Pak. J. Agri. Sci., Vol. 49(4), 549-556; 2012
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

EVALUATION OF GROUND WATER QUALITY FOR IRRIGATION AND DRINKING PURPOSES OF THE AREAS ADJACENT TO HUDIARA INDUSTRIAL DRAIN, LAHORE, PAKISTAN

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This study was designed to assess the ground water quality of areas adjacent to Hudiara industrial drain, Lahore, Punjab, Pakistan. Thirty three groundwater samples were collected from tube wells located within 3 Km on either side of the Hudiara drain from different depths. This area falls under Indus plain which hosts one of the biggest ground water reservoirs in the world and is the main source of water for drinking as well as agriculture. To check the suitability of ground water, samples were analysed for different irrigational and drinking quality parameters. The minimum and maximum values of these parameters were found as EC (496 to 2060 μScm^{-1}), SAR (2.2 to 15.9), RSC (1.8 to 11.2 meq L^{-1}), MAR (21.4 to 66.1%) and Cl (0.22 to 3.80 meq L^{-1}). Among the heavy metals, Lead (Pb), Nickel (Ni), Chromium (Cr), Copper (Cu) and Cobalt (Co) were not detected. The maximum values of Manganese (Mn), Zinc (Zn) and NO_3 were found within safe limits whereas Fluoride concentration was higher in one sample. Permissible limits set by World Health Organisation (WHO) and Agriculture Department, Government of the Punjab were considered as standard for evaluating samples for drinking and irrigation suitability, respectively. As a whole, drinking quality of collected water samples was found satisfactory and free of contaminants of human origin. In terms of SAR, 75.7% water samples were fit while regarding RSC, 18% samples were marginally suitable and 82% samples were unfit for irrigation. Chloride level of 97% water samples was in safe limits. Collectively 21% samples were marginally suitable which can be used for irrigation along with some amendments and adopting special management practices while 79% samples were unfit for irrigation purposes.
Keywords: Indus plain, drinking water quality, sodium adsorption ratio, residual sodium carbonate, heavy metals

INTRODUCTION

Water is essential component of all forms of life and it is mainly obtained from two sources, i.e. surface water which includes rivers, canals, fresh water lakes, streams etc. and ground water like well water and borehole water (McMurry and Fay, 2004). Because of unique chemical properties of water due to its polarity and hydrogen bonding, it has ability to suspend, dissolve, absorb and adsorb many different compounds. Thus water is not pure in nature, as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities (Mendie, 2005; Chitmanat and Traichaiyaporn, 2010). Groundwater is the major source of drinking water in Pakistan, besides it is an important source of water for agriculture and industrial purposes. Because of over burden of the human population, unplanned urbanization, unsustainable and unrestricted abstraction policies and inappropriate dumping of solid as well as liquid wastes, lack of strict enforcement of law and loose governance has resulted in the deterioration of ground water quality and quantity in Pakistan (WWF, 2007). Among contaminants of ground water heavy metals are of particular concern because of their strong toxicity even at low concentrations, with their occurrence in water bodies of either natural origin e.g. eroded minerals within sediments, leaching of ore deposits and volcanism extruded products or of anthropogenic origin i.e. solid waste disposal, industrial or domestic effluents, harbour channel dredging (Marcovecchio *et al*., 2007). It has been reported that the water quality of major cities of Pakistan, such as Sialkot, Gujarat, Faisalabad, Karachi, Kasur, Peshawer, Lahore, Rawalpindi and Sheikhupura is deteriorating because of unchecked disposal of untreated municipal and industrial wastewater and unscrupulous use of fertilizers, pesticides and insecticides (Bhutta *et al*., 2002). A study of eleven cities of Punjab showed an excess of arsenic and fluoride concentrations in water supply systems of six cities; Multan, Bhawalpur, Sheikhupura, Kasur, Gujranwala, and Lahore (PCRWR, 2005). Ullah *et al*. (2009) found that concentrations of EC, TDS, SO_4, Cl, total hardness, Zn, Pb and Fe were above the permissible levels established by World Health Organisation in Sialkot, an industrial city of Pakistan.

