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WATER QUALITY - CATION AND ANION CHARACTERISTICS OF SWETA RIVER BASIN, TAMIL NADU, INDIA

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Abstract: *This study is employed in Sweta River Basin, Water quality data for 34 control wells collected from Groundwater Division for the year 1980-2010 are taken into consideration for the analysis. These observation wells are regularly maintained by the Public Works Department of Government of Tamil Nadu. The results show that the type of water that predominated in the study area, during pre and post monsoon seasons and were analyzed for hydro geochemical parameters such as (Calcium (Ca+), magnesium (Mg+), Sodium (Na+), Potassium (K+), (HCO3-), Chloride (Cl-), Sulphate (SO4-), Carbonates (CO3), Nitrite (NO2-) Nitrate (NO3-) and Fluoride (F) was assessed by Hydro chemical Facies.*

Key words: Major Cations and Anions variations, Hydro chemical Facies, Piper Diagram and Sweta River Basin

Introduction

Groundwater is important resource for agricultural, domestic, and industrial activities depends on it. Groundwater has more minerals concentration in comparison with surface water. The demand for groundwater in a study area requires detail consideration of availability and quality. However, a number of trace elements are found in water which can limit its use for irrigation, especially anion and cation variations determined by the water quality. Groundwater often consists of seven major chemical elements Calcium, magnesium, Chloride, Potassium, Sulphate and Sodium (Kelley, W. P.1940) and (Wilcox. L. V.1948). The control of water quality must be effective. High clean up costs for effluent treatment and the low general public awareness are the main reasons why an improvement in the situation is difficult to achieve (Mull et al. 1992). Evaluated the groundwater quality in the upper Gunjanaeru River basin, Cuddapah District, Andhra Pradesh, South India (Raju, 2007). Kumaresan *et al.,* (2006) have considered major ion chemistry of environmental samples around sub-urban of Chennai city. Jagdap *et al.,* (2002) and Sunitha *et al.,* (2005) classify the water in order to assess the water quality for various purposes.

The Study Area

The Sweta River basin lies in the districts of Namakkal, Salem, Tiruchirappalli and Perambalur of Tamil Nadu State. The Sweta River originates from the northern parts of Kolli hills in Namakkal District. It is located between 11^0 15' N and 11^0 45' N latitudes and 78^0 15' E and 78^0

58’ E longitudes (as read from the survey of Indian Topographic sheets C44A6 (58 I/6), C44A7 (58 I/7), C44A10(58 I/10), C44A11(58 I/11) and C44A15(58 I/15) (Fig.1). The river originates from the northern parts of Kolli hills, a part of Manmalai, adjoining Kolli hills and Palakkadu Malai in Pachamalai. The total geographical area of the basin is 1,034.43 Sq.km (1,03,443 ha) within 82 Revenue villages. The study area is based upon the three major relief orders such as the hills, uplands, and the plains. The river runs over 116 kms from the west to the east, and joins Vellar River, which runs into the Bay of Bengal.

