

Statistical Representation of Groundwater Analysis for Irrigation Purposes of Sanganer Tehsil, Jaipur, Rajasthan

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ABSTRACT: Groundwater quality is an important issue for drinking and irrigation purpose. For representing groundwater analysis statistically water quality parameters were measured to assess the groundwater quality of different villages of Sanganer Tehsil. The analyses indicated EC, TDS, nitrate, fluoride and chloride in some samples are in high proportions in comparison to WHO standards. For classifying groundwater quality for different purposes and in particular for irrigation, plots like Durov, Schoeller, Wilcox diagrams have been drawn. The ionic dominance for major cations and anions is respectively $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^{2-}$ & $\text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^+$. Schoeller diagram shows moderate to acceptable quality of water while Wilcox method indicates that mostly water samples are in C3S1 class (high salinity-low SAR).

KEYWORDS: Groundwater quality, irrigation, Durov diagram, Schoeller diagram, Wilcox method.

I. INTRODUCTION

Rapid industrial and agricultural development has influenced water demand considerably, thereby increasing environmental pollution. In some parts of the country, the current rate of groundwater extraction is depleting resources faster and therefore is causing imbalance in recharging it in natural way. Thus it becomes imperative to understand basic processes in managing this significant resource with regards to groundwater and also the factors that affect its quantity and quality in one way or the other. The physico-chemical characteristics of groundwater determine its usefulness for domestic, industrial, municipal and agricultural applications. The quality of water is more emphatically compared to quantity in planning any water related issues. We studied such aspects with the help of assessment of groundwater sources for suitability for irrigation of Sanganer Tehsil of Jaipur for pre – monsoon period [1] and now have investigated groundwater analysis of studied parameters for irrigation purposes by statistical representations for post- monsoon period.

II. MATERIALS AND METHODS

[a] STUDY AREA

Sanganer Tehsil is attached with the main Jaipur city. It lies between 26°49'N to 26°51' N latitude and 75°46'E to 75°51' E longitude. It covers an area of 635.5 sq. km. Water samples of Sanganer area were collect with the view to understand the quality of potable and irrigation water quality.

[b] WATER SAMPLING, PRESERVATION AND DATA ANALYSES

A total 40 samples were collected from different wells, tube-wells or hand-pumps from 40 villages of Sanganer Tehsil during post-monsoon period [05 to 15 October, 2014]. All samples were labelled according to prerequisites for analyses of samples. Temperature, pH, electrical conductivity, total dissolved solids, salinity were measured on site using potable meter (PCS Tester 35 Multi-parameter). All other parameters were analysed according to the standard methods

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of APHA [2] and compared with WHO standards [3]. Sampling sites with source type are shown in Table-1 and Figure-1 by using GIS software.

Table-1: Source & location of samples of different villages of Sanganer Tehsil

Sample No.	Sampling Source	Village	Sample No.	Sampling Source	Village
S1	Hand Pump	Asawala	S21	Hand Pump	Lakhawas
S2	Hand Pump	Bagru	S22	Well	Laxmipura No. 1
S3	Tube Well	Bagru Rawan	S23	Hand Pump	Mahapura
S4	Hand Pump	Baksawala	S24	Tube Well	Mahel
S5	Well	Bamoriya	S25	Hand Pump	Manoharpura
S6	Well	Bar ka Balaji	S26	Hand Pump	Mohanpura
S7	Hand Pump	Beelwa	S27	Hand Pump	Muhana
S8	Hand Pump	Bhankrota	S28	Tube Well	Nevta
S9	Tube Well	Bhatawala	S29	Hand Pump	Pratapnagar
S10	Hand Pump	Dayalpura	S30	Tube Well	Ramchandrapura
S11	Hand Pump	Durgapura	S31	Tube Well	Ramsinghpura
S12	Tube Well	Goner	S32	Hand Pump	Sanganer
S13	Tube Well	Govindpura	S33	Tube Well	Seemliya
S14	Tube Well	Hajiwala	S34	Tube Well	Shikarpura
S15	Hand Pump	Heerapura	S35	Hand Pump	Sirani
S16	Hand Pump	Jagannathpura	S36	Tube Well	Sitapura
S17	Tube Well	Jaranwala	S37	Tube Well	Sukhdeopura
S18	Hand Pump	Khetapura	S38	Hand Pump	Surajpura
S19	Hand Pump	Khori	S39	Tube Well	Teelawas
S20	Hand Pump	Kishorpura	S40	Tube Well	Vatika

