

## Original Research Article

### Ground Water Quality Assessment of Different Villages of Kheda District of Gujarat

#### Abstract

The Kheda district lies in the Cambay basin situated between Saurashtra crater and Aravalli Swell and Deccan Shield in the east. The basin comprises both marine formations, is the principal source of water supply for middle Gujarat region. The quality evaluation for this groundwater is very important tool for sustainable development and decision for water management. A survey work during April-May, 2016 for Ground water quality assessment of 'Khedadistrict of middle Gujarat was conducted. A total of 160 groundwater samples, from shallow, springs, and deep aquifers, were collected, storage and analysed to evaluate its quality suitability for domestic and agriculture purposes. 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<sup>-1</sup>. 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<sup>-1</sup>. The overall mean value of SSP was found 34.34, which varied from 8.00 to 77.26. The SAR values ranged from 0.36 to 29.96 with a mean value of 7.48.

**Keywords:** Ground water, physico-chemical analysis, water quality index

#### INTRODUCTION

Water is a renewable resource, but its availability is variable and limited, especially under arid conditions (Abotalibet *al.* 2016). At certain times of the year, almost every country in the world experiences water shortages (Gleick 2014). In fact, water resources are of importance in increasing employment in all sectors of society. Ongley (1999) stated that experts describe the global water situation as a crisis. Freshwater quality will become the principal limiting factor for sustainable development for many countries in the twenty-first century (Elawa *et al.* 2013).

Groundwater is an integral freshwater source that serves different human needs in many parts of the world. For agricultural purposes, groundwater contributes to approximately 43% of worldwide water usage for irrigation (Siebert *et al.* 2010). Despite its

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importance, the quantity and quality of groundwater resources are increasingly threatened by both natural and anthropogenic factors. Climate change has potential impacts on groundwater such as seawater intrusion and groundwater level decline. Additionally, a rapid increase in water demand and contamination from anthropogenic pollutants such as fertilizer residue and untreated wastewater has worsened this water source.

The water used for irrigation purpose always contain soluble salts in respective of their source, but the total concentrations and the kind of salt present in any irrigation water are important in deciding whether 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.

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.

The use of saline water is indispensable in some area where no alternative facility for irrigation is available; such water is 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).

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**Comment [n10]:** Globally, area equipped for irrigation is currently about 301 million ha of which 38% are equipped for irrigation with groundwater (Siebert *et al.*, 2010).

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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.

## MATERIALS AND METHODS

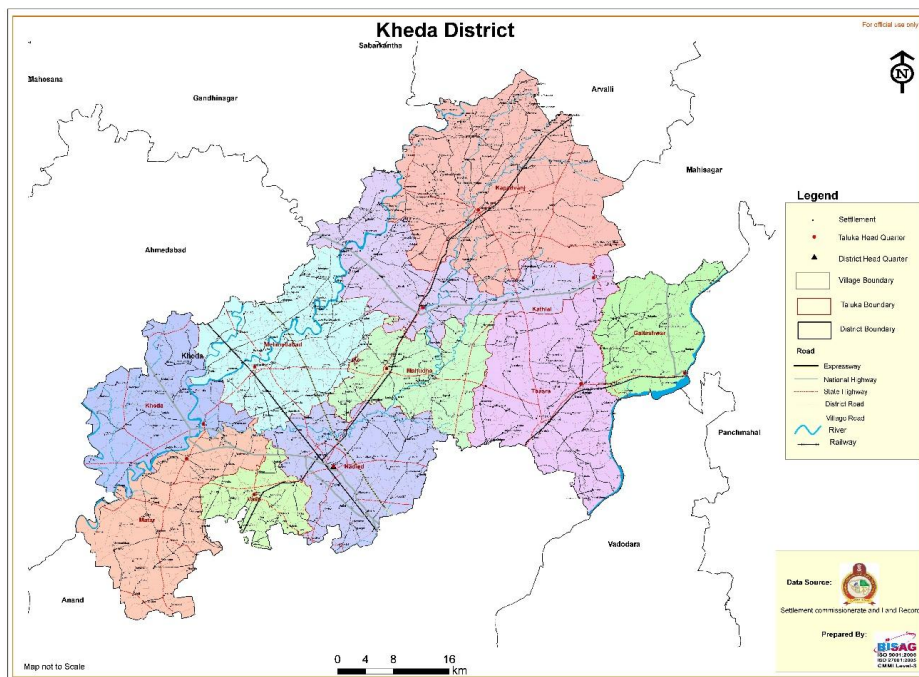
The general features of Kheda district viz, geographic location, physiography, geology, climate, soil, water, vegetation, land use pattern and cropping pattern are described below.