Figure 1: Location of Study area

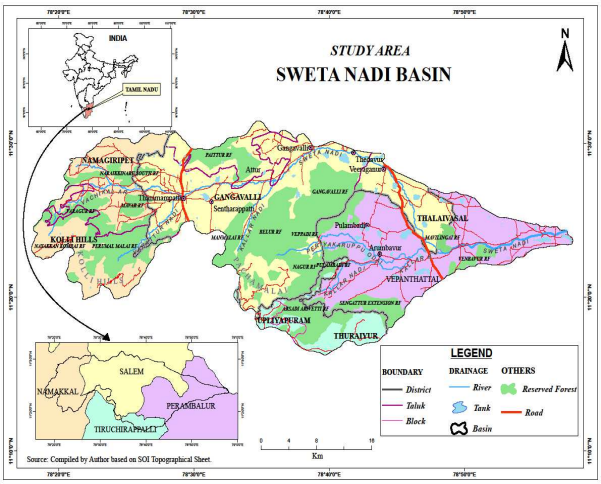
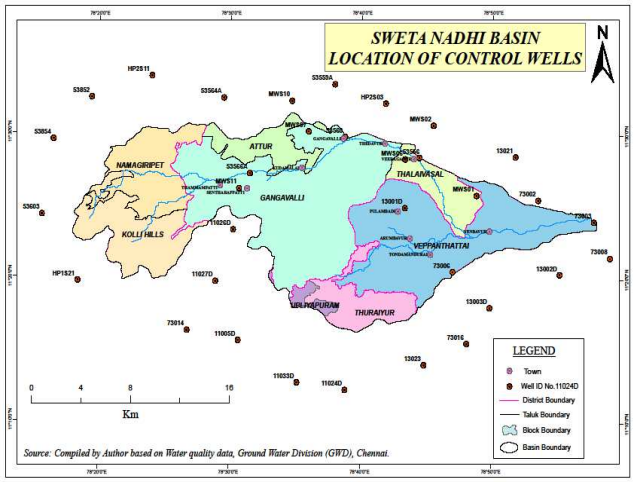


Figure 2: Location of Control wells



Objectives

The study aims to understand the distribution of groundwater quality of Sweta River basin and the main objectives of anion and cation characteristics variations in post and pre monsoon seasons.

Methodology

The Study area selected control wells around the basin and inside the basin totally 34 control wells are selected for this analysis (Fig.2). Water quality data collected form Ground Water Division (GWD), Tamil Nadu, Chennai. Water quality data are utilized in the present study to analyze the groundwater cation and anion variations from 1980 to 2010 for both pre monsoon (July) and post monsoon (December) seasons.

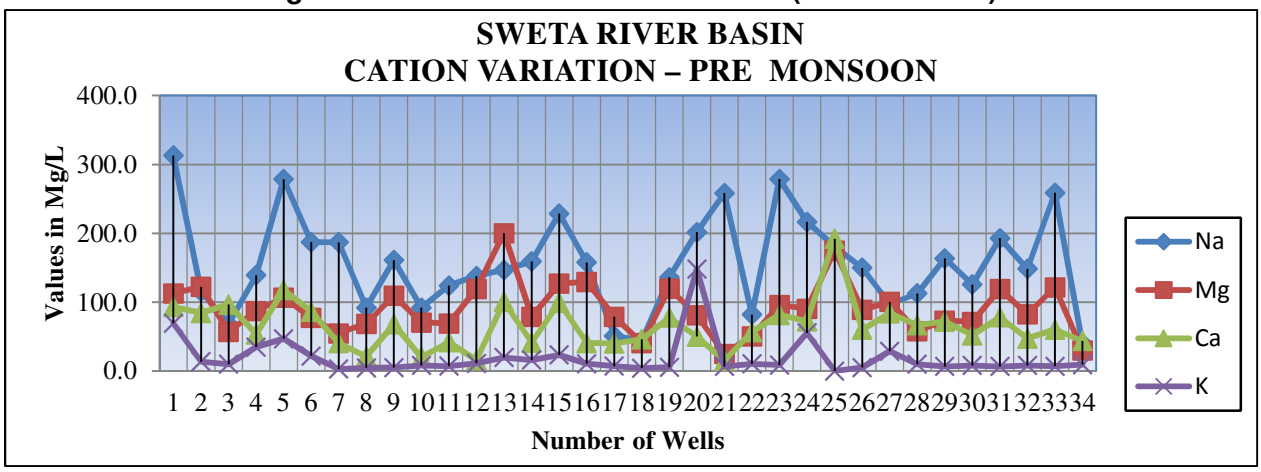
RESULTS AND ANALYSIS OF GROUNDWATER QUALITY

Hydro-geochemical status of various cations and anions of the groundwater wells of both pre- and post-monsoon seasons are dealt in the following sections.