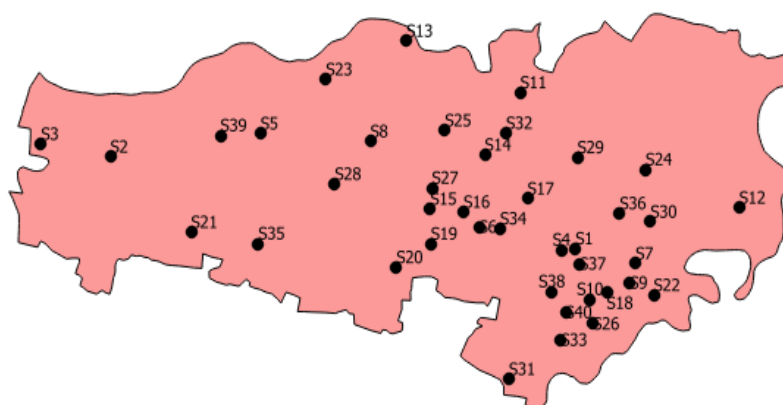


Fig. 1 Map of location with different villages of Sanganer Tehsil using GIS

III. RESULTS & DISCUSSION

Results are measured with field and analytical physico-chemical parameters, which include Durov, Wilcox and Schoeller diagrams for graphical representation to demonstrate the similarities and differences in groundwater chemistry between the sites.

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[a] PHYSICO-CHEMICAL PARAMETERS OF GROUNDWATER

The respective values of all water quality parameters are summarized in Table-2 (a), (b) & (c). Field Chemistry measurements were done for every sampling event. Results for field EC ranged from 560 μ mhos/cm (S12) to 4506 μ mhos/cm (S7) with an average of 1569.83 μ mhos/cm and a standard deviation of 910.88 μ mhos/cm. Field pH ranged from 7.20 (S30) to 9.00 (S3, S22, S39) with an average of 8.27 and a standard deviation of 0.48. The field temperature ranged from 24.0°C (S11, S23) to 26.8°C (S7, S26, S31) with an average of 25.41°C and a standard deviation of 0.80°C.

Table-2 (a): Minimum, maximum, average & S. D. of field analytical results of Sanganer Tehsil in post-monsoon period

Parameter	Temp. (°C)	EC (μ mhos/cm)	pH	Salinity (mg/L)	TDS
Minimum	24.0 (S11,23)	560 (S12)	7.20 (S30)	98 (S29)	329.50
Maximum	26.8 (S7, 26, 31)	4506 (S7)	9.00 (S3, S22,	1028 (S9)	1984.26
Average	25.41	1569.83	8.27	328.18	775.67
Standard	0.80	910.88	0.48	252.73	340.43

Field salinity ranged from 98 mg/L (S29) to 1028 mg/L (S9) with an average of 328.18 mg/L with a standard deviation of 252.73 mg/L. Results for TDS ranged from 329.50 mg/L (S17) to 1984.26 mg/L (S5) with an average of 775.67 mg/L and a standard deviation of 340.43.

The results for Na⁺ ranged from 43 mg/L (S6) to 602 mg/L (S5) with an average of 160.75 mg/L and a standard deviation value of 106.87. K⁺ ranged from 1 mg/L (S2, S4, S14, S18 and S35) to 14 mg/L (S28) with an average of 3.20 mg/L and a standard deviation of 2.17.

Table-2 (b): Minimum, maximum, average & S. D. of major cations analytical results of Sanganer Tehsil in post-monsoon period

Parameter	Ca ²⁺ (mg/L)	Mg ²⁺ (mg/L)	Na ⁺ (mg/L)	K ⁺ (mg/L)
Minimum	32 (S17)	6.00 (S19)	43 (S6)	1 (S2, S4, S14, S18, S35)
Maximum	228 (S34)	97.92 (S7)	602 (S5)	14 (S28)
Average	72.48	29.53	160.75	3.20
Standard Deviation	34.45	19.56	106.87	2.17

The results for Ca²⁺ ranged between 32 mg/L (S17) to 228 mg/L (S34) with an average of 72.48 mg/L and 34.45 as standard deviation value. Mg²⁺ ranged from 6.00 mg/L (S19) to 97.92 mg/L (S7) with an average of 29.53 mg/L and with standard deviation of 19.56.

