Estimation Spatial Distribution of Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) in Groundwater of Tando Muhammad Khan Pakistan

Benish Nawaz Merani[1,*], Saghir Ahmed Sheikh[1], Mahvish Jabeen Channa[2], Aasia Akbar Panhwar[1] and Aijaz Hussain Soomro[1]

[1]*Institute of Food Sciences and Technology, Sindh Agriculture University Tandojam, Hyderabad Pakistan*

[2]*Department of Nutrition and Food Technology, University of Sindh Jamshoro, Pakistan*

Abstract: This study was conducted to evaluate factors regulating groundwater quality in an area with agriculture as main use. Water samples for determining the water quality were collected in one liter polyethylene bags by observing standard sample collection method. It was ensured that sample collection sites must be at least 500 feet away from each other.

Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were determined from the collected water and it was observed that in Tando Muhammad Khan taluka, the Sodium Adsorption Ratio (SAR) in the samples ranged from 11.06 to 53.29, the highest (53.29) SAR was in UC Tando Saindad, while lowest (11.06) in the sample collected from UC-2 of Tando Muhammad Khan. The Residual Sodium Carbonate (RSC) in 36 collected groundwater samples ranged from 0.61 to 5.15 meq/l, the highest (5.15 meq/l) was in UC Tando Saindad, while lowest (0.61) in the sample collected from UC-3 of Tando Muhammad Khan.

It was concluded that the SAR levels of groundwater samples indicated an alarming situation and most of the groundwater samples had SAR (<7.5 meq/l) and RSC (<2.0 meq/l) above permissible limits of WHO for agriculture use therefore, it is not suitable for agriculture as well as drinking.

Keywords: Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Ground water.

1. INTRODUCTION

Water is the most important resource for human existence. Ensuring access to cheap and clean drinking water is emerging as one of the most difficult challenges of this century. In rural side, there is an acute crisis of potable water with some of the water pockets containing excess salinity, hardness, fluoride, arsenic, or harmful pathogens which cause several health problems [1]. Therefore, excessive use of groundwater aquifers is growing. The increased exploitation of groundwater resources can decrease regional water quality as a whole [2].

It is essential to safeguard the future of our water resources by studying its past and present both quantitatively and qualitatively [3]. Huge quantities of groundwater, particularly from the shallow aquifers, are used for irrigation and in the absence of adequate surface water in the dry season; irrigation becomes heavily dependent on groundwater [4].

Irrigation water quality refers to the kinds and amounts of salts present in the water and their effects on crop growth and development. High salt concentrations influence osmotic pressure of the soil solution and affect the ability of plants to absorb water through their roots [5]. Irrigation water quality is generally judged by some determining factors such as sodium adsorption ratio (SAR), soluble sodium percentage (SSP), residual sodium carbonate (RSC), and electrical conductance (EC) [6]. Along with the above indicators, some additional indices to categorize the groundwater for irrigation like magnesium adsorption ratio (MAR), Kelly's ratio (KR), total hardness (TH), permeability index (PI), residual sodium bicarbonate (RSBC) should be studied [4]. The composition of water changes through reactions with the environment and the natural chemistry can have an important bearing on anything living that utilizes this resources including human beings, livestock and even plants [3].

High value of SAR means that sodium in the water may replace calcium and magnesium ions in the soil, potentially causing damage to the soil structure [7]. An increase in RSC value leads also to precipitate calcium and magnesium that can cause an increase in sodium content in the soil. The high concentration of bicarbonate ion in irrigation water leads to its toxicity and affects the mineral nutrition of plants. The variation in chemical composition of groundwater may be due to leaching of terrestrial salts, extensive use of chemical

*Address correspondence to this author at the Institute of Food Sciences and Technology, Sindh Agriculture University Tandojam, Pakistan;
Tel: +92-3332711539; E-mail: benishmirani@gmail.com

ISSN: 2223-3806 / E-ISSN: 1927-5951/14

fertilizers and ion exchange between water and the host rock [3], so a detailed analysis of major, minor and trace constituents of groundwater is very important.

