*International Research Journal of Earth Sciences*__________________________________E-ISSN 2321–2527
Vol. **4(2),** 15-22, February **(2016)** *Int. Res. J. Earth Sci.*

Evaluation of Ground Water Quality in Chintamani Taluk, Chikkaballapur District, Karnataka, India

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Available online at: www.isca.in, www.isca.me
Received 23rd December 2015, revised 5th January 2016, accepted 11th February 2016

Abstract

This paper intends to evaluate the ground water quality with reference to drinking purpose in the Chintamani taluk, Chikkaballapur district, Karnataka. The total area occupied is about 884 Km^2 and underlain by Archaean rocks. 34 ground water samples from dug wells and bore wells were collected in the year 2014 and analyzed for Hydrogen Ion concentration (pH), Total dissolved solids (TDS), Total Hardness (TH), cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) and anions (HCO_3^-, CO_3^-, SO_4^{2-}, Cl^-, NO_3^-, F^-, PO_4^{3-}). A comparison of the ground water quality in relation to drinking water standards was made. Results show that, pH values of ground water range from 7.0 to 8.4 with an average of about 7.7, suggesting their alkaline nature and are considered to be suitable for drinking purpose. In the study area total hardness ranges from 50 to 740 mg/l with an average of about 287.9 mg/l. 41% of samples fall under "Hard category" and 35 % of the samples fall under "very hard category". Hence, there is a need for softening of these two categories of water, if it is to be used for drinking purpose. Most of the samples are within the permissible limits as per the standards proposed by BIS (2004). Piper's trilinear plot reveals that majority of the ground water samples are alkali rich than alkaline earths (65%) followed by the strong acids rich than weak acids (62 %),implying that they are suitable for drinking purpose except very few samples which exceeds the permissible limit.

Keywords: Groundwater, Quality, Chintamani, Karnataka.

Introduction

Water is a vital component for the sustenance of life. It is a natural renewable resource of earth. Taking into consideration the total amount of water present on earth, only 2.4 % is present in the main land. Ground water quality of an area can also be determined by its surrounding lithology, reaction between the water and the rock type present, the velocity with which the ground water is flowing and its interaction with the other type of aquifers present[1]. Due to the modernization and increase in the human population in the different parts of the world, there has been an increased for the fresh water. The anthropogenic activities such as agricultural waste, industrial discharge and urbanization shows their severe effect on the quality of the ground water [2, 3]. Due to which the different elements and other constituents get added to the ground water, which deteriorates the quality of the water and making it unsafe for drinking and irrigational purpose. Therefore, to understand better the hydrochemical processes and pollutant source, regular monitoring of water quality are essential for sustainable development and effective management of ground water resources [4-17]. The present study aims to evaluate the ground water quality of Chintamani taluk, Chikkaballapur district, Karnataka and to study the effect on drinking water of the area.

Study Area: The study area lies in the south east part of Karnataka at an average elevation of 865 mts from mean sea level. It is one among the 6 taluks of Chikkaballapur district. The total geographical area is 884 Km^2 and bounded by latitude N13°16'15"- N13°40'32.5" and longitude E77°57'26"- E78°12'27" (Figure-1). The study area is covered in the survey of India toposheets numbered 57G/14, G/15, 57K/2 and K/3on a scale of 1:50,000. The study area is bounded by Sidlaghatta to the west followed by Bagepalli in the north-west. Lithologically the age of the basement rock formations belongs to the Archaean with Gneissic complex to Granitic complex as the basement rocks of the Archaean times. The quaternary formations over lie the Archaean formations in the study area. The quaternary formations consist of red loamy soil, laterite, clay formation and in between these two formations dolerite dyke also exists. The north-eastern part of the study area consists of amphibolitic metapelitic schist/politic schist. There is an occurrence of pink and grey granite in the central and southern part of the study area. Speaking about the soil, the red soil is the common soil found in the study area.

