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Assessment of Groundwater Quality for Irrigation in Hafizabad District, Punjab, Pakistan

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Abstract

The water and environment has become an emotive issue with the people and policy makers. The chief causes for the pollution of water and environment are anthropogenic activities of human beings. The primary objective of this paper is to study the groundwater quality parameters in the surrounding tube wells of Hafizabad district, Punjab, Pakistan. The availability of groundwater, namely fresh water, with the passage of time is becoming too less. This alarming situation provokes the scientific community for further investigations and research in the field of groundwater exploration of fresh water and natural recharge estimation endeavors, which are the most important components essential to formulate dependable groundwater management strategies in scarcity, affected regions. Hydrochemical studies were conducted in Lower Chenab Canal System District, Hafizabad, Punjab. Pakistan Groundwater samples from 71 locations were collected from bore wells during 15 May - 15 June 2013 (Pre-Monsoon) and 15 October - 15 November 2013 (Post-Monsoon) period and analyzed for EC, SAR and RSC parameters. Based on various indices for irrigation purpose the average value for EC, SAR and RSC parameters were 1.26 (pre) 1.23 (post), 5.12 (pre) 5.09 (post) and 1.53 (pre) 1.53 (post) respectively. On the basis of these parameters and water quality standards, the water is classified for safe irrigation uses. The concentration of EC in groundwater ranges from 0.80-1.40 dSm-1. EC, SAR and RSC reflect that the water belong to fit or unfit for irrigation. The calculated results suggest that most of the samples are within the permissible limits which can be used for irrigation. High SAR and RSC content in groundwater can be attributed to the continuous water rock interaction during the process of percolation with soluble salts bearing country rocks under arid, low precipitation and high evaporation conditions of the study area. During last few years, the utilization of surface and groundwater for drinking, industrial and agricultural purposes has increased manifolds but consequently it is observed that the water is polluted and affecting the human health, soil nutrients, livestock, biomass and environment in certain areas. Hence a study has been carried out for the quality of the available ground water.

Keywords: Groundwater; Tube wells/Bore wells; EC; SAR; RSC fit; Unfit

Introduction

Pakistan, is a tropical county especially Punjab with a vast diversity of climate, topography and vegetation. Though blessed with fairly high annual rainfall, it is not uniformly distributed in time and space resulting in bulk of the rainfall escaping as runoff. This results in incomplete utilization of available surface water. The scarcity of surface water especially in the lean season in most parts of the country means that groundwater plays a decisive role. Water is one of the most indispensable resources and is the elixir of life and primary cause for the origin of life on earth planet. Water constitutes about 70% of the body weight of almost all living organisms. Life is not possible on this planet without water. It exists in three states namely solid, liquid and gas. It acts as a media for both chemical and biochemical reactions and also as an internal and external medium for several organisms. About 97.2% of water on earth is salty and only 2.8% is available as fresh water from which about 20% constitutes groundwater. The main source of water in the earth is through rivers, lakes, oceans and the subsurface groundwater aquifers. Groundwater is highly valued because of certain properties not possessed by surface water. Water can be used for various purposes like domestic, agriculture, industrial and etc.

Due to increase in human population and technology growth day by day, the available storage of groundwater is over exploited without considering its adverse effect on the aquifer system, which causes depletion in water level and deterioration in quality of groundwater. The availability of groundwater, namely fresh water is too less. The storage of groundwater mostly depends on the rainfall and how much recharge is taking place during rains. But due to non-uniform distribution of rainfall and failure of monsoon in our country, the existing available groundwater resources are not able to meet the increasing demand of human population [1]. This situation provokes the scientific community to further research in the field of groundwater exploration of fresh water and natural recharge estimation, which is the most important components essential to formulate dependable groundwater management strategies in scarcity, affected regions. The present study gives out the objectives, to estimate the fitness and unfitness of the groundwater samples and to assess the groundwater quality for irrigation purpose.