The investigation will serve as an avenue to update groundwater data bank of the study area for those whose responsibility is the provision of safe drinking water to the entire populace around the area. It will also help in planning agricultural practices in advising the farmers on choosing the appropriate crops to be cultivated around the study area.

2. METHODOLOGY

2.1. Area of Study

According to the new government setup in June 2005, Taluka Tando Muhammad Khan is emerged as a new district on map of Sindh province with its Head quarter located at Tando Muhammad Khan Town/ City. It is spread over a geographical area of about 1733.99 square kilometers (428469 acres). It is located at height of 55 ft above mean sea level and between 250 07’ 28” N latitudes and 680 31’ 59” E longitudes. In North of the district, Hyderabad and Tando Allahyar districts are located, Badin district lies on South and East, West boundary is shared by district Thatta and the river Indus flows through North-West (Figure **1**).

The evaluation of water quality was carried out in each Union Council (UC) of District Tando Muhammad Khan, Sindh, Pakistan. Water samples for determining the water quality were collected in one liter polyethylene bottles by observing standard sample collection method. It was ensured that sample collection sites must be at least 500 feet away from each other. Before sample collection the bottles were washed and rinsed properly with distilled water so as to remove any possible contamination. Water samples were collected using one liter polyethylene bottles and standard methods for this purpose were adopted. After purging, the polyethylene bottles and their caps were washed with same water and then sample was collected in bottle for getting maximum accuracy in result.

The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation [8].

2.2. Sodium Adsorption Ratio (SAR)

The sodium adsorption ratio (SAR) is commonly used as an index for evaluating the sodium hazard associated with an irrigation water supply. It is generally recognized as the most applicable technique for determining the adjusted SAR hazard index [6, 9, and 10].SAR is calculated from the ratio of sodium to calcium and magnesium, because calcium and magnesium helps to counter the effects of sodium in water. Calcium and magnesium contents were determined by EDTA titration using Eriochrome black T as indicator. The sodium content was determined by using flame photometer instrument. SAR is very important factor to determine the suitability of water for irrigation purpose and it can be obtained by following formula of Richards [11]:

$$SAR = \frac{Na^{+}(meq/l)}{\frac{\sqrt{Ca^{2+}(meq/l + Mg^{2+}(meq/l)}}{2}}$$

2.3. Residual Sodium Carbonate (RSC)

The RSC occurs when carbonate and bicarbonate levels exceed the levels of calcium and magnesium in water. High bicarbonate levels increase the tendency of calcium and magnesium to precipitate in water and as

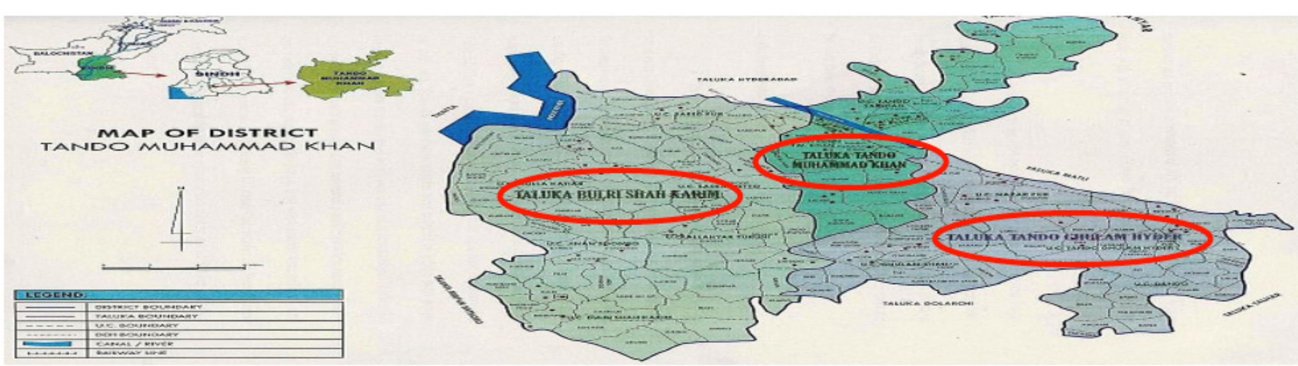

Figure 1: Tando Muhammad Khan ecological areas (Encircled the area of study: Taluka Tando Muhammad Khan, Taluka Tando Ghulam Hyder and Taluka Bulri Shah Karim).

