International Journal of Scientific & Engineering Research, Volume 5, Issue 2, February-2014 318
ISSN 2229-5518

Preliminary study on irrigational quality of some ground water sources of Kashmir, India

Rifat Ara Wani[1], Aabid Hussain Mir[2]*, Aasimah Tanveer[1], Arshid Jehangir[1], A. R. Yousuf[1]

Abstract— In order to assess the groundwater quality for irrigational purposes, samples from seven stations were collected on monthly basis from June to November 2011. The samples were chemically analyzed for physico-chemical parameters including; pH, Conductivity, total solids, total dissolved and soluble salts, Alkalinity (CO_3^{2-}, HCO_3^-), Calcium, Magnesium, Sodium, and Potassium and to determine irrigational status Sodium adsorption ratio (SAR), Magnesium adsorption ratio (MAR), Percent sodium, Residual sodium carbonate (RSC), Kelley's ratio (KR), Permeability index (PI) and Soluble sodium percentage (SSP) were calculated. Chemically water was found to be mineralized, fresh and alkaline. Based on SAR, RSC, MAR, PI and KR all the samples fall within permissible irrigational range. The correlation between sodium-adsorption ratio and electrical conductivity showed 43% of samples fall under C_2S_1 (medium salinity and low alkali hazard) and 57% C_3S_1 (high salinity) category. While plotting %Na against electrical conductivity on Wilcox's diagram it was found that 43% samples had water quality varying from excellent to good while others (57%) had water quality varying from good to permissible. The overall values indicated that the ground water in the study area can be applied for irrigation purpose without any alkali or bicarbonate and magnesium hazard.

Index Terms— Agricultural activity, alkali hazard, bicarbonate hazard, dug well, magnesium hazard, tube well

1 INTRODUCTION

ABOUT 97.2% of world's water is found in oceans and seas and the remaining 2.8% of water is found as ground water and surface water, of which ground water (0.59%) is 30 times greater than surface water (0.02%). Groundwater quality as one of the most important aspects in water resource studies is largely controlled by discharge and recharges pattern, nature of host and associated rocks, and contaminated activities [1], [2]. In recent years, an increasing threat to ground water quality as well as quantity due to human activities has become of great importance [3], [4]. With the advent of the tube well along with the rapid growth of demand for agricultural and municipal water, annual global groundwater extraction has increased in recent decades from 100 km³/year in 1950 to a current estimated use of about 800 km³ a year [5], [6]. Currently about 43% of global irrigation, with 45% in India as well as more than 50% of the worlds drinking water supply and a large share of global industrial activity depend on groundwater. Quality of water is assuming great importance with the rising pressure on agriculture and rise in standard of living [7].

The adequate amount and quality of water which is being used for irrigation purpose should also be well within the permissible limit otherwise it could adversely affect the plant growth, as its quality of irrigation depends primarily on the presence of dissolved salts and their concentrations [8], [9].

Further, the excessive amounts of dissolved ions in irrigation water affect soil physically and chemically, thus reducing the primary productivity [9], [10]. Over-abstraction and pollution has resulted in sharp declines in the groundwater quality and quantity, posing a risk to world food production. Nitrates and other ions contaminate the groundwater mainly by leaching [11] and its occurrence can be used to identify aquifer settings vulnerable to contamination [12]. Besides, natural factors contributing to its chemical composition are precipitation, geological structure, mineralogy of the watershed, the quality of recharge water and aquifers and geological processes within the aquifer medium [13], [14], [15], but mainly anthropogenic stresses have greatly affected its quality as well as quantity rendering ground water as useless [16], [17].

Lot of work has been done on the ground water and its related irrigational as well as drinking water quality in different parts of Indian subcontinent [38], [39], [9]. Only few studies have been done on the ground water of the valley [18], [40], and scanty information is available related to the issue. Since there is an ever increasing demand for the ground water resources as a result of the change in climatic regime, scanty rainfall as well as dry winters, which have led to water scarcity in the region, especially in the Srinagar and its adjoining areas. Therefore this study was undertaken to find the suitability of some ground water sources of the region for irrigational purposes, so as to better understand the prevailing conditions. The study is of broad scope as it will not only help to find out the irrigational quality of the ground water sources of the area, but will also provide baseline data for agricultural planners, as well as for the future studies.