## GENERAL INFORMATION OF KHEDA DISTRICT

### Geographic Location

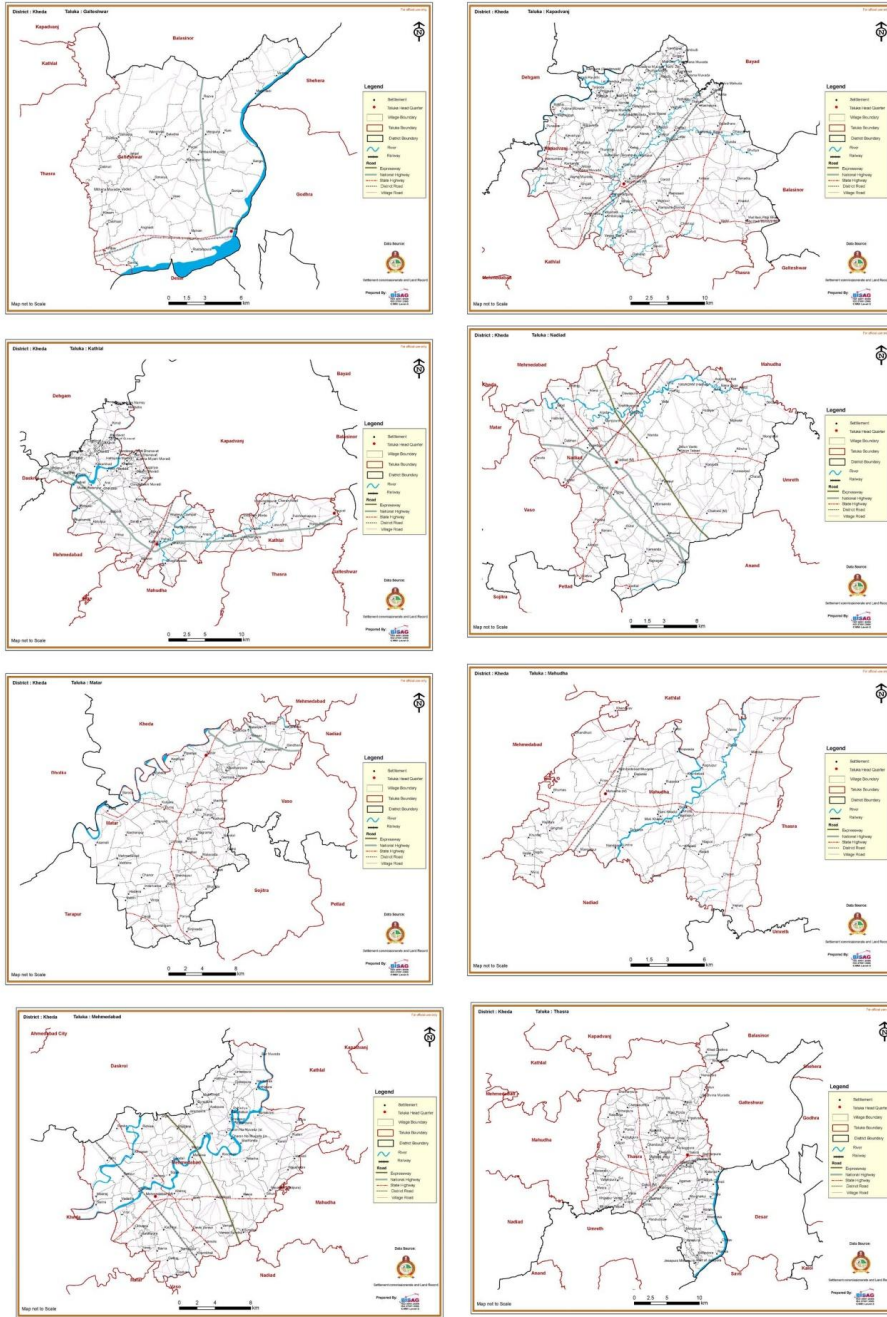
Kheda district falls in Middle Gujarat Agro Climatic Zone, located at  $22^{\circ} 30' N-72^{\circ} 32' E$ ,  $23^{\circ} 18' N-73^{\circ} 37' E$ . It has an average elevation of 21 meters (68 ft). It is bounded by Sabarkantha district to the North, Ahmedabad district to the West, Panchmahal district 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 decades 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