1. Cation Variation

Most important cations, (Calcium (Ca+), magnesium (Mg+), Sodium (Na+) and Potassium (K+) have been taken into consideration as far as cation variation is concerned. The concentration of cation for 34 control wells is worked out for pre-monsoon and post monsoon seasons (Fig.3 & 4).

Figure 3: Cation Variation - 1980 -2010(Pre-Monsoon)



1.1. Sodium (Na+)

The concentration of cations during the pre-monsoon season at different control wells of the study area is shown in Figure.3. It is observed that among the cations, sodium is found to be the most predominant in the study area. The concentration of sodium ion ranges from 39.8 mg/L to 313 mg/L during pre monsoon period and 0.0 mg/L to 694.3 mg/L during post-monsoon period in the entire basin. Sodium is the first dominant ion in the basin. The highest concentration (more than 250 mg/l) of sodium ion is found in south and central part of the study area, highly concentrated in South part of Thalugai control well in Tiruchirappalli district during Post monsoon totally 6 control wells comes under this category.

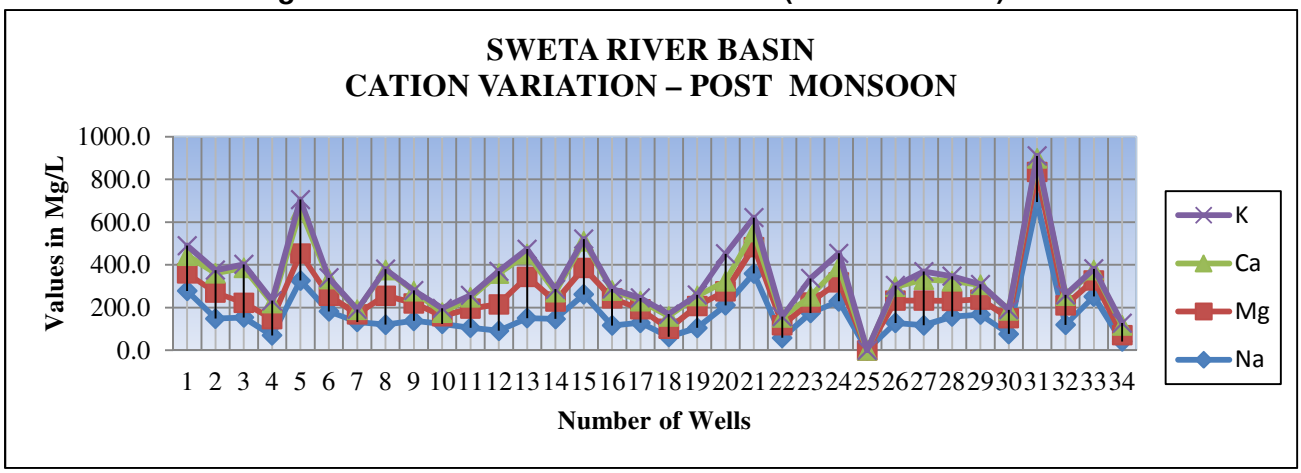
1.2. Magnesium (Mg+)

Magnesium is the Second dominant ion in the study area. Its concentration ranges Between 25 mg/L to 200.3 mg/L during the pre-monsoon period and 30.1 mg/L to 193 mg/L during the post-monsoon period in the entire basin. Tirumandurai, Kallatukombai and Poolambadi control wells are less than 50 mg/L during pre-monsoon. The trend is decreasing from central to east of the basin. A very low (*less than 50 mg/L*) to very high (*more than 200 mg/L*) concentration of magnesium ion occur at northern rim and western central part of the study area. In the case of post-monsoon season Magnesium concentration does not show much variation. The concentration of magnesium ion found to be very low (*less than 50 mg/L*) in five control wells The average concentration of magnesium is 90.1 mg/L in pre-monsoon and 87 mg/L during post-monsoon season.