Hydrogeology: Groundwater occupies the open spaces of weathered and fractured vesicular basalts, limestone and shale. In the weathered zone formations, groundwater is generally found under water table conditions. In the fractured and jointed formations, it is found in the semi-confined condition, which is overlain by highly weathered clayey zone. Groundwater movement is controlled by difference in potential head. The lateral movements of groundwater are reflected in the vertical movements of water level. The rise in water level is due to recharge from rainfall infiltration, seepage from surface water bodies and applied irrigation. Due to over-exploitation, groundwater use and natural discharge of the water level has deepened.

Methodology

Thirty-four ground water samples were collected from all available dug wells and bore wells during the year 2014 to evaluate the quality of ground water (Figure-2). Water samples were collected in one liter pre-washed polyethylene bottles. The water from the wells was pumped for 5–10 minutes and the polyethylene bottles were rinsed for 2 – 3 times with the water to be sampled. Garmin 78S GPS was used to record the longitudes and latitudes of the sample locations. Electrical Conductivity (EC) and Hydrogen ion concentration (pH) were noted on the site by using the portable EC and pH meters respectively. Chemical analyses were carried at Regional Chemical Laboratory of Central ground Water Board, Bangalore. The analyses of major ions were carried out as per the standard procedure recommended by APHA[18]. The representative samples collected from the study area were analyzed for total cation (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and total anions (HCO_3^-, CO_3^-, SO_4^{2-}, Cl^-, NO_3^-, F^-, PO_4^{3-}).

Results and Discussion

The hydrochemical analysis data of the ground water samples of the study area is presented in Table.1. Results of hydrochemical parameters of the ground water were compared with standard guideline values as recommended by BIS[19] for drinking and public health purpose.

Hydrogen Ion concentration (pH): The hydrogen ion concentration of the studied samples varies from 7.0 to 8.4 with an average of about 7.7, thus suggesting their alkaline nature. All the samples are within permissible limit as per standard prescribed by BIS[19] and are suitable for drinking purpose.

Total dissolved solids (TDS): Natural sources and sewage discharge are the reasons for the total dissolved solids to originate in the water. Electrical conductivity has its direct effect on the total dissolved solids concentration, hence the TDS values were determined by multiplying the electrical conductivity value with the factor of 0.64[20]. The hydrogeological reactions between the water and the rock type will have its effect on the TDS concentration. The studied samples have been classified into different groups based on the TDS concentration as per the U. S. Geological Survey and the results are given in Table-2. 71 % of the studied samples fall under the fresh water category, while 29 % under slightly saline category. TDS value of the studied samples ranging from 121.6 to 1830.4 mg/l with an average of about 784.1 mg/l, are well within the permissible limit and suitable for drinking purposes[19].

Total Hardness (TH): Total hardness of ground water depends primarily on the concentrations of calcium carbonate and magnesium carbonate. Because, hardness plays an important role in determining the usability of ground water for domestic and many industrial purposes, the studied samples have been classified for its domestic and industrial suitability based on total hardness. Total hardness of the studied samples ranges from 50 to 740 mg/l with an average of about 287.9 mg/l suggesting that 41% of samples fall under hard category, while 35 % of the samples fall under very hard category (Table 3)[21].This calls for immediate softening of these two categories of water, in order to make it usable for drinking purpose. Remaining samples falling under soft (3%) to moderately hard (21%) category is suitable for domestic usage. All the samples are within permissible limit as per standards prescribed by BIS[19] and are suitable for dinking purpose (except two samples).

Cation Geochemistry: Calcium (Ca): Being one of the major constituent of rocks and soils, calcium is mainly derived from the silicate minerals like feldspars, pyroxenes, and amphiboles when the water interacts with soil and rocks. The silicate minerals on weathering release significant quantities of soluble calcium, which ultimately finds its way into ground water. Calcium is present in all groundwater due to its abundance and its solubility. The calcium content of the studied samples, ranging from about 8 to 168 mg/l with an average of about 51.8 mg/l, are well within the permissible limit and suitable for drinking purposes as per BIS[19].

