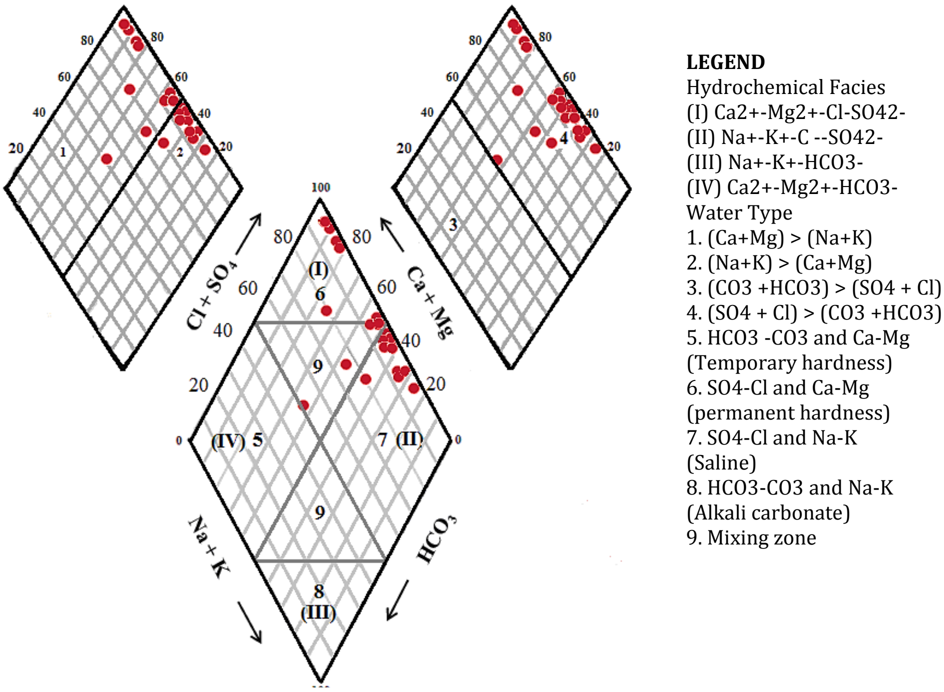

Figure 4: Hydrochemical facies on Piper's trilinear diagram appear alongside dominant anions, cations and classification water samples

4.3.2 Chadha's plot

Chadha Hydrochemical diagram is used to identify the various hydrochemical processes. In the present study, 50% of the samples fall in field 2 (Ca-Mg-Cl) types of reverse ion-exchange waters. The remaining of the samples (50 %) falls in field 3 (Na-Cl) suggesting that the water shows typical seawater mixing (Figure 5). The results obtained from Chadha's plot are considered compatible with those obtained from piper diagram. Eventually, the results obtained from Piper's and Chadha's diagrams revealed that the strong acidic anions (Cl^-, SO_4^{2-}) are dominant over the weak acidic anions (CO_3^{2-}, HCO_3^-) and the hydrochemical facies are Na-K-Cl-SO_4 and Ca-Mg-Cl-SO_4 type.