Location and Extent

In order to assess the groundwater quality for irrigation uses a Lower Chenab Canal System District, Hafizabad, Punjab. Pakistan is selected. Geologically the area consists of granites, gneisses and pegmatite of igneous origin belonging to the Archaean age. The soils of the study area are clay loam with pH 7.83 and ECe is 4.02 d Sm-1 [2,3]. The area of Hafizabad is about 2367 km2. Hafizabad is situated at 800 feet (240 m) above sea-level in central Punjab. The district is located between 32°-20' (32°4'0.120"N) north latitudes and 73°-12' and 73°-46' (73°40'59.880"E) east longitude and Altitude is 207 m. The river Chenab forms the northern and northwestern boundary of the district. Hafizabad shares its borders with Sheikhupura District and Gujranwala District in the east, Mandi Bahauddin District in the north, Sargodha District in the west, Faisalabad and Chiniot District in the south. Hafizabad is situated at a distance of 303 km from the Federal Capital, Islamabad, and is 109 km away from the Provincial Capital, Lahore. The district has a total area of 2,367 square kilometers and comprises two tehsils, namely Hafizabad and Pindi Bhattian. Major villages are Kaleke Mandi, Sukheke Mandi, Jalalpur Bhattian, Vanikay Tarrar, Burj Dara, Lawaray Kalan, Narianwala Shreef, Shameer Bhattian, Kolo Tarar and Rahgo Syedan. The climate of the district is hot and dry during the summer and moderately cold in the winter. The maximum summer temperature in the month of June is 45 °C (113 °F), while in winter, during January, the lowest minimum temperature is 1 °C (34 °F). Owing to the proximity of the hills, there is more rainfall in the east than the west. The monsoon season usually starts in the middle of July and continues until September. The soils are alluvial and fertile. Majors' crops are rice and wheat. Besides, Sugarcane, Bajra, Tobacco, Maize, Jawar, Mash, Moong, Masoor, Gram, Maize, Oil Seed such as Rape/ Mustard and Sunflower are also grown in minor quantities in the district. The granites are pink and grey in color, hard massive to foliated and well jointed. The soil cover is of well developed residual soil of weathered granite. The soil is fairly permeable with brown-reddish color. The soil can absorb most of the rain except for more intensive rains, which can cause considerable surface flow and erosion.

Research Methodology

Groundwater samples were collected in pre-cleaned 1 liter polyethylene bottle following from the bore wells, which are used for the irrigation purposes during May 2013 (Pre-monsoon) and October 2013 (Post-monsoon) period. The water samples from the wells were collected after pumping out water for about 10 min to remove stagnant water from the well. Seventy one groundwater samples were collected and analyzed for EC, SAR and RSC parameters [4,5]. The GPS values were measured with the help of Garmin Oregon 550. The groundwater sample locations in the study area are represented in Table 1.

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Table 1: The groundwater quality parameter values in the study area.

