

# Groundwater Quality Appraisal and Categorization in Pillu Khera Block of Jind District, Haryana (India)

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**Abstract:** A study has been carried out for the quality appraisal of the groundwater of Pillu Khera block of Jind district in Haryana state, India. For the study 150 tube-well water samples from 23 villages of Pillu Khera block were collected during March 2004. Dominant cation in irrigation water was sodium followed by calcium and magnesium. Likewise, in case of anions, chloride was the dominant ion followed by bicarbonate and sulphate. RSC was observed only in tube-well waters having EC upto  $5 \text{ dS m}^{-1}$  and subsequent EC range of water did not show presence of RSC. Maximum number of underground water samples had EC between 1 and  $2 \text{ dS m}^{-1}$  and with increase in EC, number of tube-well water samples decreased, under various ranges. Groundwater having EC up to  $4 \text{ dS m}^{-1}$  can be used with no appreciable harmful effect on crop and soil but its long-term use depends on type of soil, rainfall and crop to be grown. Groundwater having EC more than  $4 \text{ dS m}^{-1}$  require special management practices depending upon the soil type, crop grown and climatic factors. Based on AICRP (1989) classification, water quality map of the block was prepared.

**Key words:** Groundwater, cation, anion, EC, RSC, SAR.

## Introduction

Development of surface and groundwater resources for irrigation plays a vital role in the production of food and fiber. Large parts of Australia, the Indian subcontinent, China, countries in the middle east, small parts of America and Europe and significant regions in north Africa are generally water deficient (Seckler et al., 1998) and the situation may further aggravate due to enhanced biotic pressure. Areas characterized by water scarcity are also usually underlain by aquifers of poor quality (Sharma, 2003). Nevertheless, driven by the pressure to produce more, even the brackish ground waters are being increasingly diverted to irrigated agriculture. The areas underlain with saline groundwater include the areas with high aridity, with high water table and water logged conditions and in the vicinity of seawater as in coastal

regions, while the alkali waters exist generally in areas with annual rainfall of 500-700 mm. Supplementary irrigation is important in India where one third of the land surface is arid and semiarid and the rainfall is seasonal and erratic. Haryana state comprises 12,840 sq. km of arid and 26,880 sq km of semi-arid area, which is respectively 4 and 3 per cent of total arid and semi-arid region in India. The semi-arid climate prevailing in Haryana necessitates the application of supplemental water for optimizing crop production. Since the tube-wells provide assured water supplies, their number has increased tremendously over the last few years. Majority of the underground tube-well waters contain high concentration of salts and their continuous use for irrigation adversely affects soil health and agricultural production. Therefore, for sound irrigation planning for assessing the possibility of salinity and alkalinity hazard

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in the soil, appraisal of the properties and extent of underground water is highly indispensable, so that where such waters are applied for irrigation, management practices may be designed, so as to sustain productivity for infinite period.

## Materials and Methods

Survey and characterization of underground irrigation water of Pillu Khera block of Jind district were undertaken during March 2004. The district comprises blocks, namely Narwana, Uchana, Safidon, Jind, Alewa and Julana besides Pillu Khera.

### Collection of Water Samples

Groundwater samples (150) were collected from 23 villages of Pillu Khera block. From each village a minimum of two and a maximum of 15 water samples were collected in the month of March 2004. Running tube-wells distantly apart within each village were

quality analysis of 150 samples, the water was categorized and classified on the basis of EC, SAR and RSC as per AICRP (1989) classification, as given in Table 1.

