VOLUME 8 (SPL 1) 2022

ISSN 2454-3055

Manuscripts under Special issue are published under the Theme "ADVANCES IN BIOLOGICAL SCIENCES"

Guest Editor: Dr. S. Mohanasundaram
Assistant Guest Editor: Dr. S.S. Syed Abuthahir

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 8, Spl 1, 48-56 (2022)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Analyzing the Quality and Stability of Ground Water for Irrigation and Human Use in Salem District, Tamil Nadu, India, Using a Hydrological Technique

Abdul Vahith R., Sajitha I.*, Sirajudeen J., Muneer Ahamath J., Syed Abuthahir S.S. and Mohamed Mahadir A.

PG and Research Department of Chemistry, Jamal Mohamed College (Autonomous), Affiliated to Bharathidasan University, Tiruchirappalli 620 020, India

**Corresponding Author*

Received: 1st December, 2022; **Accepted:** 18th December, 2022; **Published online:** 28th December, 2022

https://doi.org/10.33745/ijzi.2022.v08i0s1.006

Abstract: The physicochemical properties of groundwater were studied by collecting and analysing samples from several sites in and around the Salem region. Thirty samples of groundwater were taken at random from both open wells and borewells. The water quality metrics pH, EC, TDS, Cl-, Bi, SO_4^{2-}, Si, Fe, Al, Ca^{++}, Mg^{++}, and Na^+ were used to evaluate the groundwater in the Salem area. Different locations in the Salem area provided information on the quality of the groundwater in the month of October, 2021. The WHO and BIS criteria were used to evaluate the groundwater's viability as a source of drinking water and irrigation. The Sodium Adsorption Ratio (SAR), Water Quality Index (WQI), Piper diagram, and Wilcox's categorization were used in the assessment of the water quality. Piper's trilinear diagram was used to determine the impact of anions and cations. Almost all the study regions have questionable groundwater quality during the winter months, making it unsuitable for use in irrigation.

Keywords: Salem District, Piper digram, Wilcox's Classification I, Physiochemical, Groundwater

Citation: Abdul Vahith R., Sajitha I., Sirajudeen J., Muneer Ahamath J., Syed Abuthahir S.S. and Mohamed Mahadir A.: Analyzing the quality and stability of ground water for irrigation and human use in Salem District, Tamil Nadu, India, using a hydrological technique. Intern. J. Zool. Invest. 8(Spl 1): 48-56, 2022.

https://doi.org/10.33745/ijzi.2022.v08i0s1.006

Introduction

In many parts of India, people rely on groundwater as their primary source of potable water for household, agricultural, and industrial needs. According to Aksoy and Scheytt (2007), groundwater resources are very valued and crucial to economic and agricultural growth. There are more than 1.5 billion people who use groundwater as their primary source of drinking water (Adimalla and Qian, 2019). This makes groundwater resources very valuable in places with little precipitation and few lakes or rivers. The chemistry of groundwater is changed by a number of geochemical processes as it travels along flows from recharge to discharge sites. Evaluating the water's kind is a great way to get a feel for the complexities of hydrochemical processes. Over 40 per cent of the water utilized in global irrigation systems comes from groundwater resources (WWAP, 2009; Siebert *et al*., 2010), which is a significant quantity of freshwaters globally. Water can dissolve everything and is a non-depletable resource. Because of its special characteristics, water is especially vulnerable to contamination. In order to trace the history of the elements that make up groundwater, an understanding of hydrochemistry is necessary. A water source's quality and potential uses are dependent on its chemical composition.

In this study thirty samples of ground water were analyzed for their pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total hardness (TH), biochemical oxygen demand (BOD), chemical oxygen demand (COD), bicarbonate (HCO_3), calcium (Ca), magnesium (Mg), chloride (Cl^-), nitrate (NO_3^-), phosphate (PO_4), sodium (Na), potassium (K), and sulphate (SO_4^{2-}). The goal of this research was to utilize the Piper diagram and the Wilcox diagram to compare the quality of groundwater sources in various parts of the Salem area to establish whether or not they were suitable for human consumption or agricultural irrigation. Recent years have seen the application of a number of different approaches that have proven useful in assessing groundwater chemistry, offering an overarching picture of water quality and a result that characterises the status of groundwater.