The results for Cl⁻ ranged from 45 mg/L (S17) to 835 mg/L (S5) with an average of 219.6 mg/L and a standard deviation of 152.33. NO₃⁻ ranged from 5.0 mg/L (S38) to 250.0 mg/L (S7) with an average of 64.50 mg/L and a standard deviation of 46.52.

Table-2 (c): Minimum, maximum, average & S. D. of major anions analytical results of Sanganer Tehsil in post-monsoon period

Parameter	HCO ₃ ⁻	Cl ⁻ (mg/L)	SO ₄ ²⁻ (mg/L)	NO ₃ ⁻ (mg/L)	F ⁻ (mg/L)
Minimum	95 (S22)	45 (S17)	0 (S33, S35, S38)	5 (S38)	0.4 (S38)
Maximum	878 (S40)	835 (S5)	210 (S7)	250 (S7)	3.5 (S40)
Average	284.93	219.6	60.13	64.50	1.11
Standard Deviation	136.55	152.33	45.84	46.52	0.63

HCO₃⁻ ranged from 95 mg/L (S22) to 878 mg/L (S40) with an average of 284.93 mg/L and with standard deviation value of 136.55. The results for SO₄²⁻ ranged between 0 mg/L (S33, S35 and S38) to 210 mg/L (S7) with an average of 60.13 mg/L and a standard deviation of 45.84. Fluoride ranged from 0.4 mg/L (S38) to 3.5 mg/L (S40) with an average of 1.11 mg/L and a standard deviation of 0.63.

[b] STATISTICAL REPRESENTATION OF GROUNDWATER PARAMETERS

Sodium Adsorption Ratio (SAR) [4]: The Sodium Adsorption Ratio (SAR) was calculated by equation-1:

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$$SAR = \frac{Na^+}{\sqrt{\left(\frac{Ca^{2+} + Mg^{2+}}{2}\right)}} \quad (1)$$

According to the classification of groundwater samples of study area with respect to SAR, 37 samples (92.50%) were under excellent category. Wilcox- diagram (Fig.-2) illustrates that most of the groundwater samples fall in the field of C3S1, indicating high salinity and low sodium water. In the present study the SAR values of 37 samples are less than 10 & can be graded as excellent for irrigation use. One sample (S34) falls in C4S1, 3 samples (S7, S10 & S18) in C4S2 and one sample (S5) is in C4S4 indicating very high salinity-low sodium water, very high salinity-medium sodium water and very high salinity-very high sodium water respectively. C4S4 class is doubtful for irrigation purpose.

Soluble Sodium Percentage (SSP) [5]: It was calculated by using equation-2:

$$SSP = \frac{(Na^+ + K^+) \times 100}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \quad (2)$$

Sodium percent is used for studying sodium hazard for the assessment of groundwater quality for irrigation purpose. The soluble sodium percentage values of groundwater in the study area range between 25.71meq/L (S34) and 78.00meq/L (S5) indicating good to doubtful category (Table-3). It is observed that 14 groundwater samples have SSP values more than 50, which can be graded as doubtful quality for irrigation.

Residual Sodium Bicarbonate (RSBC) [5, 6]: RSBC was calculated by using equation-3:

$$RSBC = HCO_3^- - Ca^{2+} \quad (3)$$

The concentration of bicarbonate and carbonate influences the suitability of water for irrigation purpose. The water with high RSBC has high pH. Therefore, land irrigated with such water becomes infertile owing to deposition of sodium carbonate. The residual sodium bicarbonate values of water samples from the study area vary from -12.02meq/L (S34) to 9.25meq/L (S40). The RSBC values in 4 samples (S13, S27, S28 & S40) are more than 3.0meq/L & are therefore considered unsafe for irrigation purpose.

Permeability Index (PI) [7]: It was calculated employing equation-4:

$$PI = \frac{(Na^+ + \sqrt{HCO_3^-})}{Ca^{2+} + Mg^{2+} + Na^+} \times 100 \quad (4)$$

PI influencing constituents are total dissolved solids, sodium bicarbonate and the soil type. In the present study, the permeability index values range varies from 34.57% (S34) to 90.04% (S40). The result suggests that water samples fall within Class I & Class II and can be categorized as good and moderate irrigation water respectively & can be classified as good class for agricultural use.