Current study involves the study of quality of ground water which is considered to be affected by the water of Hudiara Drain. Hudiara Drain is a transboundary water channel which originates from India and enters into Pakistan territory near village Lallo. The total length of the drain is 98.6 km, 44.2 Km in Indian Territory and 54.4 km in Pakistan territory (Afzal *et al*., 2000). Once it was a storm water stream but now turned into a polluted wastewater drain due to indiscriminate discharge of untreated industrial effluents and sewage waste (WWF and EPD Punjab, 2001; IPD, 2002; Afzal *et al*., 2000; Yasar *et al*., 2005). Around 120 different industries discharge their untreated industrial effluents into this drain. Total annual discharge of this drain is 178 cusecs (Yamin and Ahmad, 2007). The adjacent sides of Hudiara drain are being used for agricultural, industrial and residential purposes. Rice, wheat, maize and potatoes are major crops of this area but fruits and vegetables are also grown to satisfy the needs of farming community. Community water supply system is based on ground water resource and is also the main source of irrigation to crops along with canal and Hudiara drain water. Long term use of untreated wastewater for crop production could result in contamination of shallow aquifers and soil profile that ultimately might appear as a potential risk to human health through food chain (Geake *et al*., 1987; Powell *et al*., 2003). This area falls under Indus plain which covers approximately 250,000 Km^2 in the province of the Punjab and Sindh in an extensive fluvial plain formed by the meandering river Indus and its tributaries. The ground water is the main source of drinking water and second source of irrigation, after canal water. Therefore, assessment of ground water quality of this area is of utmost importance not only for agriculture purpose but also for human consumption. This groundwater quality data will provide a snapshot to the planners responsible for the provision of safe drinking water to the resident community around the Hudiara drain and Lahore city. This study will also helpful to the local farming community in planning irrigation schedule and selection of crops according to the quality of available ground water resource.

MATERIALS AND METHODS

***Location of study area*:** Hudiara Drain lies between latitude of 31.4 (31° 23' 42 N) and a longitude of 74.13 (74° 8' 1 E) in Lahore, Pakistan (Fig. 1). There is series of confined aquifers present in this area, most of which are not in geologic contact with surficial aquifers (Afzal *et al*., 1998). The average annual rainfall in the area is about 650 mm, of which 65% occur during the south west monsoon (June to September) while the contribution from northeast monsoon is nearly 20% and the rest is received during the pre-monsoon period. Hudiara drain flows over fluvial deposits