Materials and Methods

Study Area:

The Salem area is well-known for its mineral resources (including magnetite, bauxite, limestone, quartzite, iron ore, and granite), Stanley Reservoir (created by Mettur Dam), and Mangoes. Stanley reservoir is filling up with water from the river Cauvery, and this water is used mostly for cultivation. The region of study is located in western Tamil Nadu, with latitudes between 11°15' and 12°00' north and longitudes between 77°35' and 78°50' east; the overall geographical area is around 5207 sq. kms, of which Stanley reservoirs circle a radius of about 164.5sq. kms.

Sample collections:

In November of 2021, physico-chemical testing was carried out on the collected ground water samples. There was an examination of many physicochemical factors, including pH, EC, TDS, DO, TH, BOD, COD, HCO_3, Ca, Mg, Cl, NO_3, PO_4, Na, K, and SO_4. The samples for this investigation were collected from locations in and around Salem. Thirty samples of water were taken from the below-listed locations. Polythene bottles holding 2.5 litres of water were used to collect the samples. The samples were collected using both borewells and deep hand pumps. It was made sure that the concentrations of several water quality measures would not vary between the time of sample collection and laboratory analysis. Separate polythene bottles of 2 litre capacity were used to measure DO, BOD, and COD. The bottles were sterilized with hydrochloric acid, washed with acid-free tap water, washed with distilled water twice, and finally rinsed with the water sample to be collected. Finally, the bottles were filled with the sample, leaving only a small air gap at the top, stopped, and sealed with paraffin wax.

Pipettes and burette were cleaned with solution before being put to use. Analytical grade chemicals and reagents were utilized. Instruments such as pH metres, conductivity metres, spectrophotometers, and flame photometers were utilized to measure these qualities. Standard procedures were used to analyze the groundwater samples, and findings (Table 1) were compared to World Health Organization (2007) standards.

Results

Sodium Adsorption Ratio:

The Sodium Adsorption Ratio is an useful criterion for categorising the irrigation potential of groundwater. Soil that can absorb more sodium than calcium and magnesium is said to have a high

Table 1: Physico-chemical parameters of ground water collected from in and around Salem district

Sample stations	Temp	pH	EC	TDS	DO	BOD	COD	SO_4	CO_3	HCO_3	NO_3	PO_4	TH	Ca	M g	Na	K	Cl	Cu	Ni	Fe	Cr	Zn	Pb
1	28.2	7.7	1325	956	9.2	9.7	28	27	ND	312	58	0.13	610	212	143	131	16	130	0.03	0.01	0.33	0.02	0.02	0.02
2	28.1	7.3	1254	854	8.3	9.5	28	18	ND	355	43	0.06	551	122	125	135	14	151	0.02	0.02	0.28	0.02	0.03	0.08
3	27.7	7.3	795	1051	7.8	10.4	27	8	ND	384	46	0	595	128	123	118	11	285	0.02	0.03	0.35	0.01	0.04	0.05
4	28	7	1265	962	9.6	6.8	24	7	ND	435	35	0.1	521	231	120	115	16	156	0.03	0.02	0.52	0.02	0.05	0.04
5	27.2	7.3	1541	1965	7.8	4.8	26	8	ND	438	78	0.13	564	192	120	98	19	224	0.03	0.02	0.42	0.06	0.06	0.08
6	26.6	7.1	1265	2484	9.2	5.5	22	20	ND	364	51	0.09	645	188	113	132	13	240	0.04	0.03	0.49	0.01	0.04	0.06
7	26.9	7.3	2715	2347	7.8	10.5	20	14	ND	254	37	0.23	574	204	108	125	14	154	0.02	0.03	0.36	0.02	0.05	0.04
8	27.6	z7.2	1784	2451	8.6	20.5	15	20	ND	334	92	0.08	735	195	120	132	16	112	0.05	0.02	0.28	0.01	0.06	0.02
9	27	7.3	954	412	9.1	15.8	38	5	ND	278	54	0.16	551	173	223	154	18	154	0.02	0.03	0.45	0.02	0.04	0.04
10	28.2	7.4	854	463	7.5	8.7	25	8	ND	331	40	0.25	205	170	213	144	14	131	0.03	0.04	0.55	0.02	0.05	0.04
11	28.1	7.4	863	865	7.6	7.8	26	6	ND	290	31	0.07	581	188	215	168	15	254	0.02	0.02	0.42	0.01	0.06	0.03
12	26.9	8.2	1308	902	7.6	3.5	31	19	ND	305	58	0.13	591	173	200	128	15	195	0.03	0.03	0.41	0.02	0.07	0.11
13	27.2	7.4	2598	1215	8.2	4.8	26	6	ND	426	52	0.15	754	182	140	141	17	181	0.03	0.04	0.45	0.02	0.04	0.04
14	28.2	7.5	2184	1064	7.2	6.4	31	18	ND	364	51	0	623	189	138	180	17	171	0.02	0.02	0.42	0.01	0.02	0.05
15	26	8.3	1940	1311	8.1	7.1	33	23	ND	375	52	0.18	621	198	85	155	16	172	0.04	0.03	0.28	0.01	0.04	0.06
16	27.6	7.5	3451	1425	9.2	10.5	31	15	ND	420	51	0.16	618	186	148	115	15	168	0.05	0.02	0.4	0.01	0.05	0.04

