finding were made by Punithraj *et al.* (2012) for Hassan district of Karnataka, Srinivasan and Poongothai (2013) for Tittakudi taluka of Tamil Nadu, Sudharani *et al.* (2013) for Visakhapatnam district of Andhra Pradesh, Polara and Chauhan (2015) for Gir Somnath district, Nagaral *et al.* (2016) for Northern Transitional Zone of Karnataka, for Kapada district of Tamil Nadu by Reddy and Naidu (2016).

4.4.1.4 Available S status:

Taluka wise range and mean values of available sulphur are given in Table 4.8. Overall, available sulphur ranged from 0.22 to 24.56 mg kg⁻¹ with mean value of 5.90 mg kg⁻¹. On the basis of mean values, the soils of Matar taluka content highest amount of sulphur (8.51 mg kg⁻¹) followed by Mahudha (7.57 mg kg⁻¹) and Kheda (7.53 mg kg⁻¹) talukas. The soils of Thasra taluka contain the lowest mean value (3.79 mg kg⁻¹) of available sulphur.

Almost 82.50, 14.37 and 3.12 per cent samples were rated as low, medium and high in content of the available sulphur, respectively (Table 4.10). Such low status of sulphur in soils of Kheda district might be because of use of K-bearing fertilizers such as Murate of potash instead of Ammonium Sulphate and Magnesium Sulphate by the cultivators. Such low status of available sulphur was also recorded by Polara and Chauhan (2015) for Gir Somnath district, Patel *et al.* (2016) for Patan district, Hadiyal *et al.* (2016) for Girgadhda and Una talukas of Gir Somanth district, Reddy and Naidu (2016) for Kapada district of Tamil Nadu.

Table 4.8: Taluka wise range and mean value for available N, P₂O₅ K₂O and S in the soils of Kheda district

Name of Taluka	Av. N (kg ha ⁻¹)	Av. P ₂ O ₅ (kg ha ⁻¹)	Av. K ₂ O (kg ha ⁻¹)	Av. S (mg kg ⁻¹)
Nadiad	78.40-266.56 (183.46)	10.02-97.19 (69.91)	164.77-851.02 (434.09)	1.79-11.75 (5.93)
Mahudha	125.44-862.40 (230.50)	27.72-89.45 (72.80)	183.59-976.82 (426.69)	3.36-13.45 (7.57)
Matar	141.12-627.20 (275.97)	33.77-92.03 (72.93)	141.12-996.44 (390.50)	2.24-16.63 (8.51)
Kheda	156.80-689.92 (255.58)	57.70-98.02 (85.40)	166.12-877.09 (458.86)	1.34-24.03 (7.53)
Kapadvanj	78.40-188.16 (152.88)	68.22-96.23 (83.95)	141.39-661.79 (323.14)	0.45-8.39 (3.94)
Thasra	125.44-266.56 (173.26)	17.32-97.77 (64.13)	194.61-963.11 (439.80)	0.22-24.56 (3.79)
Mehmedabad	141.12-349.66 (176.64)	16.83-98.22 (52.39)	71.50-766.08 (264.24)	0.22-24.25 (4.79)
Kathlal	141.12-250.88 (171.70)	20.76-95.98 (68.12)	112.09-948.60 (422.39)	0.22-21.22 (5.11)
Overall	78.40-862.40 (202.50)	10.02-98.22 (71.20)	71.50-996.44 (394.96)	0.22-24.56 (5.90)

Note: Values in parenthesis are mean values

4.4.2 DTPA Extractable Micronutrients:

Taluka wise range and mean values for DTPA extractable micronutrients are given in Table 4.9

4.4.2.1 DTPA Extractable Fe:

The overall Fe status of the soils of Kheda district was medium (Table 4.9). It was ranged from 2.31 to 17.83 mg kg⁻¹ with mean value of 8.02 mg kg⁻¹. Soils of Matar taluka recorded the highest mean value of DTPA extractable Fe (11.61 mg kg⁻¹) followed by that of Kheda (9.53 mg kg⁻¹) and Mehmedabad (8.83 mg kg⁻¹) talukas,

whereas, the lowest mean value (5.32 mg kg^{-1}) of DTPA extractable Fe was found in the soils of Kapadvanj talukas.

About 28.12, 41.87 and 30 per cent samples rated as low, medium and high in DTPA-Fe status, respectively (Table 4.10). Similar results were also reported for villages of northern Madhya Pradesh by Rajput *et al.* (2015), Hadiyal *et al.* (2016) for Girgadhda and Una talukas of Gir Somanth district, Karajanagi *et al.* (2016) for Malaprabha command area of Karnataka, for Patan district by Patel *et al.* (2016), Wagh *et al.* (2016) for Nagpur district of Maharashtra.

4.4.2.2 DTPA Extractable Mn:

The soils of Kheda district were ranged from 3.93 to 18.17 mg kg^{-1} with mean value of 10.11 mg kg^{-1} in case of DTPA-Mn (Table 4.9). The soils of Mahudha taluka had highest mean value (12.77 mg kg^{-1}) followed by Kapadvanj (10.85 mg kg^{-1}) and Kathlal (10.63 mg kg^{-1}) talukas. The lowest mean value (8.30 mg kg^{-1}) was observed in Kheda taluka.

About 6.87, 42.50 and 50.62 per cent samples rated as low, medium and high in DTPA-Mn status, respectively (Table 4.10). Similar results were also reported for villages of northern Madhya Pradesh by Rajput *et al.* (2015), Hadiyal *et al.* (2016) for Girgadhda and Una talukas of Gir Somanth district, Karajanagi *et al.* (2016) for Malaprabha command area of Karnataka, for Patan district by Patel *et al.* (2016), Wagh *et al.* (2016) for Nagpur district of Maharashtra.

4.4.2.3 DTPA Extractable Zn:

The DTPA-Zn status of the soils of Kheda district was medium. It was ranged from 0.24 to 2.08 mg kg^{-1} with a mean value of 1.0 mg kg^{-1} . Mahudha taluka soils had highest mean value (1.38 mg kg^{-1}) of DTPA-Zn followed by Kheda (1.17 mg kg^{-1}) and Matar (1.10 mg kg^{-1}) talukas. Soils of Kathlal taluka had the lowest mean value (0.75 mg kg^{-1}) for DTPA-Zn status (Table 4.9).

About 7.5, 46.25 and 46.25 per cent soil samples were categorized as low, medium and high in DTPA-Zn status, respectively (Table 4.10). Similar results were also reported for Coastal Region of Kutch district by Patel *et al.* (2012), by Srinivasan and Poongothai (2013) for villages of Tittakudi taluka of Tamil Nadu, by Verma *et al.* (2013) for Malkharauda block of Janjgir Champa district, Singh *et al.* (2014) for Chambal region of Madhya Pradesh, by Kumar (2015) for Saharsa district of Bihar.

4.4.2.4 DTPA Extractable Cu:

In general, the DTPA-Cu status of the soils of Kheda district was high (Table 4.9). The DTPA-Cu ranged from 0.14 to 2.02 mg kg⁻¹ with mean value of 0.95 mg kg⁻¹. The highest mean value of DTPA-Cu was observed in Nadiad (1.25 mg kg⁻¹) followed by soils of Mahudha (1.16 mg kg⁻¹) and Matar (1.13 mg kg⁻¹) talukas. The lowest mean value was registered in Kapadvanj taluka (0.47 mg kg⁻¹). About 0.62, 10.62 and 88.75 per cent samples were found in low, medium and high categories of DTPA-Cu, respectively (Table 4.10). Results reported in present investigation find supports from the work reported elsewhere for villages of northern Madhya Pradesh by Rajput *et al.* (2015), Hadiyal *et al.* (2016) for Girgadhda and Una talukas of Gir Somanth district, Karajanagi *et al.* (2016) for Malaprabha command area of Karnataka, for Patan district by Patel *et al.* (2016), Wagh *et al.* (2016) for Nagpur district of Maharashtra.

Table 4.9: Taluka wise range and mean values for DTPA extractable micronutrients in the soils of Kheda district

Name of Taluka	Fe (mg kg ⁻¹)	Mn (mg kg ⁻¹)	Zn (mg kg ⁻¹)	Cu (mg kg ⁻¹)
Nadiad	3.87-14.25 (7.62)	5.75-15.24 (9.39)	0.46-1.89 (1.04)	0.89-1.82 (1.25)
Mahudha	3.23-15.12 (8.09)	5.05-18.17 (12.77)	0.58-1.96 (1.38)	0.58-1.74 (1.16)
Matar	4.49-17.83 (11.61)	4.15-14.56 (9.05)	0.40-2.08 (1.10)	0.56-1.76 (1.13)
Kheda	2.45-14.56 (9.53)	3.93-13.67 (8.30)	0.38-1.94 (1.17)	0.76-1.50 (1.11)
Kapadvanj	3.33-12.23 (5.32)	4.99-15.45 (10.85)	0.52-1.45 (0.91)	0.14-1.14 (0.47)
Thasra	2.31-14.56 (5.90)	4.55-15.07 (10.17)	0.34-1.78 (0.82)	0.30-2.02 (0.91)
Mehmedabad	3.25-15.97 (8.83)	4.33-14.71 (9.71)	0.32-1.56 (0.79)	0.36-1.80 (0.99)
Kathlal	3.99-13.19 (7.26)	4.93-14.75 (10.63)	0.24-1.72 (0.75)	0.22-1.04 (0.60)
Overall	2.31-17.83 (8.02)	3.93-18.17 (10.11)	0.24-2.08 (1.00)	0.14-2.02 (0.95)

Note: Values in parenthesis are mean values

4.4.3 Nutrient Index Values of Available Nutrients In Soils

4.4.3.1 Nutrient Index Ranges of Available Macronutrients

The nutrient index values for available macronutrient are presented in Table 4.10 and appendix -VII. According to nutrient index value, all the talukas have low fertility status in respect to S and medium fertility status in respect to O.C, where as soils of all the talukas were high in available P_2O_5 and K_2O except Mehmedabad which was fall in medium status of available P_2O_5 and K_2O . Based on nutrient index values of soils and the criteria suggested by Parker *et al.* (1951) and Ramamurthy and Bajaj (1969), the soils of Kheda district found low with respect to available S (Fig. 4.4) and medium with respect to O.C (Fig. 4.1), while in high fertility class for available P_2O_5 (Fig. 4.2) and K_2O (Fig. 4.3) status. Similar results were also reported for Muzaffarnagar district of Uttar Pradesh by Prakash *et al.* (2008) and for Bhavnagar district by Rajput and Polara (2012).

4.4.3.2 Nutrient Index Value of Available Micronutrients

The nutrient index values for available micronutrient are presented in Table 4.10 and appendix VII. According to Nutrient index value of DTPA extractable Fe, Kapadvanj and Thasra talukas have low fertility status, while Nadiad, Mahudha, Mehmedabad and Kathlal fall in medium fertility status as well as Matar and Kheda have high fertility status. While in respect of DTPA extractable Mn, all the talukas have high fertility status except Matar and Kheda fall in medium fertility status. The soils of all the talukas have high fertility status in respect of DTPA extractable Zn, except Thasra, Mehmedabad and Kathlal talukas have medium fertility status. Whereas all the talukas of Kheda district fall in high fertility status of DTPA extractable Cu. Based on nutrient index values of soils and the criteria suggested by Ramamoorthy and Bajaj (1969), the soils of Kheda district found in high categories for DTPA-Mn (Fig. 4.6), Zn (Fig. 4.7) and Cu (Fig. 4.8), while in medium status of DTPA-Fe (Fig. 4.5). Similar results were made for Bhavnagar district by Rajput and Polara (2012).

Table 4.10: Percentage distribution of soil samples into different categories of soil fertility status of Kheda district

Name of Taluka	Soil fertility status	Percentage distribution							
		N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu
Nadiad	Low	95 (19)	5 (1)	0 (0)	85 (17)	35 (7)	0 (0)	5 (1)	0 (0)
	Medium	5 (1)	10 (2)	35 (7)	15 (3)	40 (8)	65 (13)	40 (8)	0 (0)
	High	0 (0)	85 (17)	65 (13)	0 (0)	25 (5)	35 (7)	55 (11)	100 (20)
Mahudha	Low	85 (17)	5 (1)	0 (0)	65 (13)	20 (4)	0 (0)	0 (0)	0 (0)
	Medium	5 (1)	10 (2)	25 (5)	35 (7)	55 (11)	15 (3)	5 (1)	5 (0)
	High	10 (2)	85 (17)	75 (15)	0 (0)	25 (5)	85 (17)	95 (19)	100 (20)
Matar	Low	60 (12)	0 (0)	0 (0)	65 (13)	5 (1)	10 (2)	10 (2)	0 (0)
	Medium	25 (5)	20 (4)	35 (7)	35 (7)	35 (7)	55 (11)	40 (8)	0 (0)
	High	15 (3)	80 (16)	65 (13)	0 (0)	60 (12)	35 (7)	50 (10)	100 (20)
Kheda	Low	80 (16)	0 (0)	0 (0)	75 (15)	15 (3)	15 (3)	5 (1)	5 (0)
	Medium	5 (1)	0 (0)	30 (6)	15 (3)	35 (7)	55 (11)	25 (5)	5 (0)
	High	15 (3)	100 (20)	70 (14)	10 (2)	50 (10)	30 (6)	70 (14)	100 (20)
Kapadvanj	Low	100 (20)	0 (0)	0 (0)	100 (20)	55 (11)	5 (1)	0 (0)	5 (1)

Name of Taluka	Soil fertility status	Percentage distribution							
		N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu
	Medium	0 (0)	0 (0)	60 (12)	0 (0)	40 (8)	40 (8)	65 (13)	40 (8)
	High	0 (0)	100 (20)	40 (8)	0 (0)	5 (1)	55 (11)	35 (7)	55 (11)
Thasra	Low	90 (18)	10 (2)	0 (0)	95 (19)	50 (10)	15 (3)	15 (3)	0 (0)
	Medium	10 (2)	25 (5)	40 (8)	0 (0)	35 (7)	25 (5)	60 (12)	10 (2)
	High	0 (0)	65 (13)	60 (12)	5 (1)	15 (3)	60 (12)	25 (5)	90 (18)
Mehmedabad	Low	95 (19)	25 (5)	20 (4)	85 (17)	15 (3)	5 (1)	15 (3)	0 (0)
	Medium	5 (1)	35 (7)	45 (9)	10 (2)	50 (10)	45 (9)	65 (13)	5 (1)
	High	5 (0)	40 (8)	35 (7)	5 (1)	35 (7)	50 (10)	20 (4)	95 (19)
Kathlal	Low	95 (19)	10 (2)	5 (1)	90 (18)	30 (6)	5 (1)	10 (2)	0 (0)
	Medium	5 (1)	25 (5)	30 (6)	5 (1)	45 (9)	40 (8)	70 (14)	30 (6)
	High	0 (0)	65 (13)	65 (13)	5 (1)	25 (5)	55 (11)	20 (4)	70 (14)
Overall	Low	87.5 (140)	6.87 (11)	3.12 (5)	82.5 (132)	28.12 (45)	6.87 (11)	7.5 (12)	0.62 (1)
	Medium	7.5 (12)	15.62 (25)	37.5 (60)	14.37 (23)	41.87 (67)	42.5 (68)	46.25 (74)	10.62 (17)
	High	5 (8)	77.5 (124)	59.37 (95)	3.12 (5)	30 (48)	50.62 (81)	46.25 (74)	88.75 (142)

Note: Values in parenthesis are number of samples in respective group

Table 4.11: Talukawise nutrient index values of macro and micro nutrients of the soils of Kheda district

Name of Taluka	O.C	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu
Nadiad	2.40 (H)	2.80 (H)	2.65 (H)	1.15 (L)	1.90 (M)	2.35 (H)	2.50 (H)	3.00 (H)
Mahudha	2.25 (M)	2.80 (H)	2.75 (H)	1.35 (L)	2.05 (M)	2.85 (H)	2.95 (H)	3.00 (H)
Matar	2.35 (H)	2.80 (H)	2.65 (H)	1.35 (L)	2.55 (H)	2.25 (M)	2.40 (H)	3.00 (H)
Kheda	2.45 (H)	3.00 (H)	2.70 (H)	1.35 (L)	2.35 (H)	2.15 (M)	2.65 (H)	3.00 (H)
Kapadvanj	1.55 (L)	3.00 (H)	2.40 (H)	1.00 (L)	1.50 (L)	2.50 (H)	2.35 (H)	2.50 (H)
Thasra	1.75 (M)	2.55 (H)	2.60 (H)	1.10 (L)	1.65 (L)	2.45 (H)	2.10 (M)	2.90 (H)
Mehmedabad	1.55 (L)	2.15 (M)	2.15 (M)	1.20 (L)	2.20 (M)	2.45 (H)	2.05 (M)	2.95 (H)
Kathlal	1.45 (L)	2.55 (H)	2.60 (H)	1.15 (L)	1.95 (M)	2.50 (H)	2.10 (M)	2.70 (H)
Overall	1.96 (M)	2.71 (H)	2.56 (H)	1.21(L)	2.02 (M)	2.44 (H)	2.39 (H)	2.88 (H)

Rating of nutrient index:

<1.67 – Low

1.67-2.33 – Medium

>2.33 – High

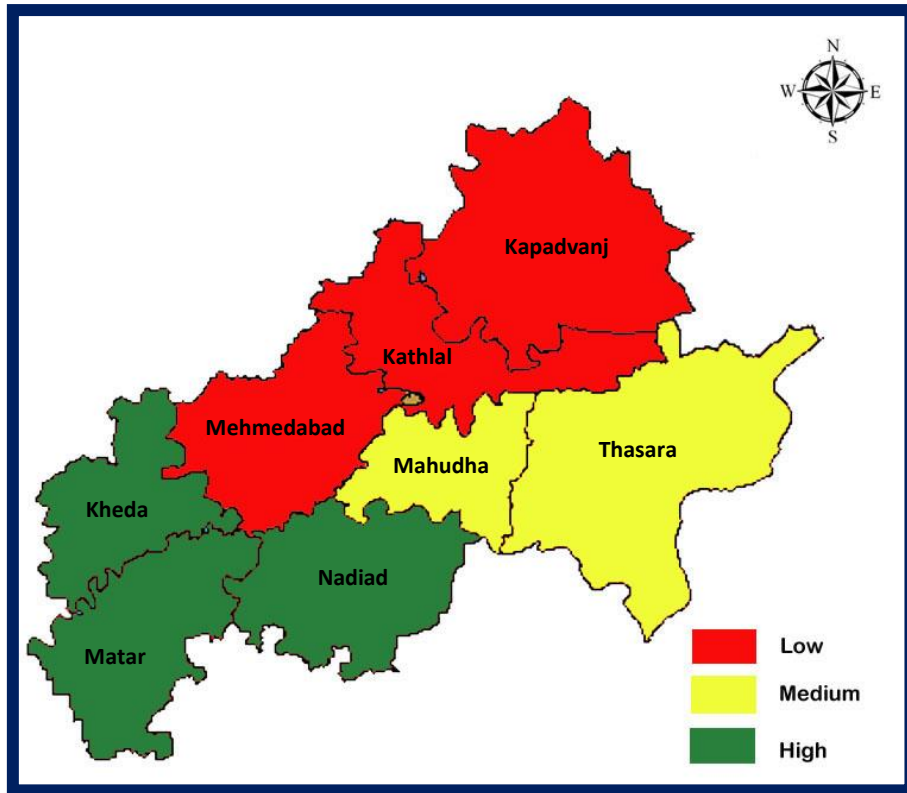


Fig. 4.1: Status of O.C. in soils of different talukas of kheda district

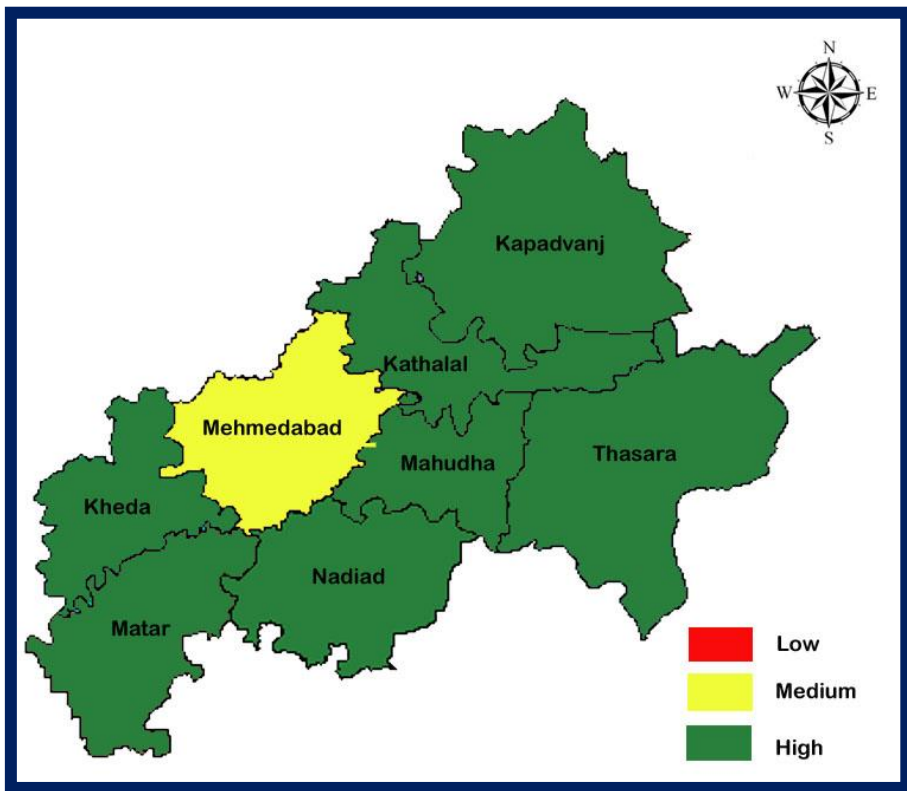


Fig. 4.2: Available P₂O₅ status in soils of different talukas of kheda district

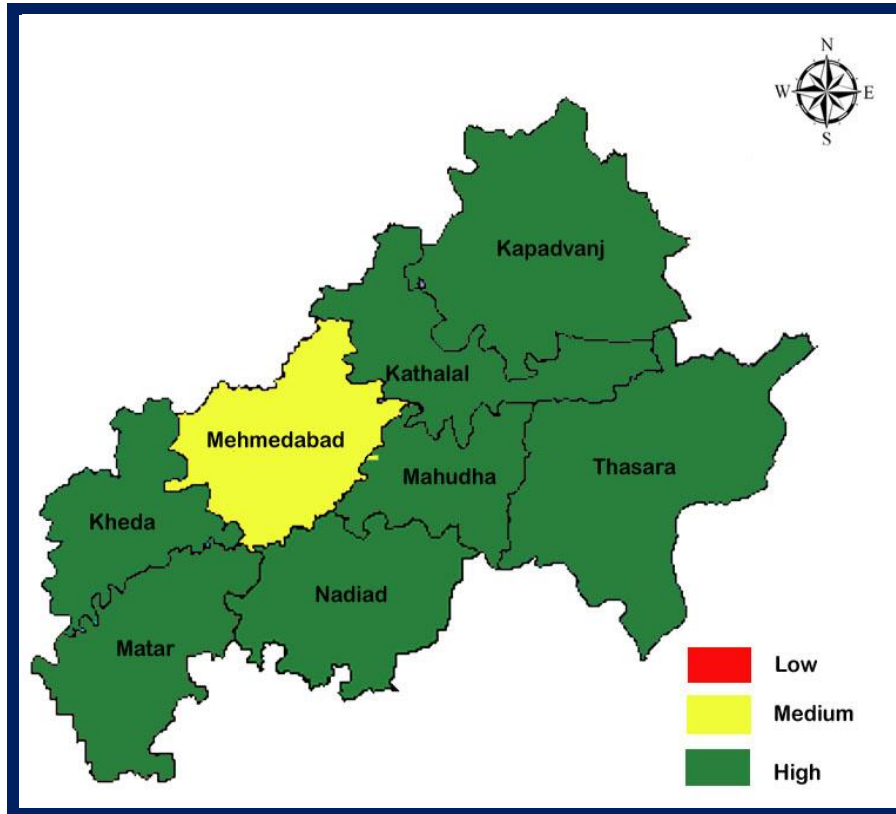


Fig. 4.3: Available K_2O status in soils of different talukas of kheda district

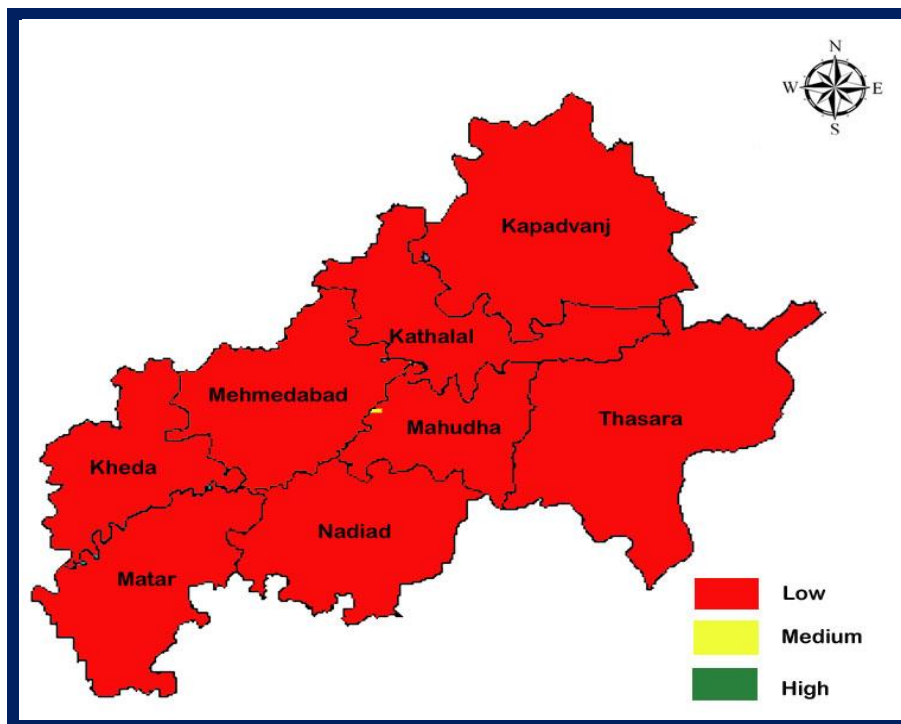


Fig. 4.4: Available S status in soils of different talukas of kheda district

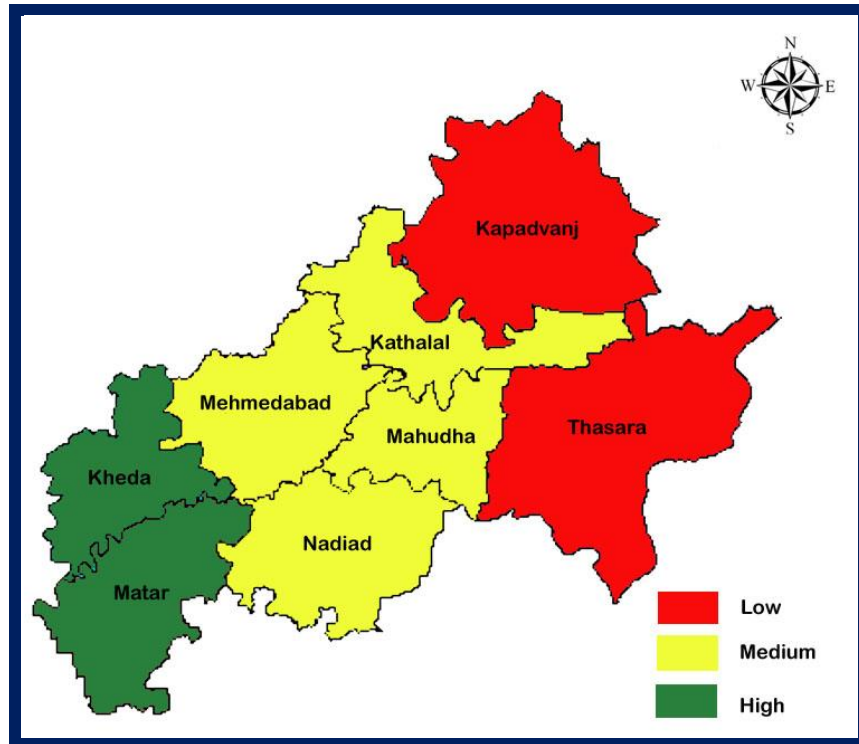


Fig. 4.5: DTPA-Fe status in soils of different talukas of kheda district

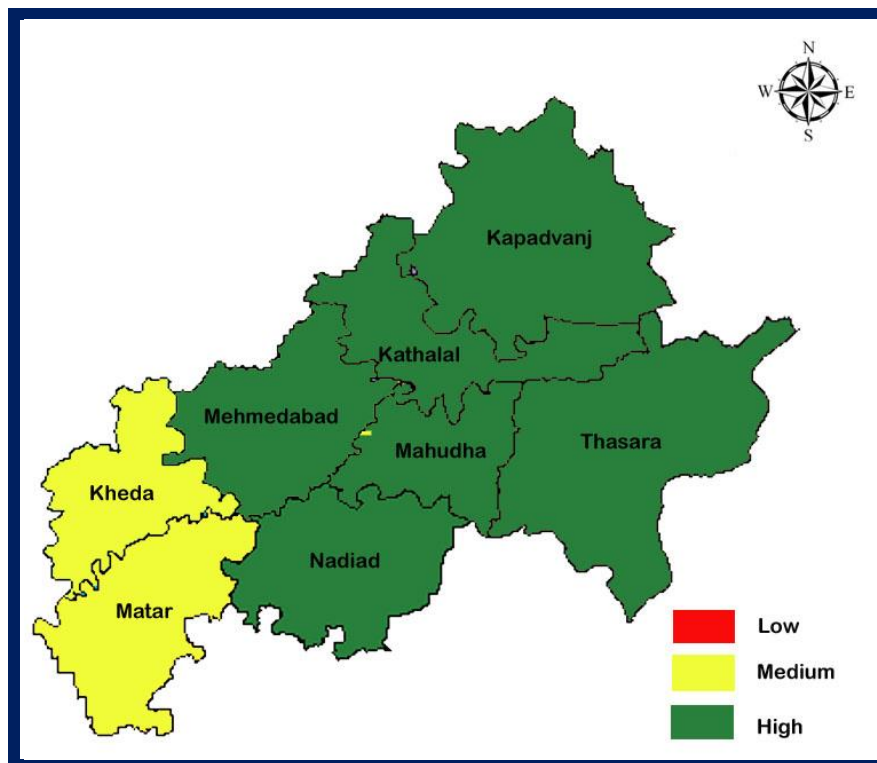


Fig. 4.6: DTPA-Mn status in soils of different talukas of kheda district

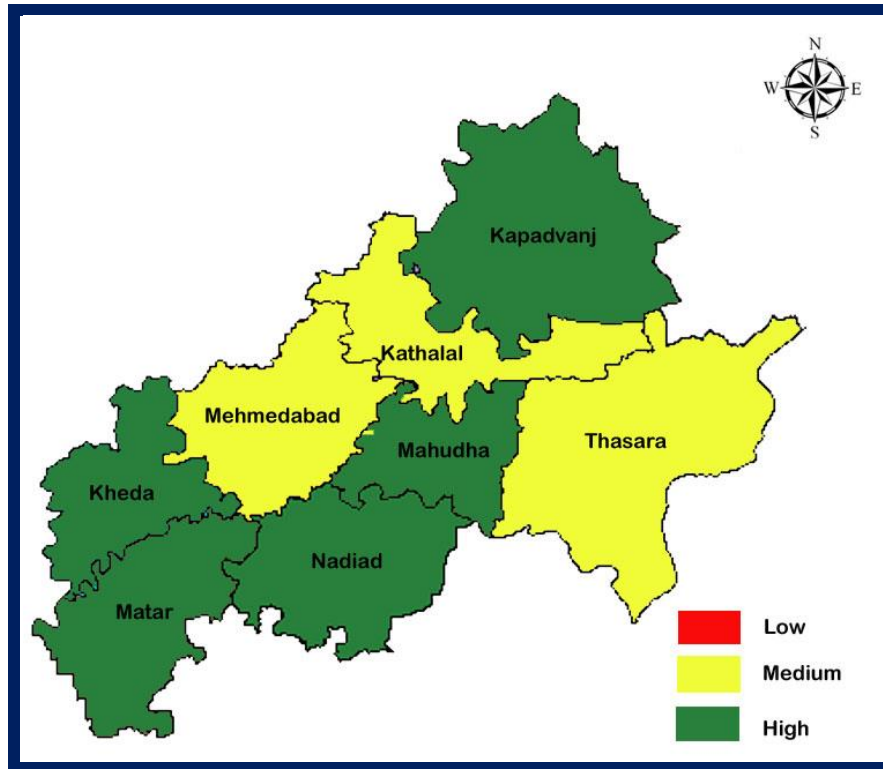


Fig. 4.7: DTPA-Zn status in soils of different talukas of kheda district

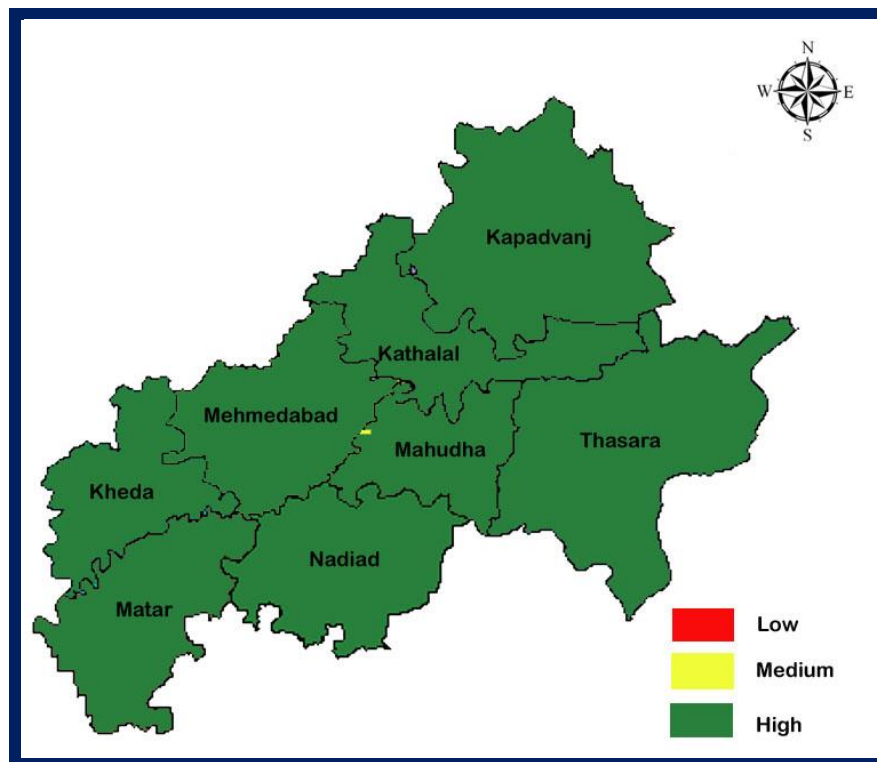


Fig. 4.8: DTPA-Cu status in soils of different talukas of kheda district

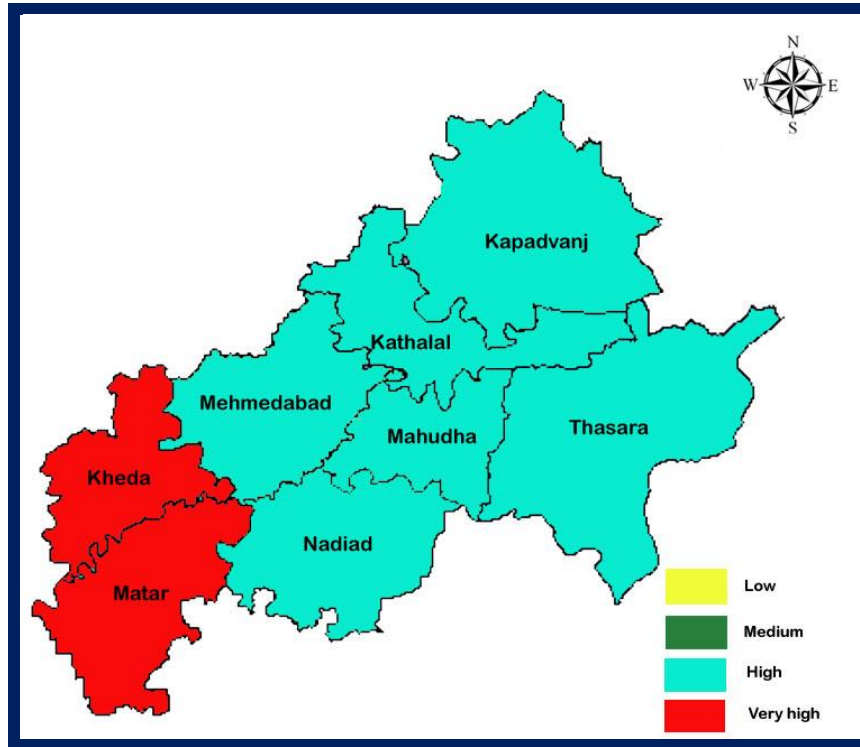


Fig. 4.9: Concentration of EC in irrigation water of different talukas of kheda district

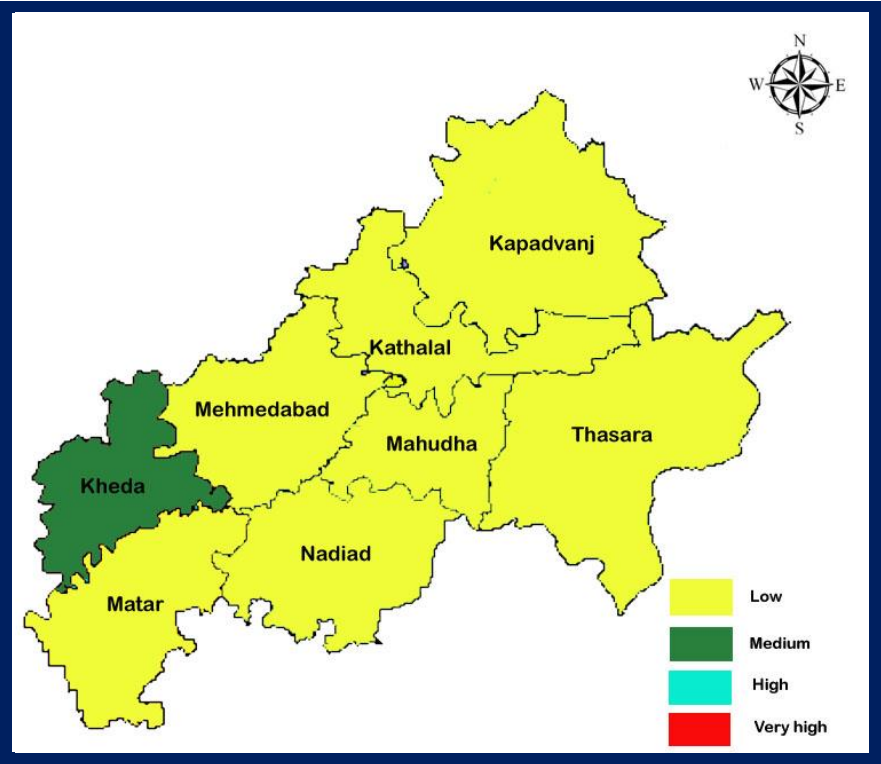


Fig. 4.10: Concentration of SAR in irrigation water of different talukas of kheda district

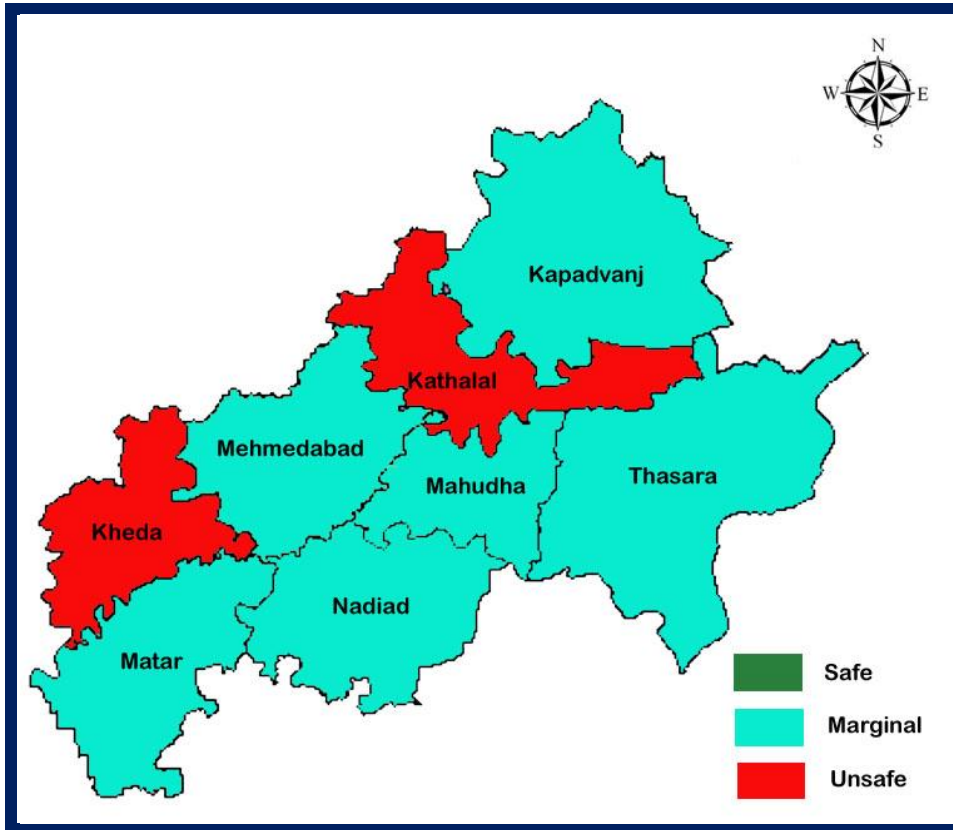


Fig. 4.11: Concentration of RSC in irrigation water of different talukas of kheda district

4.5 INTERRELATIONSHIP AMONG AND BETWEEN FERTILITY AND SALINITY/SODICITY PARAMETERS OF SOILS

4.5.1 Correlation Study

The correlation among fertility parameters of soil (O.C., available N, P₂O₅, K₂O and S) and with salinity/sodicity parameters (EC_{2.5}, EC₅, EC_e, pH_{2.5}, pH₅, pH_s, CaCO₃) were worked out and presented in Table 4.12. The correlation values were indicates that the highly significant positive relation of EC_e with EC_{2.5} ($r = 0.952^{**}$), EC₅ ($r = 0.947^{**}$), ESP ($r = 0.688^{**}$) and SAR ($r=0.132$). Similarly, all the above properties were also correlated with EC_{2.5} and EC₅. Whereas, pH_s was highly significant correlated with pH_{2.5} ($r = 0.966^{**}$), pH₅ ($r = 0.978^{**}$), RSC ($r = 0.352^{**}$), SAR ($r = 0.460^{**}$) and ESP ($r=0.242^{**}$). In case of ESP, the highly positively significant correlated with SAR ($r = 0.504^{**}$), EC_{2.5}($r = 0.705^{**}$), EC_e ($r = 0.688^{**}$), EC₅ ($r = 0.706^{**}$), pH_{2.5} ($r = 0.966^{**}$), pH₅ ($r = 0.978^{**}$), pH_s ($r = 0.242^{**}$) and SSP ($r = 0.476^{**}$). Similar results were also obtained by Pandey *et al.* (2000) and Patel (2004).

4.5.2 Regression Study

Use of EC_e is recommended by the USDA as it simulates field soil moisture condition. However, it is cumbersome in practice and more so when large number of samples are to be handled for characterization of soils of a region or an area. To overcome this constraint, many workers have tried to correlate EC_{2.0}, EC_{2.5} or EC_{5.0} values with EC_e and if this association is significant than regression equation is worked out. Such equations are very useful in characterization of a large number of samples.

Linear regression equation were worked out for predicting the EC_e and pH_s from the measured EC and pH values of 1:2.5 and 1:5 soil water extracts. The soils were further grouped in to three classes, *viz*; saline, sodic and saline-sodic and the groupwise as well as overall regression equations were computed.

Table 4.12: Correlation co-efficient among and between fertility and salinity/sodicity indices of soils of the Kheda district

	EC _{2.5}	EC ₅	ECe	pH _{2.5}	pH ₅	pHs	SSP	RSC	SAR	ESP	O.C.	CaCO ₃	N	P ₂ O ₅	K ₂ O	S
EC _{2.5}	1.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EC ₅	0.996**	1.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ECe	0.952**	0.947**	1.000	--	--	--	--	--	--	--	--	--	--	--	--	--
pH _{2.5}	-0.059	-0.054	-0.072	1.000	--	--	--	--	--	--	--	--	--	--	--	--
pH ₅	-0.052	-0.048	-0.063	0.978**	1.000	--	--	--	--	--	--	--	--	--	--	--
pHs	-0.100	-0.094	-0.109	0.966**	0.955**	1.000	--	--	--	--	--	--	--	--	--	--
SSP	0.062	0.048	0.056	0.470**	0.502**	0.456**	1.000	--	--	--	--	--	--	--	--	--
RSC	-0.232**	-0.251**	-0.278**	0.371**	0.413**	0.352**	0.522**	1.000	--	--	--	--	--	--	--	--
SAR	0.139	0.131	0.132	0.477**	0.513**	0.460**	0.948**	0.409**	1.000	--	--	--	--	--	--	--
ESP	0.705**	0.706**	0.688**	0.276**	0.296**	0.242**	0.476**	0.106	0.504**	1.000	--	--	--	--	--	--
O.C.	0.241**	0.238**	0.220**	-0.203**	-0.132	-0.190*	0.168*	0.088	0.154	0.116	1.000	--	--	--	--	--
CaCO ₃	-0.015	-0.009	-0.004	-0.413**	-0.392**	-0.373**	-0.060	-0.051	0.114	0.005	0.148	1.000	--	--	--	--
N	0.273**	0.285**	0.243**	-0.141	-0.092	-0.141	0.029	-0.048	0.056	0.109	0.422**	0.029	1.000	--	--	--
P ₂ O ₅	0.051	0.053	0.048	-0.060	-0.014	-0.028	-0.050	-0.058	-0.004	-0.028	0.308**	-0.058	0.138	1.000	--	--
K ₂ O	0.168*	0.174*	0.153	-0.069	-0.040	-0.065	-0.103	-0.025	0.001	0.091	0.258**	-0.030	0.142	0.261**	1.000	--
S	0.440**	0.442**	0.458**	-0.043	-0.015	-0.090	0.049	-0.019	0.100	0.352**	0.235**	-0.097	0.246**	0.071	0.129	1.000

* Significant at 5 per cent level

** Significant at 1 per cent level

4.5. 2.1 Prediction of EC_e From $EC_{2.5}$ And EC_5

The significant correlation coefficient (r) values were obtained between EC of 1:2.5 and 1:5 with EC of saturation extract in all the soil groups (Table 4.13). Significant correlation coefficients between EC_e and EC of 1:2.5 and 1:5 soil:water extracts were observed in saline ($r = 0.962, 0.986$), saline-sodic ($r = 0.852, 0.843$) and overall ($r = 0.926, 0.920$) soil groups, respectively. The result of overall regression also significant, which showed that prediction of EC_e using $EC_{2.5}$ value are more precise with over all regression equation than based on individual soil group wise regression.

It is obvious from the data in (Table 4.13) show that the regression coefficient (b) of all the soil groups were highly significant (at 1 percent level) for the 1:2.5 soil:water extract. The highly regression coefficient was noticed in overall ($b = 3.206$), followed by saline-sodic ($b = 3.033$) and sodic ($b = 2.642$) soil groups. The results regarding the regression equation for predicting EC_e with EC_5 values, just similar type for all the soil groups. To sum up, the overall regression equation obtained from $EC_{2.5}$ can be conveniently used for precise prediction of EC_e for the salt affected soils of Kheda district.

4.5. 2.2 Prediction of pH_s From $pH_{2.5}$ And pH_5

In order to predict pH_s (saturation extract) from $pH_{2.5}$ and pH_5 for overall as well as soil group wise equation were computed. The correlation was found to be significant for all the soil groups at 1:2.5 and 1:5, soil: water ratios (Table 4.14). The regression coefficient (r) for the different soil group was ranging from in saline ($r = 0.972, 0.624$), saline-sodic ($r = 0.909, 0.939$) and overall ($r = 0.953, 0.956$) soil groups. The overall correlation coefficient (r) is higher (0.956^*) in soil: water (1:5) as compared to soil:water (1:2.5). The percentage of variance was higher with 1:5 soil water ratio (91.40) as compared to that of 1:2.5 soil:water ratio (90.80).

Thus, the pH_s can provide better prediction estimate than $pH_{2.5}$. Overall prediction equation had higher 'r' value than that of saline and sodic soil groups.

Table 4.13: Regression equation for EC of salt affected soil samples of soils of Kheda district

Sr No.	Soil group	No. of Samples	Régression équation (y = a + bx)	Percentage of variance (R ²)	Correlation of Coefficient (r)
Soil:water (1:2.5)					
1	Saline	03	$EC_e = 1.069 + 2.375^{**}EC_{2.5}$	92.50	0.962*
2	Saline-sodic	22	$EC_e = 0.580 + 3.033^{**}EC_{2.5}$	72.60	0.852*
3	Sodic	24	$EC_e = 0.281 + 2.642^{**}EC_{2.5}$	84.20	0.918*
4	Overall	49	$EC_e = -0.082 + 3.206^{**}EC_{2.5}$	85.80	0.926*
Soil:water (1:5)					
1	Saline	03	$EC_e = 1.573 + 3.759^{**}EC_5$	97.20	0.986*
2	Saline-sodic	22	$EC_e = 0.379 + 5.835^{**}EC_5$	71.10	0.843*
3	Sodic	24	$EC_e = 0.332 + 4.685^{**}EC_5$	74.50	0.863*
4	Overall	49	$EC_e = -0.251 + 6.124^{**}EC_5$	84.70	0.920*

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.14: Regression equation for pH of salt affected soil samples of soils of Kheda district

Sr. No.	Soil group	No. of Samples	Regression equation ($y = a + bx$)	Percentage of variance (R^2)	Correlation of Coefficient (r)
Soil:water (1:2.5)					
1	Saline	03	$pH_s = 4.898 + 0.326^{**}pH_{2.5}$	94.40	0.972*
2	Saline-sodic	22	$pH_s = 1.780 + 0.748^{**}pH_{2.5}$	82.60	0.909*
3	Sodic	24	$pH_s = -0.113 + 1.000^{**}pH_{2.5}$	97.50	0.987*
4	Overall	49	$pH_s = 0.537 + 0.913^{**}pH_{2.5}$	90.80	0.953*
Soil:water (1:5)					
1	Saline	03	$pH_s = 5.592 + 0.230^{**}pH_5$	38.90	0.624*
2	Saline-sodic	22	$pH_s = 1.410 + 0.780^{**}pH_5$	88.20	0.939*
3	Sodic	24	$pH_s = 0.132 + 0.948^{**}pH_5$	93.20	0.965*
4	Overall	49	$pH_s = 0.604 + 0.887^{**}pH_5$	91.40	0.956*

* Significant at 5 per cent level

** Significant at 1 per cent level

4.6 IRRIGATION WATER QUALITY APPRAISAL

In order to present a water quality appraisal, 160 underground water/tube well water samples (20 samples from each taluka) were collected. Irrigation water samples were analyzed for EC, pH, cations (Ca^{++} , Mg^{++} , Na^+ and K^+), anions (CO_3^- , HCO_3^- , Cl^- and SO_4^-) and water quality appraisal was prepared by making use of EC and SAR values as suggested by USDA. Taluka wise (range and mean values of) EC, pH, RSC, SSP and SAR are given in Table 4.17. Percentage distribution of water samples into different EC and SAR classes are given in Table 4.18. Sample wise values of different parameters (for all the 160 samples) are given in Appendix VI.