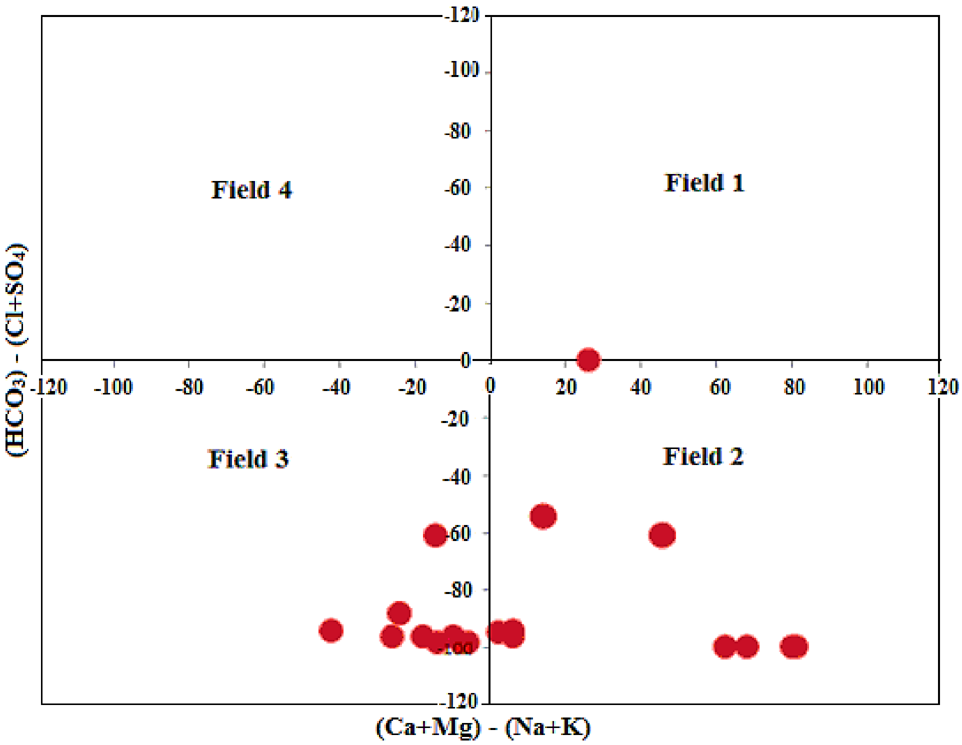

Figure 5: Chad's Scheme to assess major geochemical processes in the study area

4.3.3 Drinking water quality index (DWQI)

The Drinking Water Quality Index (DWQI) for 20 ground water samples ranges from 2.71 to 121.94 with an average of 48.73 and standard deviation of 36.83. The calculated DWQI classified the groundwater into excellent to unsuitable quality based on the data in Table 4. The DWQI method appears to be more realistic for assessing water quality at sampling stations. The high value of DWQI of these wells has been found to be mainly from the higher values of EC, TDS, hardness, sulphate and potassium. Accordingly, 35% of wells water falls in the excellent water quality and 20% falls in the good water quality. On the other hand, about 15 % of water samples are falling in poor quality while 20 % are in very poor range. Two samples only (10%) are unfit for drinking purpose (Tables 1, 4 and Figure 6).

Table 4: Classification of groundwater samples based on Piper trilinear diagram

Class Groundwater types /characteristics of corresponding subdivisions of diamond-shaped fields	Samples in the category	
	No. of samples	%
(I) Ca^{2+}- Mg^{2+}- Cl^- - SO_4^{2-}	10	50
(II) Na^+- K^+- Cl^- - SO_4^{2-}	10	50
(III) Na^+- K^+- HCO_3^-	--	--
(IV) Ca^{2+}- Mg^{2+}- HCO_3^-	--	--
1. Alkaline earth (Ca + Mg) exceed alkalies (Na + K)	10	50
2. Alkalies exceeds alkaline earths	10	50
3. Weak acids (CO_3 + HCO_3) exceed strong acids (SO_4 + Cl)	--	--
4. Strong acids exceeds weak acids	20	100
5. HCO_3-CO_3 and Ca-Mg (temporary hardness); magnesium bicarbonate type (carbonate hardness exceeds 50 %)	--	--
6. SO_4-Cl and Ca-Mg (permanent hardness); calcium chloride type (non-carbonate hardness exceeds 50 %)	6	30
7. SO_4-Cl and Na-K (saline); sodium chloride type (non-carbonate alkali exceeds 50 %)	10	50
8. HCO_3-CO_3 and Na-K (alkali carbonate); sodium bicarbonate type (carbonate alkali exceeds 50 %)	--	--
9. Mixing zone (no one cation–anion exceed 50 %)	4	20

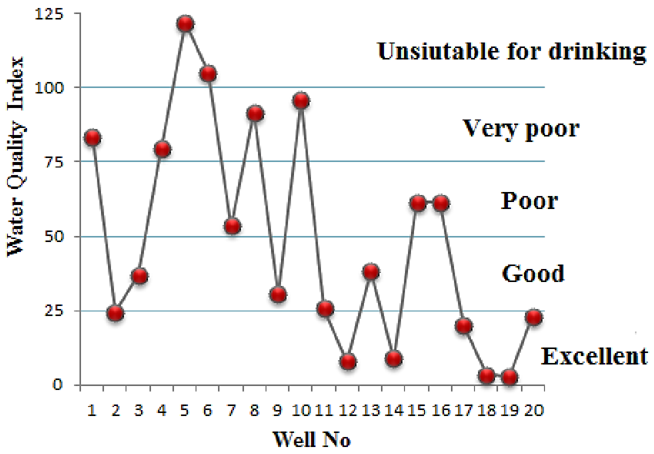

Figure 6: Water quality index (WQI) values for drinking water samples

4.3.4 Statistical analysis

Table 5: Water quality classification based on WQI limits for drinking proposes

WQI value	Water quality	No. of water samples	% of water samples
0-25	Excellent water quality	7	35
25-50	Good water quality	4	20
50-75	Poor water quality	3	15
75-100	Very poor water quality	4	20
> 100	Unfit for drinking	2	10

The degree of linear correlation between any two—water quality parameters and with DWQI measured by a simple correlation coefficient (r) is showed in Table 5. DWQI showed highly significant interrelated with the values of EC (r = 0. 834**), TDS (r = 0.835**), TH (r = 0.774**), Ca^{2+} (r =0.617**), Mg^{2+} (r = 0.760**), Cl^- (r = 0.781**) SO_4^{2-}(r 0.690**) and significant interrelated with the values of pH (r = 0.546*), Na^+ (r = 0.525*), K^+ (r = 0.528*). The highest r value between DWQI and other parameters and ions indicate that the DWQI value affected by these ions and parameters. The correlation coefficients of the pH of the groundwater and that of the Cl^- are highest positively correlation (r = 0.568**).