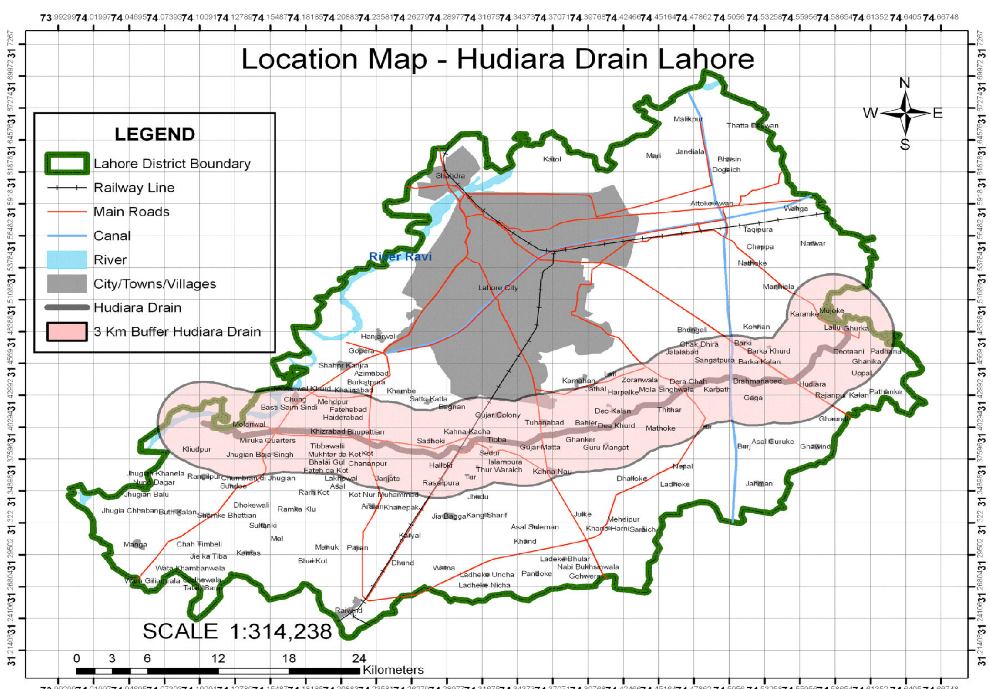

Figure 1. Location map of Hudiara drain, Lahore Pakistan

of river Ravi and river Sutluj. These sediments were deposited by meandering river systems. They are composed of point bars channel belt's deposits, levee deposits and flood plain deposits. They are composed of fine sands, silts and clay plus silt deposits. The sandy horizons occur as aquifers whereas the silt/clay deposits occur as barriers. However in all overall deposits the silt and clay occur as extensive lenses within sandy deposits. The shallow aquifers are likely to be contaminated easily while deeper aquifers are protected by at least three impermeable horizons of silt or silt and clay. The area is used for agriculture purpose with the industrial zone situated on both sides of the drain.

***Water sampling*:** Ground water samples were randomly collected from 33 village sites from tube wells within 3 kilometre range of Hudiara drain using standard sampling procedures and were analysed for different agricultural and drinking parameters during the year 2011. Depth of tube wells varied from 160 to 600 feet. Position of each sampling point was recorded by GPS (Global Positioning System). Clean bottles were used for sampling purpose. Before sampling, each tube well was allowed to run for 20 minutes. Labelling was done properly indicating date of sampling and location. Samples were stored in a clean and cool ice case and were brought to soil and water testing laboratory for research, Lahore, for chemical analysis.

***Analytical methods*:** All chemicals and reagents were of the analytical grade and were obtained from BDH Chemicals Ltd, UK. Working standards were prepared from Certified Reference Material (CRM) with certificate of analysis traceable to National Institute of Standards and Technology (NIST).

Analytical techniques followed during analysis along with instrument make, model and method reference are mentioned in Table 1. Sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were calculated by following equations (Richards, 1954).

$$SAR = Na^{+} / [(Ca^{+2} + Mg^{+2}) /2]^{½}$$

$$RSC = (CO_3^{-2} + HCO_3^{-}) – (Ca^{+2} + Mg^{+2})$$

Magnesium adsorption ratio (MAR) was calculated according to Raghunath (1987).

$$MAR = Mg^{2+}\times100/Ca^{+2}+Mg^{+2}$$

All cations and anions concentrations are expressed in meq L^{-1}.

***Heavy metals analysis*:** Analysis for heavy metals, i.e. Pb, Ni, Cr, As, Cu, Co, Fe, Mn and Zn were performed on Atomic Absorption Spectrophotometer (AAS). The results obtained from the AAS analysis of ground water samples for selected area indicated that values of Cr, Ni, Pb, Co and Cu were below detectable limits and were not detected (ND).

RESULTS AND DISCUSSION

Water quality for drinking as well as for irrigation purpose was assessed on the basis of analytical results. World Health Organisation (WHO, 2011) and Agriculture Department, Government of the Punjab (Malik *et al*., 1984) limits were considered as standard for drinking and irrigation respectively while others are mentioned only for comparison.