1.3. Calcium (Ca+)

During the pre-monsoon season, calcium concentration is ranging between 14.8 mg/L and 192 mg/L in the entire basin. It is found to be very low (*less than 50 mg /L*) in 12control wells. The concentration of calcium during post-monsoon ranges from 16 mg/L to 204 mg/L and it is very high (*more than 100 mg/L*) at Kalkurichi, Illupanatham, Pudupatti, Sendarapatti, Gangavalli and Sendarappatti control wells, It is less than 50 mg/L of calcium ion concentration. The average concentration of calcium in the entire basin is 65.2 mg/L during pre monsoon season and it is 69.5 mg/L during post-monsoon season.

Figure 4: Cation Variation -1980 -2010 (Post-Monsoon)



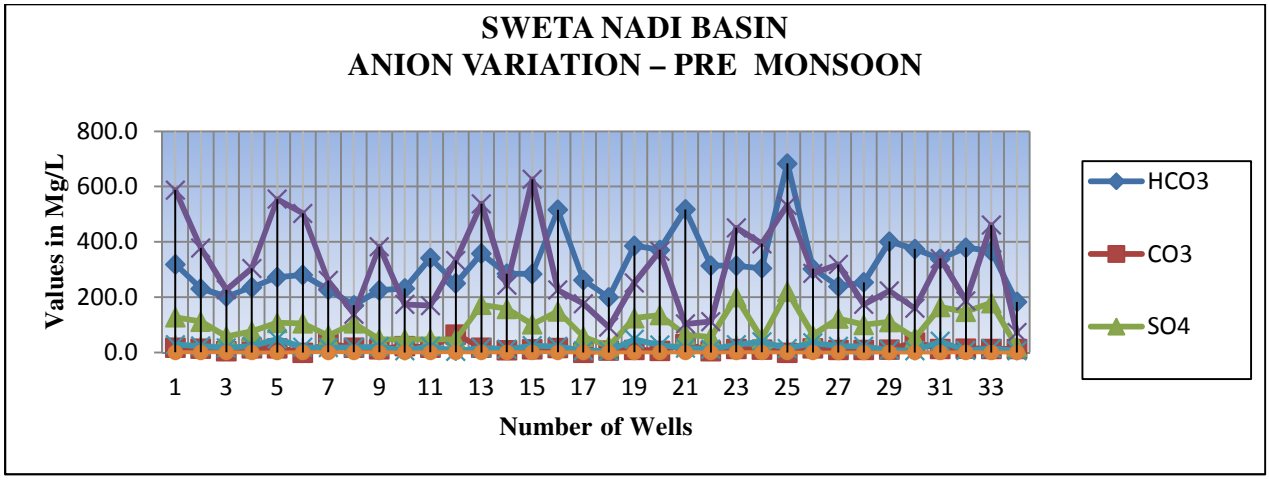
1.4. Potassium (K+)

Among the cation, potassium stands in the last place in the study area. During the pre monsoon season, the concentration of potassium ranges from 3.0 mg/L to 148 mg/L. In 31 and 32 control wells in both seasons the concentration potassium ion is found to be below (less than 50 mg/L) in the study area. A high concentration is noticed at Pasumbalur, Veeraganur and Esanai pre monsoon season and Pasumbalur, Tirumandurai, Ladapuram and Esanai post monsoon season.

2. Anion Variation

For the present study, major anion in groundwater such as Bicarbonate (HCO3-), Chloride (Cl-), Sulphate (SO4-), Carbonates (CO3), nitrite (NO2-) nitrate (NO3-) and Fluoride (F) are carefully studied in order to understand their influence of groundwater chemistry. In the study area, Bicarbonate (HCO3-) is predominant anion. The few differences observed between these two periods are represented graphically by using simple linear graphs and are shown in Figure.5 & 6.