Also, a strong positive correlation and highly significant was found between EC and TH, Mg^{2+}, $SO_4^{2-}$$Ca^{2+}$, Cl^- and K^+ with r values of 0.982**, 0.959**, 0.921**, 0.809**, 0.779**and 0.484*, respectively. Since, it was observed that the TDS or ECw were controlled by total hardness (r = 0.982**), magnesium (r = 0.959**), Sulphate (r = 0.921**), chloride (r = 0.779**) and potassium (r = 0.484*).

Total hardness shows highly correlation with Mg^{2+}, SO_4^{2-}, Ca^{2+}, Cl^- and K^+ with r values of 0.990**, 0.908**, 0.761**, 0.754** and 0.452*, respectively. The contents of Ca^{2+}, SO_4^{2-}, Mg^{2+} and Na^+ are positively correlated with correlation coefficients of 0.906**, 0.661**, and 0.455*, respectively. The good correlation between calcium and sulphate suggests that a part of the SO_4^{2-} and Ca^{2+} may also be derived by the weathering of calcium sulfate mineral ($CaSO_4$). A close correlation was noted between magnesium and sulphate, chloride and potassium (r = 0.853**, 0.795**and 0.481*, respectively) suggests also, that a part of the SO_4^{2-} and Ca^{2+} may be derived by the weathering of magnesium sulfate mineral ($MgSO_4$). The relationship between K^+ and Cl^- and between Cl^- and SO_4^{2-}concentrations is characterized by a relatively low correlation coefficient (r = 0.497* and 0.479**). It was observed that sodium was not correlated with any ions. Also, HCO3- was not correlated with other ions.

Generally, to insure the suitability of groundwater for drinking purposes the obtained geochemical parameters of the groundwater of the study area were compared with the guidelines recommended by WHO (traditional method) and DWQI which indicate that most of the groundwater samples of the study area were suitable for drinking purposes. When comparing the two methods (WHO and DWQI), the results showed that no significant variation was found between them. However, the accuracy of the results obtained by the DWQI method was higher and more realistic than the results of the traditional method (WHO).

4.4 Groundwater quality for irrigation

The quality of groundwater is importance for irrigation in arid and semi-arid areas. In order to determine the suitability of groundwater in the study area for irrigation, the following was discussed (Tables 6 and 7):

Table 6: Correlation coefficient matrix of water quality parameters and DWQI for study samples

Parameter	pH	EC	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	DWQI
pH	1.00											
EC	0.238	1.00										
TDS	0.240	1.00**	1.00									
TH	0.221	0.982**	0.982**	1.00								
Ca	-0.088	0.809**	0.809**	0.761**	1.00							
Mg	0.273	0.959**	0.959**	0.990**	0.661**	1.00						
Na	0.196	0.424	0.424	0.253	0.455*	0.192	1.00					
K	0.321	0.484*	0.484**	0.452**	0.189	0.481**	0.398	1.00				
HCO_3	0.267	-0.330	-0.329	-0.296	-0.241	-0.291	-0.272	-0.155	1.00			
Cl	0.568**	0.779**	0.779**	0.754**	0.352	0.795**	0.431	0.497*	-0.254	1.00		
SO_4	-0.40	0.921**	0.921**	0.908**	0.906**	0.853**	0.348	0.407	-0.326	0.479*	1.00	
DWQI	0.546*	0.834**	0.835**	0.774**	0.617**	0.760**	0.525*	0.528*	-0.083	0.781**	0.690**	1.00

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

Table 7: Suitability of groundwater for irrigation based on several classifications

Quality of parameters	Range	Type of water	No. of samples	% of samples
EC_W (µS/cm)	100 - 250	Excellent	9	45
	250 - 750	Good	5	25
	750 - 2250	Doubtful	4	20
	> 2250	Unsuitable	2	10
Soluble sodium percentage (%)	0 - 20	Excellent	4	20
	20 - 40	Good	2	10
	40 - 60	Permissible	10	50
	60 - 80	Doubtful	4	20
	> 80	Unsuitable	--	--
SAR (epm)	0 -10	Excellent	20	100
	10 - 18	Good	--	--
	18 - 26	Doubtful	--	--
	> 26	Unsuitable	--	--
Permeability index (%)	< 25	Safe	5	25
	25 - 75	Moderate	11	55
	> 75	Unsafe	4	20
Kelly's Ratio (epm)	< 1	Safe	12	60
	> 1	Unsuitable	8	40
Magnesium Adsorption Ratio (%)	< 50	Suitable	11	55
	> 50	Unsuitable	9	45
Potential Salinity (epm)	< 5	Excellent to good	14	70
	5 - 10	Good to Injurious	2	10
	> 10	Injurious to Unsatisfactory	4	20