Water quality evaluation for drinking purpose:

***pH and electrical conductivity (EC)*:** The pH value of water indicates whether the water is acidic or alkaline. Water with a pH value ranged from 6.5 to 8.5 is generally considered satisfactory for drinking purpose. Acidic water usually with pH below 6 corrodes plumbing and faucets. Alkaline water with pH above 8.5 has bitter taste. In study area pH value of water samples ranged between 6.75 to 8.45 with mean value of 7.23 and standard deviation of 0.3 (Table 2). All the water samples analysed have pH within the safe limits set by WHO (2011). Electrical conductivity of water is generally related to the amount of dissolved solid or minerals (ions). It represents the ability of water to conduct an electric current. The EC for all the sampling sites varied between 496 to 2060 µS cm^{-1} with mean value of 1086 µS cm^{-1} and standard deviation of 385 (Table 2). The highest EC value of 2060 µS cm^{-1} was recorded at sampling point 18 (Village Baraki) whereas sampling point 3 (Jhugian Bajs Singh) registered the lowest EC value (496 µS cm^{-1}) (Table 7). Over all 45% samples showed EC value below permissible limit of 1000 µS cm^{-1} (Table 4).

Table 1. Analysis techniques with references

Parameters	Technique	Instrument make and model	Method Reference
pH	pH-metry	pH 200 Sensodirect	Richards (1954)
Electrical Conductivity	Conductivity meter	CON200 Sensodirect, Lovibond	Richards (1954)
Na and K	Flame photometry	PFP-7, Jenway	Richards (1954)
Ca, Mg, CO_3, Cl and HCO_3	Titrimetric method	-	APHA (2000)
Fluoride, Cl and NO_3	Ion selective electrode	Orian4star, Thermoelectron	APHA (2000)
Pb, Ni, Cr, As, Cu, Co, Fe, Mn and Zn	Atomic Absorption Spectrophotometry	SpectrAA 250 Plus, Varian	Instrument operating manual

Table 2. Range, mean and standard deviation of drinking water quality parameters

Parameters	Range	Mean	Standard Deviation	Guideline values (mgL^{-1}) WHO	PCRWR	WWF	IWQS
pH	6.75 – 8.45	7.23	0.3	6.5 – 8.5	6.5 – 9.2	6.5 – 8.5	6.5 – 9.2
EC ($\mu S.cm^{-1}$)	496 – 2060	1086	385	1000	2343	1250	2343
CO_3 (mgL^{-1})	ND	–	–	N/A	N/A	N/A	N/A
HCO_3 (mgL^{-1})	252.2 – 794.4	450.0	139.5	1000	N/A	N/A	N/A
Cl (mgL^{-1})	7.9 –135.0	41.8	24.2	250[a]	600[b]	250[b]	1000[b]
F (mgL^{-1})	0.06 – 1.95	0.28	0.3	1.5	1.5	N/A	1.5
NO_3 (mgL^{-1})	0.03 – 20.3	1.96	4.7	50	45.0	10.0	45.0
Na (mgL^{-1})	58.0 – 350.0	152.1	70.0	200[a]	N/A	N/A	N/A
Ca (mgL^{-1})	13.0 – 67.0	44.0	15.0	75	N/A	N/A	200[b]
Mg (mgL^{-1})	4.2– 30.0	18.3	7.0	50	150[b]	N/A	150[b]

a: Levels likely to give rise consumer complaints; b: Guideline value; ND: Not detected; N/A: Not available

Table 3. Range, mean and standard deviation of heavy and trace elements

Element	Range (ppb)	Mean (ppb)	Standard Deviation	WHO Guideline value [31-36] (ppb)	WWF [38] (ppb)
Pb	ND	–	–	10[b]	50[b]
Ni	ND	–	–	70[b]	100
Cr	ND	–	–	50[c]	50[b]
As	2.0 – 9.0	5.0	2.0	10	50
Cu	ND	–	–	2000[b]	1500[b]
Co	ND	–	–	N/A	N/A
Mn	0.0 – 140.0	40.0	30.0	500[b]	100[b]
Zn	0.0 – 80.0	30.0	10.0	3000[a]	5000[b]

N/A: Not available; ND: Not detected; b: Guideline value; c: Provisional Guideline value