17	25.2	7.3	3178	965	7.5	10.6	35	9	ND	362	42	0.19	415	189	133	164	13	142	0.02	0.03	0.51	0.02	0.06	0.02
18	27.6	7.5	854	925.4	8.6	20.5	40	3	ND	430	30	0.09	416	165	133	167	18	156	0.03	0.03	0.46	0.03	0.04	0.03
19	27.3	7.6	965	925	9.3	20.8	33	5	ND	396	42	0.07	524	155	130	101	19	179	0.02	0.02	0.38	0.02	0.05	0.04
20	26.4	8.2	1318	934	7.5	20.6	31	5	ND	321	31	0.06	528	159	130	115	13	149	0.03	0.03	0.51	0.01	0.06	0.02
21	27.4	7.6	1298	1165	8.1	15.2	31	12	ND	520	32	0.13	551	125	130	135	14	159	0.02	0.02	0.39	0.02	0.07	0.06
22	26.2	7.2	1387	1158	9.3	20.3	26	7	ND	562	44	0	426	129	130	115	13	165	0.02	0.03	0.28	0.01	0.05	0.04
23	26.8	6.9	1451	1135	7.4	6.1	31	10	ND	495	45	0.28	451	123	128	119	19	178	0.03	0.02	0.32	0.01	0.04	0.02
24	26.7	7.2	1254	1148	8.5	8.3	32	59	ND	387	34	0	415	126	128	115	17	186	0.04	0.03	0.45	0.02	0.07	0.03
25	26.4	7.5	1326	1065	9.6	10.9	32	7	ND	334	41	0	523	189	128	116	20	189	0.05	0.02	0.38	ND	0.06	0.04
26	27.4	7.3	1584	924	7.2	10.6	27	8	ND	432	43	0.19	574	171	103	104	15	215	0.02	0.03	0.47	0.02	0.02	0.05
27	27.4	7.7	1365	874	8.1	17.2	19	8	ND	375	42	0	436	165	103	105	14	236	0.03	0.02	0.29	0.01	0.03	0.04
28	27.5	8.1	1165	1423	7.5	10.1	14	8	ND	356	42	0.08	524	165	100	101	13	229	0.02	0.03	0.39	0.01	0.04	0.02
29	27.4	8.1	1357	964	7.6	9.9	17	6	ND	384	43	0	423	191	105	119	20	201	0.03	0.02	0.37	0.02	0.05	0.03
30	28.2	8.2	1154	1054	8.1	15.2	53	12	ND	365	45	0.12	520	168	183	100	14	215	0.03	0.03	0.31	0.03	0.06	0.04