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<https://kheda.gujarat.gov.in/village-maps>

**Fig. 1 Map of Kheda District**



<https://kheda.gujarat.gov.in/village-maps>

**Fig. 2 Different Taluka of Kheda District**

### **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).

### **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.

### **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 3<sup>rd</sup> week of June and the normal cessation is in the 4<sup>th</sup> 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.

### **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 Nadiadtalukas. 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 Mehmedabadtaluka.

### COLLECTION OF WATER SAMPLES

Twenty representative irrigation water samples were 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.

### 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 1: Methods Used for Analysis of Irrigation Water**

| Characteristics  | Methods used                           | Reference               |
|--|--|-------------------------|
| pH   | Potentiometric method                  | Richard (1979)          |
| EC   | Conductivity method                    | Richard (1979)          |
| CO <sub>3</sub> <sup>-</sup> & HCO <sub>3</sub> <sup>-</sup> | Volumetric titration                   | Reitemeier (1943)       |
| Cl <sup>-</sup>  | AgNO <sub>3</sub> precipitation method | Richard (1979)          |
| SO <sub>4</sub> <sup>-</sup>                                 | Turbidity method                       | Chesnin and Yien (1951) |
| Na <sup>+</sup>  | Flame photometry                       | Richard (1979)          |
| K <sup>+</sup>   | Flame photometry                       | Richard (1979)          |
| Ca <sup>++</sup>   | Versenate method                       | Cheng and Bray (1951)   |
| Mg <sup>++</sup>   | Versenate method                       | Cheng and Bray (1951)   |

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

### 1) Soluble Sodium Percentage (SSP)

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

### 2) Sodium Adsorption Ratio (SAR)

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

(Concentrations of all cations in me L<sup>-1</sup>)

### 3) Residual Sodium Carbonate (RSC)

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

(All ionic concentrations are in me L<sup>-1</sup>)

### RATINGS USED FOR WATER QUALITY

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

#### Rating Used for Water Quality Appraisal

**Table 2.0: Electrical Conductivity (Richard, 1979)**

| EC (dSm <sup>-1</sup> at 25 °C) | Symbol         | Salinity class |
|---------------------------------|----------------|----------------|
| 0-0.25                          | C <sub>1</sub> | Low            |
| 0.25-0.75                       | C <sub>2</sub> | Medium         |
| 0.75-2.25                       | C <sub>3</sub> | High           |
| 2.25-5.00                       | C <sub>4</sub> | Very high      |

**Table 3.0: Sodium Adsorption Ratio (Richard, 1979)**

| SAR value | Symbol         | Salinity class     |
|-----------|----------------|--------------------|
| 0-10      | S <sub>1</sub> | Low Na water       |
| 10-18     | S <sub>2</sub> | Medium Na water    |
| 18-26     | S <sub>3</sub> | High Na water      |
| >26       | S <sub>4</sub> | Very high Na water |

**Table 4.0: Residual Sodium Carbonate (Eaton, 1950)**

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

**Table 5.0: Soluble Sodium Percentage (Richard, 1979)**

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

## 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)**.

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## RESULTS AND DISCUSSION

### 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 analysed for EC, pH, cations ( $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Na}^+$  and  $\text{K}^+$ ), anions ( $\text{CO}_3^-$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$  and  $\text{SO}_4^-$ ) and water quality appraisal was prepared by making use of EC and SAR values as suggested by USDA.