4.6.1 Cation Concentration in Well/Tube Well Water Samples

Taluka wise range and mean values of different cations present in well/tube well water samples are given in Table 4.15. Among the cations, overall highest proportion of Na^+ (13.12 me l^{-1}) was observed, which was followed by Mg^{++} (4.79 me l^{-1}), Ca^{++} (1.62 me l^{-1}) and K^+ (0.07 me l^{-1}). The presence of large proportion of Na^+ in most of the area under investigation is indicative of a potential danger for the alkalinity hazards. The overall concentration of Ca^{++} , Mg^{++} , Na^+ and K^+ varied from 0.20 to 6.50, 0.50 to 13.10, 0.79 to 45.93 and 0.00 to 0.97 me l^{-1} , respectively (Table 4.15). The highest mean value for Na^+ (21.06 me l^{-1}) was found in Kheda taluka followed by Matar (17.74 me l^{-1}) and Mahudha (15.36 me l^{-1}), the lowest mean value for Na^+ (6.46 me l^{-1}) was reported in Kapadvanj taluka. Similar results were also found by Timbadia (1988) for Jafrabad and Rajula talukas of Amreli district.

4.6.2 Anion Concentration In Well/Tube Well Water Samples

In case of anions, the highest overall mean value of 10.82 me l^{-1} was recorded for Cl^- and it was followed by HCO_3^- (7.52 me l^{-1}), CO_3^- (1.30 me l^{-1}) and SO_4^- (1.10 me l^{-1}). The highest mean value of Cl^- (20.83 me l^{-1}) was observed in Matar talukas while the highest mean value of HCO_3^- (8.90 me l^{-1}) was observed in Mehmedabad taluka as well as CO_3^- (1.55 me l^{-1}), SO_4^- (1.71 me l^{-1}) were observed in Mahudha and Kheda talukas, respectively. The overall range values for CO_3^- , HCO_3^- , Cl^- and SO_4^- were 0.00 to 4.00, 1.00 to 14.00, 1.00 to 71.50 and 0.00 to 2.13 me l^{-1} , respectively (Table 4.16). Similar results were also found by Timbadia (1988) for Jafrabad and Rajula talukas of Amreli district.

Table 4.15: Taluka wise range and mean values of cations of well/tube well water samples of Kheda district

Name of Taluka	Cations in me l ⁻¹			
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺
Nadiad	0.20-3.40 (1.16)	1.00-10.60 (5.35)	0.94-45.93 (13.43)	0.00-0.58 (0.08)
Mahudha	0.40-2.70 (1.45)	2.70-13.10 (5.99)	1.99-40.71 (15.36)	0.00-0.20 (0.05)
Matar	0.60-4.70 (2.06)	1.30-11.00 (4.82)	4.35-45.80 (17.74)	0.01-0.65 (0.09)
Kheda	0.70-6.50 (2.66)	0.50-9.50 (4.03)	3.50-36.60 (21.06)	0.01-0.97 (0.13)
Kapadvanj	0.30-2.20 (1.18)	0.90-9.20 (3.69)	2.35-13.10 (6.46)	0.00-0.06 (0.02)
Thasra	0.40-3.00 (1.56)	2.20-7.80 (4.69)	0.79-31.53 (10.90)	0.01-0.48 (0.06)
Mehmedabad	0.50-2.90 (1.39)	4.10-9.70 (6.37)	2.74-30.02 (9.87)	0.01-0.97 (0.07)
Kathlal	0.60-2.90 (1.52)	0.70-6.60 (3.38)	2.91-19.30 (10.12)	0.01-0.20 (0.05)
Overall	0.20-6.50 (1.62)	0.50-13.10 (4.79)	0.79-45.93 (13.12)	0.00-0.97 (0.07)

Note: Values in parenthesis are mean values

Table 4.16: Taluka wise range and mean values of anions of well/tube well water samples of Kheda district

Name of Taluka	Anions in me l ⁻¹			
	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻
Nadiad	1.00-3.00 (1.30)	3.00-11.00 (7.30)	1.00-70.00 (12.43)	0.00-2.11 (1.52)
Mahudha	1.00-4.00 (1.55)	3.00-14.00 (8.15)	1.50-42.50 (12.20)	0.00-2.09 (1.01)
Matar	0.00-2.00 (1.15)	3.00-12.00 (8.00)	3.00-71.50 (20.83)	0.00-2.13 (1.61)
Kheda	0.00-3.00 (1.25)	4.00-13.00 (7.95)	3.00-37.50 (16.88)	0.75-2.11 (1.71)
Kapadvanj	1.00-2.00 (1.10)	3.00-12.00 (6.20)	2.00-10.00 (3.68)	0.00-1.96 (0.39)
Thasra	1.00-4.00 (1.40)	1.00-14.00 (6.85)	1.50-27.00 (8.25)	0.00-2.02 (0.68)
Mehmedabad	1.00-4.00 (1.30)	5.00-12.00 (8.90)	1.50-27.00 (6.35)	0.00-1.98 (0.83)
Kathlal	1.00-2.00 (1.35)	3.00-12.00 (6.80)	2.00-19.50 (5.93)	0.00-1.79 (1.08)
Overall	0.00-4.00 (1.30)	1.00-14.00 (7.52)	1.00-71.50 (10.82)	0.00-2.13 (1.10)

Note: Values in parenthesis are mean values

4.6.3 Electrical Conductivity (EC)

The overall mean value of EC was found 2.04 dS m⁻¹, which was varied widely from 0.51 to 8.50 dS m⁻¹. The lowest value of EC (0.51 dS m⁻¹) was recorded in a sample taken from Kapadvanj taluka whereas the highest value of EC (8.50 dS m⁻¹) was reported in Matar taluka. The highest mean value (3.16 dS m⁻¹) was obtained in Matar taluka followed by Kheda (2.77 dS m⁻¹) and Mahudha (2.25 dS m⁻¹) talukas due to poor quality ground water. The lowest mean value (1.07 dS m⁻¹) was obtained in Kapadvanj taluka (Table 4.17). The higher mean value of EC is an indicative of potential development of

saline soils in Kheda district. Similar findings were made by Churu district (Rajasthan) by Verma *et al*, (2003), for Amreli district by Kabaria (2004), for Mahboob Nagar district of Andhra Pradesh by Prasad and Minhas (2007) and for Bhavnagar district by Rajput and Polara (2013).

If we observe the percentage distribution of samples in different EC classes, then 0.00, 9.37, 63.75 and 27.50 per cent samples were falling under C₁, C₂, C₃ and C₄ classes of EC, respectively. None of the sample falls under C₁ classes of EC. In Kheda district 101 samples fall under C₃ class of EC and 44 samples under C₄ and 15 samples fall under C₂ class. So, the salinity hazard of irrigation water is the cause of the development of secondary salinization in the soils of Kheda district (Table 4.18). The result also revealed that overall, irrigation water of kheda district fall in C₃ class (highly saline) irrigation water. The Nadiad, Mahudha, Kapadvanj, Mehmedabad and Kathlal talukas having high saline irrigation water. Whereas, Matar and Kheda having very high saline irrigation water (Table 4.17). This finding is in conformity with the findings for Churu district (Rajasthan) by Verma *et al*, (2003), for Amreli district by Kabaria (2004), For Mahboob Nagar district of Andhra Pradesh by Prasad and Minhas (2007) and for Bhavnagar district by Rajput and Polara (2013).

4.6.4 pH

In general, the waters of this district were alkaline in reaction. The pH values were ranged from 6.84 to 9.30 with a mean value of 7.97. The highest mean value of pH 8.27 was recorded in Kathlal taluka whereas the lowest mean value of pH 7.70 was recorded in Mahudha taluka (Table 4.17). This finding is in conformity with the findings for Churu district (Rajasthan) by Verma *et al*, (2003), for Amreli district by Kabaria (2004), For Mahboob Nagar district of Andhra Pradesh by Prasad and Minhas (2007) and for Bhavnagar district by Rajput and Polara (2013).

4.6.5 Residual Sodium Carbonate (RSC)

Taluka wise range and mean values of RSC is given in Table 4.15 and percentage distributions of water samples in different RSC classes (as suggested by USDA) are presented in Table 4.18.

The overall RSC values were ranged from -4.80 to 10.50 with a mean value of 2.41 me l⁻¹ which was less than 2.5 me l⁻¹ indicated poor quality irrigation water. The highest mean value of RSC (3.26 me l⁻¹) was recorded in Kathlal taluka indicate poor

quality water, whereas the lowest mean value (2.01 me l^{-1}) was obtained in Thasra taluka (Table 4.17). For all talukas, except Kheda and Kathlal the RSC mean values were falling between 1.25 to 2.50 me l^{-1} , which showed that irrigation water having marginal carbonate hazards and marginally fit for irrigation with adequate leaching. It also noted that the Kheda and Kathlal talukas having irrigation water not suitable for irrigation purpose. This finding is in conformity with the findings for Churu district (Rajasthan) by Verma *et al.*, (2003), for Amreli district by Kabaria (2004), For Mahboob Nagar district of Andhra Pradesh by Prasad and Minhas (2007) and for Bhavnagar district by Rajput and Polara (2013).

Overall 34.37, 20.62 and 45.0 per cent samples fall under safe, marginal and unsafe classes of RSC, respectively (Table 4.18). This finding is in concurrence with the findings of Nilsood *et al.* (1998).

4.6.6 Soluble Sodium Percentage (SSP)

Taluka wise range and mean values of SSP is given in Table 4.17 and percentage distributions of water samples in different SSP classes (as suggested by USDA) are presented in Table 4.18.

The overall mean value of SSP was 34.34 and ranged from 8.00 to 77.26 (Table 4.17). The highest mean value (43.65) was recorded in Mehmedabad taluka whereas, the lowest mean value (22.83) was recorded in Kheda taluka. Overall 94.37 and 5.62 per cent samples fall under safe and unsafe classes of SSP, respectively (Table 4.18). The result also revealed that in respect to SSP, all the talukas and overall Kheda district was safe from SSP hazards. This finding is in concurrence with the findings of Nilsood *et al.*(1998). For most of soil samples SSP values were more than 60, which in an indicative of alkali hazards in these waters. This finding is in conformity with the findings for Churu district (Rajasthan) by Verma *et al.*, (2003), for Amreli district by Kabaria (2004), For Mahboob Nagar district of Andhra Pradesh by Prasad and Minhas (2007) and for Bhavnagar district by Rajput and Polara (2013).

4.6.7 Sodium Adsorption Ratio (SAR)

The SAR value is an important criterion for studying the alkali hazards in irrigation water. Therefore, taluka wise, range and mean values of SAR is given in Table 4.15 and per cent distribution of water sample in different SAR classes (as suggested by USDA) are presented in Table 4.18.

The overall mean value of SAR was 7.48 and it was varied from 0.36 to 29.96. The lowest (0.36) and the highest (29.96) SAR value was reported in water samples collected from Nadiad taluka, respectively. The highest (11.55) and the lowest (4.64) mean SAR values were registered in water samples collected from Kheda and Kapadvanj talukas, respectively. This finding is in conformity with the findings for Churu district (Rajasthan) by Verma *et al.*, (2003), for Amreli district by Kabaria (2004), For Mahboob Nagar district of Andhra Pradesh by Prasad and Minhas (2007) and for Bhavnagar district by Rajput and Polara (2013).

About 75.0, 21.87, 2.50 and 0.62 per cent samples fall under S_1 , S_2 , S_3 and S_4 classes of SAR, respectively. Almost 120 samples had SAR value less than 10 and 35 samples had SAR value greater than 10 (Table 4.18). The result also revealed that overall, irrigation water of Kheda district fall in S_1 class (Low Na) irrigation water. Whereas, all the talukas of Kheda district having low Na irrigation water except Kheda taluka fall in S_2 (Medium Na) irrigation water (Table 4.17). This finding is in concurrence with the findings of Nilsood *et al.* (1998) and Kabaria (2004).

4.6.8 EC and SAR classes of Well/Tube Well Water Samples

Taluka wise EC and SAR classes of well/tube well water samples are given in Table 4.17. The result revealed that overall, irrigation water of Kheda district fall in C_3S_1 class (high saline-low Na) irrigation water. Whereas, same result found in all talukas of Kheda district except Matar and Kheda fall in C_4S_1 and C_4S_2 irrigation water classes, respectively. This finding is in concurrence with the findings of Nilsood *et al.* (1998) and Kabaria (2004).

Table 4.17: Taluka wise range and mean values of EC, pH and different indices of well/tube well water samples of Kheda district

Name of Taluka	EC (dS m ⁻¹)	pH	RSC (me l ⁻¹)	SSP	SAR	EC and SAR classes
Nadiad	0.73-8.20 (2.22)	7.32-9.30 (8.20)	-3.40-6.70 (2.10)	9.18-77.26 (33.89)	0.36-29.96 (7.79)	C3S1
Mahudha	0.60-5.50 (2.25)	6.85-8.70 (7.70)	-4.80-8.70 (2.26)	16.65-62.77 (35.92)	1.39-15.93 (7.58)	C3S1
Matar	0.70-8.50 (3.16)	7.49-9.16 (7.90)	-4.00-7.40 (2.28)	12.72-43.38 (26.89)	3.55-18.12 (9.60)	C4S1
Kheda	0.70-4.80 (2.77)	7.18-8.54 (7.91)	-4.20-8.60 (2.51)	14.65-47.94 (22.83)	2.30-16.68 (11.55)	C4S2
Kapadvanj	0.51-2.10 (1.07)	7.30-8.42 (7.82)	-1.80-8.80 (2.44)	8.82-60.73 (40.90)	1.33-15.63 (4.64)	C3S1
Thasra	0.62-4.10 (1.66)	6.84-8.90 (7.82)	-3.00-10.40 (2.01)	10.87-73.83 (39.61)	0.41-18.73 (6.48)	C3S1
Mehmedabad	0.69-4.10 (1.69)	7.61-8.58 (8.11)	-0.70-7.20 (2.45)	25.33-61.65 (43.65)	1.73-12.80 (4.93)	C3S1
Kathlal	0.70-2.40 (1.48)	7.64-8.62 (8.27)	-4.60-10.50 (3.26)	8.00-54.01 (31.04)	1.77-20.11 (7.25)	C3S1
Overall	0.51-8.50 (2.04)	6.84-9.30 (7.97)	-4.80-10.50 (2.41)	8.00-77.26 (34.34)	0.36-29.96 (7.48)	C3S1

Note: Values in parenthesis are mean values

Table 4.18: Percentage distribution of well/tube well water samples into different EC and SAR, RSC and SSP classes

Name of Taluka	EC (dS m ⁻¹)				SAR classes				RSC classes			SSP classes	
	C ₁	C ₂	C ₃	C ₄	S ₁	S ₂	S ₃	S ₄	Safe	Marginal	Unsafe	Safe	Unsafe
Nadiad	00 (00)	10 (02)	60 (12)	30 (06)	80 (16)	15 (03)	00 (00)	05 (01)	30 (06)	25 (05)	45 (09)	95 (19)	05 (01)
Mahudha	00 (00)	10 (02)	55 (11)	35 (07)	65 (13)	35 (07)	00 (00)	00 (00)	30 (06)	25 (05)	45 (09)	90 (18)	10 (02)
Matar	00 (00)	05 (01)	55 (11)	40 (08)	65 (13)	30 (06)	05 (01)	00 (00)	45 (09)	05 (01)	50 (10)	100 (20)	00 (00)
Kheda	00 (00)	05 (01)	25 (05)	70 (14)	35 (07)	65 (13)	00 (00)	00 (00)	40 (08)	05 (01)	55 (11)	100 (20)	00 (00)
Kapadvanj	00 (00)	25 (05)	75 (15)	00 (00)	95 (19)	05 (01)	00 (00)	00 (00)	40 (08)	20 (04)	40 (08)	90 (18)	10 (02)
Thasra	00 (00)	10 (02)	60 (12)	30 (06)	85 (17)	05 (01)	10 (02)	00 (00)	45 (09)	20 (04)	35 (07)	85 (17)	15 (03)
Mehmedabad	00 (00)	05 (01)	85 (17)	10 (02)	95 (19)	05 (01)	00 (00)	00 (00)	20 (04)	45 (09)	35 (07)	95 (19)	05 (01)
Kathlal	00 (00)	05 (01)	90 (18)	05 (01)	80 (16)	15 (03)	05 (01)	00 (00)	25 (05)	20 (04)	55 (11)	100 (20)	00 (00)
Overall	00 (00)	9.37 (15)	63.75 (101)	27.50 (44)	75.0 (120)	21.87 (35)	2.5 (04)	0.62 (01)	34.37 (55)	20.62 (33)	45.00 (72)	94.37 (151)	5.62 (09)

Note: Values in parenthesis are number of samples in respective group

4.7 INTERRELATIONSHIP BETWEEN PROPERTIES OF IRRIGATION WATER AND IRRIGATED SOILS OF KHEDA DISTRICT

4.7.1 Correlation

The correlation is observed between irrigation water properties and soil properties. So, the correlation between the different properties of irrigation waters (EC_{iw} , pH_{iw} , RSC_{iw} , SSP_{iw} and SAR_{iw}) and properties of irrigated soils ($EC_{2.5}$, EC_e , EC_5 , $pH_{2.5}$, pH_5 , $SAR_{2.5}$, $RSC_{2.5}$, $SSP_{2.5}$, and ESP_{se}) were worked out and are presented in Table 4.19. The data indicates, highly significant relations between EC_{iw} with SAR_{iw} ($r = 0.463^{**}$), EC_5 ($r = 0.343^{**}$), EC_e ($r = 0.281^{**}$), SSP_{iw} ($r = -0.267^{**}$) and $EC_{2.5}$ ($r = 0.339^{**}$), of soils. This indicates that $EC_{2.5}$ and SAR increases and $pH_{2.5}$ decrease with increase in the EC_{iw} and EC_{iw} with SAR_{iw} and SSP_{iw} were also observed highly significant correlation, which indicates the SSP_{iw} and SAR_{iw} of irrigation water increase with increasing the EC of irrigation water (Table 4.19).

The pH_{iw} was significantly positive correlation with RSC_{iw} ($r = 0.142$), SAR_{iw} (0.079) and negatively correlation with SSP_{iw} (-0.120), $SSP_{2.5}$ (-0.016), $SAR_{2.5}$ (-0.057) and ESP (-0.017). The SSP_{iw} was negatively correlated with EC_5 ($r = -0.192^*$), EC_e ($r = -0.166^*$), $RSC_{2.5}$ ($r = -0.090$), SAR_{iw} ($r = -0.858^{**}$), $EC_{2.5}$ (-0.186*), $SSP_{2.5}$ ($r = -0.125$), $pH_{2.5}$ ($r = -0.166^*$), pH_5 ($r = -0.216^{**}$), $SAR_{2.5}$ ($r = -0.136$) and ESP ($r = -0.258^{**}$). The SAR_{iw} was highly significantly positive correlated with $EC_{2.5}$ ($r = 0.265^{**}$), EC_5 ($r = 0.268^{**}$), EC_e ($r = 0.288^{**}$), ESP ($r = 0.327^{**}$) and significant positive relation with $SAR_{2.5}$ ($r = 0.151$), $SSP_{2.5}$ ($r = 0.116$) and RSC ($r = 0.080$). The RSC_{iw} was significantly positive correlated $EC_{2.5}$, EC_5 , EC_e , $SSP_{2.5}$, $SAR_{2.5}$, SSP_{iw} while highly significant relation with SAR_{iw} . Almost similar relationship was also obtained by Paliwal and Maliwal (1971), Prasad and Prasad (2001) and Kabaria (2004).

Table 4.19: Correlation coefficients among different properties of irrigation water and irrigated soils of Kheda district

	EC _{iw}	pH _{iw}	RSC _{iw}	SSP _{iw}	SAR _{iw}	EC _{2.5}	ECe	EC ₅	pH _{2.5}	pHs	pH ₅	SSP _{2.5}	SAR _{2.5}	RSC _{2.5}	ESP _{se}
EC _{iw}	1.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--
pH _{iw}	-0.120	1.000	--	--	--	--	--	--	--	--	--	--	--	--	--
RSC _{iw}	-0.237**	0.142	1.000	--	--	--	--	--	--	--	--	--	--	--	--
SSP _{iw}	-0.267**	-0.120	-0.512**	1.000	--	--	--	--	--	--	--	--	--	--	--
SAR _{iw}	0.463**	0.079	0.286**	-0.858**	1.000	--	--	--	--	--	--	--	--	--	--
EC _{2.5}	0.339**	0.022	0.016	-0.186*	0.265**	1.000	--	--	--	--	--	--	--	--	--
ECe	0.281**	0.015	0.076	-0.166*	0.288**	0.952**	1.000	--	--	--	--	--	--	--	--
EC ₅	0.343**	0.026	0.017	-0.192*	0.268**	0.996**	0.947**	1.000	--	--	--	--	--	--	--
pH _{2.5}	-0.073	0.074	0.142	-0.166*	0.115	-0.059	-0.072	-0.054	1.000	--	--	--	--	--	--
pHs	-0.077	0.046	0.141	-0.175*	0.111	-0.100	-0.109	-0.094	0.966**	1.000	--	--	--	--	--
pH ₅	-0.027	0.059	0.140	-0.216**	0.159*	-0.052	-0.063	-0.048	0.978**	0.955**	1.000	--	--	--	--
SSP _{2.5}	0.116	-0.016	0.075	-0.125	0.116	0.062	0.056	0.048	0.470**	0.456**	0.502**	1.000	--	--	--
SAR _{2.5}	0.164*	-0.057	0.050	-0.136	0.151	0.139	0.132	0.131	0.477**	0.460**	0.513**	0.948**	1.000	--	--
RSC _{2.5}	0.047	0.111	-0.039	-0.090	0.080	-0.232**	-0.278**	-0.251**	0.371**	0.352**	0.413**	0.522**	0.409**	1.000	--
ESP _{se}	0.386**	-0.017	0.111	-0.258**	0.327**	0.705**	0.688**	0.706**	0.276**	0.242**	0.296**	0.476**	0.504**	0.106	1.000

* Significant at 5 per cent level

** Significant at 1 per cent level

5. SUMMARY AND CONCLUSIONS

For evaluating physical properties and fertility, salinity/ sodicity status of soils and quality of underground well/tube well waters, about 160 surface soil samples (20 soil samples from each taluka) and 160 underground irrigation water samples were collected from the cultivated fields. The soil samples were analyzed for fertility parameters viz., available N, P₂O₅, K₂O, S, Fe, Mn, Cu and Zn, salinity/sodicity parameters viz., E_{Ce}, pHs, ESP, SAR and SSP. In addition to this, chemical properties like organic carbon, EC_{2.5}, pH_{2.5}, free lime content and CEC were also determined. For appraising quality of irrigation water, water quality parameters like EC, pH, SAR, RSC and SSP were determined. The results are summarized as under.

5.1 PHYSICAL PROPERTIES OF SURFACE SOILS OF KHEDA DISTRICT

The overall range of bulk density, particle density, porosity and MWHC of soils were 1.24 to 1.54 Mg m⁻³, 2.21 to 2.89 Mg m⁻³, 38.01 to 48.79 per cent and 22.71 to 50.63 per cent with a mean values of 1.40 Mg m⁻³, 2.47 Mg m⁻³, 43.31 per cent and 35.21 per cent, respectively. The highest bulk density (1.44 Mg m⁻³) of soil was noted in Kapadvanj and Kathlal talukas, whereas highest particle density (2.52 Mg m⁻³) was noted in Kapadvanj and Thasra talukas. The porosity (44.21 per cent) and MWHC (39.44 per cent) of soils were noted highest in Thasra and Matar talukas, respectively. The lowest bulk density (1.36 Mg m⁻³) of soil was found in Matar, while lowest particle density (2.42 Mg m⁻³) of soil was found in Nadiad and Matar talukas. The porosity (42.54 per cent) and MWHC (31.18 per cent) of soil were noted the lowest in Kathlal taluka.

5.2 CHEMICAL PROPERTIES OF SURFACE SOILS OF KHEDA DISTRICT

The overall range of EC_{2.5}, pH_{2.5}, CaCO₃, O.C. and CEC of soils was 0.14 to 6.0 dS m⁻¹, 7.01 to 8.73, 3.22 to 6.75 per cent, 0.08 to 0.97 per cent and 15.13 to 59.45 Cmol (p⁺) kg⁻¹ with a mean values of 0.87 dS m⁻¹, 7.80, 4.55 per cent, 0.60 per cent and 31.44 Cmol (p⁺) kg⁻¹, respectively. The highest EC_{2.5} (1.27 dS m⁻¹) of soil was noted in Mahudha taluka, while highest pH_{2.5} (7.93) was noted in soils of Nadiad taluka, whereas highest CaCO₃ (4.71 per cent) was found in Matar and Kathlal talukas. The highest organic carbon (0.73 per cent) of soils was noted in Matar and

Kheda talukas as well as highest CEC ($38.04 \text{ Cmol (p}^+) \text{ kg}^{-1}$) was noted in Matar taluka. The lowest $\text{EC}_{2.5}$ (0.40 dS m^{-1}) and CaCO_3 (4.32 per cent) were observed in Kapadvanj taluka, while lowest $\text{pH}_{2.5}$ (7.66) was noted in soils of Matar and Thasra talukas. The lowest organic carbon (0.46 per cent) and CEC ($27.81 \text{ Cmol (p}^+) \text{ kg}^{-1}$) were noted in soils of Kathlal taluka.