Figure 5: Anion Variation - 1980 -2010 (Pre-Monsoon)



2.1 Bi-Carbonate (HCO3-)

Under normal condition, the bicarbonate concentration in Ground water ranges from 0.9 mg/L to 683 mg/L. The presence of bicarbonate in the groundwater of the study area may be due to the dissolution of carbon-di-oxide, when the water passes through soil containing organic matter. During the pre-monsoon, bi-carbonate is ranging from 170.8 mg/L to 683 mg/L. The highest concentration (*more than 400 mg/L)* is found in Uppliyapuram, Nadukombai, Tirumandurai and Peraiyur control wells and the range is increasing towards south to southeastern part and western middle part.

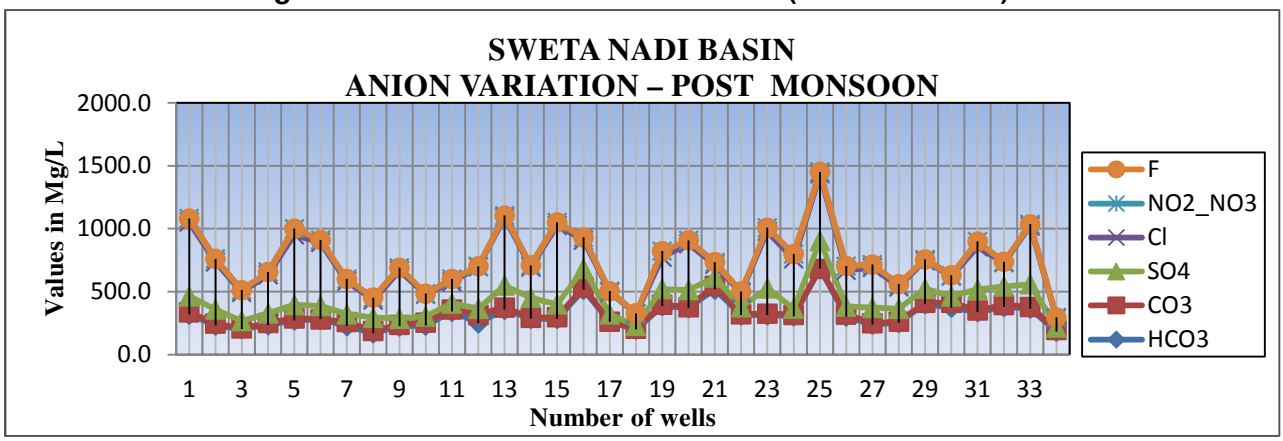
The concentration of bi-carbonate is found to be very low (*less than 200mg/L*) in Illupanatham, Kallatukombai and Poolambadi. The concentration of bi-carbonate is moderated (*200 to 400 mg/L*) falls under 27 control wells central and northern part of the study area. During the post-monsoon season the bicarbonate concentration is diluted when compared to pre-monsoon season in almost all the control wells.

The concentration of bi-carbonate ion during the post-monsoon season ranges from 0.9 mg/L and 646 mg/L and it is found to be highest (*more than 400 mg/L*) in Thalugai, Nadukombai and Tirumandurai control wells. It is low (*less than 200 mg/L*) in Peraiyur, Sendarapatti, Kallatukombai and Kaikalathur control wells inside the basin boundary. The rest of the 27 control wells fall under moderate category. The average concentration of bi-carbonate is 312.5 mg/L during pre-monsoon and 310.1 mg/L during post-monsoon season. More than average values are found in 27 control wells in both the seasons.

2.3 Chloride (Cl-)

Chloride is the third predominant ion in anion group of groundwater in the whole study area. The concentration of chloride ion during the pre-monsoon period ranges from 72.5 mg/L to 626.4 mg/L. The concentration of chloride ion during this season is found to be low (*less than 100 mg/L*) in Kallatukombai and Poolambadi control wells. High (*more than 400 mg/L*) concentration is noticed in 8 control wells of northeast part and some patches in the west part of the study area. The concentration of chloride ion during the post-monsoon period ranges from 25 mg/L to 681.7 mg/L. Its concentration is found to be low (*less than 100 mg/L*) occurring in four control wells of Rajapalayam, Kadambur, Kallatukombai and Poolambadi during this season. High *(more than 400 mg/L*) concentration of chloride is recorded at ten control wells of western middle parts, central and northern rim of the basin. The average concentration of chloride is 304.4 mg/L observed during pre and it is 298.5 mg/L during post-monsoon season. Sendarappatti and Pudupatti have more than average concentration in both the seasons also it is found in the western part of the study area during pre-monsoon. The main reason for the higher occurrence of chloride in these parts is owing to the intensity of industrial activities.