a result sodium ratio is increased in the form of sodium bicarbonate [12]. Carbonate and bicarbonates were determined by acid-base titration methods whereas, RSC level was calculated from the water by using given formula:

$$RSC = (HCO_3(meq/l) - + CO_3^{2-}(meq/l) \\ -(Ca^{2+}(meq/l) + Mg^{2+}(meq/l))$$

3. RESULTS

3.1. Water Quality for Agricultur

3.1.1. Taluka Tando Muhammad Khan

The Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) in groundwater samples collected from various Union Councils of Taluka Tando Muhammad Khan are presented in Table **1**. The SAR in the samples ranged from 11.06 to 53.29, the highest

Table 1: Determination of Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) in Groundwater Samples for Irrigation in Taluka Tando Muhammad Khan

Sr#	Union Council	Sample Code	Sodium Adsorption Ratio (SAR) (meq/l)	SAR within permissible limits (Yes/No)	Residual Sodium Carbonate /RSC (meq/l)	RSC Below permissible limits (Yes/No)
Maximum Permissible Limit			<7.5		<2.0	
1	3	03A	36.17	No	0.99	Yes
2	3	03B	21.14	No	0.61	Yes
3	3	03C	16.50	No	0.75	Yes
4	3	03D	18.33	No	1.00	Yes
5	3	03E	21.48	No	1.09	Yes
6	3	03F	25.50	No	2.01	No
7	1	1 H	29.27	No	2.72	No
8	1	2 H	30.12	No	2.72	No
9	1	3 H	45.46	No	4.01	No
10	1	4 H	25.22	No	2.50	No
11	1	5 H	39.39	No	3.25	No
12	1	6 H	18.05	No	2.06	No
13	2	1 I	26.58	No	2.07	No
14	2	2 I	43.66	No	4.01	No
15	2	3 I	11.06	No	1.07	Yes
16	2	4 I	29.36	No	2.35	No
17	2	5 I	14.44	No	1.26	Yes
18	2	6 I	20.56	No	2.26	No
19	Lakhat	1 J	45.84	No	3.84	No
20	Lakhat	2 J	24.20	No	2.33	No
21	Lakhat	3 J	28.99	No	2.69	No
22	Lakhat	4 J	21.94	No	2.19	No
23	Lakhat	5 J	36.20	No	3.37	No
24	Lakhat	6 J	52.36	No	4.37	No
25	Sh. Bhirkio	1 K	18.58	No	1.22	Yes
26	Sh. Bhirkio	2 K	33.80	No	2.89	No
27	Sh. Bhirkio	3 K	21.82	No	2.04	No
28	Sh. Bhirkio	4 K	21.86	No	1.84	Yes
29	Sh. Bhirkio	5 K	24.92	No	2.52	No
30	Sh. Bhirkio	6 K	15.65	No	1.70	Yes
31	T. Saindad	1 L	21.42	No	2.16	No
32	T. Saindad	2 L	28.43	No	2.64	No
33	T. Saindad	3 L	53.29	No	5.15	No
34	T. Saindad	4 L	20.35	No	2.18	No
35	T. Saindad	5 L	35.17	No	3.47	No
36	T. Saindad	6 L	22.66	No	2.33	No

Sh. Bhirkio= Shaikh Bhirkio, T. Saindad = Tando Saindad.

(53.29) SAR was in UC Tando Saindad, while lowest (11.06) in the sample collected from UC-2 of Tando Muhammad Khan. The above SAR values of groundwater samples indicated an alarming situation and not a single groundwater sample had SAR within permissible limits of WHO for agriculture use (<7.5).