Sr. No.	GIS#	X-coradinate	Y-coradinate	Major Canal	Disty/ Minor	Bore depth (ft)	Discharge (Cs)	Screen length (ft.)	Jun-13	Oct-13		Jun-13	Oct-13		Jun-13	Oct-13		Status
									EC	EC	Mean	SAR	SAR	Mean	RSC	RSC	Mean	
1	5	073” 43.061	032” 15.734	L.C.C	Ramnagar	70	0.38	60	1.05	0.90	0.98	1.58	1.70	1.64	1.00	1.00	1.00	Fit
2	6	073” 42.210	032” 15.833	L.C.C	Out of CCA	35	-	30	1.32	1.20	1.26	1.46	1.40	1.43	1.30	1.20	1.25	Fit
3	7	073” 41.202	032” 15.905	L.C.C	Ramnagar	60	0.42	50	1.30	1.20	1.25	1.74	1.80	1.77	0.20	0.20	0.20	Fit
4	8	073” 42.120	032” 12.417	L.C.C	Gajar Gola	60	0.46	50	1.29	1.20	1.25	1.27	1.20	1.24	1.10	1.00	1.05	Fit
5	10	073” 43.321	032” 08.772	L.C.C	Gajar Gola	70	0.42	60	1.20	1.10	1.15	1.80	1.70	1.75	1.60	1.55	1.58	Fit
6	11	073” 42.315	032” 10.481	L.C.C	Gajar Gola	90	0.46	80	1.20	1.10	1.15	1.62	1.60	1.61	1.30	1.20	1.25	Fit
7	12	073” 33.589	032” 13.980	L.C.C	Vanike	90	0.38	80	0.95	1.00	0.98	3.00	2.70	2.85	1.50	1.55	1.53	Fit
8	13	073” 39.855	032” 11.300	L.C.C	Vanike	80	0.38	70	1.25	1.15	1.20	2.33	2.40	2.37	1.60	1.65	1.63	Fit
9	14	073” 40.294	032” 15.290	L.C.C	Vanike	90	0.38	80	0.98	1.05	1.02	4.31	4.30	4.31	1.40	1.50	1.45	Fit
10	15	073” 40.402	032” 15.345	L.C.C	Out of CCA	70	0.42	60	1.20	1.10	1.15	1.90	1.80	1.85	1.30	1.25	1.28	Fit
11	16	073” 34.776	032” 13.069	L.C.C	Out of CCA	70	0.42	60	1.20	1.10	1.15	2.50	2.40	2.45	1.60	1.65	1.63	Fit
12	17	073” 33.550	032” 12.920	L.C.C	Out of CCA	70	0.42	60	1.15	0.95	1.05	3.90	3.80	3.85	1.40	1.50	1.45	Fit
13	18	073” 32.770	032’ 11.802	L.C.C	Vanike	80	0.46	70	1.25	1.10	1.18	4.00	4.10	4.05	1.10	1.05	1.08	Fit
14	19	073” 41.145	032” 07.968	L.C.C	Gajar Gola	90	0.46	80	1.22	1.10	1.16	5.50	5.40	5.45	0.50	0.60	0.55	Fit
15	20	073” 41.941	032” 05.812	L.C.C	Battarey	80	0.46	70	1.30	1.20	1.25	3.77	3.80	3.79	1.00	1.10	1.05	Fit
16	25	073” 38.071	032” 04.090	L.C.C	Shah jamal	80	0.38	70	0.90	1.00	0.95	3.20	3.30	3.25	1.00	1.10	1.05	Fit
17	26	073” 33.550	032” 12.920	L.C.C	Gajar Gola	90	0.42	80	0.80	0.90	0.85	2.95	3.00	2.98	1.30	1.40	1.35	Fit
18	27	073” 33.440	032” 10.968	L.C.C	Gajar Gola	100	0.46	0	1.10	1.20	1.15	2.31	2.40	2.36	0.30	0.20	0.25	Fit