5.3 SALINITY/SODICITY OF SURFACE SOILS OF KHEDA DISTRICT

Among the exchangeable cations, Ca^{++} was the dominant exchangeable cation followed by Mg^{++} , Na^+ and K^+ . The overall range of exchangeable Ca^{++} , Mg^{++} , Na^+ and K^+ was 3.00 to 70.00, 0.00 to 27.00, 0.26 to 24.17 and 0.19 to 2.97 with their corresponding mean values of 16.34, 12.53, 4.68 and 0.70 $\text{Cmol (p}^+) \text{ kg}^{-1}$. The highest exchangeable Ca^{++} ($23.30 \text{ Cmol (p}^+) \text{ kg}^{-1}$) and Mg^{++} ($16.55 \text{ Cmol (p}^+) \text{ kg}^{-1}$) were noted in soils of Matar and Nadiad talukas, respectively. The highest exchangeable Na^+ ($7.90 \text{ Cmol (p}^+) \text{ kg}^{-1}$) and K^+ ($0.87 \text{ Cmol (p}^+) \text{ kg}^{-1}$) were found in soils of Kheda and Kathlal talukas, respectively. And lowest exchangeable Ca^{++} ($12.10 \text{ Cmol (p}^+) \text{ kg}^{-1}$) and Na^+ ($1.89 \text{ Cmol (p}^+) \text{ kg}^{-1}$) were noted in soils of Kapadvanj taluka, as well as lowest exchangeable Mg^{++} ($8.90 \text{ Cmol (p}^+) \text{ kg}^{-1}$) and K^+ ($0.47 \text{ Cmol (p}^+) \text{ kg}^{-1}$) were found in soils of Kathlal and Mehmedabad talukas, respectively.

Among the water soluble cations, Na^+ was dominant water soluble cation followed by Ca^{++} , Mg^{++} and K^+ . The overall range of exchangeable Ca^{++} , Mg^{++} , Na^+ and K^+ was 0.60 to 7.60, 0.10 to 8.00, 0.30 to 5.19 and 0.01 to 1.71 with their corresponding mean values of 1.64, 1.41, 2.47 and 0.20 me l^{-1} . The highest water soluble Ca^{++} (2.60 me l^{-1}) and Mg^{++} (1.87 me l^{-1}) were noted in soils of Matar and Thasra talukas, respectively. Whereas highest water soluble Na^+ (3.35 me l^{-1}) and K^+ (0.33 me l^{-1}) were found in soils of Kheda and Mahudha talukas, respectively. While lowest water soluble Ca^{++} (1.15 me l^{-1}) and K^+ (0.07 me l^{-1}) noted in soils of Mehmedabad taluka as well as lowest water soluble Mg^{++} (1.00 me l^{-1}) and Na^+ (1.91 me l^{-1}) were found in soils of Nadiad and Thasra talukas, respectively. In case of water soluble anions, Cl^- was predominant one followed by HCO_3^- , SO_4^- and CO_3^- . The overall range of water soluble HCO_3^- , Cl^- and SO_4^- varied between 1.00 to 6.00, 1.00 to 35.00 and 0.24 to 5.00 with mean values of 2.38, 6.42 and 1.10 me l^{-1} , respectively. While water soluble CO_3^- was absent in soil sample collected from the different talukas of Kheda district. The highest water soluble HCO_3^- (3.70 me l^{-1}) and Cl^- (8.55 me l^{-1}) were found in soils of Kheda taluka, while highest SO_4^- (1.78 me l^{-1}) was noted in soils of Kapadvanj taluka. Whereas lowest

HCO_3^- (1.35 me l^{-1}) and Cl^- (4.03 me l^{-1}) were found in soils of Kapadvanj taluka as well as lowest SO_4^- (0.60 me l^{-1}) was noted in soils of Nadiad taluka.

The overall range of EC_e, pH_s, ESP, SSP and SAR were varied from 0.41 to 18.80dS m⁻¹, 7.0 to 8.65, 1.0 to 48.47, 8.90 to 75.92 and 0.37 to 7.71 with their corresponding mean values of 2.87dS m⁻¹, 7.66, 13.48, 42.16 and 308, respectively. The highest EC_e (3.78dS m^{-1}), ESP (20.10), SSP (53.72) and SAR (4.49) of soils were noted in Kheda talukas, while highest pH_s (7.80) was found in soils of Nadiad and Kapadvanj talukas. Whereas lowest EC_e (1.35dS m^{-1}) and ESP (7.46) were noted in soils of Kapadvanj taluka, while lowest SSP (31.53) and SAR (2.08) were found in soils of Thasra talukas. The lowest pH_s (7.52) was noted in soils of Matar taluka.

About 1.87, 13.75, 15.0 and 69.37 percent soil samples were found saline, saline-sodic, sodic and normal, respectively. sodic soils are the predominant salt affected soils in the district, followed by saline-sodic soils in Kheda and Matar talukas. Among all the talukas highest percentage of salt affected soils were found in Kheda as well as Nadiad talukas, followed by Matar and Mahudha.

Highly significant positive relations were observed between EC_e with EC_{2.5}, EC₅, ESP and SAR_{2.5} which indicate that almost all indices increased with increasing EC_{2.5}. The pH_s was highly significantly and positively correlated with pH_{2.5}, pH₅, RSC_{2.5}, ESP_{2.5} and SAR_{2.5}. In case of ESP, the highly positively significant correlated with SAR, EC_{2.5}, EC_e, EC₅, pH_{2.5}, pH₅, pH_s and SSP was observed.

The regression equations for the soils of Kheda district were computed for calculating the EC_e and pH_s values from the measured EC and pH value of 1:2.5 and 1:5 soil:water extracts. The overall equations, in general, provided a better estimate and these are as under.

$$\text{EC}_e = -0.082 + 3.206^{**}\text{EC}_{2.5} \quad (r = 0.926^*)$$

$$\text{EC}_e = -0.251 + 6.124^{**}\text{EC}_5 \quad (r = 0.920^*)$$

$$\text{pH}_s = 0.537 + 0.913^{**}\text{pH}_{2.5} \quad (r = 0.953^*)$$

$$\text{pH}_s = 0.604 + 0.887^{**}\text{pH}_5 \quad (r = 0.956^*)$$

5.4 FERTILITY STATUS OF THE SOILS OF KHEDA DISTRICT

The soils of Kheda district were found low in available nitrogen and sulphur while high in phosphorus and K_2O , and it was ranging from 78.40 to 862.40 $kg\ ha^{-1}$, 0.22 to 24.56 $mg\ kg^{-1}$, 10.02 to 98.22 $kg\ ha^{-1}$ and 71.50 to 996.44 $kg\ ha^{-1}$ with their corresponding mean value of 202.50 $kg\ ha^{-1}$, 5.90 $mg\ kg^{-1}$, 71.20 $kg\ ha^{-1}$ and 394.96 $kg\ ha^{-1}$, respectively. The highest available nitrogen (275.97 $kg\ ha^{-1}$) and sulphur (8.51 $mg\ kg^{-1}$) were noted in soils of Matar taluka, while highest available phosphorus (85.40 $kg\ ha^{-1}$) and K_2O (458.86 $kg\ ha^{-1}$) were found in soils of Kheda taluka. The lowest available nitrogen (152.88 $kg\ ha^{-1}$) and sulphur (3.79 $mg\ kg^{-1}$) were noted in soils of Kapadvanj and Thasra talukas, respectively. The lowest available phosphorus (52.39 $kg\ ha^{-1}$) and K_2O (264.24 $kg\ ha^{-1}$) were found in soils of Mehmedabad taluka.

Among the micronutrients, the soils of Kheda district were medium in DTPA-Fe while high in DTPA-Mn, Zn and Cu. It was ranging from 2.31 to 17.83, 3.93 to 18.17, 0.24 to 2.08 and 0.14 to 2.02 with their corresponding mean values of 8.02, 10.11, 1.00 and 0.95 $mg\ kg^{-1}$, respectively. The highest DTPA-Fe (11.61 $mg\ kg^{-1}$) and Cu (1.25 $mg\ kg^{-1}$) were found in soils of Matar as well as Nadiad talukas, respectively. While highest DTPA-Mn (12.77 $mg\ kg^{-1}$) and Zn (1.38 $mg\ kg^{-1}$) were found in soils of Mahudha taluka. Whereas lowest DTPA-Fe (5.32 $mg\ kg^{-1}$) and Cu (0.47 $mg\ kg^{-1}$) were noted in soils of Kapadvanj taluka. The lowest DTPA-Mn (8.30 $mg\ kg^{-1}$) and Zn (0.75 $mg\ kg^{-1}$) were found in soils of Kheda and Kathlal talukas, respectively.

According to nutrient index value, all the talukas have low fertility status in respect to available S and medium fertility status in respect to O.C, whereas the soils of all the talukas, were high in available P_2O_5 , K_2O and DTPA-Cu, except Mehmedabad which was in medium status of available P_2O_5 and K_2O . According to nutrient index value of DTPA-Fe, Kapadvanj and Thasra talukas have low fertility status, while Nadiad, Mahudha, Mehmedabad and Kathlal fall in medium fertility status as well as Matar and Kheda have high fertility status. While in respect of DTPA-Mn, all the talukas have high fertility status except Matar and Kheda, which were fall in medium fertility status. The soils of all the talukas have high fertility status in respect of DTPA-Zn, except Thasra, Mehmedabad and Kathlal talukas fall in medium fertility status.

Overall the soils of Kheda district found low with respect to available N and S, while medium in DTPA-Fe and high fertility class for available P_2O_5 , K_2O as well as DTPA-Mn, Zn and Cu.

5.5 QUALITY OF UNDERGROUND WELL/TUBE WELL WATER AND THEIR CLASSIFICATION

In general, underground well/tube well water was neutral to alkaline in reaction except some village of Mahudha and Thasra talukas. The overall range of EC, pH, RSC, SSP and SAR were varied from 0.51 to 8.50 dS m⁻¹, 6.84 to 9.30, -4.80 to 10.50 me l⁻¹, 8.0 to 77.26 and 0.36 to 29.96 with their corresponding mean values of 2.04 dS m⁻¹, 7.97, 2.41 me l⁻¹, 34.34 and 7.48. The highest EC (3.16 dS m⁻¹) and SAR (11.55) were found in irrigation water of Matar and Kheda talukas, respectively. While highest pH (8.27) and RSC (3.26 me l⁻¹) were noted in irrigation water of Kathlal taluka, whereas highest SSP (43.65) was found in irrigation water of Mehmedabad taluka. The lowest EC (1.07 dS m⁻¹) and SAR (4.64) were noted in irrigation water of Kapadvanj taluka, while lowest pH (7.70) and RSC (2.01 me l⁻¹) were found in irrigation water of Mahudha and Thasra taluka. Whereas lowest SSP (22.83) was found in irrigation water of Kheda taluka.

The irrigation waters of Kheda (C₄S₂) and Matar (C₄S₁) talukas of Kheda district are poor in quality. Overall 9.37, 63.75 and 27.50 per cent samples were found in C₂, C₃ and C₄ classes of EC, respectively. No sample was found in C₁ class of EC. Whereas overall 34.37, 20.62 and 45.00 per cent samples were found under safe, marginal and unsafe classes of RSC, respectively. Overall 75.00, 21.87, 2.50 and 0.62 per cent samples fall under S₁, S₂, S₃ and S₄ classes of SAR, respectively. While overall 94.37 and 5.62 per cent samples were found under safe and unsafe classes of SSP, respectively.

Among the water soluble cations, overall highest proportion of Na⁺ (13.12 me l⁻¹) was observed, which was followed by Mg⁺⁺ (4.79 me l⁻¹), Ca⁺⁺ (1.62 me l⁻¹) and K⁺ (0.07 me l⁻¹). The concentration of Ca⁺⁺, Mg⁺⁺, Na⁺ and K⁺ were in the range of 0.20 to 6.50, 0.50 to 13.10, 0.79 to 45.93 and 0.0 to 0.97 with their corresponding mean values of 1.62, 4.79, 13.12 and 0.07 me l⁻¹ respectively. The highest water soluble Ca⁺⁺ (2.66 me l⁻¹), Na⁺ (21.06 me l⁻¹) and K⁺ (0.13 me l⁻¹) were noted in irrigation water of Kheda taluka, while highest water soluble Mg⁺⁺ (6.37 me l⁻¹) was found in irrigation water of Mehmedabad taluka. Whereas lowest water soluble Ca⁺⁺ (1.16 me l⁻¹) and Mg⁺⁺ (3.38 me l⁻¹) were found in irrigation water of Nadiad and Kathlal talukas, respectively. As well as lowest water soluble Na⁺ (6.46 me l⁻¹) and K⁺ (0.02 me l⁻¹) were found in irrigation water of Kapadvanj taluka.

Among the water soluble anions, overall highest proportion of Cl^- (10.82 me l^{-1}) was observed, which was followed by HCO_3^- (7.52 me l^{-1}), CO_3^- (1.30 me l^{-1}) and SO_4^- (1.10 me l^{-1}). The overall water soluble CO_3^- , HCO_3^- , Cl^- and SO_4^- were in the range of 0.0 to 4.0, 1.0 to 14.0, 1.0 to 71.50 and 0.0 to 2.13 with their corresponding values of 1.30, 7.52, 10.82 and 1.10 me l^{-1} , respectively. The highest water soluble CO_3^- (1.55 me l^{-1}) and HCO_3^- (8.90 me l^{-1}) were found in irrigation water of Mahudha and Mehmedabad talukas, respectively. While highest water soluble Cl^- (20.83 me l^{-1}) and SO_4^- (1.71 me l^{-1}) were found in irrigation water of Matar and Kheda talukas, respectively. Whereas all the water soluble anions CO_3^- (1.10 me l^{-1}), HCO_3^- (6.20 me l^{-1}), Cl^- (3.68 me l^{-1}) and SO_4^- (0.39 me l^{-1}) were noted lowest in Kapadvanj taluka.

5.6 RELATIONSHIP BETWEEN DIFFERENT PROPERTIES OF WELL/TUBE WELL WATER AND SOIL PROPERTIES

Highly significant positive relationship between EC_{iw} with EC_e , $\text{EC}_{2.5}$, EC_5 , SAR_{iw} , SSP_{iw} , $\text{SSP}_{2.5}$, $\text{SAR}_{2.5}$, and $\text{RSC}_{2.5}$ was observed. The pH_{iw} was highly significantly and positively correlated with RSC_{iw} and SAR_{iw} while negatively correlation with SSP_{iw} , $\text{SSP}_{2.5}$, $\text{SAR}_{2.5}$ and ESP of soils. The RSC_{iw} was highly significantly and positively correlated with $\text{SSP}_{2.5}$ and $\text{SAR}_{2.5}$ of soils. The SSP_{iw} was negatively correlated with $\text{EC}_{2.5}$, EC_e , EC_5 , $\text{pH}_{2.5}$, pH_5 , $\text{SSP}_{2.5}$, $\text{SAR}_{2.5}$ and $\text{RSC}_{2.5}$ of the soils. The SAR_{iw} was highly significantly and positively correlated with $\text{EC}_{2.5}$, EC_5 , EC_e , ESP while significant positive relation with $\text{SSP}_{2.5}$, $\text{RSC}_{2.5}$ and $\text{SAR}_{2.5}$ of soils. This study shows that there is a need to use such underground water with almost caution.

CONCLUSIONS

The soils of Kheda districts were alkaline in reaction with low to medium in organic carbon. Majority of the soils of Kheda district were low in available nitrogen and sulphur, while high in available phosphorus and potassium. The status of available iron was medium, whereas the available manganese, zinc and copper were high. Being the light to medium texture soils, their overall cation exchange capacity was 31.44 Cmol (p⁺) kg⁻¹. Calcium was the dominant-exchangeable cation followed by Mg⁺⁺. About 1.87, 13.75, 15.0 and 69.37 per cent soil samples were found saline, saline-sodic, sodic and normal, respectively.

The well/tube waters of Kheda (C₄S₂) and Matar (C₄S₁) talukas of Kheda district are poor in quality. More than half of the samples of well/tube well waters from cultivator's fields were saline (EC 0.75 dS m⁻¹ and above). This is indicative of the potential development of saline soils in the Kheda district. Therefore, secondary salinization is one of the causes for development of salt affected soils. The problem of salinity will be even increased in this district in future. Therefore suitable holistic management practices should be implemented for the sustainable agriculture in this district.

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APPENDICES

Appendix I: Taluka/Sample wise name of Farmer, Taluka and Village from where soil and water samples collected.

Sr. No.	Name of Farmer	Name of Village	Soil/Water sample
Nadiad			
1	Parmar Shankarbhai Revajibhai	Bhumel	YES
2	Patel NitinbhaiVithhalbhai	Utarsanda	YES
3	Patel Rakeshbhai Ravjibhai	Chaklashi	YES
4	Patel Bharatbhai Ravjibhai	Alindra	YES
5	Patel Harshadbhai Ranchhodhbhai	Mohalel	YES
6	Sodha Chandubhai Ramabhai	Nanavaga	YES
7	Pathan Ayupkhan Kasamkhan	Hathaj	YES
8	Patel Kantibhai Motibhai	Marida	YES
9	Patel Kiritbhai Armanbhai	Manjipura	YES
10	Chunara Bhupatbhai Narajibhai	Dabhan	YES
11	Chauhan Ashokkumar Bhagvandas	Palana	YES
12	Prajapati Ramjibhai Jivabhai	Rampur	YES
13	Zala Udaysinh Nathasinh	Vaso	YES
14	Patel Ghanshyambhai Chaturbhai	Pinj	YES
15	Patel Arvindbhai Bhailalbhai	Tundel	YES
16	Parmar Bhagabhai Sodhabhai	Dumral	YES
17	Patel Rameshbhai Somabhai	Piplata	YES
18	Solanki Rameshbhai Chaturbhai	Valetva	YES
19	Patel Dineshbhai Jayantibhai	Vadtal	YES
20	Bharvad Danabhai Haribhai	Angaj	YES
Mahudha			
21	Mirza Shamsherbhai Kasambhai	Mulaj	YES
22	Sodha Punambhai Shanabhai	Bagdu	YES
23	Sodha Ajabsinh Punjabhai	Khuntaj	YES

Sr. No.	Name of Farmer	Name of Village	Soil/Water sample
24	Paramar Chandubhai Shamalbhai	Bhumas	YES
25	Patel Dineshbhai Bahecharbhai	Finav	YES
26	Malek Habibbhai Ishambhai	Mehmedabadnamuvada	YES
27	Patel Babubhai Purushotambhai	Vadthal	YES
28	Patel Daksheshbhai Ramanbhai	Vadthal	YES
29	Parmar Meenaben Sodhaben	Mehmedabadnamuvada	YES
30	Sodha Ishvarbhai Galabbhai	Minavada	YES
31	Patel Kanubhai Dahyabhai	Khadol	YES
32	Pathan Yashimkhan Kasamkhan	Balol	YES
33	Vaghela Chimanbhai Manibhai	Kaiyaj	YES
34	Rajput Yuvsinh Vikramsinh	Kadi	YES
35	Bhujani Bhathibhai Punambhai	Khodiyarpura	YES
36	Sodha Laxmanbhai Rumalbhai	Baladi	YES
37	Patel Dhurabhai Chaturbhai	Chunel	YES
38	Patel Ravjibhai Dahyabhai	Heranj	YES
39	Parmar Bhikhabhai Mangalbhai	Alina	YES
40	Patel Ashokbhai Javaharbhai	Mahisha	YES
Matar			
41	Malek Siyarmiya Najumiya	Sandhana	YES
42	Patel Jagdishbhai Gordhanbhai	Siholadi	YES
43	Patel Rohitbhai Chotabhai	Siholdi	YES
44	Patel Jigneshbhai Maganbhai	Raghvanaj	YES
45	Rathod Dilipbhai Chotabhai	Uantai	YES
46	Patel Arvindbhai Purushotambhai	Khandhali	YES
47	Solanki Chaganbhai Naranbhai	Khandhali	YES
48	Rathod Othabhai Manibhai	Vashai	YES
49	Patel Dilipbhai Damodarbhai	Vashai	YES
50	Solanki Rameshbhai Bhikhabhai	Limbasi	YES
51	Solanki Budhabhai Somabhai	Vashtrola	YES

Sr. No.	Name of Farmer	Name of Village	Soil/Water sample
52	Bharvad RajabhaiVirabhai	Valotri	YES
53	Vaghela Mafatbhai Bhavsangbhai	Bamangam	YES
54	Rathod Ravjibhai Desaibhai	Pariaej	YES
55	Barot Rajibhai Chimbhai	Sinjiwada	YES
56	Solanki Dineshbhai Budhabhai	Shikhupur	YES
57	Bharvad Govindbhai Popatbhai	Kharati	YES
58	Bharvad Haribhai Laxmanbhai	Palla	YES
59	Paramar Kanabhai Ravjibhai	Punaj	YES
60	Patel Vishnubhai Bakorbhai	Pipariya	YES
Kheda			
61	Chavda Fatehsinh Harisinh	Hariyala	YES
62	Zala Mafatji Gokalji	Vaikunthpura	YES
63	Gohil Mohanji Nanaji	Mangupura	YES
64	Patel Kalpeshbhai Narendrabhai	Vasnamargiya	YES
65	Patel Ashokbhai Manilal	Vanamargiya	YES
66	Bhoi Jaytibhai Shakrabhai	Sakhanj	YES
67	Patel Chandrakant Ambalal	Sakhanj	YES
68	Patel Bhanubhai Bhailalbhai	Sarsa	YES
69	Patel Vinubhai Ishvarbhai	Sarsa	YES
70	Patel Jitubhai Prabhubhai	Lali	YES
71	Thakor Dhanjibhai Tajabhai	Bidaj	YES
72	Patel Jaytibhai Laljibhai	Bidaj	YES
73	Patel Rajendrabhai Naranbhai	Umiyapur	YES
74	Patel Arpitbhai Dineshbhai	Navagam	YES
75	Chauhan Rameshbhai Bhalabhai	Talindra	YES
76	Thakor Banthabhai Punjabhai	Nayka	YES
77	Pandya Arvindbhai Chimanbhai	Nayka	YES
78	Patel Jaytibhai Prahladbhai	Kaloli	YES
79	Bharvad Karmshibhai Vibhabhai	Tadhal	YES

Sr. No.	Name of Farmer	Name of Village	Soil/Water sample
80	Pandya Krushankant Natvarlal	Vasna	YES
Kapadvanj			
81	Parmar Rajubhai Bhikhabhai	Savali	YES
82	Zala Raysangbhai Durabhai	Rampura	YES
83	Vaghela Bharatbhai Arjanbhai	Vadol	YES
84	Desai Amaratbhai Karshanbhai	Atisar	YES
85	Zala Maheshbhai Salambhai	Reliya	YES
86	Makvana Kantibhai Narshibhai	Lalpur	YES
87	Solanki Shambhubhai Shankarbhai	Jagdumpur	YES
88	Parmar Majulaben Manubhai	Ghadiya	YES
89	Zala Kalabhai Laxmanbhai	Gaucharnamuvada	YES
90	Solanki Udaysinh Magansinh	Sultanpur	YES
91	Talati Manglaben Shankarlal	Sultanpur	YES
92	Patel Indravardhanbhai Trikambhai	Karkariya	YES
93	Shekh Murtuzamiya Hamindmiya	Aantroli	YES
94	Rathod Amarsinh Vajabhai	Mahmadpura	YES
95	Patel Ambalal Shankarbhai	Aambaliyar	YES
96	Patel Becharbhai Kalidas	Nirmali	YES
97	Patel Rajeshkumar Jeshangbhai	Shihora	YES
98	Patel Dineshbhai Naranbhai	Shihora	YES
99	Patel Bharatbhai Shankarbhai	Narshihpur	YES
100	Gadhavi Anuvdan Shivdan	Rozavada	YES
Thasra			
101	Rathod Dilipbhai Kanjibhai	Bordi	YES
102	Chauhan Jitendrabhai Rameshbhai	Vallabhpura	YES
103	Parmar Budhabhai Ratilal	Sui	YES
104	Patel Harshadkumar Manubhai	Dakor	YES
105	Solanki Arjunbhai Abhaysinh	Chandasar	YES
106	Parmar Budhabhai Bavabhai	Vithalpur	YES

Sr. No.	Name of Farmer	Name of Village	Soil/Water sample
107	Chavda Jashvantbhai Bhalabhai	Revaliya	YES
108	Jadav Ishvarbhai Ambalal	Aozrala	YES
109	Sodha Udabhai Kantilal	Kothanamuvada	YES
110	Mahera Rameshbhai Khatubhai	Dabhali	YES
111	Malek Mohmadali Gulamarsul	Jargal	YES
112	Pathan Ahmadkhan Husainkhan	Rozva	YES
113	Behlim Firazbhai Rasulbhai	Padal	YES
114	Parmar Nanjibhai Jaysingbhai	Malvan	YES
115	Patel Ankitkumar Kantibhai	Angadi	YES
116	Parmar Bharatbhai Shanabhai	Thasra	YES
117	Parmar Natvarsinh Bharatsinh	Udhmatpura	YES
118	Rathod Ranjitsinh Shamalsinh	Marghakui	YES
119	Dabhi Jashvantbhai Bhikhabhai	Kalshar	YES
120	Chavda Kanubhai Ajabsinh	Bhadrasa	YES
Mehmedabad			
121	Pathan Nashidkhan Mohmadkhan	Khanmbhali	YES
122	Rathod Jaishangbhai Gotabhai	Samaspur	YES
123	Chauhan Vinubhai Shanabhai	Vansol	YES
124	Mishtri Kantaben Mohanlal	Kesara	YES
125	Parmar Mangalbhai Sunthabhai	Sihunj	YES
126	Patel Thakorabhai Kanubhai	Akalacha	YES
127	Parmar Jagaji Chandaji	Karoli	YES
128	Parmar Mahendrabhai Melabhai	Rudan	YES
129	Baraiya Aatmarambhai Dhurabhai	Sarshvati	YES
130	Khad Punambhai Ramtubhai	Haldarvas	YES
131	Rabari Jayrambhai Gandabhai	Ghodasar	YES
132	Chauhan Somabhai Shivabhai	Modaj	YES
133	Chauhan Shanabhai Babarbhai	Godali	YES
134	Chauhan Bharatbhai Ramabhai	Aamsaran	YES

Sr. No.	Name of Farmer	Name of Village	Soil/Water sample
135	Jadav Rameshbhai Gotabhai	Nenpur	YES
136	Chauhan Dilipbhai Vaghjibhai	Malataj	YES
137	Patel Bhikhabhai Shanabhai	Sansoli	YES
138	Chauhan Javanbhai Danbhai	Sujeli	YES
139	Chauhan Nanabhai Punambhai	Jibhayapura	YES
140	Chauhan Punjabhai Pratapbhai	Khatraj	YES
Kathlal			
141	Sodha Ravjibhai Fatabhai	Kathlal	YES
142	Chauhan Abhaysinh Rumalsinh	Jitpura	YES
143	Joshi Harshadbhai Shivabhai	Jamani	YES
144	Rathod Shaileshbhai Arajanbhai	Sarali	YES
145	Darbar Natubhai Chandubhai	Kaniyal	YES
146	Zala Prabhatsinh Babarbhai	Chipdi	YES
147	Dabhi Dahyabhai Gebabhai	Aral	YES
148	Rathod Ambalal Punjabhai	Pata	YES
149	Patel Kantibhai Kanabhai	Jashvantpura	YES
150	Gohel Laxmanbhai Punjabhai	Khalal	YES
151	Dabhi Shankarbhai Galabhai	Gandvel	YES
152	Parmar Kantibhai Shanabhai	Sahpur	YES
153	Parmar Manibhai Kodarbhai	Anara	YES
154	Parmar Prabhatbhai Punabhai	Kathana	YES
155	Parmar Pravinbhai Koyabhai	Ladvel	YES
156	Chavda Punabhai Shanabhai	Lasundra	YES
157	Patel Vijaybhai Sureshbhai	Vishvnathpura	YES
158	Parmar Arjunbhai Somatbhai	Porada	YES
159	Sodha Gumansinh Sabhasinh	Porada	YES
160	Rathod Shanabhai Laxmanbhai	Fagvel	YES

Appendix II: Taluka/Sample wise value of some important physical properties of soils of Kheda district.

