Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 14	No. 1	pp. 107-112	2015

Original Research Paper

Groundwater Quality and its Suitability for Drinking and Agriculture from the Vel River Basin, Part of Pune District, Maharashtra, India

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 4-7-2014
Accepted: 23-8-2014

Key Words:
Drinking water
Groundwater quality
Water quality standards
Vel river basin

ABSTRACT

Assessment of suitability of groundwater for domestic and agricultural purposes was carried out in Vel river basin, Maharashtra, India. The study area covers an area of 44.23 km^2 and lies on the northern side of Pune. Groundwater is the major source for drinking and agricultural activity in this area. Groundwater samples were collected from 15 wells during pre-monsoon period in the year 2012. The water samples were analysed for physical and chemical characteristics. Suitability of groundwater for irrigation was evaluated based on salinity hazard, sodium percent, sodium adsorption ratio, US salinity diagram, Gibbs diagram, Kelly's ratio and permeability index. Physical and chemical parameters of groundwater such as electrical conductivity, pH, total hardness, Na^+,K^+,Ca^{2+},Mg^{2+},Cl^-, $HCO3^-$,CO_3^{2-}, SO_4^{2-}, and NO_3^- were determined. Interpretation of analytical data shows that mixed Ca-Mg-Cl, Ca-Cl, and Na-Cl are the dominant hydrochemical facies in the study area. The results of analysis were compared with the water quality standards of Indian Standard Institute (ISI), and World Health Organization (WHO). The overall groundwater quality is suitable for drinking purposes and for irrigation purpose which was evaluated by calculating Sodium Adsorption Ratio (SAR), resulting in SAR values less than 10 for all dug wells. The systematic planning of groundwater exploitation using modern technology is essential for the proper utilization of this precious natural resource. Information from this study could be used for effective identification of suitable locations for extraction of potable water for rural population.

INTRODUCTION

Water is a precious natural resource. It is also one of the most manageable of the natural resources as it is capable of diversion, transport, storage and recycling (Kumar et al. 2006). All these properties impart to water its great utility for human beings. In India, there are over 20 million private wells, in addition to the government tube wells (Datta 2005). Through them the overexploitation of groundwater is leading to reduction of low flows in the rivers and declining of the groundwater resources. It accounts for about 80% of domestic water requirement and more than 45% of the total irrigation in the country (Kumar et al. 2006).

Groundwater is the major source of water for domestic, agricultural and industrial purposes in many countries. India accounts for 2.2% of the global land and 4% of the world water resources and has 16% of the world's population. It is estimated that approximately one third of the world's population use groundwater for drinking. Therefore, water quality issues and its management options need to be given greater attention in developing countries. Intensive agricultural activities have increased the demand of groundwater resources in India. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices. Once undesirable constituents enter the ground, it is difficult to control their dissolution. The chemical characteristics of groundwater play an important role in classifying and assessing water quality. Geochemical studies of groundwater provide a better understanding of possible changes in quality.

Many naturally occurring major, minor and trace elements in drinking water can have a significant effect on human health, either through deficiency or excessive intake (Frengstad et al. 2001). Several research groups have discussed in detail the potential health impact due to poor quality of water (Frengstad et al. 2000). In India and various parts of the world, numerous studies have been carried out to assess the geochemical characteristics of groundwater (Aghazadeh & Mogaddam 2010, Alexakis 2011, Ahmad & Qadir 2011). The study of groundwater quality gives clues about the sources of major and trace ions and its quality from drinking as well as irrigation point of view. The objective of this study is to determine the groundwater quality of Vel River basin for hydrochemical constituents related to whether it is suitable or unsuitable for drinking and irrigation purposes.