2 MATERIALS AND METHODS

The current hydro-chemical study was undertaken by randomly collecting the groundwater samples from seven stations representing one dug well and six bore wells, every month from June to November 2011. The details of the sampling sites are presented in Fig. 1 and Table 1. The samples were collected in sterilized bottles, prior to sample collection, wells were flushed for about 5-10 minutes, and sampling containers were washed and then rinsed with the groundwater,

- [1] Department of Environmental Science University of Kashmir-190006, J& K India
- [2]Department of Environmental Studies North-Eastern Hill University Shillong- 793022, Meghalaya, India
*Correspnding author email- naturelover42@yahoo.in aabidm4@gmail.com
Tel: +91-8974013152 +91-9858980965

which followed by sample collection.

Table: 1. Details of sampling sites.

Sites	Latitude	Longitude
Potulbagh (I)	33° 58′ 26.7″ N	74° 55′ 0.14″ E
Marwal (II)	33° 58′ 10″ N	74° 54′ 13.0″ E
Nuhama (III)	33° 59′ 26.5″ N	74° 53′ 58.3″ E
Aramwari (IV)	34° 03′ 56.7″ N	74° 50′ 19.4″ E
Bonumsar (V)	34° 04′ 22.0″ N	74° 50′ 24.0″ E
Tengpora (VI)	34° 07′ 54.3″ N	74° 43′ 10.0″ E
Kreshbagh(VII)	34° 07′ 44.3″ N	74° 44′ 30.5″ E

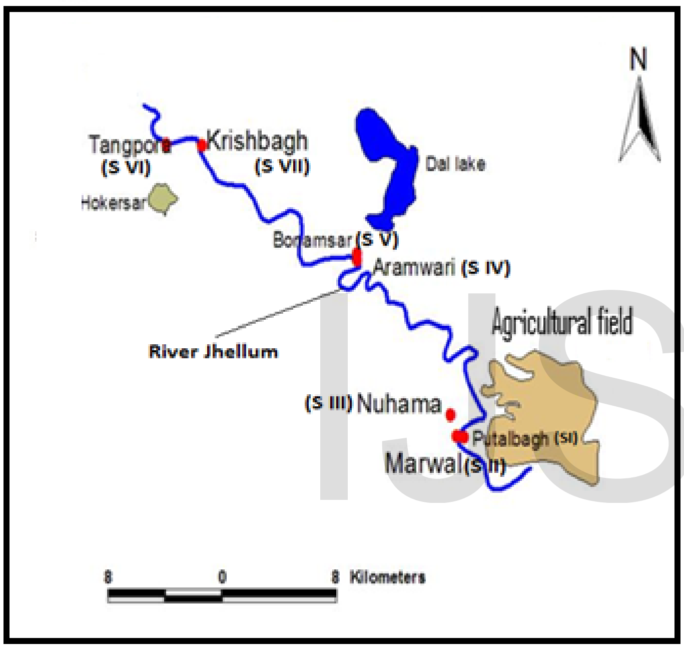

Fig.1 Map showing different study sites.

After proper collection, the samples were sealed and brought to the laboratory for analysis. The analysis of the samples was done, using standard procedures recommended [19], [20]. Temperature, pH and electrical conductivity (EC) were measured using digital instruments (Thermometer, digital pH meter and digital conductivity meter) immediately after sampling. The parameters like; Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Carbonates (CO_3^{2-}), and bicarbonates (HCO_3^{-}) were analyzed by Titrimetry methods, while Sodium (Na^{+}) and Potassium (K^{+}) were analysed by Flame Photometric method. In order to find irrigational quality, Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR), Permeability Index (PI), Percent Sodium (%Na), Soluble Sodium Percentage (SSP), Residual sodium carbonate (RSC) and Kelley's ratio (KR) were calculated using standard equations which are given in Table 2.