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Nadiad				
1	31.04	1.44	2.55	43.53
2	34.94	1.41	2.53	44.27
3	34.87	1.42	2.51	43.43
4	34.93	1.42	2.5	43.20
5	39.95	1.35	2.45	44.90
6	47.96	1.27	2.36	46.19
7	37.34	1.38	2.41	42.74
8	39.45	1.36	2.38	42.86
9	36.51	1.39	2.4	42.08
10	36.23	1.38	2.33	40.77
11	35.29	1.4	2.47	43.32
12	38.27	1.37	2.41	43.15
13	33.43	1.44	2.42	40.50
14	38.63	1.36	2.43	44.03
15	37.46	1.37	2.26	39.38
16	34.33	1.4	2.49	43.78
17	36.32	1.41	2.48	43.15
18	45.56	1.3	2.31	43.72
19	41.44	1.35	2.36	42.80
20	48.75	1.26	2.31	45.45
Min.	31.04	1.26	2.26	39.38
Max.	48.75	1.44	2.55	46.19
Average	38.13	1.37	2.42	43.16

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Mahudha				
21	39.56	1.35	2.42	44.21
22	36.87	1.39	2.43	42.80
23	36.47	1.38	2.47	44.13
24	35.24	1.4	2.51	44.22
25	34.35	1.43	2.51	43.03
26	47.68	1.27	2.34	45.73
27	28.73	1.48	2.55	41.96
28	28.00	1.46	2.53	42.29
29	28.09	1.47	2.38	38.24
30	26.82	1.49	2.45	39.18
31	35.08	1.41	2.41	41.49
32	33.89	1.42	2.55	44.31
33	35.49	1.4	2.56	45.31
34	35.65	1.41	2.44	42.21
35	48.74	1.26	2.31	45.45
36	37.89	1.38	2.45	43.67
37	46.82	1.29	2.3	43.91
38	36.95	1.39	2.46	43.50
39	41.10	1.35	2.45	44.90
40	39.68	1.38	2.55	45.88
Min.	26.82	1.26	2.30	38.24
Max.	48.74	1.49	2.56	45.88
Average	36.66	1.39	2.45	43.32

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Matar				
41	46.15	1.28	2.31	44.59
42	41.39	1.34	2.33	42.49
43	37.61	1.36	2.45	44.49
44	34.28	1.42	2.56	44.53
45	42.80	1.34	2.45	45.31
46	38.47	1.37	2.44	43.85
47	33.94	1.44	2.41	40.25
48	35.01	1.41	2.51	43.82
49	44.48	1.31	2.41	45.64
50	42.67	1.33	2.42	45.04
51	31.62	1.45	2.55	43.14
52	38.11	1.38	2.32	40.52
53	38.05	1.37	2.49	44.98
54	46.95	1.28	2.47	48.18
55	37.92	1.37	2.21	38.01
56	46.06	1.28	2.22	42.34
57	42.59	1.34	2.44	45.08
58	42.59	1.33	2.36	43.64
59	29.44	1.45	2.49	41.77
60	38.74	1.36	2.51	45.82
Min.	29.44	1.28	2.21	38.01
Max.	46.95	1.45	2.56	48.18
Average	39.44	1.36	2.42	43.67

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Kheda				
61	42.20	1.34	2.46	45.53
62	31.67	1.44	2.55	43.53
63	36.92	1.4	2.51	44.22
64	32.65	1.43	2.5	42.80
65	33.18	1.41	2.5	43.60
66	40.98	1.36	2.43	44.03
67	41.63	1.35	2.41	43.98
68	39.24	1.35	2.42	44.21
69	39.31	1.35	2.33	42.06
70	38.12	1.36	2.46	44.72
71	39.14	1.37	2.43	43.62
72	34.42	1.4	2.51	44.22
73	44.50	1.3	2.38	45.38
74	40.96	1.35	2.34	42.31
75	32.56	1.44	2.48	41.94
76	33.50	1.43	2.52	43.25
77	31.99	1.45	2.55	43.14
78	50.63	1.24	2.28	45.61
79	32.13	1.43	2.51	43.03
80	33.97	1.42	2.55	44.31
Min.	31.67	1.24	2.28	41.94
Max.	50.63	1.45	2.55	45.61
Average	37.48	1.38	2.46	43.78

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Kapadvanj				
81	33.16	1.41	2.46	42.68
82	42.73	1.33	2.35	43.40
83	34.41	1.4	2.51	44.22
84	35.37	1.41	2.42	41.74
85	28.65	1.46	2.5	41.60
86	34.59	1.4	2.42	42.15
87	32.84	1.43	2.41	40.66
88	41.32	1.34	2.36	43.22
89	32.14	1.44	2.33	38.20
90	28.16	1.47	2.52	41.67
91	29.19	1.46	2.51	41.83
92	24.91	1.51	2.64	42.80
93	25.55	1.5	2.63	42.97
94	28.73	1.47	2.65	44.53
95	31.57	1.45	2.6	44.23
96	34.29	1.41	2.58	45.35
97	29.23	1.45	2.57	43.58
98	24.94	1.52	2.64	42.42
99	28.80	1.46	2.61	44.06
100	28.44	1.46	2.6	43.85
Min.	24.91	1.33	2.33	38.20
Max.	42.73	1.52	2.65	45.35
Average	31.45	1.44	2.52	42.76

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Thasra				
101	38.51	1.37	2.59	47.10
102	38.13	1.37	2.48	44.76
103	35.38	1.4	2.49	43.78
104	36.94	1.39	2.44	43.03
105	37.15	1.38	2.46	43.90
106	38.14	1.37	2.41	43.15
107	38.13	1.36	2.48	45.16
108	30.43	1.45	2.58	43.80
109	27.75	1.47	2.55	42.35
110	33.82	1.42	2.55	44.31
111	30.30	1.45	2.57	43.58
112	37.00	1.37	2.51	45.42
113	37.56	1.36	2.52	46.03
114	34.45	1.41	2.48	43.15
115	30.25	1.44	2.47	41.70
116	31.69	1.45	2.56	43.36
117	35.99	1.4	2.42	42.15
118	35.15	1.41	2.47	42.91
119	27.23	1.48	2.89	48.79
120	37.96	1.36	2.51	45.82
Min.	27.23	1.36	2.41	41.70
Max.	38.51	1.48	2.89	48.79
Average	34.60	1.41	2.52	44.21

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Mehmedabad				
121	30.66	1.45	2.56	43.36
122	27.80	1.47	2.55	42.35
123	31.15	1.43	2.51	43.03
124	35.27	1.41	2.5	43.60
125	32.20	1.42	2.47	42.51
126	32.00	1.41	2.59	45.56
127	31.91	1.43	2.5	42.80
128	28.39	1.46	2.56	42.97
129	30.39	1.45	2.54	42.91
130	31.94	1.44	2.51	42.63
131	27.80	1.47	2.55	42.35
132	32.85	1.43	2.49	42.57
133	41.74	1.34	2.35	42.98
134	31.10	1.44	2.44	40.98
135	28.41	1.48	2.46	39.84
136	40.88	1.35	2.41	43.98
137	34.34	1.41	2.57	45.14
138	35.86	1.4	2.55	45.10
139	37.36	1.37	2.4	42.92
140	33.33	1.42	2.47	42.51
Min.	27.80	1.34	2.35	39.84
Max.	41.74	1.48	2.59	45.56
Average	32.77	1.42	2.50	43.00

Sample No.	MWHC (%)	B.D (Mg m ⁻³)	P.D. (Mg m ⁻³)	Porosity (%)
Kathlal				
141	28.22	1.46	2.53	42.29
142	26.04	1.49	2.58	42.25
143	31.22	1.44	2.48	41.94
144	26.41	1.49	2.56	41.80
145	22.71	1.54	2.63	41.44
146	46.08	1.28	2.38	46.22
147	35.42	1.41	2.48	43.15
148	28.79	1.47	2.57	42.80
149	27.73	1.48	2.59	42.86
150	28.25	1.47	2.58	43.02
151	32.67	1.43	2.55	43.92
152	24.55	1.52	2.65	42.64
153	27.53	1.48	2.48	40.32
154	27.91	1.49	2.55	41.57
155	32.74	1.43	2.47	42.11
156	33.37	1.42	2.42	41.32
157	37.28	1.38	2.38	42.02
158	31.95	1.44	2.55	43.53
159	43.14	1.32	2.37	44.30
160	31.54	1.44	2.45	41.22
Min.	22.71	1.28	2.37	40.32
Max.	46.08	1.54	2.65	46.22
Average	31.18	1.44	2.51	42.54

Appendix III: Taluka/Sample wise values of EC_{2.5}, pH_{2.5}, EC_{5.0}, pH_{5.0}, O. C., fertility status, and CaCO₃ of soil

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
Nadiad														
1	0.65	8.06	0.29	8.19	0.79	188.16	66.86	307.51	6.55	5.01	10.22	0.56	1.06	3.75
2	1.23	8	0.68	8.21	0.59	156.80	70.68	187.62	6.09	7.77	9.91	0.46	1.32	3.25
3	0.3	7.78	0.16	7.89	0.80	172.48	82.34	449.97	7.47	6.95	9.21	1.10	1.54	4.5
4	1.1	8.03	0.61	8.17	0.66	266.56	49.24	491.10	7.01	3.97	8.56	0.88	1.08	3.65
5	0.43	7.96	0.25	8.2	0.85	219.52	85.14	735.40	2.69	3.87	9.27	1.42	1.66	3.5
6	0.56	8.21	0.33	8.68	0.89	219.52	89.80	261.54	3.59	11.31	6.87	1.10	1.01	5.25
7	0.34	7.12	0.2	7.27	0.43	188.16	29.22	164.77	2.91	14.25	6.65	0.66	1.48	5.75
8	0.17	7.08	0.11	7.2	0.52	203.84	79.54	188.16	5.18	9.67	9.07	0.80	1.42	6.25
9	0.89	8.73	0.48	8.94	0.78	219.52	80.02	328.20	2.01	8.57	10.93	1.25	1.23	3.5
10	1.15	7.86	0.64	8.12	0.88	235.20	75.09	628.30	7.70	3.87	12.22	0.76	1.40	4.51
11	1.59	7.7	0.83	7.77	0.63	156.80	63.60	590.28	9.82	4.97	11.02	1.32	1.02	4.35

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
12	2.1	7.41	1.1	7.58	0.86	172.48	65.07	172.57	10.03	12.23	8.66	1.45	0.89	5.25
13	1.36	7.92	0.72	8.03	0.54	78.40	10.02	224.99	5.64	4.45	9.45	0.92	1.50	4.02
14	1.52	8.12	0.82	8.21	0.69	188.16	97.19	851.02	11.75	4.69	7.85	1.12	1.82	3.5
15	1.23	8.43	0.67	8.78	0.74	188.16	75.02	748.07	10.02	12.97	10.02	1.12	1.11	6.22
16	0.7	8.67	0.42	8.81	0.78	156.80	73.43	283.85	4.72	5.25	6.65	0.62	1.02	3.73
17	0.53	8.57	0.43	8.6	0.50	94.08	84.23	214.50	2.91	9.31	5.75	1.06	1.12	3.25
18	0.72	7.08	0.4	7.31	0.72	188.16	90.21	460.72	4.95	7.87	11.97	0.90	1.14	6.02
19	0.38	7.92	0.19	7.98	0.55	172.48	66.86	765.64	5.86	4.59	15.24	1.35	1.12	3.78
20	1.04	7.91	0.6	8.09	0.85	203.84	64.69	627.65	1.79	10.91	8.33	1.89	1.02	3.7
Min.	0.17	7.08	0.11	7.20	0.43	78.40	10.02	164.77	1.79	3.87	5.75	0.46	0.89	3.25
Max.	2.10	8.73	1.10	8.94	0.89	266.56	97.19	851.02	11.75	14.25	15.24	1.89	1.82	6.25
Average	0.90	7.93	0.50	8.10	0.70	183.46	69.91	434.09	5.93	7.62	9.39	1.04	1.25	4.39

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
Mahudha														
21	3.5	7.02	1.8	7.16	0.85	501.76	27.72	321.75	10.95	12.11	14.25	1.44	1.2	6.25
22	0.56	7.53	0.28	7.68	0.84	125.44	89.45	554.27	3.36	15.12	14.67	1.92	1.1	5.03
23	0.58	7.72	0.3	8	0.61	172.48	68.49	500.24	3.82	5.81	11.47	1.2	1.4	4.5
24	2.8	8.16	1.5	8.33	0.67	141.12	82.79	402.12	12.23	5.65	7.21	1.08	1	5.23
25	0.78	8.07	0.42	8.24	0.59	125.44	78.12	711.42	8.62	5.05	13.85	1.28	1.12	3.5
26	0.8	7.08	0.46	7.1	0.78	203.84	68.23	478.46	11.02	14.02	15.29	1.56	1.02	6.25
27	0.38	8.28	0.24	8.45	0.59	203.84	85.45	385.46	3.59	8.01	15.87	1.48	1.13	6.74
28	0.35	7.95	0.18	8.16	0.35	141.12	81.78	264.77	5.41	7.55	15.01	1.14	0.74	3.73
29	0.97	7.85	0.53	7.87	0.25	141.12	39.38	183.59	5.64	7.47	12.01	0.58	0.58	4.52
30	0.29	8.08	0.16	8.15	0.55	156.80	69.04	257.51	3.36	8.95	11.02	1.24	0.62	3.5
31	1.77	7.44	1.02	7.59	0.85	172.48	84.24	401.05	13.45	11.02	13.02	1.7	1.06	5.21
32	0.29	7.83	0.16	7.98	0.51	188.16	75.65	422.55	3.82	4.19	18.17	1.26	0.86	4.5

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
33	0.26	7.45	0.14	7.65	0.74	188.16	87.43	435.72	10.25	9.39	11.89	1.86	1.22	5.21
34	6	7.68	3	7.75	0.69	188.16	75.65	319.60	7.88	4.79	9.89	1.28	1.4	4.21
35	0.39	7.23	0.22	7.51	0.80	329.28	81.25	231.17	5.18	8.89	13.01	1.08	1.26	5.25
36	0.5	7.68	0.23	7.91	0.89	188.16	77.87	278.21	3.36	12.85	15.59	1.26	1.74	4.35
37	1.22	8.04	0.67	8.19	0.72	172.48	33.77	337.08	7.70	3.57	5.05	1.2	1.2	3.75
38	0.85	8.14	0.47	8.34	0.73	172.48	75.02	976.82	6.55	3.23	12.45	1.38	1.56	3.51
39	2.3	7.54	1.31	7.54	0.71	862.40	85.87	544.05	13.30	7.83	12.22	1.78	1.34	4.22
40	0.72	7.69	0.48	7.73	0.89	235.20	88.83	527.92	11.89	6.37	13.45	1.96	1.56	4.22
Min.	0.26	7.02	0.14	7.10	0.25	125.44	27.72	183.59	3.36	3.23	5.05	0.58	0.58	3.50
Max.	6.00	8.28	3.00	8.45	0.89	862.40	89.45	976.82	13.45	15.12	18.17	1.96	1.74	6.74
Average	1.27	7.72	0.68	7.87	0.68	230.50	72.80	426.69	7.57	8.09	12.77	1.38	1.16	4.68

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
Matar														
41	0.75	8.3	0.43	8.46	0.64	172.48	44.02	222.03	3.14	8.53	5.81	1.22	1.06	6.74
42	1.41	7.3	0.73	7.38	0.88	235.20	54.51	416.37	5.41	12.11	11.21	1.78	0.56	5.25
43	0.74	8.72	0.43	8.92	0.47	156.80	85.02	492.44	4.95	5.85	6.83	0.70	0.96	3.5
44	0.67	7.59	0.37	7.73	0.62	172.48	87.56	141.12	9.32	14.56	9.17	1.10	1.60	4.25
45	0.4	7.1	0.21	7.3	0.90	235.20	75.48	281.16	3.59	12.78	7.35	0.45	0.89	5.72
46	3.4	7.53	1.77	7.68	0.85	203.84	79.04	996.44	12.11	16.49	8.26	0.88	1.72	4.24
47	2.1	7.01	1.17	7.17	0.89	235.20	92.03	457.50	14.02	13.29	9.45	0.78	1.02	6.25
48	0.84	7.48	0.47	7.66	0.67	141.12	88.45	288.96	6.78	9.33	13.24	0.56	1.02	5.28
49	0.82	7.57	0.45	7.8	0.89	250.88	74.23	854.56	7.70	15.71	9.75	1.50	1.12	4.25
50	0.55	7.72	0.35	7.91	0.75	235.20	33.77	184.93	5.64	8.56	7.03	1.40	0.80	4.51
51	0.26	8	0.16	8.25	0.67	266.56	82.34	283.85	13.06	8.47	9.27	0.40	0.94	3.75
52	0.39	8.03	0.27	8.19	0.65	627.20	80.10	550.77	13.05	12.99	12.31	0.72	1.68	3.65

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
53	0.47	7.32	0.29	7.34	0.68	172.48	86.30	193.80	9.98	8.55	14.56	0.62	1.20	5.22
54	0.61	7.62	0.35	7.88	0.79	313.60	53.98	278.48	7.45	10.69	6.79	0.74	1.76	4.21
55	0.34	7.77	0.24	7.78	0.46	141.12	61.99	312.08	10.22	4.49	11.83	1.08	0.90	4.48
56	3.1	7.39	1.82	7.54	0.82	595.84	69.04	556.15	12.45	15.01	12.22	2.08	0.86	5.25
57	0.33	8.05	0.2	8.27	0.73	172.48	68.22	438.41	16.63	10.79	4.89	0.88	1.11	3.78
58	3.1	7.48	1.71	7.65	0.84	580.16	71.02	504.00	7.88	9.87	11.55	1.90	1.33	5.25
59	1.18	7.58	0.66	7.74	0.81	344.96	87.25	206.98	2.24	17.83	5.29	1.56	1.20	4.26
60	1.25	7.57	0.67	7.71	0.66	266.56	84.25	149.99	4.50	16.39	4.15	1.58	0.86	4.28
Min.	0.26	7.01	0.16	7.17	0.46	141.12	33.77	141.12	2.24	4.49	4.15	0.40	0.56	3.50
Max.	3.40	8.72	1.82	8.92	0.90	627.20	92.03	996.44	16.63	17.83	14.56	2.08	1.76	6.74
Average	1.14	7.66	0.64	7.82	0.73	275.97	72.93	390.50	8.51	11.61	9.05	1.10	1.13	4.71

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
						Kheda								
61	1.35	8.03	0.73	8.26	0.88	595.84	98.02	877.09	3.14	6.21	13.15	1.20	1.14	3.73
62	0.43	7.68	0.25	7.82	0.72	172.48	69.04	232.51	1.34	13.55	6.13	0.54	1.06	4.22
63	0.8	7.92	0.49	8.12	0.89	203.84	94.23	745.22	4.04	9.31	6.57	1.02	0.94	3.72
64	0.92	7.2	0.44	7.25	0.87	172.48	88.24	319.60	3.14	12.03	12.55	1.62	1.06	5.24
65	0.37	7.48	0.17	7.65	0.85	203.84	97.77	217.73	4.50	11.45	4.33	0.66	1.00	5.29
66	0.43	8.1	0.25	8.25	0.81	188.16	82.01	449.70	2.01	2.79	7.89	1.50	1.12	3.51
67	1.22	8.13	0.6	8.53	0.75	564.48	84.56	185.20	22.11	6.33	6.61	0.74	1.11	3.52
68	0.94	7.92	0.47	8.28	0.68	689.92	89.01	370.41	6.32	12.11	5.77	0.94	1.22	3.65
69	0.67	7.8	0.33	8.09	0.78	203.84	97.85	554.80	3.82	12.59	10.77	1.26	1.04	4.5
70	0.33	7.51	0.17	7.72	0.84	219.52	72.56	166.12	24.03	9.45	3.99	1.94	1.04	5.22
71	0.52	7.95	0.29	8	0.76	172.48	84.23	798.34	15.56	9.81	3.93	1.14	1.34	3.73
72	0.62	8.51	0.32	8.71	0.46	156.80	57.70	234.66	18.23	3.03	7.59	0.38	0.88	3.25

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
73	2.1	8	1.08	8.19	0.69	188.16	89.02	618.24	17.86	9.41	8.67	1.72	0.76	3.75
74	0.85	7.14	0.4	7.37	0.78	235.20	94.25	518.78	4.27	13.29	13.67	1.08	1.22	5.75
75	3.2	7.72	1.57	7.85	0.84	188.16	96.23	506.42	8.86	14.56	8.73	1.50	1.06	4.5
76	4.7	7.56	2.6	7.71	0.77	219.52	95.24	423.09	3.14	10.17	12.09	1.38	1.12	4.25
77	1.49	7.95	0.81	8.25	0.55	172.48	80.66	243.80	2.46	11.63	5.77	0.54	1.22	3.74
78	1.4	8.25	0.78	8.49	0.68	250.88	89.01	628.45	2.01	9.88	7.97	1.74	1.50	6.25
79	1.05	7.92	0.59	8.15	0.46	156.80	75.21	308.04	2.24	10.51	6.37	1.52	1.21	3.65
80	1.12	8.2	0.62	8.47	0.60	156.80	73.22	778.89	1.56	2.45	13.35	1.04	1.20	5.25
Min.	0.33	7.14	0.17	7.25	0.46	156.80	57.70	166.12	1.34	2.45	3.93	0.38	0.76	3.25
Max.	4.70	8.51	2.60	8.71	0.89	689.92	98.02	877.09	24.03	14.56	13.67	1.94	1.50	6.25
Average	1.23	7.85	0.65	8.06	0.73	255.58	85.40	458.86	7.53	9.53	8.30	1.17	1.11	4.34

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
Kapadvanj														
81	0.49	7.7	0.23	7.84	0.41	141.12	86.30	341.38	3.14	3.81	15.45	0.80	0.34	4.25
82	0.44	8.24	0.22	8.45	0.76	188.16	87.16	373.36	3.36	3.33	8.57	1.10	0.52	5.25
83	0.51	7.61	0.27	7.81	0.68	172.48	85.16	566.90	8.39	3.81	12.24	0.90	0.64	4.25
84	0.68	8.07	0.37	8.14	0.42	141.12	95.46	281.16	5.41	3.67	13.02	0.52	0.46	3.75
85	0.33	8.03	0.18	8.12	0.63	172.48	85.22	252.67	2.46	3.73	9.97	0.74	0.54	3.25
86	0.47	8.45	0.27	8.66	0.81	188.16	78.24	272.29	6.32	6.19	8.89	0.86	0.76	6.22
87	0.28	8.48	0.15	8.55	0.49	156.80	89.02	221.22	0.45	3.41	13.22	0.92	0.56	3.25
88	0.51	7.54	0.25	7.7	0.45	141.12	88.02	141.39	5.18	12.23	6.45	0.94	1.14	4.21
89	0.69	7.9	0.39	7.95	0.51	156.80	74.56	242.46	4.50	4.33	14.02	0.54	0.32	3.74
90	0.35	7.68	0.19	7.85	0.32	125.44	68.22	231.71	6.55	6.59	10.51	1.36	0.32	4.23
91	0.23	7.9	0.11	8.01	0.29	141.12	94.01	661.79	4.50	6.55	8.05	1.30	0.30	4.5
92	0.37	7.81	0.22	7.82	0.62	188.16	96.23	228.48	3.14	6.85	13.56	1.22	0.92	4.45