#### **Cation Concentration in Well/Tube Well**

**Comment [n17]:** Cations

Water Samples Taluka wise range and mean values of different cations present in well/tube well water samples are given in Table 6.0. Among the cations, overall highest proportion of  $\text{Na}^+$  (13.12 me  $\text{L}^{-1}$ ) was observed, which was followed by  $\text{Mg}^{++}$  (4.79 me  $\text{L}^{-1}$ ),  $\text{Ca}^{++}$  (1.62 me  $\text{L}^{-1}$ ) and  $\text{K}^+$  (0.07 me  $\text{L}^{-1}$ ). The presence of large proportion of  $\text{Na}^+$  in most of the area under investigation is indicative of a potential danger for the alkalinity hazards. The overall concentration of  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Na}^+$  and  $\text{K}^+$  varied from 0.20 to 6.50, 0.50 to 13.10, 0.79 to 45.93 and 0.00 to 0.97 me  $\text{L}^{-1}$ , respectively (Table 6.0). The highest mean value for  $\text{Na}^+$  (21.06 me  $\text{L}^{-1}$ ) was found in Khedataluka followed by Matar (17.74 me  $\text{L}^{-1}$ ) and Mahudha (15.36 me  $\text{L}^{-1}$ ), the lowest mean value for  $\text{Na}^+$  (6.46 me  $\text{L}^{-1}$ ) was reported in Kapadvanjtaluka. Similar results were also found by Timbadia (1988) for Jafrabad and Rajulatalukas of Amreli district.

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#### **Anion Concentration in Well/Tube Well**

**Comment [n19]:** Anions

Water Samples In case of anions, the highest overall mean value of 10.82 me  $\text{L}^{-1}$  was recorded for  $\text{Cl}^-$  and it was followed by  $\text{HCO}_3^-$  (7.52 me  $\text{L}^{-1}$ ),  $\text{CO}_3^{--}$  (1.30 me  $\text{L}^{-1}$ ) and  $\text{SO}_4^{--}$  (1.10 me  $\text{L}^{-1}$ ). The highest mean value of  $\text{Cl}^-$  (20.83 me  $\text{L}^{-1}$ ) was observed in

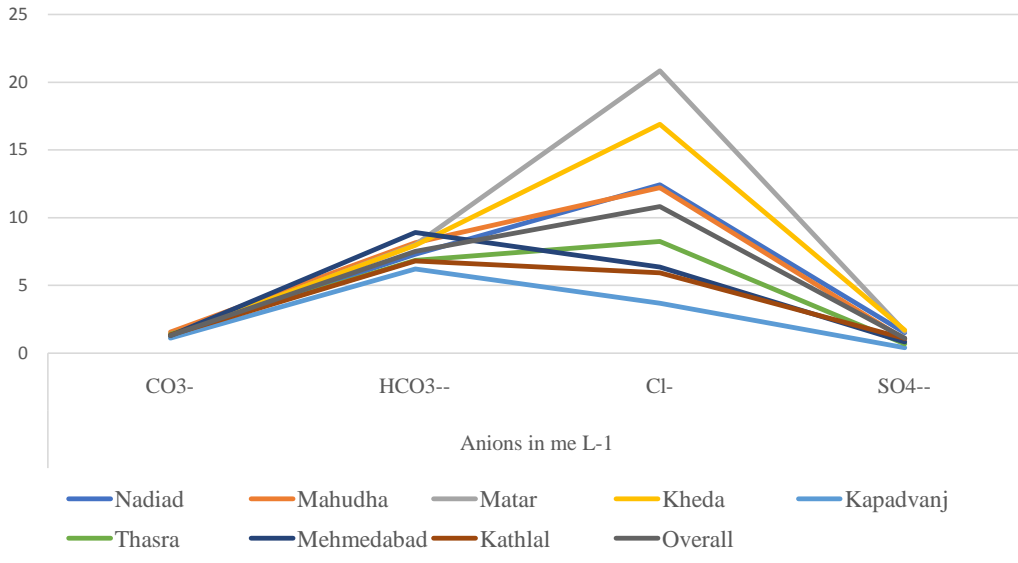
Matartalukaswhile the highest mean value of  $\text{HCO}_3^-$  (8.90 me  $\text{L}^{-1}$ ) was observed in Mehmedabadtaluka as well as  $\text{CO}_3^{--}$  (1.55 me  $\text{L}^{-1}$ ),  $\text{SO}_4^{--}$  (1.71 me  $\text{L}^{-1}$ )were observed in Mahudha and Khedatalukas, respectively. The overall range values for  $\text{CO}_3^{--}$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$  and  $\text{SO}_4^-$  were 0.00 to 4.00, 1.00 to 14.00, 1.00 to 71.50 and 0.00 to 2.13 me  $\text{L}^{-1}$ , respectively (Table 7.0). Similar results were also found by Timbadia (1988) for Jafrabad and Rajulatalukas of Amreli district