Magnesium Adsorption Ratio (MAR) [8]: It was calculated by using equation-5:

$$MAR = \frac{Mg^{2+} \times 100}{Ca^{2+} + Mg^{2+}} \quad (5)$$

The value of magnesium adsorption ratio of groundwater in present study varies from 11.63% (S19) to 66.02% (S7) indicating that 82.50% groundwater samples have less MAR than 50% and considered to be good for irrigation purpose. High magnesium adsorption ratio puts a harmful effect to soil when it exceeds 50% (17.50% samples). So in these samples, soils become more saline and will adversely affect crop yields.

Kelley's Ratio (KR) [9]: The Kelly's Ratio was calculated employing the following equation-6:

$$KR = \frac{Na^+}{Ca^{2+} + Mg^{2+}} \quad (6)$$

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The Kelley's Ratio (KR) values of the study area ranged between 0.34 (S34) – 3.53 (S5). Our investigations indicate that 55% groundwater samples however fall within permissible limits of 1.0 and are considered suitable for irrigation purposes but remaining 45% samples are in danger zone and are unsuitable for irrigation with regards to alkali hazard.

Residual Sodium Carbonate (RSC) [4]: The relative proportion of sodium in water is increased in the form of sodium carbonate and this excess is denoted by Residual Sodium Carbonate (RSC) and is calculated by using equation-7:

$$RSC = [HCO_3^- + CO_3^{2-}] - [Ca^{2+} + Mg^{2+}] \quad (7)$$

RSC values for 80% samples from study area are less than 1.25, 17.50% samples between 1.25-2.50 and 2.50% samples above than 2.5, suggesting these water samples to be safe, marginally suitable & unsuitable respectively for irrigation use.

Chloro-Alkaline Indices (CAI) [10]: The chloro-alkaline indices indicate ion exchange. CAI is used in the evaluation of base-exchange and is calculated using the equation-8:

$$CAI = \frac{[Cl^- - (Na^+ + K^+)]}{Cl^-} \quad (8)$$

The negative value of CAI indicates that there is exchange between sodium and potassium ($Na^+ + K^+$) in water with calcium and magnesium ($Ca^{+2} + Mg^{+2}$) by a type of Base Exchange reactions. The positive value represents the absence of base-exchange reactions and existence of cation-anion exchange type of reactions [11]. In the study area, 25 samples have the negative value of CAI proving the base-exchange reactions while 15 samples indicate the cation-anion exchange reactions.

All irrigation parameters with their minimum, maximum, average and standard deviation values are shown in Table-3 and summarized in Table-4.

Table-3: Minimum, maximum, mean and S. D. of groundwater irrigation quality parameters results of post-monsoon period

Parameter	SSP (%)	RSC (meq/L)	RSBC (meq/L)	SAR (meq/L)	KR
Minimum	25.71 (S34)	-12.021 (S34)	-6.51 (S34)	1.62 (S6)	0.34 (S34)
Maximum	78.00 (S5)	9.251 (S40)	10.39 (S40)	19.22 (S5)	3.53 (S5)
Average	52.07	-0.65	1.05	5.89	1.28
Standard Deviation	13.81	3.06	2.30	3.63	0.79

Parameter	MAR (%)	PI (%)	CAI-1	r ₁	r ₂
Minimum	11.63 (S19)	34.57 (S34)	-1.68 (S27)	-5.01 (S34)	-4.98 (S34)
Maximum	66.02 (S7)	90.04 (S40)	0.61 (S34)	19.11 (S25)	19.99 (S25)
Average	38.81	69.80	-0.32	1.62	1.76
Standard Deviation	12.85	13.20	0.54	4.28	4.43

Base-exchange indices (r₁) [12]: The base-exchange indices were estimated using the following equation-9:

$$r_1 = \frac{(Na^+ - Cl^-)}{SO_4^{2-}} \quad (9)$$

,where r₁ is the base-exchange index and Na⁺, Cl⁻ and SO₄²⁻ concentrations, expressed in meq/L. If r₁<1, the groundwater sources are of Na⁺ & SO₄²⁻ type, while r₁>1 indicates the sources are of Na⁺ & HCO₃⁻ type. Based on the base-exchange indices (r₁) about 57.50% groundwater samples are classified as Na⁺ & SO₄²⁻ type (r₁<1) and rest are Na⁺ - HCO₃⁻ type (r₁>1).