Magnesium (Mg): Magnesium, an important component of rock forming minerals, is housed in minerals like chlorite, serpentine, biotite, hornblende, olivine and augite. Therefore, the magnesium content in ground water attains wide range. Magnesium salts occur in significant concentrations in natural water and are often less than that of calcium concentrations due to its low abundance than the calcium in all rock type. In the study area, the magnesium content in groundwater ranges from 7 mg/l to 77 mg/l with an average value of 38.1mg/l and are well within the permissible limit as per BIS[19].

Sodium (Na) and Potassium (K): Sodium gets enriched in groundwater mainly due to the interaction with silicate minerals, precipitation from the atmosphere and halite deposition, while Potassium concentration is a function of rate of weathering of silicate minerals such as orthoclase, microcline and biotite, and the application of fertilizers. Potassium concentration in most natural waters is very low because it does not dissolve readily, and is released easily and quickly during weathering. The sodium concentration in the studied samples ranges from 19 to 357 mg/l with an average of about 138.7 mg/l, while that of potassium concentration from 0.8 to 107 mg/l with an average of about 13.7 mg/l.

Anions geochemistry: Nitrate (NO_3): Nitrate in ground water is enriched due to natural and anthropogenic activities, such as precipitation, usage of extensive fertilizers, waste of the humans and animals, etc. Most of the nitrate content in the studied samples, ranging from 20 to 120 mg/l with an average of about 50.3 mg/l, are within the permissible limit (except few) and suitable for drinking purposes as per WHO[22].

Sulphate (SO_4): Barite, epsomite, gypsum, etc. are the natural sources for the sulphate to occur in the groundwater in the dissolved form[23]. Anomalies in sulphate concentration in ground waters is encountered in the ore zones especially pyrite. Further, extensive usage of sulphate fertilizers also enriches sulphate concentration in groundwater. The sulphate concentration in the studied samples ranges from 8 to 164 mg/l with an average concentration of about 67.2 mg/l and are well within the permissible limit as per BIS[19].

Carbonate (CO_3) and Bicarbonate (HCO_3): Dissolved CO_2 in rainwater is the primary source of carbonate and bicarbonate ions in groundwater. Temperature and pressure controls the solubility of CO_2 in water – more soluble with increase in temperature and decrease in pressure, and vice-versa. Water rich in CO_2 dissolves carbonate minerals, present in soils and rocks, as it flows through to give bicarbonates. Due to limited variations in the interstitial pores of the rocks in the aeration zone, the bicarbonate concentration remains fairly constant. The concentration of the carbonate in the studied samples ranges from 0 to 15 mg/l with an average concentration of about 0.4 mg/l, while bicarbonate ranges from 30 mg/l to 525 mg/l with an average concentration of about 256.4 mg/l.

Phosphate (PO_4): The concentration of the phosphate in the groundwater will be increased by natural processes such as the decomposition of rocks and minerals, atmospheric deposition, run off, sedimentation, etc. Apart from the natural processes, the anthropogenic sources such as the fertilizers, animal waste, phosphate mining, industrial discharge, etc. also contributes to the phosphate level to go up in the groundwater. Phosphate is not much mobile because of the instability and is one of the reasons for low concentration of phosphate[24]. Phosphate concentration in the study area ranges from 0.02 to 0.68mg/l with an average concentration of 0.22 mg/l.

Chloride (Cl): Leaching of the chloride bearing rocks and minerals such as sodalite and chloroapatite can result in the natural process of concentration of chloride in groundwater. The uncontrolled discharge of waste products from agriculture, industries, sewage, etc. can also cause chloride concentration. High concentration of the chloride in the groundwater results in bad taste for water. Chloride ion combines with the sodium to from sodium chloride, thus increasing the salinity of the groundwater. The concentration of chloride in the groundwater of the study area ranges from 21 to 795 mg/l with an average concentration of about 197.5 mg/l. According to BIS[19], the permissible limit of chloride in drinking water is 1000 mg/l. Therefore, all the samples from the study area are within the permissible limit and suitable for drinking purpose.

