Mehran University Research Journal of Engineering & Technology
Vol. 38, No. 1, 143-150, January 2019
p-ISSN: 0254-7821, e-ISSN: 2413-7219
DOI: 10.22581/muet1982.1901.12

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

JHAMAN DAS SUTHAR*, INAYATULLAH RAJPER*, ZIA-UL-HASSAN*, NIZAMUDDIN DEPAR**, AND VELO SUTHAR***

RECEIVED ON 20.12.2017 ACCEPTED ON 12.02.2018

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, CO_3^{2-}, HCO_3^-, Cl^-, Ca^{2+}, Mg^{2+} 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

Authors E-Mail: (jhaman@gmail.com, irajpar@yahoo.com, zhnshah@gmail.com, ndepar@gmail.com, vsutahar@yahoo.co.uk)
* Department of Soil Science, Sindh Agriculture University, Tando Jam, Pakistan.
** Soil & Environmental Division, Nuclear Institute of Agriculture, Tando Jam, Pakistan.
*** Department of Statistics, Sindh Agriculture University, Tando Jam, Pakistan.

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 EC_{iw} 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 Ca^{2+} and $(Ca^{2+} + Mg^{2+})$ 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 (NH_4Cl-NH_4OH) and few drops of Eriochromeblack-T as an indicator for calcium plus magnesium. Whereas for anion like CO_3^{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 HCO_3^-. H_2SO_4 (0.01 N) was used for titration in the case of carbonates and bicarbonate analysis. Whereas chlorides were analyzed through 0.005 N $AgNO_3$ (Mohrs's titration) using potassium chromate (K_2CrO_4) 5% as an indicator.

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

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

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

TABLE 1. WATER QUALITY CRITERIA BASED ON EC_{IW}, SAR AND RSC

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)

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).

TABLE 2. NAME OF SITES, DEPTH, EC_{IW} AND PH, SAR, RSC AND CLASSES WITH DESCRIPTIVE STATISTICS OF WATER BODIES OF STUDY AREA OF TALUKA MITHI AND ISLAMKOT

Site No.	Name of Village	Depth (m)	ECiw 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.	Kakjuneja	54.9	9.1	8.0	7.5	2.74	C3S1R2
8.	Malanhore Khanji-1	62.5	3.4	8.0	4.4	-1.85	C3S1R1
9.	Malanhore Khanji-2	51.8	5.4	8.0	5.3	-4.55	C3S1R1
10.	Hemasar-1	61.0	2.5	8.0	4.2	0.30	C2S1R1
11.	Hemasar-2	51.8	3.5	8.0	5.4	-1.23	C3S1R1
12.	Hemasar-3	53.3	5.0	8.0	4.7	-1.44	C3S1R1
13.	Hothiar	50.3	10.3	8.0	8.4	0.48	C3S1R1
14.	SaatarKolhi	57.9	1.5	8.3	13.0	3.48	C1S2R2
15.	Tabho Menghwar-1	61.0	4.4	8.5	5.5	2.12	C3S1R1
16.	Tabho Menghwar-2	62.5	5.6	7.9	5.7	1.30	C3S1R1
17.	Abdulah-Ji-Dhani	39.6	7.6	8.6	5.8	1.89	C3S1R1
18.	Pabe Jo Tar	67.1	5.5	8.1	6.7	3.46	C3S1R2
19.	Mithario Bhatti-1	68.6	3.2	7.9	10.9	2.29	C3S2R1
20.	Mithario Bhatti-2	73.2	3.2	8.0	7.6	0.63	C3S1R1
21.	MitharioBheel	41.1	4.6	7.3	8.9	0.03	C3S1R1
22.	Bhope Jo Tar	53.3	3.3	7.8	5.8	2.32	C3S1R1
23.	Bughar	57.9	4.2	8.6	7.5	6.24	C3S1R3
24.	Nauhonto	30.5	0.3	7.7	6.8	1.67	C1S1R1
25.	Khario Nara	76.2	9.1	7.5	7.2	2.20	C3S1R2
26.	Borli M-1	45.7	1.8	7.4	6.7	-0.14	C2S1R1
27.	Borli M-2	48.8	5.1	8.0	15.5	-0.05	C3S2R1
28.	Wadhan	24.4	1.2	8.0	13.0	-0.70	C1S2R1
29.	Ghoralsio	25.9	1.0	8.0	8.8	-0.39	C1S1R1
30.	Aakali	27.4	1.1	9.0	7.4	0.30	C1S1R1
31.	Doonjh-1	27.4	4.5	8.0	11.7	-3.87	C3S2R1
32.	Doonjh-2	25.9	2.6	8.0	8.5	0.71	C2S1R1
33.	ShurabWasaipota	39.6	3.0	8.0	9.2	-0.80	C2S1R1
34.	Khankhanyar-B	48.8	0.9	8.0	4.3	0.05	C1S1R1
35.	LakhiTobho	33.5	2.7	8.0	5.2	-3.54	C2S1R1
36.	DabhoNajar	30.5	5.3	8.0	6.2	2.71	C3S1R2
37.	MisriMemon	61.0	3.9	7.3	6.4	1.51	C3S1R1
38.	Siranghoo	54.9	2.2	8.1	5.3	0.03	C2S1R1
39.	Warvai	56.4	2.6	7.9	6.4	-0.47	C2S1R1
40.	MitharaooChhuto	48.8	2.7	7.8	7.8	-1.17	C2S1R1
41.	Nau-Tar	51.8	7.7	7.3	7.3	-1.81	C3S1R1
42.	Nikno	54.9	13.5	8.7	8.5	2.01	C3S1R1
43.	Areri	18.3	1.7	8.6	6.4	8.40	C2S1R3
44.	VeeHingorja	51.8	2.1	7.9	5.2	0.81	C2S1R1
45.	Bhatian Je Veri	30.5	8.5	8.3	6.7	4.23	C3S1R2
46.	Joglahar	53.3	8.5	8.6	7.3	4.32	C3S1R2
47.	Joglahar	57.9	2.1	8.3	11.6	4.00	C2S2R2
48.	BoriliTarai	48.8	1.6	8.2	8.1	1.79	C2S1R1
49.	JogiMarhi	61.0	3.3	7.5	8.3	0.09	C3S1R1
50.	BanbhnioBheel	76.2	4.8	7.7	6.0	-0.45	C3S1R1
51.	Thario Halepota	61.0	3.9	8.0	6.6	3.43	C3S1R2
52.	Dharam	21.3	4.4	8.3	9.1	4.72	C3S1R2
53.	Chunhar	51.8	8.6	8.1	6.3	0.44	C3S1R1
Minimum		18.3	0.3	7.3	4.2	-7.08	C1S1R1
Maximum		76.2	13.5	9.0	15.5	8.40	C3S2R1
Mean		49.2	4.9	8.1	7.4	0.74	
Mode		51.8	Ñ	8.0	Ñ	0.03	C3S1R1
STD		14.2	3.2	0.39	2.4	2.77	
CV		0.29	0.65	0.05	0.32	3.74	