Table 4. Percent distribution of water samples based on different parameters

Parameters	WHO		WWF		PCRWR	
	Fit (%)	Unfit (%)	Fit (%)	Unfit (%)	Fit (%)	Unfit (%)
pH	100	Nil	100	Nil	100	Nil
EC ($\mu S.cm^{-1}$)	45.4	54.6	63.6	36.4	100	Nil
CO_3 (mgL^{-1})	100	Nil	100	Nil	100	Nil
HCO_3 (mgL^{-1})	N/A	N/A	N/A	N/A	N/A	N/A
Cl (mgL^{-1})	100	Nil	100	Nil	100	Nil
F (mgL^{-1})	97	3	N/A	N/A	97	3
NO_3 (mgL^{-1})	100	Nil	94	6	100	Nil
Na (mgL^{-1})	78.8	21.2	N/A	N/A	N/A	N/A
Ca (mgL^{-1})	100	Nil	N/A	N/A	N/A	N/A
Mg (mgL^{-1})	100	Nil	N/A	N/A	100	Nil
Pb (ppb)	100	Nil	100	Nil	100	Nil
Ni (ppb)	100	Nil	100	Nil	100	Nil
Cr (ppb)	100	Nil	100	Nil	N/A	N/A
As (ppb)	100	Nil	100	Nil	N/A	N/A
Cu (ppb)	100	Nil	100	Nil	100	Nil
Co (ppb)	100	Nil	100	Nil	100	Nil
Mn (ppb)	100	Nil	97	3	100	Nil
Zn (ppb)	100	Nil	100	Nil	100	Nil

N/A: No permissible limit available/set so far

Table 5. Range, mean and standard deviation of irrigation quality parameters of ground water

Parameter	Range	Mean	Standard Deviation
EC ($\mu S\ cm^{-1}$)	496 – 2060	1085.78	385.00
SAR	2.2 – 15.9	5.00	2.66
RSC ($me\ L^{-1}$)	1.8 – 11.2	4.47	2.19
MAR (%)	21.4 – 66.1	40.71	10.90
Cl ($me\ L^{-1}$)	0.22 – 3.80	1.18	0.68

Table 6. Percent distribution of ground water against irrigation parameters

Parameter	Class interval	Percent distribution	Status
Electrical conductivity, EC ($\mu S\ cm^{-1}$)	<1000	45.4	Fit
	1001-1250	18.2	Marginally Fit
	>1250	36.4	Unfit
Sodium Adsorption Ratio, SAR	<6	75.7	Fit
	6-10	18.2	Marginally Fit
	>10	6.0	Unfit
Residual Sodium Carbonate, RSC (me L^{-1})	<1.25	0	Fit
	1.25-2.50	18	Marginally Fit
	>2.50	82	Unfit
Magnesium Adsorption Ratio (MAR)	<50%	76	Fit
	>50%	24	Unfit
Chloride (me L^{-1})	0-3.9	97	Fit
	>3.9	3.0	Unfit

Table 7. Village wise categorization of ground water along with salt added (Kg) per acre foot irrigation