4.5 The traditional method

4.5.1 Electrical conductivity (EC)

The electrical conductivity is or TDS a good measure of how salinity hazard is to soil or crops [35]. The EC data showed that 45% of the groundwater was excellent, 25% of the groundwater was suitable for irrigation, and 20% was questionable in irrigation. On the other hand, only 10% of the groundwater samples were not suitable for irrigation. This indicates the filtration and solubility of salts in the surface aquifer in the studied area.

4.5.2 Sodium adsorption ratio (SAR)

Sodium adsorption ratio (SAR) values range from 0.16 to 4.48 with an average of 1.81 and a standard deviation of 1.12. SAR is a measure of the alkaline / sodium of water and how dangerous it is for crops. Consequently, all the groundwater samples have excellent SAR values and acceptable for irrigation.

4.5.3 USSL diagram

The sodicity and EC_w hazard diagram of the US salinity scheme [36] was used. The SAR (sodicity) was plotted against the EC (salinity) and the irrigation water samples were divided into categories (Figure 7). The USSL plot indicates that 45% of the groundwater samples were in C1-S1 class (low salinity low sodium type) and 25% of the samples were in C2-S1class (medium salinity and low sodicity). This indicates that the groundwater in the study area has low to medium salinity with low sodium content and can be used for irrigation on each type of soil. About 20% of groundwater samples are fall in C3-S1, indicating high salinity and low sodicity type. Only 10 % falls in the very high salinity to low sodicity category (C4-S1). This type of water can be used to irrigate tolerant crops under favorable drainage conditions without danger of exchangeable sodium.

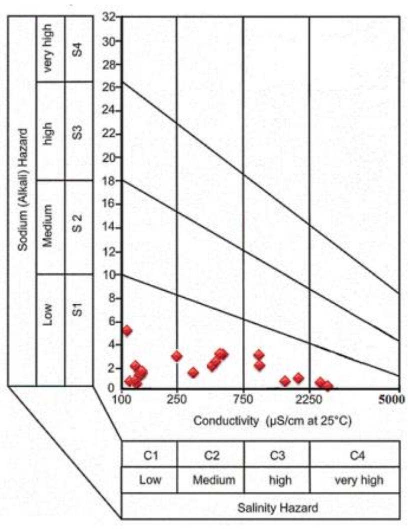

Figure 7: Evaluation of the quality of irrigation water in the study area using the USSL (1954)

4.5.4 Soluble sodium percentage (SSP)

The values of soluble sodium percent (SSP) range from 9.59 to 70.81% with an average value 44.73% and standard deviation of 18.82%. Sodium hazard was an important factor in irrigation water quality. The results revealed that 20% of SSP in groundwater samples fall in the excellent category, 10% fall in good and 50 % fall in permissible category. While the remaining 20% is of SSP groundwater samples fall in the doubtful water quality for irrigation.

4.5.5 Wilcox's Diagram

The percentage of sodium and electrical conductivity plotted on the Wilcox scheme indicates that 70% of the groundwater samples in the study area were excellent to good class, 15% was good to permissible category and 15% were in the permissible to doubtful category (Figure 8). Consequently, most of the groundwater samples were suitable for irrigation.

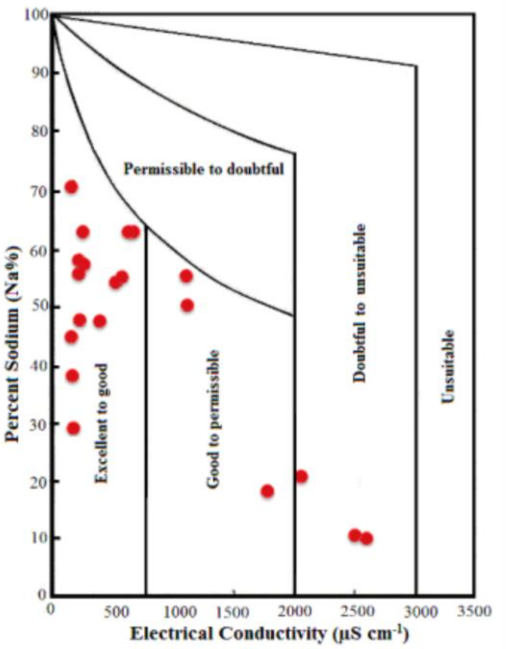

Figure 8: Classification of irrigation water quality, with respect to total salt concentration and sodium present