Figure 6: Anion Variation - 1980 -2010 (Post-Monsoon)



2.4 Sulphate (SO4-)

The concentration of sulphate ion during the pre-monsoon period ranges from 20.4 mg/L to 221 mg/L. The concentration of sulphate ion during this season is found to be low (*less than 50 mg/L*) in six control wells in central and some control wells located northern rim of basin boundary, Kallatukombai, Poolambadi, Paithur, Kadambur, Sendarapatti, Sokkanur and Agraharam. High (*above 150mg/L*) concentration of sulphate is noticed at Malayalapatti, Thalugai, Kalkurichi, Perumalpalaiyam, Ladapuram and Peraiyur (6 control wells). The concentration of sulphate ion during the post-monsoon period ranges from 9 mg/L to 230 mg/L and it is found to be low (*less than 50 mg/L*) in six control wells located in eastern part of the study area. Moderate concentration (*50-150 mg/L*) is noticed in 23 control wells in Gangavalli and Rasipuram taluk. High (*more than 150 mg/L*) concentration is recorded in five control wells at Thalugai, Sendarappatti, Esanai and Nadukombai. It indicates that water from the basins has more than 150 mg/L sulphate concentration may perhaps be recommended for agriculture and domestic purpose.

2.5 Nitrite (NO2-) Nitrate (NO3-)

In the present study, nitrate concentration is comparatively higher in the post monsoon season than that of the pre-monsoon season. During the pre monsoon season, the range of nitrate is from 4 mg/L to 49.1 mg/L and it is from 3.0 mg/L to 81.3 mg/L during post- monsoon. The concentration of nitrogen ion during pre-monsoon is found to be low (*less than 50 mg/L*) all control wells in and outer part of the basin area. Moderate concentration is noticed (*50-100 mg/L*) in three wells from Illupanatham, Mettupalayam and Sendarappatti during post monsoon season. The concentration of nitrogen ion low to moderate found to be entire basin. The concentration of nitrate in water directly indicates the role of fertilizers in agriculture. The average concentration of nitrate is 20.3 mg/L during pre-monsoon and 24.6 mg/L during post-monsoon.

2.6 Carbonate (CO3-)

Carbonate concentration in pre-monsoon is comparatively higher than that of post-monsoon season. Two control wells in pre monsoon and 5 control wells in post monsoon do not contain

carbonate at all. Maximum numbers of control wells have lower (*less than 50 mg/L*) concentration of carbonate ion during both the seasons. During the pre-monsoon season, carbonate concentration is little higher than that of the post-monsoon season. The range of carbonate is from 0.6 mg/L to 42 mg/L during post-monsoon season. Concentration is noticed in the extreme north and northeast part of the study area. The presence of carbonate is low. The average concentration of carbonate is 15.4 mg/L during pre-monsoon and 11.1 mg/L during post-monsoon season.

2.7 Fluoride (F)

The fluoride concentration ground water quality of the study area. Varies between 0.5 to 1.3 mg/l in a pre-monsoon season and 0.2 to 1.2 in the post monsoon season with an average value of 0.8 and of 0.6 mg/l pre and post monsoon seasons. The maximum allowable limit of fluoride is 1.5 mg/l according to WHO (1993). The concentration level low 1.5 mg/l in all control wells.