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19	28	073” 32.767	032” 10.803	L.C.C	Vanike	80	0.42	70	0.98	1.00	0.99	4.10	4.20	4.15	1.90	2.00	1.95	Fit
20	29	073” 34.761	032” 11.288	L.C.C	Out of CCA	110	0.42	100	1.00	1.10	1.05	5.12	5.20	5.16	1.20	1.30	1.25	Fit
21	30	073’ 33.550	032” 12.920	L.C.C	Out of CCA	100	0.42	90	1.20	1.25	1.23	2.50	2.60	2.55	1.20	1.30	1.25	Fit
22	31	073” 22.540	032” 03.761	L.C.C	Out of CCA	90	0.42	80	1.00	1.10	1.05	3.90	3.80	3.85	1.40	1.30	1.35	Fit
23	32	073” 33.442	032” 09.968	L.C.C	Out of CCA	80	0.42	70	1.30	1.20	1.25	5.38	5.40	5.39	1.00	1.10	1.05	Fit
24	33	073” 33.524	032” 07.228	L.C.C	Kot Chian	100	0.46	90	0.80	0.90	0.85	4.20	4.30	4.25	0.50	0.60	0.55	Fit
25	34	073” 20.170	031” 59.564	L.C.C	Kot Nakka	110	0.42	100	0.90	1.00	0.95	5.20	5.30	5.25	0.90	1.00	0.95	Fit
26	45	072” 18.865	031” 17.267	R.B	Ratteki Mr	110	0.38	100	1.20	1.30	1.25	6.80	6.90	6.85	1.20	1.10	1.15	Fit
27	46	073” 33.657	032” 04.094	L.C.C	Jalalpur	100	0.46	90	1.20	1.10	1.15	5.70	5.60	5.65	1.40	1.50	1.45	Fit
28	47	073” 25.519	032” 04.645	L.C.C	Jalalpur	120	0.38	110	1.40	1.30	1.35	6.77	6.50	6.64	1.70	1.60	1.65	Fit
29	48	073” 25.519	032” 04.645	L.C.C	Fateh Pur	110	0.38	100	1.25	1.30	1.28	6.82	6.70	6.76	1.50	1.40	1.45	Fit
30	49	073” 27.814	032” 12.792	L.C.C	Gajar Gola	110	0.38	100	1.39	1.30	1.35	5.80	5.70	5.75	1.80	1.70	1.75	Fit
31	50	073” 44.739	032” 03.815	L.C.C	Gajar Gola	120	-	110	1.20	1.10	1.15	5.80	5.70	5.75	1.40	1.30	1.35	Fit
32	51	073” 23.520	032” 08.217	L.C.C	Out of CCA	130	0.38	120	1.30	1.20	1.25	6.38	6.30	6.34	1.50	1.40	1.45	Fit
33	52	073” 23.521	032” 08.217	L.C.C	Out of CCA	35	-	30	1.45	1.40	1.43	5.10	5.00	5.05	1.10	1.20	1.15	Fit
34	53	073” 23.521	032” 08.217	L.C.C	Gajar Gola	90	-	80	1.41	1.30	1.36	7.84	7.70	7.77	0.90	1.00	0.95	Fit
35	54	073” 32.652	031” 59.059	L.C.C	Jalalpur	90	0.38	80	1.45	1.30	1.38	6.63	6.50	6.57	1.10	1.20	1.15	Fit
36	55	073” 25.515	032” 03.642	L.C.C	Jalalpur	90	0.42	80	1.40	1.30	1.35	6.00	6.10	6.05	2.00	2.10	2.05	Fit
37	56	073” 32.654	031” 70.219	L.C.C	Medhora	100	0.46	90	1.10	1.20	1.15	5.33	5.20	5.27	1.20	1.30	1.25	Fit
38	57	073” 32.651	032” 59.052	R.B	Jandoke	100	0.46	90	1.10	1.00	1.05	5.30	5.20	5.25	1.40	1.30	1.35	Fit
39	58	072” 18.579	031” 18.729	R.B	Ratteki Mr	110	0.42	90	1.20	1.10	1.15	7.50	7.40	7.45	1.80	1.90	1.85	Fit