4.5.6 Kelly's Ratio (KR)

Kelly's ratio (KR) values vary between 0.08 and 2.19 meq/l with an average value of 0.88 meq/l and standard deviation of 0.61 meq/l. According to Kelley's Ratio (KR), water containing less than one is considered suitable for irrigation, while those containing more than one are considered unsuitable for irrigation. The data showed that 60% Kelley's ratio (KR) values for the groundwater of study area were less than 1 and indicate good quality water for irrigation while remaining (40%) was more than 1 which indicated unsuitable water quality for irrigation.

4.5.7 Permeability Index (PI)

The permeability index (PI) values in the study area vary from 8.56 to 86.86% with an average value of 52.75% and standard deviation of 25.84%. It is another indicator of the suitability of groundwater for irrigation. The results of PI of groundwater reveal that 25% of the groundwater samples fall in safe category and 55% are moderate for irrigation purpose. On other hand, 25% of the groundwater samples are unsafe for irrigation purpose.

4.5.8 Doneen diagram

Doneen's scheme is use to assess the quality of irrigation water and to help assess the potential impacts of groundwater from the study area on soil hydraulic properties when used in irrigation. Doneen's scheme (Figure 9) showed that 95% of the groundwater of the study area were in the first and second categories, indicating that most of the groundwater samples were suitable for irrigation, with the exception of one sample (5%) falling in the third category which is not suitable.

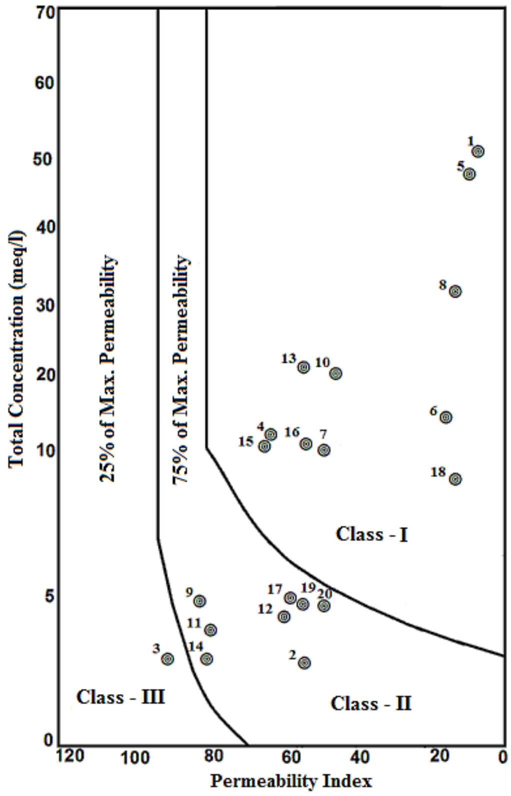

Figure 9: Doneen's diagram for classification of groundwater quality in study area

4.5.9 Magnesium Adsorption Ratio (MAR)

The magnesium adsorption ratio (MAR) value ranged from 22.22 to 95.41% with an average value of 51.87% and a standard deviation of 20.19%. MAR is anticipated of the risk of using high magnesium in water and the soil, resulting in poor crop production. In the study area, 55% of the collected samples showed that the MAR ratio was less than 50% (suitable for irrigation) while 45% was falls in the inappropriate category more than 50% which may have adversely affect cultivated soil and crop production.

4.5.10 Potential Salinity (PS)

The potential salinity (PS) values of the study area vary from 0.65 to 16.02 meq/l with an average value of 5.26 meq/l and standard deviation of 5.41 meq/l. The high values of PS above the critical level of 5 meq/l where due to the higher concentration of Cl and SO_4 ions in the groundwater may have negative effects on the plant and soil. Accordingly, 70% of the samples of the study area were excellent to good, 10% are good to injurious and 20% are injurious to unsatisfactory for irrigation.