MATERIALS AND METHODS

The area under study forms the part of Vel River basin, a tributary of Bhima River in the Rajgurunagar Tehsil of Pune district. The study area lies on the northern side of Pune city. The study area includes prominent towns such as Peth, Beth, Kurwandi and Pargaon. The area is bound by longitudes 73°50' to 73°58.5' E and latitudes 18° 53' to 19°00' N, and is included in the Survey of India's toposheets No. 47 F/13 of scale 1:50,000. It covers an area of about 44.23 sq.km (Fig. 1).

The area under study rises near Matewadi in the hilly areas, and after a winding course of about 18.3 kilometres, joins the Pargaon dam and further from that its flows down and meet the Bhima River near Vithalwadi. The major water reservoir structure in the study area is Pargaon dam located in south-east part of the study area. Water samples were collected in plastic containers of one-litre capacity for detailed chemical analysis, from the selected dug wells, bore wells and surface waters. These containers were washed thoroughly with distilled water and dried before being filled with water samples (Fig. 2). The containers were numbered serially along with a proper record of well/sample location, date, static water level of well, etc. prior to the sampling. The samples were collected and analysed in the Geochemistry Lab, by standard methods (APHA 1998) and Trivedy & Goel (1984) in the Department of Geology and Environmental Science, University of Pune.

RESULTS AND DISCUSSION

The major elements data plotted on Piper's trilinear diagram show Ca+Mg, Na+K; Cl+SO_4, HCO_3 hydrochemical facies, indicating that the alkaline earth is exceeding the alkalis and the strong acids exceed the weak acids. However, in the sample BW-8, an exactly opposite trend was found with the acids only.

The data on chemistry of the groundwaters have been used for the evaluation of quality of water for drinking and irrigation purposes. Comparisons of data with the water quality standards indicate that the groundwater in the study area is suitable for drinking purpose. It is observed from Table 4 that all the samples are below the maximum permissible limit. Hence, all the wells in the upper Vel River basin are suitable for drinking purposes. The suitability of groundwater for irrigation use was evaluated by calculating Sodium Adsorption Ratio (SAR). In the present study, all the dug wells show the SAR values less than 10 (Fig. 3). The water from the study area can thus, be graded as excellent for irrigation use. Hydrochemical survey was carried out in the Vel River basin in the post-monsoon 2012. The summary of the chemical survey showing minimum, maximum, and average concentrations of the dissolved constituents for the various sampling sites is given in Tables 1 and 2.

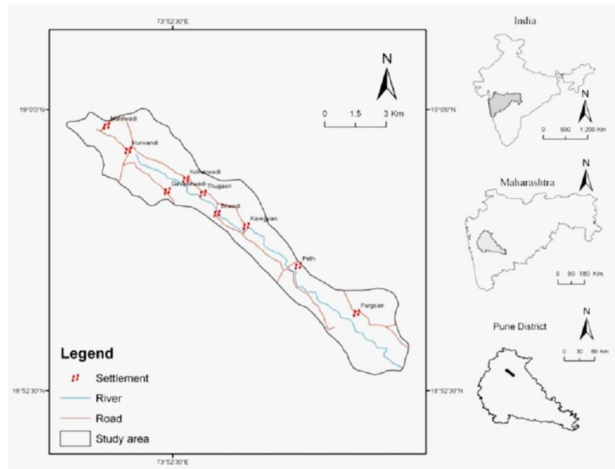

Fig. 1: Location map of the study area.

The high pH is recorded in the lower part of the basin while low is seen in the upper parts. Mostly alkaline pH of groundwater (pH 6.95-8.35) slightly amplifies owing to loss of CO_2 and precipitation of mineral salts (Fig. 4). EC is high (2080µS/cm) at BW-6 in the north-central part of the study area, while low EC values were reported at DW-10 in central part of the area under study (Fig. 5). The average value of EC (1085 µS/cm) is pinpointing to diminutive mineralization of groundwater (Pawar et al. 2008).

Spatial variation in anions: Anions present in the ground water from upper Vel River basin are reflecting the influence of various chemical and biochemical processes active in breaking down of rock minerals. In the study area, chloride is the principal anion followed by bicarbonate, sulphate and nitrate.