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
93	0.15	8.1	0.11	8.17	0.24	78.40	87.21	261.00	2.24	6.17	4.99	0.78	0.26	3.5
94	0.25	8.05	0.13	8.09	0.41	141.12	83.02	192.73	1.56	4.95	11.91	0.66	0.24	3.65
95	0.49	7.49	0.26	7.69	0.58	172.48	74.56	652.65	1.12	6.31	8.77	1.02	0.54	5.38
96	0.31	7.76	0.17	7.92	0.45	141.12	72.22	424.70	1.79	5.03	9.05	1.45	0.48	4.51
97	0.6	7.35	0.34	7.45	0.53	156.80	79.05	422.28	2.01	7.01	15.01	0.64	0.44	5.21
98	0.23	7.88	0.13	7.94	0.34	141.12	85.25	220.95	4.50	4.63	12.81	0.80	0.28	4.52
99	0.44	7.76	0.27	7.85	0.51	172.48	89.06	242.19	5.41	4.07	11.71	0.66	0.22	4.5
100	0.14	8	0.1	8.2	0.33	141.12	81.11	231.44	6.78	3.79	8.89	1.02	0.14	3.73
Min.	0.14	7.35	0.10	7.45	0.24	78.40	68.22	141.39	0.45	3.33	4.99	0.52	0.14	3.25
Max.	0.69	8.48	0.39	8.66	0.81	188.16	96.23	661.79	8.39	12.23	15.45	1.45	1.14	6.22
Average	0.40	7.89	0.22	8.01	0.49	152.88	83.95	323.14	3.94	5.32	10.85	0.91	0.47	4.32

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
Thasra														
101	0.3	7.7	0.18	7.87	0.72	203.84	78.98	302.67	2.24	6.65	5.03	0.80	1.02	4.22
102	0.27	8.39	0.17	8.47	0.37	156.80	56.10	237.62	1.12	3.13	4.97	0.96	0.86	6.25
103	0.29	7.9	0.18	8.09	0.68	188.16	85.16	263.96	1.79	3.11	6.91	0.52	0.78	4.53
104	0.59	7.73	0.34	7.92	0.54	172.48	77.87	508.03	4.50	5.07	11.48	1.44	1.26	4.5
105	0.4	7.74	0.26	7.95	0.67	188.16	97.77	251.60	4.04	5.11	4.55	0.50	0.66	4.51
106	0.3	7.28	0.18	7.41	0.49	141.12	17.32	364.22	5.64	6.13	13.02	0.62	0.58	5.25
107	0.24	7.38	0.14	7.53	0.84	250.88	90.85	194.61	3.59	13.25	12.15	0.72	0.78	5.26
108	0.27	7.36	0.17	7.4	0.24	141.12	89.71	644.31	0.45	4.63	13.33	0.52	0.58	5.22
109	0.41	7.46	0.24	7.47	0.62	188.16	17.81	370.94	3.59	3.27	6.25	0.84	0.36	4.22
110	4.4	7.67	2.4	7.85	0.56	156.80	87.89	561.52	24.56	8.31	14.02	1.78	1.28	4.29
111	0.78	8.04	0.4	8.06	0.49	156.80	61.45	825.02	3.14	3.11	13.09	0.36	1.12	3.78
112	0.58	7.59	0.29	7.6	0.85	266.56	89.11	590.55	3.36	8.05	8.83	0.98	1.58	4.25

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
113	0.29	7.15	0.17	7.26	0.76	188.16	84.56	667.97	3.14	13.11	15.07	1.36	2.02	5.75
114	0.33	8.14	0.18	8.25	0.48	141.12	28.72	236.54	2.91	2.31	7.79	0.62	0.70	3.52
115	0.49	7.7	0.26	7.85	0.35	141.12	39.38	511.53	0.45	2.79	12.26	0.76	0.56	4.35
116	0.72	7.72	0.42	7.72	0.29	125.44	34.27	264.50	0.45	3.09	13.79	0.44	0.58	4.5
117	0.14	7.22	0.1	7.34	0.52	156.80	70.13	207.51	0.22	6.19	11.11	1.04	0.48	5.25
118	0.26	8.02	0.14	8.05	0.24	141.12	34.78	199.45	5.18	3.31	4.89	0.34	0.30	3.74
119	0.75	7.83	0.39	7.98	0.30	141.12	55.57	963.11	4.50	2.75	14.25	0.56	0.78	4.5
120	0.33	7.12	0.17	7.25	0.81	219.52	85.09	630.34	0.89	14.56	10.57	1.30	1.96	5.74
Min.	0.14	7.12	0.10	7.25	0.24	125.44	17.32	194.61	0.22	2.31	4.55	0.34	0.30	3.52
Max.	4.40	8.39	2.40	8.47	0.85	266.56	97.77	963.11	24.56	14.56	15.07	1.78	2.02	6.25
Average	0.61	7.66	0.34	7.77	0.54	173.26	64.13	439.80	3.79	5.90	10.17	0.82	0.91	4.68

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
Mehmedabad														
121	1.09	7.81	0.58	7.95	0.28	156.80	16.83	160.74	7.24	5.31	12.53	0.46	1.74	4.5
122	3.4	8.47	1.71	8.55	0.32	141.12	53.98	167.73	24.25	7.63	8.83	0.64	1.30	3.25
123	0.46	7.34	0.25	7.52	0.97	349.66	78.08	419.06	6.78	8.81	11.65	1.56	1.64	5.22
124	2.3	7.74	1.13	7.95	0.74	219.52	66.31	343.53	15.22	9.87	12.03	0.62	1.80	4.52
125	0.28	7.3	0.15	7.39	0.43	156.80	57.70	223.10	2.46	5.85	8.85	0.44	0.82	5.25
126	0.69	7.8	0.36	7.86	0.21	141.12	23.23	135.21	2.24	11.58	11.31	0.64	0.66	4.5
127	0.25	7.83	0.13	7.95	0.52	156.80	20.76	201.87	0.45	12.61	9.54	0.54	0.36	4.5
128	0.56	7.8	0.29	7.92	0.54	172.48	64.15	382.50	2.91	12.65	12.43	0.66	1.52	4.53
129	0.33	7.23	0.2	7.4	0.27	156.80	83.47	626.57	0.67	7.97	12.56	0.64	0.92	5.26
130	0.38	7.8	0.21	7.81	0.37	141.12	44.54	200.26	1.79	8.13	11.23	0.62	0.66	4.51
131	0.23	7.18	0.13	7.3	0.58	188.16	53.45	223.91	0.45	11.23	11.21	0.94	1.48	5.25
132	0.35	7.95	0.2	7.97	0.63	188.16	81.22	286.81	0.22	3.25	9.33	0.82	0.52	3.75

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
133	0.47	8.26	0.27	8.35	0.48	156.80	29.22	90.85	0.22	12.02	5.59	0.78	1.30	6.75
134	0.25	8.42	0.16	8.5	0.58	172.48	37.33	246.22	0.89	4.13	8.29	0.94	0.70	6.25
135	0.58	7.82	0.42	7.84	0.49	141.12	98.22	154.83	3.36	6.63	6.71	1.42	0.50	4.5
136	1.79	8.5	1.05	8.55	0.66	203.84	51.86	766.08	13.16	14.37	14.71	1.42	1.02	3.25
137	0.54	8.5	0.34	8.56	0.45	156.80	43.50	175.26	3.36	5.11	4.33	0.58	0.52	3.23
138	0.46	7.69	0.27	7.84	0.74	203.84	22.74	101.88	9.55	9.41	11.05	0.68	0.54	4.22
139	0.3	8.45	0.19	8.54	0.36	156.80	24.23	71.50	0.22	4.01	6.41	0.32	0.44	3.22
140	0.54	8.19	0.36	8.26	0.54	172.48	97.02	306.97	0.45	15.97	5.57	1.10	1.38	5.25
Min.	0.23	7.18	0.13	7.30	0.21	141.12	16.83	71.50	0.22	3.25	4.33	0.32	0.36	3.22
Max.	3.40	8.50	1.71	8.56	0.97	349.66	98.22	766.08	24.25	15.97	14.71	1.56	1.80	6.75
Average	0.76	7.90	0.42	8.00	0.51	176.64	52.39	264.24	4.79	8.83	9.71	0.79	0.99	4.59

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
						Kathlal								
141	0.55	7.68	0.3	7.95	0.52	141.12	95.98	220.95	2.01	5.77	14.75	0.98	0.32	4.21
142	0.46	7.64	0.27	7.77	0.28	141.12	94.25	159.94	0.89	6.73	11.01	0.52	0.28	4.26
143	0.62	7.91	0.3	8.01	0.39	156.80	78.22	406.96	3.14	5.03	8.15	0.62	0.34	4.03
144	0.82	7.82	0.47	7.98	0.31	156.80	89.56	643.24	0.22	11.17	12.03	0.52	0.54	4.52
145	1.81	8.01	1.01	8.12	0.08	141.12	50.29	112.09	2.24	9.43	14.45	0.66	0.22	3.75
146	0.66	8.23	0.4	8.44	0.39	172.48	80.20	405.35	0.45	10.29	7.21	0.28	0.68	5.22
147	0.32	8.04	0.17	8.15	0.54	188.16	87.45	234.66	0.67	4.51	4.93	0.64	0.32	3.74
148	0.44	7.97	0.27	8.14	0.53	156.80	83.22	314.76	8.39	4.71	6.63	0.70	0.28	3.72
149	0.66	7.1	0.39	7.24	0.61	203.84	78.02	948.60	9.32	12.71	13.21	1.72	0.86	5.73
150	0.37	8.39	0.22	8.42	0.32	156.80	25.72	206.98	1.79	4.19	13.47	0.88	0.46	6.25
151	1.34	8.28	0.79	8.35	0.63	235.20	68.77	233.59	6.78	11.22	10.71	1.14	0.92	6.75
152	0.36	7.74	0.24	7.86	0.41	172.48	84.22	362.34	5.86	8.87	12.45	0.72	0.46	4.51

Sample No.	EC _{2.5}	pH _{2.5}	EC _{5.0}	pH _{5.0}	O.C (%)	Kg ha ⁻¹			mg kg ⁻¹					CaCO ₃ (%)
						N	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu	
153	0.46	7.76	0.27	7.82	0.38	156.80	44.54	476.85	6.55	5.15	9.97	0.52	0.62	4.52
154	0.21	7.32	0.12	7.65	0.37	156.80	20.76	271.22	0.22	6.87	10.02	0.62	0.70	5.22
155	0.78	7.56	0.5	7.82	0.42	172.48	87.56	645.93	8.85	6.89	14.22	1.12	1.04	4.25
156	0.27	7.75	0.2	7.92	0.49	141.12	50.29	889.90	0.89	5.05	8.77	0.80	0.84	4.51
157	0.93	7.09	0.61	7.2	0.41	141.12	72.22	453.73	15.68	13.19	8.85	0.24	0.96	5.65
158	0.86	7.86	0.51	8.02	0.83	250.88	87.43	721.23	5.18	4.49	12.81	1.12	0.90	4.36
159	1.16	7.68	0.68	7.88	0.43	172.48	53.98	379.55	21.22	4.89	8.99	0.50	0.72	4.51
160	0.84	7.75	0.51	7.87	0.77	219.52	29.73	359.92	1.79	3.99	9.87	0.60	0.58	4.5
Min.	0.21	7.09	0.12	7.20	0.08	141.12	20.76	112.09	0.22	3.99	4.93	0.24	0.22	3.72
Max.	1.81	8.39	1.01	8.44	0.83	250.88	95.98	948.60	21.22	13.19	14.75	1.72	1.04	6.75
Average	0.70	7.78	0.41	7.93	0.46	171.70	68.12	422.39	5.11	7.26	10.63	0.75	0.60	4.71

Appendix IV: Taluka/Sample wise values of ECe, pHs, exchangeable cations, and different indices and salinity-sodicity classes of soil.

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Nadiad									
1	2.25	7.98	6	20	2.47	0.38	27.95	8.85	N
2	3.65	7.98	7	23	7.45	0.26	35.71	20.87	SO
3	0.98	7.65	10	22	0.59	0.59	30.18	1.97	N
4	3.85	7.95	5	18	3.93	0.63	26.56	14.81	N
5	1.25	7.84	6	21	1.00	2.97	28.95	3.45	N
6	1.7	8.12	26	19	4.89	0.44	48.31	10.13	N
7	1.35	7.02	17	13	0.48	0.27	24.43	1.96	N
8	1.01	7.01	14	8	0.52	0.30	23.85	2.20	N
9	2.65	8.65	14	14	6.63	0.51	33.13	20.01	SO
10	3.15	7.62	10	17	4.53	2.65	32.16	14.10	N
11	4.8	7.45	5	15	6.98	0.67	26.62	26.24	SS
12	6.25	7.32	10	14	13.22	0.34	36.52	36.21	SS
13	4.11	7.6	3	17	8.34	0.37	27.70	30.11	SS
14	3.89	7.94	9	17	8.04	1.66	33.65	23.90	SO
15	3.26	8.35	14	10	10.45	1.23	34.58	30.22	SO
16	2.58	8.54	9	13	5.39	0.42	27.78	19.41	SO
17	1.32	8.28	13	10	4.93	0.34	26.22	18.80	SO
18	2.54	7	10	15	2.97	0.79	27.25	10.90	N
19	1.11	7.84	8	18	2.00	0.61	27.36	7.32	N
20	2.8	7.81	49	27	7.65	1.04	48.05	15.92	SO
Min.	0.98	7.00	3.00	8.00	0.48	0.26	23.85	1.96	
Max.	6.25	8.65	49.00	27.00	13.22	2.97	48.31	36.21	
Average	2.73	7.80	12.25	16.55	5.12	0.82	31.35	15.87	

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Mahudha									
21	9.88	7	30	17	12.44	0.53	55.45	22.43	SS
22	1.24	7.35	7	19	4.27	1.08	25.31	16.86	SO
23	1.45	7.48	13	11	4.56	0.97	28.21	16.18	SO
24	8.1	8.03	10	16	18.04	0.67	42.52	42.44	SS
25	2.9	8.03	9	10	2.68	1.58	22.77	11.77	N
26	2.78	7.05	29	10	4.91	0.99	43.21	11.37	N
27	1.55	8.1	11	6	2.76	0.66	22.78	12.11	N
28	1.02	7.81	10	5	1.47	0.48	21.23	6.92	N
29	2.65	7.75	9	9	3.68	0.32	16.20	22.75	SO
30	0.98	7.92	11	7	1.18	0.46	20.25	5.81	N
31	5.62	7.31	20	19	5.05	0.63	43.86	11.51	S
32	1.02	7.65	10	12	0.43	0.66	22.03	1.96	N
33	1.01	7.33	7	13	1.64	0.72	17.44	9.38	N
34	16.84	7.41	24	22	11.96	0.51	54.41	21.98	SS
35	1.48	7.1	8	21	2.60	0.37	30.28	8.58	N
36	1.84	7.42	19	20	4.64	0.33	42.86	10.82	N
37	3.24	7.92	28	16	5.81	0.44	48.45	12.00	N
38	2.26	8.02	8	21	4.91	1.36	33.26	14.75	N
39	6.39	7.36	12	17	3.21	0.89	31.24	10.27	S
40	2.57	7.54	31	6	1.00	0.97	36.48	2.75	N
Min.	0.98	7.00	7.00	5.00	0.43	0.32	16.20	1.96	
Max.	16.84	8.10	31.00	22.00	18.04	1.58	55.45	42.44	
Average	3.74	7.58	15.30	13.85	4.86	0.73	32.91	13.63	

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Matar									
41	2.54	8.15	18	20	4.73	0.32	28.41	16.65	SO
42	4.21	7.28	20	22	4.17	0.45	44.69	9.33	S
43	2.21	8.65	17	11	10.41	0.60	32.21	32.32	SO
44	2.14	7.45	13	13	3.79	0.23	26.78	14.17	N
45	1.44	7.02	15	16	2.29	0.38	32.58	7.02	N
46	10.6	7.31	13	13	13.06	1.47	37.63	34.71	SS
47	6.32	7	11	12	10.68	0.63	33.84	31.56	SS
48	2.24	7.34	15	10	5.02	0.46	28.78	17.45	SO
49	2.35	7.45	17	16	6.03	2.32	39.21	15.38	SO
50	1.61	7.62	26	13	1.05	0.35	37.96	2.76	N
51	0.75	7.94	28	9	0.67	0.45	37.84	1.76	N
52	1.57	7.81	48	1	1.76	0.99	31.04	5.66	N
53	1.98	7.24	10	19	0.87	0.37	29.75	2.93	N
54	2.55	7.45	34	11	4.21	0.51	48.63	8.65	N
55	1.59	7.48	17	18	0.68	0.53	26.93	2.53	N
56	9.32	7.24	38	16	22.57	0.87	58.72	38.43	SS
57	1.03	7.85	48	9	4.65	0.67	56.85	8.19	N
58	9.58	7.42	31	14	19.42	0.86	57.64	33.69	SS
59	3.98	7.42	29	11	2.99	0.31	39.26	7.62	N
60	3.88	7.33	18	14	2.62	0.25	32.12	8.16	N
Min.	0.75	7.00	10.00	1.00	0.67	0.23	26.78	1.76	
Max.	10.60	8.65	48.00	22.00	22.57	2.32	58.72	38.43	
Average	3.59	7.52	23.30	13.40	6.08	0.65	38.04	14.95	

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Kheda									
61	4.3	7.83	37	19	8.91	1.45	56.48	15.78	SS
62	1.22	7.58	12	10	1.54	0.37	22.84	6.76	N
63	2.35	7.78	22	7	4.72	1.92	32.89	14.34	N
64	2.55	7.15	23	2	1.93	0.54	26.45	7.30	N
65	1.1	7.25	11	13	2.51	0.36	21.98	11.40	N
66	1.29	7.82	10	21	2.63	0.79	32.41	8.10	N
67	3.78	7.93	15	15	9.36	0.34	37.58	24.90	SO
68	3.01	7.82	15	26	6.86	0.59	46.63	14.71	N
69	2.22	7.65	15	19	4.97	0.87	37.96	13.09	N
70	0.98	7.45	16	7	3.97	0.27	27.04	14.67	N
71	1.9	7.55	15	14	1.66	1.16	30.56	5.43	N
72	1.98	8.39	13	19	5.21	0.29	37.45	13.92	N
73	6.52	7.95	11	16	13.88	0.72	39.85	34.84	SS
74	2.51	7.05	13	15	7.44	0.61	35.03	21.24	SO
75	9.46	7.61	24	12	15.54	0.51	48.05	32.34	SS
76	14.55	7.42	28	12	23.69	0.44	57.86	40.94	SS
77	4.78	7.92	17	13	10.96	0.26	40.45	27.10	SS
78	4.67	8.18	23	19	16.09	0.65	52.26	30.79	SS
79	3.14	7.85	12	8	7.38	0.30	26.78	27.55	SO
80	3.35	8.18	14	11	8.74	2.06	23.80	36.71	SO
Min.	0.98	7.05	10.00	2.00	1.54	0.26	21.98	5.43	
Max.	14.55	8.39	37.00	26.00	23.69	2.06	57.86	40.94	
Average	3.78	7.72	17.30	13.90	7.90	0.72	36.72	20.10	

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Kapadvanj									
81	1.25	7.65	18	2	1.94	0.36	22.25	8.73	N
82	1.88	8.21	16	11	4.24	0.56	30.78	13.77	N
83	1.98	7.58	18	15	2.02	0.84	33.21	6.08	N
84	2.02	8.03	11	20	3.04	0.47	26.96	11.29	N
85	1.06	8.01	16	13	1.67	0.43	30.96	5.38	N
86	1.44	8.36	10	12	7.47	0.49	28.78	25.96	SO
87	0.85	8.35	9	6	2.48	0.40	21.25	11.68	N
88	1.45	7.42	18	15	3.99	0.29	34.56	11.54	N
89	2.15	7.78	10	8	3.93	0.43	22.85	17.21	SO
90	1.05	7.54	8	8	0.69	0.40	18.17	3.77	N
91	0.88	7.65	13	2	0.37	1.19	21.56	1.70	N
92	1.54	7.74	9	8	0.51	0.38	18.85	2.69	N
93	0.89	8.05	9	11	0.28	0.45	20.47	1.39	N
94	1.28	7.84	7	8	0.93	0.33	18.26	5.11	N
95	1.64	7.32	11	11	1.08	1.10	18.03	5.99	N
96	0.92	7.62	13	11	0.36	0.71	21.96	1.66	N
97	1.88	7.32	10	11	0.63	0.71	22.56	2.79	N
98	1.06	7.85	9	5	0.71	0.43	15.13	4.69	N
99	1.31	7.65	11	6	1.19	0.60	18.45	6.45	N
100	0.41	7.95	16	2	0.26	0.35	19.03	1.37	N
Min.	0.41	7.32	7.00	2.00	0.26	0.29	15.13	1.37	
Max.	2.15	8.36	18.00	20.00	7.47	1.19	34.56	25.96	
Average	1.35	7.80	12.10	9.25	1.89	0.55	23.20	7.46	

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Thasra									
101	1.03	7.45	20	26	1.06	0.57	46.74	2.27	N
102	1.22	8.26	16	12	3.30	0.44	30.63	10.78	N
103	1.58	7.78	29	8	1.02	0.48	24.20	4.22	N
104	1.59	7.65	70	10	1.54	0.87	59.45	2.60	N
105	1.14	7.68	36	16	1.50	0.46	52.01	2.88	N
106	0.98	7.12	28	13	0.95	0.50	41.06	2.31	N
107	1.47	7.28	22	12	1.65	0.35	35.78	4.62	N
108	1.26	7.26	12	8	0.59	1.33	21.85	2.70	N
109	1.18	7.38	14	22	0.87	0.64	35.74	2.42	N
110	18.8	7.5	18	16	18.90	1.08	53.79	35.13	SS
111	3.1	8.01	9	10	4.87	2.64	24.52	19.88	SO
112	2.24	7.48	13	17	4.80	1.09	33.42	14.35	N
113	1.48	7.1	18	15	0.69	1.29	34.89	1.98	N
114	1.68	8.06	20	13	1.98	0.49	34.64	5.72	N
115	2.29	7.65	7	12	2.36	0.95	17.24	13.67	N
116	2.14	7.42	13	12	1.59	0.42	21.23	7.48	N
117	1.02	7.02	9	13	0.65	0.36	19.52	3.33	N
118	1.45	7.92	12	11	0.59	0.35	22.76	2.59	N
119	2.94	7.75	9	14	3.61	1.13	25.26	14.28	N
120	1.85	7.03	16	14	2.15	0.85	34.59	6.21	N
Min.	0.98	7.02	7.00	8.00	0.59	0.35	17.24	1.98	
Max.	18.80	8.26	70.00	26.00	18.90	2.64	59.45	35.13	
Average	2.52	7.54	19.55	13.70	2.73	0.82	33.46	7.97	

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Mehmedabad									
121	3.24	7.72	10	9	8.42	0.23	26.56	31.72	SO
122	9.6	7.73	12	16	24.17	0.22	49.88	48.47	SS
123	1.45	7.21	11	11	1.78	0.55	20.01	8.90	N
124	16.3	7.56	23	15	22.83	0.42	55.52	41.11	SS
125	1.45	7.21	14	11	0.82	0.32	24.89	3.31	N
126	2.56	7.65	12	6	4.84	0.20	17.12	28.26	SO
127	1.59	7.63	8	3	1.35	0.34	15.23	8.90	N
128	2.14	7.45	9	12	3.12	0.56	24.63	12.68	N
129	1.54	7.01	13	2	0.37	1.17	16.42	2.27	N
130	1.89	7.65	10	9	1.88	0.35	21.96	8.57	N
131	0.65	7.02	17	14	0.76	0.40	30.85	2.45	N
132	1.01	7.85	12	11	1.45	0.54	22.21	6.53	N
133	1.48	8.03	11	18	3.75	0.28	30.59	12.24	N
134	0.88	8.25	12	7	2.60	0.49	21.02	12.37	N
135	1.98	7.66	14	11	3.25	0.33	22.53	14.45	N
136	5.1	7.95	19	17	22.15	1.68	54.56	40.59	SS
137	2.14	7.93	19	7	4.25	0.35	28.96	14.68	N
138	2.02	7.55	14	11	2.09	0.23	24.56	8.49	N
139	0.9	8.32	15	7	2.27	0.19	22.23	10.21	N
140	1.65	8.01	18	16	4.43	0.62	30.79	14.39	N
Min.	0.65	7.01	8.00	2.00	0.37	0.19	15.23	2.27	
Max.	16.30	8.32	23.00	18.00	24.17	1.68	55.52	48.47	
Average	2.98	7.67	13.65	10.65	5.83	0.47	28.02	16.53	

Sample No.	ECe (dS m ⁻¹)	pHs	Exchangeable cations				Indices of soil		Salinity/Sodicity Class
			(Cmol (p+) kg ⁻¹)				(Cmol (p+) kg ⁻¹) CEC	ESP	
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			
Kathlal									
141	1.53	7.53	9	9	1.64	0.42	19.89	8.22	N
142	1.87	7.58	11	4	2.40	0.32	16.85	14.27	N
143	1.84	7.83	8	8	1.81	0.73	18.52	9.78	N
144	2.45	7.74	10	5	3.12	1.44	21.78	14.31	N
145	5.25	7.93	8	4	9.52	0.23	21.45	44.36	SS
146	1.86	8.14	10	16	4.61	0.80	31.03	14.85	N
147	0.88	7.82	20	6	0.90	0.47	25.43	3.53	N
148	1.86	7.82	21	9	1.18	0.48	30.25	3.90	N
149	2.24	7.02	9	10	0.34	2.22	20.06	1.71	N
150	1.45	8.24	11	6	2.39	0.42	18.89	12.67	N
151	4.56	8.03	14	4	12.74	0.43	30.06	42.37	SS
152	1.87	7.52	12	2	0.72	0.69	16.76	4.32	N
153	1.35	7.51	17	0	0.78	0.80	16.89	4.61	N
154	0.62	7.22	10	6	0.50	0.47	16.96	2.96	N
155	2.32	7.45	26	9	0.83	1.19	36.45	2.27	N
156	0.81	7.56	25	14	0.39	1.91	39.45	1.00	N
157	2.78	7.02	47	10	0.82	0.73	56.78	1.44	N
158	3.45	7.78	22	8	4.26	2.37	34.25	12.43	N
159	3.52	7.64	29	23	7.65	0.68	39.22	19.50	SO
160	2.35	7.73	26	25	3.63	0.67	45.26	8.02	N
Min.	0.62	7.02	8.00	0.00	0.34	0.23	16.76	1.00	
Max.	5.25	8.24	47.00	25.00	12.74	2.37	56.78	44.36	
Average	2.24	7.66	17.25	8.90	3.01	0.87	27.81	11.33	

Appendix V: Taluka/Sample wise values of water soluble ions (me l⁻¹) and indices of soil.