4.5.11 Irrigation water quality indices (IWQI)

Table 8: Grads of Water Quality Index (WQI) for irrigation proposes

WQI value	Water quality	No. of water samples	% of water samples
> 50	Excellent	3	15
50-100	Good	17	85
100-200	Doubtful	--	--
200 - 300	Permissible	--	--
>300	Unsuitable	--	--

The computed IWQI values range from 33.68 to 74.57 with an average value of 60.41 and standard deviation of 11.33. Irrigation Water Quality Index (IWQI) results were presented in Table 8. The various parameters such as EC, SAR, SSP, PI, MAR, KR and PS were considered to assess the ground water quality for irrigation. The indices value summed, then classified into excellent to unfit groundwater quality. The results in Table 8 and Figure 10 revealed that 15% of IWQI of the sample fall in excellent water quality and therefore it can be used for irrigation purposes. On other hand, most of the samples (85 %) were of good water quality which can be also, used for irrigation purposes. Figure (11) illustrated the comparison between Drinking Water Quality Index (DWQI) and Irrigation Water Quality Index IWQI.

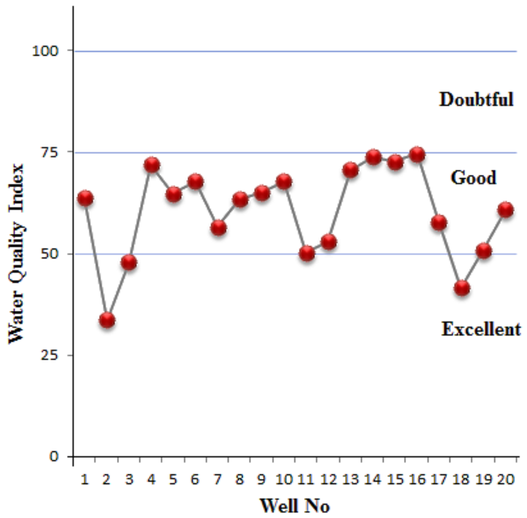

Figure 10: Water quality index (WQI) values for irrigation water samples

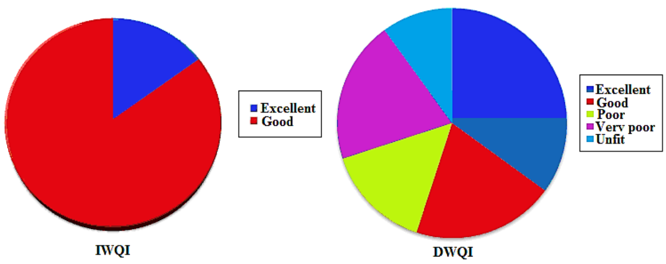

Figure 11: The comparison between Drinking Water Quality Index (DWQI) and Irrigation Water Quality Index IWQI

4.5.12 Statistical analysis

The correlation matrix of the 8 parameters analyzed (EC, SSP, SAR, MAR, PI, KR, PS and IWQI) given in Table 9 allows to distinguish high correlation coefficients, which indicate several relevant parametric relationships. The good positive correlation between EC with PS and MAR (r = 0.984^{**} and 0.759^{**}). Also, highly negative correlation between EC and PI, SSP and KR (r = - 0.812^{**}, - $0.771^{**}$and - 0.533^{*}, respectively). SSP shows highly correlation with KR, PI and SAR with r values of 0.857^{**}, $0.737^{**}$and 0.524^{*}, respectively. It was also observed that the negative correlation between SSP with PS and MAR (r = - 0.767^{**} and - 0.728^{**}). The relationship between SAR and PI values is characterized by a relatively low positive correlation coefficient (r = 0.523^{*}) and negative correlation coefficient with MAR (r = - 0. 519^{*}). The high correlation observed values between MAR and PS (r = 0.805^{**}). The relationship between MAR with PI and KR is negatively (r = - 0.730^{**} and - 0.628^{**}). A close positive correlation noticed between the PI and KR (r = 0.559^{*}) and negative correlation (r = - 0.818^{**}) between the PI and PS. The correlation coefficients of the KR and that of the PS is moderately negative correlation (r = - 0.559^{*}). There is no correlation between computed IWQI and other parameters except KR has correlation coefficients 0.509^{*}.

In general, to verify the suitability of groundwater for irrigation purpose the different parameters (traditional method) and IWQI were used for the study area, which indicated that most of the groundwater samples of the study area were suitable for irrigation purpose. The results showed that when comparing the two methods, there was a slight difference between them.