The results for Residual Sodium Carbonate (RSC) in groundwater samples collected from various Union Councils of Taluka Tando Muhammad Khan (Table **1**) indicated that only 10 samples out of 36 the samples had RSC within permissible limits of WHO for agriculture use water (<2.0 meq/l), while 26 samples indicated RSC in exceeded levels over the permissible limits of WHO in water for agriculture use (<2.0 meq/l). The RSC in 36 collected groundwater samples ranged from 0.61 to 5.15 meq/l, the highest (5.15 meq/l) was in UC Tando Saindad, while lowest (0.61) in the sample collected from UC-3 of Tando Muhammad Khan.

Table 2: Determination of Sodium Adsorption Ratio (SAR) Residual Sodium Carbonate (RSC) in Groundwater Samples for Irrigation in Taluka Bulri Shah Karim

Sr#	Union Council	Sample Code	Sodium Adsorption Ratio (SAR) (meq/l)	SAR within permissible limits (Yes/No)	Residual Sodium Carbonate /RSC (meq/l)	RSC Below permissible limits (Yes/No)
Maximum Permissible Limit			<7.5		<2.0	
1	B.S.Karim	1 M	51.71	No	4.30	No
2	B.S.Karim	2 M	64.43	No	5.27	No
3	B.S.Karim	3 M	63.78	No	5.88	No
4	B.S.Karim	4 M	57.25	No	5.08	No
5	B.S.Karim	5 M	51.24	No	4.78	No
6	B.S.Karim	6 M	62.36	No	5.58	No
7	J. Soomro	1 N	17.88	No	1.89	Yes
8	J. Soomro	2 N	49.24	No	4.15	No
9	J. Soomro	3 N	26.26	No	1.90	Yes
10	J. Soomro	4 N	33.20	No	2.79	No
11	J. Soomro	5 N	63.84	No	6.17	No
12	J. Soomro	6 N	25.48	No	1.90	Yes
13	Saeed Pur	1 G	57.57	No	8.35	No
14	Saeed Pur	2 G	75.63	No	7.63	No
15	Saeed Pur	3 G	57.86	No	6.95	No
16	Saeed Pur	4 G	57.30	No	4.51	No
17	Saeed Pur	5 G	41.69	No	3.52	No
18	Saeed Pur	6 G	40.80	No	4.13	No
19	A.Y. Turk	1 O	20.33	No	1.89	Yes
20	A.Y. Turk	2 O	33.88	No	3.45	No
21	A.Y. Turk	3 O	21.62	No	2.24	No
22	A.Y. Turk	4 O	61.74	No	5.75	No
23	A.Y. Turk	5 O	5.91	Yes	0.00	No
24	A.Y. Turk	6 O	61.24	No	6.24	No
25	Mulakatair	1P	77.83	No	4.37	No
26	Mulakatair	2P	75.91	No	7.80	No
27	Mulakatair	3P	44.70	No	3.76	No
28	Mulakatair	4P	26.56	No	2.45	No
29	Mulakatair	5P	22.98	No	2.09	No
30	Mulakatair	6P	41.99	No	4.13	No
31	Saeed Matto	1 Q	60.15	No	7.06	No
32	Saeed Matto	2 Q	63.32	No	5.24	No
33	Saeed Matto	3 Q	35.59	No	2.77	No
34	Saeed Matto	4 Q	17.73	No	1.11	Yes
35	Saeed Matto	5 Q	22.58	No	2.07	No
36	Saeed Matto	6 Q	26.41	No	2.55	No

B.S. Karim= Bulri Shah Karim, J. Soomro=Jinan Soomro, A.Y. Turk= Allahyar Turk.