Sr.#	Village	Fit	M. Fit	Unfit	Unfit due to					Salt added to soil Kg/acre foot irrigation
					EC	RSC	EC + RSC	SAR + RSC	EC + SAR+ RSC	
1	Hulloki	-	-	unfit	-	-	unfit	-	-	1221.3
2	Molanwal	-	-	unfit	-	-	-	-	unfit	1446.2
3	Jhugian Bajs Singh	-	-	unfit	-	unfit		-	-	391.3
4	Kliudpur	-	-	unfit	-		unfit	-	-	1128.2
5	Kahna Kacha	-	-	unfit	-	-	unfit	-	-	1215.0
6	Basti Saim Sindhi	-	-	unfit	-	-	unfit	-	-	1016.2
7	Miruka Quarters	-	-	unfit	-	-	unfit	-	-	1002.8
8	Bhupattian	-	-	unfit	-	unfit	-	-	-	894.7
9	Bhalai Gul	-	-	unfit	-	unfit	-	-	-	728.2
10	Kot Chananpur	-	-	unfit	-	unfit	-	-	-	959.4
11	Kacha Sadui	-	-	unfit	-	unfit	-	-	-	832.4
12	Kacha Sadui	-	-	unfit	-	unfit	-	-	-	693.5
13	Khana Nau	-	-	unfit	-	-	unfit	-	-	1019.3
14	Khana Nau	-	-	unfit	-	-	unfit	-	-	1114.0
15	Guru Mangat	-	-	unfit	-	-	unfit	-	-	1080.9
16	Dea Khurd	-	-	unfit	-	unfit		-	-	749.5
17	Mathoke	-	-	unfit	-	unfit		-	-	651.7
18	Baraki	-	-	unfit	-	-	unfit	-	-	1625.3
19	Baraki	-	-	unfit	-	unfit		-	-	778.7
20	Rassilpura	-	-	unfit	-	-	unfit	-	-	1175.6
21	Thithar	-	M. Fit	-	-	M. Fit		-	-	594.9
22	Dera ChahKarbath	-	M. Fit	-	-	M. Fit		-	-	436.3
23	Dera ChahKarbath	-	M. Fit	-	-	M. Fit	-	-	-	433.1
24	Gaga	-		unfit	-	unfit	-	-	-	783.4
25	Barhmanabad	-	M. Fit	-	-		M. Fit	-	-	878.1
26	Barhmanabad	-	M. Fit	-	-	M. Fit	-	-	-	550.7
27	Hudiara	-	M. Fit	-	-	M. Fit	-	-	-	418.9
28	Hudiara	-	-	unfit	-	unfit	-	-	-	681.7
29	Hudiara	-	-	unfit	-	unfit	-	-	-	454.4
30	Uppal	-	-	unfit	-		unfit	-	-	994.9
31	Deotanni	-	M. Fit		-	M. Fit	-	-	-	523.9
32	Lallu	-	-	unfit	-	unfit	-	-	-	818.2
33	Gunrka	-	-	unfit	-	unfit	-	-	-	976.7

***Chlorides (Cl)*:** Chlorides can corrode metals and affect the taste of food products (APHA, 2000). However, it does not pose any health hazard. In the study area chloride level ranged from 7.9 to 135 mg L^{-1} (Table 2) which is far below the maximum allowable concentration of 250 mg L^{-1}.

***Nitrates (NO_3)*:** Sources of nitrate in water may be fertilizers, food preservatives and human and animal wastes. Higher levels of nitrate could result in Methaemoglobinaemia. Nitrate level was found in the range of 0.03-20.3 mg/L (Table 2) with mean value of 1.96±4.7. All samples were within maximum allowable concentration of WHO (2011) standard for nitrate of 50 mg/L.

***Fluoride (F)*:** Fluoride in small concentrations in drinking water has beneficial effect on human body. Concentration of fluoride below 0.5 mg/L causes dental caries and higher concentration beyond 1.5 mg/L causes dental and skeletal fluorosis. Concentrations of fluoride in analysed samples ranged from 0.06 mg/L to 1.95 mg/L. Out of 33 samples taken from running tube wells in study area, all samples were within maximum allowable limit of 1.5 mgL^{-1} except one sample of the village Molanwal which has value higher than permissible limit (Table 2 & 4).

***Cations (Ca^{++}, Mg^{++}, Na^{++})*:** The values for cations like calcium (Ca), magnesium (Mg) and sodium (Na) were found to be in range of 13.0-67.0, 4.2-30.0 and 58.0-350 mgL^{-1} respectively. Results revealed that Ca and Mg ions concentration in all samples was within permissible limit (75 mg/L and 50 mg/L respectively). 78.8 % samples of studied area were within maximum permissible limit for sodium ions concentration (200 mg/L). 21.2 % samples crossed the limit (Table 2 & 4).

***Anions (CO_3 and HCO_3)*:** Carbonate (CO_3) ions were not detected in any of the samples. Bicarbonate (HCO_3) ions concentration was found in the range of 252 mg/L to 794 mg/L so all water samples were under permissible limit of HCO_3 1000 mg/L.