## Results and Discussion

### Chemical Composition of Groundwater

The range and mean of different water quality parameters of Pillu Khera block are presented in Table 2, EC values ranged between 0.26 and 7.80 dS m<sup>-1</sup> with a mean EC of 2.71 dS m<sup>-1</sup>. The lowest salt content (EC 0.26 dS m<sup>-1</sup>) in water samples was observed in village Mandikhurd and the highest value (7.80 dS m<sup>-1</sup>) was recorded in village Kalwa. SAR ranged from 0.20 to 14.50 (m mol L<sup>-1</sup>)<sup>1/2</sup> with a mean value of 4.26 (m mol L<sup>-1</sup>)<sup>1/2</sup>. Lowest SAR value was observed in village Mandikhurd (0.20) and the highest value recorded in village Kalawati (14.50). RSC varied between nil to 7.20 me L<sup>-1</sup> with an average value of 2.26 me L<sup>-1</sup>. Maximum value of RSC was found in village Hadwa. Sodium concentration in the samples

**Table 1: Irrigation water quality classifications, AICRP (1989)**

| S. No. | Quality           | Quality parameters |                             |  |                              |
|--------|-------------------|--------------------|-----------------------------|--|------------------------------|
|        |                   | Class              | EC<br>(dS m <sup>-1</sup> ) | SAR<br>(m mol L <sup>-1</sup> ) <sup>1/2</sup> | RSC<br>(me L <sup>-1</sup> ) |
| 1.     | Good              | A                  | <2                          | <10  | <2.5                         |
| 2.     | Marginally saline | B                  | 2-4                         | <10  | <2.5                         |
| 3.     | Saline            | C                  | >4                          | <10  | <2.0                         |
| 4.     | High SAR saline   | D                  | >4                          | >10  | <2.5                         |
| 5.     | Marginally alkali | E                  | <4                          | <10  | 2.5-4.0                      |
| 6.     | Alkali            | F                  | <4                          | <10  | >4.0                         |
| 7.     | Highly alkali     | G                  | Variable                    | >10  | >4.0                         |

selected randomly for collection of water samples. Each selected tube-well was run for three to four hours and then the samples were collected in thoroughly cleaned plastic bottles, properly labeled and brought to the laboratory for further chemical analysis.

### Analysis of Water Samples

Water samples were analyzed for pH, EC, cations (Ca<sup>++</sup>, Mg<sup>++</sup>, Na<sup>+</sup>, K<sup>+</sup>) and anions (CO<sub>3</sub><sup>-</sup>, HCO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>) by the standard methods of USDA Hand Book No. 60 (Richards, 1954) and sulphate was determined by Chesnin and Yein's (1950) method.

### Classification of Irrigation Waters

To characterize the quality of irrigation waters, electrical conductivity (EC), sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were worked out. After

**Table 2: Range and average of different water quality parameters in Pillu Khera block**

| S. No. | Parameters  | Range      | Average |
|--------|---|------------|---------|
| 1.     | EC (dS m <sup>-1</sup> )                            | 0.26-7.8   | 2.71    |
| 2.     | pH  | 7.03-9.30  | 8.00    |
| 3.     | Na <sup>+</sup> (me L <sup>-1</sup> )               | 0.55-48.0  | 11.96   |
| 4.     | K <sup>+</sup> (me L <sup>-1</sup> )                | 0.02-2.72  | 0.42    |
| 5.     | Mg <sup>++</sup> (me L <sup>-1</sup> )              | 0.60-20.0  | 6.26    |
| 6.     | Ca <sup>++</sup> (me L <sup>-1</sup> )              | 0.80-30.0  | 9.29    |
| 7.     | CO <sub>3</sub> <sup>=</sup> (me L <sup>-1</sup> )  | 0.00-2.40  | 0.83    |
| 8.     | HCO <sub>3</sub> <sup>-</sup> (me L <sup>-1</sup> ) | 2.00-24.8  | 9.33    |
| 9.     | Cl <sup>-</sup> (me L <sup>-1</sup> )               | 0.80-59.6  | 14.00   |
| 10.    | SO <sub>4</sub> <sup>=</sup> (me L <sup>-1</sup> )  | 0.56-23.81 | 4.28    |
| 11.    | RSC (me L <sup>-1</sup> )                           | 0.00-7.2   | 2.26    |
| 12.    | SAR (m mol L <sup>-1</sup> ) <sup>1/2</sup>         | 0.20-14.5  | 4.26    |

had a wider range (0.55 to 48.00 me L<sup>-1</sup>) followed by magnesium (0.60 to 20.00 me L<sup>-1</sup>), calcium (0.80 to 30.00 me L<sup>-1</sup>) and potassium (0.02 to 2.72 me L<sup>-1</sup>). Mean value for Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>++</sup> and Mg<sup>++</sup> was 11.96, 0.42, 9.29 and 6.26 me L<sup>-1</sup> respectively.