3.1.2. Taluka Bulri Shah Karim

The results on analysis of Sodium Adsorption Ratio (SAR) in groundwater samples collected from various Union Councils of Taluka Bulri Shah Karim are presented in Table **2**. The SAR in the samples ranged from 5.91 to 77.83, the highest (77.83) SAR was in UC Mulakatiar, while lowest (5.91) in the sample collected from UC Allayar Turk. The above SAR values indicated that the groundwater quality in taluka Bulri Shah Karim is not suitable for agriculture use, because in most of the samples the SAR values were far ahead of the permissible limits of WHO for agriculture use (<7.5). The situation needs special attention of the concerned government agencies to take concrete measures to improve groundwater quality in the area of study, because out of 36, only one sample showed SAR within permissible limits of WHO for water suitability for agriculture purposes.

The results for Residual Sodium Carbonate (RSC) in groundwater samples collected from various Union Councils of Taluka Bulri Shah Karim (Table **2**) indicated that only 5 samples out of 36 had RSC within permissible limits of WHO for agriculture use water (<2.0 meq/l), while 31 samples indicated RSC in exceeded levels over the permissible limits of WHO in water for agriculture use (<2.0 meq/l). The RSC in 36 collected groundwater samples ranged from 0 to 7.80 meq/l, the highest (7.80 meq/l) was in UC Mulakatiar, while lowest (0) in the sample collected from UC Allahyar Turk of taluka Bulri Shah Karim.

3.1.3. Taluka Tando Ghulam Hyder

The results on analysis of Sodium Adsorption Ratio (SAR) in groundwater samples collected from various Union Councils of Taluka Tando Ghulam Hyder are presented in Table **3**. The SAR in the samples ranged from 15.37 to 67.30, the highest (67.30) SAR was in UC Ghulam Shah Bagrani Moya, while lowest (15.37) in the sample collected from UC Dando. The above SAR values indicated that the groundwater quality in taluka Tando Ghulam Hyder is totally unsuitable for

Table 3: Determination of Sodium Adsorption Ratio (SAR) Residual Sodium Carbonate (RSC) in Groundwater Samples for Irrigation in Taluka Tando Ghulam Hyder

Sr#	Union Council	Sample Code	Sodium Adsorption Ratio (SAR) (meq/l)	SAR within permissible limits (Yes/No)	Residual Sodium Carbonate /RSC (meq/l)	RSC Below permissible limits (Yes/No)
Maximum Permissible Limit			<7.5		<2.0	
1	T.G. Hyder	1 R	35.36	No	2.89	No
2	T.G. Hyder	2 R	33.36	No	3.21	No
3	T.G. Hyder	3 R	16.94	No	1.04	Yes
4	T.G. Hyder	4 R	34.14	No	3.30	No
5	T.G. Hyder	5 R	28.14	No	2.53	No
6	T.G. Hyder	6 R	25.62	No	2.21	No
7	Nazarpur	1 S	31.66	No	3.37	No
8	Nazarpur	2 S	56.25	No	5.10	No
9	Nazarpur	3 S	44.03	No	4.11	No
10	Nazarpur	4 S	29.88	No	1.02	Yes
11	Nazarpur	5 S	51.57	No	4.42	No
12	Nazarpur	6 S	55.98	No	4.73	No
13	Dando	1 T	16.97	No	0.68	Yes
14	Dando	2 T	22.66	No	0.92	Yes
15	Dando	3 T	17.10	No	0.90	Yes
16	Dando	4 T	18.93	No	1.19	Yes
17	Dando	5 T	15.37	No	0.71	Yes
18	Dando	6 T	17.06	No	0.78	Yes
19	G.S.B.Moya	1 U	52.54	No	4.73	No
20	G.S.B. Moya	2 U	51.82	No	4.73	No
21	G.S.B. Moya	3 U	67.30	No	7.53	No
22	G.S.B. Moya	4 U	32.13	No	3.03	No
23	G.S.B. Moya	5 U	65.82	No	7.26	No
24	G.S.B. Moya	6 U	39.01	No	3.04	No

T.G. Hyder = Tando Ghulam Hyder; G.S.B. Moya= Ghulam Shah Bagrani Moya.

agriculture use, because in all the 24 samples collected, SAR values were found exceeding the permissible limits of WHO for agriculture use (<7.5). The results clearly indicated that in case of shortage of surface water, the people of the area depend on agriculture could not survive and special efforts are needed to improve the groundwater quality for agriculture use.