Table 2: Categorization based on SAR

S. No.	S.A.R	Category	Percentage of Samples
			Pre-monsoon
1	0-10	Excellent	98.0
2	10-18	Good	2.0
3	18-26	Fair	Nil
4	>26	Poor	Nil

Table 3: Categorization of Groundwater during October 2021 based on Piper's Trilinear Diagram

S. No.	Descriptions	October 2021
1.	Anion dominance	48% by bicarbonate
		28.37 % Chloride
		22 % by no dominate type
2.	Cation dominance	35.55% by sodium and potassium
		0.3 % By Calcium
		61.11 % no dominate type
3.	Combined concentration	38 % Calcium ,Magnesium and Bicarbonate
		27.35 % alkali metal , Sulphate and chloride
		31.1 % of no dominate type

Sodium Adsorption Ratio. Adding sodium to the soil in lieu of calcium and magnesium would make it impermeable (Sreedevi, 2004). Too much salt is harmful because it decreases soil permeability (Kelley, 1951, Karanth, 1987). Excess salt in the irrigation water may cause the soil to become sodic if it is allowed to seep into the ground. Sodic soil is distinguished by the physical properties of reduced permeability and increased imperviousness. It is possible that this might cause plant development to slow down or even cease if water levels continue to rise. So, low specific absorption rate (SAR) water is ideal for irrigation. Table 2 (Ragunath 2007) shows the SAR classifications for irrigation purposes according to IS 2296-1963, and these ratings, together with the corresponding equation 1, may be seen below:

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

Table 2 shows that over both seasons, 30 places are rated as exceptional (96.5%), whereas a single location is rated as good (5%).

Piper Diagram:

The analytical data from the hydrochemical study was used to produce a Piper diagram for the Salem District (Fig. 1) The points on the piper diagram may be categorised according to the dominant anions and cations present as follows: (A) Ca type, (B) No Dominant type, (C) Na and K type, (D) Mg type, (E) HCO_3 type, (F) Cl type, and (G) SO_4 type. Research was done in the groundwater environment in October 2021, when mineral dissolution was the dominant process. Given the rapid pace of the current, there would not be much time for rain to fall. Ca and Mg preponderance in high-topography groundwater samples hinted to an inverted ion exchange mechanism. At this point, the groundwater's Na will have traded places with Ca from the Aquifer matrix. But in the lower topographic area, which is represented by the discharge zone, Na and Cl ions predominate in the water. Rock-water interactions may be robust in these relatively flat areas because of the slow flow (Fethi *et al.*, 2013).

Alkaline earths are more stable than alkali metals. The alkaline metals are more common than the alkaline earths. Strong acidic anions are outnumbered by their weaker counterparts. By a wide margin, strong acidic anions dominate their weaker counterparts.