Meteoric genesis indices (r₂) [12]: The groundwater sources can also be classified based on meteoric genesis index and can be computed equation-10:

$$r_2 = \frac{[(Na^+ + K^+) - Cl^-]}{SO_4^{2-}} \quad (10)$$

where r₂ is the meteoric genesis index and concentration of K⁺, Na⁺, Cl⁻ and SO₄²⁻ are expressed in meq/L. If r₂<1 the groundwater source is of deep meteoric water percolation type while r₂>1 indicates that is of shallow meteoric genesis indices. Based on r₂ values of groundwater sources are of deep meteoric water percolation type and the rest are shallow

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meteoric water percolation type. Furthermore all Na^+ & SO_4^{2-} (except S2, S5, S12, S13, S14, S15, S16, S17, S19, S20, S21, S23, S25, S27, S28, S29 & S40) type groundwater samples are of deep meteoric water and percolation type in nature. The meteoric genesis indices demonstrated that 57.50% groundwater sources belong to deep meteoric water percolation type and 42.50% belong to a shallow meteoric water type as shown in Table-3.

Table-4: Irrigation quality parameters range of Sanganer Tehsil with number of villages in post-monsoon period

Parameters	Range	Class	No. of samples	% of samples
			Post-monsoon	Post-monsoon
SAR (Richard, 1954)	<10	Excellent	37	92.50
	10-18	Good	2	5.00
	18 – 26	Doubtful	1	2.50
	>26	Unsafe	0	0.00
EC (Wilcox, 1955)	<250	Excellent	0	0.00
	250 – 750	Good	7	17.50
	750 – 2250	Permissible	28	70.00
	2250 – 5000	Unsuitable	5	12.50
	>5000	Unsuitable	0	0.00
TH(Sawyer & McCarty, 1967)	<75	Soft	0	0.00
	75 – 150	Moderate	2	5.00
	150 – 300	Hard	22	55.00
	>300	Very Hard	16	40.00
TDS	<500	Suitable for drinking	6	15.00
	500 – 1000	Permissible	29	72.50
	1000 – 3000	Useful for irrigation	5	12.50
	>3000	Unfit for irrigation	0	0.00
RSC (Richard, 1954)	<1.25	Safe	32	80.00
	1.25 – 2.50	Marginally suitable	7	17.50
	>2.50	Unsuitable	1	2.50
MAR (Raghunath,1987)	<50	Suitable	33	82.50
	>50	Unsuitable	7	17.50
SSP (Wilcox, 1955)	<20	Excellent	0	0.00
	20 - 40	Good	8	20.00
	40 - 60	Permissible	18	45.00
	60 - 80	Doubtful	14	35.00
	>80	Unsafe	0	0.00
KR (Kelly, 1963)	<1.0	Suitable	22	55.00
	>1.0	Unsuitable	18	45.00
PI (Doneen, 1964)	<80	Good	29	72.50
	80 – 100	Moderate	11	27.50
	100 - 120	Poor	0	0.00
CAI (Schoeller, 1967)	Base exchange reaction	Negative values	25	62.50
	Cation-anion exchange reaction	Positive values	15	37.50
Chloride (Stuyfzand, 1989)	<0.14	Extremely fresh	0	0.00
	0.14-0.85	Very fresh	0	0.00
	0.85-4.23	Fresh	15	37.50
	4.23-8.46	Fresh-brackish	17	42.50
	8.46-28.21	Brackish	8	20.00
	28.21-282.06	Brackish salt	0	0.00
	282.06-564.13	Salt	0	0.00
>564.13	Hyper saline	0	0.00	
r₁	<1.0	$\text{Na}^+ - \text{SO}_4^{2-}$	23	57.50
	>1.0	$\text{Na}^+ - \text{HCO}_3^-$	17	42.50

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r_2	<1.0	Deep meteoric water type	23	57.50
	>1.0	Shallow-meteoric water type	17	42.50

It has been found that 55% samples are in ‘Hard’ class and 40% samples are in very hard class for TH and 12.5% samples are in ‘unsuitable class’ and no sample in excellent class for EC values while some samples are unsuitable for irrigation as indicated in Table-4 for 70% samples fall in just ‘permissible’ class.

[c] GRAPHICAL REPRESENTATION OF PHYSICO-CHEMICAL PARAMETERS

EC is used for the expression of total concentration of soluble salt or salinity hazard in irrigation water. The extent of this replacement of sodium hazards has been expressed by SAR or percent sodium. Wilcox diagram [13] is used to interpreting the combined effect of salinity and sodium hazards [14].