The results for Residual Sodium Carbonate (RSC) in groundwater samples collected from various Union Councils of Taluka Tando Ghulam Hyder (Table **3**) indicated that only 07 samples out of 24 had RSC within permissible limits of WHO for agriculture use water (<2.0 meq/l), while 17 samples indicated RSC in exceeded levels over the permissible limits of WHO in water for agriculture use (<2.0 meq/l). The RSC in 24 collected groundwater samples ranged from 0.68 to 7.53 meq/l, the highest (7.53 meq/l) was in UC Ghulam Shah Bagrani Moya, while lowest (0.68 meq/l) in the sample collected from UC Dando of taluka Tando Ghulam Hyder.

4. DISCUSSION

Pakistan is an agricultural country, ponds, wells, streams and waste treatment plants are common sources of irrigation water. Problem levels of sodium (Na), calcium (Ca), magnesium (Mg) and carbonates can occur in any of these sources. The continued application of poor quality drinking and irrigation water has harmful effects on human beings, crops and soil and it reduces the quality and growth of different crops. However, with proper precautions and altered management practices, poor quality irrigation water may be used to produce high quality agricultural commodities.

In the present study Union Council (UC) of District Tando Muhammad Khan, Sindh, Pakistan was selected for evaluation of SAR and RSC from groundwater. Groundwater was chosen in the present study mainly because of its dynamic nature and it is most affected by various human activities such as, expansion of cultivated and irrigated lands, industrialization and urbanization etc.

Due to the fact that, it represents the largest available source of fresh water lying beneath the ground, it has become crucial not only for targeting of groundwater potential zones, but also monitoring and conserving this important resource. The groundwater is usually clear, colorless and remains relatively at constant temperature, is therefore normally superior to surface water from sanitary considerations. But ground water has higher salt contents than surface waters because slowly moving water remains in contact with substrata for longer period thereby increasing the soluble mineral content in water until a condition of equilibrium is reached. Water being a universal solvent carries minerals in solution which, though present in small quantities, determine its suitability for various purposes. Quality of groundwater may vary from place to place and from stratum to stratum. It also varies from season to season. The requirement of quality of water or various purposes such as drinking water, industrial water and irrigation water vary widely [1]. According to Nishanthiny *et al.* [13] from Jaffna, Sri Lanka, Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC) can be used as a criterion for finding the suitability of irrigation waters and reported that about 35.3% of the wells have unsuitable irrigation water quality in which bicarbonate hazard was identified as major hazard which is due to the influence of carbonate rock dissolution.

In Tando Muhammad Khan taluka, the Sodium Adsorption Ratio (SAR) in the samples ranged from 11.06 to 53.29, the highest (53.29) SAR was in UC Tando Saindad, while lowest (11.06) in the sample collected from UC-2 of Tando Muhammad Khan. The above SAR values of groundwater samples indicated an alarming situation and not a single ground-water sample had SAR within permissible limits of WHO for agriculture use (<7.5). In case of Taluka Bulri Shah Karim, the Sodium Adsorption Ratio (SAR) in groundwater samples collected from various Union Councils ranged from 5.91 to 77.83. The SAR values indicated that the groundwater quality in taluka Bulri Shah Karim is not suitable for agriculture use, because in most of the samples the SAR values were far ahead of the permissible limits of WHO for agriculture use (<7.5). In Taluka Tando Ghulam Hyder, the SAR in the samples ranged from 15.37 to 67.30, the highest (67.30) SAR was in UC Ghulam Shah Bagrani Moya, while lowest (15.37) in the sample collected from UC Dando, which indicated that the groundwater quality in taluka Tando Ghulam Hyder is totally unsuitable for agriculture use, because in all the 24 samples collected, SAR values were found exceeding the permissible limits of WHO for agriculture use (<7.5).

