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CHARACTERIZATION AND ESTIMATION OF IRRIGATION WATER QUALITY: A GENERAL STUDY OF DISTRICT GUJRAT, PUNJAB-PAKISTAN

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Abstract

The quality of irrigation water determines the soil health. The good quality irrigation water ensures the better yield of crops. A study was conducted all over Gujrat District, Pakistan to interpret the quality of irrigation water. In this study the random sampling for water samples was carried out throughout three tehsils of district Gujrat including Gujrat, Kharian and Sara-i-Alamgir for a period of five years. The irrigation water quality was assessed on three parameters i.e., EC (uS/cm), RSC (meq/L) and SAR (Sodium adsorption ratio). About 2020 water samples from Tehsil Gujrat, 259 from Tehsil Kharian, and 12from Tehsil Sara-i-Alamgir were collected. The highest values of EC (522-1645), SAR (0.00-14.97) and RSC (0.00-9.4) was noted in Tehsil Gujrat which is the biggest Tehsil of Gujrat District. The study revealed higher fitness in EC as compared to RSC and SAR. The overall fit water samples were 78.27 % that reflected good water quality of District Gujrat, while marginally fit water samples were5.45%, and unfit water samples were 16.23%. It was also concluded that 91% water samples were unfit due to EC. Hence, it may be recommended where the quality parameters are poor, the water needs reclamation for better crop yield.

Keywords: *EC, Irrigation water, Jhelum, RSC, SAR, Soil fertility*

INTRODUCTION

The Gujrat lies in between Jhelum and Chenab Rivers and it covers an area of 3192 square kilometers. The total cultivated area is 572911 acres (1). It has a semi-arid climate with distinct seasons. It has moderate climate that is hot in summer and cold in winter. During peak summer, the day temperature goes up to 50 °C, but the hot periods are relatively shorter due to proximity of mountains of Azad Kashmir. The winter seasons are very pleasant and the minimum temperature may fall below 2 °C. The average rainfall on the Kashmir border is over 1000 mm, at Kharian it is 750 mm, at Gujrat 670 mm, and at Sara-i-Alamgir 500 mm (2). The literacy rate of Gujrat is significantly higher than national average of Pakistan which was 60.7% in 2023. The district of Gujrat is an agricultural land along with industrial city and a huge number of people depend on their livelihood through agriculture production (3). The most basic and critical requirement for survival of living organisms is water. With the increasing expansion of industrialization and urbanization, ensuring the sustainable use of water resources to solve the supply–demand gap remains a global problem (4). The inadequacy of water resources is one of the leading challenges in the world, predominantly for the primary freshwater consumer, i.e., agriculture (5). Water scarcity and suitable irrigation water management in arid regions represent tangible challenges for sustainable agriculture (6). It is a fact that agriculture is the largest consumer of water, especially in arid and semi-arid regions, hence detecting and managing quality of surface water in these areas is mandatory to preserving water resources

and promoting sustainable agriculture (7). The underground water is one of the most precious sources of water on earth. It is mostly utilized in the form of agricultural activities, domestic, industrial, and it is the purest water as compared to other sources due to many filtration processes beneath soil (8).All the irrigation waters in general contain dissolved constituents in the form of cations and anions. The concentration and nature of these dissolved constituents determine the quality of the irrigation water. Water containing lower concentration of salts of carbonate and bicarbonate ions but having a high proportion of divalent cations (Ca^{2+} + Mg^{2+}) over sodium (Na^{+}) is considered to be of good quality. Therefore, the evaluation of important chemical parameters of water quality covering the hydrochemistry of the different areas is being carried out extensively throughout the world. These quality parameters play a vital role in management practices in ground water (9, 10). Periodic assessment of irrigation water quality evaluates the harnessing effect of water on soil physical, chemical and biological properties. Characterization of irrigation water quality at field level will help farmers directly in crop management practices and reclaiming soil health (11). A lot of different indices of water quality have been considered for evaluation (12). The groundwater quality is also going at alarming levels due to industrial processes that are contaminating the sub soil water reservoirs finally affecting human health and the ecosystem entirely (13, 14). The water quality deterioration is a threat to public health (15). In addition, the human-induced actions, like improper disposal of industrial and municipal effluents and excessive use of chemical fertilizers and pesticides are also playing a pivotal role in deteriorating the quality of ground water (16, 17). The dominant hydro-chemical facies were Ca-Mg/Cl-SO_4 and results suggested that natural sources play a role in shaping hydrochemistry (18). Identifying the water contamination of a water body that worsens the dependent ecological community is a pillar for sustainable management (19). There is no any specific method or reclamation technique to solve the problem of unfit water, however, as a collective efforts can be made to minimize the consequences of poor quality water (20).