**Table 6.0.: Taluka wise range and mean value of cations of well/tube well water samples ofKheda district**

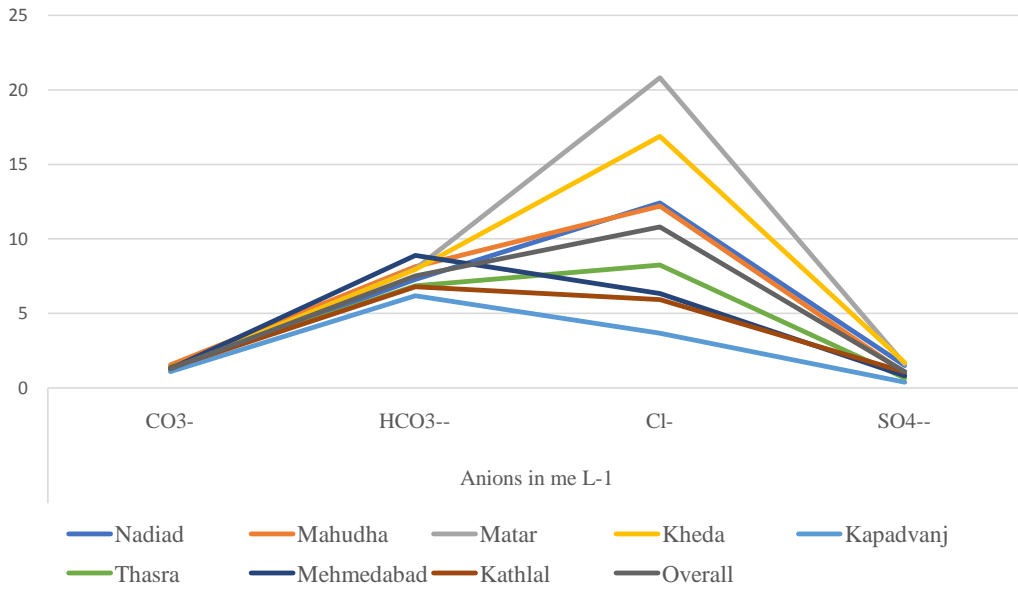
| NameofTaluka      | CationsinmeL <sup>-1</sup> |                      |                       |                     |
|-------------------|----------------------------|----------------------|-----------------------|---------------------|
|                   | Ca <sup>++</sup>           | Mg <sup>++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