3. Hydro chemical Facies

The concentrations of major ionic constituents of groundwater control wells are plotted in the piper's trilinear diagram (Piper, 1953) to determine the water type (Fig.7). The Auqua Chem software is used to construct the Piper's trilinear diagram and the values are used in milliequivalents per liter (epm). The classification for the cation and anion facies, in terms major ion percentages and water types, is made according to the domain in which they occur in the diagram segments (Blacks, 1966). Diagrammatic representation of chemical constituents is very effective to understand the results of the analysis and to provide a means for comparing the analysis with each other. These tri-linear diagrams (Figure.7) is useful in bringing out chemical relationships among groundwater quality in more definite terms rather than with other possible plotting methods is presented in Table 2.

4. Modified Piper's Trilinear Method

The cationic and anionic triangular fields of the Piper's diagram, during pre monsoon season, exhibit that 55.9% (19 control wells) of the wells fall in the 'No dominant type' , about 26.5 % (9 Control wells) of the wells fall into 'Sodium or Potassium type' and the remaining 17.6% (6 control wells) fall into Magnesium type among the cation facies. On the other hand, 64.7 % (22 control wells) of the wells fall into 'Bicarbonate type', about 23.5 % (8 control wells) of the wells fall into 'Chloride type' and the remaining 11.8 % of the control wells fall into no dominant type.

During the post monsoon season, as per the cationic and anionic triangular fields of Piper's diagram, it is observed that 70.4% (24 control wells) fall into 'No dominate type' among the anions facies (table.1) and 17.6 % (6 control wells) fall into 'Magnesium type' and the reaming about 11.8 % (4 control wells) fall into 'Sodium or potassium type'(Fig.7).