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻			
Nadiad											
1	1.10	1.00	2.84	0.12	0.00	2.00	3.50	0.94	56.13	3.92	-0.10
2	1.10	1.00	2.82	0.04	0.00	3.00	7.50	0.53	56.85	3.89	0.90
3	1.50	0.80	0.78	0.16	0.00	2.00	3.50	0.4	23.99	1.03	-0.30
4	1.30	1.60	1.64	0.29	0.00	3.00	9.50	0.46	33.93	1.92	0.10
5	0.90	0.90	1.50	0.99	0.00	3.00	3.00	1.71	34.92	2.23	1.20
6	1.50	0.60	4.08	0.14	0.00	2.00	5.00	0.37	64.60	5.64	-0.10
7	1.20	1.00	0.65	0.04	0.00	3.00	3.00	0.5	22.42	0.87	0.80
8	1.10	0.40	0.69	0.09	0.00	1.00	2.50	0.31	30.39	1.13	-0.50
9	1.00	1.00	4.78	0.17	0.00	3.00	7.00	0.4	68.78	6.76	1.00
10	1.50	1.70	5.18	0.81	0.00	3.00	7.00	0.99	56.37	5.79	-0.20
11	1.40	2.00	3.29	0.20	0.00	3.00	14.00	0.63	47.72	3.57	-0.40
12	1.40	1.20	1.84	0.12	0.00	3.00	9.50	0.78	40.32	2.28	0.40
13	1.10	0.30	4.50	0.04	0.00	3.00	9.50	0.42	75.78	7.61	1.60
14	1.10	1.60	1.20	0.39	0.00	3.00	11.00	0.57	28.01	1.46	0.30
15	0.80	0.50	1.49	0.17	0.00	5.00	8.00	0.46	50.36	2.62	3.70
16	0.90	0.40	3.27	0.10	0.00	5.00	5.50	0.94	70.03	5.74	3.70
17	1.00	0.30	4.27	0.10	0.00	4.00	4.00	0.4	75.30	7.48	2.70
18	1.10	1.40	3.11	0.21	0.00	2.00	2.50	0.31	53.44	3.94	-0.50
19	1.10	0.60	1.68	0.10	0.00	3.00	4.00	0.46	48.20	2.58	1.30
20	1.90	1.70	4.98	0.11	0.00	4.00	8.00	0.34	57.33	5.25	0.40
Min.	0.80	0.30	0.65	0.04	0.00	1.00	2.50	0.31	22.42	0.87	-0.50
Max.	1.90	2.00	5.18	0.99	0.00	5.00	14.00	1.71	75.78	7.61	3.70
Average	1.20	1.00	2.73	0.22	0.00	3.00	6.38	0.60	49.74	3.79	0.80

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻			
Mahudha											
21	0.90	2.00	3.05	0.23	0.00	2.00	20.50	0.66	49.33	3.58	-0.90
22	6.60	6.00	3.17	0.16	0.00	4.00	4.00	0.48	19.88	1.78	-8.60
23	0.80	0.90	3.25	0.17	0.00	3.00	6.00	0.61	63.52	4.99	1.30
24	1.20	2.70	3.38	0.21	0.00	4.00	19.00	1.92	45.12	3.42	0.10
25	1.00	0.80	3.07	1.71	0.00	3.00	5.50	0.63	46.61	4.57	1.20
26	1.60	1.00	3.72	0.12	0.00	2.00	5.50	1.73	57.75	4.62	-0.60
27	1.10	0.90	2.40	0.22	0.00	3.00	4.00	3.09	51.95	3.39	1.00
28	2.30	1.20	1.76	0.16	0.00	6.00	3.50	1.12	32.53	1.89	2.50
29	1.40	1.80	4.70	0.08	0.00	2.00	6.00	0.85	58.88	5.26	-1.20
30	1.00	0.80	1.31	0.16	0.00	1.00	4.00	0.89	40.13	1.96	-0.80
31	1.10	1.30	1.40	0.08	0.00	4.00	13.50	1.17	36.13	1.81	1.60
32	1.40	0.30	0.44	0.25	0.00	2.00	3.50	0.96	18.21	0.67	0.30
33	1.00	0.60	1.36	0.22	0.00	2.00	4.00	0.84	42.68	2.15	0.40
34	1.30	1.50	1.66	0.49	0.00	3.00	35.00	0.94	33.55	1.99	0.20
35	1.50	0.60	1.98	0.09	0.00	1.00	3.00	2.05	47.51	2.73	-1.10
36	1.00	0.60	2.63	0.07	0.00	3.00	3.50	0.29	61.24	4.17	1.40
37	2.10	3.50	5.19	0.14	0.00	3.00	7.00	0.7	47.48	4.38	-2.60
38	1.70	0.70	4.36	0.61	0.00	4.00	6.50	1.02	59.12	5.62	1.60
39	4.70	7.10	3.62	0.90	0.00	4.00	6.00	2.12	22.19	2.11	-7.80
40	2.80	2.30	1.01	0.55	0.00	2.00	3.50	0.28	15.17	0.89	-3.10
Min.	0.80	0.30	0.44	0.07	0.00	1.00	3.00	0.28	15.17	0.67	-8.60
Max.	6.60	7.10	5.19	1.71	0.00	6.00	35.00	3.09	63.52	5.62	2.50
Average	1.83	1.83	2.67	0.33	0.00	2.90	8.18	1.12	42.45	3.10	-0.76

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻			
Matar											
41	1.80	0.60	3.50	0.06	0.00	2.00	3.00	2.53	58.74	4.52	-0.40
42	1.90	2.10	3.80	0.07	0.00	2.00	7.50	0.79	48.25	3.80	-2.00
43	1.60	0.40	4.05	0.10	0.00	2.00	4.50	0.88	65.85	5.72	0.00
44	1.40	1.30	2.59	0.04	0.00	2.00	4.00	1.03	48.62	3.15	-0.70
45	1.10	0.10	1.06	0.05	0.00	2.00	2.50	1.35	45.86	1.93	0.80
46	2.90	3.20	2.84	0.56	0.00	4.00	14.00	0.93	29.91	2.30	-2.10
47	1.00	2.10	1.40	0.12	0.00	1.00	9.50	0.65	30.30	1.59	-2.10
48	1.30	0.50	3.37	0.06	0.00	2.00	5.50	1.59	64.39	5.02	0.20
49	1.20	0.60	3.08	0.23	0.00	1.00	4.50	2.28	60.24	4.59	-0.80
50	2.40	1.20	0.86	0.04	0.00	2.00	1.00	0.7	19.01	0.90	-1.60
51	1.30	0.40	0.30	0.05	0.00	2.00	4.50	0.53	14.73	0.46	0.30
52	1.30	0.40	0.75	0.11	0.00	3.00	4.00	0.68	29.35	1.15	1.30
53	1.70	0.70	0.63	0.04	0.00	2.00	3.00	1.02	20.45	0.81	-0.40
54	1.50	0.40	2.41	0.04	0.00	2.00	4.00	1.04	55.33	3.49	0.10
55	1.40	0.40	0.43	0.07	0.00	3.00	3.00	0.84	18.61	0.64	1.20
56	3.60	1.10	3.17	0.15	0.00	3.00	15.00	0.33	39.51	2.92	-1.70
57	3.30	0.70	1.65	0.09	0.00	3.00	3.00	1.05	28.81	1.65	-1.00
58	3.10	1.50	1.83	0.27	0.00	4.00	14.00	1.15	27.32	1.71	-0.60
59	3.60	1.70	2.64	0.10	0.00	1.00	4.50	0.39	32.88	2.30	-4.30
60	3.80	2.00	2.33	0.08	0.00	2.00	5.50	0.49	28.37	1.93	-3.80
Min.	1.00	0.10	0.30	0.04	0.00	1.00	1.00	0.33	14.73	0.46	-4.30
Max.	3.80	3.20	4.05	0.56	0.00	4.00	15.00	2.53	65.85	5.72	1.30
Average	2.06	1.07	2.13	0.12	0.00	2.25	5.83	1.01	38.33	2.53	-0.88

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻			
Kheda											
61	2.10	1.40	2.41	0.30	0.00	3.00	8.50	0.85	38.82	2.58	-0.50
62	1.40	0.80	1.72	0.10	0.00	3.00	4.00	0.78	42.74	2.32	0.80
63	1.50	1.00	4.82	0.86	0.00	4.00	5.00	0.53	58.88	6.09	1.50
64	2.20	1.80	2.12	0.30	0.00	2.00	6.50	0.63	33.03	2.12	-2.00
65	1.40	0.70	1.98	0.08	0.00	3.00	4.00	1.28	47.58	2.73	0.90
66	1.30	0.30	2.28	0.19	0.00	3.00	4.50	0.79	56.10	3.61	1.40
67	1.20	0.40	4.87	0.06	0.00	5.00	8.50	0.92	74.58	7.71	3.40
68	1.20	0.80	5.06	0.11	0.00	3.00	8.00	0.58	70.62	7.16	1.00
69	1.30	0.60	3.83	0.16	0.00	4.00	5.50	0.55	65.04	5.56	2.10
70	1.00	0.30	2.22	0.13	0.00	4.00	4.50	0.6	60.81	3.89	2.70
71	1.60	0.70	1.90	0.70	0.00	3.00	6.00	0.58	38.74	2.50	0.70
72	1.20	0.10	4.27	0.05	0.00	4.00	6.50	0.68	75.92	7.48	2.70
73	1.70	0.90	4.01	0.35	0.00	4.00	13.00	0.9	57.66	4.98	1.40
74	1.30	0.40	4.55	0.17	0.00	3.00	6.50	1.54	70.82	6.97	1.30
75	3.80	3.00	4.71	0.27	0.00	5.00	15.50	1.75	39.98	3.61	-1.80
76	7.00	8.00	2.84	0.28	0.00	6.00	31.00	1.06	15.65	1.46	-9.00
77	1.50	1.10	3.26	0.10	0.00	4.00	8.50	0.63	54.74	4.05	1.40
78	1.20	0.30	3.91	0.18	0.00	4.00	8.50	0.5	69.93	6.39	2.50
79	1.80	0.60	3.84	0.16	0.00	3.00	7.50	0.86	59.98	4.96	0.60
80	1.30	0.40	2.41	1.54	0.00	4.00	9.00	0.88	42.69	3.70	2.30
Min.	1.00	0.10	1.72	0.05	0.00	2.00	4.00	0.50	15.65	1.46	-9.00
Max.	7.00	8.00	5.06	1.54	0.00	6.00	31.00	1.75	75.92	7.71	3.40

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻			
Kapadvanj											
81	1.70	1.00	2.28	0.17	0.00	1.00	4.50	1.28	44.28	2.78	-1.70
82	1.70	0.40	3.90	0.11	0.00	2.00	3.50	0.75	63.88	5.39	-0.10
83	2.70	1.30	2.39	0.26	0.00	2.00	4.50	0.94	36.01	2.39	-2.00
84	2.50	0.70	3.57	0.11	0.00	2.00	4.00	0.55	51.89	4.00	-1.20
85	1.90	1.10	2.06	0.09	0.00	2.00	3.00	1.36	39.96	2.37	-1.00
86	1.50	0.50	5.02	0.09	0.00	1.00	3.50	1.26	70.60	7.10	-1.00
87	1.00	0.60	2.82	0.06	0.00	1.00	2.50	0.45	62.92	4.46	-0.60
88	1.00	1.20	3.57	0.02	0.00	2.00	4.50	0.58	61.63	4.82	-0.20
89	2.00	0.90	4.56	0.10	0.00	1.00	5.00	0.29	60.36	5.36	-1.90
90	1.40	1.80	0.82	0.11	0.00	1.00	3.50	2.66	19.89	0.92	-2.20
91	1.20	1.20	0.45	0.45	0.00	2.00	4.00	2.27	13.76	0.59	-0.40
92	1.90	1.60	0.62	0.14	0.00	1.00	4.50	2.31	14.51	0.66	-2.50
93	1.50	1.40	0.32	0.13	0.00	1.00	3.50	4.32	9.44	0.37	-1.90
94	0.90	1.20	1.08	0.09	0.00	1.00	3.00	1.5	33.06	1.49	-1.10
95	2.10	1.40	1.34	0.40	0.00	1.00	4.50	1.21	25.55	1.43	-2.50
96	1.80	1.70	0.38	0.25	0.00	1.00	6.00	5	9.16	0.40	-2.50
97	1.60	3.30	0.77	0.22	0.00	2.00	4.50	2.78	13.12	0.70	-2.90
98	1.10	1.50	0.92	0.13	0.00	1.00	3.00	2.79	25.22	1.14	-1.60
99	1.30	1.90	1.81	0.20	0.00	1.00	4.50	1.73	34.77	2.02	-2.20
100	1.20	2.20	0.62	0.09	0.00	1.00	4.50	1.57	15.18	0.68	-2.40
Min.	0.90	0.40	0.32	0.02	0.00	1.00	2.50	0.29	9.16	0.37	-2.90
Max.	2.70	3.30	5.02	0.45	0.00	2.00	6.00	5.00	70.60	7.10	-0.10
Average	1.60	1.35	1.97	0.16	0.00	1.35	4.03	1.78	35.26	2.45	-1.60

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻			
Thasra											
101	1.90	1.50	0.89	0.06	0.00	2.00	4.00	1.66	20.37	0.96	-1.40
102	0.70	1.40	2.79	0.06	0.00	1.00	5.50	0.66	56.43	3.85	-1.10
103	1.60	1.30	0.96	0.06	0.00	2.00	3.00	1.49	24.49	1.13	-0.90
104	2.80	2.30	1.05	0.11	0.00	2.00	6.50	1.89	16.74	0.93	-3.10
105	2.20	1.40	1.20	0.05	0.00	2.00	5.50	2.27	24.75	1.27	-1.60
106	1.80	1.40	0.76	0.07	0.00	1.00	4.00	2.07	18.83	0.85	-2.20
107	1.10	1.70	1.28	0.04	0.00	1.00	4.00	0.68	31.07	1.53	-1.80
108	1.50	1.70	0.62	0.35	0.00	1.00	4.50	0.9	14.87	0.69	-2.20
109	1.80	1.70	0.80	0.12	0.00	1.00	4.00	1.54	18.10	0.86	-2.50
110	7.60	4.60	5.05	0.39	0.00	1.00	19.50	1.75	28.63	2.89	-11.20
111	1.70	1.00	4.88	0.49	0.00	2.00	8.00	1.06	60.46	5.94	-0.70
112	0.80	1.90	4.05	0.14	0.00	1.00	7.00	0.63	58.76	4.93	-1.70
113	1.40	1.50	0.60	0.17	0.00	1.00	4.50	0.5	16.31	0.70	-1.90
114	1.30	1.10	1.87	0.06	0.00	1.00	4.50	0.86	43.18	2.41	-1.40
115	0.80	2.70	2.69	0.22	0.00	2.00	4.50	0.88	41.95	2.87	-1.50
116	2.00	3.00	1.86	0.12	0.00	2.00	5.00	1.28	26.65	1.66	-3.00
117	0.90	1.50	0.58	0.04	0.00	1.00	5.00	0.75	19.26	0.75	-1.40
118	1.10	2.00	0.60	0.06	0.00	1.00	4.50	0.94	15.85	0.68	-2.10
119	1.10	2.30	3.86	0.31	0.00	2.00	7.50	0.55	50.98	4.18	-1.40
120	1.00	1.40	1.91	0.14	0.00	2.00	6.00	1.36	42.88	2.46	-0.40
Min.	0.70	1.00	0.58	0.04	0.00	1.00	3.00	0.50	14.87	0.68	-11.20
Max.	7.60	4.60	5.05	0.49	0.00	2.00	19.50	2.27	60.46	5.94	-0.40
Average	1.76	1.87	1.91	0.15	0.00	1.45	5.85	1.19	31.53	2.08	-2.18

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻			
Mehmedabad											
121	0.80	1.90	1.95	0.06	0.00	2.00	8.00	1.26	41.40	2.37	-0.70
122	0.90	1.50	4.78	0.05	0.00	3.00	25.00	0.45	66.14	6.17	0.60
123	1.00	1.50	2.18	0.17	0.00	3.00	4.50	0.58	44.94	2.76	0.50
124	1.70	1.40	4.64	0.05	0.00	2.00	11.50	0.29	59.61	5.27	-1.10
125	1.20	1.70	0.91	0.05	0.00	2.00	3.50	2.66	23.63	1.07	-0.90
126	0.60	0.80	1.39	0.04	0.00	1.00	5.00	2.27	49.20	2.35	-0.40
127	0.80	1.30	1.69	0.06	0.00	2.00	3.00	1.98	43.90	2.34	-0.10
128	0.90	1.70	3.90	0.08	0.00	2.00	4.00	4.32	59.28	4.84	-0.60
129	1.90	0.30	0.40	0.29	0.00	1.00	3.00	1.5	13.76	0.54	-1.20
130	2.90	0.60	2.24	0.05	0.00	1.00	5.00	1.13	38.72	2.39	-2.50
131	1.90	1.00	0.84	0.03	0.00	1.00	3.50	0.46	22.36	0.99	-1.90
132	0.90	2.00	1.82	0.08	0.00	2.00	4.50	0.78	37.99	2.14	-0.90
133	1.00	1.30	3.60	0.02	0.00	3.00	3.50	0.45	60.84	4.75	0.70
134	0.80	0.70	2.45	0.08	0.00	1.00	4.50	1.45	60.72	3.99	-0.50
135	1.60	1.80	3.79	0.07	0.00	2.00	5.50	1.48	52.24	4.11	-1.40
136	0.80	1.20	3.42	0.16	0.00	3.00	11.50	1.18	61.27	4.83	1.00
137	0.80	1.30	4.85	0.05	0.00	3.00	4.50	1.44	69.31	6.69	0.90
138	0.80	1.80	2.87	0.03	0.00	1.00	5.00	2.76	52.15	3.56	-1.60
139	1.10	1.10	2.51	0.01	0.00	2.00	3.50	1.13	53.11	3.38	-0.20
140	0.60	1.50	4.09	0.07	0.00	3.00	4.50	0.46	65.34	5.65	0.90
Min.	0.60	0.30	0.40	0.01	0.00	1.00	3.00	0.29	13.76	0.54	-2.50
Max.	2.90	2.00	4.85	0.29	0.00	3.00	25.00	4.32	69.31	6.69	1.00
Average	1.15	1.32	2.72	0.07	0.00	2.00	6.15	1.40	48.79	3.51	-0.47

Sample No.	Water soluble ions in me l ⁻¹ (1:2.5)								SSP	SAR	RSC (me l ⁻¹)
	Cations				Anions						
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻			
Kathlal											
141	1.30	2.00	2.14	0.11	0.00	1.00	4.50	0.64	38.53	2.36	-2.30
142	1.00	1.40	3.03	0.06	0.00	2.00	5.50	0.45	55.18	3.92	-0.40
143	1.20	1.60	2.67	0.23	0.00	2.00	5.00	1.57	46.81	3.19	-0.80
144	1.40	1.60	4.42	0.50	0.00	1.00	6.00	1.48	55.77	5.10	-2.00
145	1.50	2.80	2.82	0.10	0.00	3.00	16.50	1.31	39.03	2.72	-1.30
146	1.70	0.50	4.64	0.08	0.00	2.00	6.50	0.81	67.01	6.25	-0.20
147	1.30	1.30	1.08	0.09	0.00	4.00	5.50	1.08	28.67	1.34	1.40
148	1.50	1.10	1.71	0.07	0.00	3.00	6.50	0.77	39.04	2.12	0.40
149	1.70	2.30	0.59	0.74	0.00	2.00	7.50	0.73	11.01	0.59	-2.00
150	0.70	1.00	3.10	0.06	0.00	3.00	7.50	1.7	63.82	4.76	1.30
151	0.80	1.40	2.58	0.09	0.00	3.00	10.00	0.71	53.02	3.49	0.80
152	1.10	1.70	1.02	0.26	0.00	1.00	3.00	0.53	24.98	1.22	-1.80
153	1.30	2.60	1.03	0.31	0.00	4.00	4.00	0.43	19.61	1.04	0.10
154	1.00	1.10	0.66	0.16	0.00	2.00	4.50	0.24	22.64	0.91	-0.10
155	3.80	2.30	0.89	0.34	0.00	2.00	3.50	0.38	12.18	0.72	-4.10
156	1.60	1.20	0.37	0.33	0.00	3.00	5.00	1.54	10.58	0.44	0.20
157	5.00	2.30	0.73	0.14	0.00	2.00	4.50	0.29	8.90	0.54	-5.30
158	1.20	2.00	4.19	0.54	0.00	2.00	6.00	0.31	52.89	4.69	-1.20
159	2.40	1.70	4.87	0.10	0.00	2.00	7.00	0.46	53.70	4.81	-2.10
160	1.80	2.00	3.33	0.08	0.00	3.00	9.00	1.12	46.16	3.41	-0.80
Min.	0.70	0.50	0.37	0.06	0.00	1.00	3.00	0.24	8.90	0.44	-5.30
Max.	5.00	2.80	4.87	0.74	0.00	4.00	16.50	1.70	67.01	6.25	1.40
Average	1.67	1.70	2.29	0.22	0.00	2.35	6.38	0.83	37.48	2.68	-1.01

Appendix VI: Taluka/Sample wise values of EC, pH, cations, anions, different water quality indices and water quality class

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Nadiad														
1	1.96	7.79	1.00	4.00	13.00	1.74	1	6.1	12.53	0.03	-2.10	6.65	34.42	C3S1
2	1.59	8.00	1.00	8.00	6.50	1.38	1	4.8	11.54	0.02	3.20	6.78	31.62	C3S1
3	1.11	8.43	1.00	7.00	2.00	1.72	0.2	5.5	5.14	0.02	2.30	3.04	51.63	C3S1
4	0.85	8.08	1.00	6.00	1.00	1.10	0.6	3.3	6.12	0.03	3.10	4.38	36.72	C3S1
5	1.32	8.06	1.00	5.00	6.50	0.96	1	5.4	7.10	0.01	-0.40	3.97	44.14	C3S1
6	1.76	7.89	2.00	6.00	9.00	1.52	1.7	4.7	13.43	0.04	1.60	7.51	29.73	C3S1
7	2.40	8.01	2.00	7.00	13.50	1.96	0.7	6	17.88	0.03	2.30	9.77	26.50	C4S1
8	0.73	9.27	1.00	5.00	1.00	1.00	0.2	2.2	7.56	0.00	3.60	6.90	23.62	C2S1
9	3.10	7.48	1.00	11.00	17.00	1.98	1.6	7	23.20	0.04	3.40	11.19	25.75	C4S2
10	2.20	9.07	3.00	9.00	8.00	2.02	0.3	7.3	14.07	0.03	4.40	7.22	34.59	C3S1
11	0.75	8.72	1.00	3.00	3.50	0.00	0.6	4.1	45.93	0.07	-0.70	29.96	9.18	C2S4
12	5.10	8.13	1.00	10.00	38.00	2.10	0.8	6.5	13.18	0.06	3.70	6.90	34.31	S1C4
13	8.20	7.84	1.00	9.00	70.00	2.11	3	10.4	0.94	0.30	-3.40	0.36	77.26	S1C4
14	3.60	8.70	1.00	11.00	22.50	2.06	0.5	10.6	24.90	0.58	0.90	10.57	30.41	C4S2
15	1.69	8.37	1.00	8.00	6.00	1.98	0.5	3.3	12.83	0.08	5.20	9.31	22.18	C3S1
16	2.04	9.30	2.00	9.00	7.50	1.98	0.9	3.4	16.91	0.01	6.70	11.53	19.45	C3S2
17	1.10	7.32	2.00	4.00	3.50	1.54	3.4	1	7.04	0.01	1.60	4.75	29.65	C3S1
18	1.15	8.19	1.00	7.00	3.50	0.00	1.4	3.6	6.27	0.22	3.00	3.97	39.45	C3S1
19	1.41	7.66	1.00	8.00	4.50	1.31	1.3	5.3	7.56	0.04	2.40	4.16	42.69	C3S1
20	2.40	7.70	1.00	9.00	12.00	1.96	2.4	6.5	14.46	0.06	1.10	6.85	34.55	C4S1
Min.	0.73	7.32	1.00	3.00	1.00	0.00	0.20	1.00	0.94	0.00	-3.40	0.36	9.18	
Max.	8.20	9.30	3.00	11.00	70.00	2.11	3.40	10.60	45.93	0.58	6.70	29.96	77.26	
Average	2.22	8.20	1.30	7.30	12.43	1.52	1.16	5.35	13.43	0.08	2.10	7.79	33.89	