In case of anions, chloride was the dominant ion with maximum value (59.60 me L<sup>-1</sup>) observed in village Kalwa and minimum value (0.60 me L<sup>-1</sup>) was recorded in village Mandikhurd. Highest value of sulphate (23.81 me L<sup>-1</sup>) was recorded in village Dharoli and minimum (0.56 me L<sup>-1</sup>) observed in village Kharak Gadian. Bicarbonate ranged from 2.0 to 24.8 me L<sup>-1</sup> with maximum value observed in the water samples of village Kalwa. The carbonates varied from 0.0 to 2.4 me L<sup>-1</sup> with maximum value in the water samples of villages Beri Khera, Kalwa and Hadwa. In village Kalwa both carbonates and bicarbonates were present in maximum amount. Mean value for CO<sub>3</sub><sup>2-</sup>, HCO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup> and SO<sub>4</sub><sup>2-</sup> was found to be 0.83, 9.33, 14.00 and 4.28 respectively. Sood et al. (1998) reported that in Talwandi Sabo tehsil (Punjab) EC of groundwater varied between 0.55 to 13.47 dS m<sup>-1</sup>, soluble carbonates, bicarbonates and RSC of these waters varied from nil to 3.2, 2.0 to 17.7 and nil to 14.6 me L<sup>-1</sup> respectively.

It was observed that underground waters of Pillu Khera block are Na<sup>+</sup> > Ca<sup>++</sup> > Mg<sup>++</sup> > K<sup>+</sup> type in respect of cations and Cl<sup>-</sup> > HCO<sub>3</sub><sup>-</sup> > SO<sub>4</sub><sup>2-</sup> type in respect of anions. In arid and semi-arid regions various workers have reported the dominance of sodium and chloride ions in irrigation waters (Paliwal and Yadav, 1976; Minhas and Gupta 1992; and Sharma, 1998). The average chemical composition and related quality parameters in different EC range for Pillu Khera block are given in Table 3. Maximum number of samples (39) was in the EC range 1-2, meaning that most of the water samples had EC between 1 and 2 dS m<sup>-1</sup>. With increase in EC of the irrigation waters number of samples in different EC range

decreased gradually. It is further observed that 78.7 per cent water samples had EC < 4 dS m<sup>-1</sup>, 21.3 per cent samples had EC 4 to 8 dS m<sup>-1</sup> and no sample was having EC > 8 dS m<sup>-1</sup>. Na, Ca and Mg were the dominant cations in the water samples and average K concentration ranged from 0.28 to 2.94 me L<sup>-1</sup>. The concentration of these cations increased with the increase in the EC of the water samples. The magnitude of increase in sodium and magnesium concentration was much higher than the other two.

Concentration of chlorine and sulphate anions increased with the increase in the EC of the water samples. However, the chlorine content remained higher than sulphate throughout. Bicarbonates were also found in appreciable quantities whereas carbonates were in low quantities, but the concentration of these two anions did not show any relation with EC of irrigation water. Residual sodium carbonate was present only in waters having EC upto 5 dS m<sup>-1</sup> and subsequent EC range of waters did not show the presence of residual sodium carbonate, as given in Table 3. Average SAR value which increased with increase in EC of the water samples ranged from 1.56 to 9.40 (m mol L<sup>-1</sup>)<sup>1/2</sup>. The water samples having EC less than 4 dS m<sup>-1</sup> can be used with no appreciable harmful effect on crop and soil, but its long-term use depends on type of soil, rainfall and crops to be grown. The samples that are having EC greater than 4 dS m<sup>-1</sup> required special management practices depending upon the soil type, crop grown and climatic factors.

### Classification of Ground Waters

Based on EC and derived parameters i.e. SAR and RSC, the water samples were classified as per criteria for water quality classification given by AICRP (1989).