MATERIALS AND METHODS

WATER SAMPLING

The present study was conducted in the Soil and Water Testing Laboratory Gujrat having water samples collected from three Tehsils of Gujrat i.e., Gujrat, Kharian and Sara-i-Alamgir. The collection of water samples was carried out from different tube wells with GPS (Geographical Positioning System) reading. Each water sample was collected at the depth of 80-250 feet after the 30 minutes of running the tube well water following sampling protocol by Department (21). The collected water samples were stored in clean, transparent plastic bottles. Each sample was labeled with necessary information

WATER ANALYSIS

During the study period, 2291 water samples were collected and analyzed for electrical conductivity, cations (Ca^{+2}, Mg^{+2}, and Na^{+}), anions ($CO3^{-2}$, HCO_3^{-1}, and Cl^{-1}) at the Soil and Water Testing Laboratory Gujrat. Residual sodium carbonates (RSC) and sodium adsorption ratio (SAR) were calculated using formulas according to the previous studies (22). During analytical work all SOPs of Soil Fertility Research Institute, Punjab, Lahore was strictly followed (21).

The parameters under study are shown in Table I.

SAR = Na; $\sqrt{Ca + Mg}/2$; RSC (Me/L) = $(CO3^{--} + HCO3^{-}) - (Ca^{++} + Mg^{++})$

Table I. Water analysis parameters criteria for irrigation water quality

Parameters	Fit	Marginally fit	Unfit
EC (µS/cm)	0-1000	1000-1250	>1250
SAR	0-6	6-10	>10
RSC (meq/L)	0-1.25	1.25-2.50	>2.50

RESULTS AND DISCUSSION

ELECTRICAL CONDUCTIVITY (µS/cm)

The categorization of water samples for fit, marginally fit and unfit based on EC (µS/cm) is

depicted in Table II. It was observed that in Tehsil Gujrat, 76.63% of samples were fit, 4.97% marginally fit and just 18.39% were found unfit. In Kharian, 80.66% of water samples were fit, 7.3% marginally fit and 12.02% were unfit. Similarly, in Sarai Alamgir, 75.59% of water samples were fit, 9.52% marginally fit and 14.88% were unfit.

Table II. Classification of water samples based on EC (µS/cm) in different Tehsils of Gujrat

Sites	Total samples	Fit		Marginally fit		Un fit	
		Samples	%age	Sample	%age	Samples	%age
Gujrat	1549	1187	76.63	77	4.97	285	18.39
Kharian	574	463	80.66	42	7.3	69	12.02
Sara-i-Alamgir	168	127	75.59	16	9.52	25	14.88

SODIUM ADSORPTION RATIO (SAR) STATUS

The categorization of water samples based on SAR is shown in Table III. The following data showed that in Tehsil Gujrat 77.66% of samples were fit, 5.68% marginally fit and 16.65% were unfit. The analytical dataregarding Kharian showed that 84.32% of water samples were fit, 6.79% marginally fit and 8.89% were unfit. In Sara-i-Alamgir, 83.92%ofwater samples were fit, 7.73% were marginally fit and 8.33% were unfit.

Table III. Classification of water sample on the basis of SAR indifferent Tehsils of Gujrat

Sites	Total samples	Fit		Marginally Fit		Unfit	
		Sample	%age	Samples	%age	Samples	%age
Gujrat	1549	1203	77.66	88	5.68	258	16.65
Kharian	574	484	84.32	39	6.79	51	8.89
Sara-i-Alamgir	168	141	83.92	13	7.73	14	8.33

RESIDUAL SODIUM CARBONATE (RSC) STATUS

The categorization of water samples based on RSC is shown in Table IV. The following data showed that in Tehsil Gujrat 79.21% of samples were fit, 6.52% marginally fit and 14.27 % were unfit. The analytical data regarding Kharian showed that 85.01% of water samples were fit, 8.53% marginally fit and 6.44% were unfit. In Sara-i-Alamgir, 81.74% of water samples were fit,

8.33% were marginally fit and 8.92% were unfit.