***Heavy Metals*:** Values of Cr, Ni, Pb, Co, Cu were not detected in any of the samples (Table 3). Remaining metals like As, Mn and Zn were found in water samples. The values of these heavy metals ranged from: As; 2.0-9.0, Mn; 0.0-140.0 and Zn; 0.0-80.0 µg/L (ppb). Data revealed that As, Mn and Zn levels at all sites were below safe limit for drinking water as recommended by WHO, 10, 500 and 3000 ppb, respectively.

Water quality for irrigation: Good quality of water for irrigation is characterized by acceptable range of electrical conductivity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), magnesium adsorption ratio (MAR) and chlorides (Cl). The results of water for these parameters are given in Table 5 with their mean value and standard deviation.

***Electrical conductivity (EC)*:** Electrical conductivity tells about the salinity hazard of water. The EC for all samples varied between 496 and 2060 µS/cm with mean value of 1085.8 $\mu S.cm^{-1}$ ±385. Concerning salinity point of view out of 33 water samples 15 (45.4%) samples were fit, 6 (18.2%) were marginally fit and 12 (36.4%) samples were unfit with high salinity (Table 6).

***Sodium adsorption ratio (SAR)*:** SAR is representation of sodium hazard. The value of SAR is used to evaluate suitability of water for irrigation. SAR is the estimation of the degree to which sodium will be adsorbed by the soil. High value of SAR means sodium enhance the dispersion of colloids or clays when it comes in contact with the soil and may replace calcium and magnesium ions in the soil resulting in damage to the soil structure and reduction in its capacity to conduct water and air (Lloyd, 1985). Thus in turn soil fertility is damaged because it increases pH and reduces availability of Zn and Fe. Increase in SAR values up to 30 decreases soil aggregate stability (Barzegar *et al*., 1994). Richards (1954) classified the groundwater based on SAR, as Excellent/suitable (<10), marginally suitable (10-18) and unsuitable (>18). The SAR values of groundwater obtained in the present study ranged from 2.2 to 15.9 with mean value of 5.00±2.66 (Table 5). Out of 33 samples 25 (75.7%) were fit, 6 samples (18.2%) were marginally fit and remaining 2 (6%) samples were unfit in term of SAR (Table 6).

***Residual sodium carbonates (RSC)*:** Bicarbonate content of the water is considered in RSC. High concentration of bicarbonate increases the pH value of water which in turn causes dissolution of organic matter. In waters having high value of RSC there is tendency for calcium and magnesium to precipitate that can cause an increase in sodium content in the soil solution. It was grouped as Good (<1.25), Doubtful/Marginal (1.25-2.5) and Unsuitable (>2.5) (Richards, 1954; Sadashivaiah *et al*., 2008). RSC values ranged from 1.8 to 11.2 meq/L with a mean value of 4.47 meq/L with standard deviation of 2.19 (Table 5). 18% samples were found marginally fit and remaining 82% samples were unsuitable for irrigation. Waters with high value of RSC can be used by adopting special irrigation and management techniques with regular monitoring of soil salinity status by laboratory analysis (Nishanthiny *et al*., 2010).

***Magnesium adsorption ratio (MAR)*:** Magnesium content is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. Generally, calcium and magnesium maintain a state of equilibrium in most waters. More magnesium in water will adversely affect crop yields as the soils become more saline (Joshi *et al*., 2009). The values of the MAR of groundwater in present study varied from 21.4 to 66.1% (Table 5). Acceptable limit for MAR is 50% (Ayers and Westcot, 1985). Eight samples out of 33 (24%) were unfit while remaining 25 samples (76%) were fit for irrigation.

***Chlorides (Cl)*:** In the study area Chloride level ranged from 0.22 meq/L to 3.80 meq/L. 97% samples were found fit for irrigation (Table 5 & 6).

***Conclusion and recommendations*:** The water quality of studied areas is found satisfactory as a whole for drinking purpose as values of physico-chemical parameters were found within maximum permissible limits of WHO. It may be concluded from this study that the aquifer is confined there is free from contamination by the human activities. For irrigation purpose 21% samples were marginally fit which can be used with some amendments while 79% samples were unfit. Overall it could be concluded that the ground water quality of studied area is not affected by human activities. So this water can be used for drinking purpose but not for irrigation purposes.

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