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Mahudha														
21	5.50	7.64	2.00	9.00	42.00	2.06	2.7	13.1	38.88	0.07	-4.80	13.83	27.53	S2C4
22	3.70	7.38	3.00	11.00	21.50	2.04	2.5	9.1	26.58	0.04	2.40	11.04	28.51	C4S2
23	5.40	7.50	4.00	6.00	42.50	2.09	1.1	12.1	40.71	0.05	-3.20	15.85	24.00	S2C4
24	3.60	7.63	3.00	12.00	19.50	2.04	1	8.4	27.71	0.07	5.60	12.78	24.66	C4S2
25	3.20	7.84	2.00	11.00	16.50	2.07	2.1	8.9	19.70	0.04	2.00	8.40	33.54	C4S1
26	1.30	7.69	1.00	8.00	4.50	0.00	1.8	5.4	5.51	0.02	1.80	2.90	49.62	C3S1
27	1.31	7.55	1.00	9.00	2.00	1.10	0.9	3.7	8.64	0.02	5.40	5.70	32.53	C3S1
28	1.01	7.88	1.00	8.00	2.00	0.00	1.3	3.58	6.50	0.02	4.12	4.16	38.49	C3S1
29	1.30	7.81	1.00	8.00	3.00	0.92	1.8	7.4	3.66	0.02	-0.20	1.70	62.77	C3S1
30	0.90	7.31	1.00	6.00	2.00	0.00	1	2.7	5.84	0.02	3.30	4.29	35.10	C3S1
31	3.30	7.96	1.00	10.00	23.00	2.05	1.6	5.8	27.90	0.06	3.60	14.50	20.05	C4S2
32	3.40	7.89	1.00	9.00	21.50	2.07	1.9	3.9	27.13	0.06	4.20	15.93	16.65	C4S2
33	0.60	7.81	1.00	4.00	1.50	0.00	0.7	3.4	1.99	0.00	0.90	1.39	60.41	C2S1
34	0.69	8.70	1.00	3.00	2.50	0.77	0.8	3.8	3.33	0.09	-0.60	2.20	52.69	C2S1
35	1.40	7.41	1.00	9.00	4.00	0.00	0.4	4.7	8.64	0.01	4.90	5.41	36.06	C3S1
36	1.16	6.85	2.00	3.00	7.50	0.00	1.6	3.8	7.58	0.02	-0.40	4.61	37.04	C3S1
37	2.10	7.40	1.00	14.00	6.00	0.00	0.5	5.8	15.10	0.07	8.70	8.51	28.77	C3S1
38	2.10	7.64	2.00	9.00	9.00	1.35	2	7.6	11.47	0.20	1.40	5.24	41.61	C3S1
39	2.00	8.37	1.00	8.00	10.00	1.67	1.5	3.1	16.20	0.05	4.40	10.68	20.63	C3S2
40	1.00	7.81	1.00	6.00	3.50	0.00	1.7	3.6	4.10	0.17	1.70	2.52	47.75	C3S1
Min.	0.60	6.85	1.00	3.00	1.50	0.00	0.40	2.70	1.99	0.00	-4.80	1.39	16.65	
Max.	5.50	8.70	4.00	14.00	42.50	2.09	2.70	13.10	40.71	0.20	8.70	15.93	62.77	
Average	2.25	7.70	1.55	8.15	12.20	1.01	1.45	5.99	15.36	0.05	2.26	7.58	35.92	

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Matar														
41	1.34	7.49	1.00	7.00	4.00	1.67	0.7	1.3	13.03	0.01	6.00	13.03	12.72	C3S2
42	2.00	9.16	1.00	9.00	9.00	1.50	1.1	4.9	13.90	0.02	4.00	8.03	28.57	C3S1
43	1.60	7.58	1.00	8.00	5.50	1.54	1.2	3.8	11.75	0.01	4.00	7.43	27.86	C3S1
44	1.50	7.84	1.00	8.00	4.00	1.79	0.6	2.4	11.00	0.01	6.00	8.98	20.55	C3S1
45	1.51	7.71	1.00	8.00	4.00	1.65	1.9	3.4	9.40	0.07	3.70	5.77	31.93	C3S1
46	1.64	7.68	1.00	8.00	5.50	1.56	0.7	3.8	11.39	0.01	4.50	7.59	27.12	C3S1
47	8.40	7.55	0.00	11.00	70.00	2.06	3.9	7.1	10.85	0.08	0.00	4.63	42.72	S1C4
48	8.50	7.71	2.00	9.00	71.50	2.06	4.7	8	11.87	0.17	-1.70	4.71	43.38	S1C4
49	3.60	7.60	1.00	10.00	23.50	2.08	3.7	9.1	22.25	0.65	-1.80	8.80	33.03	C4S1
50	1.52	7.77	2.00	8.00	4.50	1.52	1.2	2.5	11.44	0.13	6.30	8.41	22.65	C3S1
51	7.70	7.96	1.00	8.00	65.00	2.12	4.5	8.5	45.80	0.09	-4.00	17.96	20.54	S2C4
52	0.77	8.66	1.00	4.00	3.50	0.00	0.9	1.9	5.65	0.01	2.20	4.78	29.95	C3S1
53	0.70	7.64	1.00	3.00	3.00	0.00	0.9	2.1	4.35	0.09	1.00	3.55	36.35	C2S1
54	1.80	7.90	2.00	8.00	7.00	1.44	2	3	13.50	0.04	5.00	8.54	24.39	C3S1
55	1.88	7.67	1.00	7.00	11.00	0.75	1.8	6.5	11.00	0.07	-0.30	5.40	39.34	C3S1
56	4.90	8.20	1.00	12.00	33.50	2.13	0.8	11	36.60	0.08	1.20	15.07	23.98	C4S2
57	5.20	8.38	1.00	8.00	41.00	2.09	2.9	7.9	42.10	0.15	-1.80	18.12	19.35	S3C4
58	3.30	7.88	1.00	8.00	21.00	2.07	1.9	4.4	26.50	0.06	2.70	14.93	18.16	C4S2
59	3.40	7.60	1.00	7.00	23.50	1.98	4.1	2.8	26.10	0.04	1.10	14.05	18.60	C4S2
60	1.90	8.06	2.00	9.00	6.50	2.09	1.6	2	16.40	0.03	7.40	12.22	16.67	C3S2
Min.	0.70	7.49	0.00	3.00	3.00	0.00	0.60	1.30	4.35	0.01	-4.00	3.55	12.72	
Max.	8.50	9.16	2.00	12.00	71.50	2.13	4.70	11.00	45.80	0.65	7.40	18.12	43.38	
Average	3.16	7.90	1.15	8.00	20.83	1.61	2.06	4.82	17.74	0.09	2.28	9.60	26.89	

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Kheda														
61	3.60	7.73	1.00	7.00	25.50	2.10	6.5	5.7	22.24	0.29	-4.20	9.00	29.80	C4S1
62	0.70	7.34	0.00	4.00	3.00	0.86	1.5	3.1	3.50	0.01	-0.60	2.30	47.94	C2S1
63	4.80	8.00	1.00	7.00	37.50	1.96	2.8	7.6	36.60	0.05	-2.40	16.05	20.88	C4S2
64	2.80	8.10	2.00	9.00	15.50	1.97	1.9	3.4	24.23	0.05	5.70	14.88	16.86	C4S2
65	2.50	8.29	1.00	12.00	11.00	1.85	0.7	3.7	22.13	0.07	8.60	14.92	16.16	C4S2
66	1.51	8.04	1.00	6.00	7.00	1.17	2.4	1.7	10.70	0.23	2.90	7.47	23.84	C3S1
67	3.10	7.54	1.00	10.00	19.00	1.97	2.7	4.9	24.77	0.05	3.40	12.71	21.67	C4S2
68	1.50	7.59	1.00	5.00	7.50	1.71	1.5	3.6	10.10	0.02	0.90	6.32	30.54	C3S1
69	1.72	8.28	1.00	8.00	7.00	1.71	1.8	2.3	12.66	0.97	4.90	8.84	22.09	C3S1
70	2.20	8.23	1.00	9.00	11.00	1.58	2.5	2.5	17.53	0.05	5.00	11.09	19.98	C3S2
71	1.18	7.96	1.00	6.00	4.00	0.84	2.7	0.5	9.20	0.08	3.80	7.27	21.19	C3S1
72	2.90	8.54	1.00	8.00	18.50	2.06	0.9	3.5	24.74	0.10	4.60	16.68	14.65	C4S2
73	3.00	8.47	1.00	12.00	16.50	0.75	2.2	3.7	24.10	0.11	7.10	14.03	18.32	C4S2
74	3.60	7.60	2.00	5.00	26.00	2.06	4.2	4.4	25.34	0.14	-1.60	12.22	22.55	C4S2
75	3.90	8.03	1.00	12.00	23.00	2.10	2.6	5.1	29.64	0.08	5.30	15.11	19.28	C4S2
76	4.30	7.18	1.00	13.00	28.00	1.23	4.1	9.5	30.41	0.05	0.40	11.66	28.27	C4S2
77	4.20	7.80	2.00	7.00	30.50	2.00	3.8	6.2	32.24	0.07	-1.00	14.42	21.72	C4S2
78	2.50	7.53	2.00	8.00	13.00	2.08	2.2	2.4	21.49	0.06	5.40	14.17	16.26	C4S2
79	2.30	8.11	1.00	6.00	13.00	2.03	1.5	3.9	16.34	0.06	1.60	9.94	23.24	C4S1
80	3.10	7.79	3.00	5.00	21.00	2.11	4.7	2.9	23.24	0.04	0.40	11.92	21.38	C4S2
Min.	0.70	7.18	0.00	4.00	3.00	0.75	0.70	0.50	3.50	0.01	-4.20	2.30	14.65	
Max.	4.80	8.54	3.00	13.00	37.50	2.11	6.50	9.50	36.60	0.97	8.60	16.68	47.94	
Average	2.77	7.91	1.25	7.95	16.88	1.71	2.66	4.03	21.06	0.13	2.51	11.55	22.83	

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Kapadvanj														
81	1.65	7.30	1.00	12.00	4.00	0.00	1.3	2.9	13.10	0.02	8.80	9.04	22.58	C3S1
82	1.40	7.79	1.00	8.00	5.00	0.00	0.5	2.3	11.06	0.01	6.20	9.35	19.50	C3S1
83	0.98	7.95	1.00	7.00	2.50	0.00	1.3	3.3	6.22	0.02	3.40	4.10	37.95	C3S1
84	1.15	7.40	1.00	8.00	3.00	0.00	2.2	3.2	7.57	0.01	3.60	4.61	35.59	C3S1
85	1.20	7.40	1.00	7.00	3.00	1.96	1	5.4	6.94	0.06	1.60	3.88	44.63	C3S1
86	1.24	7.46	2.00	7.00	3.00	0.75	0.3	0.9	12.11	0.02	7.80	15.63	8.82	C3S2
87	1.50	8.42	1.00	9.00	4.00	1.21	0.9	2.6	10.80	0.02	6.50	8.16	23.03	C3S1
88	0.64	8.06	1.00	3.00	3.00	0.00	0.9	3.5	2.35	0.04	-0.40	1.58	57.53	C2S1
89	0.70	7.77	1.00	4.00	2.00	0.00	0.5	4.2	2.54	0.02	0.30	1.66	60.73	C2S1
90	0.70	8.20	1.00	4.00	2.50	0.00	1.2	2.9	2.57	0.01	0.90	1.79	52.13	C2S1
91	0.69	7.92	1.00	4.00	2.50	0.00	1	3.4	3.70	0.00	0.60	2.49	48.35	C2S1
92	0.91	8.02	1.00	4.00	5.00	0.00	2.2	4.6	2.46	0.02	-1.80	1.33	59.35	C3S1
93	0.80	7.81	1.00	5.00	3.00	0.00	0.8	2.6	5.25	0.05	2.60	4.03	35.98	C3S1
94	1.35	8.18	1.00	8.00	4.00	0.90	1.2	4.2	8.36	0.02	3.60	5.09	36.10	C3S1
95	0.51	7.65	1.00	4.00	4.00	0.00	1.5	1.9	5.04	0.02	1.60	3.87	34.21	C2S1
96	0.78	7.46	2.00	4.00	2.50	0.00	1.6	4.5	2.37	0.02	-0.10	1.36	60.58	C3S1
97	1.00	7.86	1.00	7.00	2.50	0.00	1.6	5.1	4.15	0.03	1.30	2.27	53.82	C3S1
98	0.90	7.85	1.00	5.00	3.50	0.00	1.2	3.7	4.65	0.03	1.10	2.97	45.58	C3S1
99	1.20	7.57	1.00	5.00	4.50	1.23	1.3	3.3	7.02	0.03	1.40	4.63	35.60	C3S1
100	2.10	8.25	1.00	9.00	10.00	1.83	1	9.2	10.99	0.04	-0.20	4.87	45.97	C3S1
Min.	0.51	7.30	1.00	3.00	2.00	0.00	0.30	0.90	2.35	0.00	-1.80	1.33	8.82	
Max.	2.10	8.42	2.00	12.00	10.00	1.96	2.20	9.20	13.10	0.06	8.80	15.63	60.73	
Average	1.07	7.82	1.10	6.20	3.68	0.39	1.18	3.69	6.46	0.02	2.44	4.64	40.90	

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Thasra														
101	2.30	8.14	2.00	11.00	9.00	1.17	0.4	2.2	20.93	0.03	10.40	18.36	10.87	C4S3
102	1.84	7.70	1.00	9.00	8.00	1.00	1.6	4.2	14.03	0.10	4.20	8.24	27.06	C3S1
103	1.63	8.22	1.00	6.00	10.00	0.00	2	3.8	10.91	0.03	1.20	6.41	31.00	C3S1
104	1.34	7.78	2.00	4.00	6.50	0.00	3	4.1	4.34	0.10	-1.10	2.30	49.17	C3S1
105	2.80	7.63	1.00	6.00	21.00	0.00	1.3	2.3	25.13	0.03	3.40	18.73	11.99	C4S3
106	1.10	7.98	2.00	7.00	2.00	0.00	0.8	3	8.11	0.01	5.20	5.88	29.90	C3S1
107	4.10	8.05	2.00	10.00	27.00	2.02	2.2	7.8	31.53	0.08	2.00	14.10	22.87	C4S2
108	2.30	7.41	1.00	8.00	13.50	0.71	1.1	5	16.50	0.01	2.90	9.45	25.74	C4S1
109	2.60	7.65	4.00	4.00	17.50	1.06	2.3	6.4	18.80	0.01	-0.70	9.01	29.20	C4S1
110	2.30	8.03	1.00	14.00	8.50	0.00	1.5	5	17.15	0.02	8.50	9.51	25.84	C4S1
111	2.10	6.84	2.00	8.00	10.00	1.44	2.1	5.9	13.25	0.16	2.00	6.63	34.26	C3S1
112	1.26	8.17	1.00	8.00	3.50	1.08	1.2	5.1	7.41	0.02	2.70	4.18	42.25	C3S1
113	1.40	7.57	1.00	8.00	4.00	1.50	2.3	4.8	6.85	0.02	1.90	3.64	43.69	C3S1
114	1.00	8.90	1.00	5.00	3.00	1.19	1.1	4.2	4.93	0.03	0.70	3.03	46.78	C3S1
115	0.98	7.65	1.00	5.00	4.50	0.00	1.1	6	3.14	0.05	-1.10	1.67	62.61	C3S1
116	1.02	7.87	1.00	9.00	3.50	1.04	2.2	6.5	5.49	0.02	1.30	2.63	53.08	C3S1
117	0.65	7.80	1.00	5.00	2.00	0.00	1.8	5.5	0.79	0.01	-1.30	0.41	73.83	C2S1
118	1.00	8.06	1.00	1.00	8.00	0.00	1	4	4.70	0.01	-3.00	2.97	46.73	C3S1
119	0.62	7.39	1.00	4.00	1.50	0.00	1.2	3.6	1.23	0.03	0.20	0.79	66.43	C2S1
120	0.85	7.48	1.00	5.00	2.00	1.36	1	4.3	2.70	0.48	0.70	1.66	58.89	C3S1
Min.	0.62	6.84	1.00	1.00	1.50	0.00	0.40	2.20	0.79	0.01	-3.00	0.41	10.87	
Max.	4.10	8.90	4.00	14.00	27.00	2.02	3.00	7.80	31.53	0.48	10.40	18.73	73.83	
Average	1.66	7.82	1.40	6.85	8.25	0.68	1.56	4.69	10.90	0.06	2.01	6.48	39.61	

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Mehmedabad														
121	3.20	7.96	1.00	12.00	19.00	1.83	2	9.7	22.57	0.03	1.30	9.33	32.26	C4S1
122	4.10	7.62	4.00	8.00	27.00	1.98	2.4	8.6	30.02	0.04	1.00	12.80	25.33	C4S2
123	1.76	8.55	1.00	8.00	8.00	1.52	1.7	7	9.13	0.04	0.30	4.38	44.55	C3S1
124	1.85	8.03	3.00	10.00	3.00	1.74	0.6	5.2	12.87	0.01	7.20	7.56	30.10	C3S1
125	0.69	7.95	1.00	5.00	1.50	0.00	0.9	4.1	2.74	0.04	1.00	1.73	57.87	C2S1
126	2.00	8.23	2.00	11.00	7.00	0.79	0.5	5.5	14.28	0.03	7.00	8.24	28.87	C3S1
127	1.40	7.90	1.00	10.00	3.00	0.90	1.8	5.1	8.30	0.02	4.10	4.47	40.59	C3S1
128	1.00	8.28	1.00	7.00	2.50	0.00	0.6	5.2	5.11	0.02	2.20	3.00	50.39	C3S1
129	1.14	7.79	1.00	8.00	3.00	0.00	0.5	5.6	6.02	0.01	2.90	3.45	48.34	C3S1
130	1.50	7.61	1.00	11.00	3.00	0.00	1.4	8.2	5.56	0.02	2.40	2.54	57.97	C3S1
131	1.90	7.90	1.00	10.00	8.00	1.00	2.9	6.5	11.19	0.01	1.60	5.16	40.02	C3S1
132	1.68	7.68	1.00	12.00	4.00	0.77	2.1	9.1	7.11	0.03	1.80	3.00	54.88	C3S1
133	1.00	8.34	1.00	6.00	3.50	0.00	1.4	6.3	3.39	0.02	-0.70	1.73	61.65	C3S1
134	1.10	8.58	1.00	8.00	2.50	0.00	0.6	4.5	6.32	0.01	3.90	3.96	42.44	C3S1
135	1.74	8.36	1.00	9.00	7.00	1.27	1.9	6.8	10.01	0.04	1.30	4.80	42.21	C3S1
136	1.72	8.20	1.00	9.00	6.00	1.71	2.1	5.2	10.25	0.97	2.70	5.37	37.15	C3S1
137	1.60	8.51	1.00	8.00	6.00	1.12	1.6	6.1	8.55	0.02	1.30	4.36	43.14	C3S1
138	1.66	8.04	1.00	10.00	5.00	0.00	1.1	6.5	8.33	0.01	3.40	4.27	44.63	C3S1
139	1.60	8.56	1.00	8.00	6.00	1.17	0.8	6.2	10.08	0.02	2.00	5.39	39.15	C3S1
140	1.18	8.15	1.00	8.00	2.00	0.87	0.8	5.9	5.51	0.01	2.30	3.01	51.50	C3S1
Min.	0.69	7.61	1.00	5.00	1.50	0.00	0.50	4.10	2.74	0.01	-0.70	1.73	25.33	
Max.	4.10	8.58	4.00	12.00	27.00	1.98	2.90	9.70	30.02	0.97	7.20	12.80	61.65	
Average	1.69	8.11	1.30	8.90	6.35	0.83	1.39	6.37	9.87	0.07	2.45	4.93	43.65	

Sample No.	EC (ds m ⁻¹)	pH	Anions (me l ⁻¹)				Cations (me l ⁻¹)				(me l ⁻¹) RSC	SSP	SAR	Water Quality Class
			CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺				
Kathlal														
141	0.90	8.50	1.00	6.00	3.00	0.00	1.1	3.2	5.70	0.01	2.70	3.89	38.74	C3S1
142	1.04	8.48	1.00	6.00	2.00	0.77	0.9	1.8	7.20	0.01	4.30	6.20	25.00	C3S1
143	1.58	8.30	1.00	10.00	5.00	0.79	1.1	2.6	12.34	0.01	7.30	9.07	21.59	C3S1
144	1.19	8.54	2.00	5.00	4.00	1.27	1.4	1.7	9.37	0.02	3.90	7.53	22.35	C3S1
145	1.20	8.62	1.00	6.00	4.00	1.44	1.2	2.2	9.66	0.02	3.60	7.41	23.84	C3S1
146	0.92	8.56	2.00	4.00	2.50	0.83	1.6	1.9	5.97	0.03	2.50	4.51	31.62	C3S1
147	0.70	8.45	1.00	4.00	2.00	0.00	1.3	2.2	2.91	0.01	1.50	2.20	45.38	C2S1
148	1.19	7.97	1.00	6.00	4.00	0.98	2.2	4.8	5.16	0.02	0.00	2.76	48.75	C3S1
149	1.10	8.54	2.00	5.00	3.50	0.83	1.6	3.2	5.88	0.03	2.20	3.79	39.09	C3S1
150	1.90	7.90	1.00	9.00	8.00	1.44	1	0.7	18.54	0.04	8.30	20.11	8.00	C3S3
151	2.20	8.54	2.00	8.00	11.50	1.08	1.3	2	19.30	0.09	6.70	15.03	13.81	C3S2
152	1.70	8.40	2.00	6.00	8.00	1.75	2	5.2	9.66	0.05	0.80	5.09	38.18	C3S1
153	1.50	8.59	2.00	8.00	4.50	1.23	1.6	3.1	10.10	0.02	5.30	6.59	28.66	C3S1
154	1.00	7.72	1.00	6.00	3.00	0.94	2.9	4.5	3.40	0.04	-0.40	1.77	54.01	C3S1
155	1.74	8.55	2.00	4.00	10.50	1.12	1.4	1.9	14.78	0.19	2.70	11.50	16.94	C3S2
156	1.85	8.03	1.00	12.00	3.00	1.74	0.6	1.9	15.16	0.03	10.50	13.56	13.69	C3S2
157	1.87	7.90	1.00	10.00	6.50	1.79	0.9	5.2	13.48	0.04	4.90	7.72	29.79	C3S1
158	2.10	7.64	1.00	10.00	9.50	1.27	2	6.5	12.57	0.20	2.50	6.10	36.84	C3S1
159	1.50	7.71	1.00	8.00	4.50	1.02	2	6.6	6.08	0.04	0.40	2.93	51.56	C3S1
160	2.40	8.37	1.00	3.00	19.50	1.21	2.3	6.3	15.15	0.05	-4.60	7.31	33.01	C4S1
Min.	0.70	7.64	1.00	3.00	2.00	0.00	0.60	0.70	2.91	0.01	-4.60	1.77	8.00	
Max.	2.40	8.62	2.00	12.00	19.50	1.79	2.90	6.60	19.30	0.20	10.50	20.11	54.01	
Average	1.48	8.27	1.35	6.80	5.93	1.08	1.52	3.38	10.12	0.05	3.26	7.25	31.04	

Appendix VII: Talukawise number of samples in different categories and nutrient indices of the available macro and micro nutrients.

Sr. No.	Name of Taluka	Status	O.C	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu
1	Nadiad	Low	1	1	0	17	7	0	1	0
		Medium	10	2	7	3	8	13	8	0
		High	9	17	13	0	5	7	11	20
		Values	2.4	2.8	2.65	1.15	1.9	2.35	2.5	3
		N Index	H	H	H	L	M	H	H	H
2	Mahudha	Low	2	1	0	13	4	0	0	0
		Medium	11	2	5	7	11	3	1	0
		High	7	17	15	0	5	17	19	20
		Values	2.25	2.8	2.75	1.35	2.05	2.85	2.95	3
		N Index	M	H	H	L	M	H	H	H
3	Matar	Low	2	0	0	13	1	2	2	0
		Medium	9	4	7	7	7	11	8	0
		High	9	16	13	0	12	7	10	20
		Values	2.35	2.8	2.65	1.35	2.55	2.25	2.4	3
		N Index	H	H	H	L	H	M	H	H
4	Kheda	Low	2	0	0	15	3	3	1	0
		Medium	7	0	6	3	7	11	5	0
		High	11	20	14	2	10	6	14	20
		Values	2.45	3	2.7	1.35	2.35	2.15	2.65	3
		N Index	H	H	H	L	H	M	H	H
5	Kapadvanj	Low	11	0	0	20	11	1	0	1
		Medium	7	0	12	0	8	8	13	8
		High	2	20	8	0	1	11	7	11
		Values	1.55	3	2.4	1	1.5	2.5	2.35	2.5
		N Index	L	H	H	L	L	H	H	H

Sr. No.	Name of Taluka	Status	O.C	P ₂ O ₅	K ₂ O	S	Fe	Mn	Zn	Cu
6	Thasra	Low	9	2	0	19	10	3	3	0
		Medium	7	5	8	0	7	5	12	2
		High	4	13	12	1	3	12	5	18
		Values	1.75	2.55	2.6	1.1	1.65	2.45	2.1	2.9
		N Index	M	H	H	L	L	H	M	H
7	Mehmedabad	Low	10	5	4	17	3	1	3	0
		Medium	9	7	9	2	10	9	13	1
		High	1	8	7	1	7	10	4	19
		Values	1.55	2.15	2.15	1.2	2.2	2.45	2.05	2.95
		N Index	L	M	M	L	M	H	M	H
8	Kathlal	Low	13	2	1	18	6	1	2	0
		Medium	5	5	6	1	9	8	14	6
		High	2	13	13	1	5	11	4	14
		Values	1.45	2.55	2.6	1.15	1.95	2.5	2.1	2.7
		N Index	L	H	H	L	M	H	M	H
9	Overall	Low	50	11	5	132	45	11	12	1
		Medium	65	25	60	23	67	68	74	17
		High	45	124	95	5	48	81	74	142
		Values	1.96	2.71	2.56	1.21	2.02	2.44	2.39	2.88
		N Index	M	H	H	L	M	H	H	H

CERTIFICATE

This is to certify that I have no objection for supplying to any scientist one copy of any part of this thesis for rendering reference service in a library of documentation centre.

Place: Anand

Date: /07/2017

(Vaghela Mahipalsinh B.)