Ground-Water Quality in Islamkot and Mithi Talukas of District Tharparkar, Sindh, Pakistan

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ABSTRACT

Surface water supplies are gradually becoming short in arid and semi-arid regions of the world. Thus, assessment of groundwater quality for crop use appears to be very essential for management and utilization of precious natural water resources. This study reports the water quality of 52 hand pumps and one tube-well located in the most remote areas of desert region, viz. Islamkot and Mithi talukas of district Tharparkar. The water samples were collected during April 2016 (just before the start of rainy season). The water samples were analyzed for EC (Electrical Conductivity), pH, CO₃²⁻, HCO₃⁻, Cl⁻, Ca²⁺, Mg²⁺ and Na⁺ concentration. The SAR (Sodium Adsorption Ratio) and RSC (Residual Sodium Carbonates) were estimated using their respective formula. The categorization of water samples based on their soluble salt content clearly revealed that the water bodies of majority (65%) of areas were hazardous, while 25% areas were marginal. Thus, only 11% water samples of the area under study had useable irrigation water. Because of SAR and RSC the majority (89 and 77%, respectively) of water samples were found to be free from the sodicity hazard. The study concluded that salinity, and not sodicity was the major threat to the area under irrigation with these water bodies. It is, therefore, suggested that the salinity tolerant crops and their genotypes may be used in this area to sustain crop production.

Key Words: Groundwater Quality, Desert Area, Tharparkar

1. INTRODUCTION

Tharparkar is a southern district of Sindh province, Pakistan. The climatic condition of the district is mostly arid and semi-arid; having average annual rainfall less than 125mm. Fresh water resources in this area are limited, even for drinking purpose. However, agricultural crops are totally dependent upon precipitation. The uneven amount and distribution of rainfall further worsen the situation and dependent nature of the area. Because of this problem, wise management practices and other resource like groundwater can be used for irrigation purpose according to its quality criteria [1]. Almost all waters containment with salts; however, the quality of water depends on the composition and concentration of ions present in it [2-3]. It is very much
critical to recognize the changes in strategies of water suitability for long term productivity of crops [4]. Quality of ground water has been assessed by different scientists in Tharparkar district. They reported that the water samples were saline and sodium hazardous [5-6]. It has been reported that the low quality of groundwater of Pakistan mainly due to available or more soluble salt within it [7]. According to the recent studies, the ground water contains high concentration of soluble salts and sodium ions that are used for irrigation purpose cause soil salinity or soil sodicity [8]. Whereas some water is suitable for irrigation purpose if it contains salt below the hazardous level [9]. This study assesses quality of ground water according to the usability for indigenous crops of the area.

2. MATERIALS AND METHOD

2.1 Water Sampling

Populous villages of two taluka of district Tharparkar, i.e. Mithi and Islamkot, were selected for this study. From the selected 53 locations (25 of Mithi Taluka and 28 of Islamkot Taluka), sampling of ground water from 52 hand pumps and 1 Tube well (Khario Nara) were collected and analyzed through the suggested methods [10]. The depth of water pumps were also noted (Table 1), which was in the range of 18.3-76.2m. Collected samples were transported to the laboratory of bio-saline, Department of Soil Science, Sindh Agriculture University, Tandojam, Pakistan, for further analysis.

2.2 Water Analysis

Collected water samples were analyzed following the suggested protocol [11], for ECiw through standardized digital EC meter (Cyber Scan CON 11, Singapore) and pH using digital pH meter (Lavibond pH110, Singapore). Different soluble including Na+ were analyzed using flame photo meter; whereas total Ca2+ and (Ca2+ + Mg2+) were determined through complex metric titration with EDTA (Ethylene Diamine Tetra Acetic Acid) solution, using 2-3mL of 2 N NaOH solution and about 50mg ammonium purpurate as an indicator for calcium and 3-5mL buffer solution (NH4Cl-NH4OH) and few drops of Eriochromeblack-T as an indicator for calcium plus magnesium. Whereas for anion like CO3^2-, 1ml phenolphthalein indicator (1%) was added to measured amount of water sample. If its colour becomes pink, it indicates the presence of carbonates. Methyl orange indicator 0.1% was used for determination of HCO3-. H2SO4 (0.01 N) was used for titration in the case of carbonates and bicarbonate analysis. Whereas chlorides were analyzed through 0.005 N AgNO3 (Mohrs’s titration) using potassium chromate (K2CrO4) 5% as an indicator.

SAR [12] and RSC [12-13] were calculated with the formulas give below:

\[
SAR = \frac{Na^+}{[(Ca^{2+} + Mg^{2+})/2]^{0.5}}
\]

\[
RSC \text{ (meq L}^{-1}) = [(CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})]
\]

| No. | Classification | ECiw (dS m⁻¹) | SAR   | RSC   |
|-----|----------------|----------------|-------|-------|
| 1.  | Useable C1S1R1 | <1.5(C1)       | <10(S1) | <2.5(R1) |
| 2.  | Marginal C2S2R2 | 1.5-3.0 (C2)  | 10-18(S2) | 2.5-5.0 (R2) |
| 3.  | Hazardous C3S3R3 | >3(C3)       | >18(S3) | >5(R3) |

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2.2 Water Quality Classification

Irrigation water quality is classified based on salinity and sodium hazard (SAR and RSC) to the plant growth and development. Critical limits for these criteria are mentioned in Table 1 [14].