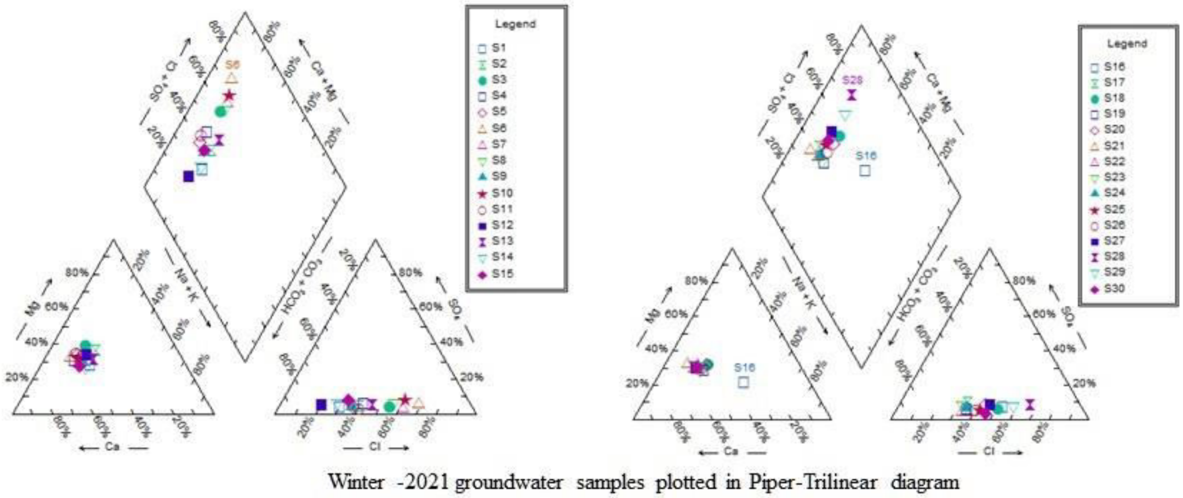

Fig. 1: Piper Trilinear Diagram – Percentage of cation and anion dominance in the study area during October 2021.

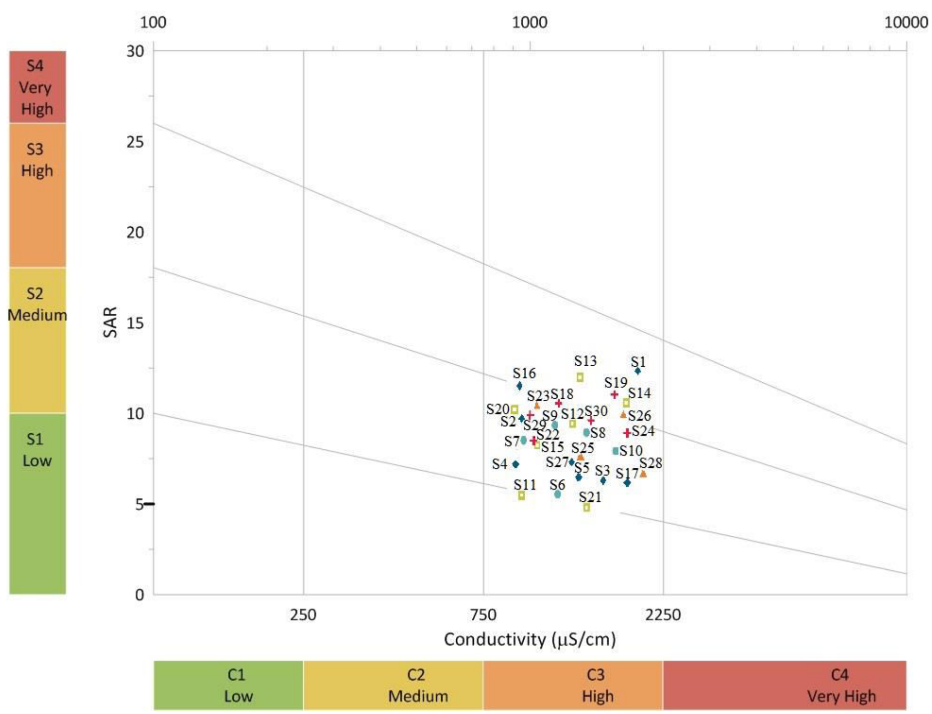

Fig. 2: Adimalla Suitability of Water based on Wilcox Classification (October 2021)

According to Table 3, bicarbonates had a significant impact on anion dominance over both seasons. During both summer and winter, sodiumand potassium dominated the cation scene. In October of 2021, the combined cation and anion concentration shows that the effects of calcium, magnesium, and bicarbonate are significant.

Hydrogeochemical Facies Analysis:

In this hydrogeochemical facies analysis, the Na+/K+/Mg+/HCO_3 and SO_4 concentrations in the water samples are inside the 5, 6, and 10 numbered triangles, respectively (Fig. 2). 66% of the samples are in the triangle 5 range, which corresponds to Mg-HCO_3 water. Thirty per cent of our research areas are of the Ca-Mg-Cl type, which is denoted by the triangle 10. Similarly, the area represented by triangle 6 (the Ca-Cl kind of water) is 4%. Only B in the Cation triangle (left side figure) has no completely covered areas of no