Table: 2. Standard equations used for determining the irrigational status of groundwater

Parameter	Ref	Equation
SAR	[35]	$\frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$
MAR	[37]	$\frac{Mg^{+} \times 100}{Ca^{2+} + Mg^{2+}}$
SSP	[25]	$\frac{Na^{+} \times 100}{Ca^{2+} + Mg^{2+} + Na^{+}}$
%Na	[26]	$\frac{Na^{+} + K^{+}}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}} \times 100$
PI	[30]	$\frac{\left(Na^{+} + \sqrt{HCO_3}\right) \times 100}{Ca^{2+} + Mg^{2+} + Na^{+}}$
KR	[36]	$\frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$
RSC	[27]	$(CO_3 + HCO_3) - (Ca^{2+} + Mg^{2+})$

3 RESULTS AND DISCUSSIONS

Hydro-chemical analysis of groundwater samples is presented in (Table 3 and 4), the data depicts that the temperature ranged from 7.2 to 18.5 ^{0}C (Average 11-14 ^{0}C). All the sites depicted alkaline pH. The conductivity was fairly good indicating good salt status. The occurrence of high EC values in the study area reflected the probable addition of some salts through the prevailing agricultural activities [21]. The total solids ranged from a low 395 mg/L to a high of 822 mg/L and Total hardness values between hard (150 to 300 mg/L) and very hard (>300 mg/L) as per Sawyer and Macarty [22]. Calcium, magnesium, sodium and potassium concentrations represented appreciable quantities. The overall cationic and anionic composition at the study sites depicted the sequence of Ca> Mg> Na> K and HCO_3> Cl> SO_4^2.

Table: 3. Average values of Physical parameters of bore wells and dug wells at study sites during June to November 2011.

Site	Temp.	pH	EC	TS	TDS	TSS
I	12	7.2	472	537	377	200
II	12	7.6	820	590	385	205
III	13	7.4	591	715	427	287
IV	14	7.5	820	787	550	237
V	14	7.8	957	687	385	302
VI	11	7.4	942	822	455	367
VII	12	7.3	695	395	162	232

All values are in mg/L except Temperature (^{0}C), conductivity (µS/cm). Where EC= electrical conductivity, TS= Total solids, TDS= total dissolved solids, TSS= total suspended solids

ISSN 2229-5518

Table: 4. Average values of Chemical parameters of bore wells and dug wells at study sites during June to November 2011.

Site	Alkalinity	Hardness	Ca^{2+}	Mg^{++}	Na	K
I	54	281	60	27	3	1
II	104	245	72	13	35	18
III	93	283	61	28	29	2
IV	80	401	73	44	34	6
V	96	325	88	26	27	13
VI	92	254	62	24	38	19
VII	80	230	52	18	29	5

All values are in mg/L

3.1 Irrigational quality of water

Since productivity of crop is mainly dependent on the quality of water used for its irrigation and the quality depends primarily on the presence of dissolved salts and their concentrations [8], [9]. Presence of salts not only limit the growth of plants physically by restricting the uptake of water through modification of osmotic processes but also can damage plant growth chemically by the effects of toxic substances on metabolic processes. Therefore, salinity, sodicity and toxicity are generally considered for evaluation of the suitability of these groundwater sources for irrigation purpose [23]. Good quality of waters for irrigation is characterized by acceptable range of sodium adsorption ratio and percent sodium. Sodium adsorption ratio (SAR), sodium percentage (Na %), residual sodium carbonate (RSC), and permeability index (PI) are important parameters for determining the suitability of ground water for irrigation uses. The potential for a sodium hazard increases in waters with higher sodium adsorption ration (SAR) values. There is a significant relationship between SAR values and the extent to which sodium is absorbed by the soil with water high in Sodium and low in Calcium, renders the cation-exchange complex saturated with Sodium [24].