Note: Valuesinparenthesisaremeanvalues

**Fig 3. Taluka wise mean value of cations of water samples of Kheda district**



**Fig 4. Taluka wise mean value of anions of water samples of Kheda district**



**Table 7.0.: Taluka wise range and mean value of anions of well/tube well water samples of Kheda district**

| Name of Taluka    | Anions in $\text{meL}^{-1}$ |                      |                       |                     |
|-------------------|-----------------------------|----------------------|-----------------------|---------------------|
|                   | $\text{CO}_3^-$             | $\text{HCO}_3^-$     | $\text{Cl}^-$         | $\text{SO}_4^{--}$  |
| <b>Nadiad</b>     | 1.00-3.00<br>(1.30)         | 3.00-11.00<br>(7.30) | 1.00-70.00<br>(12.43) | 0.00-2.11<br>(1.52) |
| <b>Mahudha</b>    | 1.00-4.00<br>(1.55)         | 3.00-14.00<br>(8.15) | 1.50-42.50<br>(12.20) | 0.00-2.09<br>(1.01) |
| <b>Matar</b>      | 0.00-2.00<br>(1.15)         | 3.00-12.00<br>(8.00) | 3.00-71.50<br>(20.83) | 0.00-2.13<br>(1.61) |
| <b>Kheda</b>      | 0.00-3.00<br>(1.25)         | 4.00-13.00<br>(7.95) | 3.00-37.50<br>(16.88) | 0.75-2.11<br>(1.71) |
| <b>Kapadvanj</b>  | 1.00-2.00<br>(1.10)         | 3.00-12.00<br>(6.20) | 2.00-10.00<br>(3.68)  | 0.00-1.96<br>(0.39) |
| <b>Thasra</b>     | 1.00-4.00<br>(1.40)         | 1.00-14.00<br>(6.85) | 1.50-27.00<br>(8.25)  | 0.00-2.02<br>(0.68) |
| <b>Mehmedabad</b> | 1.00-4.00<br>(1.30)         | 5.00-12.00<br>(8.90) | 1.50-27.00<br>(6.35)  | 0.00-1.98<br>(0.83) |
| <b>Kathlal</b>    | 1.00-2.00<br>(1.35)         | 3.00-12.00<br>(6.80) | 2.00-19.50<br>(5.93)  | 0.00-1.79<br>(1.08) |
| <b>Overall</b>    | 0.00-4.00<br>(1.30)         | 1.00-14.00<br>(7.52) | 1.00-71.50<br>(10.82) | 0.00-2.13<br>(1.10) |

Note: Values in parenthesis are mean values

#### Electrical Conductivity (EC)

The overall mean value of EC was found  $2.04 \text{ dS m}^{-1}$ , which was varied widely from  $0.51$  to  $8.50 \text{ dS m}^{-1}$ . The lowest value of EC ( $0.51 \text{ dS m}^{-1}$ ) was recorded in a sample taken from Kapadvanj taluka whereas the highest value of EC ( $8.50 \text{ dS m}^{-1}$ ) was reported in Matartaluka. The highest mean value ( $3.16 \text{ dS m}^{-1}$ ) was obtained in Matartaluka followed by Kheda ( $2.77 \text{ dS m}^{-1}$ ) and Mahudha ( $2.25 \text{ dS m}^{-1}$ ) talukas due to poor quality ground water. The lowest mean value ( $1.07 \text{ dS m}^{-1}$ ) was obtained in Kapadvanj taluka (Table 8.0). 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  $C_1$ ,  $C_2$ ,  $C_3$  and  $C_4$  classes of EC, respectively. None of the sample falls under  $C_1$  classes of EC. In Kheda district 101 samples fall under  $C_3$  class of EC and 44 samples under  $C_4$  and 15 samples fall under  $C_2$  class. So, the salinity hazard of irrigation water is the cause of the development of

secondary

salinization in the soils of Kheda district (Table 8.0). The result also revealed that overall, irrigation water of Kheda district fall in C<sub>3</sub> class (highly saline) irrigation water. The Nadiad, Mahudha, Kapadvanj, Mehmedabad and Kathlaltalukas having high saline irrigation water. Whereas, Matar and Kheda having very high saline irrigation water (Table 8.0). 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).

### **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 Kathlaltaluka whereas the lowest mean value of pH 7.70 was recorded in Mahudhataluka (Table 8.0). 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).