2.3 Statistical Analysis

The data were statistically analyzed for minimum value, maximum value, mean, mode standard deviation and coefficient variance using Microsoft Excel [15].

3. RESULTS AND DISCUSSION

3.1 Chemical Composition and Properties of Groundwater

There are some specific quality parameters of groundwater related to the managing irrigation for better crop production. Parameters including EC$_{iw}$, pH, different ions, SAR and RSC were used to evaluate the water quality for irrigation purposes [14,16].

3.1.1 Electrical Conductivity

EC is the measurement of conductance in water. The conductance increases with increasing salt concentration in water [17]. The data reported in Table 2 shows that EC$_{iw}$ of groundwater ranges from 0.3-13.5 dS m$^{-1}$ and 38% of samples recoded (Table 3) above the mean (4.9 dS m$^{-1}$) value. According to classification [14], groundwater containing EC$_{iw}$ values less than 1.5 dS m$^{-1}$ have been considered as useable, whereas in the range of 1.5-3 dS m$^{-1}$ as marginal and more than 3 dS m$^{-1}$ considered as hazardous for irrigating the crops.

3.1.2 pH

The pH indicates the acidity and alkalinity of groundwater and the normal range of pH is 6.5-8.4 for irrigation water [16]. Out of collected 53 groundwater samples 54.7% fall in the normal range and others were above that normal limit. The pH value recorded of groundwater samples were varied from 7.3-9.0 (Table 2) and mean value (8.06) was in the normal range.

3.1.3 Sodium Adsorption Ratio

The quality of irrigation water mainly depends upon the salinity and sodicity parameters. SAR is the measurement of potential hazardous of Na$^+$ over the Ca$^{2+}$ and Mg$^{2+}$. The SAR values are mostly used for predicting the accumulation of Na$^+$ in soil that causes the sodicity problem [18]. The minimum SAR (4.0) and maximum SAR (15.5) and mean (7.4) values were recorded (Table 2) of groundwater samples.

3.1.4 Residual Sodium Carbonates

RSC is the excess value of Ca$^{2+}$+Mg$^{2+}$ as of CO$_3^{2-}$+HCO$_3^-$ that effects the quality of irrigation water [19]. The collected samples of groundwater had value of RSC as recorded in Tables 2-3 aranging from -7.08-8.4 with average value (0.74). A negative RSC value indicates low sodium hazardous, whereas positive value shows high risk and accumulation of Na$^+$ on soil sites with releasing of Ca$^{2+}$ and Mg$^{2+}$[20].

3.2 Categorization of Water Samples

Groundwater water samples were categorized [14] in different classes (Table 1), based on three parameters EC$_{iw}$ (C), SAR (S) and RSC (R), each parameter divided into useable, marginal and hazardous.

As per classification [14], EC values 11, 25 and 64%, SAR values 89, 11 and 0% and as of RSC values 77, 19 and 4% groundwater samples fall in the categories of useable, marginal and hazardous respectively (Fig. 1).
| Site No. | Name of Village     | Depth (m) | ECw (dS/m) | pH | SAR | RSC | Classes     |
|---------|---------------------|-----------|------------|----|-----|-----|-------------|
| 1       | Mithi-1             | 51.8      | 11.1       | 8.7 | 8.1 | -5.39 | C3S1R1     |
| 2       | Mithi-2             | 54.9      | 11.4       | 8.7 | 7.1 | 2.01  | C3S1R1     |
| 3       | Mithi-3             | 54.9      | 11.1       | 8.6 | 5.2 | 1.93  | C3S1R1     |
| 4       | Mithi-4             | 53.3      | 9.7        | 8.7 | 8.8 | 1.15  | C3S1R1     |
| 5       | Pabuhar-1           | 39.6      | 2.9        | 7.3 | 4.4 | -7.08 | C2S1R1     |
| 6       | Pabuhar-2           | 41.1      | 9.2        | 8.0 | 9.2 | 0.01  | C3S1R1     |
| 7       | Kakshemeja          | 54.9      | 9.1        | 8.0 | 7.5 | 2.74  | C3S1R1     |
| 8       | Mithi-1             | 54.9      | 11.4       | 8.7 | 8.1 | -5.39 | C3S1R1     |
| 9       | Mithi-2             | 54.9      | 11.1       | 8.6 | 5.2 | 1.93  | C3S1R1     |
| 10      | Mithi-3             | 53.3      | 9.7        | 8.7 | 8.8 | 1.15  | C3S1R1     |
| 11      | Mithi-4             | 53.3      | 9.7        | 8.7 | 8.8 | 1.15  | C3S1R1     |
| 12      | Mithi-5             | 53.3      | 9.7        | 8.7 | 8.8 | 1.15  | C3S1R1     |