3.1.1 Sodium Adsorption Ratio (SAR)

Groundwater is classified into different categories as Excellent (10), Good (10-18), Doubtful (18-26) and Unsuitable (>26) based on SAR values [25]. The studied samples showed SAR values from 0.1-1.2 meq/L (Table 5). All the samples fall in excellent (S1) category (Table 6), indicating that these ground water sources are suitable for irrigation purpose with no danger of exchangeable sodium.

Table: 5. Average values of SAR, MAR, PI, %Na, KR, RSC and SSP of groundwater at different stations

Site	SAR	%Na	MAR	KR	RSC	SSP	PI
I	0.1	4	41.5	0.02	-4.3	2.4	19.9
II	1	28	17.3	0.33	-3.0	24.6	22.2
III	0.8	23	34.8	0.24	-3.8	19.1	19.8
IV	0.9	23	41.4	0.20	-6.0	16.9	14.3
V	0.6	18	27.7	0.18	-5.0	15.2	17.4
VI	1	30	29.4	0.33	-3.6	24.6	19.5
VII	0.9	25	27.7	0.31	-2.8	23.6	22.2

All values are in meq/L

When the correlation between sodium-adsorption ratio and electrical conductivity was plotted on the US salinity diagram, in which EC is taken as salinity hazard and SAR is taken as alkalinity hazard, it was found that sites II, IV, V and VI fall in the field of C_3S_1 category indicating high salinity and low alkali hazard, and sites I, III and VII fall under C_2S_1 indicating medium salinity and low alkali hazard (Table 7).

Table: 6. Classification of groundwater samples on the basis of SAR, KR, SSP and RSC.

Parameter	Range	Water Class	Samples (%)
SAR [35]	< 10	Excellent (S1)	100
	10–18	Good (S2)	Nill
	18–26	Doubtful (S3)	Nill
	> 26	Unsuitable (S4)	Nill
KR [36]	<1	Good	100
	>1	Unsuitable	Nill
SSP [25]	<50	Good	100
	>50	Bad	Nill
RSC [27]	<1.25	Good	100
	1.25–2.5	Doubtful	Nill
	> 2.5	Unsuitable	Nill
TDS [34]	<1000	Non saline	100
	1000-3000	Slightly saline	Nill
	3000-10,000	Moderately saline	Nill
	>10,000	Very saline	Nill

The plots of groundwater chemistry of study area in USSL diagram are shown (Fig. 2). These groundwater sources can be used to irrigate all types of soils with little danger of exchangeable sodium but ground water of sites II, IV, V and VI which fall in the C_3S_1 (high salinity) category may not be fit for irrigation purposes in all soil types. Similarly low values of SAR were found in groundwater sources of south Kashmir Jehangir et al. [18].

Table: 7. Mean values of SAR, %Na, Conductivity and respective irrigational criteria.

Sites	SAR (meq/L)	% Na	EC (µS/cm)	Salinity Hazard
Site I	0.1	4	472	C_2S_1
Site II	1.0	28	870	C_3S_1
Site III	0.8	23	591	C_2S_1
Site IV	0.9	23	820	C_3S_1
Site V	0.6	18	957	C_3S_1
Site VI	1.0	30	942	C_3S_1
Site VII	0.9	25	695	C_2S_1

3.1.2 Percent sodium (%Na)

According to Wilcox [26], groundwater was grouped based on average percent sodium as Excellent (< 20 %), Good (20-40 %), Permissible (40-60 %), Doubtful (60-80 %) and Unsuitable (> 80 %). According to this only twenty percent samples fall in excellent category, while the rest fall in good one, hence suitable for irrigation purposes (Table 6).

While plotting %Na against electrical conductivity on Wil-

ISSN 2229-5518

cox's diagram (Fig. 3), it was found that site I, III and VII had water quality varying from excellent to good while others (II, IV,V and VI) had water quality varying from good to permissible. Low SAR and %Na may be due to the presence of significant quantities of divalent cations like Ca and Mg which are more strongly bonded and tend to replace monovalent ions like sodium and potassium.