The results clearly indicated that in case of shortage of surface water, the people of the area depend on agriculture could not survive and special efforts are needed to improve the groundwater quality for agriculture use. The results regarding SAR and RSC in groundwater samples collected from various talukas of Tando Muhammad Khan district of Sindh are in concurrence with those of Abu-Rukah and Al-Kofahi [14], who examined SAR in Jordan and reported that it exceed the permissible limits, while from India under similar soil and water conditions. Latha *et al.* [15] found highest (34.20meq/l) sodium adsorption ratio (SAR) in Palladam samples. In another study from India, Phogat *et al*. [16] reported high sodium adsorption ratio (SAR) in groundwater samples and considered the water in the saline categories. Shah and Mistry [8] from western India also confirmed that groundwater sample is unsuitable for irrigation purpose according to Sodium adsorption ratio (SAR).

The Residual Sodium Carbonate (RSC) in 36 collected groundwater samples ranged from 0.61 to 5.15 meq/l, the highest (5.15 meq/l) was in UC Tando Saindad, while lowest (0.61) in the sample collected from UC-3 of Tando Muhammad Khan. Only 10 samples out of 36 the samples had RSC within permissible limits of WHO for agriculture use water (<2.0 meq/l), while 26 samples indicated RSC in exceeded levels over the permissible limits of WHO in water for agriculture use. Residual Sodium Carbonate (RSC) in groundwater samples collected from various Union Councils of Taluka Bulri Shah Karim indicated that only 5 samples out of 36 had RSC within permissible limits of WHO for agriculture use water (<2.0 meq/l), while 31 samples indicated RSC in exceeded levels over the permissible limits of WHO in water for agriculture use (<2.0 meq/l). The RSC in 36 collected groundwater samples ranged from 0 to 7.80 meq/l, the highest (7.80 meq/l) was in UC Mulakatiar, while lowest (0) in the sample collected from UC Allahyar Turk of taluka Bulri Shah Karim. Residual Sodium Carbonate (RSC) in groundwater samples indicated that only 07 samples out of 24 had RSC within permissible limits of WHO for agriculture use water (<2.0 meq/l), while 17 samples indicated RSC in exceeded levels over the permissible limits of WHO in water for agriculture use (<2.0 meq/l). The RSC in 24 collected groundwater samples ranged from 0.68 to 7.53 meq/l, the highest (7.53 meq/l) was in UC Ghulam Shah Bagrani Moya, while lowest (0.68 meq/l) in the sample collected from UC Dando of taluka Tando Ghulam Hyder.

Latha *et al.* [15] reported water samples with residual sodium carbonate (RSC) ranging from 5.0-7.5 meq/l and EC >3 dS/m are unsuitable for irrigation as they are liable to cause salinity and sodicity problem in soils. Abu-Rukah and Al-Kofahi [14] in their study found the high RSC levels in different water samples collected from Jordan. The results of present study are also in confirmation with Sarkar and Hassan [17] who reported that RSC values were higher (3.26 to 4.16 meq/l) than the permissible limit (>2.5 meq/l) due to higher HCO_3^- content in the irrigation water that may induce some permeability problem.

5. CONCLUSION

It was concluded that the SAR levels of groundwater samples indicated an alarming situation and most of the ground-water samples had SAR (<7.5 meq/l) and RSC (<2.0 meq/l) above permissible limits of WHO for agriculture use therefore, it is not suitable for agriculture as well as drinking. In case of shortage of surface water, the people of the area depend on agriculture could not survive and special efforts are needed to improve the groundwater quality for agriculture use. The situation needs special attention of the concerned government agencies to take concrete measures to improve groundwater quality in the area of study.

REFFRENCES

[1] Nag SK, Lahiri A. Hydrochemical Characteristics of Groundwater for Domestic and Irrigation Purposes in Dwarakeswar Watershed Area, India. Am J Climate Change 2012; 1: 217-30. http://dx.doi.org/10.4236/ajcc.2012.14019

[2] Kardovani P. The problems of waters in iran: Saline water, Tehran University Press 2007; 2: 237(in persian).