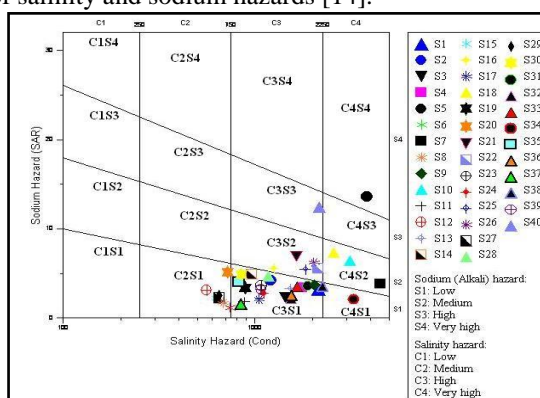


Figure: 2 Wilcox diagram of study areas during post-monsoon period

Waters have been divided into C1, C2, C3, and C4 categories on the basis of salinity hazard and S1, S2, S3 and S4 categories on the basis of sodium hazard. According to Wilcox diagram, most of the ground water samples have the high salinity and low or medium sodium (alkalinity) hazards as shown in Figure -2. The results indicate that 24 and 4 out of 40 groundwater samples are found in C3S1 class with high salinity and low sodium hazards and C3S2 class with high salinity and medium alkalinity hazards respectively. The ground water of these samples can be used for irrigation with most crops under special management for salinity control due to high salinity hazards. It is classified that one sample (S34) in C4S1 class is not suitable for irrigation under ordinary conditions due to very high salinity hazard. In the study area, six samples in C2S1 class can be used for irrigation with most crops on most soils but one sample (S40) in C3S3 class can't be used for irrigation without special practices for salinity and alkalinity control. One sample (S5) in C4S4 class with very high salinity & very high sodium hazard is unsuitable for irrigation.

The Durov diagram is an alternative form of the Piper trilinear diagram. Durov plots the major ions as percentage of meq/L in two base triangles and total cations and total anions are set equal to 100%. The data points in the two base triangles are projected into square of the main field which lies perpendicular to the third axis in each triangle. It shows clustering of water quality data points and finally displays some possible geochemical processes that could affect the water genesis [15].

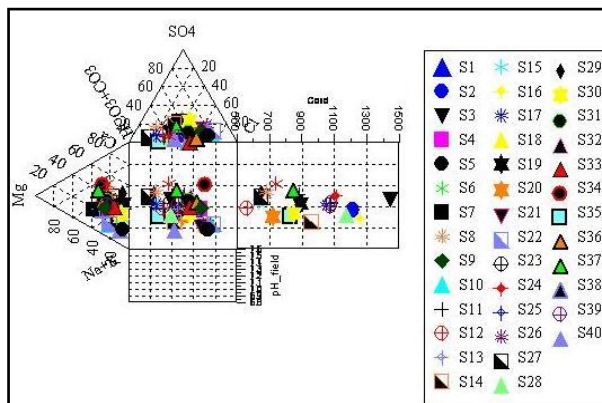


Fig. 3 Durov diagram of study areas during post-monsoon period

This Figure -3 specifies that most of the ground water samples in the study area show no dominant cation or anion indicating water exhibiting simple dissolution or mixing. Water type of most of the samples is dominated by Na^+ & K^+ and HCO_3^- ions representing an important ion exchange process while some samples are dominated by SO_4^{2-} and Ca^{2+} ions indicating probable mixing influences.

The Schoeller diagram is used to study comparative changes in the concentrations and ratios of water quality parameters for different samples. The different water quality parameters are plotted along with their concentrations (meq/L) as shown in Figure- 4. Results specify that lines of similar slope connecting concentrations of different parameters are indicative of water from a similar source. The most water type of high sodium content also has high concentration of chloride [10].

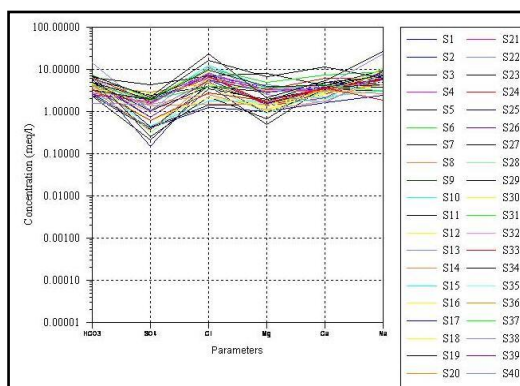


Fig. 4 Schoeller diagram of study areas during post-monsoon period

The water samples can be divided into two types on the basis of sodium content, one type has low sodium content in the range 1.8-8.5 meq/L and other has high sodium content in the range 8.9meq/L to 26.17meq/L.