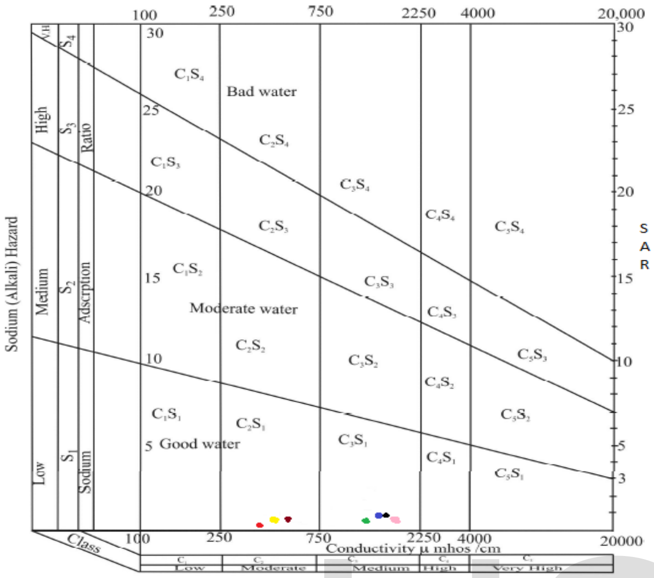

Fig.2 Plotting SAR against Electrical Conductivity (USSL, 1954)

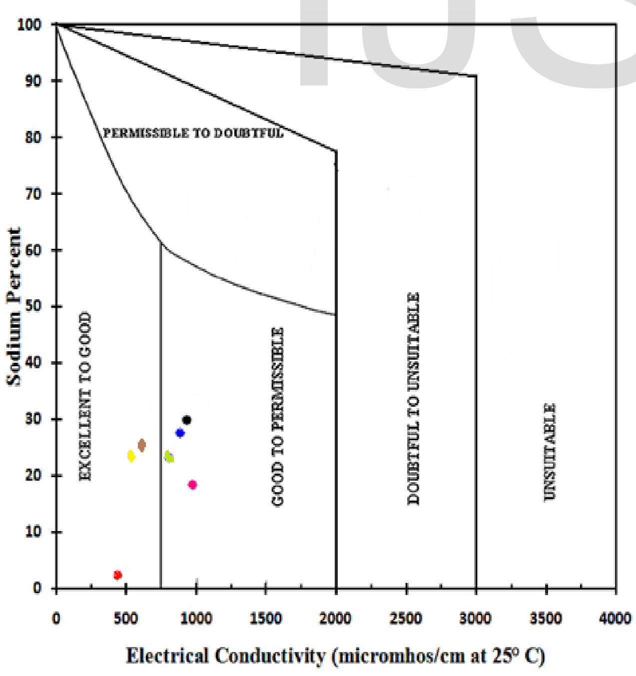

Fig.3 Plotting % Na against Electrical Conductivity

3.1.3 Residual Sodium Carbonate (RSC)

The concentration of bicarbonate and carbonate influences the suitability of water for irrigation purpose. The water with high RSC has high pH. Therefore, land irrigated with such water becomes infertile owing to deposition of sodium carbonate [27]. Residual carbonate levels less than 1.25 meq/L are considered safe. Waters with RSC of 1.25 - 2.50 meq/l are within the marginal range. It was grouped as Good (< 1.25), Doubtful (1.25-2.5) and Unsuitable (>2.5). The lesser the value, the better the water is for irrigation. The potential for a sodium hazard is increased as Residual sodium carbonate (RSC) increases, and much of the calcium and sometimes the magnesium are precipitated out of solution when water is applied to the soil. Salts become concentrated when the soil dries out, as less soluble ions such as calcium and magnesium tend to precipitate out and are removed from the solution [28]. The values of Residual sodium carbonate (RSC) ranges from -2.8 to -6.0 (Table 5). Hence based on Residual sodium carbonate **(**RSC) values, all the samples are having values less than 1.25 and are safe for irrigation.