[3] Abdullahi AS, Isa FI, Ayodele AS, Peter Z, Muhammad DBB. Investigation of Groundwater quality for Domestic and Irrigation purposes around Gubrunde and Environs, northeastern Nigeria. J Am Sci 2010; 6(12): 664-72.

[4] Moasheri SA, Honarbakhsh A, Farsani PA. Estimation Spatial Distribution of Sodium Adsorption ratio (sar) in Groundwater's using Ann and Geo Statistics Methods, The Case of Birjand Plain, Iran. Int J Agric: Res Rev 2013; 3(4): 908-16.

[5] Glover CR. Irrigation water classification systems. Guide A-116. Cooperative Extension Service, College of Agriculture and Home Economics, New Mexico State University 1996.

[6] Richards LA. Diagnosis on Improvement of Saline and Alkali Soils, U.S.D.A., Handbook No.60, Agri. Handbook .U.S. Dep. Agric 1954; 160.

[7] Lloyd JW, Heathcote JA. Natural Inorganic Hydrochemistry in Relation to Groundwater. Oxford Press Oxford 1985; 296.

[8] Shah SM, Mistry NJ. Groundwater Quality Assessment for Irrigation Use in Vadodara District, Gujarat, India. World Acad Sci Eng Technol 2013; 79: 1625-30.

[9] Darwisha T, Atallahb T, Francisb R, Sabb C, Jomaaa I, Shaabana A, Sakkac H, Zdrulic P. Observations on Soil and Groundwater Contamination with Nitrate: A Case Study From Lebanon-East Mediterranean", Agricultural Water Management (Elsevier), 2011; 99: 74– 84. U.S. Dep. Agric., 160.

[10] Lesch SM, Suarez DL. A Short Note on Calculating the Adjusted SAR Index. Am Soc Agric Biol Eng 2009; 52(2): 493-96.

[11] Richards LA. Diagnosis on Improvement of Saline and Alkali Soils, U.S.D.A., Handbook No.60, Agri. Handbook .U.S. Dep. Agric., 1954; 160.

[12] Sadashivaiah C, Ramakrishnaiah CR, Ranganna G. Hydrochemical analysis and evaluation of groundwater quality in Tumkur Taluk, Karnataka State, India. Intl J Environ Res Public Health 2008; 5(3): 158-64. http://dx.doi.org/10.3390/ijerph5030158

[13] Nishanthiny SC, Thushyanthy M, Barathithasan T, Saravanan S. Irrigation Water Quality Based on Hydro Chemical Analysis, Jaffna, Sri Lanka. Am-Eurasian J Agric Environ Sci 2010; 7(1): 100-102.

[14] Abu-Rukah Y, Al-Kofahi O. The assessment of the effect of landfill leachate on ground-water quality - a case study. El-Akader landfill site - north Jordan. J Arid Environ 2001; 49(3): 615-30. http://dx.doi.org/10.1006/jare.2001.0796

[15] Latha MR, Indirani R, Sheeba S, Francis HJ. Ground water quality of Coimbatore district, Tamil Nadu. J Ecobiol 2002; 14(3): 217-21.

[16] Phogat V, Satyavan, Kaushik RD, Kumar S. Assessment of ground water quality for irrigation of Narnaund block of Hisar District of Haryana. Annals Agric Biol Res 2004; 9(1): 95-98.

[17] Sarkar AA, Hassan AA. Water quality assessment of a groundwater basin in Bangladesh for irrigation use. Pak J Biol Sci 2006; 9 (9): 1677-84. http://dx.doi.org/10.3923/pjbs.2006.1677.1684

Received on 13-03-2014 Accepted on 30-04-2014 Published on 14-05-2014

DOI: http://dx.doi.org/10.6000/1927-5951.2014.04.02.12