Table IV. Classification of water sample on the basis of RSC in different Tehsils of Gujrat

Sites	Total samples	Fit		Marginally Fit		Unfit	
		Sample	%age	Samples	%age	Samples	%age
Gujrat	1549	1227	79.21	101	6.52	221	14.27
Kharian	574	488	85.01	49	8.53	37	6.44
Sara-i-Alamgir	168	139	82.74	14	8.33	15	8.92

CUMULATIVE IMPACTS OF EC, SAR & RSC ON QUALITY OF IRRIGATION WATER QUALITY

Ultimately classifying the water samples on the three quality parameters EC (µS/cm), RSC (meq/L), and SAR in district Gujrat, the results were shown in Table V. It is concluded that according to the values of EC (µS/cm), 77.56% of water samples were fit, 5.89% marginally fit, and 16.54%unfit. Likewise, based on values of RSC (meq/L), 80.92% of samples were fit, 7.16% were marginally fit and 11.92% found unfit. As inthe case of SAR, 79.79% of samples were fit, 6.11% were marginally fit and 14.10% were unfit.

The groundwater quality for irrigation use was the mandate of this study. Based on the classification, the analytical data shows that 18.39%, 12.02% and 14.88% of water samples were unfit due to EC in Tehsil Gujrat, Kharian and Sara-i-Alamgir, respectively having high content of soluble salts. The quality of irrigation depends on amount of dissolved salts. The quantity and type of dissolved salts in water

determine its suitability for irrigation. The Water infiltration rate, salinity and specific ion toxicity are most often monitored to evaluate water quality (15). Based on the classification, the analytical data shows that 16.65%, 8.89% and 8.33% of water samples were found to be unfit due to SAR in Tehsil Gujrat, Kharianand Sara-i-Alamgir, respectively. Many researchers(23, 24) also reported that calcium and sodium is dominant in groundwater as compared to other cations which result due to minerals and rocks composition, chemical reaction, and dissolution of those minerals which are enriched with Na^+ and Ca^{2+}. It is also reported that anions like Cl^- and SO_4^{2-} were also dominant. Based on the classification, the analytical data shows that 14.27%, 6.44% and 8.92% of water samples were found to be unfit due to RSC in Tehsil Gujrat, Kharian and Sara-i-Alamgir, respectively. The sodium reacts with carbonate and bicarbonate and consequently leads to higher RSC. These carbonate react with alkaline earth cations specifically calcium and magnesium to produce calcium carbonate and bicarbonate that are all preponderance to increasing the RSC value of groundwater(8). Actually, in the Potohar areas, being arid and semi arid region, a higher ratio of sodium to chloride retained at the surface of the soil due to low rainfall, high temperature (25). Ina nutshell, it was observed that all three parameters are considered to assess the appropriateness of the quality status of underground water. In all of the Tehsils, it was noticed that 14.19% of tube wells have poor quality water and deteriorating the soil health. It has been scientifically proved that poor quality of water put hazardous effects on soil quality and fertility.

Table V. Classification of water sample on the basis of EC, RSC and SAR in different Tehsils of Gujrat

Quality parameters	Total	Fit		Marginally fit		Unfit	
		Samples	%age	Samples	%age	Samples	%age
EC (µS/cm)	2291	1777	77.56	135	5.89	379	16.54
RSC (meq/L)	2291	1854	80.92	164	7.16	273	11.92
SAR	2291	1828	79.79	140	6.11	323	14.10

CONCLUSION

The mixing of good quality water with tube well water is an approach to minimize the groundwater brackish effect that will reduce the EC of groundwater and make it suitable water for crops. The lining of gypsum stones placed at water channels releases calcium and sulphate minimize SAR of irrigation water. Commercial acids like sulfuric acid and elemental sulfur are beneficial to neutralize carbonate and bicarbonates which finally reduce RSC of groundwater. The use of efficient irrigation methods and water harvesting techniques for rainwater for the recharge of groundwater is the need of hour.

Conflict of interest:

There is no conflict of interest in this study.

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Authors' contribution:

SA Conceptualization, methodology, writing original draft; MSA & ST Conceptualization and methodology; TM & AH Methodology, investigation, visualization and formal analysis; AW, MUHK & MN Formal analysis, investigation and visualization; IAS, SAl & HRA Data curation, writing, review and editing.

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