3.1.4 Kelley's Ratio (KR)

While calculating Kelley's ratio it was found that 100% samples were in good category indicating their suitability for irrigation (Table 5 and 6). Kelley's Ratio (KR) of more than one indicates an excess level of sodium in waters. Hence waters with a Kelley's Ratio less than one are suitable for irrigation, while those with a ratio more than one are unsuitable for irrigation.

3.1.5 Soulble sodium percent (SSP)

Soluble Sodium Percent has been calculated to check the irrigational status of water sources, because high percentage of sodium in water for irrigation purpose may stunt the plant growth and reduce soil permeability [29]. The Soluble Sodium Percent (SSP) values less than 50 or equal to 50 indicates good quality water and if it is more than 50 indicates the unsuitable water quality for irrigation. Based on the calculation it was found that all the samples qualify the said criteria and hence suitable for irrigation (Table 5 and 6).

3.1.6 Permeability index (PI)

Doneen [30] has evolved a criterion for assessing the suitability of water for irrigation based on PI. The soil permeability is affected by long-term irrigation influenced by Na^{+}, Ca^{2+}, Mg^{2+} and HCO_3 contents of the water. PI was ranging from 14.3 to 22.2 (Table 5). According to PI values, the groundwater samples fall in Class I indicating water is good for irrigation purposes [31].

3.1.7 Magnesium Adsorption Ratio (MAR)

Magnesium content of water 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 [30]. At the same level of salinity and SAR, adsorption of sodium by soils and clay minerals is more at higher Mg: Ca ratios. This is because the bonding energy of magnesium is less than that of calcium, allowing more sodium

ISSN 2229-5518

adsorption and it happens when the ratio exceeds more than 4 [32]. High MAR causes a harmful effect to soil when it exceeds 50 [33]. Therefore in the present study all the samples have MAR less than 50 thus are not harmful for soil to cause magnesium hazard.

3.1.8 Total Dissolved Solids (TDS)

Salts of calcium, magnesium, sodium, potassium present in the irrigation water may prove to be injurious to plants. When present in excessive quantities, they reduce the osmotic activities of the plants and may prevent adequate aeration. The TDS value of the study area ranged from 162 to 550 mg/L. Therefore can be classified as excellent irrigation water according to Robinove et al. [34] (Table 6).

4 Conclusion

Physico-chemical analysis showed that these waters are hard and highly mineralized. Calcium and magnesium were the dominant cations and bicarbonate as the dominant anion. The calculated values of Sodium adsorption Ratio integrated with the Electrical Conductivity indicated that the ground water tapped in the study area can be applied for irrigation purpose without any threat of imposition of any hazard (saline or alkaline hazard, magnesium and Bicarbonate hazard). Therefore use of these groundwater sources in irrigation will be very beneficial as it will reduce the water demand and increase the yield.

ACKNOWLEDGMENT

The authors are highly thankfull to Head, Department of Environmental Science Univerity of Kashmir (A.N. Kamili) for providing necessary lab facilities and support. The authors also wish to thank the faculty and staff of the department, especially Prof. A.K. Pandit, Prof. G.A. Bhat, Dr. Samiullah Bhat, Dr. Mudasir Ali, Dr. Bazigah Badder for their kind help and valued suggestions. Thanks to all other friends for their help.

REFERENCES

[1] M. Ackah, O. Agyemang, A.K. Anim, "Assessment of groundwater quality for drinking and irrigation: The case study of Teiman-Oyarifa Community, Ga East Municipality, Ghana". *Proc. Int. Ac. Eco. Env. Sci.,* 2011, 1: 186-194.

[2] M.G. Sayyed, G.S Wagh, "An assessment of groundwater quality for agricultural use: A case study from solid waste disposal site SE of Pune, India". *Proc. Int. Ac. Eco. Env. Sci.,* 2011, 1: 195-201.

[3] K.R. Aher, "*Groundwater quality studies of Chikalthana area of Aurangabad".* Ph.D thesis submitted to Dr. BA. Marathwada University, Aurangabad (MS) India, 2012.