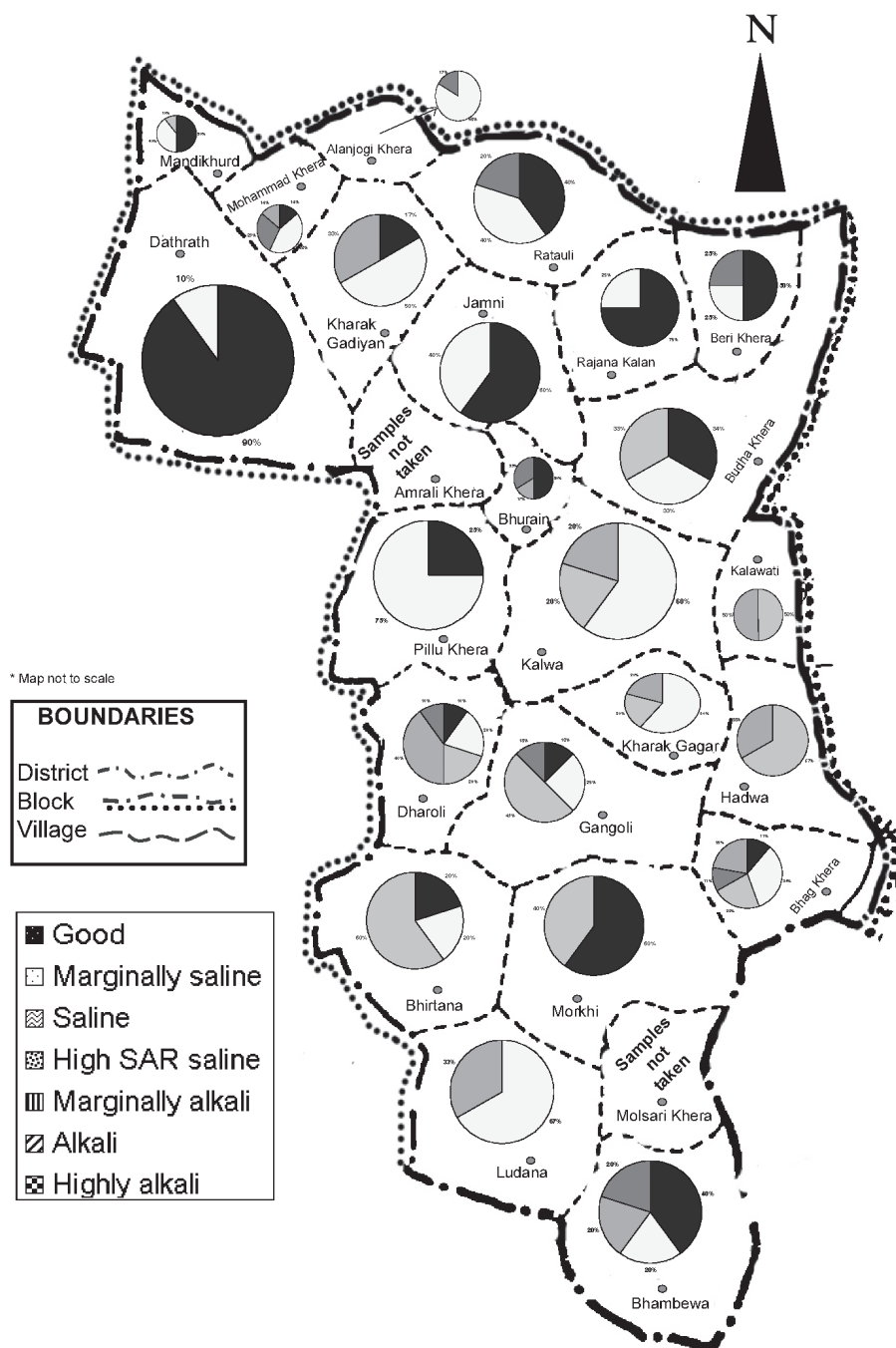
**AICRP Classification:** According to AICRP classification, in Pillu Khera block, 30 per cent water samples were found under good category, 30 per cent