### **Residual Sodium Carbonate (RSC)**

Taluka wise range and mean values of RSC is given in Table 8.0 and percentage distributions of water samples in different RSC classes (as suggested by USDA) are presented in Table 8.0. The overall RSC values were ranged from 4.80 to 10.50 with a mean value of 2.41 me l<sup>-1</sup> which was less than 2.5 me l<sup>-1</sup> indicated poor quality irrigation water. The highest mean value of RSC (3.26 me l<sup>-1</sup>) was recorded in Kathlaltaluka indicate poor quality water, whereas the lowest mean value (2.01 me l<sup>-1</sup>) was obtained in Thasraluka (Table 8.0). For all talukas, except Kheda and Kathlal the RSC mean values were falling between 1.25 to 2.50 me l<sup>-1</sup>, which showed that irrigation water having marginal carbonate hazards and marginally fit for irrigation with adequate leaching. It also noted that the Kheda and Kathlaltalukas 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 Nagardistrict 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 8.0). This finding is in concurrence with the findings of Soodet *al.* (1998).

#### **Soluble Sodium Percentage (SSP)**

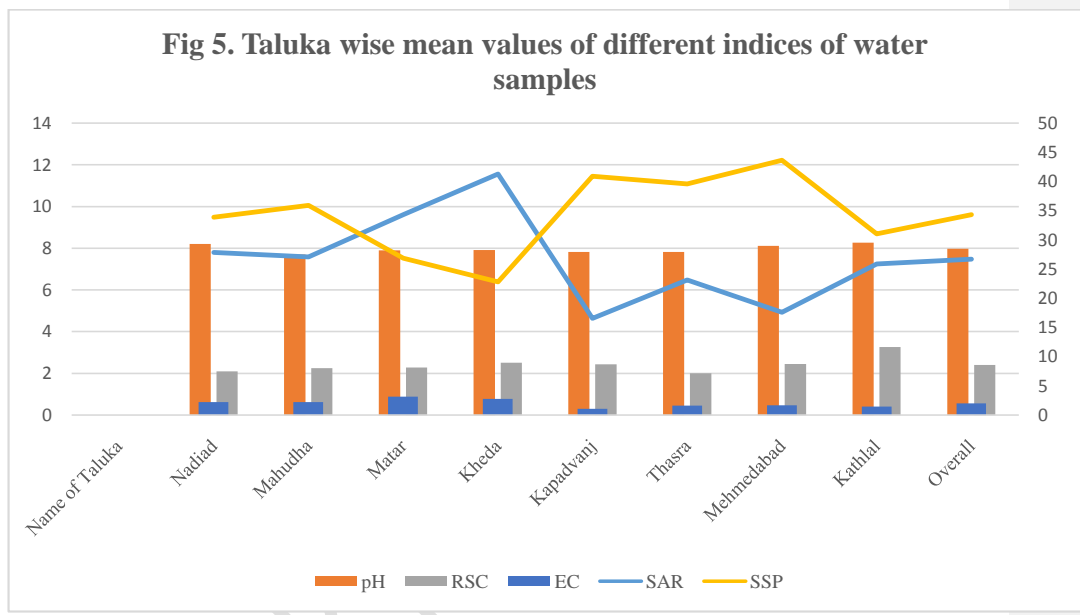
Taluka wise range and mean values of SSP is given in Table 8.0 and percentage distributions of water samples in different SSP classes (as suggested by USDA) are presented in Table 8.0. The overall mean value of SSP was 34.34 and ranged from 8.00 to 77.26 (Table 8.0). The highest mean value (43.65) was 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 8.0). 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 Soodet *al.* (1998). For most of soil samples SSP values were more than 60, which is 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).

#### **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 8.0. and per cent distribution of water sample in different SAR classes (as suggested by USDA) are presented in Table 8.0. The overall mean value of SAR was 7.48 and it 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<sub>1</sub>, S<sub>2</sub>, S<sub>3</sub> and S<sub>4</sub> classes of SAR, respectively. Almost 120 samples had SAR value less than 10 and 35 samples had SAR value greater than 10 (Table 8). The result also revealed that overall, irrigation water of Kheda district fall in S<sub>1</sub> class (Low Na) irrigation water. Whereas, all the talukas of Kheda district having low Na irrigation water except Kheda taluka fall in S<sub>2</sub> (Medium Na) irrigation water (Table 8.0). This finding is in concurrence with the findings of Soodet *al.* (1998) and Kabaria (2004).