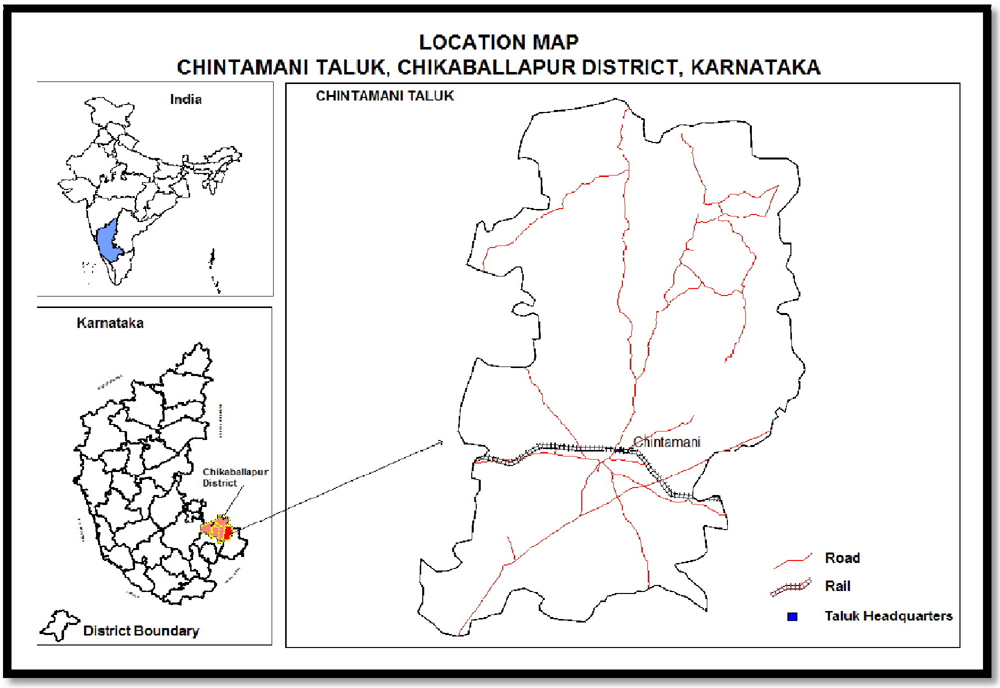

Figure-1
Location map of the study area

Fluoride (F): Natural processes such as the breaking down of the rocks and soil or weathering and deposition of atmospheric volcanic particles can lead to the concentration of fluoride in the groundwater. Apart from the natural processes, the anthropogenic activities such as the extensive use of fertilizers, untreated sewage and septic disposal, industrial wastes can also contribute for the fluoride concentration in the groundwater. Lower fluoride concentrations in drinking water reduces the risk of dental cavities, while higher concentrations can severely affect the teeth and bones. The concentration of the fluoride in the studied samples ranges from 0.32 to 1.7 mg/l, with the average concentration of about 1.14 mg/l. According to BIS[19] the permissible limit of fluoride in drinking water is 1.5 mg/l, suggesting most of the studied samples are within permissible limit.

Piper's trilinear method: Piper diagram is used to understand the hydrochemical characteristics and problems pertaining to geochemical evolution of groundwater[25]. The results of the groundwater analysis of the study area were plotted in Piper trilinear diagram[26] using the Groundwater-Chart software. Various characteristic types of groundwater can be distinguished by their concentrations in certain sub-divisions of the diamond shaped field, as shown in Figure-3 and the percentage of the samples in different categories are given in the Table-4. The results from the piper trilinear diagram reveals that the alkalies exceed alkaline earths (65%) followed by the strong acids exceeds weak acids (62 %).