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40	73	072" 04.821	031" 24.659	R.B	Uddoke II	40	-	35	1.20	1.30	1.25	5.60	5.50	5.55	1.50	1.40	1.45	Fit
41	74	072" 18.861	031" 17.678	R.B	Uddoke II	110	0.42	100	1.35	1.40	1.38	5.30	5.20	5.25	2.10	2.00	2.05	Fit
42	75	073" 32.652	031" 59.052	L.C.C	Medhora	100	0.46	90	1.30	1.20	1.25	5.47	5.40	5.44	1.40	1.30	1.35	Fit
43	76	073" 32.652	031" 59.052	L.C.C	Medhora	90	-	80	1.40	1.35	1.38	6.10	6.20	6.15	1.60	1.50	1.55	Fit
44	77	073" 25.841	032" 03.642	L.C.C	Jalalpur	90	0.42	80	1.35	1.30	1.33	8.21	8.20	8.21	2.90	2.70	2.80	unfit
45	78	073" 25.841	032" 03.642	L.C.C	Out of CCA	110	0.38	100	0.80	0.90	0.85	6.37	6.20	6.29	1.90	2.00	1.95	Fit
46	79	073" 24.514	032" 05.036	L.C.C	Out of CCA	110	-	100	1.30	1.25	1.28	5.10	5.20	5.15	1.40	1.30	1.35	Fit
47	80	073" 20.305	031" 59.564	L.C.C	Out of CCA	90	0.38	80	0.85	1.00	0.93	5.14	5.30	5.22	2.30	2.10	2.20	Fit
48	81	073" 17.839	032' 04.872	L.C.C	Out of CCA	100	0.38	90	1.20	1.10	1.15	5.68	5.50	5.59	1.00	0.90	0.95	Fit
49	82	073" 20.171	031" 57.660	L.C.C	Out of CCA	40	-	35	1.40	1.35	1.38	7.18	7.20	7.19	0.90	1.00	0.95	Fit
50	83	073" 20.171	031" 57.666	L.C.C	Medhora	100	0.42	90	1.43	1.35	1.39	7.77	7.60	7.69	1.40	1.35	1.38	Fit
51	84	073" 32.652	031" 59.052	L.C.C	Jandoke	120	0.46	110	1.40	1.30	1.35	6.70	6.80	6.75	2.10	2.20	2.15	Fit
52	85	073" 24.257	031" 59.052	L.C.C	Jandoke	100	0.42	90	1.30	1.20	1.25	5.80	5.60	5.70	1.60	1.50	1.55	Fit
53	86	073" 04.839	031" 24.655	R.B	Ratehki Minor	120	0.38	110	1.20	1.10	1.15	7.20	7.00	7.10	1.70	1.60	1.65	Fit
54	111	072" 18.688	031" 18.872	R.B	Fatehki	160	0.42	150	2.10	1.90	2.00	8.80	8.70	8.75	1.60	1.70	1.65	unfit
55	112	073" 19.939	031" 49.379	L.C.C	Medhora	130	0.42	120	1.40	1.35	1.38	6.50	6.40	6.45	3.10	3.20	3.15	unfit
56	113	073" 21.170	031" 57.665	L.C.C	Out of CCA	100	0.46	90	1.60	1.70	1.65	7.20	7.10	7.15	3.50	3.60	3.55	unfit
57	114	073" 20.171	031" 57.666	L.C.C	Medhora	100	0.38	90	1.40	1.30	1.35	7.20	7.10	7.15	2.00	2.10	2.05	Fit
58	115	073" 17.196	031" 56.037	L.C.C	Jandoke	110	0.38	100	1.40	1.20	1.30	6.30	6.40	6.35	1.60	1.70	1.65	Fit
59	116	073" 20.170	031" 59.564	L.C.C	Out of CCA	100	0.38	90	1.00	1.10	1.05	5.60	5.50	5.55	0.90	1.00	0.95	Fit
60	117	073" 12.120	031" 55.945	L.C.C	Out of CCA	130	0.42	120	1.45	1.40	1.43	6.40	6.30	6.35	1.60	1.50	1.55	Fit

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61	118	073" 12.120	031" 55.945	L.C.C	Medhora	120	0.42	110	1.00	1.10	1.05	4.80	4.90	4.85	1.50	1.60	1.55	Fit
62	119	073" 20.366	031" 53.908	L.C.C	Jandoke	130	0.42	120	1.64	1.70	1.67	8.40	8.50	8.45	3.30	3.40	3.35	unfit
63	120	073" 18.430	031" 53.709	L.C.C	Out of CCA	110	0.46	100	1.80	1.90	1.85	7.81	7.60	7.71	2.10	2.20	2.15	unfit
64	121	072" 18.575	031" 17.792	R.B	Marh Mr	100	0.38	90	1.82	1.90	1.86	8.90	8.70	8.80	3.10	3.20	3.15	unfit
65	147	073" 20.654	031" 48.607	L.C.C	Out of CCA	100	0.42	90	2.10	2.00	2.05	6.80	6.70	6.75	3.30	3.40	3.35	unfit
66	148	073" 15.760	031" 46.197	L.C.C	Baranwala	110	0.38	100	1.38	1.30	1.34	6.30	6.40	6.35	1.40	1.30	1.35	Fit
67	149	073" 14.750	031" 52.746	L.C.C	Out of CCA	98	0.38	90	1.36	1.40	1.38	3.95	4.00	3.98	1.50	1.40	1.45	Fit
68	152	073" 14.750	031" 52.746	L.C.C	Medhora	120	0.38	110	1.25	1.30	1.28	5.10	5.20	5.15	1.60	1.50	1.55	Fit
69	153	.73" 03.152	031" 34.098	JB	Baranwala	50	-	40	1.20	1.10	1.15	3.90	4.00	3.95	1.60	1.50	1.55	Fit
70	154	073" 16.571	031" 46.102	JB	Baranwala	120	0.38	110	1.10	0.90	1.00	2.80	2.70	2.75	1.60	1.50	1.55	Fit
71	180	073" 13.491	031" 47.788	JB	Malian	50	-	40	1.00	1.10	1.05	2.00	2.20	2.10	0.90	1.00	0.95	Fit
								Mean	1.26	1.23	1.24	5.12	5.09	5.11	1.53	1.53	1.53	