Table 4: Categorization of Groundwater Samples for Irrigation based on Wilcox Diagram

S. No.	Classification	October 2021	
		Sample locations	Percentage of locations
1.	Low	NIL	
2.	Medium	S2,S3,S4,S5,S6,S7,S8,S9 ,S10,S11, S12,S13,,S15,S16, S17,S18,S9,S20,S21,S2 2,S23,S25,S27 S28,S30	83.3
3.	High	S1,S14,S28,s24,S26	16.6
4.	Unsuitable	NIL	

dominating ion type water. A 57 per cent coverage area of HCO_3 type water (E), 30 per cent coverage area of Cl type water (F), and 13 per cent coverage area of no dominant ion type water (B) make up the Anion triangle (right side figure). In the diamond section of the figure, the Na-K, Mg, HCO_3, and SO_4 concentrations of the water samples all fall inside the 5, 6, and 10 numbered triangles, respectively. Nearly half of the samples (43%), which correspond to Mg-HCO_3 type water, fall into Triangle 5.

The Ca-Mg-Cl type, represented by the triangle 10, accounts for 35% of the locations in our analysis. Likewise, the area covered by the triangle numbered 6 (the Ca-Cl kind of water) is 22 per cent. Only B in the Cation triangle (left side figure) has no completely covered areas of no dominating ion type water. Anion triangle (right side diagram): Cl type water (61% coverage), HCO_3 type water (22% coverage), and no dominating ion type water (17% coverage) are all represented by the letters F, E, and B, respectively. Triangles 5, 6, and 10 in the diamond represent the limits of the Na-K, Mg, HCO_3, and SO_4 concentrations in the water samples. Seventy per cent of the samples are located in the triangle 10, which is indicative of Ca-Mg-Cl water. One-seventh of the places in our research were classified as Ca-Cl, which is represented by triangle 6. The area represented by triangle 5 is 13%, and it stands for Mg-HCO_3 water. Only B represents no dominating ion type water inside the Cation triangle (left side figure), covering 100% of the region. B stands for "no dominating ion" water, which accounts for 44% of the Anion triangle's area (right side diagram), F stands for "Cl" water, which accounts for 43% of the space, and E stands for "HCO_3" water, which accounts for 13% of the area. There is clear zoning of the region under investigation with respect to changes in the principal chemical compositions of their groundwater, and studying seasonal variations of the water type in various areas has revealed some fascinating facts.

Wilcox Classification:

The percentage of salt in water is a metric used to determine the resource's fitness for use in irrigation systems (Wilcox, 1948). The electrical conductivity and sodium percentage measurements were plotted on the x and y axes of a Wilcox chart. Soils that contain high concentrations of sodium carbonate or sodium chloride are created, respectively. Neither soil type is conducive to plant development (Sreedevi, 2004).

The sodium per cent is calculated by the formula mentioned below:

$$\text{Sodium per cent (Na \%)} = \frac{Na + K}{Ca + Mg + Na + K} \times 100$$

The analysed results based on Wilcox diagram for October 2021 is shown in Figure 2 and Table 4.

Discussion

All of the samples tested in Udaipur city are exceedingly hard and included high levels of salts in solution. When considering overall hardness, both magnesium and sulphate have positive and substantial connections. However, total alkalinity and bicarbonate were shown to have a positive and statistically significant association. The majority of samples revealed unsafe levels of fluoride (Bishnoi and Malik, 2008). Geological formations, agricultural practises, and irrigation systems make Andhra Pradesh's north-eastern Anantapur district notable. 65% of pre-monsoon samples and 45% of post-monsoon samples had nitrate concentrations >45 mg/l, making them unsafe for human consumption. Due to extensive agriculture, poor sewage, and organic waste management, nitrate is found in shallow and deep aquifers (Reddy *et al*., 2009).