Figure 7: Piper Trilinear Diagram – Sweta River Basin

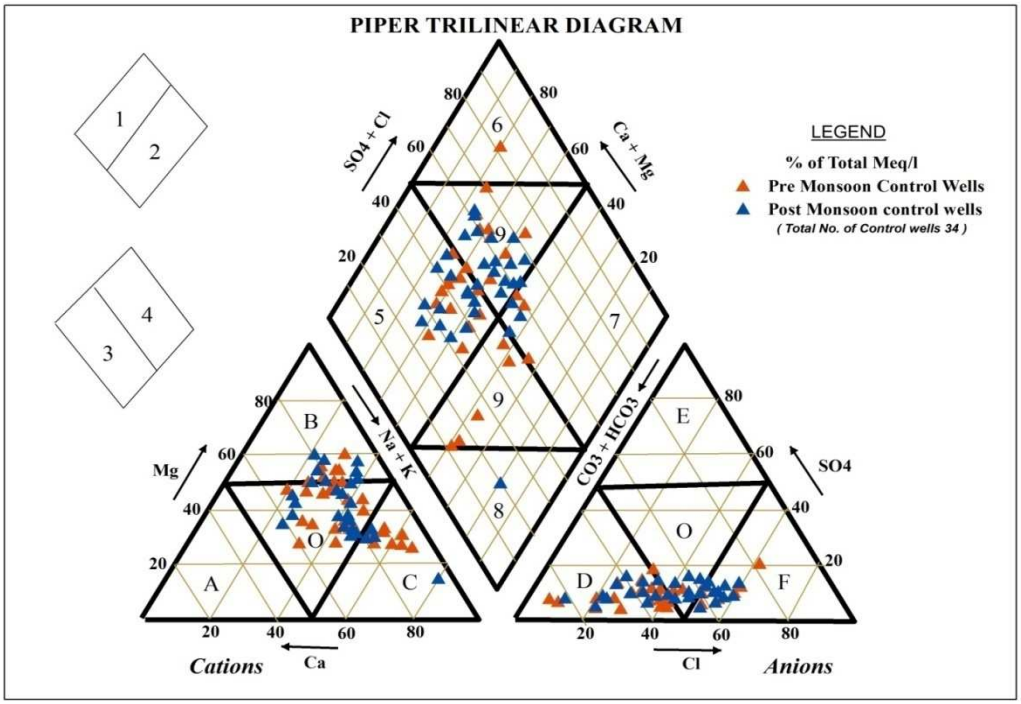


Table 1: Piper's Triangle fields classification

Sl.No	Subdivision of the triangles	Characteristics of corresponding subdivisions of triangle-shaped field	Pre Monsoon		Post Monsoon	
			No. of Wells	%	No. of Wells	%
1	Cation facies	A- calcium type	Nil	Nil	Nil	Nil
		B-magnesium type	6	17.6	6	17.6
		C-sodium or potassium type	9	26.5	4	11.8
		O-no dominant type	19	55.9	24	70.6
2	Anion facies	D- bicarbonate type	22	64.7	14	41.2
		E-sulphate type	Nil	Nil	Nil	Nil
		F-Chloride type	8	23.5	11	32.4
		O-no dominant type	4	11.8	9	26.5

On the other hand 41.2% (14 control wells) of the wells fall into 'Bicarbonate type', and about 32.4%(11 control wells) fall into 'Chloride type' and the remaining about 26.5 % (9 control wells) of the wells fall into 'No dominant type' among the anions facies (table.1). While looking difference between is found between pre and post monsoon seasons (Fig.7).

To define a composition class, Back and Co-workers suggested subdivisions of the tri-linear diagram. The cations and anion fields are combined to show a single point in a diamond-shaped field, from which inference is drawn on the basis of the hydro geochemical facies concept. It evidently explains the variations or domination of cation and anion concentrations during pre and post-monsoon as shown in Figure.7.

Table 2: Characteristics of corresponding subdivisions of diamond-shaped field

Sub Division of the diamond	Characteristics of corresponding subdivisions of diamond-shaped field	Pre Monsoon		Post Monsoon		Sub Division of the diamond	Characteristics of corresponding subdivisions of diamond-shaped field	Pre Monsoon		Post Monsoon	
		No. of Wells	%	No. of Wells	%			No. of Wells	%	No. of Wells	%
1	Alkaline earths (Ca+Mg) exceeds alkalies (Na+K)	26	76.5	15	44.1	5	Carbonate hardness (secondary alkaline exceeds 50%)	14	41.2	13	38.24
2	Alkaline exceeds alkaline earths	8	23.5	19	55.9	6	Non-Carbonate hardness (secondary salinity exceeds 50%)	1	2.9	Nil	Nil
3	weak acids (CO3+HCO3) exceeds strong acids (SO4+Cl)	21	61.8	16	47.1	7	Non-Carbonate alkali (primary salinity exceeds 50%)	4	11.8	3	8.824
4	Strong acids exceeds weak acids	13	38.2	18	52.9	8	Carbonate alkali (primary alkalinity exceeds 50 %)	Nil	Nil	1	2.941
						9	None of the Cation - Anion pairs exceeds 50 %	15	44.1	17	50

Alkaline earth (Ca+Mg) exceeds alkalies (76.5%) and (44.1%) and the 26 control wells fall under pre monsoon, 15 control wells in post monsoon season. The type Strong Acids exceeds weak acids 38.2% (13 control wells) and 52.9 % (18 control wells) respectively, based on hydro-chemical facies as shown in Table 2.

Conclusion

The present study reveals that the assessments of ground water quality were classified into different types of cation and anion groups. The cation groups identified as magnesium type and sodium or potassium type below the 30 % and calcium type were nil in both seasons. Its shows that water characteristics imbalance of calcium and magnesium, it may be agricultural crops are affecting by sulfate salts. Anion groups were identified as bicarbonate type 64.7 % in pre monsoon season and 41.2 % in post monsoon season. Bicarbonate amount is important one in water, because water has continued use of bicarbonate ratio leads to a breakdown in the physical structure of soil properties. The soil becomes hard and dry, increasingly resistant to water penetration. No dominant type of water cation facies above the 50 % both seasons and anion facies that group have below 30% experienced both seasons. The quality of water condition indicated severe limitation for irrigation and moderated hard based on the seasonal changes were found to have significant in the river basin.

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