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Table 2: The average values of the each quality parameter.

Parameters	Minimum Value	Maximum Value	Average
EC	0.80	2.10	1.26 (pre) 1.23 (post)
SAR	1.20	8.90	5.12 (pre) 5.09 (post)
RSC	0.20	3.60	1.53 (pre) 1.53 (post)

Results

In 71 water quality samples only 8 samples are unfit while 63 are fit for irrigation purposes. The unfit water samples are due to higher electrical conductivity and RSC values. The salt concentration is generally measured by determining the electrical conductivity of water. Excess salt increases the osmotic pressure of the soil solutions that can result in physiological drought conditions. It has been observed from the analysis that the electrical conductivity in both seasons (pre monsoon & post monsoon) on average basis has a minor difference i.e. 1.26 (pre) 1.23 (post). Hence the electrical conductivity has no difference in both season and in whole year. The minor change in electrical conductivity might be due to leaching of salts due to rains in post monsoon. The highest value of conductivity may be due to high concentration of ionic constituents present in the water bodies. The collected water quality samples are 88.73% are found fit and 11.27% are unfit for irrigation purpose. The groundwater quality parameter values in the study area are shown in the Table 1. The average values of the each quality parameter are shown in the Table 2. The minimum and maximum values of EC, SAR and RSC parameters are shown in Figure 1.

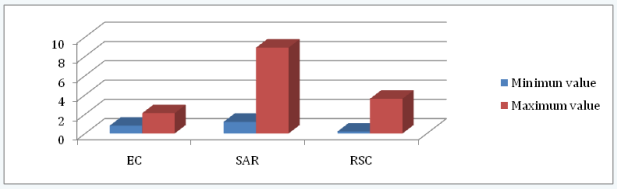

Figure 1: The minimum and maximum values of EC, SAR and RSC parameters.

The majority alkalinity values (EC, SAR, RSC) in the study area are within the permissible limit and are ranging from 0.80- 1.50 d Sm^{-1}, 1.20-.90 and 0.20-3.60 meq/l during pre and post monsoon period. The high alkalinity of groundwater in certain locations in the study area may be due to the presence of bicarbonate and some salts. The alkaline water may decrease the solubility of metals. Few values of SAR and RSC are beyond the safe limit. These values are slighter higher in pre monsoon than post monsoon. High SAR and RSC content in groundwater can be attributed to the continuous water rock interaction during the process of percolation with soluble salts bearing country rocks under arid, low precipitation and high evaporation conditions of the study area. During last few years, the utilization of surface and groundwater for drinking, industrial and agricultural purposes has increased manifolds but consequently it is observed that the water is polluted and affecting the human health, soil nutrients, livestock, biomass and environment in certain areas.

Conclusion

Groundwater quality in and around Hafizabad has been analyzed in the present work. The majority area has fit ground water quality due to the influence of seepage and recharge from Chenab River, Lower Chenab Canal and Qadirabad Balloki Link Canal. High SAR and RSC content in groundwater can be attributed to the continuous water rock interaction during the process of percolation with soluble salts bearing country rocks under arid, low precipitation and high evaporation conditions of the study area.

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