Chloride ranges from 31.24 to 80.1 mg/L with an average of 56.60 mg/L. It is observed that the high values of chloride concentration are predominant in the lower part of the area under study.

The lateral variations in chloride concentrations could be considered indicative of discharge and recharge zones of local groundwater flow regime. Thus, lower concentrations of Cl^- correspond with topographic highs and are indicative of recharge zones whereas higher Cl^- values corresponding with topographic lows, suggest discharge zones. High concentration of chloride (80.1 mg/L in SW-15), may be due to the evaporation of surface water (Fig. 6).

High values of HCO_3^- are observed in uppermost and lowermost parts of the basin while low are in the central part of the study area. The HCO_3^- values range from 65 mg/L to 148 mg/L (avg. 112.3 mg/L). High values of HCO_3^- in groundwater (Fig. 7) entail abundant supply of CO_2 by rain-

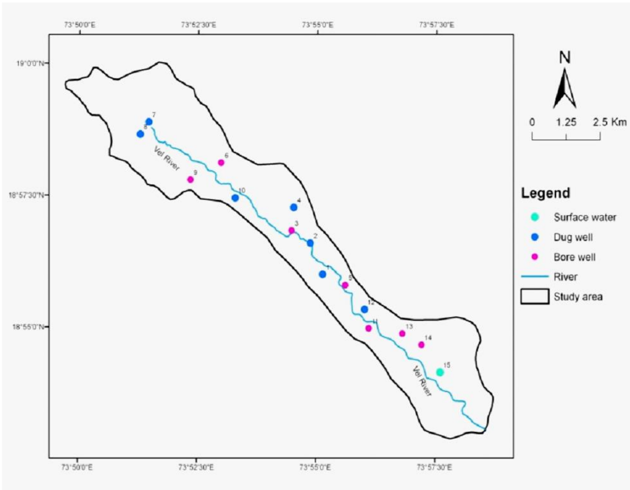

Fig. 2: Sampling location of groundwater in the study area.

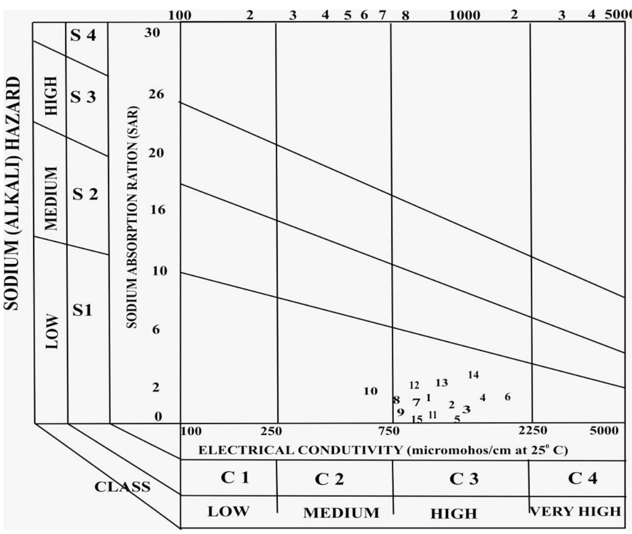

Fig. 3: US Salinity Laboratory diagram for classification of irrigation waters (Richards 1954).

water recharge and availability of larger surface area for rock-water interaction and vice versa (Matthess & Harvey 1982, Drever 1982, Pawar et al. 2008).

It is observed that the high values of sulphate concentration are predominant in the south-eastern part of the area under study, while low are in central part of the basin indicating lateral changes in sulphate concentration from recharge to discharge area (Fig. 8). The spatial distribution for NO_3^- are shown in Fig. 9. High concentration of NO_3^- (68.62 mg/L), is observed in BW-3 due to the agricultural activities, which are high in lower stretch of Vel River (Pawar et al. 2008). Fertilizers used for irrigation could be the source of NO_3^- in groundwater (Pawar et al. 2008).