It was concluded that the water in Karur was too salty, too brackish, and not suitable for human consumption. In these areas, seed germination was drastically reduced for all crops except rice. Research shows that rice, wheat (starch), and sugarcane (sugar) all have much lower reserve food amounts when irrigated with contaminated ground water, indicating that the water alters the metabolic route of these crops (Kannan *et al*., 2005). The ground water in the Gujarat area was divided into five different categories based on their sodium adsorption ratio (SAR), percentage sodium (PS), residual sodium carbonate (RSC), Kelley's ratio, and electrical conductivity.

According to the sodium adsorption ratio result, most samples (9 out of 10) pose little to no sodium risk. The proportion of salt and electrical conductivity were used by Wilcox (1948) to categorise samples and found that just one sample was inappropriate for irrigation, while another was in the good category (Patel *et al*., 2005). When the WQI, chloride, and EC all cluster in the same locations, it indicates that the groundwater quality is subpar. SAR, Na%, and TH levels were consistently high throughout the year, indicating that most groundwater basins are unsuitable for irrigation (Sirajudeen and Vahith, 2014; Sirajudeen *et al*., 2014).

Conclusion

All groundwater samples tested showed adequate suitability for irrigation. Wiilcox diagram values were in the excellent range, indicating that the water in the research location is safe for human consumption. The goal of this article was to provide a simple, reliable technique for describing the findings of numerous factors in order to analyse groundwater quality in the Salem area by using the Wilcox and Piper diagram methodology. Wells that are suitable for drinking water should be identified and protected from future pollution, and frequent monitoring of groundwater quality should be performed to pinpoint the origins of the most harmful pollutants and other inhibitory substances.

Acknowledgement

Authors are thankful to the Principal, College Management Committee members, DST-FIST Funded and DBT Star College Scheme.

References

Adimalla N and Qian H. (2019) Groundwater quality evaluation using water quality index (WQI) for drinking purposes and human health risk (HHR) assessment in an agricultural region of Nanganur, south India. Ecotoxicol Environ Saf. 176: 153-161.

Aksoy AO and Scheytt T. (2007) Assessment of groundwater pollution around Torbali, Izmir, Turkey. Environ Geology 53(1): 19-25.

Bishnoi M and Malik R. (2008) Ground water quality in environmentally degraded localities of Panipat city, India. J Environ Biol. 29(6): 881-886.

Kannan V, Ramesh R and Sasikumar C. (2005) Study on ground water characteristics and the effects of discharged effluents from textile units at Karur District. J Environ Biol. 26(2): 269-272.

Karanth KR. (1987) Groundwater assessment, development and management. Tata McGraw Hill Publishing Company Limited, New Delhi, pp. 720.

Kelley WP. (1951) Alkali soils - their formation properties and reclamation. Reinold Publication Corporation, New York.

Fethi Mohamed, Ben Hamouda, Ahmed Mamou, Jelloul Bejaoui and Klaus F. (2013) Hydrochemical and isotopic study of groundwater in the North Djeffara Aquifer, Gulf of Gabès, Southern Tunisia. Int J Geosciences 4: 1-10.

Patel SR and Desai KK. (2005) Study of ground water quality for irrigation in some villages of Surat District, Gujarat (India). J Environ Sci Eng. 47(4): 304-309.

Raghunath HM. (2007) Groundwater. New Age International Publishers, New Delhi, pp. 308.

Reddy AG, Niranjan Kumar K, Subba Rao D and Sambashiva Rao S. (2009) Assessment of nitrate contamination due to groundwater pollution in north eastern part of Anantapur District, A.P. India. Environ Monit Assess. 148(1-4):463-476.

Siebert SJ, Burke J, Faures M, Frenken K, Hoogeveen J, Döll P and Portmann FT. (2010) Groundwater use for irrigation--A global inventory. Hydrol Earth Syst Sci. 14: 1863-1880.

Sirajudeen J and Vahith RA. (2014) Applications of water quality index for groundwater quality assessment on Tamilnadu and Pondicherry, India. J Environ Res Develop. 8(3): 443-450.

Sirajudeen J, Kadhar Mohidheen M and Abdul Vahith R. (2014) Water quality index of ground water in and around Tirunelveli district, Tamilnadu, India. World J Pharmacy Pharmaceut Sci. 3(10): 653-661.