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 useable 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_{IW}, PH, SAR AND RSC

Parameters	Mean Value	Number of Samples far above the Mean Value	
ECiw (dS m^{-1})	4.90	20	38%
pH	8.06	11	29%
SAR	7.40	29	55%
RSC	0.74	16	30%

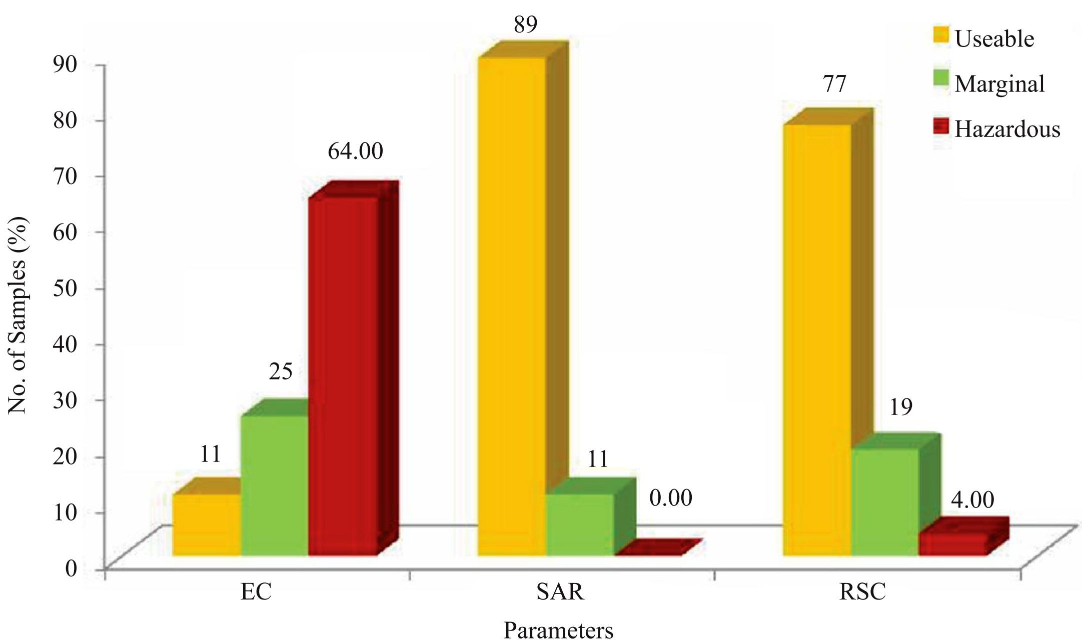

FIG 1. GROUNDWATER QUALITY OF TALUKA MITHI AND ISLAMKOT ON THE BASIS OF EC, SAR AND RSC

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, sorghum
Moderately Sensitive	(Marginal) Just above useable	Cucumber, egg-plant, musk melon, radish, Spinach, water melon, pearl millet, mung bean
Sensitive	Useable	Carrot, lemon, onion, sesame

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 EC_{iw} 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, 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.