5. CONCLUSION

In the present study, interpretation of hydrochemical analysis reveals that the groundwater samples of the study area indicate that water is nature (pH around 7). The electrical conductivity values, total dissolved solids values total hardness of Wadi Al-Hayaa groundwater were found almost to be permissible limit of WHO. The order of the concentrations of the major cations and anions in the groundwater of Wadi Al-Hayaa were Na > Ca > Mg > K and SO_4 > Cl >HCO_3. In the Gibbs' diagram the cations and anions fall within the zone of the country rocks. The samples of the area fall in subfield of Na-K-Cl-SO_4 (saline type) and Ca-Mg-Cl-SO_4 (sulfate type) of hydrochemical facies according to Piper trilinear diagram and Chadha's plot. The groundwater of the study area was chemically suitable for drinking uses according to WHO (traditional method). While, DWQI revealed that 35% of the samples were excellent water quality and 20 % were good for drinking. However, 15, 20 and 10 percentages of samples were poor, very poor and unfit for drinking, respectively. Such waters are not suitable for drinking purposes under normal condition and further action for salinity control is required. The high value of DWQI at these sites has been found to be mainly due to the higher values of TDS, EC, K^+, Mg^{2+}, SO_4^{2-} and TH. When compared between the traditional and DWQI methods, it was not found much varied between them. Based on the water quality parameters analyzed like EC, SAR, SSP, MAR, PI, KR and PS (traditional method), the suitability of groundwater samples for irrigation was excellent to good in most cases, indicating low saline and sodic water. For calculating the IWQI, the results show that 15% of water sample falls in excellent categories and 85% falls in the good water category. The results also showed that, when comparing between the traditional and IWQI methods, it was found little varied was found between them. Therefore, the results were concluded, that the study area groundwater quality was in general suitable for irrigation.

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REFERENCES

[1] Bagherzadeh, A., Paymard, P. 2015. Assessment of Land Capability for Different Irrigation Systems by Parametric and Fuzzy Approaches in the Mashhad Plain, Northeast Iran. Soil and Water Research, 10 (2), 90–98.

[2] Dagar, I.C. 2009. Opportunities for alternate land uses in salty and water scarcity areas. International Journal of Environmental Science and Technology, 35 (1), 53-66.

[3] FAO. 2003. The irrigation challenge: increasing irrigation contribution to food security through higher water productivity from canal irrigation systems. IPTRID Issue Paper 4, IPTRID Secretariat, Food and Agricultural Organization of the United Nations, Rome.

[4] Ifabiyi, I.P. 2008. Self-Purification of a Freshwater Stream in Ile-Ife: Lessons for Water Management, Kamlaraj. Journal of Human Ecology, 24 (2), 131-137.

[5] Alam, M., Rais S., Aslam, M. 2012. Hydro chemical investigation and quality assessment of ground water in rural areas of Delhi, India. Environmental Earth Sciences, 66 (1), 97-110.

[6] Abd El-Aziz, S.H. 2017. Evaluation of groundwater quality for drinking and irrigation purposes in the north-western area of Libya (Aligeelat). Environmental Earth Sciences, 76, 147. DOI 10.1007/s12665-017-6421-3.

[7] Rao, G.S., Nageswararao, G. 2013. Assessment of Groundwater quality using Water Quality Index. Archives of Environmental Science, 7, 1-5.

[8] Thapa, R., Gupta, S., Guin, S., Kaur, H. 2017. Assessment of groundwater potential zones using multi-influencing factor (MIF) and GIS: a case study from Birbhum district, West Bengal. Applied Water Science, 7 (1), 1-15.

[9] Pawar, R.S., Panaskar, D.B., Wagh, V.M. 2014. Characterization of groundwater using water quality index of solapur industrial belt, maharashtra, India. International Journal of Engineering & Technology, 2 (4), 31-36.

[10] Rupal, M., Tanushree, B., Sukalyan, C. 2012. Quality Characterization of Groundwater using Water Quality Index in Surat city, Gujarat, India. International Research Journal of Environmental Sciences, 1 (4), 14-23.

[11] Al-Hadithi, M. 2012. Application of water quality index to assess suitability of groundwater quality for drinking purposes in Ratmao-Pathri Rao watershed, Haridwar District, India. American Journal of Scientific and Industrial Research, 3 (6), 395-402.

[12] Stigter, T.Y., Ribeiro, L., Carvalho Dill, A.M.M. 2006. Application of a groundwater quality index as an assessment and communication tool in agro-environmental policies -Two Portuguese case studies. Journal of Hydrology, 372, 578-591.

[13] Kakati, S.S., Sarma, H.P. 2007. Water quality index of drinking water of Lakhimpur district. Indian Journal of Environmental Protection, 27 (5), 425- 428.

[14] Mustapha, M.K. 2008. Assessment of the Water Quality of Oyun Reservoir, Offa, Nigeria, Using Selected Physico-Chemical Parameters. Turkish Journal of Fisheries and Aquatic Sciences, 8, 309-319.

[15] Ramakrishnaiah, C.R., Sadashivaiah, C., Ranganna, G. 2009. Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India. European Journal of Chemistry, 6 (2), 523-530.

[16] Chauhan, A., Pawar, M., Lone, S.A. 2010. Water quality status of Golden Key Lake in Clement Town, Dehradun, Uttarakhand. Journal of American Science, 6 (11), 459-464.