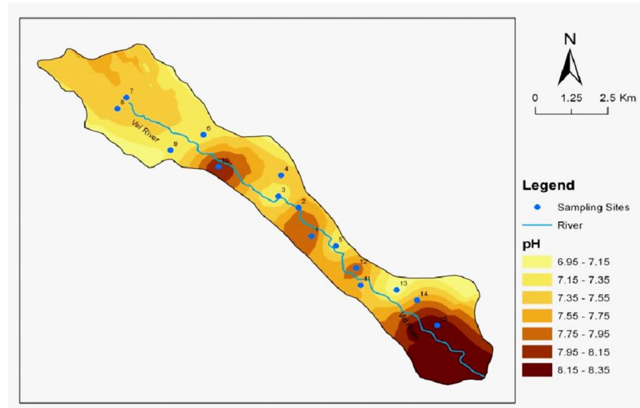

Fig. 4: Spatial variation of pH in the study area.

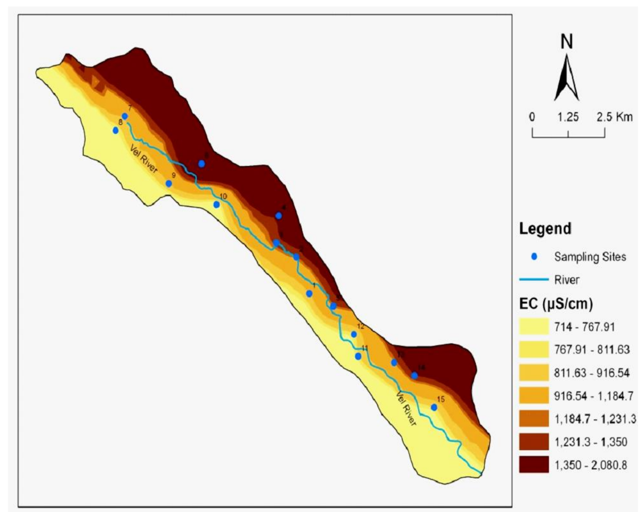

Fig. 5: Spatial variation of electrical conductivity (EC) in the study area.

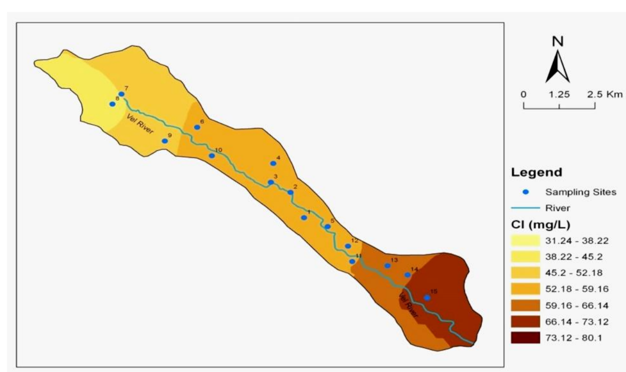

Fig. 6: Spatial variation of chloride (Cl^-) in the study area.

The data of cations and anions were plotted manually. The Piper's trilinear diagram showing chemical relationship of groundwater constituents from study area is shown

Table 1: Physico-chemical characteristics of water samples in study area. All values are in mg/L except pH and EC µS/cm)).