**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 8.0. The result revealed that overall, irrigation water of Kheda district fall in C<sub>3</sub>S<sub>1</sub> class (high saline-low Na) irrigation water. Whereas, same result found in all talukas of Kheda district except Matar and Kheda fall in C<sub>4</sub>S<sub>1</sub> and C<sub>4</sub>S<sub>2</sub> irrigation water classes, respectively. This finding is in concurrence with the findings of Soodet *al.* (1998) and Kabaria (2004).



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**Table 8.0 : TalukawiserangeandmeanvaluesofEC,pH anddifferentindicesofwell/tubewellwatersamplesofKhedadistrict**

| <b>Nameof Taluka</b> | <b>EC (dSm<sup>-1</sup>)</b> | <b>pH</b>           | <b>RSC (meL<sup>-1</sup>)</b> | <b>SSP</b>             | <b>SAR</b>            | <b>ECandSAR classes</b>       |
|----------------------|------------------------------|---------------------|-------------------------------|------------------------|-----------------------|-------------------------------|
| <b>Nadiad</b>        | 0.73-8.20<br>(2.22)          | 7.32-9.30<br>(8.20) | -3.40-6.70<br>(2.10)          | 9.18-77.26<br>(33.89)  | 0.36-29.96<br>(7.79)  | C <sub>3</sub> S <sub>1</sub> |
| <b>Mahudha</b>       | 0.60-5.50<br>(2.25)          | 6.85-8.70<br>(7.70) | -4.80-8.70<br>(2.26)          | 16.65-62.77<br>(35.92) | 1.39-15.93<br>(7.58)  | C <sub>3</sub> S <sub>1</sub> |
| <b>Matar</b>         | 0.70-8.50<br>(3.16)          | 7.49-9.16<br>(7.90) | -4.00-7.40<br>(2.28)          | 12.72-43.38<br>(26.89) | 3.55-18.12<br>(9.60)  | C <sub>4</sub> S <sub>1</sub> |
| <b>Kheda</b>         | 0.70-4.80<br>(2.77)          | 7.18-8.54<br>(7.91) | -4.20-8.60<br>(2.51)          | 14.65-47.94<br>(22.83) | 2.30-16.68<br>(11.55) | C <sub>4</sub> S <sub>2</sub> |
| <b>Kapadvanj</b>     | 0.51-2.10<br>(1.07)          | 7.30-8.42<br>(7.82) | -1.80-8.80<br>(2.44)          | 8.82-60.73<br>(40.90)  | 1.33-15.63<br>(4.64)  | C <sub>3</sub> S <sub>1</sub> |
| <b>Thasra</b>        | 0.62-4.10<br>(1.66)          | 6.84-8.90<br>(7.82) | -3.00-10.40<br>(2.01)         | 10.87-73.83<br>(39.61) | 0.41-18.73<br>(6.48)  | C <sub>3</sub> S <sub>1</sub> |
| <b>Mehmedabad</b>    | 0.69-4.10<br>(1.69)          | 7.61-8.58<br>(8.11) | -0.70-7.20<br>(2.45)          | 25.33-61.65<br>(43.65) | 1.73-12.80<br>(4.93)  | C <sub>3</sub> S <sub>1</sub> |
| <b>Kathlal</b>       | 0.70-2.40<br>(1.48)          | 7.64-8.62<br>(8.27) | -4.60-10.50<br>(3.26)         | 8.00-54.01<br>(31.04)  | 1.77-20.11<br>(7.25)  | C <sub>3</sub> S <sub>1</sub> |
| <b>Overall</b>       | 0.51-8.50<br>(2.04)          | 6.84-9.30<br>(7.97) | -4.80-10.50<br>(2.41)         | 8.00-77.26<br>(34.34)  | 0.36-29.96<br>(7.48)  | C <sub>3</sub> S <sub>1</sub> |

Note: Values in parenthesis are mean values

## CONCLUSIONS

The well/tube waters of Kheda (C<sub>4</sub>S<sub>2</sub>) and Matar (C<sub>4</sub>S<sub>1</sub>) 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<sup>-1</sup> 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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