ACKNOWLEDGEMENTS

This study is the part of Ph.D. dissertation research of first author sponsored by Higher Education Commission (HEC) of Pakistan under "HEC Indigenous Ph.D. Fellowship Program".

REFERENCES

[1] Beltran, J.M., "Irrigation with Saline Water: Benefits and Environmental Impact", Agricultural Water Management, Volume 40, No. 2, pp. 183-194, 1999.

[2] Rowell, D.L., "The Preparation of Saturation Extracts and the Analysis of Soil Salinity and Sodicity", Soil Science Methods and Applications", Longman Group., UK, 1994.

[3] Barlow, P.M., "Ground Water in Fresh Water-Salt Water Environments of the Atlantic", Geological Survey, 2003.

[4] Brady, N.C., and Weil, R.R., "The Nature and Properties of Soil", 12th Edition,Prentice-Hall Inc., Upper Saddle River, New Jersey, 1999.

[5] Khemani, P.K., Khatri, K.L., Jamro G.M., and Rajpar, I., "Quality of Irrigation and Drinking Water in Nangarparkar Region of Thar Desert of Pakistan", International Journal of Physical Sciences, Volume 7, No. 29, pp. 5118-5126, 2012.

[6] Sial, N.B., Rajpar, I., Mangio, H.R., and Suthar, J.K., "Assessing Irrigation Quality of Well Water in Thar Desert (Pakistan)", Pakistan Journal of Agriculture, Agricultural Engineering & Veterinary Sciences, Volume19, No. 2, pp. 8-10, 2003.

[7] Nazir, A., "Ground Water Resources of Pakistan", Ripon Press Ltd. Lahore, Pakistan, 1974.

[8] Al-Naeem, A.A., "Evaluation of Groundwater of Al-Hassa Oasis, Eastern Region Saudi Arabia", Research Journal of Environmental Sciences, Volume 5, No. 7, pp. 624, 2011.

[9] Tanninen, J., Kamppinen, L., and Nystrom, M., "Pre-Treatment and Hybrid Processes: Nanofiltration-Principles and Application", Advanced Technology Publisher, Volume 13, pp. 978-1, London, 2005.

[10] Estefan, G., Sommer, R., and Ryan, J., "Methods of Soil, Plant, and Water Analysis: AManual for the West Asia and North Africa Region", International Center for Agricultural Research in the Dry Areas, Volume 143, Beirut, Lebanon, 2013.

[11] Jaiswal, P.C., "Soil, Plant and Water Analysis", Kalyani Publishers, 2011.

[12] Richards, L.A., "Diagnosis and Improvement of Saline and Alkali Soils", US Department of Agriculture, Washington, 1969.

[13] Eaton, F.M., "Significance of Carbonates in Irrigation Waters", Soil Science, Volume 69, No. 2, pp. 123-134, 1950.

[14] Qureshi, R.H., and Barrett-Lennard, E.G., "Saline Agriculture for Irrigated Land in Pakistan: AHandbook, Australian Centre for International Agricultural Research, 1998.

[15] Shelly, G.B., Cashman, T.J., and Quasney, J.J., "Microsoft Office Excel 2007", Comprehensive Concepts and Techniques, Cengage Learning, 2007.

[16] Ayers, R.S., and Westcot, D.W., "Water Quality for Agriculture", FAO Irrigation and Drainage Paper 29 Rev. 1, Food and Agricultural Organization, Rome, Volume 1, pp. 74, 1985.

[17] Wilde, F.D., Radtke, D.B., Gibs, J., Iwatsubo, R.T., "National Field Manual for the Collection of Water-Quality Data", US Geological Survey Techniques of Water-Resources Investigations, Book 9, A-6, 1998.

[18] Jalali, M., and Merrikhpour, H., "Effects of Poor Quality irrigation Waters on the Nutrient Leaching and Groundwater Quality from Sandy Soil", Environmental Geology, Volume 53, No. 6, pp. 1289-1298, 2008.

[19] Nishanthiny, S.C., Thushyanthy, M., Barathithasan, T., and Saravanan, S., "Irrigation Water Quality Based on Hydro Chemical Analysis, Jaffna, Sri Lanka", American-Eurasian Journal Agriciculture & Environmental Science, Volume 7, No. 1, pp. 100-102, 2010.

[20] Sagar, T.V., "Water Quality of Some Polluted Lakes in GHMC Area, Hyderabad-India", Methodology, Volume 6, pp. 60-80.

[21] Al-Tabbal, J.A., and Al-Zboon, K.K., "Suitability Assessment of Groundwater for Irrigation and Drinking Purpose in the Northern Region of Jordan", Journal of Environmental Science and Technology, Volume 5, No. 5, pp. 274-290, 2012.

[22] Singh, S., Raju, N.J., and Ramakrishna, C., "Evaluation of Groundwater Quality and Its Suitability for Domestic and Irrigation Use in Parts of the Chandauli-Varanasi Region, Uttar Pradesh, India", Journal of Water Resource and Protection, Volume 7, No. 7, pp. 572, 2015.