[4] L.N. Plummer, L.M. Bexfield, S.K. Anderholm, "How ground-water chemistry helps us understand the aquifer". In: Bartolino J.R, Cole J.C, eds. *U.S. Geological Survey Circular,* 2003: 1222.

[5] J. Margat, "*Exploitations et utilisations des eaux souterraines dans le monde – BRGM, UNESCO*": PHI, Paris, 2008.

[6] Y. Wada, P.H. Luovicus, L.H. Beek, C.M. Kempen, J.M. Reckman, S. Vasak, M.P. Bierkens, "Global depletion of groundwater resources". *Geophy. Res. Lett.,* 2010, 37: 20-28.

[7] M. Wijnen, B. Augeard, B. Hiller, C. Ward, P. Huntjens, "*Managing the invisible understanding and improving groundwater governance".* http://www.worldbank.org/water.Draft Report no. 10, 2012.

[8] C.W. Fetter, "*Applied hydrology".* 3rd ed: Prentice Hall, Inc. New Jersey, 1994, 420 – 425.

[9] S.M. Deshpande, K.R. Aher, "Evaluation of Groundwater Quality and its Suitability for Drinking and Agriculture use in Parts of Vaijapur, District Aurangabad, MS, India". *Res. J. Chem. Sci.,* 2012, 2: 25-31.

[10] M.L. Yesilnacar, M.S. Gulluoglu, "Hydrochemical characteristics and the effects of irrigation on ground water quality in Harran plain, GAP project, Turkey". *Envi. Geol.,* 2008, 54: 183-196.

[11] A. Ewusi, S. Obiri-yeboah, H. Voigt, B.A. Asabere, K.C. Bempah, "Groundwater Quality Assessment for Drinking and Irrigation Purposes in Obuasi Municipality of Ghana, A Preliminary Study". *Res. J. Envi. E. Sci.,* 2013, 5: 6-17.

[12] A. Sorichetta, C. Ballabio, M. Masetti, G.R. Robinson, S. Sterlacchini, "A Comparison of Data driven Groundwater Vulnerability Assessment Methods". *Ground Water,* 2013, 1-14.

[13] L. Andre, M. Franceschi, P. Pouchan, O. Atteia, "Using geochemical data and modeling to enhance the understanding of groundwater flow in a regional deep aquifer, Aquitain Basin, south-west of France". *J. Hydr.,* 2005, 305: 40–62.

[14] A. Nosrat, A. Mogaddam, "Assessment of Groundwater Quality and its Suitability for Drinking and Agricultural Uses in the Oshnavieh Area, Northwest of Iran". *J. Envi. Prot.,* 2010, 1: 30-40.

[15] K. Singh, H.S. Hundal, S. Dhanwinder, "Geochemistry and assessment of hydrogeochemical processes in groundwater in the southern part of Bathinda district of Punjab, North-West India". *Envi. E. Sci.*, 2011, 64: 1823–1833.

[16] F.M. Howari, Y. Abu-Rukah, R. Shinaq, "Hydrochemical analysis and evaluation of ground water resources of north Jordan". *W. Res.,* 2005, 32: 555- 564.

[17] A. Papaioannou, C.Mavridou, P. Hadjichristodoulou, O. Papastergiou, E. Pappa, E. Dovriki, I. Rigas, "Application of multivariate statistical methods for ground water physico chemical and biological quality assessment in the context of public health". *Envi. Mont. Ass.,* 2010, 170: 87-97.

[18] A. Jehangir, A. Tanveer, A.R. Yousuf, M.A. Naqash, "Geochemistry and Irrigation Quality of Ground water along Jhelum River in South Kashmir". *Rec. Res. Sci. Tech.,* 2011, 3: 57-63.

[19] CSIR. "*Analytical Guide*" (Laboratory Techniques) CSIR, Pretoria, South Africa, 1974.

[20] APHA. "*Standards Methods for the Examination of water and waste waters".* 20th edtn: Amercian Public Health Assoc, New York, USA, 1998.