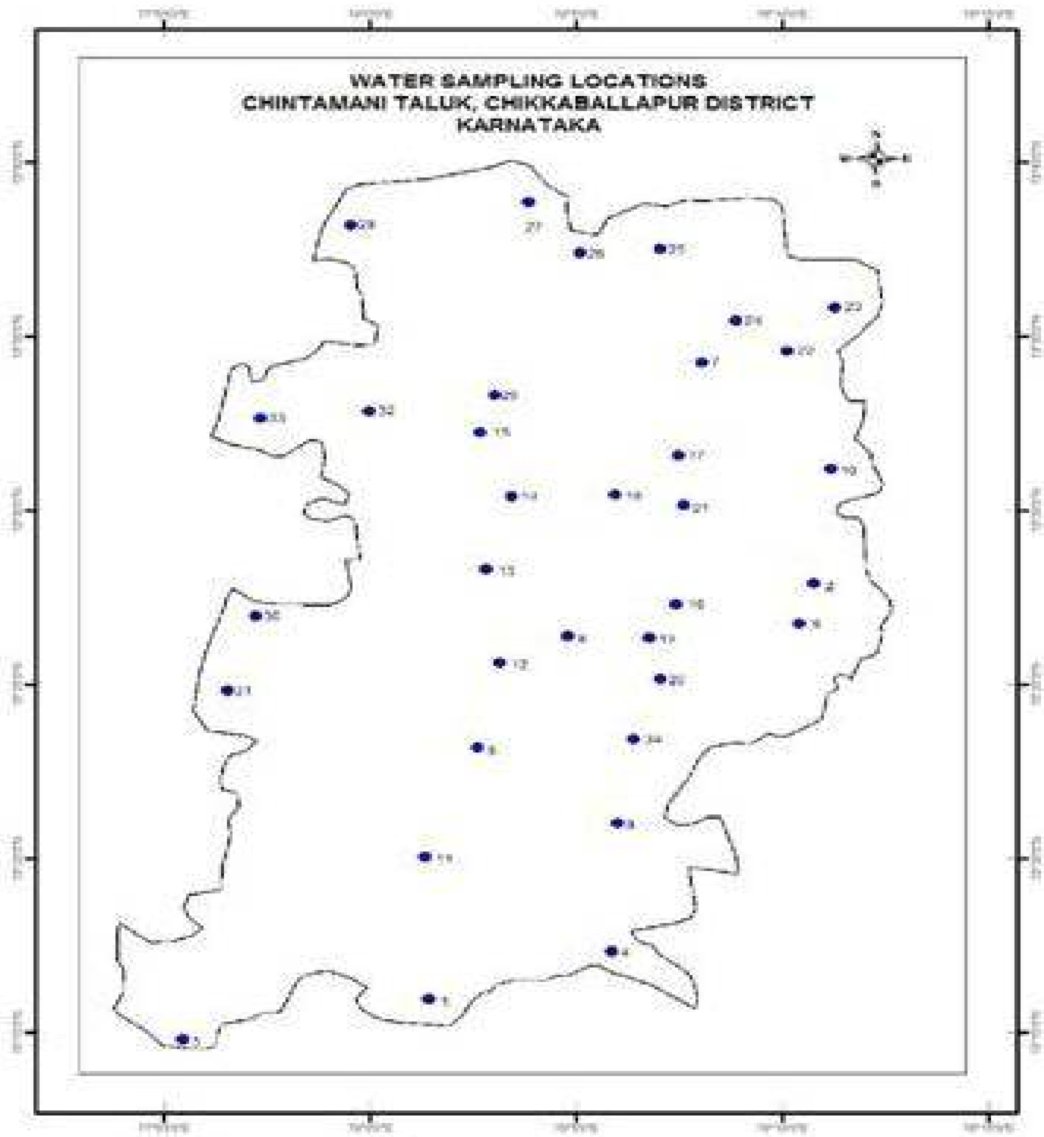

Figure-2
Sample location map of study area

Table-1
Physico - chemical parameter of water samples from Chintamani study area

Location	Well Type	Latitude	Longitude	pH	EC	TH	TDS	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	PO_4^{3-}	F^{-}
Kurupalli	DW	13.1039	78.0996	7.6	1990	550	1273.6	112	65	194	6.8	0	226	511	48	42	0.2	0.64
Peddur	BW	13.4822	78.1796	7.6	1580	500	1011.2	132	41	129	5.3	0	262	270	118	75	0.2	0.76
Kallahalli	BW	13.2739	77.9467	7.0	2410	740	1542.4	168	77	211	1.2	0	378	483	96	100	0.23	0.32
Sikalur	DW	13.3138	78.1048	7.9	2310	590	1478.4	148	53	237	34.8	0	140	596	100	89	0.21	0.95
Chintamani	DW	13.4068	78.0553	7.6	1890	350	1209.6	60	48	209	107	0	390	348	80	48	0.24	1.30
Digavapalli	DW	13.4636	78.1739	7.7	910	110	582.4	16	17	154	5	0	256	128	32	22	0.68	1.10
Battalahalli	DW	13.5832	78.1382	7.7	1980	400	1267.2	88	43	200	106	0	525	256	164	27	0.67	1.15
Bhumisettihalli	BW	13.4582	78.0889	7.8	1680	440	1075.2	100	46	177	9.9	0	488	234	78	20	0.17	0.42
Doddaganjur	BW	13.3726	78.1070	7.6	1220	320	780.8	88	24	114	30.4	0	122	234	94	80	0.18	0.70
Junjunhalli	BW	13.5165	79.3149	7.8	860	200	550.4	16	39	101	4.9	0	213	106	52	45	0.02	1.59
Chinnasandra	BW	13.3574	78.0363	7.2	1420	300	908.8	48	43	182	8.8	0	140	234	158	96	0.05	0.70
N. Kottur	BW	13.4460	78.0636	7.5	980	220	627.2	40	29	119	3.7	0	238	121	82	42	0.12	1.40
Kottagal	BW	13.4887	78.0586	7.8	730	180	467.2	16	34	82	2.2	0	232	57	54	36	0.06	1.50
Kancharahalli	BW	13.5220	78.0679	8.0	550	150	352	20	24	56	1.9	0	122	71	36	30	0.16	1.70
Gonenahalli	BW	13.5509	78.0566	7.5	910	220	582.4	20	41	102	2.5	0	293	85	48	47	0.12	1.12
Subrayanhalli	BW	13.5227	78.1061	7.7	850	200	544	24	34	101	2.7	0	268	64	58	49	0.18	1.40