[17] Reza, R., Singh, G. 2010. Assessment of Ground Water Quality Status by Using Water Quality Index Method in Orissa, India. World Applied Sciences Journal, 9 (12), 1392-1397.

[18] Ganeshkumar, B., Jaideep, C. 2011. Groundwater quality assessment using Water Quality Index (WQI) approach - Case study in a coastal region of Tamil Nadu, India. International Journal of Environmental Science and Technology, 1 (2), 50-55.

[19] Thilagavathi, R., Chidambaram, S., Prasanna, M.V., Thivya, C., Singaraja, C. 2012. A study on groundwater geochemistry and water quality in layered aquifers system of Pondicherry region, southeast India. Applied Water Science, 2, 253-269.

[20] Ahamed, J.A., Loganathan, K., Ananthakrishnan, S. 2013. A comparative evaluation of groundwater suitability for drinking and irrigation purposes in Pugalur area, Karur district, Tamilnadu, India. Archives of Applied Science Research, 5 (1), 213-223.

[21] Shweta, T., Sharma, B., Singh, P., Dobhal, R. 2013. Water Quality Assessment in Terms of Water Quality Index. Ame. J. Water Res., 1 (3), 34-38.

[22] Al-Shujairi, S.O.H. 2013. Develop and Apply Water Quality Index to Evaluate Water Quality of Tigris and Euphrates Rivers in Iraq. International Journal of Modern Engineering Research, 3 (4), 2119-2126.

[23] Anbazhagan, S., Jothibasu, A. 2014. Modeling water quality index to assess shallow groundwater quality for sustainable utilization in Southern India. International Journal of Geo-Information, 2 (2), 122-129.

[24] Gummadi, S., Swarnalatha, G., Venkataratnamma, V., Vishnuvardhan, Z. 2014. Water quality index for groundwater of Bapatla Mandal, coastal Andhra Pradesh, India. International Journal of Environmental Sciences, 5 (1), 23 - 33.

[25] Mahmood, A.A., Eassa, A.M., Mohammed, M.H., Shubbar, I.Y. 2014. Assessment of ground water quality at Basrah, Iraq by water quality index (WQI). Journal of University of Babylon for Pure and Applied Sciences, 7 (21), 2531- 2543.

[26] Goher, M.E., Hassan, A.M., Abdel-Moniem, I.A., Fahmy, A.H., El-sayed, S.M. 2014. Evaluation of surface water quality and heavy metal indices of Ismailia Canal, Nile River, Egypt. Egyptian Journal of Aquatic Research, 40, 225-233

[27] Khwakaram, A., Majid, N.S., Ahmed, Z.H., Hama, N.Y. 2015. Application of water quality index (WQI) as a possible indicator for agriculture purpose and assessing the ability of self-purification process by qalyasan stream in sulaimani city/iraqi kurdistan region (ikr). International Journal of Plant, Animal and Environmental Sciences, 5 (1), 162-173.

[28] Ravikumar, P., Somashekar, R.K. 2017. Principal component analysis and hydrochemical facies characterization to evaluate groundwater quality in Varahi river basin Karnataka state India. Applied Water Science, 7 (2), 745–755.

[29] Srinivas, Y., Aghil, T.B., Oliver, D.H., Nair, C.N., Chandrasekar, N. 2017. Hydrochemical characteristics and quality assessment of groundwater along the Manavalakurichi coast, Tamil Nadu, India. Applied Water Science, 7 (3), 1429–1438.

[30] Elaalem, M. 2010. The Application of Land Evaluation Techniques in Jeffara Plain in Libya using Fuzzy Methods. Ph. D thesis, Department of Geography, University of Leicester.

[31] APHA American Public Health Association. 2005. Standard method for examination of water and wastewater, 21st ed. APHA, AWWA, WPCF, Washington.

[32] WHO. 2011. World Health Organization. Guidelines for drinking-water quality - 4th ed.

[33] Srinivas, P., Kumar, G.N.P., Prasad, A.S., Hemalatha, T. 2011. Generation of Groundwater Quality Index Map- A case study. Civil and Environmental Research, 1 (2), 9-21.

[34] Robbins, J. 2010. Irrigation water for greenhouses and nurseries. US Department of Agriculture and County Governments Cooperating No. 6061 Agriculture and Natural Resources, University of Arkansas, Division of Agriculture.

[35] Tank, D.K., Chandel, C.P.S. 2009. A hydro chemical elucidation of the groundwater composition under domestic and irrigated land in Jaipur city. Environmental Monitoring and Assessment, 166 (1-4), 69-77. doi:10.1007/s10661-009- 0985-7.

[36] USSL. 1954. Diagnosis and improvement of saline and alkali soil USDA Hand Book no. 60, Washington.