[d] CORRELATION MATRIX

A correlation analysis is a bivariate method that describes the degree of relationship between two variables. For this purposes, spearman’s correlation coefficient with the help of SPSS, has been calculated using physico-chemical parameters of groundwater samples as shown in Table-5. A high correlation coefficient means a good relationship between two variables [16].

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Table-5: Correlation matrix between different parameters in post-monsoon period

Parameter	Temp.	EC	pH	TDS	HCO ₃ ⁻	CO ₃ ²⁻	TA	TH	Ca ²⁺	Mg ²⁺	Cl	F	SO ₄ ²⁻	NO ₃ ⁻	Na ⁺	K ⁺
Temp.	1	0.352	-0.06	0.305	0.109	0.042	0.112	0.212	0.144	0.23	0.275	-0.031	0.253	0.137	0.242	0.165
EC		1	-0.153	0.764	0.121	0.166	0.139	0.537	0.295	0.654	0.797	0.086	0.517	0.325	0.616	-0.03
pH			1	-0.199	-0.131	0.224	-0.1	-0.309	-0.287	-0.25	-0.163	-0.059	-0.304	-0.004	-0.09	0.193
TDS				1	0.531	0.254	0.549	0.587	0.528	0.498	0.881	0.406	0.518	0.432	0.877	0.051
HCO ₃ ⁻					1	0.13	0.993	0.31	0.349	0.19	0.193	0.626	-0.029	0.264	0.501	0.219
CO ₃ ²⁻						1	0.249	0.243	0.213	0.211	0.119	0.134	0.154	0.298	0.098	-0.25
TA							1	0.333	0.367	0.212	0.203	0.628	-0.01	0.295	0.501	0.184
TH								1	0.882	0.867	0.515	0.135	0.426	0.309	0.137	-0.02
Ca ²⁺									1	0.53	0.472	0.221	0.26	0.194	0.134	0.059
Mg ²⁺										1	0.428	0.011	0.492	0.351	0.105	-0.09
Cl											1	0.214	0.384	0.119	0.79	0.049
F												1	0.055	0.066	0.437	0.31
SO ₄ ²⁻													1	0.356	0.343	-0.11
NO ₃ ⁻														1	0.28	-0.19
Na ⁺															1	0.099
K ⁺																1

In study area pH shows negative correlation with most of the variables indicating that pH of the samples is not dependent on any variable. The value of TDS & EC indicates highly positive correlation with most of the variables such as Cl, TH, Mg²⁺, Na⁺ and SO₄²⁻. The good positive correlation was observed between Ca²⁺ and TH, TH & Cl, TA & Na⁺, TH & Mg²⁺, TA & HCO₃⁻, HCO₃⁻ & Na⁺ and F & HCO₃⁻.

IV. CONCLUSION

The study revealed that most of samples in the Sanganer Tehsil are slightly alkaline and brackish salty. The SAR values show that samples belong to excellent to doubtful category for irrigation purposes. The percent sodium level of samples indicated that 35% samples are doubtful while 20% samples are in good category of the sodium hazards for irrigation purposes. The negative CAI values of 62.50% samples are related to base-exchange type of reaction and remaining 37.50% samples having positive values are associated with the cation-anion exchange type of reactions. The Durov diagram indicates most of the samples to be dominated by Na⁺ & K⁺ and HCO₃⁻ ions pointing to an important ion exchange process while samples dominated by SO₄²⁻ and Ca²⁺ ions indicate probable mixing influences. The Schoeller diagram specifies that most of the samples have similar ground water source. Wilcox diagram exhibits C3S1 (high salinity-low sodium hazard) and C3S2 class (high salinity-medium sodium hazard) for most of the samples. These samples are suitable for irrigation purposes under special management for salinity control due to high salinity. S5 (Bamoriya village) in C4S4 class (very high salinity-very high sodium hazard) is unsuitable for irrigation purpose. It is concluded that a mixed pattern of suitability of groundwater for irrigation in study area is observed by statistical representation of studied parameters and special management for salinity control appears to be the requirement in areas with disturbed value indicators.

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