Source	pH	EC	TH	Na^{++}	K^{+}	Ca^{++}	Mg^{++}	Cl^{-}	HCO_3^-	SO_4^{2-}	NO_3^-	ECBE (%)
DW-1	7.99	897.6	134.35	50.0	1.51	20	20.50	53.96	75	45.00	33.59	7.32
DW-2	7.73	1203.6	151.72	45.6	0.94	18.25	25.78	58.04	100	42.56	65.00	-1.68
BW-3	7.1	1295.4	140.48	47.3	6.03	17.18	23.70	55.4	115	44.28	68.62	-4.36
DW-4	7.49	1356.6	133.29	52.2	1.13	16.08	22.62	54.32	65	43.21	61.92	4.93
BW-5	7.12	1213.8	153.26	48.0	1.13	18.24	26.16	63.00	119	41.60	63.35	-4.04
BW-6	7.15	2080.8	161.71	51.0	1.51	20.04	27.12	58.32	127.5	42.54	39.75	2.1
DW-7	7.42	928.2	143.44	52.9	0.94	22.32	21.30	52.54	109.4	43.78	36.34	4.19
DW-8	7.58	754.8	137.23	48.7	0.38	17.64	22.63	31.24	120.2	45.02	68.2	-0.17
BW-9	7.14	918.0	150.87	48.7	0.57	20.02	24.50	49.07	97.8	41.52	38.34	7.06
DW-10	8.23	714.0	161.90	56.7	1.88	26.86	23.03	59.06	126.5	44.23	31.58	5.31
BW-11	7.53	816.0	167.97	55.3	0.76	22.35	27.24	53.82	129.0	42.20	38.60	5.9
DW-12	7.91	775.2	163.42	53.9	0.75	26.28	23.75	53.64	102.3	44.25	38.65	8.65
BW-13	6.95	1183.2	155.60	58.9	0.94	23.10	23.78	60.68	136.5	44.28	38.62	1.81
BW-14	7.72	1346.4	161.99	60.9	0.94	28.10	22.30	65.80	148.2	43.23	33.62	1.56
SW-15	8.35	795.6	161.11	47.0	2	20.02	27.00	80.10	113	53.90	2.12	0.45
MAX	8.35	2080.8	167.97	60.88	6.03	28.10	27.24	80.10	148.2	53.90	68.62	
MIN	6.95	714.0	133.29	45.59	0.38	16.08	20.50	31.24	65.0	41.52	2.12	
AVG	7.56	1085.3	151.89	51.81	1.43	21.10	24.09	56.60	112.3	44.11	43.89	

Table 2: Data of major constituents of water samples in the study area, with water quality for irrigation (All values are in epm except SAR).

Source	Na^{++}	K^{+}	Ca^{++}	Mg^{++}	Cl^{-}	HCO_3^-	SO_4^{2-}	NO_3^-	SAR
DW1	2.18	0.04	1.00	1.69	1.52	1.23	0.94	0.54	1.88
DW2	1.98	0.02	0.91	2.12	1.64	1.64	0.89	1.05	1.61
DW3	2.06	0.15	0.86	1.95	1.56	1.88	0.92	1.11	1.74
DW4	2.27	0.03	0.80	1.86	1.53	1.07	0.90	1.00	1.97
DW6	2.09	0.03	0.91	2.15	1.78	1.95	0.87	1.02	1.69
DW7	2.22	0.04	1.00	2.23	1.65	2.09	0.89	0.64	1.75
DW8	2.30	0.02	1.11	1.75	1.48	1.79	0.91	0.59	1.92
DW9	2.12	0.01	0.88	1.86	0.88	1.97	0.94	1.10	1.81
DW10	2.12	0.01	1.00	2.02	1.38	1.60	0.86	0.62	1.73
DW11	2.47	0.05	1.34	1.89	1.67	2.07	0.92	0.51	1.94
DW12	2.40	0.02	1.12	2.24	1.52	2.12	0.88	0.62	1.86
DW13	2.35	0.02	1.31	1.95	1.51	1.68	0.92	0.62	1.84
DW14	2.56	0.02	1.15	1.96	1.71	2.24	0.92	0.62	2.05
DW15	2.65	0.02	1.40	1.83	1.86	2.43	0.90	0.54	2.08

in (Fig. 10). The detailed hydrochemical facies at each location is given in Table 3.