Irugampalli	BW	13.5406	78.1297	7.5	1410	270	902.4	32	46	189	5.9	0	305	206	96	70	0.18	0.91
Gundlapalli	BW	13.4724	78.1285	8.1	590	130	377.6	16	22	72	3.7	0	220	36	36	22	0.23	1.5
Bairanahalli	BW	13.4572	78.1186	7.8	530	130	339.2	28	14	59	1.8	0	146	50	24	45	0.19	1.6
Murugumala	BW	13.4385	78.1228	7.5	580	150	371.2	32	17	34	50	0	159	50	48	40	0.37	1.2
Junjanahalli	BW	13.5180	78.1315	7.8	1120	290	716.8	28	53	121	2.5	0	305	121	58	80	0.26	1.21
Munganahalli	BW	13.5882	78.1694	7.9	650	100	416	20	12	100	1.8	0	250	43	28	27	0.18	1.61
Erumalapaddi	BW	13.6084	78.1871	7.6	830	160	531.2	20	27	110	3.9	0	287	71	38	42	0.26	1.21
Bodampalli	DW	13.6021	78.1509	7.9	190	50	121.6	8	7	19	0.8	0	30	21	8	35	0.22	0.7
Kadadalampar	BW	13.6350	78.1228	7.6	1710	390	1094.4	28	77	212	2.3	0	268	369	58	50	0.19	1.3
Chinnepalli	BW	13.6333	78.0932	7.9	1960	510	1254.4	91	68	212	4.4	0	384	334	124	65	0.18	0.97
Chilakalnerupu	BW	13.6565	78.0743	7.9	2860	620	1830.4	168	48	357	22.7	0	73	795	132	120	0.22	0.8
Salamakalahal	BW	13.6460	78.0086	8.4	800	180	512	28	27	98	2.6	15	183	121	22	26	0.20	1.7
Kodegandlu	BW	13.5681	78.0616	8.0	930	160	595.2	32	19	133	3.6	0	323	92	32	42	0.37	1.1
Yeshwanatapu	BW	13.4671	77.9739	8.2	1120	240	716.8	20	46	143	3.2	0	335	135	44	45	0.24	1.18
Ullappanahalli	BW	13.4330	77.9635	8.0	780	160	499.2	36	17	104	1.9	0	207	92	52	32	0.28	1.7
Jangalahalli	BW	13.5608	78.0156	7.5	1110	280	710.4	28	51	123	2.7	0	342	128	56	27	0.20	0.97
Korlapatti	BW	13.5575	77.9757	7.9	830	190	531.2	24	31	100	2.1	0	317	57	38	25	0.20	1.2
Battalapalli	BW	13.4109	78.0031	7.1	1390	310	889.6	28	58	164	18.1	0	293	199	96	70	0.17	1.3
Average				**7.7**	**1225**	**287**	**784.1**	**51**	**38**	**138**	**13.7**	**0.4**	**256**	**197**	**67**	**50**	**0.22**	**1.14**