[21] K.V. Ramana, K.R. Aher, "Hydro Geochemical Processes in the Groundwater Environment of Vemula area, Kadapa District, South India". *Int. J. Rec. Tren. Sci. Tech.,* 2012, 3: 18-24.

[22] C.N. Sawyer, P.C. McCarty, "*Chemistry for sanitary Engi-*

ISSN 2229-5518
neers", 2nd ed.: McGraw Hill, New York, 1967, 518p.

[23] L. Khodapanah, W.A. Sulaiman, N. Khodapanah, "Groundwater quality assessment for different purposes in Eshtehard district, Tehran, Iran". *Eur. J. Sci. Res.,* 2009, 36: 543-553.

[24] R.K. Tatawat, C.P. Chandel, "Quality of ground water of Jaipur city and its suitability for domestic and irrigation purpose". *App. Ecol. Envi. Res.*, 2007, 6: 79-88.

[25] D.K. Todd, "*Groundwater Hydrology"*. Wiley International Edition, John Wiley and Sons. Inc., New York, 1980. pp 28.

[26] L.V. Wilcox, "*Classification and Use of Irrigation Waters"*. US Dept. Agric. Circ. 969, Washington D C, 1955, 19 pp.

[27] F.M. Eaton, "Significance of carbonates in irrigation water". *Soil Science,* 1950, 39: 123-133.

[28] C.R. Glover, "*Irrigation Water Classification Systems"*. Guide A-116, Las Cruces, NM 5C, 2 India, 1996.

[29] D.M. Joshi, A. Kumar, N. Agrawal, "Assessment of the irrigation water quality of River Ganga in Haridwar District India". *J. Chem.,* 2009, 2: 285-292.

[30] L.D. Doneen, "*Notes on water quality in agriculture"*. Published as a water science and engineering paper 4001, Department of Water Science and Engineering, University of California, 1964.

[31] K. Arumugam, K. Elangovan, "Hydrochemical characteristics and groundwater quality assessment in Tirupur Region, Coimbatore District, Tamil Nadu India". *Envi. Geol.,* 2009, 58: 1509–1520.

[32] A.M. Michael, "*Irrigation Theory and Practice"*. Vikas Publishing House Pvt. Ltd. New Delhi, 1978, *pp*. 713.

[33] R.S. Ayers, W. Westcot, "*Water quality for agriculture: FAO. irrigation and drain"*. 1985, 29: 1-109.

[34] C.J. Robinove, R.H. Longfort, J. Brook, "Saline water resource of North Dakota. US Geol. Surv". Water Supp. no. 1428, 1958.

[35] L.A. Richards, "*Diagnosis and Improvement of Saline and Alkali Soils, Agric Handbook* 60": US Department of Agriculture, Washington DC, 1954.

[36] W.P. Kelley, S.M. Brown, G.F. Liebig, "Chemical effects of saline irrigation waters on soils". *Soil Science,* 1940, 49: 95-107.

[37] I.I.M. Raghunath, "*Groundwater"*. Wiley Eastern Ltd., New Delhi, India, 1987, 344-369.

[38] M. Vasanthavigar, K. Srinivasamoorthy, M.V. Prasanna, "Evaluation of groundwater suitability for domestic, irrigational, and industrial purposes: a case study from Thirumanimuttar river basin, Tamilnadu, India". *Envi. Monit. Assess.,* 2011, DOI 10.1007/s10661-011-1977-y.

[39] S. Kundu, D. Thakur, G.S. Gill, N. Tuli, S.A. Yadav, "comparative study of seasonal variations in groundwater quality along the Ghaggar River in Haryana and Punjab". *Int. J. Envi. Sci.,* 2010, 1: 269-277.

[40] F.A. Bhat, M. Irshad, A.R. Mir, B. Parveez, M. Iqbal, "Hydro geochemistry and groundwater quality for drinking and agricultural purposes: a case study of Srinagar district, Jammu and Kashmir, India". *Int. J. Cur Res Rev.,* 2013, 5(10): 01-16.