All the water sources showing the Ca+Mg, Na+K; Cl+SO_4 and HCO_3 hydrochemical facies, indicate the alkaline earth exceeding the alkalis, and the strong acids exceed the weak acids. The sample BW-8 shows the exactly opposite trend containing mainly the acids.

Groundwater quality for drinking purposes: The water to be used for drinking purposes must meet very high standards of physical, chemical and biological purity. It should be appetizing, clear, transparent with constant temperature and free from undesirable physical properties like cloudiness, objectionable odour and taste (Nikumbh 1997).

Certain minimum quality parameters for this requirement have been suggested by World Health Organization (WHO 1971). It is evident from these values that the major ions are under the permissible limits given by WHO (1971). All the samples are of good quality for drinking point of view except some parameters like EC and NO_3.

CONCLUSION

The area under investigation is a part of the Deccan Trap. The lithology in the area is a part of Lonavala and Diveghat subgroup. The Indrayani and Karla formations are the part of Lonavala subgroup while Diveghat formation is from Diveghat subgroup. The groundwater of the area under study was subjected to major ion analysis to ascertain the suitability of water for agricultural and drinking purposes. The major elements data were plotted on Piper's trilinear dia-

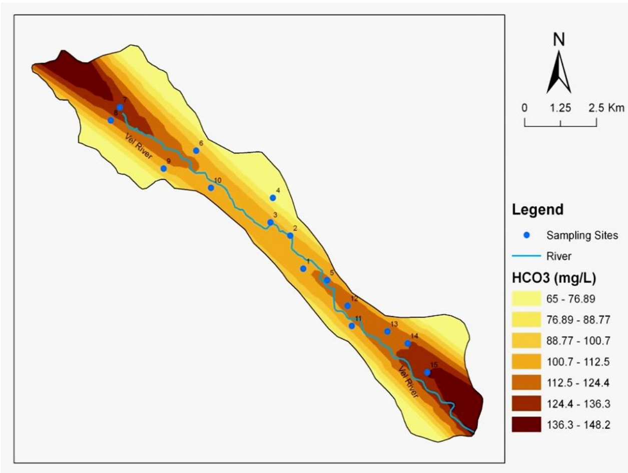

Fig. 7: Spatial variation of alkalinity (HCO_3^-) in the study area.

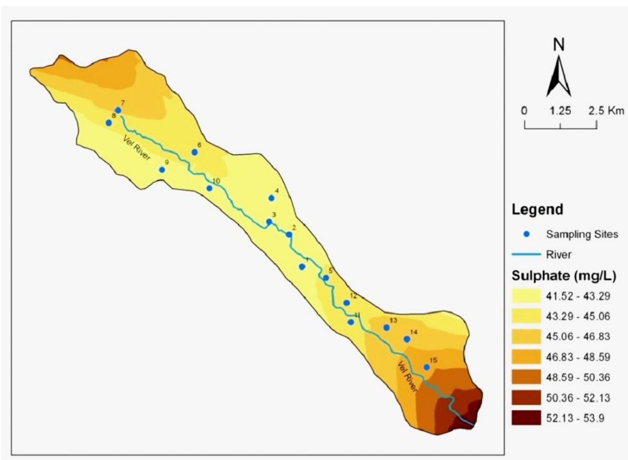

Fig. 8: Spatial variation of sulphate (SO_4^{2-}) in the study area.