Table-2
Classification of ground water based on concentration of TDS as per U.S Geological survey

Category	TDS (ppm)	No. of Samples	Percentage
Fresh Water	0 - 1000	24	71
Slightly Saline	1000 – 3000	10	29
Moderately Saline	3000 – 10000	-	-
Very Saline	10000 – 35000	-	-
Brine	More than 35000	-	-

Table-3
Classification of ground water based on Total Hardness

Hardness as $CaCO_3$ (mg/l)	Water class	No. of samples	Percentage	Remarks
0-75	Soft	1	3	Require little or no softening
75-150	Moderately Hard	7	21	Require little or no softening
150-300	Hard	14	41	Require softening
Above 300	Very Hard	12	35	Require softening

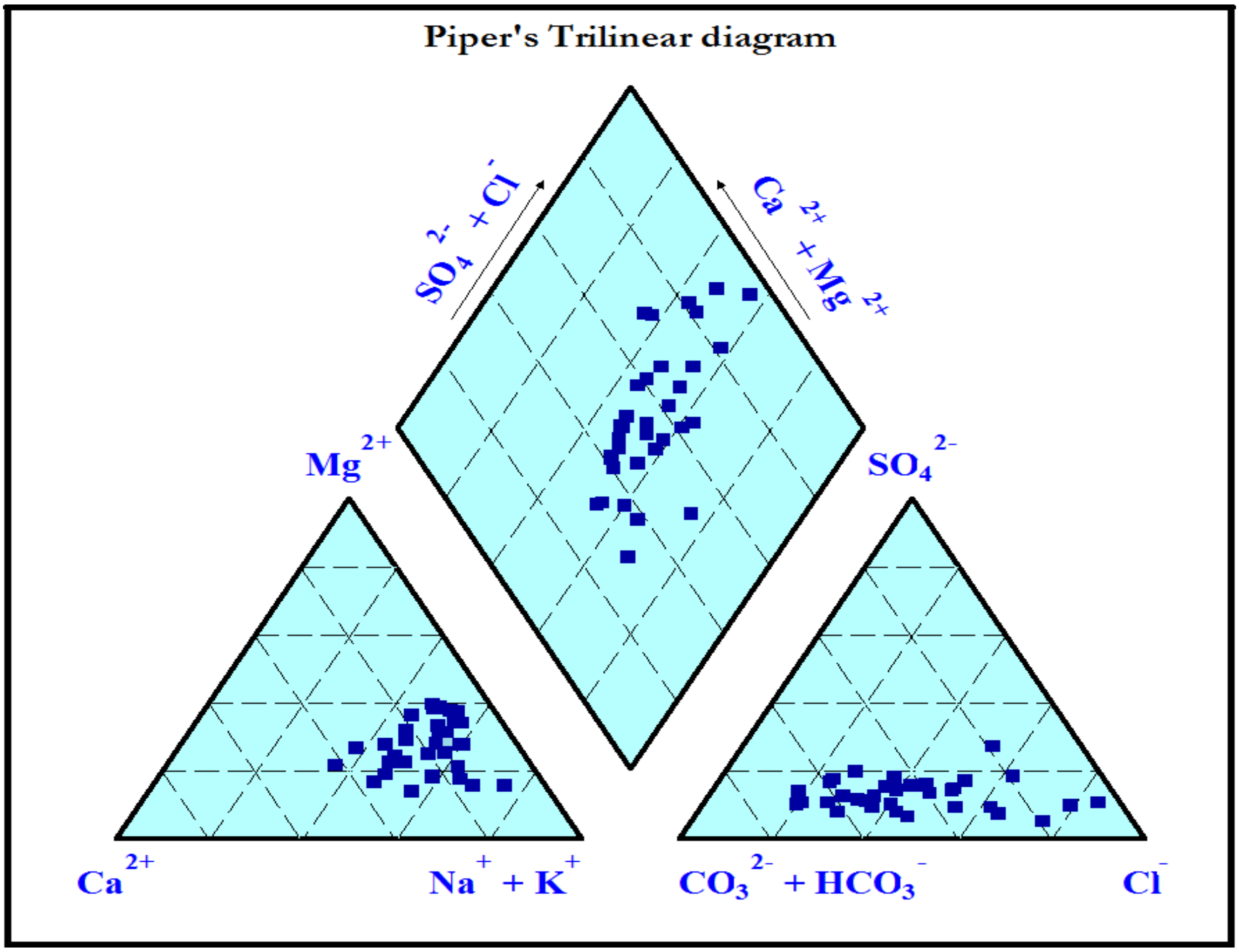

Figure-3
Piper's trilinear diagram

Table-4
Classification of groundwater based on Piper's Trilinear Diagram

Sub-division number of the Diamond shaped Field	Characteristics of corresponding self-division of the diamond shaped field	Percentage of the samples
1	Alkaline earths (Ca+Mg) exceeds alkalies	35
2	Alkalies exceed alkaline earths	65
3	Weak acids (CO_3 - HCO_3) exceeds strong acids (SO_4 + Cl)	38
4	Strong acids exceeds weak acids	62
5	Carbonate hardness (secondary alkalinity) exceeds 50% i.e.; chemical properties are dominated by alkaline earths and strong acids	9
6	Non-carbonate alkali (secondary salinity) properties are dominated by alkaline earths and strong acids.	0
7	Non-carbonate alkali (primary salinity) exceeds 50% i.e.; chemical properties are dominated by alkalies.	38
8	Carbonate alkali (primary alkalinity) exceeds 50% i.e.; chemical properties are dominated by alkalies and weak acids.	0
9	No one cation - anion pair 50%	53

Conclusion

The evaluation of ground water quality of Chinthamani taluk, Chikkaballapur district, Karnataka suggests that the studied samples are slightly alkaline in nature and are suitable for drinking purpose according to BIS[19] standards. The TDS concentration is within the permissible limit while the total hardness ranges from 50 to 740 mg/l. 41% of samples fall under hard category and 35 % of the samples fall under very hard category. Hence, there is a need for softening of these two categories of water, if it is to be used for drinking purpose. In piper trilinear diagram, most of the samples fall in alkalies exceed alkaline earths (65%) followed by the strong acids exceeds weak acids (62 %). Comparison of the studied hydrochemical parameters with the standard guidelines recommended by BIS[19] and WHO[22] reveals that the ground water of the study area is suitable for drinking purpose and public health.

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