**TABLE 2. NAME OF SITES, DEPTH, ECw, AND pH, SAR, RSC AND CLASSES WITH DESCRIPTIVE STATISTICS OF WATER BODIES OF STUDY AREA OF TALUKA MITHI AND ISLAMKOT**

Minimum: 18.3  N  8.0  N  0.03  C3S1R1
Maximum: 76.2  13.5  9.0  15.5  8.40  C3S1R2
Mean: 49.2  4.9  8.1  7.4  0.74  C3S1R1
Mode: 51.8  8.0  0.03  C3S1R1
STD: 14.2  3.2  0.39  2.4  2.77  C3S1R1
CV: 0.29  0.65  0.05  0.32  3.74  C3S1R1
3.3 **Classification of Groundwater Samples**

Groundwater samples were classified (Table 4) in the different groups according to the suggestions [14], with number of sites including C1S1R1 (4), C1S2R1 (1), C1S2R2 (1), C2S1R1 (11), C2S1R3 (1), C2S2R2 (1), C3S1R1 (22), C3S1R2 (8), C3S1R3 (1), and C3S2R1 (3). Majority of samples fall in the category C3S1R1 that is saline hazardous, but SAR and RSC in usable limits. Only four samples were of the category C1S1R1 (Good quality water related to all parameters).

3.4 **Recommendation of Selected Plant Species**

Tolerance plants have decreased growth at higher concentration, but maintained at low salt concentration. Whereas salt-sensitive crop is affected by the low concentration of salt. The different plant species (Table 5) fall in the various categories, i.e. tolerant, moderately tolerant, moderately sensitive and sensitive.

| TABLE 3. PERCENTAGE OF SAMPLES FALL ABOVE MEAN VALUE OF EC\textsubscript{w}, PH, SAR AND RSC |
|---------------------------------|-----------------|-----------------|
| **Parameters** | **Mean Value** | **Number of Samples far above the Mean Value** |
| EC\textsubscript{w} (dS m\textsuperscript{-1}) | 4.90 | 20 | 38% |
| pH | 8.06 | 11 | 29% |
| SAR | 7.40 | 29 | 55% |
| RSC | 0.74 | 16 | 30% |

**FIG 1. GROUNDWATER QUALITY OF TALUKA MITHI AND ISLAMKOT ON THE BASIS OF EC, SAR AND RSC**
5. CONCLUSION

Quality of groundwater should be suggested periodically, because the properties of water changes time by time. Our results reveal that the water samples vary from useable, marginal and hazardous quality as per salinity ECw and RSC values. However, almost all groundwater samples fall in two categories useable and marginal as of SAR values, whereas no one sample had sodium hazardous for irrigation. There were presence of major cations and anions sequences in groundwater Na\(^+\) > Mg\(^{2+}\) > Ca\(^{2+}\) and Cl\(^-\) > HCO\(_3^-\) > CO\(_3^{2-}\). The samples were slightly alkaline to highly alkaline pH in nature. All water samples were classified into different groups and each group consisted of number of samples like 4, 1, 11, 1, 1, 22, 8, 1 and 3 in separate group C1S1R1, C1S2R1, C1S2R2, C2S1R1, C2S1R3, C2S2R2, C3S1R1, C3S1R2, C3S1R3 and C3S2R1, respectively. In crux, we report that salinity, and not sodicity, was the major threat to the area under irrigation through these water bodies. Hence, we suggest the use of saline-tolerant crop and their genotypes in these areas for sustainable crop production.

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### TABLE 4. GROUNDWATER QUALITY CLASSES OF TALUKA MITHI AND ISLAMKOT

| Classes   | No. of Samples | Sampling Site Numbers |
|-----------|----------------|-----------------------|
| C1S1R1    | 4              | 24, 29, 30 and 34    |
| C1S2R1    | 1              | 28                    |
| C1S2R2    | 1              | 14                    |
| C2S1R1    | 11             | 5, 10, 26, 32, 33, 35, 38, 39, 40, 44 and 48 |
| C2S1R3    | 1              | 43                    |
| C2S2R2    | 1              | 47                    |
| C3S1R1    | 22             | 1, 2, 3, 4, 6, 8, 9, 11, 12, 13, 15, 16, 17, 20, 21, 22, 37, 41, 42, 49, 50 and 53 |
| C3S1R2    | 8              | 7, 18, 25, 36, 45, 46, 51 and 52 |
| C3S1R3    | 1              | 23                    |
| C3S2R1    | 3              | 19, 27 and 31         |

### TABLE 5. SELECTED SALT-TOLERANT PLANT SPECIES GROWN UNDER DIFFERENT SALINE WATER ENVIRONMENT [14]

| Plant Categories         | Water Quality Criteria | Plant Species                                                                 |
|--------------------------|------------------------|-------------------------------------------------------------------------------|
| Tolerant                 | Hazardous              | Barley, cotton, date palm                                                     |
| Moderately Tolerant      | Marginal               | Guar, jujube, sorgham                                                         |
| Moderately Sensitive     | Just above useable     | Cucumber, egg-plant, musk melon, radish, Spinach, water melon, pearl millet, mung bean |
| Sensitive                | Useable                | Carrot, lemon, onion, sesame                                                   |
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