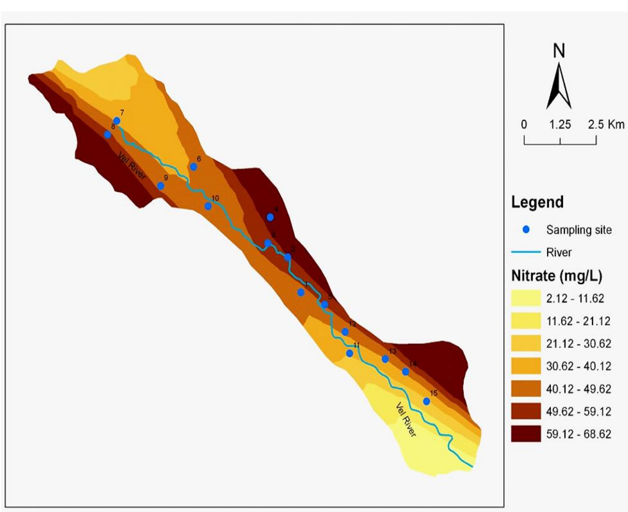

Fig. 9: Spatial variation of nitrate (NO_3^-) in the study area.

Table 3: Showing the source-wise hydrochemical facies of water.

S.No.	Hydrochemical Facies
DW-1	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
DW-2	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
DW-4	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
BW-5	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
BW-6	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
DW-7	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
DW-8	Ca+Mg, Na+K HCO_3, $Cl+SO_4$
BW-9	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
DW-10	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
BW-11	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
DW-12	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
BW-13	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
BW-14	Ca+Mg, Na+K $Cl+SO_4$, HCO_3
SW-15	Ca+Mg, Na+K $Cl+SO_4$, HCO_3

Table 4: Drinking water quality of dug well samples (WHO 1971).

Parameter	Permissible limit for drinking	% of Samples Below	Optimum	Higher
pH	6.9-9.2	-	100%	-
EC	300, µS/cm	-	-	100%
TH	100-500, mg/L	-	100%	-
Na	50-60, mg/L	40.3%	53%	6.6%
K	20m, g/L	100%	-	-
Ca	75-200, mg/L	100%	-	-
Mg	30-150, mg/L	100%	-	-
Cl	200-600, mg/L	100%	-	-
SO_4	200-400, mg/L	100%	-	-
NO_3	40-50, mg/L	67%	-	33%
HCO_3	200, mg/L	100%	-	-

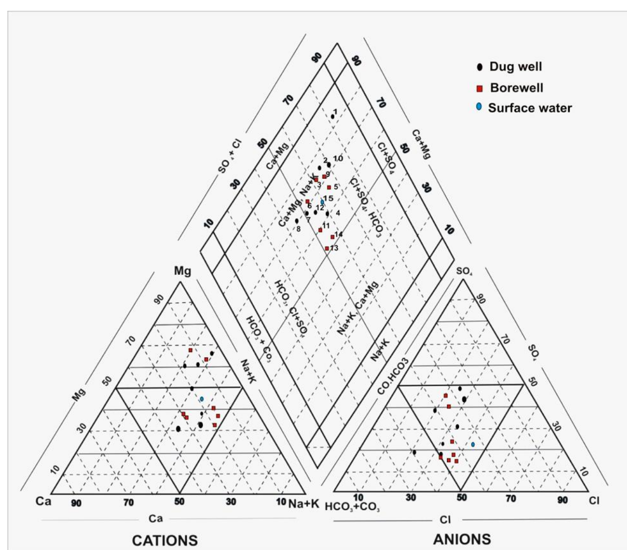

Fig. 10: Classification of hydrochemical facies of groundwater on Piper trilinear diagram.

gram shows that all the water sources Ca+Mg, Na+K; Cl+SO_4, HCO_3 hydrochemical facies indicate the alkaline earth exceeding the alkalis and the strong acids exceed the weak acids. The sample BW-8 shows the exactly opposite trend containing mainly the acids. The data on chemistry of the groundwaters have been used for the evaluation of quality of water for drinking and irrigation purposes. Comparisons of data with the water quality standards indicate that the groundwater in the study area is suitable for drinking purposes. It is observed that all the samples are below the maximum permissible limits. Hence, all the wells in the upper Vel River basin are suitable for drinking purposes.

ACKNOWLEDGEMENT

The authors are thankful to Prof. S. Govindaiah, Chairman of Department of Earth Science, Karnataka, Mysore for his encouragement and constant support.

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