**Table 3: Mean chemical composition and related quality parameters in different EC (dS m<sup>-1</sup>) range**

| S. No.             | EC range (dS m <sup>-1</sup> ) | No. of Samples | pH   | Na <sup>+</sup> | K <sup>+</sup> | Ca <sup>++</sup> | Mg <sup>++</sup> | CO <sub>3</sub> <sup>2-</sup> | HCO <sub>3</sub> <sup>-</sup> | Cl <sup>-</sup> | SO <sub>4</sub> <sup>2-</sup> | RSC  | SAR                                     |
|--------------------|--------------------------------|----------------|------|-----------------|----------------|------------------|------------------|-------------------------------|-------------------------------|-----------------|-------------------------------|------|---|
| me L <sup>-1</sup> |                                |                |      |                 |                |                  |                  |                               |                               |                 |                               |      | (m mol L <sup>-1</sup> ) <sup>1/2</sup> |
| 1                  | 0 - 1                          | 28             | 8.03 | 2.19            | 0.28           | 2.80             | 1.99             | 0.53                          | 4.25                          | 2.01            | 0.85                          | 0.58 | 1.56                                    |
| 2                  | 1 - 2                          | 39             | 8.00 | 8.03            | 0.38           | 4.43             | 3.27             | 0.71                          | 7.47                          | 5.73            | 1.77                          | 1.55 | 4.50                                    |
| 3                  | 2 - 3                          | 26             | 8.02 | 8.18            | 0.66           | 9.23             | 6.32             | 0.80                          | 9.48                          | 10.46           | 3.03                          | 0.12 | 2.98                                    |
| 4                  | 3 - 4                          | 22             | 7.95 | 13.69           | 0.47           | 12.48            | 8.03             | 0.70                          | 11.58                         | 17.20           | 4.93                          | 0.27 | 4.55                                    |
| 5                  | 4 - 5                          | 16             | 7.94 | 19.26           | 0.53           | 14.73            | 10.62            | 1.20                          | 13.26                         | 25.11           | 6.30                          | 0.80 | 5.87                                    |
| 6                  | 5 - 6                          | 9              | 8.13 | 26.65           | 0.84           | 19.81            | 11.68            | 1.44                          | 14.02                         | 35.31           | 10.99                         | Nil  | 7.27                                    |
| 7                  | 6 - 7                          | 8              | 7.85 | 37.46           | 0.49           | 20.15            | 13.81            | 1.25                          | 13.73                         | 41.53           | 18.54                         | Nil  | 9.25                                    |
| 8                  | 7 - 8                          | 2              | 8.25 | 41.50           | 2.94           | 25.50            | 14.00            | 1.80                          | 18.80                         | 58.60           | 17.28                         | Nil  | 9.40                                    |

| Salinity Level       | Percentage |
|----------------------|------------|
| A: Good              | 32%        |
| B: Marginally saline | 30%        |
| C: Saline            | 16%        |
| D: High SAR Saline   | 9%         |
| E: Marginally Alkali | 8%         |
| F: Alkali            | 5%         |

**Figure 1: Water quality classification of Pillu Khera block based on AICRP (1998) classification.**



**Figure 2: Quality distribution of underground waters in Pillu Khera Block.**

## Conclusion

Based on the results of the present investigation it can be concluded that maximum number of underground water samples of Pillu Khera block in district Jind had EC between 1 and 2 dS m<sup>-1</sup> and with increase in EC, number of tube-well water samples under various EC range gradually decreased. Dominant cation was sodium followed by calcium and magnesium. Likewise, in case of anions, chloride was dominant ion followed by bicarbonate and sulphate. RSC was observed only in tube-well waters having EC upto 5 dS m<sup>-1</sup> and subsequent EC range of water did not show presence of RSC. Groundwater having EC up to 4 dS m<sup>-1</sup> can be used with no appreciable harmful effect on crop and soil but its long-term use depends on type of soil, rainfall and crop to be grown. Groundwater having EC more than 4 dS m<sup>-1</sup> require special management practices depending upon the soil type, crop grown and climatic factors.

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